PLATFORMER POOL FIRE INCIDENT INVESTIGATION JULY 19, 2018

KERN OIL& REFINING CO.

Final Report

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Kern Oil & Refining Co.

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1 INTRODUCTION

1.1 General

On July 19, 2018, a pool fire occurred in the Platformer Unit at the Kern Oil & Refining Co. (Kern Oil) refinery in Bakersfield, CA, while contractors were preparing to work in the area. No one was injured, but electrical and control equipment and cables were damaged.

Kern Oil initiated the incident investigation at approximately 1:30 pm July 19, 2018 by taking witness statements following the emergency response. For the purposes of the incident investigation, Kern Oil treated this pool fire as a major incident under 8 CCR 5189.1(o) [ref. 1].

Baker Engineering & Risk Consultants, Inc. (BakerRisk®) was contracted to lead the investigation and facilitate a Root Cause Analysis (RCA), jointly with a small multi-discipline team of Kern Oil employees knowledgeable in the operation and maintenance of the refinery. BakerRisk mobilized to the refinery on July 24, 2018, and the investigation continued through August and September 2018.

1.2 Scope of Work

The scope of work included the following tasks:

- Evidence gathering, including site inspection and witness interviews, as well as review of documentation and records, photographs/videos, and any physical evidence;
- Analyzing evidence to identify the most likely scenarios;
- Developing an incident timeline for the most likely (proven) scenario;
- Identifying causal factors from the timeline; and
- Facilitating a RCA to determine the underlying causes of the incident.

The RCA employed BakerRisk's Cause Analysis Tree (CAT) methodology, followed by the 5 Whys? technique. This approach was conducted in line with the guidance provided by the Center for Chemical Process Safety (CCPS) for RCA using a pre-defined tree method [ref. 2].

1.3 Investigation and Root Cause Analysis Team

The Investigation Team members were:

Mike Broadribb	Senior Principal Consultant, BakerRisk® (Leader)
Alissa Reed	Vice President – Safety & Employee Development, Kern Oil
Quinlan Brown	Health & Safety Advisor, Kern Oil
Jerry Franklin	Snr. Manager Operations/Maintenance, Kern Oil
Ron Grant	Operations Superintendent, Kern Oil

Brian Keller	Health & Safety Manager, Kern Oil
Amrik Khangura	Instrument & Electrical Technician, Kern Oil
Jess Montgomery	Unit Board Operator, Kern Oil

2 BACKGROUND

The Kern Oil facility in Bakersfield, CA is an integrated refinery with several process units, including Crude Unit, Platformer Unit, Kerosene, Diesel and Naphtha Hydrotreater Units, Reformer Unit, Sulfur Plant, and storage and utility systems. The refinery processes approximately 25000 BPD of mostly Kern County crude oil to produce consumer fuels. The refinery operates on 12-hour shifts, 2 shifts per day, 7 days per week. Total number of staff is approximately 125, which is supplemented by contractors.

The Platformer Unit converts low-octane naphtha (Unifinate) into a high-octane gasoline stock. The reforming reactions take place at high pressure and temperature in a hydrogen-rich atmosphere in the presence of a platinum-rhenium bimetallic catalyst. The process generates hydrogen, which is recycled to prevent the formation of coke on the catalyst, and supplied to other process units, the sweet gas system, or relieved to the flare gas system.

The Platformer Unit was shut down on July 15, 2018 in preparation for a turnaround involving internal inspection of process vessels, heat exchanger tube bundle cleaning, reactor catalyst offsite regeneration, PSV servicing, valve replacements, and other tasks. The turnaround activities were scheduled for both the day and night shifts involving multiple contract companies. During the course of the turnaround, a number of projects, including the installation of a valve on the flare header, were also scheduled while the unit was shut down. The project work was managed independently of the main turnaround work.

On Thursday, July 5, 2018, a Superintendent informed project personnel that their plan to cold cut the live flare header and install an isolation valve was rejected, and recommended the use of a stopple valve. However, on Saturday, July 15, 2018, a Shift Supervisor approved the plan to install the isolation valve without the use of a stopple valve.

The refinery flare system has periodically experienced problems due to the buildup of hydrocarbon liquid. This was identified in the July 9, 2018 LPG Recovery Unit Process Hazard Analysis (PHA) report [ref. 3]. In the days leading up to the incident, liquid was repeatedly drained from the flare header via a 1-inch valve by flexible hose to the sump at the north end of the Platformer unit. This location was approximately 30 feet south of where the project wanted to cold cut and install the isolation valve near Compressor (3528.07).

3 DESCRIPTION OF THE INCIDENT

At the time of the incident the Platformer Unit was shut down for the turnaround. In preparation for installation of the flare header valve, Operations personnel were not able to determine the source of the liquid in the flare header. On Wednesday, July 18, 2018, a sample of the liquid was taken and its specific gravity measured. The liquid had a similar gravity to that of Unifinate, a light hydrocarbon with a low flash point (20 - 55˚F).

The turnaround activities progressed on July 17th and 18th, 2018 involving multiple tasks in the area around the High Pressure Separator (3510.02) and High Pressure Effluent Cooler Exchangers (3530.09 and 3530.10). These tasks required heavy equipment, including two cranes and a heat exchanger tube bundle puller, in addition to scaffolding to allow pipe fitters access to remove heat exchanger heads and piping. On the morning of Tuesday, July 18, 2018, the tube bundles were pulled from the High Pressure Effluent Cooler Exchangers. Plant inspectors and electrical contractors were also present working in the area. All of these activities took place around the electrical conduit that was broken at some stage on Tuesday/Wednesday, July 18/19, 2018.

At approximately 3:00 am Wednesday, July 19, 2018, the operators in the South Control Room first noticed the lights flicker. Just over half an hour later, a contractor reported seeing sparks from a broken conduit between the High Pressure Separator (3510.02) and the High Pressure Effluent Cooler Exchangers (3530.09 and 3530.10). The contractor shut down all work in the area. The night shift Maintenance Supervisor observed that the electrical breaker had not tripped, discussed the situation with the Shift Supervisor, and, as a safety measure, taped off an area across the High Pressure Effluent Cooler Exchangers to the High Pressure Separator. When the day shift Maintenance Supervisor arrived around 5:50 am, he was shown the broken conduit by his night shift counterpart and arranged for an Instrument & Electrical (I&E) Technician to isolate the conduit wiring. The I&E Technician arrived and observed the broken conduit leaning against the steel wheel of the heat exchanger bundle puller, and that the ground around the conduit was dry. He then traced the broken conduit to the Platformer Control Room, but it was not possible to identify the appropriate wiring in the electrical box. By about 7:50 am, the I&E Technician informed operators that he needed to trip multiple breakers to identify the correct circuit. However, the Shift Supervisor refused without management permission, and the I&E Technician and Maintenance Supervisor agreed to call out an electrical contractor.

From approximately 6:00 am to 7:40 am July 19, 2018, liquid was drained from the flare header using hoses to the sump. By about 11:00 am, a contractor was getting prepared to cold cut the flare header, so the Shift Supervisor with the contractor checked for liquid in the flare header by loosening the blank flange on a 3-inch drain valve near Compressor 3528.07. When the drain

valve was opened, some residual liquid was released on to the ground when it hit the blank flange. A contractor employee used a water hose to push the liquid towards a drain by the Platformer Control Room. The contractor managing the project work stopped by and was aware of the liquid draining on to the ground. When the liquid stopped draining, the Shift Supervisor gave the contractor permission to proceed and left the unit. The water hose was left running.

The contractor set up their equipment and started to work on the flare header just before 11:20 am. At approximately 11:20 am, a large slug of liquid started draining from the open drain valve by Compressor 3528.07, and the contractor stopped their work (Note: the cutting device had barely scored the surface of the flare header). A contractor used the water hose to start pushing the liquid towards the drain by the Platformer Control Room. By 11: 45 am, the Shift Supervisor was aware of the problem. Continued use of the water hose started to back up the drain and flood the area around the Platformer compressors and aisle.

At approximately 12:35 pm, the I&E Technician returned with an electrical contractor to work on the broken conduit, but did not check in with Operations or the contractor managing the project work. Near the broken conduit, they observed a small pool of liquid (approximately 24-inch diameter), which was not obviously hydrocarbon. When the electrical contractor touched the conduit, a spark ignited small lazy flames on the surface of the pool of liquid and on the wetted soles of his boots. Within seconds, the flames flashed 15 to 20 feet to the west, and then 50 feet north to a much larger fire in the Platformer aisle. Smoke visible from the security camera at the front gate of the refinery indicates that the fire started approximately 12:39 pm.

An operator raised the alarm by radio, as the proximity of the fire on top of the water backed up at the drain by the Platformer Control Room prevented access to the emergency horn. While contractors evacuated the area, several Kern employees activated fire monitors and hoses. However, by approximately 12:51 pm, the fire was extinguished and the source of fuel isolated by closing the drain valve by Compressor 3528.07.

There were no injuries, but the fire resulted in damage to instrument and electrical systems, and caused the South Control Room to lose the DCS without serious upset to other process units. Figure 1 and Figure 2 illustrate some of the fire damage.

Figure 1. Damage to Instrumentation

Figure 2. Damage to Overhead Piperack

After the fire was extinguished, the Technician identified the correct breaker for the broken conduit. It was faintly labeled "Chemical Pump". The pump was out of service and had been removed. The conduit was isolated and a GUA conduit outlet box installed.

4 EVIDENCE

Kern Oil personnel started evidence gathering immediately following the emergency response. Photographs were taken, security camera videos were secured, and written statements and interviews of eyewitnesses were conducted by Kern Oil on July 19, 2018 and subsequent days. The site of the pool fire was secured to enable the Investigation Team to take photographs and gather evidence.

4.1 Interviews

During the week commencing July 23, 2018, BakerRisk interviewed Kern Oil personnel who had knowledge of the incident. Interviewees represented management, operations, maintenance, instrumentation/electrical, project engineering, and EHS. In addition, BakerRisk was given access to the records of eyewitness interviews conducted by Kern Oil on the day of the incident and subsequent days. However, neither BakerRisk nor Kern Oil were able to interview employees of the major contractors. Interviews with employees of major contractors were repeatedly requested, but contractors did not make their employees available to the Kern Oil investigation team. Contractors similarly did not provide any requested documentation. As a result, the team conducted as thorough investigation as was possible under the circumstances.

4.2 Documents and Records

Documentation and records pertaining to the equipment and actions associated with the incident were provided to the Investigation Team. These documents included:

- Engineering drawings of the Platformer Unit,
- Turnaround plan/schedule and work orders,
- Meteorological data,
- Operations, maintenance, and engineering notes, and
- Relevant PSM studies and analysis documents, such as LPG Recovery Unit PHA report [ref. 3], Platformer - 2018 Hierarchy of Hazard Controls Analysis (HCA) report [ref. 4], and Platformer - 2018 Damage Mechanism Review (DMR) report [ref. 5].

4.3 Photographic Evidence

The Investigation Team took multiple photographs of the scene of the fire within the Platformer unit. Security camera footage in the direction of the Platformer Unit on July 19, 2018 was secured and reviewed.

4.4 Physical

Through interviews of persons involved in the emergency response, the Investigation Team was able to identify any changes that occurred during the emergency response.

5 EVIDENCE ANALYSIS

The Investigation Team relied primarily on the physical and documentary evidence collected. The interview testimony given by witnesses was also carefully considered. In line with the CCPS investigation guidance [ref. 2], the testimony of an individual was given less importance unless it was possible to corroborate the testimony through other means, such as testimony from another witness or physical evidence. The Investigation Team looked for additional evidence in order to resolve inconsistencies in the initial testimony of some witnesses. Given that early witness interviews are likely to be more reliable than later testimony, those early interviews were valued more highly.

The following hierarchy represents the weighting put upon the evidence gathered:

- Security camera footage (Note: DCS / PLC data not relevant for this incident)
- Paper / electronic documents
- Multiple witness statements (where consistent)
- Visual inspection (possibly disturbed by emergency response)
- Process sample analysis (possibly changed by delay in sampling)
- Process equipment testing (possibly damaged/changed by incident)
- Single uncorroborated witness statement

Analysis of key items of evidence is discussed below.

5.1 Asset Integrity

5.1.1 Corroded Conduit

The conduit that was broken was corroded where the conduit passes underground through the concrete pad. This corrosion made the conduit susceptible to impact damage. In the 48 hours prior to the incident, there were multiple activities taking place within close proximity to the conduit. These activities included heavy equipment (two cranes and heat exchanger tube bundle puller), scaffolding erection, and heat exchanger head and piping removal. The damage to the conduit was not immediately reported to Operations, but it is highly likely that one or more of these activities were responsible for the damage. Figure 3 shows the heat exchanger tube bundle puller in front of the High Pressure Effluent Cooler Exchangers (3530.09 and 3530.10) with the broken conduit to the right. Note that the red safety tape has been removed. Figure 4 is a close up of the broken conduit after the fire when the wiring had been made safe.

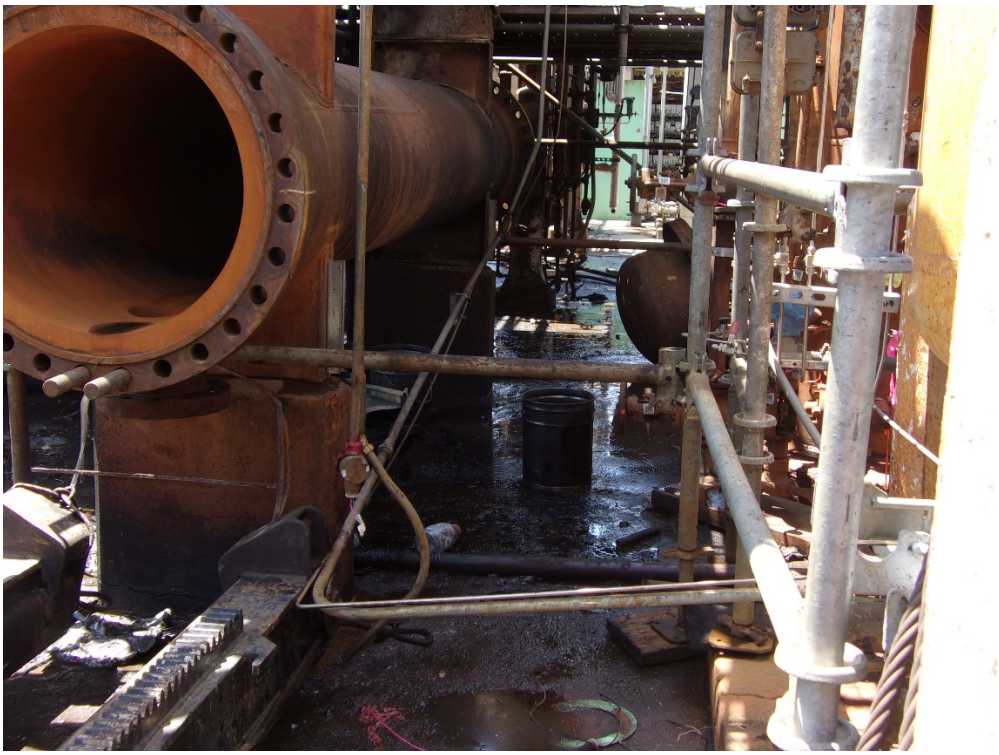

Figure 3. Heat Exchanger Tube Bundle Puller beside Broken Conduit

Figure 4. Broken Conduit with Wiring Protected after Fire

The refinery's asset integrity program is focused on equipment that is more critical to safety and production, such as pressure vessels, PSV's, rotating equipment, fired heaters, instrumentation, etc. Historically conduit on the Platformer Unit was not an integrity priority.

5.1.2 Out of Service Electrical Circuit

The broken conduit produced sparks from its live wiring. This particular circuit originally supplied a chemical pump that was removed a number of years ago, but the circuit was left in an energized state. The Investigation Team could not identify anyone with knowledge of the chemical pump removal.

5.1.3 Circuit Breaker

The circuit breaker associated with the broken conduit did not trip when the conduit was broken nor during sparking prior to the fire. The breaker was tested after the fire and found to be in working order. The reason that it did not trip was due to improper grounding and neutral path to the breaker panel in the Platformer Control Room. During the sparking, the circuit remained energized and unable to trip, because there was not enough available fault current at the breaker panel for proper operation. The electrical code [ref. 6] provides details of why the neutral wire grounded to the conduit or equipment should not be used:

> *To prevent a fire, electric shock, improper operation of circuit protection devices, as well as improper operation of sensitive equipment, the grounding of electrical systems, the bonding of equipment and circuit conductors must be done in a manner that prevents objectionable current (neutral return current) from flowing on conductive materials, electrical equipment, or on grounding and bonding paths*
>
> *Improper neutral-to-case connections can create a fire hazard, electric shock and electrocution, improper operation of protection devices, and power quality issues for sensitive electronic equipment. Particularly when the neutral is open or it has a high impedance path.*

5.2 Safe Work Practices

5.2.1 Work Permit and Job Safety Analysis

No work permits or job safety analyses (JSA) were issued by the refinery for the turnaround and project work on July 19, 2018. This work included extracting, transporting, washing, and installing heat exchanger tube bundles, internal inspection of pressure vessels, replacing gate and check valves, and erecting scaffolding. While some contractors were aware of the broken conduit through word of mouth, there was no formal communication by turnaround leadership, such as a daily pre-job meeting, to all personnel working on the Platformer Unit. Neither were some contractors aware of work being performed by other contract companies on the same unit.

The refinery practice was to hand over the Platformer Unit to the Maintenance Department, responsible for the turnaround work, after the unit was shut down, depressured, and purged. The Maintenance Department considered the unit safe and allowed the turnaround contractors access to the equipment with limited oversight. The contractors were given responsibility to conduct JSAs prior to starting work. The Investigation Team has been unable to determine if any JSA's were conducted, as the team was not permitted to interview the main contractors.

5.2.2 Draining Liquid from Flare Header

The Platformer flare header was drained from a 1 inch valve for several days prior to the incident using a closed system of flexible hoses to the sump at the north end of the unit. On July 19, 2018, in preparation for the proposed cold cutting of the flare header, a location closer to the cut was used. Residual liquid drained through a 3-inch valve by Compressor 3528.07 on to the ground, and a contractor used a water hose to flush the liquid towards a drain by the Platformer Control Room. Later a slug of liquid continued to drain to ground for several minutes and was the source of the main fire. Figure 5 shows the 3-inch drain valve with the loosened blank flange below.

Figure 5. Flare Header Drain Valve by Compressor 3528.07

Draining of light hydrocarbons to ground is not a preferred practice, and especially so on a day with high ambient temperature (ca. 100˚F) that would evaporate a significant proportion of the liquid to produce a flammable vapor cloud. At the time of the incident, the refinery did not have a general safe work practice covering line and equipment breaking, although several operating procedures did address specific aspects for certain processes. The refinery issued a new line and equipment breaking procedure in August 2018 [ref. 7].

5.2.3 Cutting Live Flare Header (Near-Miss)

Although it was a near-miss, the Project Team proposed to cold cut the flare header on the Platformer Unit in order to install an isolation valve. The intended plan involved cutting a live flare header without appropriate energy isolation. Such a plan could have released any H_2S and hydrocarbon liquid in the flare system from the open flare header. The job was aborted on July 19th when the pool fire occurred. Previously, a Superintendent had rejected the project plan on July 5, 2018, and recommended the use of a stopple valve. Unaware, a Shift Supervisor approved the original project plan on July 15, 2018. If the safe work practice system described above had been in practice, a properly performed Safe Work Permit and JSA should have identified the hazards and appropriate safeguards for the proposed work.

5.3 Contractor Management

5.3.1 Oversight

As described above, the turnaround contractors were allowed access to the Platformer Unit with limited oversight of their work tasks. Multiple activities were scheduled throughout the unit on both day and night shifts, resulting in the Maintenance Supervisor being unable to comprehensively monitor every task. Similarly, a contractor was managing the project work activities conducted by different contractors. The turnaround and project teams had different management and generally worked independently of each other. The daily turnaround meeting sometimes changed the work plan priorities for that or the next day, and were not always adequately communicated to all personnel.

Certain work activities were more critical from a safety perspective, and warranted improved communication between all parties and greater oversight by the relevant supervisor. Examples of safety critical activities included multiple tasks in the congested area around the broken conduit, and cold cutting the flare header. Contractors undertaking either activity did not receive comprehensive oversight.

5.4 Conduct of Operations

Conduct of operations is the execution of operational and management tasks in a deliberate and structured manner, and is closely related to an organization's culture. From a Human Factors perspective, neither of the examples discussed below meet refinery management's expectations and values. The Investigation Team also heard anecdotal comments that some contractors do not consistently follow safe work practices.

5.4.1 Damage Reporting

The conduit appears to have been broken at some time during July 18/19, 2018. With multiple tasks involving heavy equipment taking place in a congested area, the possibility of human error is recognized. The Investigation Team speculated that several days of high ambient temperatures (>100˚F) could have influenced the error through fatigue or diminished performance, but there was no evidence available to support this. However, the damage was not immediately reported, as required by the refinery's contractor orientation training. There may have been a reluctance by the individual (or group) to report for fear of blame or more likely that bad news was not welcome. Eventually, a contractor observed sparking at 3:35 am on July 19, 2018, and reported the issue to the operators in the Platformer Control Room.

5.4.2 Removal of Safety Cordon

Following reports of the sparking seen on the night shift, the Maintenance Supervisor cordoned off an area approximately 8 feet by 5 feet around the broken conduit using red safety tape at 4:30 am July 19, 2018. This clearly delineated an area where access was prohibited due to a personnel safety issue. The tape was still in place when the day shift Maintenance Supervisor was shown the broken conduit around 5:50 am. However, an unknown person(s) removed the tape and contractors proceeded to work in the area, including installing the cleaned tube bundles in the HP Effluent Cooler Exchangers (3530.09 and 3530.10). The Investigation Team speculated that this may have been due to a self-imposed pressure by a contractor to meet their schedule, but there was no evidence available to support this. A witness stated that the tape had already been removed when they visited the area about 7:00 to 7:30 am July 19. Remnants of the red tape can be seen in Figure 6.

Figure 6. Remnants of Safety Cordon

6 ASSUMPTIONS, LIMITATIONS AND UNCERTAINTIES

Some changes were made to the scene of the fire as a result of the emergency response actions.

The Investigation Team determined that the position of the 3-inch drain valve on the flare header near Compressor 3528.07 was changed after the incident. This valve was reportedly closed using a wrench and snipe.

The Investigation Team also determined that the broken conduit was altered after the incident. The conduit was de-energized and a GUA conduit outlet box installed on the end of the conduit.

The security camera at the refinery Front Gate is motion-activated, so that there is no recorded video footage during periods lacking motion within the field of view of the camera. Smoke visible in the footage from this camera was used to determine the time and duration of the fire.

Interviews with employees of major contractors were repeatedly requested, but contractors did not make their employees available to the Kern Oil Investigation Team. Contractors similarly did not provide any requested documentation. As a result, the team conducted as thorough investigation as was possible under the circumstances.

7 HYPOTHETICAL SCENARIOS

Normally, BakerRisk would develop a number of potential scenarios for the incident and gather evidence for all scenarios in order to prove/disprove each hypothesis and arrive at a single scenario that fits all of the facts. However, this incident is unusual in that there were multiple eye witnesses for:

- Release of flammable hydrocarbons (draining the flare header to ground), and
- Initial ignition and rapid development of the fire (sparking conduit igniting adjacent pool of liquid).

Multiple witnesses corroborated each other's statements; therefore, it was considered unnecessary to develop multiple hypotheses for the fire scenario.

Hence, the scenario for the Platformer Unit fire on July 19, 2018, is as follows:

1. Light hydrocarbon (similar to Unifinate – flash point 20-55˚F) was being drained from the flare header. The liquid hit the blank flange below the drain valve and sprayed out on to the ground and on to water being used to flush the hydrocarbon towards a drain at the Platformer Control Room.
2. Ambient temperature was 98˚F. A significant proportion of the light hydrocarbon evaporated to form a vapor cloud.
3. A small pool of liquid (water with some hydrocarbon on the surface) was close to the broken conduit. The presence of this liquid was most likely from using a water hose to flush liquid draining from the flare header or from water washing of the concrete pad.
4. The conduit sparked when touched and ignited the hydrocarbon on the surface of the small pool of liquid.
5. The wind direction was from North West. The vapor cloud drifted towards the flames on the small pool of liquid.
6. The vapor cloud ignited and flashed back igniting the light hydrocarbon floating on top of the water in the Platformer aisle, compressors, and around the backed up drain at the Platformer Control Room.

8 ROOT CAUSE ANALYSIS METHODOLOGY

The Root Cause Analysis (RCA) employed a pre-defined tree methodology in line with the guidance provided by the Center for Chemical Process Safety (CCPS) [ref. 2]. The BakerRisk® Cause Analysis Tree (CAT) pre-defined tree was used followed by the 5 Whys? Technique. This methodology was broken down into the following sub-tasks:

- Team orientation
- Review of the Incident Timeline
- Identification of Causal Factors from the Incident Timeline
- Identification of Immediate Causes using CAT
- Identification of Near Root Causes using CAT
- Identification of Root Causes using the 5 Whys? Method

This approach acknowledges the system theory of incident causation, where an incident is seen as an abnormal effect or result of the management system [ref. 8]. This is also known as the multiple-cause theory [ref. 9]. The multiple-cause theory states that:

- Almost all incidents have multiple root causes; and
- Some of these root causes did not directly cause the subject incident, i.e. they were near-misses on this occasion.

A thorough investigation and RCA, such as conducted by BakerRisk, will not only find the root causes of the subject incident, but will also find other issues that were near-misses this time. If not found and addressed, these near-misses may cause a future incident even if the root causes of the subject incident are corrected.

The RCA contains the immediate, near root causes, and root causes of the incident that occurred on July 19, 2018. These are detailed in Table 2 through Table 6.

9 TIMELINE

A detailed chronology of the events leading up to the incident was compiled based upon available evidence, including documentation and records, witness interviews, and security camera footage. Table 1 contains the detailed chronology of events. Approximate times are denoted by *.

Table 1. Chronology of Events

Date	Time	Event/Condition	Information Source
2018			
July 5		Superintendent rejects plan to install isolation valve on flare header near Compressor 3528.07, recommends stopple valve.	Superintendent – Interview
July 9		Flare header has problem with liquid build up.	PHA Report Health & Safety Mgr.
July 15		Platformer unit shut down for turnaround	
July 15		Shift Supervisor approves installation of isolation valve near Compressor 3528.07 on live flare header.	Superintendent - Interview
July 15		Liquid in flare header drained to sump.	Supervisor - Interview
July 16		Liquid in flare header drained to sump.	Supervisor - Interview
July 17		Liquid in flare header drained to sump for 2 hours, but liquid still present. Draining shut down.	Supervisor - Interview
July 17		Operations unable to determine source of hydrocarbon liquid in flare header.	Superintendent -Interview
July 17	8:30 PM*	Heat exchanger 3530.10 head removed.	Engineering Turnaround Notes
July 17	9:00 PM*	Heat exchanger 3530.09 head removed.	Engineering Turnaround Notes
July 18		Liquid in flare header drained to sump.	Supervisor - Interview
July 18	8:30 AM*	Heat exchanger 3530.09 tube bundle pulled; found covered in white scale.	Engineering Notes- re: JVG
July 18	10:00 AM*	Began pulling heat exchanger 3530.10 tube bundle pulled.	Engineering Notes- re: JVG
July 18	11:20 AM*	3530.10 tube bundle pulled. Appears same as 3530.09 with white scale.	Engineering Notes
July 18	11:20 AM*	Platformer HP Separator (3510.02) opened and contractor washes off white scale.	Engineering Notes

Date	Time	Event/Condition	Information Source
2018			
July 18	12:30 PM*	Channels removed from HP Effluent exchangers 3510.01 and 3530.02 to 3530.07, crack found on one of the baffles.	Engineering Notes
July 18	12:30 PM*	Working on Reactor #3 (3510.07) bottom piping. Removed Effluent Condensers 3530.09 & 10 process pipe for mods.	Engineering Notes - re: TWI
July 18	12:30 PM*	Working on removing plugs from HP fin fan (3530.08).	Engineering Notes - re: JVG
July 18	12:30 PM*	Piping on 3530.09 & 10 just above the broken conduit unbolted and lifted out with crane. Not sure if damage was caused.	Maintenance Dept. - Interview- re: TWI, Engineering Notes
July 18	1:20 PM*	Inspection tech. reports faulty data readings from fin fan tubes (3530.08).	Engineering Notes- re: APPLUS
July 18	1:20 PM*	Fin fan tubes (3530.08) cleaned with 20k psi pump to get better inspection data.	Engineering Notes
July 18	3:00 PM*	Liquid in flare header drained to sump for 2 hours. Advised Shift Supervisor to drain again morning July 19.	Supervisor - Interview
July 18		Specific gravity of the liquid in the flare header tested in Lab. Result similar to Unifinate.	Supervisor - Interview
July 18		Unifinate: Flash Point = 20-55 °F, Vapor Pressure 2.0 psia at 100 °F. LEL = 1.2%, UEL = 6.0.	Kern Safety Data Sheet
July 19		No work permit or JSA issued by Kern for Platformer turnaround work	Health & Safety Manager - Interview
July 19	3:00 AM*	Lights began flickering in South Control Room.	Multiple Operators - Interviews
July 19	3:35 AM*	Supervisor reported sparks at the broken conduit to Control Room operator. All contractor work in area shut down.	Multiple Operators - Interviews
July 19	4:30 AM*	Maintenance Supervisor aware of broken conduit and taped off area. In discussion with Shift Supervisor agreed to call electrical crew. Some contractors not formally notified.	Maintenance Supervisor - Interview
July 19	4:30 AM*	Sparks observed when conduit moved. Conduit was broken off at the ground but no exposed wires near 3530.09 and 3530.10. Unable to locate breaker.	Maintenance Supervisor - Interview
July 19	5:30 AM*	Ground was dry around turnaround activities.	Maintenance Supervisor - Interview
July 19	5:50 AM*	Maintenance Supervisor (night) showed Maintenance Supervisor (day) broken conduit.	Maintenance Supervisors - Interview

Date	Time	Event/Condition	Information Source
2018			
July 19	5:50 AM* to 7:30 AM*	Unknown person(s) removed safety tape around broken conduit.	
July 19		• JVG removed bundles 3530.01 & 05, and installed bundles 3530.09 and 10. • Turner Translift assisted JVG with HP Effluent bundle extraction and installation. • ProSafety/Applus completed internal inspection of all three reactors. • TWI transported bundles between wash pad and Platformer; loaded flow bins onto truck for shipment; replaced gas valves on Platformer Heaters; replaced gate and check valves on both Steam Gen Pumps. • Ancon cleaned shells 3530.01 & 05 and HP Effluent bundles at wash pad. • Safway modified scaffolding as needed.	Maintenance Notes – Work Plan for July 19
July 19	6:00-7:40 AM*	Flare header full of liquid. Liquid in flare header drained to sump. Shift Supervisor unaware of broken conduit.	Shift Supervisor - Interview
July 19	7:30 AM*	I&E Tech left shop to look at the broken conduit.	Maintenance Supervisors - Interview
July 19	7:30 AM*	Conduit observed to be damaged before bundle puller was sited. Bundle puller sited at 3530.09 and 10, and caused further damage to conduit.	I&E Tech - Interview
July 19	7:45 AM*	Broken conduit traced back to the Platformer control room.	I&E Tech. - Interview Operators - Interviews
July 19	7:50 AM*	I&E Tech opens electrical box but unable to identify correct breaker. Informs operator he needs to trip multiple breakers.	I&E Tech. - Interview
July 19	7:50 AM*	Shift Supervisor refuses permission to trip breakers without management approval.	I&E Tech. - Interview
July 19		Electrical contractor called out.	I&E Tech. - Interview
July 19	10:54 AM	Weather conditions: 94 °F, Sunny, Wind from WNW to ESE, 7 mph.	Bakersfield Weather (Time and Date.com)

Date	Time	Event/Condition	Information Source
2018			
July 19	11:00 AM*	Welding contractor prepare for cold cut of flare header. Operations not aware of a JSA. Shift Supervisor with Welder opens flare header drain valve at Compressor 3528.07. Residual liquid (suspected Unifinate) sprayed onto drain valve blank flange. Contractor employee used water hose to flush liquid toward Control Room drain. No LEL meter. Shift Supervisor left for office when liquid stopped.	Shift Supervisor - Written Statement.
July 19	11:00 AM* to 12.45 PM*	Water hose was left running, backing up drain and area with water.	Contractor - Interview
July 19		Contractor managing work was aware of draining liquid to ground.	Engineering Contractor - Interview
July 19	11:00 AM*	Contractor set up and started cold cut machine.	Cal / OSHA informed Kern
July 19	11:20 AM*	More liquid at drain valve at Compressor 3528.07. Water hose used to flush liquid towards drain at Control Room.	Supervisor - Interview
July 19	11:45 AM*	Report of problem at Platformer.	Supervisor - Notes.
July 19	11:54 AM	Weather conditions: 98 °F, Sunny, Wind from NW to SE, 10 mph	Bakersfield Weather (Time and Date.com)
July 19	12:00 AM*	Water hose was still running. Drain backed up and concrete area around compressors and aisle wet.	Contractor - Interview
July 19		Prior to electrical work on broken conduit, there was no conversation with Operations or contractor managing work.	Electrical contractor - Interview Engineering Contractor - Interview
July 19	12:35 PM*	I&E Tech. and electrical contractor on site. Above ground conduit separated from buried conduit and leaning on steel wheel of bundle puller. Water on live wire did not trip breaker.	I&E Tech. - Interview Notes
July 19	12:35 PM*	Liquid pool approximately 24 inches in diameter observed near broken conduit. No indication of hydrocarbons.	Electrical contractor - Interview
July 19		Circuit tester did not indicate voltage on wiring in broken conduit.	Electrical contractor - Interview
July 19	12:38 PM	No smoke observed from Platformer.	Video Camera - Front Gate (NIST time)
July 19	12:39 PM*	Electrical contractor touched the broken conduit and a spark ignited a small lazy flame on the pool of liquid.	Electrical contractor - Interview
July 19	12:39 PM*	Flames traveled 15-20 feet west from the pool of liquid, and then 50 feet north toward the Platformer aisle.	Electrical contractor - Interview I&E Tech - Interview

Date	Time	Event/Condition	Information Source
2018			
July 19	12:39 PM*	Liquid observed at the north drain. Emergency horn inaccessible, radio announcement made.	Operator - Interview
July 19	12:39 PM*	South Control Room lost Distributed Control System.	Operator - Interview
July 19	12:39 PM*	Contractor heard someone shout “fire” and looked to the SE and saw small fire. Reported seeing flames moving N, and then evacuated the unit to NE direction.	Contractor - Written Statement
July 19	12:39 PM*	Employees began evacuating. I&E Tech and Maint. Supervisor operated fire monitors P-5, P-6, and P-7 were used. Fire Hose Station P-4 was used.	Operators - Written Statements
July 19	12:39:50 PM	Black smoke observed coming from the Platformer Unit near Compressor 3528.07.	Video Camera - Front Gate (NIST time). Multiple witnesses - Interviews.
July 19	12:43 PM	Wisp of smoke seen on video.	Video Camera - Front Gate (NIST time)
July 19	12:45 PM*	Operations closed flare header drain valve with wrench and snipe isolating the source of the fire.	Interview - Superintendent
July 19	12:46 PM	Wisp of smoke seen on video.	Video Camera - Front Gate (NIST time)
July 19	12:51 PM	Fire extinguished. No further smoke seen on video.	Video Camera - Front Gate (NIST time)
July 19	12:54 PM	Weather conditions: 101°F, Sunny, Wind from NW to SE, 9 mph	Bakersfield Weather (Time and Date.com)
July 19	post fire	Correct breaker to turn power off of broken conduit not obvious. I&E Tech identified the correct breaker, labeled "chemical pump". Supply to out of service chemical pump shut off / disconnected. GUA conduit outlet box installed on end of broken conduit.	Electrical Contractor - Interview I&E Tech. - Interview
July 24	post fire	Low point observed in concrete within 6 inches of broken conduit.	Investigation Team - Observation

10 CAUSAL FACTORS

The evidence in the timeline (Table 1) was broken into discrete blocks of events or conditions to identify the Causal Factors.

> **Causal Factor** is a major unplanned/unintended contributor to the incident (a negative event or undesirable condition) that if eliminated would have either prevented the occurrence or reduced its severity or frequency.

The following Causal Factors were identified that if eliminated would have prevented or reduced the possibility of the incident on July 19, 2018, occurring or reduced its severity:

CF-1. Broken Conduit

The July 2018 Platformer turnaround involved multiple activities in the vicinity of conduit adjacent to the Platformer HP Effluent Coolers (3530-09 & 3530.10). At some stage prior to 3:00am on July 19th, the conduit (containing live wiring) was broken at ground level. The damage was not immediately reported to Operations. A contractor observed sparking from the conduit and informed operators in the Platformer control room at approximately 3:35am on July 19th. The broken conduit was observed leaning against the wheel of a heat exchanger bundle pulling device.

CF-2. Breaker on Broken Conduit did not Trip

The electrical breaker on the wiring within the broken conduit did not trip when the conduit was broken, nor when the wiring sparked. Maintenance personnel could not identify the breaker in order to manually trip it until after the fire.

CF-3. Liquid on Ground near Broken Conduit

The immediate area around the broken conduit was taped off at approximately 4:30am July 19th after sparking had been reported. The ground around the broken conduit was observed to be dry. By the time a contract electrician arrived at approximately 12:30pm, a small pool of liquid was on the ground near the broken conduit. When the electrician moved the conduit, the cable sparked and ignited lazy flames on the surface of the liquid.

CF-4. Draining Flare Header

Liquid was identified within the Platformer flare header for several days prior to the incident. The liquid was similar in gravity to Unifinate, a light hydrocarbon. The liquid was drained from the main Platformer flare header to the Platformer sump using a hose. On July 19th, as contractors prepared to cold cut the flare header, a small amount of residual liquid was drained from the header above the compressors to ground and flushed with water to a drain. After the cold cutting started, a significant amount of liquid was drained to ground and work stopped. As this liquid was being flushed with water to a drain, the main fire ignited.

An additional causal factor was identified for a Near-Miss, and is presented below:

CF-5. Cold Cutting Live Flare Header (NEAR-MISS)

Despite the Platformer being shutdown, the unit flare header was live. Project personnel intended to cold cut the flare header without adequate energy isolation (LO/TO), leaving an open-ended pipe until such time as a thread could be cut on the pipe and a valve or end cap installed. The flare header was **not** cold cut due to the pool fire that occurred while draining residual liquid from the flare header.

11 CAUSES

For each Causal Factor, possible Immediate (or basic) Causes were identified using the BakerRisk® Cause Analysis Tree (CAT) Chart.

> **Immediate Cause** is an unsafe act or condition that resulted in (or could have resulted in) the incident.

Each Immediate Cause was taken in turn and Near Root Causes were identified using the CAT Chart.

> **Near Root Cause** is one of the possible causes illustrated on the CAT Chart that does not quite meet the definition of a Root Cause (see below), i.e. it is possible to go further and identify an underlying cause within the management systems.

Finally, each Near Root Cause was taken and the 5 Whys? technique applied in an attempt to identify deeper underlying Root Causes (a.k.a. management system causes).

> **Root Cause** is a fundamental, underlying, system-related reason why an incident occurred that identifies a correctable failure(s) in management systems.

It is not always possible to ask and answer 5 Whys, and it is often necessary to stop after a lesser number to avoid speculation. All of the Whys are recorded in Appendix 1. The last 'why' is regarded as **the** root cause and is recorded in the tables that follow.

The Immediate, Near Root, and Root Causes of the incident that occurred on July 19, 2018, are detailed in Table 2 to Table 5, which are arranged in the order of the four Causal Factors.

An additional analysis was conducted on a Near-Miss. The Immediate, Near Root, and Root Causes of the Near-Miss are presented in Table 6.

THE IMMEDIATE AND ROOT CAUSES OF THE INCIDENT THAT OCCURRED ON JULY 19, 2018

Causal Factor: Broken Conduit

The July 2018 Platformer turnaround involved multiple activities in the vicinity of conduit adjacent to the Platformer HP Effluent Coolers (3530-09 & 3530.10). At some stage prior to 3:00am, July 19th, the conduit (containing live wiring) was broken at ground level. The damage was not immediately reported to Operations. A contractor observed sparking from the conduit and informed operators in the Platformer control room at approximately 3:35am, July 19th. The broken conduit was observed leaning against the wheel of a heat exchanger bundle pulling device.

Table 2. Root Cause Analysis - Causal Factor 1. Broken Conduit [1]

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
1. *Equipment Factor: Faulty Equipment.* (Conduit with live wiring broken at ground level)	(1) *Asset Integrity & Reliability: Deficiencies, Inadequate inspection* (Conduit was corroded where it passed under concrete ground, making it relatively easy to break.)	Focus of asset integrity program has been on more critical equipment than inspecting conduit.

[1] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
2. *Work Environment Factor: Worksite, Layout Congested* (Two cranes, heat exchanger bundle puller, scaffolding, multiple contractors in relatively small area)	(2.1) *Control of Work: Planning, Inadequate consideration of simultaneous operations* (There were multiple turnaround activities taking place in the immediate vicinity of the conduit that became damaged, including scaffolders, plant inspectors, heat exchanger bundle work and cranes, piping work, and electrical contractors.) (2.2) *Control of Work: Supervision, Critical job not monitored continuously* (Daily turnaround meeting confirms forward work plan. Maintenance supervisor had oversight of multiple other turnaround activities in addition to activities in the congested area of the broken conduit.)	Each group (turnaround and project personnel) working independently of each other. Inadequate prioritization of work in the area by turnaround & project groups.
3. *Personnel Factor: Personal Performance, Unintentional Error* (Conduit was accidentally broken during the turnaround; probably as a result of one or more activities in a congested area.)	(3.1) *Human Factors: Ergonomics, Poor access to equipment* (Multiple turnaround activities taking place in a congested area around the conduit that was broken.)	Limited access for turnaround personnel to: • locate scaffolding, cranes, and heat exchanger bundle puller, and • work on the Platformer HP Effluent Coolers (3530-09 & 3530.10) and other equipment adjacent to the conduit.
4. *Personnel Factor: Management System, Infringement of Management System by individual or group* (Contractor orientation emphasizes the expectation that individuals report hazards and damage. The broken conduit was not immediately reported [although it is possible it was not seen].)	(4.1) *Conduct of Operations: Communication, No communication between work groups* (4.2) *Human Factors: Personal Factors, Behavior, Inappropriate behavior* (4.3) *Process Safety Culture: Culture, Inadequate compliance with policy* (The broken conduit was not immediately reported to Operations by the individual or group responsible.)	Existing safety culture of reluctance to report damage

Causal Factor: Breaker on Broken Conduit did not Trip

The electrical breaker on the wiring within the broken conduit did not trip when the conduit was broken, nor when the wiring sparked. Maintenance personnel could not identify the breaker in order to manually trip it until after the fire.

Table 3. Root Cause Analysis - Causal Factor 2. Breaker on Broken Conduit did not Trip [2]

IMMEDIATE CAUSES	NEAR ROOT CAUSES	ROOT CAUSE
5. *Equipment Factor: Faulty Equipment.* (The wiring in the broken conduit was unsuitable.)	(5) *Standards, Codes & Regulations: Management System, Inadequate specification* (The wiring in the broken conduit did not meet code, i.e., neutral wire was to ground via conduit rather than use a separate ground wire.)	No formal policy addressing wiring standards.
6. *Work Environment Factor: Man-Machine Interface, Poor Labeling.* (Correct breaker could not be readily identified in order to manually trip the breaker.)	(6.1) *Human Factors: Ergonomics, Poor labeling of equipment* (The label on the breaker was hand written and faint. It was labeled as a chemical pump that was removed.) (6.2) *Tools / Equipment: Inadequate specification of tools / correct tools not provided* (Operations would not allow I & E technician to trip each breaker in turn to identify the correct breaker. An appropriate industrial circuit tester was not available to identify the correct breaker.)	No formal policy for labeling equipment. Culture of lack of deference to expertise (i.e., requests for circuit tester from technicians).

[2] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

IMMEDIATE CAUSES	NEAR ROOT CAUSES	ROOT CAUSE
7. *Equipment Factor: Other, Out of service electrical equipment still energized.* (The breaker and wiring in the broken conduit was out of service but still energized.)	(7) *Hazard Identification & Risk Analysis: Program, Inadequate hazard identification / inadequate risk tolerance* (The breaker and wiring in the broken conduit was originally for Platformer chemical pumps that were removed.)	No policy on out of service equipment and de-energizing systems.

Causal Factor: Liquid on Ground Near Broken Conduit

The immediate area around the broken conduit was taped off at approximately 4:30am, July 19th, after sparking had been reported. The ground around the broken conduit was observed to be dry. By the time a contract electrician arrived at approximately 12:30pm, the tape had been removed and a small pool of liquid was on the ground near the broken conduit. When the electrician moved the conduit, the cable sparked and ignited lazy flames on the surface of the liquid.

Table 4. Root Cause Analysis - Causal Factor 3. Liquid on Ground Near Broken Conduit [3]

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
8. *Equipment Factor: Faulty Equipment* (The wiring within the broken conduit was energized, and sparked when moved.)	(8.1) *Conduct of Operations: Communication, No communication with contractors.* (8.2) *Contractor Management: Worksite, Inadequate pre-job safety meeting* (8.3) *Control of Work: Conduct of Work, Inadequate pre-job safety meeting* (Contractors were not formally notified of the hazard of the broken conduit, but some contract personnel were aware through talking to others.)	Turnaround leadership did not have a practice to hold a formal start of shift meeting with all contractors to discuss job plan and hazards such as the broken conduit. [Note: Refinery Maintenance Dept. does have a daily practice to meet with contractors before work commences.]
9. *Personnel Factor: Equipment Misuse, Safeguard Disabled* (The area around the broken conduit with energized wiring was taped off on night shift, but someone removed the tape and work continued in the area.)	(9.1) *Conduct of Operations: Procedures, No adherence to safe work practices* (9.2) *Human Factors: Behavior, Inappropriate behavior* (The area around the Platformer HP Effluent Coolers (3530-09 & 3530.10) and the broken conduit was taped off because of the hazard of energized wiring. Person(s) unknown removed the tape before 7:30am so that work could continue.)	)) Inconsistent enforcement of safe work practices by refinery management.))

[3] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

Causal Factor: Draining Flare Header

Liquid was identified within the Platformer flare header for several days prior to the incident. The liquid was similar in gravity to Unifinate, a light hydrocarbon. The liquid was drained from the main Platformer flare header to the Platformer sump using a hose. On July 19th, as contractors prepared to cold cut the flare header, a small amount of residual liquid was drained from the header above the compressors to ground and flushed with water to a drain. After the cold cutting started, a significant amount of liquid was drained to ground and work stopped. As this liquid was being flushed with water to a drain, the main fire ignited.

Table 5. Root Cause Analysis - Causal Factor 4. Draining Flare Header [4]

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
10. *Personnel Factor: Management System, Other* (The flare header was drained to ground without a proper consideration of the hazards.)	(10.1) *Hazard Identification & Risk Analysis: Program, Inadequate program for hazard identification* (At the time of the incident, there were no practices involving safe work permits, and the involvement of Operations in JSAs. There was no JSA covering draining liquid from the flare header.)	Lack of understanding by some management of the value of JSA and other safe work practice improvements.
	(10.2) *Control of Work: Safe Work Practices, Program, Inadequate program for safe work practices* (At the time of the incident, there was no general procedure covering line and equipment breaking, such as draining and cold cutting the flare header.)	Lack of understanding by some management of the value of a general line and equipment breaking procedure.

[4] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
11. *Work Environment Factor: Exposure to Hazards, Chemical / Electrical* (Residual liquid in the flare header was drained to ground without a proper consideration of all the hazards.)	(11.1) *Control of Work: Planning, Inadequate planning of task* (11.2) *Control of Work: Planning, Inadequate consideration of simultaneous operations* (The flare header was drained by partially unbolting a blind flange on a block valve and opening the valve. When planning the job, no consideration was given to: • Potential for a slug of liquid in the flare header and the ability to close the valve quickly, and • Other hazards in the vicinity, such as sparks from the broken conduit.)	) No formal simultaneous operations (SIMOPS) practice and limited awareness of the concept of SIMOPS.)

Causal Factor: Cold Cutting Live Flare Header (NEAR-MISS)

Despite the Platformer being shutdown, the unit flare header was live. Project personnel intended to cold cut the flare header without adequate energy isolation (LO/TO), leaving an open-ended pipe until such time as a thread could be cut on the pipe and a valve or end cap installed. The flare header was **not** cold cut due to the pool fire that occurred while draining residual liquid from the flare header. **Therefore, this causal factor is related to a near-miss rather than an accident.**

Table 6. Root Cause Analysis - Causal Factor 5. Cold Cutting Live Flare Header (NEAR-MISS)[5]

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
12. *Work Environment Factor: Exposure to Hazards, Chemical* (Cold cutting a live flare header without proper consideration of the hazards.)	(12.1) *Control of Work: Control of Work: Supervision, Other, Specified safety requirements not implemented* (12.2) *Hazard Identification & Risk Analysis: Use of Safety/Hazard/Risk Studies, Risk reduction measures, Selection of inappropriate risk reduction measures* (12.3) *Training & Performance Assurance: Competency, Other, Inadequate knowledge and experience for tasks performed* (Several days before, an experienced Superintendent advised project personnel not to cold cut the flare header without some form of energy isolation (e.g., stopple valve) due to potential for H2S and liquid hydrocarbons.)	))) Lack of knowledge and experience of personnel involved [See also item #10 above regarding lack of safe work permit, JSA, and line and equipment breaking procedure that would ensure greater involvement of Operations personnel.]))

[5] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

IMMEDIATE CAUSES	NEAR ROOT CAUSE	ROOT CAUSE
13. *Personnel Factor: Management System, Other* (Contractor draining and cutting a live flare header without adequate oversight.)	13.1) *Contractor Management: Program, Content, Inadequate job oversight process* (Contractor orientation program mentions oversight, but there is no practice requiring a Person Leading Work (PLW) to supervise jobs.)	No written procedure covering contractor oversight
	(13.2) *Contractor Management: Use of Program, Worksite, Inadequate job oversight* (Draining flammable liquids and cutting live piping are potentially high hazard activities requiring careful planning and supervision. This job was managed in a similar way to other less hazardous turnaround and project activities.)	Project and some Operations personnel did not understand that a job of this criticality warranted comprehensive planning and continuous oversight.

12 INTERIM MEASURES ALREADY IMPLEMENTED

The following interim measures have already been implemented by Kern Oil and address some of the recommendations of the investigation:

12.1 Provide Line and Equipment Breaking training to refinery employees. Line and Equipment Breaking training was conducted for all refinery employees between July 31 and August 4, 2018. [Note: Training of a few Operations and Maintenance employees remains].

12.2 Develop and provide Job Safety Analysis (JSA) training to all permit issuing and performing authorities. JSA training was conducted for all refinery Operations employees, and JSA refresher training for all refinery Maintenance employees, between July 31 and August 4, 2018. This training is being expanded to other departments (excluding office workers), and is scheduled to be completed by the end of October 2018.

12.3 Refresher training was conducted for all refinery employees between July 31 and August 4, 2018 in the following topics:

- Hot Work,
- Lock Out/Tag Out,
- Hazard Materials Release – Control and Prevention, and
- Stop Work Authority.

12.4 Ensure that the Instrument & Electrical Technicians have the appropriate equipment, such as an industrial circuit tester, to investigate and analyze electrical problems. Six industrial circuit testers were acquired on September 26, 2018.

13 RECOMMENDATIONS

The following recommendations address the root causes identified by the Investigation Team. The refinery must ensure that actions are followed through and that verification processes are reinforced to ensure that all existing policies and procedures are being followed. In addition, adequate resources will need to be provided in order to complete all actions items in this report in a timely manner, and to ensure that the actions achieve the desired outcomes.

13.1 People

13.1.1 Training

a. Develop and provide Safe Work Permit training to all permit issuing and performing authorities.

b. Develop and provide Job Safety Analysis (JSA) training to all permit issuing and performing authorities.

c. Provide Line and Equipment Breaking training to contractor employees.

d. Emphasize in contract documentation and contractor orientation that all contract employees are expected to immediately report any hazards and damage to process equipment that they observe.

13.1.2 Policy Enforcement

a. Emphasize that all managers and other persons in a position of authority/supervision have a duty to enforce Kern Oil policies and procedures (including safe work practices) at all times.

13.2 Procedures

13.2.1 Work Permits

a. Establish a Safe Work Permit (or Cold Work Permit) practice to cover all non-routine tasks, including turnarounds, not covered by a risk-assessed procedure or other type of work permit. Define minimum competency (knowledge, skill, ability) requirements for permit issuing authorities.

b. Develop and implement Job Safety Analysis (JSA) or equivalent form of task risk assessment to supplement work permits (including Safe Work Permit) for non-routine work with potential for fatality/injury. This JSA practice should involve both Operations (knowledgeable in the process unit hazards) and the work performing authority (e.g. Maintenance/Contractor knowledgeable in the hazards of the work activity).

c. Develop and implement a Simultaneous Operations (SIMOPS) practice to manage the risk of multiple activities occurring in close proximity to each other.

13.2.2 Turnarounds

a. Establish leadership of future turnarounds to help ensure that:
    i. Overall work plan (turnaround work **and** any project work) is managed, coordinated and communicated as a single organization.
    ii. Safety critical tasks and multiple tasks in congested/confined areas are prioritized to receive more thorough planning and oversight.
    iii. Work permits are issued for all non-routine turnaround tasks not covered by a risk-assessed procedure.
    iv. Work permits are supplemented by a Job Safety Analysis (JSA) for non-routine work with potential for fatality/injury.
    v. A competent permit issuing authority(s) is assigned to the turnaround to manage all turnaround work permits and JSAs with a specific focus on Simultaneous Operations (SIMOPS).

b. Implement a practice that future turnarounds conduct daily pre-job safety meetings to ensure that all personnel are aware of hazards and simultaneous operations (SIMOPS).

13.2.3 Contractor Management

a. Establish a practice for oversight of contractors performing turnaround tasks within the refinery. The extent of oversight should be related to the hazards/risks associated with the task.

b. Consider identifying a Contract Manager (or Person Leading Work) for each contract company to ensure that contractor performance meets Kern Oil expectations.

13.3 Equipment

13.3.1 Conduit

a. Inspect all conduit on the Platformer Unit to ensure that it meets code, and rectify any wiring using the neutral as ground.

b. Add conduit on the Platformer Unit to the asset integrity program and inspect for corrosion at ground level.

13.3.2 Out of Service Equipment

a. Establish a refinery policy/practice on retired equipment to ensure that it is adequately de-energized.

b. Check all out of service equipment on the Platformer Unit to ensure that it is de-energized.

13.3.3 Labeling

a. Establish a refinery policy/practice for labeling of electrical equipment.

b. Review labeling of electrical equipment in the Platformer Control Room, and rectify any poor or missing labels.

14 REFERENCES

1. *Process Safety Management for Petroleum Refineries*, § 5189.1., California OSHA

2. *Guidelines for Investigating Chemical Process Incidents*, 2nd Edition, Center for Chemical Process Safety, American Institute of Chemical Engineers, New York, 2003.

3. *LPG Recovery Unit (LRU) Process Hazard Analysis Report*, Total Prevention Systems, Inc., Santa Ana, CA, July 9, 2018.

4. *Platformer - 2018 Hierarchy of Hazard Controls Analysis (HCA) Report*, Total Prevention Systems, Inc., Santa Ana, CA, July 31, 2018.

5. *Platformer - 2018 Damage Mechanism Review (DMR) Report*, 4th Revision, Becht Engineering Co., Inc., Newport Beach,, CA, October 3, 2018.

6. *National Electrical Code®*, NFPA 70 (Section 250.6), National Fire Protection Association, Quincy, MA, 2017.

7. *Safe Work Procedure for Line and Equipment Breaking*, Kern Oil & Refining Co., August 3, 2018.

8. Recht, I.L., *System Safety Analysis - A Modern Approach to Safety Problems,* National Safety News, December 1965 - June 1966.

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APPENDIX 1:
5 WHYS FOR EACH NEAR ROOT CAUSE

5 WHYS FOR EACH NEAR ROOT CAUSE

The following tables illustrate the application of the 5 Whys methodology to each Near Root Cause. The table numbers correspond to the table numbers in the main body of this report. The last Why in each section is **the** Root Cause.

Table 7. Root Cause Analysis - Causal Factor 1. Broken Conduit [6]

NEAR ROOT CAUSE	5 WHYS
(1) *Asset Integrity & Reliability: Deficiencies, Inadequate inspection* (Conduit was corroded where it passed under concrete ground, making it relatively easy to break.)	1. No inspection of conduit for corrosion at ground level. 2. Not identified as needed for the asset integrity program. 3. Conduit has not been an asset integrity priority. 4. Focus of asset integrity program has been on more critical equipment than inspecting conduit.
(2.1) *Control of Work: Planning, Inadequate consideration of simultaneous operations* (There were multiple turnaround activities taking place in the immediate vicinity of the conduit that became damaged, including scaffolders, plant inspectors, JVG heat exchanger bundle work and cranes, TWI piping work, and electrical contractors.) (2.2) *Control of Work: Supervision, Critical job not monitored continuously* (Daily turnaround meeting confirms forward work plan. Maintenance supervisor had oversight of multiple other turnaround activities in addition to activities in the congested area of the broken conduit.)	1. Multiple turnaround and project activities on the Platformer. 2. Inadequate coordination and communication between groups (turnaround and project personnel). 3. Each group (turnaround and project personnel) working independently of each other. 1. Multiple turnaround and project activities on the Platformer. 2. Inadequate communication when turnaround meeting changes priorities. 3. Inadequate prioritization of work in the area by turnaround & project groups.

[6] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

NEAR ROOT CAUSE	5 WHYS
(3.1) *Human Factors: Ergonomics, Poor access to equipment* (Multiple turnaround activities taking place in a congested area around the conduit that was broken.)	1. Limited access for turnaround personnel to: • locate scaffolding, cranes, and heat exchanger bundle puller, and • work on the Platformer HP Effluent Coolers (3530-09 & 3530.10) and other equipment adjacent to the conduit.
(4.1) *Conduct of Operations: Communication, No communication between work groups* (4.2) *Human Factors: Personal Factors, Behavior, Inappropriate behavior* (4.3) *Process Safety Culture: Culture, Inadequate compliance with policy* (The broken conduit was not immediately reported to Operations by the individual or group responsible.)	1. Existing safety culture of reluctance to report damage

Table 8. Root Cause Analysis - Causal Factor 2. Breaker on Broken Conduit did not Trip [7]

NEAR ROOT CAUSES	5 WHYS
(5) *Standards, Codes & Regulations: Management System, Inadequate specification* (The wiring in the broken conduit did not meet code, i.e., neutral wire was to ground via conduit rather than use a separate ground wire.)	1. Lack of organizational awareness/recognition that policy on electrical equipment required. 2. Lack of knowledge and expertise of potential electrical hazards in refinery workforce with long service (30+ years). 3. No formal policy addressing wiring standards.
(6.1) *Human Factors: Ergonomics, Poor labeling of equipment* (The label on the breaker was hand written and not readily visible. It was labeled as a chemical pump that does not exist.)	1. Lack of organizational awareness that policy on electrical equipment labeling requirements. 2. Lack of knowledge of importance of labeling in refinery workforce with long service (30+ years). 3. No formal policy for labeling equipment.
(6.2) *Tools / Equipment: Inadequate specification of tools / correct tools not provided* (Operations would not allow I & E technician to trip each breaker in turn to identify the correct breaker. An appropriate industrial circuit tester was not available to identify the correct breaker.)	1. Middle management did not recognize the need for proper tool, such as industrial circuit tester. 2. Lack of expertise in electrical discipline within middle management. 3. Culture of lack of deference to expertise (i.e., requests for circuit tester from technicians).
(7) *Hazard Identification & Risk Analysis: Program, Inadequate hazard identification / inadequate risk tolerance* (The breaker and wiring in the broken conduit was originally for Platformer chemical pumps that were removed over 20 years ago.)	1. Poor understanding of potential hazard/risk of retired electrical systems. 2. Inadequate risk tolerance leaving out of service wiring energized. 3. No policy on out of service equipment and de-energizing systems.

[7] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

Table 9. Root Cause Analysis - Causal Factor 3. Liquid on Ground Near Broken Conduit [8]

NEAR ROOT CAUSE	5 WHYS
(8.1) *Conduct of Operations: Communication, No communication with contractors.* (8.2) *Contractor Management: Worksite, Inadequate pre-job safety meeting* (8.3) *Control of Work: Conduct of Work, Inadequate pre-job safety meeting* (Contractors were not formally notified of the hazard of the broken conduit, but some contract personnel were aware through talking to others.)	1. The small pool of liquid was possibly due to washing down the area and/or water hoses used to flush residual liquid draining to ground from the flare header. 2. Some contract work crew personnel were unaware of the hazard of the broken conduit. 3. Turnaround leadership did not have a practice to hold a formal start of shift meeting with all contractors to discuss job plan and hazards such as the broken conduit. [Note: Refinery Maintenance Dept. does have a daily practice to meet with contractors before work commences.]
(9.1) *Conduct of Operations: Procedures, No adherence to safe work practices* (9.2) *Human Factors: Behavior, Inappropriate behavior* (The area around the Platformer HP Effluent Coolers (3530-09 & 3530.10) and the broken conduit was taped off because of the hazard of energized wiring. Person(s) unknown removed the tape before 7:30am so that work could continue.)	)) 1. Some contractors do not consistently follow safe work practices, such as a taped off area. 2. Inconsistent enforcement of safe work practices by refinery management.))

[8] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

Table 10. Root Cause Analysis - Causal Factor 4. Draining Flare Header [9]

NEAR ROOT CAUSE	5 WHYS
(10.1) *Hazard Identification & Risk Analysis: Program, Inadequate program for hazard identification* (At the time of the incident, there were no practices involving safe work permits, and the involvement of Operations in JSAs. There was no JSA covering draining liquid from the flare header.)	1. Limited knowledge of current industry practices. 2. Culture of resisting change by some management. 3. Lack of understanding by some management of the value of JSA and other safe work practice improvements.
(10.2) *Control of Work: Safe Work Practices, Program, Inadequate program for safe work practices* (At the time of the incident, there was no general procedure covering line breaking, such as draining and cold cutting the flare header.)	1. Limited knowledge of current industry practices. 2. Culture of resisting change by some management. 3. Lack of understanding by some management of the value of a general line breaking procedure.
(11.1) *Control of Work: Planning, Inadequate planning of task* (11.2) *Control of Work: Planning, Inadequate consideration of simultaneous operations* (The flare header was drained by partially unbolting a blind flange on a block valve and opening the valve. When planning the job, no consideration was given to: • Potential for a slug of liquid in the flare header and the ability to close the valve quickly, and • Other hazards in the vicinity, such as sparks from the broken conduit.)	) 1. Lack of understanding by project personnel of the hazards of working on a live flare header despite the Platformer being shutdown. 2. No formal communication to Project personnel of the hazards (e.g., liquid in flare system, sparking wiring), although contract project engineer was aware there might be liquid. 3. Each group (turnaround and project personnel) working independently of each other. 4. No formal simultaneous operations (SIMOPS) practice and limited awareness of the concept of SIMOPS.)

[9] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree

Table 11. Root Cause Analysis - Causal Factor 5. Cold Cutting Live Flare Header (NEAR-MISS)[10]

NEAR ROOT CAUSE	5 WHYS
(12.1) *Control of Work: Control of Work: Supervision, Other, Specified safety requirements not implemented* (12.2) *Hazard Identification & Risk Analysis: Use of Safety/Hazard/Risk Studies, Risk reduction measures, Selection of inappropriate risk reduction measures* (12.3) *Training & Performance Assurance: Competency, Other, Inadequate knowledge and experience for tasks performed* (Several days before, an experienced Operations Superintendent advised project personnel not to cold cut the flare header without some form of energy isolation (e.g., stopple valve) due to potential for H2S and liquid hydrocarbons.)	)) 1. Lack of deference to expertise (i.e., ignoring Superintendent's advice) by project personnel 2. Inadequate risk tolerance by individual 3. Lack of knowledge and experience See also item #10 above regarding lack of safe work permit, JSA, and line breaking procedure that would ensure greater involvement of Operations personnel.))
13.1) *Contractor Management: Program, Content, Inadequate job oversight process* (Contractor orientation program mentions oversight, but there is no practice requiring a Person Leading Work (PLW) to supervise jobs.) (13.2) *Contractor Management: Use of Program, Worksite, Inadequate job oversight* (Draining flammable liquids and cutting live piping are potentially high hazard activities requiring careful planning and supervision. This job was managed in a similar way to other less hazardous turnaround and project activities.)	1. Oversight of contractors is informal 2. No written procedure covering contractor oversight 1. Project and some Operations personnel did not understand that a job of this criticality warranted comprehensive planning and continuous oversight.

[10] Text in italics refers to selected items from the BakerRisk® Cause Analysis Tree