# Kern Oil & Refining Co.
# DHT Heater (H-11) April 8, 2020 Fire
# Incident Investigation

## 1 BACKGROUND

### 1.1 Introduction and Overview

On April 8, 2020, at approximately 3:30 a.m., Kern Oil & Refining Co. (Kern) lost electrical power, causing a refinery-wide shut down. During restart activities, at approximately 10:04 a.m., the Diesel Hydrotreater (DHT) Charge Heater (H-11) caught fire. This occurred after the spark plug on a pilot light on the H-11 assembly was cleaned and tested, and while applying the fuel gas to H-11 via the fuel gas regulator valve.

***Response Actions:*** The Shift Supervisor and Operators immediately took responsive action. Personnel assumed their emergency response duties to shut off the main gas valve to the heaters, ensured the compressors were off and blocked in, and blocked in the charge pump discharge valve. During the fire, Kern Operators activated fire monitors and fire hose stations and pointed them towards the heater. Kern County Fire Department (KCFD) arrived at approximately 10:11 a.m. The incident was controlled, and the fire extinguished in approximately 22 minutes. There were no injuries as a result of the event.

***Agency Notification and Response:*** Notifications were made to Cal OES, Cal OSHA PSM Unit, and Kern County Environmental Health (CUPA).

### 1.2 Investigation Team Composition

Kern initiated an incident investigation into the H-11 fire on April 8, 2020 by convening a multi-disciplinary team of employees knowledgeable in the operation and maintenance of the refinery. Investigation team members included representatives from Kern's Safety, Engineering, Operations, and Maintenance departments. For the purposes of the incident investigation, Kern treated this incident as a major incident under 8 C.C.R. § 5189.1(o).

### 1.3 Root Cause Analysis Methodology and Materials Reviewed

The site of the H-11 fire was promptly secured to enable the investigation team to take photographs and gather evidence. Kern 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 on April 8, 2020, and subsequent days. In connection with its investigation, the team reviewed relevant DHT Process Safety Management ("PSM") information, including Damage Mechanism Review ("DMR") information, Hierarchy of Hazard Controls Analysis ("HCA") information, and Process Hazards Analysis ("PHA") information. The team also reviewed other documentation associated with the incident, including process data, engineering drawings for the affected unit, work orders, and operations, maintenance, and engineering notes. Finally, the team examined DHT charge heater convection tubes, and reviewed a third-party metallurgical failure analysis of selected DHT convection tubes.

The investigation team applied Process Improvement Institute's Root Cause Chart methodology, which is a modified 5 Whys? technique. This approach was conducted in line with the guidance provided by the Center for Chemical Process Safety (CCPS) for root cause analyses.

# 2 ROOT CAUSE ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

## 2.1 Analysis and Findings

To develop its findings, the investigation team relied primarily on a third-party metallurgical analysis of the likely failure of the DHT charge heater convection tubes. The team also considered process data relevant to H-11 operation, witness statements and interviews, security camera footage, visual inspection, and documentation and records pertaining to the equipment and actions associated with the incident.

The investigation team submitted to Element Materials Technology Houston (EHO) two samples of H-11 charge heater convection tubes for failure analysis. The purpose of this failure analysis was to determine the cause of the rupture on one sample (Tube 1) and evaluate the condition of the second sample (Tube 2; a H-11 convection tube that had not ruptured, but was positioned directly above the ruptured tube). EHO's failure analysis concluded that, during the start-up of H-11, the stack temperature rose from 410 degrees F to 1,600 degrees F over approximately 2.5 hours. This exceeded the recommended design temperature of H-11, which is 995 °F.

EHO observed that the longitudinal rupture on Tube 1 was relatively smooth and showed no wall thinning, which is indicative of a brittle rupture. Intergranular cracking was also observed throughout the wall thickness at the rupture location, and relatively deep and narrow inside and outside surface pits were observed in an area just outside the rupture. Based on this, EHO concluded that the rupture was caused by long-term stress rupture. Long term stress rupture is an elevated temperature failure mechanism that reduces the yield strength and, consequently, the resistance to deformation of a material.

No metallurgical defects were observed on Tube 2. The results of the chemical analysis, hardness testing, and metallographic examination found no differences between the two tubes to explain why Tube 1 failed, and Tube 2 did not. Based on EHO's metallurgical analysis and an analysis of corresponding H-11 process data, the investigation team concluded that long-term stress rupture, due to an elevated temperature failure mechanism, was the applicable damage mechanism to the failure of Tube 1.

Additionally, the investigation team identified low recycle compressor hydrogen flow and excess liquid in the fuel gas as contributing causes to the incident. The investigation team concluded that a JVG Recycle Compressor flow decrease on the morning of the incident contributed to lower recycle rates. The lower recycle rates created an insufficient pressure drop, which prevented proper distribution between H-11 passes. This condition contributed to the H-11 tube rupture. The investigation team also identified excess hydrocarbon liquids in the refinery fuel gas. Combustion of this material can cause combustion issues within H-11, including the formation of soot. Soot build up can and did affect the H-11 heater spark plug components. These conditions contributed to the incident because they made start-up more difficult, as H-11 components required removal and cleaning prior to restart.

## 2.2 Conclusion and Root Causes

The investigation team identified the following factors that caused or contributed to the incident:

- A third-party metallurgical analysis indicates that the H-11 tube failure was caused by long-term stress rupture. Long term stress rupture is an elevated temperature failure mechanism that reduces the yield strength and, consequently, the resistance to deformation of a material.

- A recycle compressor flow decrease on the morning of the incident contributed to lower recycle rates. The lower recycle rates created an insufficient pressure drop, which prevented proper distribution between H-11 passes. This condition contributed to the H-11 tube rupture.

- Excess hydrocarbon liquids in the refinery fuel gas also contributed to the incident. Combustion of this material can cause combustion issues within H-11, including the formation of soot. Soot build up can and did affect the H-11 heater spark plug components. These conditions contributed to the incident because they made start-up more difficult, as H-11 components required removal and cleaning prior to restart.

## 2.3 Interim Measures and Recommendations

***Interim Measures:*** Kern implemented the following interim measures to address the causes identified above:

1. Repaired the damage to H-11 as follows:

    - Installed new radiant tubes and refractory into shell;
    - Installed new fuel gas ring (4") and 1" pilot gas ring;
    - Installed new fuel gas piping and pilot gas piping;
    - Installed new ½ inch airline;
    - Installed new convection section;
    - Made repairs/reinforcements to the shell of the radiant section; and,
    - Replaced damaged instruments and wiring.

2. As a precaution, installed a new fuel gas coalescer, V-24, to better remove liquids from the fuel gas system.

***Recommendations:***

***Background***

Implementation of Integrity Operating Windows ("IOWs") for process equipment can help guard against equipment degradation by creating, documenting, and implementing set operational windows that are identified based on potential damage mechanisms and process conditions. Applying IOWs to process equipment can assist refiners in more closely monitoring and measuring process variables associated with that equipment, and provides useful operating parameters for equipment alarms and variances. (American Petroleum Institute ("API") Recommended Practice 584.)

In consideration of the above, the investigation team developed the following recommendations to address incident investigation findings that were not already addressed by interim measures:

- Kern will develop IOWs for H-11. H-11 IOW development will address H-11 low hydrogen flow conditions as well as provide guidance regarding stack temperature alarms and interlocks; and,
- Kern will develop IOWs for Crude Unit, DHT, KHT, NHT, Platformer, Reformer, and Transmix #1 and #2 Unit heaters.