



LOS ANGELES REFINERY
DU-22 PUMP FIRE
MARCH 15, 2019

INCIDENT INVESTIGATION REPORT
IMPACT #324432

Location:	Los Angeles Refinery, Carson Plant
Date of Incident:	March 15, 2019
Time of Incident:	7:13 pm
Date and Time Investigation Began:	March 17, 2019; 7:00 am
Date of Report:	April 18, 2019
Name of Incident:	Crude Unit Pump DU-22 Fire
Incident Risk Rank:	IV
Method of Investigation:	Cause-Effect Mapping

Executive Summary

On Friday, March 15, 2019 at 7:13 p.m., a fire started in the DU-5 Crude Unit due to an ignition of Upper Circulating Reflux (UCR) material released from the DU-22 Upper Circulating Reflux Pump. UCR is an unstabilized distillate material approximately C₇ – C₁₉. The site emergency response team was dispatched along with local fire responders, and the fire was extinguished at approximately 9:30 p.m. The fire resulted in a shutdown of the DU-5 Crude Unit. No injuries occurred.

The Investigation Team focused on identifying the release point, identifying cause(s) of the release, and developing recommended action items. The key learning from this incident is the need to check and document mechanical readiness prior to placing equipment in-service following repairs.

Background and Incident Description

Normal DU-5 Distillation Tower operations require an Upper Circulating Reflux (UCR) and a Middle Circulating Reflux (MCR) pumparound. Both UCR and MCR are unstabilized distillate streams with UCR being slightly lighter than MCR. Pump DU-21 operates in MCR service. Pump DU-23 operates in UCR service. Pump DU-22 can operate in either MCR or UCR service (i.e. – it serves as a common spare).

Pump DU-22 experienced higher than expected vibration during portions of December 2017 and January 2018. Vibration readings for this type of pump are expected to be in the range of 0.1 to 0.3 inches per second (IPS), but in late December and early January, vibration readings were recorded at approximately 1.2 IPS. During this period of high vibration, a cracked coupling was observed. Misalignment and the cracked coupling are suspected causes of the higher vibration readings. In January 2018, the coupling was replaced and an alignment performed on Pump DU-22. Following these repairs, Pump DU-22 was not placed in-service until March 15, 2019 other than for periodic “rotation bump testing.” As a result, the effectiveness of the coupling replacement and alignment in reducing the higher than expected vibration was not verified following the repair. The periodic “rotation bump testing” that occurred was of insufficient duration to verify whether the vibration issue was eliminated.

On Friday, March 15, 2019, operations personnel needed to place Pump DU-22 into service because the primary pump in operation, DU-23, developed a seal cooler leak. Pump DU-22 was lined up in UCR service by opening the suction and discharge valves, and at 12:11 p.m., operations personnel started the pump. Statements provided to the Investigation Team by operations personnel, as well as process data, indicated that the pump’s operation was steady. Outside operations and supervisory personnel informed the Investigation Team that DU-22 sounded a bit “noisy”, but the noise was not perceived to be caused by pump cavitation or bearing issues. They stated that the noise was from the pump, not the motor. Outside operations personnel checked Pump DU-22 approximately 5 times prior to the incident and no significant changes were noted. At 7:13 p.m., the Crude Unit Outside Operator heard what he described as a prolonged abnormal “huff” sound and he began to investigate. Approximately 15 seconds later, he observed a fire in the vicinity of Pump DU-22.

The refinery Emergency Response Team was immediately dispatched and soon thereafter joined by local fire responders. Emergency responders focused on keeping the fire away from surrounding equipment to prevent the fire from spreading and creating a larger incident. The responders protected the surrounding equipment and eventually were able to enter the DU-22 area to close the suction and discharge valves. Once the pump was isolated, the fire was extinguished (approximately 9:30 p.m.). Multiple responders informed the Investigation Team that the fire originated from the seal area of pump DU-22. The fire resulted in a shutdown of the Crude Unit. No injuries occurred.

Following the incident and upon opening Pump DU-22, the Investigation Team discovered a ¾-inch nut on the discharge side of the pump casing. The Investigation Team observed minor pump suction-side impeller damage and concluded that this condition was likely caused by the nut. This may have contributed to the high vibration found in December 2017 and January 2018; however, since the ¾-inch nut was not lodged in the impeller upon disassembly, the Investigation Team was not able to determine if the nut caused an imbalance condition for any significant duration.

Upon disassembly of the pump at an off-site location, shop personnel observed cracks in the pump case at the nozzles and feet. These cracks were likely caused by excessive forces on the pump nozzles. Based on the conditions observed, the cracks existed prior to the fire. In addition, the pump inboard bearing was inspected by the bearing manufacturer. The manufacturer agreed with the Investigation Team that the bearing failure was likely caused by a combination of the pump being non-operational for 15 months while subjected to vibration from nearby equipment, and previously operating the pump with high vibration.

History and Timeline

Date	Description
Nov. 2000	DU-22 seal and bearing were replaced.
Mar. 2016	DU-22 vibration readings were taken and documented as within tolerance.
Oct. 2016	Piping material was changed from carbon steel to stainless steel. Pipe strain calculations performed indicate high, but tolerable per API-610, stresses on the pump.
6/7/2017 – 1/9/2018	DU-22 was operated in UCR service.
12/27/2017	DU-22 was observed by Mechanical Engineer as having high vibration.
12/27/2017 – 12/29/2017	Couplings on DU-21 (MCR service) and DU-22 (UCR service) were observed to have cracked shim packs, and work notifications were submitted for both. Both DU-21 and DU-22 remained in-service.
1/2/2018	DU-22 was observed by machinist as having high vibration. Pump continued to run in UCR service.
1/9/2018	DU-21 was idled; therefore, DU-22 was changed to MCR service.
1/10/2018 Morning	DU-21 was locked and tagged out (LOTO) for mechanical work (replace coupling and hot alignment)
1/10/2018 Afternoon	DU-22 was idled. DU-21 was started.
1/17/2018	DU-22 was LOTO'd for mechanical work (replace coupling and hot alignment).
1/18/2018	DU-22 mechanical work was complete. Pump DU-22 was lined up in standby MCR service (not operated).
1/17/2018 – 2/27/2018	Multiple operations supervisor logs stated that DU-22 was "Unavailable for service."
1/18/2018 – 3/15/2019	DU-22 was not operated in MCR or UCR service.
Jan. 2018 – Mar. 2019	DU-22 was "rotation bump tested" monthly per Operator Routine tasks.
Approx. 3/1/2019	DU-23 developed a seal cooler leak. It was not immediately addressed because of a valve bushing issue on DU-22 suction valve. The DU-23 seal cooler leak was deemed minor enough to remain in-service while a repair attempt was made on the DU-22 suction valve.
3/14/2019 Night	DU-23 seal cooler leak increased to a point where operations personnel wanted to take it out-of-service.
3/15/2019 12:11 PM	DU-23 was idled, and DU-22 was placed in UCR service.
3/15/2019 Afternoon	Operators checked DU-22 several times throughout the afternoon. Nothing out of the ordinary was noted. There was a slightly louder pump noise but nothing concerning to operations.
3/15/2019 7:13 p.m.	Outside Operator heard a "huff" type sound. He observed a fire 15 seconds later.
3/15/2019 ~9:15 p.m.	Responders reported seeing fire coming from DU-22 pump seal.
3/15/2019 ~9:30 p.m.	Fire extinguished upon closing DU-22 suction and discharge valves.

Incident Causes

The Investigation Team concluded that UCR material released from the pump mechanical seal (single seal arrangement) and ignited upon contacting the bearing housing. There was evidence of the bearing housing being hot enough to cause ignition. The seal failed due to a vibration-induced bearing failure. Vibration-induced bearing failure was caused by a combination of one or more of the following:

1. The pump operated for at least 14 days in December 2017 and January 2018 with high vibration.
2. Misalignment of the pump to the motor and/or misalignment of the internal pump rotor to the pump housing due to pipe strain as evidenced by cracks observed in the pump at the nozzles and feet.
3. Misalignment of the pump/motor due to an ineffective previous alignment.
4. Presence of a foreign object (¾-inch nut) in the pump impeller leading to an imbalance.

Although the pump coupling was replaced in January 2018, there was no evidence of a post-repair test confirming that this repair was effective in eliminating the high vibration.

Incident Corrective Actions

Implementing the following recommendations will reduce the likelihood of a future seal failure due to the causes of this incident:

1. Consider creating a rotating equipment return-to-service procedure that includes appropriate mechanical personnel involvement. Consider using the reinstallation checklist in the existing Useful Practice document M-45-UP-4. Consider including a vibration check as a step on the work order.
2. Consider establishing requirements to check and document pipe strain and alignment following repairs. Consider utilizing existing M-45-UP-4 Pump Inspection Package, and Refining Engineering Practice 6-8-1R or alignment software records in the pump repair documentation.
3. Consider revising the current pump switching program to include vibration checks. Consider validating that all pumps are included in the program and operated long enough to collect vibration data. Consider developing a process for managing exceptions to the program.
4. Consider revising the existing site equipment closure document to specifically verify absence of loose hardware and debris. Existing *Equipment Closure Form - Tower or Column* located in Los Angeles Refinery Policy and Procedure 2-2-34 *Approval of Equipment for Closure* only specifies that the equipment is “clean” prior to closure.
5. Prior to starting up Pumps DU-21, DU-22, and DU-23, perform pipe strain calculations and reinstall piping, supports, and pumps so the forces on the pump are within allowable limits for the applicable pump design.

Investigation Team

Phillips 66 Corporate HSE Process Safety Manager – Team Lead (External to Site)

Los Angeles Refinery Mechanical Engineer

Los Angeles Refinery Operations Superintendent

Los Angeles Refinery USW Health and Safety Representative

Refining Business Improvement (RBI) Director, Rotating Equipment

Refining Business Improvement (RBI) Specialist, Rotating Equipment

CALIFORNIA PROCESS SAFETY MANAGEMENT/ ACCIDENTAL RELEASE PREVENTION ADDENDUM

- **Date and time of the incident**

See the main body of the Incident Investigation Report.

- **Date and time the investigation began**

See the main body of the Incident Investigation Report.

- **A detailed description of the incident**

See the main body of the Incident Investigation Report.

- **The factors that caused or contributed to the incident, including direct causes, indirect causes, and root causes, determined through the root cause analysis**

See the main body of the Incident Investigation Report.

- **A list of any DMR(s), PHA(s), HCA(s), and SPA(s) that were reviewed as part of the investigation, and documentation of relevant finding from the review, if any**

- May 2015 Crude PHA – No applicable findings

- **Interim recommendations to prevent a recurrence or similar incident, and interim measures implemented**

No applicable interim measures that will reduce the risk of recurrence or similar incident were identified.

- **Recommendations for permanent corrective actions**

See the main body of the Incident Investigation Report.