Investigation Update

June 2023

This document provides an update on the CSB investigation of the September 20, 2022, incident at the BP-Husky Toledo Refinery in Oregon, Ohio.

Incident Summary

On September 20, 2022, at approximately 6:09 p.m., flammable liquid naphtha began to fill a Fuel Gas Mix Drum ("Mix Drum") at the BP-Husky Toledo Refinery. The liquid overflowed from the normally vapor-only Mix Drum, sending naphtha through vapor piping to various boilers and furnaces in the refinery. Several of these boilers and furnaces started to emit highly visible plumes of smoke (**Figure 1**). To decrease the level in the Mix Drum, at approximately 6:17 p.m. liquid naphtha was sent to the refinery flare system and drained to an oily water sewer. Starting at approximately 6:32 p.m., naphtha from the Mix Drum was also drained directly to the ground creating a vapor cloud. At approximately 6:46 p.m., the vapor cloud of flammable naphtha that had formed on the ground reached an ignition source, which generated a large fire that fatally injured two employees [Max Morrissey and Ben Morrissey] and resulted in substantial property damage within the refinery.

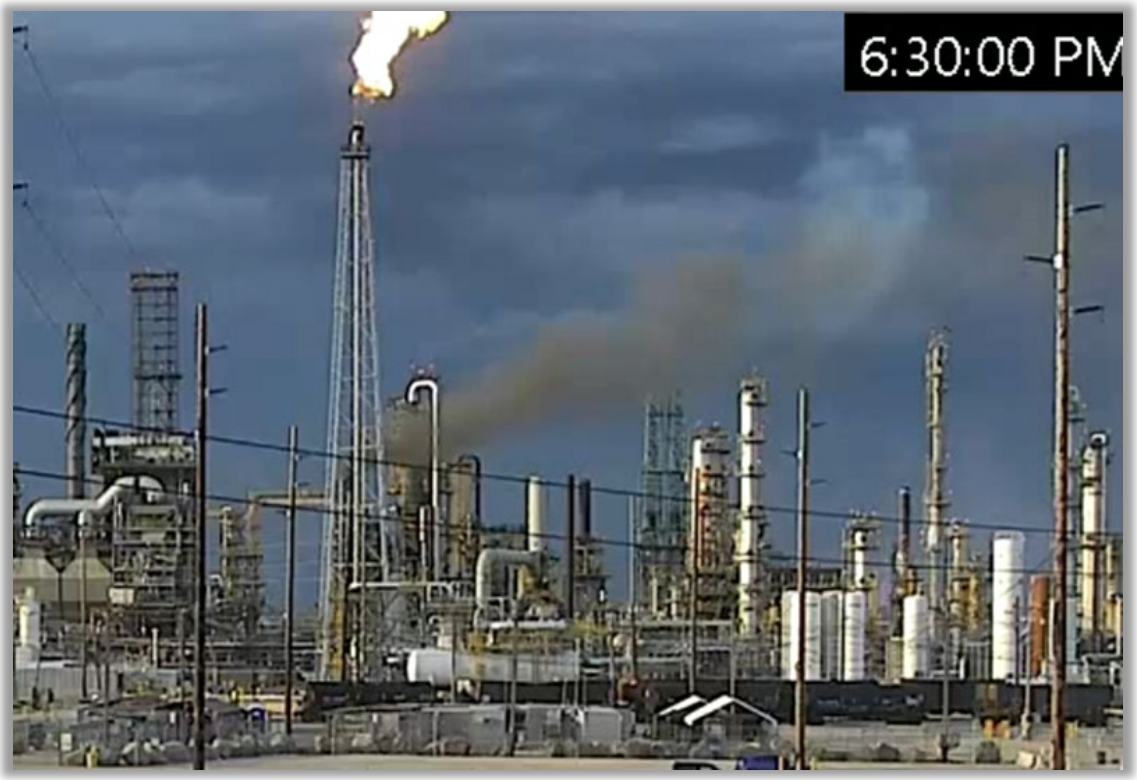

Figure 1. Smoking furnace and refinery flare prior to the incident. (Credit: BP)

Background Information

BP-Husky Toledo Refinery

The BP-Husky Toledo Refinery is located on 586 acres east of the city of Toledo, in Oregon, Ohio, and has operated since 1919 [1]. The refinery can process approximately 160,000 barrels of crude oil per day, providing gasoline, diesel, jet fuel, propane, asphalt, and other products [2]. As of September 2022, the refinery employed 588 people.

In 2008, BP-Husky Refining LLC (BPHR) acquired the Toledo Refinery. BPHR was a 50/50 joint venture formed from subsidiaries of BP Products North America Inc. ("BP")[a] and the Husky Oil Toledo Company (HOTC), an indirect subsidiary of Husky Energy Inc. ("Husky") [3]. BP continued to serve as the refinery's operator.

In 2021, Cenovus Energy Inc. merged with Husky [4]. On August 6, 2022, HOTC agreed to purchase BP's ownership interest in BPHR. The transaction closed on February 28, 2023, making HOTC the sole owner of the refinery [5]. After the closing of the transaction on February 28, 2023, BPHR was renamed Ohio Refining Company LLC which became both the owner and operator of the refinery.

Naphtha

Naphtha is a fraction of crude oil that boils between approximately 85 °F and 400 °F. It includes hydrocarbons ranging from C_5 to C_{12}. Naphtha comprises approximately 15-30 weight percent of raw crude oil [6]. Naphtha is an extremely flammable liquid, and vapor material can contain hydrogen sulfide (H_2S), a toxic and extremely flammable gas.

Refinery Fuel Gas

Fuel gas is typically produced as a by-product in various refinery units including catalytic reforming, hydrotreating and hydrocracking, catalytic cracking, and coking [7]. According to the U.S. Environmental Protection Agency (EPA), a refinery fuel gas system includes the piping and control system that gathers gaseous streams generated by refinery operations and distributes the blended gaseous fuel at suitable pressures for use as fuel in heaters, furnaces, boilers, incinerators, gas turbines, and other combustion devices. The fuel is typically piped directly to each individual combustion device, and the fuel system typically operates above atmospheric pressure. These gaseous hydrocarbon streams commonly contain a mixture of methane, light hydrocarbons, hydrogen, and other miscellaneous species [8].

At the BP-Husky Refinery, fuel gas streams from seven refinery sources are routed to the Mix Drum where vapors mix before being distributed to thirteen fuel users throughout the refinery. **Figure 2** is a simplified diagram of the Mix Drum. The liquid level in the bottom portion of the normally vapor-only drum was

[a] BP acquired Sohio and the Toledo refinery in 1987 [14].

monitored and measured by a differential pressure level instrument,[a] a guided wave radar level instrument,[b] and a transparent level gauge commonly called a "sight glass."[c]

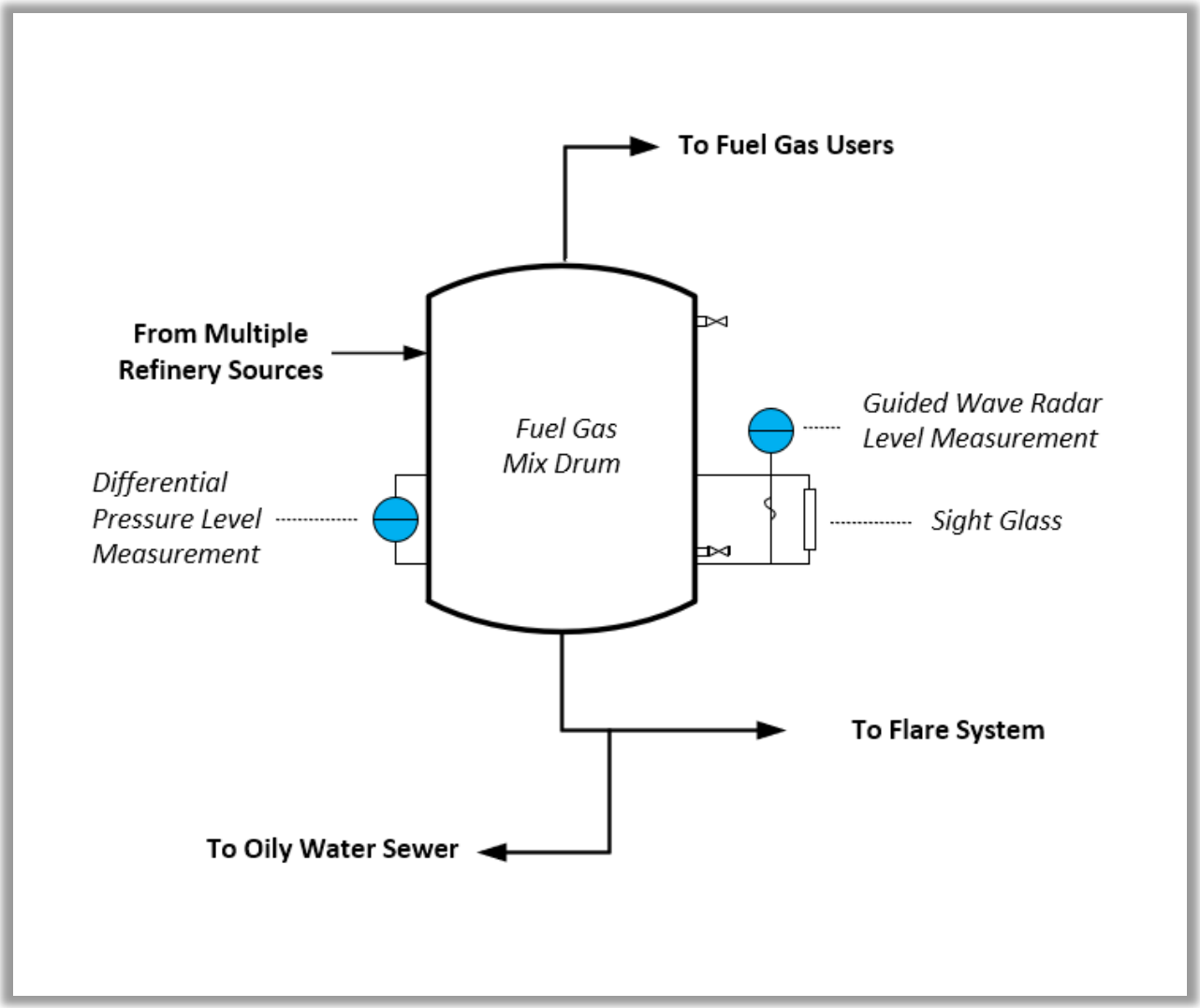

Figure 2. Simplified Fuel Gas Mix Drum (not to scale). (Credit: CSB)

[a] Liquid level can be measured (inferred) by measuring a differential pressure caused by the weight of a fluid column in a vessel balanced against a reference [12, p. 454].

[b] A guided wave radar level measurement has a waveguide which is a probe immersed in a liquid. High-frequency pulses are transmitted down the probe and reflected at the point between the vapor and the liquid. Those reflections are measured by high-speed circuitry in a transmitter to provide the level measurement [13].

[c] Process level is read visually, as directly indicated in a glass gauge [12, p. 488].

Refinery Layout

The Mix Drum was located within the Crude 1 Unit of the refinery. The Mix Drum is where the liquid naphtha was released. **Figure 3** shows the Mix Drum location with a red circle. A fluid catalytic cracking (FCC) unit is across a street to the north of the Crude 1 Unit, and the Crude 1 Furnace is less than 75 feet to the south.

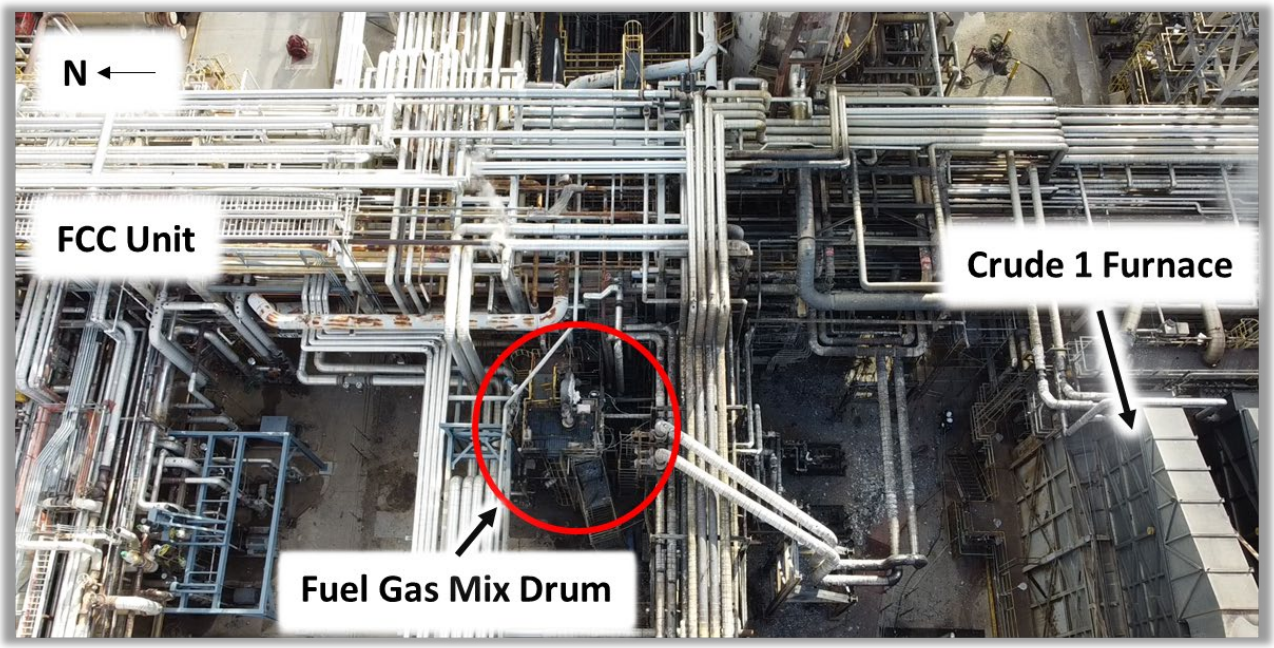

Figure 3. Naphtha release location. (Credit: BP with annotations by CSB)

Incident Description

Naphtha Hydrotreater Feed Release

At approximately 3:20 a.m. on Tuesday, September 20, 2022, an emergency pressure-relief valve ("relief valve") on the feed to the naphtha hydrotreater[a] (NHT) opened during the Monday night shift. After a shift change, the Tuesday day shift took over operations, and this same relief valve opened at approximately 8:00 a.m. Another relief valve just upstream on the NHT feed also opened around this time, and the inlet piping to this relief valve began vibrating severely.

The vibration continued as refinery workers attempted to troubleshoot and reduce pressure in the system. The fire suppression water spray system was activated in anticipation of a release event. The refinery's emergency response team was called to the scene.

[a] Hydrotreating processes help remove impurities such as sulfur and nitrogen from distillate fuels - naphtha, kerosene, and diesel - by treating the feed with hydrogen at elevated temperature and pressure, in the presence of a catalyst [10].

As the piping vibration continued, a weld in a branch connection to a ¾-inch drain valve failed, releasing an estimated 63,625 pounds of naphtha.

The refinery's emergency response team successfully isolated the leak. The NHT and the saturated gas plant (SGP)[a] were shut down, and the coker gas plant (CGP) was bypassed.[b] The Crude 1 Unit and all other units continued to operate while refinery teams began to evaluate a repair plan for the failed branch connection.

Crude 1 Upset

By 4:30 p.m. on September 20, Crude 1 operations were stable at reduced rates, with naphtha from the Crude 1 tower's overhead accumulator drum being sent to storage due to the earlier shutdown of the NHT unit. After the Tuesday night shift personnel arrived, a worker discovered a seal leak on a crude oil pump supplying sweet crude to the Crude 1 Unit. The worker shut down the pump at approximately 5:10 p.m. Another pump, connected to conventional heavy crude oil storage, automatically increased speed to maintain the feed flow rate to the Crude 1 Unit.

The change in crude feed composition combined with the earlier shutdown of the NHT and bypassing of the CGP resulted in unstable operating conditions in the Crude 1 Unit. During this time all the pump-arounds supplying cooling to the Crude 1 tower were not circulating. The decreased cooling increased the vapor flow up the tower leading to additional material flashing overhead and condensing. The additional overhead flow in the Crude 1 tower resulted in a high liquid level in the Crude 1 overhead accumulator drum. Liquid from the overhead accumulator drum would normally be sent to three locations: NHT, CGP, and liquid storage. The NHT was shut down and the CGP was bypassed because of the loss of containment earlier in the day. The liquid naphtha, therefore, was being directed to a storage tank.

To reduce the liquid level in the Crude 1 overhead accumulator drum, at approximately 5:42 p.m., a control room operator opened a flow control valve, sending liquid naphtha to the CGP which was in bypass mode. Naphtha began accumulating in a 138-foot tower until the liquid level reached CGP vapor bypass piping which directed the naphtha to the Mix Drum.

By 6:09 p.m., the Mix Drum level started rising and was soon overfilling, sending liquid naphtha through what was normally vapor piping to various refinery furnaces and boilers. Workers used the plant radio system to report smoke coming out of furnaces and boiler stacks.

A control room operator noticed a Mix Drum high-level alarm at approximately 6:16 p.m. and requested via radio for workers to respond to the Mix Drum level. Four workers initially responded and made their way to the Mix Drum. They began draining the Mix Drum to the flare and oily water sewer system. Shortly after this, two of the workers left, and the remaining two workers began draining liquid from the Mix Drum to the ground while wearing Self-Contained Breathing Apparatus.

[a] The word *saturates* is a synonym for light hydrocarbons with no double bonds; that is, all the carbon atoms are "*saturated* with hydrogen atoms" [11]. At the refinery, these gas streams are handled in a unit called the sat gas plant.

[b] Bypass of the Coker Gas Plant indicates no vapor feed but still inventoried with liquid.

A worker in the nearby FCC unit told the CSB that they saw two workers near the Mix Drum along with a visible vapor cloud. An approaching rainstorm shifted the wind, which likely directed the vapor cloud towards the nearby Crude 1 Furnace, igniting the vapor cloud.

Figure 4 shows surveillance camera images at approximately 6:46 p.m., a six-second period after the ignition of the release from the Mix Drum. Within seconds, the area around the Mix Drum and nearby Crude 1 Unit equipment was engulfed in a large fire. The fire fatally burned the two workers who were responding to the level in the Mix Drum.

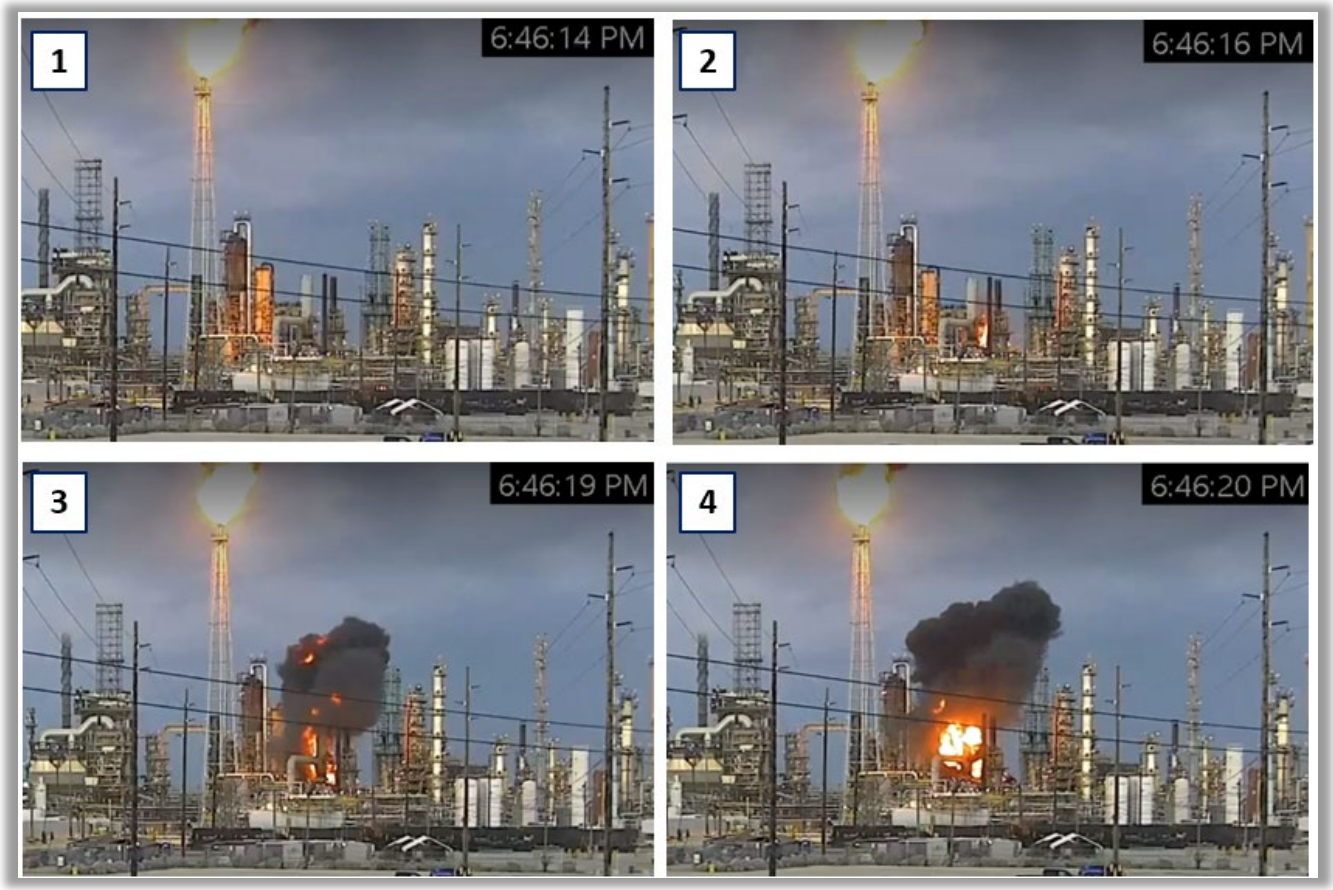

Figure 4. Initial six seconds of the fire from the Fuel Gas Mix Drum. (Credit: BP)

At 7:04 p.m., a control room operator closed the flow control valve feeding liquid naphtha to the CGP which was flowing to the Mix Drum.

The refinery emergency response team spent the next three hours containing the fire and assembled teams to approach the Mix Drum. The response team closed numerous valves to isolate the naphtha being released from the Mix Drum.

Figure 5 shows the Mix Drum after the incident. Emergency responders closed the Mix Drum valves to the flare system and the drain valve to the oily water sewer. In addition, responders put out a jet fire by closing a valve on the side of the Mix Drum where a blind flange had been opened to the atmosphere.

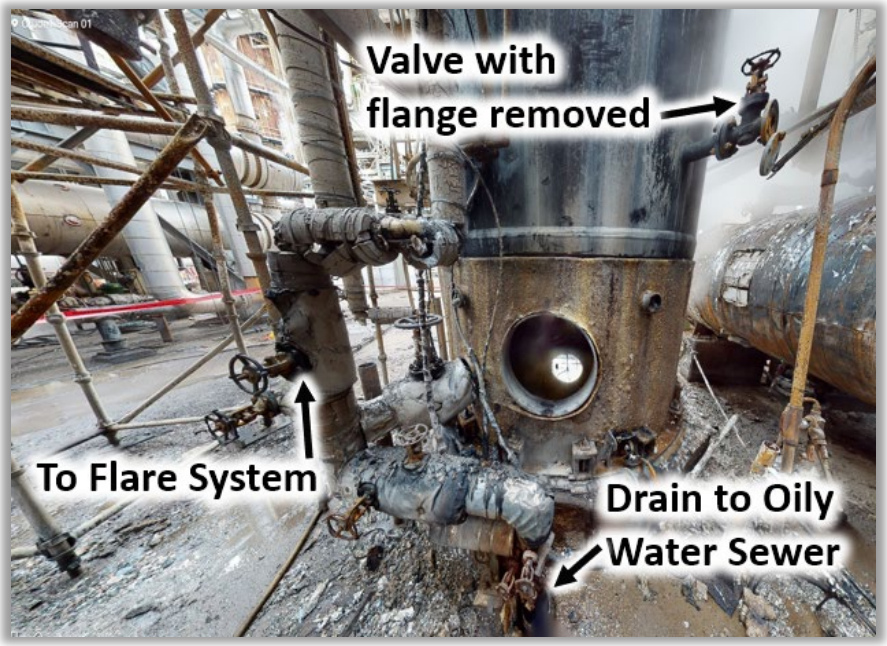

Figure 5. Fuel Gas Mix Drum after the incident. (Credit: CSB)

Figure 6 shows the Mix Drum level sight glass where emergency responders closed valves to stop the liquid naphtha draining to the ground where a drain plug was removed from a valve.

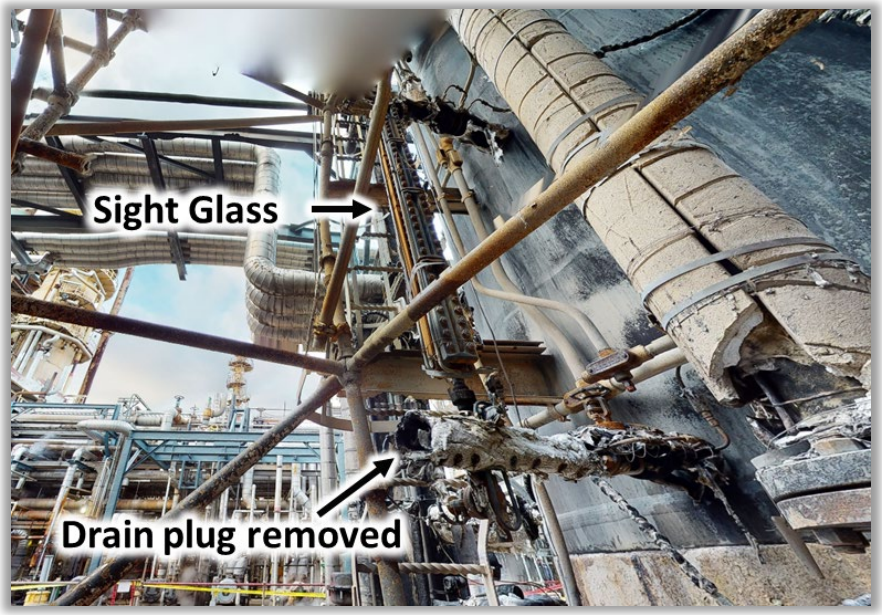

Figure 6. Fuel Gas Mix Drum Sight Glass after the incident. (Credit: CSB)

Emergency responders also closed valves to address a disconnection of the high-side pressure tap[a] of the differential pressure level measurement that was allowing liquid to flow to the ground as well as drain valves from the guided wave radar device to the oily water sewer.

The fire was extinguished by 10:15 p.m. An estimated 23,502 pounds of naphtha were released from the Mix Drum during the incident.

Coker Gas Plant

In 2018, the BP-Husky Toledo refinery commissioned a new $115 million coker gas plant to reduce the environmental impact of its operations [9]. The coker gas plant removes sulfur and light hydrocarbon compounds from the gas produced in the coker units before it goes to the Mix Drum, resulting in fewer emissions from the refinery's furnaces [9].

The flammable liquid naphtha from the Crude 1 Unit reached the Mix Drum by flowing through piping associated with the new coker gas plant.

Path Forward

The CSB is continuing to gather facts and analyze several key areas, including:

- Hierarchy of Controls;
- Human Factors for Process Plant Operations;
- Managing Abnormal Situations; and
- Regulations, industry standards, and guidance.

The investigation is ongoing. Complete findings, analyses, and recommendations, if appropriate, will be detailed in the CSB's final investigation report.

[a] The high-side pressure tap refers to the high-pressure side, or lower elevation, tap on the Mix Drum.

References

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