VOLUME: 3
DATE: JULY 22, 2025

INCIDENT REPORTS

EVENTS REPORTED TO THE CSB UNDER THE ACCIDENTAL RELEASE REPORTING RULE

U.S. Chemical Safety and
Hazard Investigation Board

U.S. Chemical Safety and Hazard Investigation Board

Members of the U.S. Chemical Safety and Hazard Investigation Board:

Table of Contents

Summary

This volume of Incident Reports covers 30 accidental release events in 15 states. These events resulted in two fatalities, 25 serious injuries, and approximately $1.8 billion in property damage.

Accidental Release Events							
Number	Incident Date	Company	City	State	Fatality	Serious Injury	Substantial Property Damage ($ Million)
1	2020-04-15	Pixelle	Jay	Maine			350
2	2020-07-19	Tyson Foods	Enid	Oklahoma		1	
3	2020-08-18	Chevron	Pasadena	Texas			3.3
4	2020-09-10	PBF Energy	Delaware City	Delaware			1.7
5	2020-09-19	Silver Eagle	Evanston	Wyoming		2	5.8
6	2020-11-20	Tyson Foods	Hutchinson	Kansas		2	
7	2021-05-05	FutureFuel	Batesville	Arkansas		1	
8	2021-11-23	PBF Energy	Oregon	Ohio			50.3
9	2021-12-23	ExxonMobil	Baytown	Texas		4	107
10	2022-01-19	Pilgrim's	Canton	Georgia		2	
11	2022-01-21	WR Meadows	Hampshire	Illinois	1	1	3.5
12	2022-01-26	Westlake	Westlake	Louisiana			9.2
13	2022-01-31	Eastman	Kingsport	Tennessee			25
14	2022-02-01	Blues City Brewery	Memphis	Tennessee		3	
15	2022-02-17	Dyno Nobel	Waggaman	Louisiana			128
16	2022-07-09	ONEOK	Medford	Oklahoma			930
17	2022-08-24	AdvanSix	Chester	Virginia		1	
18	2022-12-24	HF Sinclair	Tulsa	Oklahoma			2.9
19	2022-12-26	SABIC	Mt. Vernon	Illinois			4.6
20	2023-03-16	Hilmar Cheese	Dalhart	Texas		1	
21	2023-04-17	Delek	Tyler	Texas		1	
22	2023-04-19	Valero	Port Arthur	Texas			2.3
23	2023-05-08	Delek	El Dorado	Arkansas			1.27
24	2023-07-31	CITGO	Lemont	Illinois		1	
25	2023-08-13	Southwestern Energy	Ohio County	West Virginia		2	
26	2023-08-26	Dow	Texas City	Texas		1	
27	2024-03-13	Sasol	Westlake	Louisiana			187
28	2024-05-17	Advantek	Westhoff	Texas	1		6.94
29	2024-06-11	Cornerstone	Waggaman	Louisiana		1	2.5
30	2025-01-16	Georgia Pacific	Monticello	Mississippi		1	
				Total	**2**	**25**	**1,821**

1. Pixelle

April 15, 2020

Jay, Maine

Incident Summary

On April 15, 2020, at approximately 12:00 p.m., a 260,000-gallon pressure vessel exploded at the Pixelle Specialty Solutions ("Pixelle") paper mill in Jay, Maine (**Figure 1**). The explosion caused an estimated $350 million in property damage, and the incident ultimately resulted in the permanent closure of the paper mill that employed 515 people.

Figure 1. Post-incident image of the Pixelle paper mill in Jay, Maine (Credit: WMTW)

Pixelle purchased the paper mill from Verso Corporation on February 10, 2020, just 66 days before the incident. Shortly after noon on the day of the incident, many of the roughly 170 employees and contractors present at the paper mill at that time were on a lunch break when a 166-foot-tall pressure vessel exploded, erupting much of its approximately 260,000 gallons of hot corrosive chemicals and wood fibers into the air (**Figure 2 & Figure 3**). The vessel—a pulp digester—was operating at a pressure of approximately 160 pounds per square inch and a temperature above 300 degrees Fahrenheit when it exploded.

Figure 2. Explosion (left), and the bottom of the remaining portion of the pulp digester (right). (Credit: Richard Carrier Trucking via WMUR 9 (left), and Pixelle (right))

Figure 3. Damaged equipment at the Pixelle paper mill. (Credit: Robert F. Bukaty/AP)

The released chemicals included sodium hydroxide, sodium carbonate, sodium sulfate, sodium sulfide, and water. This large carbon steel pressure vessel, made in 1964, was a digester that converted wood chips into pulp. No serious injuries resulted from the incident. The paper mill operated two digesters, which were situated close to each other, and the explosion also destroyed the second digester.

Pixelle's investigation found that the digester failed while operating within the normal pressure and temperature range. The company's metallurgical examination revealed that the pressure vessel failed along a weld seam joining two sections of carbon steel plate in its shell. Extensive preexisting cracks were found throughout the area where the digester failed. These cracks were caused by caustic stress corrosion cracking, a damage mechanism known to occur in pulp digesters. Cracking was located along weld fusion lines and in weld heat-affected zones. The failure-initiating crack was found to have breached roughly 70 percent of the vessel's wall thickness. At that point, the normal operating temperature and pressure stretched the remaining metal to failure, initiating the explosion as the crack propagated through the wall and into adjacent wall sections, as the digester catastrophically ruptured.

Pixelle's investigation identified many preexisting cracks in the digester near welds with high metal hardness. The company concluded that these welds were from vessel repairs where the heat was not controlled during or after the welding or from poor welding practices.

In addition, Pixelle concluded that an ineffective mechanical integrity program contributed to the incident. The digester was last inspected in September 2019, seven months before the incident. Pixelle concluded that previous inspections should have identified and repaired the preexisting cracks in the digester's walls.

Probable Cause

Based on Pixelle's investigation, the CSB determined that the probable cause of the incident was the catastrophic failure of a large pressure vessel that served as a pulp digester. The digester failed from extensive caustic stress corrosion cracking along weld seams in the vessel's carbon steel shell. The facility's mechanical integrity program lacked effective inspection and weld repair practices, contributing to the incident.

2. Tyson Foods

July 19, 2020

Enid, Oklahoma

Incident Summary

On July 19, 2020, at approximately 9:00 a.m., toxic anhydrous ammonia was released at the Tyson Foods 54th Street Facility ("Tyson Foods") in Enid, Oklahoma (**Figure 1**), seriously injuring a Tyson Foods employee. The Advance Food Company, LLC, which is a subsidiary of Tyson Foods, owned and operated this Tyson Foods facility.

Figure 1. Tyson Foods facility in Enid, Oklahoma. (Credit: Google Earth)

The Tyson Foods employee, a refrigeration technician, was troubleshooting a high-temperature condition in an ammonia refrigeration system. The technician went to the roof of the building to inspect a cooler's ammonia strainer. After draining ammonia from the system and isolating the strainer assembly, the technician started loosening bolts at the top of the strainer assembly to remove any residual pressure (**Figure 2**). Pressurized ammonia sprayed through the loosened bolts toward the technician's face, impacting the technician. The technician was transported and admitted to a hospital for treatment. Tyson Foods estimated that approximately one pound of anhydrous ammonia was released.

Tyson Foods' investigation found that its procedure for opening ammonia equipment required depressurizing the strainer by connecting a hose to the strainer's drain valve (**Figure 2**) and directing residual ammonia into a water drum to absorb the ammonia. On this occasion, the technician did not connect a hose to the strainer because the drain valve's plug was damaged, and the technician could not remove it. Tyson Foods' investigation concluded that had the strainer plug been in good condition, the technician could have used the drain valve to direct the residual ammonia into water, which should have prevented the incident.

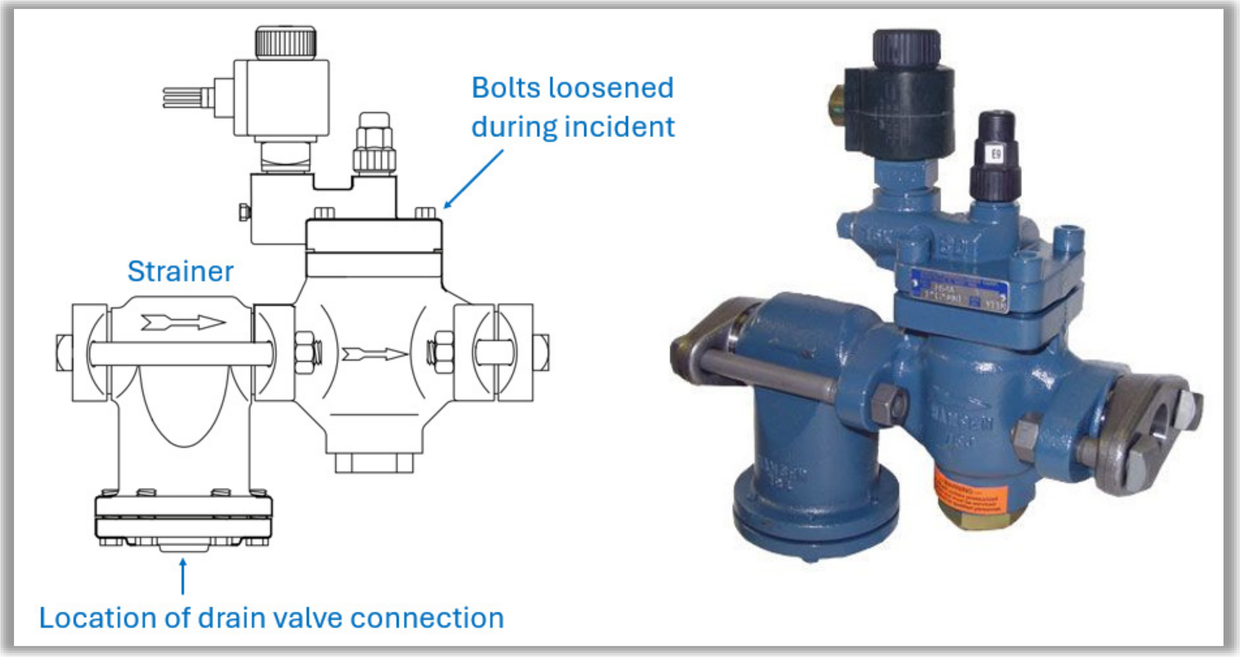

Figure 2. Schematic of strainer assembly. (Credit: Hansen Technologies Corporation and Keep Supply, modified by CSB)

Tyson Foods' investigation also identified that its ammonia equipment opening procedure required the technician to wear respiratory protection and obtain a work permit before opening the strainer. However, the technician did not wear respiratory protection, and the company's investigation revealed that neither a supervisor nor a designee was available to authorize an ammonia equipment opening work permit on the day of the incident.

Probable Cause

Based on Tyson Foods' investigation, the CSB determined that the probable cause of the incident was opening equipment while it was pressurized with anhydrous ammonia. The damaged condition of the strainer's drain valve plug prevented the technician from depressurizing the equipment through the drain valve and into a water drum, contributing to the incident. Not wearing respiratory protection during the equipment opening work contributed to the severity of the incident.

3. Chevron

August 18, 2020

Pasadena, Texas

Incident Summary

On August 18, 2020, at 5:54 a.m., a 3.4-million-gallon storage tank was overpressured and caught fire at the Chevron refinery in Pasadena, Texas (**Figure 1**). The incident caused an estimated $3.3 million in property damage.

Figure 1. The damaged storage tank at the Chevron refinery. (Credit: KHOU 11)

The storage tank was designed to hold vacuum residuum, the heaviest crude oil fraction from the bottom of the refinery's vacuum distillation column. On the morning of the incident, high-pressure conditions developed inside the tank, tearing the top of the tank open along its frangible roof seam. A frangible roof seam is an intentionally weaker roof-to-shell weld that will preferentially tear open to relieve pressure before other welded joints when the tank is overpressurized. As the hot hydrocarbon escaped from the open roof, a fire erupted. Emergency responders extinguished the fire in approximately 36 minutes.

Chevron's investigation revealed that on August 17, 2020, the day before the incident, the refinery's tank farm lost power due to a lightning strike and a failure of the backup power generator during a storm. This power failure stopped the regular supply of crude oil, leading to an emergency shutdown of the crude unit. During this shutdown, light crude oil flowed into the storage tank.

Chevron's investigation found that after power was restored and the crude unit was restarted on the morning of the incident, a flow restriction in the vacuum tower bottoms coolers resulted in hotter material being directed into the storage tank. The combination of this hotter and lighter hydrocarbon material inside the storage tank created high-pressure conditions that overwhelmed the tank's atmospheric vents, causing the top of the tank to tear open along the seam of the frangible roof. The fire was likely ignited by a spark produced by metal-to-metal contact when the roof seam opened.

Chevron's investigation determined that the storage tank's atmospheric vents were sized correctly for all filling and draining scenarios. However, the storage tank was not designed to contain light hydrocarbons at elevated temperatures, so additional safeguards were necessary to prevent these materials from being added. The company's investigation recommended conducting a hazard analysis to identify and implement safety measures to keep light hydrocarbons out of this storage tank.

Probable Cause

Based on Chevron's investigation, the CSB determined that the probable cause of the incident was combining hot heavy hydrocarbons (vacuum residuum) with lighter hydrocarbons (crude oil) in a tank designed to store heavy hydrocarbon liquids. The heating of the lighter hydrocarbon material generated vapor that pressurized the storage tank and ultimately ripped its frangible roof open. The flammable hydrocarbons were likely ignited by a spark created by metal-to-metal contact when the roof separated at its seam, resulting in the fire. The lack of sufficient safeguards to prevent sending materials into a storage tank not designed to contain them contributed to the incident.

4. PBF Energy

September 10, 2020

Delaware City, Delaware

Incident Summary

On September 10, 2020, at approximately 8:15 a.m., a large fire erupted at the PBF Holding Company LLC ("PBF Energy") refinery in Delaware City, Delaware. The Delaware City Refining Company LLC operates the refinery (**Figure 1**). PBF Energy estimated that the fire caused $1.7 million in property damage.

Figure 1. The PBF Energy refinery in Delaware City, Delaware. (Credit: Google Maps)

On the night of the incident, PBF Energy operators were preparing to start up a unit that had been down for maintenance. During this outage, equipment was opened and needed to be purged with nitrogen to displace the oxygen before restarting. Six valves were opened to allow the nitrogen and displaced oxygen to be discharged into the atmosphere. A board operator was then asked to open a specific control valve to begin the nitrogen flow through the piping, valves, and other equipment. Less than five minutes later, a fire erupted in the unit, fueled by hydrocarbons being released into the atmosphere from the six open valves. The fire lasted approximately five minutes until the open control valve was damaged and its spring-loaded actuator closed the valve (failed closed). PBF Energy estimated that 5,300 pounds of flammable hydrocarbons were released.

PBF Energy's investigation concluded that the flammable hydrocarbons were ignited by a fired heater located approximately 100 feet downwind from one of the six release points. The opened control valve was not needed to displace oxygen from the system, and its manual isolation valve should have been closed. Instead of supplying nitrogen to the piping, a stream of flammable hydrocarbons, primarily butane, flowed into the system when the control valve was opened. In addition, the company's investigation also found that the startup procedure did not specify the steps needed for oxygen-freeing this equipment.

Probable Cause

Based on PBF Energy's investigation, the CSB determined that the probable cause of the incident was an inadvertent valve alignment that directed flammable hydrocarbons into piping and equipment with six valves open to the atmosphere to displace the oxygen from this system. A nearby furnace ignited the flammable hydrocarbons, resulting in the fire. Additionally, the unit startup procedure did not include the proper steps to remove the oxygen from this system, contributing to the incident.

5. Silver Eagle

September 19, 2020

Evanston, Wyoming

Incident Summary

On September 19, 2020, at approximately 10:20 a.m., flammable hydrocarbon vapor was released while loading a tanker truck ("truck") at the Silver Eagle refinery near Evanston, Wyoming. The flammable vapor ignited, resulting in an explosion and fire that seriously injured two truck drivers and caused approximately $5.8 million in property damage (**Figure 1**).

Figure 1. Post-incident image of the truck and the loading rack at the Silver Eagle refinery. (Credit: Silver Eagle, modified by CSB)

On the day of the incident, a truck delivered a load of naphtha to the refinery. After unloading the naphtha, the truck was moved into a building at the refinery to be loaded with diesel fuel. The building was a metal structure with corrugated metal walls on the sides and roll-up doors at the ends to allow trucks to enter and exit. The truck had three liquid storage compartments with a total capacity of 9,500 gallons (**Figure 2**).

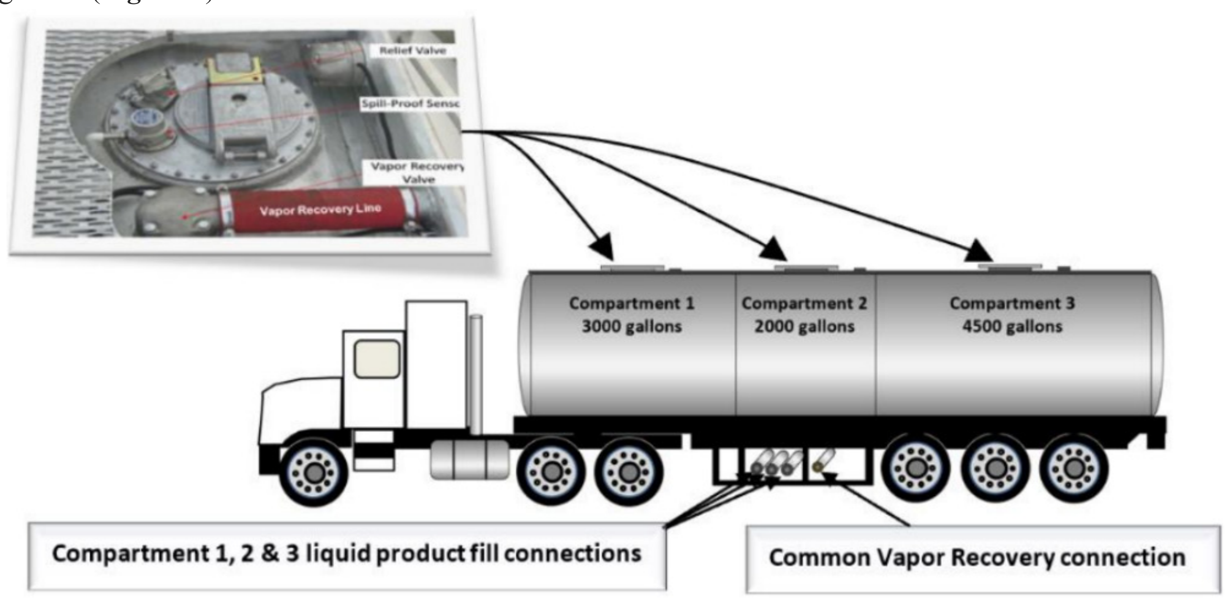

Figure 2. The truck's compartments and hose connections. (Credit: Silver Eagle)

The driver connected the hoses for the liquid fill and vapor recovery connections and loaded 2,900 gallons of diesel into Compartment 1 of the truck. During loading, the truck's engine was off, and the truck's compressed air system was used to open the vapor recovery valve to direct flammable vapor from the compartment being loaded to Silver Eagle's flare. The driver then switched the liquid fill hose to fill Compartment 2 with diesel. While Compartment 2 was filling, there was an explosion in the building. The truck driver and a second truck driver, who was loading a truck with gasoline, were both knocked down by the explosion's pressure wave and injured from the heat of the flames produced. Both truck drivers were able to escape from the building. They were transported by ambulance to a local hospital and then by helicopter to a burn center, where they were admitted for treatment.

Silver Eagle's investigation determined that high-pressure conditions developed while loading Compartment 2 with liquid diesel fuel because the air-operated vapor recovery valve to the flare was closed. With no open path for the displaced vapor to flow to the flare system, the pressure inside Compartment 2 increased and ultimately activated the truck's emergency pressure-relief system (set at 3 pounds per square inch), which directed the flammable vapor above the truck but within the enclosed building, forming a vapor cloud. The flammable vapor then ignited, triggering the explosion and fire.

Silver Eagle's investigation concluded that the most likely explanation for the closed vapor recovery valve to the flare system was that the truck's compressed air system pressure was too low to either open the valve or to keep the valve in the open position. The low pressure within the compressed air system likely occurred because of a combination of contributing factors, including the duration of the loading operation being extended because high wind speeds (about 28 miles per hour) had repeatedly extinguished the flame on the flare, which automatically stopped loading operations until the flare pilot was lit, and the flame was reestablished. Leaks from the compressed air system also lowered the pressure over time, and the truck's air compressor was shut off as a requirement to conduct the loading operation.

In addition, Silver Eagle's investigation also evaluated several potential ignition sources, concluding that the building's overhead lighting or the electrical wiring for these lights was the most likely ignition source. The company's investigation also identified that the building's electrical classification was based on an outdoor hazardous area (well-ventilated) classification rather than on indoor requirements.

Probable Cause

Based on Silver Eagle's investigation, the CSB determined that the incident was caused by high-pressure conditions that developed in Compartment 2 during loading, due to the air-operated vapor recovery valve being closed because the truck's compressed air system lacked sufficient pressure to keep the valve open. Ultimately, the increasing pressure activated the truck's pressure relief device, which discharged excess vapor from Compartment 2 into the air above the truck, but inside the building. The released flammable hydrocarbon formed a vapor cloud that was most likely ignited by an overhead light or its electrical wiring, triggering the explosion.

6. Tyson Foods

November 20, 2020

Hutchinson, Kansas

Incident Summary

On November 20, 2020, at approximately 8:30 a.m., approximately 29 pounds of toxic anhydrous ammonia vapor were released inside the Tyson Prepared Foods, Inc. ("Tyson Foods") facility in Hutchinson, Kansas (**Figure 1**). Exposure to the toxic ammonia seriously injured two employees.

Figure 1. The Tyson Foods facility in Hutchinson, Kansas. (Credit: Google Maps)

At the time of the incident, two Tyson Foods employees disassembled an out-of-service heat exchanger used in the facility's ammonia refrigeration system. Both workers wore full-face air-purifying respirators when performing the task. As the employees loosened bolts from the heat exchanger, gaseous ammonia was released from the system, spraying both employees and engulfing the room. The injured employees were transported to a hospital and admitted for medical treatment.

OSHA's investigation found that the two employees suffered inhalation injuries when their respirator cartridges became saturated, preventing the cartridges from effectively purifying the air they breathed.

Tyson Foods' investigation found that downstream valves had not been closed before the employees disassembled the heat exchanger. In addition, a check valve likely failed, allowing ammonia to backflow into the heat exchanger. The investigation also found that Tyson Foods did not complete an equipment opening permit, and the system had not been depressurized before the work began. The only indicator of the system's contents was a pressure gauge on the roof, which the company did not review before starting the disassembly work inside the facility.

Probable Cause

Based on the investigations by OSHA and Tyson Foods, the CSB determined that the probable cause of the incident was the opening of a heat exchanger that contained anhydrous ammonia. Not isolating and depressurizing the equipment before disassembly contributed to the incident. The use of air-purifying respirators that were overwhelmed by the ammonia release contributed to the severity of the incident.

7. FutureFuel

May 5, 2021

Batesville, Arkansas

Incident Summary

On May 5, 2021, at 7:22 a.m., approximately 73,300 pounds of oleum (fuming sulfuric acid) were released at the FutureFuel Chemical Company ("FutureFuel") facility (**Figure 1**) in Batesville, Arkansas. Exposure to the corrosive liquid oleum seriously injured one FutureFuel operator.

Figure 1. FutureFuel facility in Batesville, Arkansas. (Credit: FutureFuel)

At the time of the incident, an operator was transferring oleum from a railroad tank car to a production building vessel connected by a flexible polymer hose to permanent metal piping. The operator was on an unloading platform above the tank car and was wearing a hard hat, safety glasses, fire-resistant clothing, steel-toed boots, and gloves.

The operator opened a valve to begin the transfer. Immediately after opening the valve, the flexible hose ruptured (**Figure 2**), spraying the operator and the surroundings with liquid oleum. The operator's personal protective equipment (PPE) did not protect him from being sprayed with corrosive oleum. For example, the fire-resistant clothing fibers absorbed the acid, allowing it to contact his skin. The release blocked the operator's path to the tank car's ladder. The operator jumped from the tank car to the ground and ran to a nearby building, where emergency responders initially treated him. The operator was then transported by helicopter to a regional burn center, where he was admitted for treatment of chemical burns. There was no remotely operated isolation valve capable of stopping the release, and the oleum continued to release from the hose for 73 minutes. At 8:35 a.m., FutureFuel emergency responders manually closed the valve, stopping the release.

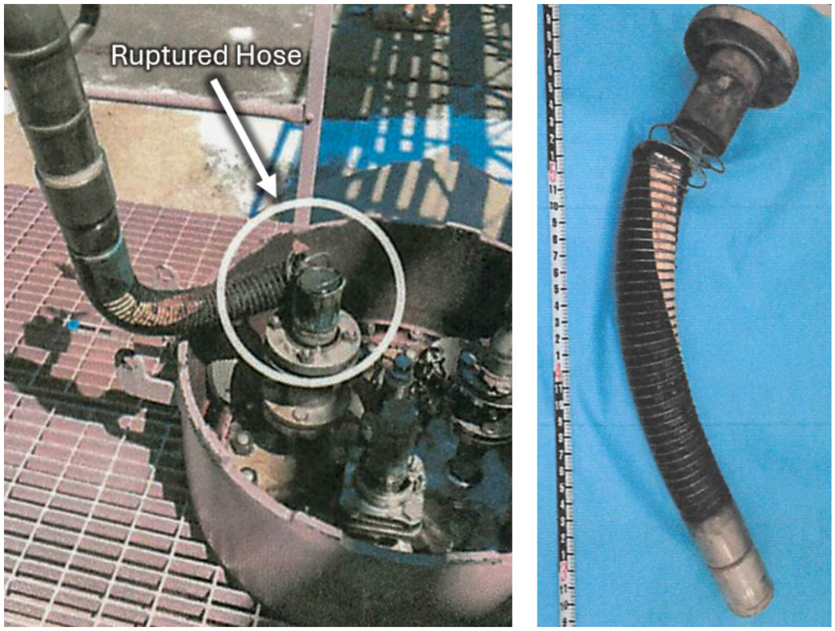

Figure 2. Ruptured Hose. (Credit: FutureFuel)

FutureFuel's investigation found that appropriate PPE to protect workers from a catastrophic hose failure was required during hose installation and testing. However, the procedure for transferring oleum did not require more protective PPE because a hose rupture was not identified as a potential hazard. FutureFuel's investigation concluded that the severity of the operator's injuries could have been lessened if the company's hazard analyses had identified hose rupture as a credible scenario and controls had been implemented to protect from this hazard.

FutureFuel's investigation revealed that the company purchased a pair of hoses for this application in July 2014. The first of these hoses was installed in 2017 and used for oleum transfers until April 28, 2021. Six days before the incident, a stain was discovered at the threaded hose fitting, prompting FutureFuel to install the second hose it had purchased in 2014. This second hose was being used to transfer oleum for the fourth time when the incident occurred.

FutureFuel's investigation determined that the failure of the incident hose occurred at the connection to the flange fitting because the hose's chemically protective inner fluoropolymer layer was damaged. This damage may have occurred due to creep during nearly seven years of storage or from a manufacturing defect, such as during the fitting's attachment. As a result, the compromised fluoropolymer layer allowed oleum to contact and degrade the structural layers of the hose, ultimately leading to its failure. Following the incident, FutureFuel eliminated the flexible hose connection and added a remotely operated isolation valve.

Probable Cause

Based on FutureFuel's investigation, the CSB determined that the probable cause of the accidental release was the catastrophic failure of a flexible polymer hose during the oleum transfer operation. Damage to the hose's chemically protective layer allowed oleum to come into contact with and degrade its structural layers, leading to the hose's failure. Not wearing PPE that could protect the operator from corrosive oleum exposure and the lack of a remotely operated isolation valve contributed to the severity of the incident.

8. PBF Energy

November 23, 2021

Oregon, Ohio

Incident Summary

On November 23, 2021, an explosion and fire occurred at the PBF Holding Company LLC ("PBF Energy") refinery in Oregon, Ohio (**Figure 1**), which is operated by the Toledo Refining Company LLC. The explosion and fire caused an estimated $50.3 million in property damage.

Figure 1. The PBF Energy refinery in Oregon, Ohio. (Credit: This Metal Sky)

Five days before the incident, PBF Energy found a small leak of flammable liquefied petroleum gas ("LPG") on a section of 1.5-inch drain piping ("drain piping"). Unable to isolate the leaking section during operation, PBF Energy authorized a management of change (MOC) and hired a contractor to design and install a leak repair clamp ("clamp") (**Figure 2**). On November 23, 2021 (the day of the incident), the clamp was leaking, and while workers added sealant, the drain piping catastrophically failed at approximately 11:03 a.m., releasing LPG into the air. The LPG formed a vapor cloud that ignited, resulting in an explosion and a fire. Refinery workers shut down the unit, while site and local emergency responders tackled the fire. PBF Energy reported that 36,000 pounds of LPG were released.

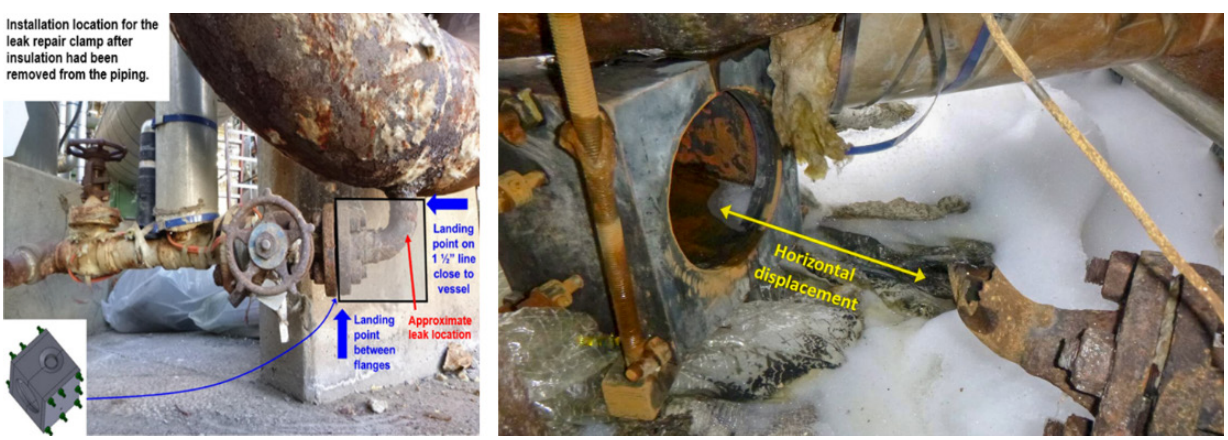

Figure 2. Pre-incident (left) and post-incident (right) images of the drain piping and clamp. (Credit: PBF Energy)

PBF Energy's investigation found that during the installation of the leak repair clamp, a grinder was used to reduce the size of the clamp's horizontal support to enable the clamp to fit. Because this modification effectively removed the clamp's horizontal support, the contractor informed PBF Energy that they planned to design and install a different type of support later. The investigation also revealed that when the clamp continued to leak, the contractor had likely applied too much sealant pressure within the clamp. PBF Energy's investigation concluded that high sealant pressure during the injection without adequate horizontal clamp support stretched and broke the drain piping.

PBF Energy's investigation determined that the drain piping was installed in 1967 and was considered an essential deadleg—necessary piping that does not usually have flow through it. In 2011, the drain piping still had over 80 percent of its original wall thickness. However, an inspection on November 11, 2021, revealed that the drain piping was severely corroded (**Figure 3**).

Figure 3. Pre-incident x-ray (left) and photo (right) of the drain piping. (Credit: PBF Energy)

PBF Energy's investigation identified internal and external damage mechanisms that could account for the accelerated corrosion since the 2011 inspection. The internal damage mechanism was corrosion caused by residual water, hydrochloric acid, and dissolved salts. Water from online water washes to upstream equipment could have settled in the drain piping, contributing to internal corrosion. The wash procedure did not include flushing low points, such as the drain piping. Corrosion under insulation (CUI) was identified as the external damage mechanism. During the 2021 inspection, temporary insulation was found covering the drain piping. PBF Energy's investigation determined that this insulation was likely added as part of the refinery's seasonal winterization program, which involved insulating deadleg piping. However, no process was in place to ensure that this insulation was removed after winter.

Probable Cause

Based on PBF Energy's investigation, the CSB determined that the probable cause of the incident was the release of flammable liquefied petroleum gas during a temporary leak repair. A section of highly corroded piping broke while sealant was being injected into a leak repair clamp. The addition of insulation for winterization, combined with more frequent water washing of upstream equipment without flushing the low point drains, likely accelerated the corrosion and contributed to the incident.

9. ExxonMobil

December 23, 2021

Baytown, Texas

Incident Summary

On December 23, 2021, at approximately 12:51 a.m., an explosion occurred at the ExxonMobil refinery in Baytown, Texas, when piping catastrophically ruptured, releasing hot flammable naphtha vapor that ignited (autoignition), creating a large fire within a hydrodesulfurization unit at the refinery (**Figure 1**). The incident seriously injured four contractors and caused approximately $107 million in property damage.

Figure 1. Fire and flaring at the ExxonMobil refinery. (Credit: Michael Ryleigh Felts)

Figure 2. Fire on December 21, 2021 (left) and steam lances being used to keep the released naphtha from catching on fire (right). (Credit: ExxonMobil)

ExxonMobil's investigation found that on December 21, 2021, two days before the incident, there was a fire at a 14-inch flange in a hydrodesulfurization unit at the refinery (**Figure 2**). The flange was on a piping elbow that was part of a reactor system. ExxonMobil personnel extinguished the fire using steam lances and continued applying steam to prevent the hydrocarbon vapor from igniting. The next day, refinery personnel examined the piping and concluded there was a leak on the 14-inch flange. At this location, the process temperature is more than 600 degrees Fahrenheit, far above the autoignition temperature of the flammable hydrocarbons. ExxonMobil developed an emergency repair plan to stop the hydrocarbon release that involved installing a "wire wrap" on the flange and replacing the flange bolts with injectable bolts.

On the night of December 22, 2021, ExxonMobil issued a work permit authorizing a team of contract workers to replace each 14-inch flange bolt, one at a time (hot bolting), while the unit was operating. The permit identified acceptable tools for the work, including hand tools, pneumatic tools, and a hydraulic wrench. After several failed attempts to loosen a bolt on the 14-inch flange using hand tools, pneumatic tools, and even hydraulic wrenches of different power capacities, the contractors decided to try to loosen a bolt on the opposite side of the 14-inch flange from where the first bolt removal was attempted. On December 23, 2021, at approximately 12:51 a.m., workers used a hydraulic wrench to loosen the opposite-side bolt. An explosion occurred when piping sections above (a 14-inch elbow) and below (24-inch piping) the 14-inch flange catastrophically ruptured, releasing hot hydrocarbon vapor that caught fire. The release and fire seriously injured four contract workers. All four workers were transported (three by helicopter) to hospitals and admitted for treatment. ExxonMobil reported that 41,000 pounds of hydrocarbon were released.

ExxonMobil's investigation found that the failed piping components were likely installed in 1962. The company's post-incident examination and testing identified that the failed 14-inch elbow experienced extreme wall thinning from sulfidation corrosion. The wall thickness in the failure area was as low as 0.028 inches. ExxonMobil's investigation concluded that the 14-inch elbow ruptured when the contractors used the hydraulic wrench in a way that allowed the tool to apply force to the elbow's thin wall. The silicon concentration of the 14-inch elbow was above 0.2 weight percent.

The CSB found that ExxonMobil's investigation did not document a causal analysis or similar evaluation to understand the underlying cause(s) of the thin piping components or the initial naphtha release and fire at the 14-inch flange. In addition, the ruptured 24-inch piping had also experienced significant corrosion with a wall thickness as low as .043 inches. The CSB's investigation found that the silicon concentration of this 24-inch piping was at or below 0.03 weight percent. A silicon concentration below 0.10 weight percent means that the 24-inch piping was a low-silicon piping component, which the refining industry knows to be susceptible to higher corrosion rates than adjacent piping components. For example, the CSB's investigation of the hydrocarbon release and massive fire at the Chevron refinery in Richmond, California, on August 6, 2012, examined the insidious danger of low-silicon piping components in refineries. To prevent a catastrophic rupture of low-silicon carbon steel piping, the CSB recommended that the refining industry perform a 100 percent component inspection to identify and replace any low-silicon piping components because they are susceptible to accelerated sulfidation corrosion.

Probable Cause

Based on ExxonMobil's investigation, the CSB determined that the probable cause of the incident was the release of hot naphtha vapor while attempting an emergency leak repair. A hydraulic torque wrench applied external force to a severely corroded piping component, initiating the rupture. The hot naphtha ignited (autoignition), resulting in the fire. The lack of an inspection that could have identified the dangerously thinned piping components contributed to the incident. ExxonMobil could have prevented this incident by inspecting the piping components to identify the accelerated sulfidation corrosion and by replacing these severely corroded components long before the emergency flange repair work was attempted.

10. Pilgrim's

January 19, 2022

Canton, Georgia

Incident Summary

On January 19, 2022, at 7:55 p.m., a release of approximately 4,500 pounds of toxic anhydrous ammonia seriously injured two employees at the Pilgrim's Pride Canton Poultry Processing Facility ("Pilgrim's") in Canton, Georgia (**Figure 1**).

Figure 1. Emergency response to the ammonia release. (Credit: Cherokee County Fire and Emergency Services)

On the night of the incident, Pilgrim's was restarting an ammonia refrigeration compressor, which had been shut down during routine sanitation work at the facility. During the restart, high-pressure conditions developed in the ammonia refrigeration system, which opened a pressure-relief valve and discharged toxic ammonia into the ambient air outside the facility's compressor building. A cloud of toxic ammonia formed and hovered outside the building. When the 34 employees and contract workers inside the facility evacuated, several were injured from inhaling toxic ammonia. The refrigeration system was shut down, and the release was stopped after 36 minutes. Emergency responders evaluated the injured workers and transported three to the hospital. One employee was treated and released at the hospital, and the other two employees were admitted for treatment.

Pilgrim's investigation found that the high ammonia pressure in the refrigeration system was caused by a compressor slide valve that failed, fully loading the compressor while the condenser fans were off. The compressor's high-pressure alarm and automatic shutoff did not work because their pressure settings exceeded the pressure-relief valve's activation pressure. Pilgrim's investigation revealed that the settings for these safety devices were not set correctly when the compressor was installed several months before the incident.

Pilgrim's investigation also determined that the ammonia discharged into the air contained a mixture of vapor and liquid. The pressure-relief system's discharge piping did not discharge the liquid ammonia to a safe location (**Figure 2**). To prevent a similar release of liquid ammonia into the air in the future, Pilgrim's redesigned the pressure-relief device so that it now discharges inside a pressure vessel containing ammonia. The relief system's atmospheric vent piping was located above a working platform near two compressor room exit doors. After the incident, Pilgrim's redesigned the relief system piping to discharge ammonia vapor at a higher location, further away from the compressor room's exit doors.

Figure 2. Discharge location (blue oval) from relief system piping. (Credit: Pilgrim's)

Probable Cause

Based on Pilgrim's investigation, the CSB determined that the probable cause of the toxic ammonia release was the activation of an emergency pressure-relief valve from high-pressure conditions that developed during the startup of an ammonia compressor. The compressor's internal slide valve was stuck open, and the condenser fans were off, causing high-pressure conditions in the ammonia refrigeration system. Incorrect settings for the compressor's high-pressure alarm and automatic shutdown contributed to the incident. The design of the pressure-relief system, which discharged ammonia in a way that harmed workers evacuating from the facility, contributed to the severity of the incident. Had Pilgrim's ensured that its pressure-relief system discharged to a safe location, workers could have evacuated from the facility without being harmed.

11. WR Meadows

January 21, 2022

Hampshire, Illinois

Incident Summary

On January 21, 2022, at 10:45 a.m., an explosion occurred within a building at the WR Meadows facility in Hampshire, Illinois (**Figure 1**). The explosion fatally injured one employee, seriously injured one employee, and resulted in $3.5 million in property damage.

Figure 1. Emergency response to the explosion at WR Meadows. (Credit: Fox 32)

At the time of the incident, WR Meadows was producing a flammable concrete curing compound by combining a powdered acrylic resin with a flammable solvent solution in a mixing tank ("tank"). Acetone was the most flammable component in the company's proprietary solvent blend. The mixing tank was open to the atmosphere inside the enclosed room where the company processed flammable liquids. The powder was transferred into the tank through a hole in the tank's top, using a screw conveyor to fill a down chute, which permitted some acrylic resin to accumulate on the top of the tank's outer surface.

Two WR Meadows employees were tasked with cleaning the acrylic resin dust from the top of the tank. An electric vacuum cleaner was used during the cleaning process. The room containing the tank was electrically classified as a potentially hazardous area and consequently had no power outlets. Extension cords connected the vacuum to an electrical outlet outside the room.

During this cleaning activity, the vapor in the tank ignited and exploded. The explosion damaged the tank and blew out the room's sacrificial wall, which was designed to vent the pressure from an explosion (**Figure 2**). The worker vacuuming the dust was fatally injured by the explosion. The other employee sustained chemical and thermal burns and was transferred and admitted to a hospital for treatment.

Figure 2. Damage from the explosion. (Credit: WR Meadows)

The WR Meadows investigation found that the hose attached to the vacuum cleaner was not electrically bonded or grounded and could accumulate static electricity. The company's investigation concluded that the process of vacuuming likely generated a static spark near the tank's opening and ignited the flammable acetone vapors inside the tank, resulting in the explosion.

Probable Cause

Based on WR Meadows' investigation, the CSB determined that the probable cause of the explosion was the use of a vacuum cleaner to collect spilled acrylic resin powder on top of the mixing tank, which contained an explosive concentration of air and flammable acetone vapor. The ignition source was likely static discharge from an ungrounded, unbonded hose connected to the electric vacuum cleaner. The incident could have been prevented by applying engineering controls to prevent the tank from containing an explosive concentration of air and flammable acetone.

12. Westlake

January 26, 2022

Westlake, Louisiana

Incident Summary

On January 26, 2022, at about 10:45 a.m., a one-million-gallon storage tank exploded, creating a fire at the Westlake US 2 LLC ("Westlake") facility in Westlake, Louisiana (**Figure 1**). Westlake estimated that the incident resulted in $9.2 million in property damage.

Figure 1. Smoke from the explosion that occurred at Westlake. (Credit: KATC 3 (left), KPLC 7 (right))

Westlake stored ethylene dichloride in a one-million-gallon storage tank ("tank"). On January 25, 2022, the day before the incident, Westlake took the tank out of service to patch several holes in its roof. The tank contained residual ethylene dichloride after the bulk of the flammable liquid had been drained from the tank. Westlake operators closed and locked valves to isolate the tank's various piping connections. Contract inspectors evaluated the tank's roof. This inspection revealed that the tank's nitrogen inerting system was heavily corroded, and holes in the fittings associated with the nitrogen pressure regulator were found. As a result, Westlake had its operators issue a work permit to contract workers to remove the tank's nitrogen pressure regulator and piping.

During the removal work, the contract workers used a battery-powered reciprocating saw to cut bolts connecting the nitrogen pressure regulator to its supply piping. One worker saw a small flame at one of the holes in the tank's roof. In response, all the workers evacuated from the tank and went to a nearby maintenance shop, where they called the control room and notified the operators. About three minutes later, at approximately 10:45 a.m., the tank exploded, fully separating from its base (**Figure 2**). About 3,000 pounds of residual ethylene dichloride were burned in the subsequent fire.

Figure 2. The tank after the explosion. (Credit: Westlake)

Westlake's investigation determined that the flammable atmosphere inside the tank was caused by a piping alignment that allowed both ethylene and oxygen gas to flow into the tank from a connected process unit for about two weeks before the tank's valves were closed to patch the holes in its roof on January 25, 2022. The flammable vapor flowing out of the holes in the tank's roof was ignited by sparks created by the battery-powered reciprocating saw. After three minutes of burning on the roof's surface, the flame was drawn into the tank, which triggered the explosion. Westlake's investigation also found that the work permit the operators issued to the contractors to remove the nitrogen pressure regulator and piping did not authorize the use of tools that produce sparks.

Probable Cause

Based on Westlake's investigation, the CSB determined that the probable cause of the incident was a flammable atmosphere created inside the tank from a piping alignment that allowed ethylene and oxygen vapor to flow from an interconnected process unit into the tank. The flammable vapor was ignited from a spark created by using a battery-powered reciprocating saw to cut corroded bolts during a maintenance activity.

13. Eastman

January 31, 2022

Kingsport, Tennessee

Incident Summary

On January 31, 2022, at about 7:26 a.m., approximately 80,000 pounds of steam were released at the Eastman Chemical Company ("Eastman") facility in Kingsport, Tennessee (**Figure 1**). The company estimated the property damage to be $25 million.

Figure 1. Steam Release at Eastman. (Credit: WJHL)

On the day of the incident, an elbow in a section of carbon steel piping that contained steam at 600 psig and 750°F ruptured. The elbow was forcefully ejected, releasing steam from both ends of the pipe. The incident caused extensive damage to the surrounding equipment (**Figure 2**). The area of the facility where the incident occurred was shut down from the loss of steam, and other areas were impacted by the loss of other utility systems, including electrical power, river water, plant air, and instrument air. Additionally, because the steam piping was insulated with asbestos, asbestos fibers were released into the neighboring community as a result of the explosion.

Figure 2. Property damage at Eastman. (Credit: Eastman)

Eastman's investigation concluded that the elbow failed due to creep deformation. Creep is a damage mechanism that results from prolonged exposure to stress at elevated temperatures. The failed elbow, an 18-inch ASTM A234 Schedule Standard Grade WPB carbon steel 90-degree bend, was installed in 1968 or 1969, but did not meet the site's 1964 piping specification. The failed elbow had a thickness of 0.375 inches, but it should have had 0.5-inch-thick walls. Eastman estimated that had the proper elbow been installed, the expected life of the elbow should have been about 450 years, compared to the actual lifespan of 53 years with the thinner-walled incident elbow. Eastman's investigation also found that the company was not performing mechanical inspections on the steam piping.

Probable Cause

Based on Eastman's investigation, the CSB determined that the probable cause of the incident was a catastrophic failure of an 18-inch carbon steel piping elbow. The elbow ruptured from creep damage. The installation of a substandard elbow and the lack of a mechanical integrity program to monitor the piping's condition contributed to the incident.

14. Blues City Brewery

February 1, 2022

Memphis, Tennessee

Incident Summary

On February 1, 2022, at approximately 10:10 a.m., a chlorine gas mixture was released at the Blues City Brewery, LLC ("Blues City Brewery") facility in Memphis, Tennessee. Three workers were seriously injured from exposure to the toxic vapor (**Figure 1**).

Figure 1. Emergency response at Blues City Brewery. (Credit: WREG Memphis)

On the day of the incident, an operator was assigned to refill a tank containing a mixture of sodium hypochlorite, sodium hydroxide, and sodium chloride ("bleach solution") used as a sanitizer at the facility (**Figure 2**). A mixture of nitric acid and phosphoric acid ("acid solution") and the bleach solution were stored in separate 330-gallon totes in the same area as totes containing the other substances (**Figure 2**). The trade names of the materials on the totes differed only by one letter (Dibac versus Dilac). The operator inadvertently transferred acid instead of bleach solution into the bleach solution tank, causing a chemical reaction that generated a vapor cloud containing chlorine gas. Emergency responders transported 10 Blues City Brewery employees to the hospital. At the hospital, seven of the employees were evaluated and released, while three of the employees were admitted for medical treatment.

Figure 2. Photos showing the bleach solution tank (blue circle - left), a bleach solution tote (middle), and an acid solution tote (right). (Credit: Blues City Brewery, modified by the CSB)

Blues City Brewery's investigation determined that the employee who typically performs these operations was not available, and the operator who performed the chemical transfer was not trained on the difference between the bleach and acid materials or on how to perform this task. Furthermore, the written procedure did not include a step for verifying that the correct chemical was selected before connecting the tote to the chemical transfer equipment. As a result, incompatible chemicals were inadvertently mixed.

Probable Cause

Based on Blues City Brewery's investigation, the CSB determined that the probable cause of the incident was mixing two incompatible solutions, bleach and acid. Similar chemical trade names and assigning an untrained worker to fill the bleach solution tank contributed to the incident.

15. Dyno Nobel

February 17, 2022

Waggaman, Louisiana

Incident Summary

On February 17, 2022, at 4:25 a.m., a fire occurred at the Dyno Nobel ammonia production facility in Waggaman, Louisiana (**Figure 1**). Dyno Nobel estimated that this event caused $128 million in property damage.

Figure 1. Dyno Nobel facility in Waggaman, Louisiana (Credit: Hydrocarbon Processing)

On the day of the incident, Dyno Nobel was starting the ammonia plant when a section of piping between the secondary reformer and a waste heat boiler ("transition pipe") ruptured. The ruptured transition pipe was a special piping component designed to contain process gas above 600 pounds per square inch at more than 1,600 degrees Fahrenheit. The transition pipe comprised four layers: an inner metal liner, an insulation layer, and an outer metal shell, all surrounded by a metal jacket containing water to maintain a consistent temperature of the shell's outer surface. When the transition pipe ruptured, hot process gas was released into the air and ignited (autoignition), resulting in a jet fire. The intense heat from the jet fire caused the transition piping to expand and rupture further (fish-mouth rupture), culminating in a large fire (**Figure 2**).

Figure 2. Transition pipe rupture (left) led to a large fire (right). (Credit: Dyno Nobel)

Dyno Nobel's investigation included a metallurgical analysis, which concluded that the initial failure resulted from creep damage (which results from prolonged exposure to stress at elevated temperatures) along a circumferential weld in the transition pipe's shell. Dyno Nobel's analysis also concluded that the lack of post-weld heat treatment contributed to the transition pipe's short life. The larger failure of the transition pipe's shell base metal resulted from short-term overheating from the initial jet fire. The company's investigation also concluded that damage to the transition pipe's liner, damage to the insulation layer, and the water jacket operating (at times) with only a partially filled liquid level all contributed to higher shell operating temperatures that led to the creep damage.

Dyno Nobel reported that 4,900 pounds of process gas, comprised of hydrogen, nitrogen, methane, carbon monoxide, and carbon dioxide, were released.

Probable Cause

Based on Dyno Nobel's investigation, the CSB determined that the probable cause of the incident was a crack from creep damage along a circumferential weld in the shell of the transition pipe. This crack allowed hot process gas to escape, which ignited and resulted in a fire. The fire further heated the shell of the transition pipe, causing a fish-mouth rupture due to short-term overheating and increasing the size of the fire. The shell operated at elevated temperatures because of damage to the transition pipe's liner and insulation layer. Additionally, reduced water jacket cooling occurred when the water jacket was operated with a partially filled liquid level, contributing to the incident.

16. ONEOK

July 9, 2022

Medford, Oklahoma

Incident Summary

On July 9, 2022, at approximately 2:13 p.m., approximately 450 barrels of an ethane and propane mixture were released at the ONEOK Hydrocarbon, L.P. ("ONEOK") facility in Medford, Oklahoma. The flammable liquid vaporized, forming a vapor cloud that soon ignited. The explosion damaged equipment, released other materials, and caused fires. The incident caused approximately $930 million in property damage (**Figure 1**).

Figure 1. News images of the fire. (Credit: KOCO)

ONEOK's investigation found that the ethane and propane mixture was released from a ruptured section of 12-inch carbon steel piping. This piping was part of the overhead condenser and reflux drum equipment for a distillation column. The failure occurred at the bottom of the piping, specifically at an elbow where the pipe turned vertically upward toward the reflux drum (**Figure 2**).

Figure 2. A pre-incident photo showing the approximate failure location. (Credit: ONEOK, modified by CSB)

ONEOK's post-incident metallurgical testing revealed that localized internal corrosion had caused thinning at the bottom wall of the carbon steel piping, which ultimately led to its failure under normal operating pressure and temperature. The testing concluded that this internal corrosion resulted from water, carbon dioxide, and hydrogen sulfide—common components found in the hydrocarbons received at the plant. The investigation determined that low fluid velocity allowed water to accumulate and form a secondary liquid layer along the bottom of the piping. In this water layer, carbon dioxide and hydrogen sulfide reacted to create carbonic and sulfuric acids, which then corroded the bottom of the steel piping (**Figure 3**).

Figure 3. Post-incident photos of the ruptured 12-inch piping. The left image shows the outside, and the right image shows the inside of the piping. (Credit: ONEOK)

ONEOK last inspected this section of piping in 2019 and determined that its remaining useful life was over ten years. The corrosion rate in the piping accelerated significantly between 2019 and 2022. The investigation attributed this increased corrosion rate to a rise in the water content of the hydrocarbon feed in 2020 following the introduction of new feed sources. As a result, plant operators had to drain water from filters and other equipment more frequently.

Probable Cause

Based on ONEOK's investigation, the CSB determined that the probable cause of the incident was a rupture in the piping. The pipe's wall had thinned from corrosion of the carbon steel due to an acidic water layer that accumulated along the bottom of the piping. The company's mechanical integrity program did not recognize the increased potential for acidic water to form a secondary layer or accelerate the piping's inspection frequency after an increase in the water content of the hydrocarbon received at the plant, contributing to the incident.

17. AdvanSix

August 24, 2022

Chester, Virginia

Incident Summary

On August 24, 2022, at approximately 11:50 a.m., a release of very hot process water seriously injured an operator at the AdvanSix, Inc. nylon resin manufacturing facility ("AdvanSix") in Chester, Virginia.

On the day of the incident, an AdvanSix operator was changing water filters (**Figure 1**). This was a routine task that the operator had performed more than 75 times in the four months before the incident. The operator installed a new filter bag inside the strainer and secured the lid. When the operator opened the inlet valve to fill the filter with hot process water, the water was released from the lid, spraying the operator. The operator suffered serious thermal burns from skin contact with the very hot liquid and was transported and admitted to a hospital for treatment.

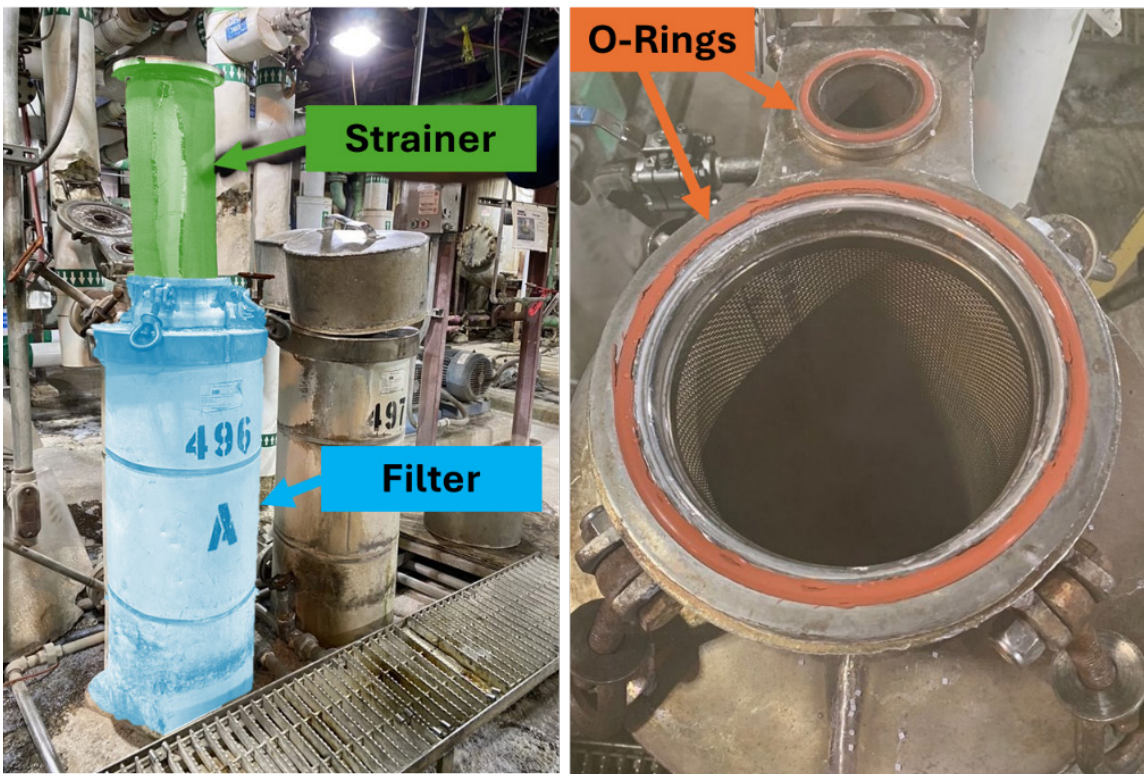

Figure 1. The left image shows a filter housing (blue) and the filter's bag and strainer (green). The right photo shows the O-rings (orange) at the top of the filter's opening. (Credit: Advansix, modified by CSB)

AdvanSix's investigation determined that a damaged O-ring in the filter's lid had prevented the lid from sealing properly. The filter's operating conditions and repetitive compression had fatigued the O-ring. The investigation also found that the site lacked a procedure to install or inspect the filter's O-rings. In addition, AdvanSix identified that a previous incident with a similar burn injury on an adjacent set of filters was not effectively investigated, and the corrective actions implemented from the earlier event did not prevent recurrence.

Probable Cause

Based on AdvanSix's investigation, the CSB determined that the probable cause of the incident was pressurizing a filter with very hot water while a damaged O-ring was installed in the filter's lid. As a result, hot water was released from the lid, spraying the operator and resulting in serious burn injuries. Additionally, the lack of procedures for installing or inspecting the filter's O-rings and an ineffective investigation of a similar previous event contributed to this incident.

18. HF Sinclair

December 24, 2022

Tulsa, Oklahoma

Incident Summary

On December 24, 2022, at 1:29 p.m., approximately 11,500 pounds of kerosene were released from a flow transmitter at the HF Sinclair Tulsa Refining LLC ("HF Sinclair") refinery in Tulsa, Oklahoma (**Figure 1**), which ignited (autoignition), causing a fire at the refinery. The company estimated that the property damage from this incident was approximately $2.9 million.

Figure 1. The HF Sinclair refinery in Tulsa, Oklahoma. (Credit: Tulsa World)

HF Sinclair's investigation found that a ½-inch tubing connection to a flow transmitter had disconnected from its compression joint, causing a release of liquid kerosene at a temperature of 250 degrees Fahrenheit (°F). Approximately 45 minutes later, some flammable kerosene vapor likely contacted a hot surface (650 °F), such as nearby pumps or piping, starting the fire (autoignition). The investigation concluded that the separation of the compression joint was likely caused by insufficient tightening during its installation in 2013 (**Figure 2**).

Figure 2. Post-incident photo of the flow transmitter's tubing connections. The left image shows the tube pulled out of its compression fitting. The right image shows the flow transmitter's other tubing with the compression fitting in place. (Credit: HF Sinclair)

In response to the incident, HF Sinclair revised its maintenance procedures to include an inspection of each compression fitting using the manufacturer's designated tool to help ensure that the installer correctly tightened the connection.

Probable Cause

Based on HF Sinclair's investigation, the CSB determined that the probable cause of the incident was insufficient tightening between a tube and a compression joint connected to a kerosene flow transmitter. HF Sinclair's mechanical integrity program contributed to the incident by not ensuring the fitting was tightened correctly.

19. SABIC

December 26, 2022

Mt. Vernon, Indiana

Incident Summary

On December 26, 2022, at approximately 3:11 a.m., a pump exploded at the SHPP US LLC ("SABIC") facility in Mt. Vernon, Indiana (**Figure 1**). SABIC estimated that the explosion caused $4.6 million in property damage.

Figure 1. The SABIC facility in Mt. Vernon, Indiana. (Credit: SABIC)

The incident occurred in SABIC's ULTEM resin manufacturing plant. On December 22, 2022, four days before the incident, a winter storm caused an unplanned shutdown of the plant. On the morning of the incident, December 26, 2022, the plant was restarting when a nitric acid pump exploded, releasing more than 15,000 pounds of nitric acid inside the processing building. The explosion completely removed the magnetically driven nitric acid pump and motor from its base (**Figure 2**). The inlet and outlet piping were severed, and the pump's casing was fractured.

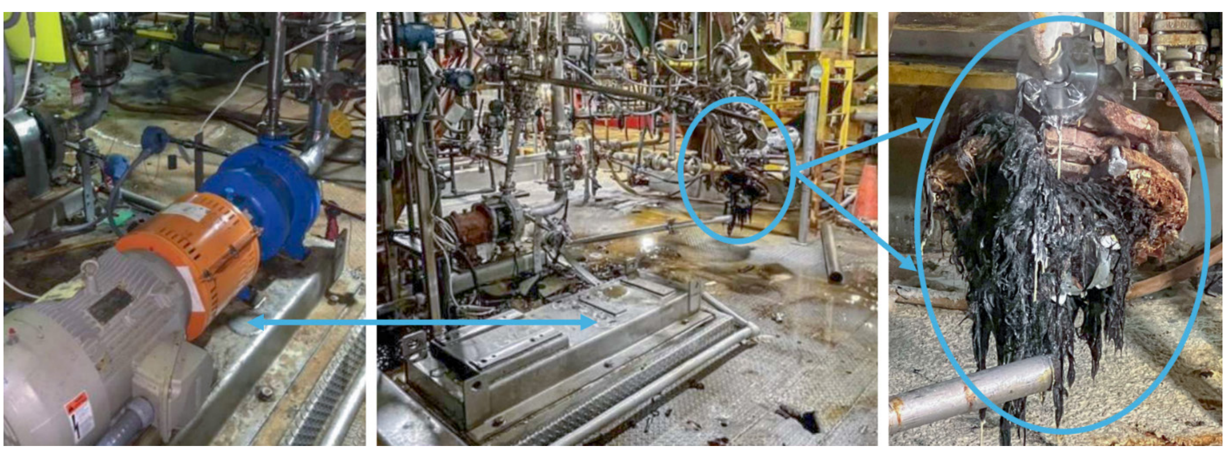

Figure 2. The nitric acid pump before (left photo) and after (middle and right photos) the explosion. (Credit: SABIC)

SABIC's investigation determined that the explosion resulted from a runaway reaction between the nitric acid process solution ("nitric acid"), the pump's lubrication oil, and the pump's ductile cast iron components. The pressure needed to rupture the pump casing was estimated to be approximately 3,750 pounds per square inch (psi). Results from SABIC's post-incident chemical testing of these materials showed temperature and pressure increases from self-heating and gaseous byproduct formation capable of creating the explosion.

The investigation found that the pump's polytetrafluoroethylene (PTFE) lining swelled and softened from prolonged exposure to nitric acid and nitrogen oxides (NO_x). The deterioration of the lining led to friction that ultimately caused it to fail. When the pump's PTFE lining breached during startup, nitric acid mixed with the lubrication oil and contacted the ductile cast iron, resulting in a violent reaction that culminated in the explosion.

SABIC's investigation found that the nitric acid pump that exploded was installed in 2020 and had been operating since January 2021. SABIC identified technology knowledge that recommended limiting the life of PTFE-lined magnetically driven nitric acid pumps to 18 months. However, this knowledge was unknown to the personnel who selected the pump in 2020. In addition, although reactivity testing had been previously completed for nitric acid with many other materials, the reactive combination of nitric acid with lubricating oil and iron was not foreseen.

Probable Cause

Based on SABIC's investigation, the CSB determined that the probable cause of the incident was the failure of the magnetically driven nitric acid pump's PTFE containment liner, allowing nitric acid, lubrication oil, and ductile cast iron to mix, react, and explode. A lack of knowledge (process safety information) about PTFE liner degradation from prolonged exposure to nitric acid and NO_x, and the violent reaction between nitric acid, lubricating oil, and iron contributed to the incident.

20. Hilmar Cheese

March 16, 2023

Dalhart, Texas

Incident Summary

On March 16, 2023, at about 9:00 a.m., toxic anhydrous ammonia was released at the Hilmar Cheese ("Hilmar") facility in Dalhart, Texas, seriously injuring one Hilmar employee.

On the day of the incident, a Hilmar mechanic was tasked with removing a section of chlorinated polyvinyl chloride ("CPVC") piping in the facility's ammonia engine room. The mechanic used a scissor lift and a reciprocating saw (Sawzall) to reach and remove the elevated CPVC piping. While cutting the CPVC piping with the saw, the worker inadvertently cut into a ½-inch pipe that delivered ammonia vapor to a non-condensable purge gas unit directly above the CPVC piping (**Figure 1**). Approximately 22 pounds of ammonia vapor were released. Although the mechanic inhaled some of the ammonia vapor, the worker was able to lower the scissor lift and escape the area. Emergency responders transported the injured worker to a hospital where he was admitted for medical treatment.

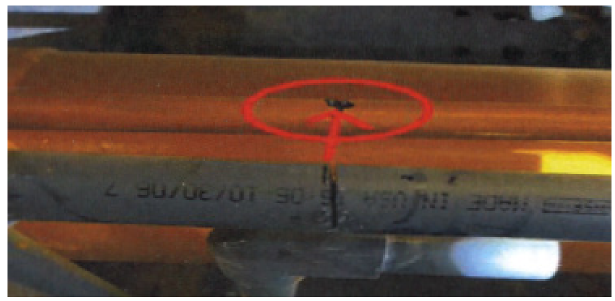

Figure 1. The cuts in the old CPVC pipe and the ½-inch ammonia pipe (Credit: Hilmar)

Hilmar's investigation determined that this incident was not considered an equipment opening ("line break") activity, and a line break permit was not issued. This task also did not include a job safety analysis, which could have identified the hazards of cutting a pipe near another that contained hazardous materials. Additionally, had the job been classified as a line break, respiratory protection should have been required. In response to the incident, Hilmar required workers to cut CPVC piping with a CPVC cutting tool instead of a reciprocating saw.

Probable Cause

Based on Hilmar's investigation, the CSB determined that the probable cause of the incident was the cutting of the ½-inch ammonia piping with a reciprocating saw. Not performing a job safety analysis, which could have identified the hazards of using a saw, contributed to the incident. Additionally, not recognizing this work as a line break resulted in the worker not wearing respiratory protection, which contributed to the severity of the incident.

21. Delek

April 17, 2023

Tyler, Texas

Incident Summary

On April 17, 2023, at approximately 3:05 a.m., hot liquid hydrocarbon was released from a sample station at the Delek US Refining GP, LLC ("Delek") refinery in Tyler, Texas (**Figure 1**). The released hydrocarbon liquid seriously injured one operator, who received third-degree burns to their hand.

Figure 1. Delek Refinery in Tyler, Texas (Credit: Jacobe Brothers Construction)

At the time of the incident, the operator was working to collect a sample of vacuum tower bottoms material ("VTB") for laboratory analysis. The operator opened the sample valve and waited for the fluid to flow. Because the material has high viscosity, it typically takes more than 10 minutes before the fluid starts flowing. While waiting to collect the sample, the operator removed one glove. During this time, VTB fluid suddenly sprayed out from the open-ended tubing, releasing about one gallon of hydrocarbon liquid at about 650 degrees Fahrenheit (**Figure 2**). When the operator closed the valve to stop the flow of VTB, some of the liquid contacted the operator's ungloved hand, causing third-degree burns. A unit manager drove the operator to a hospital for treatment. The operator was then transported by helicopter to a burn center and admitted for medical treatment.

Delek's investigation found that the sampling equipment required external heating to help the viscous liquid flow. However, the insulation and heat tracing had been removed from this equipment during a maintenance turnaround earlier in 2023. Although work orders were written to reinstall the insulation and heat tracing, this work was not completed. The sample station also previously had a shield installed to help protect employees from exposure to the hot liquid, but because it was not well made, Delek had removed it in 2018. In addition, the company's investigation discovered that some operators used their stop work authority to not take this sample due to safety concerns. However, the VTB sample was still included on the list of shift samples, and some operators continued collecting it.

Figure 2. Post-incident image of the VTB release and sampling equipment. (Credit: Delek)

Figure 3. Enclosure installed after the incident. (Credit: Delek)

In response to the incident, Delek improved the sample station. Heat tracing and insulation were applied, and an enclosure was installed to help protect workers from being sprayed with the hot VTB liquid (**Figure 3**).

Probable Cause

Based on Delek's investigation, the CSB determined that the probable cause of the incident was the sudden release of hot hydrocarbon liquid from the sample tubing. The sample equipment's lack of heat tracing, insulation, and shielding contributed to the incident, and the operator's removal of a glove during the sampling contributed to its severity.

22. Valero

April 19, 2023

Port Arthur, Texas

Incident Summary

On April 19, 2023, at approximately 11:00 a.m., a hose ruptured at the Valero Port Arthur Refinery ("Valero") in Port Arthur, Texas (**Figure 1**), releasing a flammable mixture containing hydrogen and hydrocarbons that ignited, resulting in a large fire at the refinery. The Premcor Refining Group Inc., a subsidiary of Valero, owns the facility. Valero estimated that the incident resulted in $2.3 million in property damage.

Figure 1. Fire at the Valero refinery in Port Arthur, Texas (Credit: Valero)

On the day of the incident, two Valero employees and one contractor were removing temporary equipment that the company had installed for a reactor's catalyst change. The temporary equipment setup included a hose with a maximum pressure rating of 300 pounds per square inch gauge (psig) connected to a flare system. Valero's investigation found that when the workers prepared to remove the temporary equipment, they opened a valve that exposed the hose to 1,800 psig of process pressure. Consequently, the hose overpressured and ruptured, releasing approximately 6,400 pounds of flammable mixture containing hydrogen and hydrocarbons (**Figure 2**). Shortly thereafter, the flammable material was ignited from an unknown source, resulting in a large fire.

Figure 2. Post-incident image of the tag (left) on the hose to the flare system (right). (Credit: Valero)

Valero's investigation found that its management of the change process for the temporary equipment was missing information. For example, the piping and instrumentation diagram did not identify hoses, and the review team assumed that piping with an appropriate pressure rating was used. However, Valero's pre-startup safety review (PSSR) team incorrectly concluded that the hose's 300 psig pressure rating was sufficient. Valero's investigation also found that the company did not apply other management systems, including a job safety analysis, or develop a procedure detailing the correct order to open the valves, as they were not identified as necessary for temporary equipment. After the incident, among other actions, Valero approved a project to install permanent piping to prevent the need for hoses during similar catalyst replacement work in the future.

Probable Cause

Based on Valero's investigation, the CSB determined that the probable cause of the incident was the overpressure of a temporary hose. Contributing to the incident was not recognizing the potential to overpressure the hose, resulting from misunderstandings during the management of change process and an ineffective pre-startup safety review. An effective hazard analysis or pre-startup evaluation would have identified the need for equipment with an increased pressure rating, which could have prevented this incident.

23. Delek

May 8, 2023

El Dorado, Arkansas

Incident Summary

On May 8, 2023, at 6:01 p.m., an 850,000-gallon storage tank exploded, and a large fire erupted at the Delek US Holdings Inc.'s ("Delek") Lion Oil refinery in El Dorado, Arkansas (**Figure 1**). Delek Logistics, a subsidiary of Delek, owned this storage tank. Delek estimated that the property damage from the incident was $1.27 million.

Figure 1. The 850,000-gallon storage tank (yellow star) at the Delek refinery in El Dorado, Arkansas. (Credit: Delek, modified by CSB)

On the day of the incident, an 850,000-gallon fixed-roof atmospheric storage tank ("tank") was fed clarified oil, a liquid hydrocarbon comprised mostly of heavier than C20 hydrocarbons. The clarified oil entered the tank through a nozzle on the roof and fell about thirty feet to the liquid surface. Allowing liquid to free fall while loading is known as "splash filling." The CSB found that the dangers from splash filling have been recognized and documented since at least 1970 (ICI Safety Newsletter No. 20, Incident 20/6). Splash filling can create a mist (aerosol) above the liquid surface with increased flammability and has also been attributed to elevated ignition risk from static charge accumulation and discharge.

On the evening of the incident, a thunderstorm occurred in the El Dorado area. A surveillance video captured a lightning strike at 6:01 p.m. that hit the tank. Moments later, the tank exploded, and a large fireball erupted from the tank (**Figure 2**). Emergency responders extinguished the fire by 7:21 p.m. Delek reported that the fire consumed 21,500 gallons of the clarified oil inside the tank.

Figure 2. Tank explosion (left) and its post-incident condition (right). (Credit: Delek)

Delek's investigation concluded that the tank's splash filling created a flammable atmosphere inside the tank. Delek found that none of its other tanks in similar applications at the facility used splash filling, and each of these other tanks was filled at the bottom. Delek's investigation concluded that the tank's grounding cable ignited flammable vapor flowing from the tank's vents. The grounding cable was routed near the two atmospheric vents, which brought the ignition source (an electric arc) near the vent as the grounding equipment dissipated the lightning strike. Shortly after this vapor ignited, the flame propagated into the tank, triggering the explosion. The tank's frangible roof opened to vent the pressure from the explosion. A frangible roof seam is an intentionally weaker roof-to-shell weld that will preferentially tear open to relieve pressure before other welded joints when the tank is overpressurized. Delek's investigation also found that neither of the tank's atmospheric vents were equipped with flame arrestors, which could have prevented the external flame from migrating back into the tank.

Probable Cause

Based on Delek's investigation, the CSB determined that the probable cause of the incident was splash filling—allowing the hydrocarbon liquid to free fall about 30 feet from the top of the tank to the surface of the liquid. As a result of splash filling, a flammable aerosol likely formed, which was ignited when lightning struck the tank. The incident could have been prevented by filling the tank from the bottom to prevent the presence of a flammable atmosphere inside the tank.

24. CITGO

July 31, 2023

Lemont, Illinois

Incident Summary

On July 31, 2023, at approximately 8:49 a.m., a flash fire occurred while loading a railcar at the CITGO refinery in Lemont, Illinois. The fire seriously injured one CITGO employee.

On the day of the incident, an employee was loading an open railcar compartment with mineral spirits, a mixture of C9-C15 hydrocarbons (**Figure 1**). Before beginning the loading operation, the employee inspected the compartment and saw some residual liquid at the bottom. The compartment previously held heptane. The employee drained the heptane (estimated to be about a pint) before transferring the mineral spirits into the railcar.

Figure 1. Loading arm and railcar hatch opening. (Credit: CITGO)

When the loading was almost complete, the employee lowered a metal sampling device into the compartment. When the sampling device approached the mineral spirits, the vapor space ignited, producing a jet flame approximately 100 feet high that erupted from the railcar's open hatch (**Figure 2**), seriously burning the employee. The employee was transported and admitted to the hospital for medical treatment.

Figure 2. A surveillance video captured the fire (red circle, left) and a picture of the sample device (right). (Credit: CITGO, modified by CSB)

The practice of loading a low vapor pressure (high-flashpoint) material into a tank that previously contained a high vapor pressure (low-flashpoint) product is called “switch loading.” The CSB found that the danger from switch loading has been recognized and documented since at least 1960. The residual vapor in the tank can be flammable, and the material being loaded often has low conductivity. The result is that static charge accumulates on the liquid surface during loading, which can ignite the vapor. A number of industry standards and good practice guidance documents that address static electricity hazards already highlight this danger and warn against switch loading, including NFPA 77, ASTM D4865-19, HSG176, and several CCPS publications.

CITGO’s investigation confirmed that loading mineral spirits into the compartment that previously held heptane was switch loading. Static discharge likely ignited the fire as the sample device approached the liquid surface. The company had not previously identified the risks of switch loading and sampling. CITGO also found that its training program did not reliably ensure workers knew of the fire and static electricity hazards associated with sampling.

CITGO’s investigation determined that the pump used to load mineral spirits could produce higher flow rates than other nearby pumps, which could increase static charge generation. To help protect from static electricity incidents, the railcar sampling procedure instructed employees to wait ten minutes after loading before taking a sample to allow for the dissipation of static electricity before introducing a sampling device. CITGO’s investigation revealed that the sampling occurred while the material was being pumped into the railcar without a waiting period. The company found that its on-the-job training did not emphasize the importance of ensuring the designated relaxation time to dissipate static charge before sampling.

To help prevent a future incident from switch loading, CITGO now requires tank cleaning and purging whenever a low-flashpoint material needs to be loaded into a tank that previously held a high-flashpoint material.

Probable Cause

Based on CITGO’s investigation, the CSB determined that the probable cause of the incident was switch loading —loading a low vapor pressure material (mineral spirits) into a railcar compartment that contained a high vapor pressure material (heptane). A static discharge likely ignited the flammable vapor in the compartment as a metal sampling device was lowered to the liquid surface. The incident could have been prevented by prohibiting switch loading, and cleaning and purging the compartment to avoid this scenario.

25. Southwestern Energy

August 13, 2023

Ohio County, West Virginia

Incident Summary

On August 23, 2023, at approximately 10:50 p.m., a fire seriously injured two people at the Southwestern Energy oil and gas well site (**Figure 1**) in Ohio County, West Virginia.

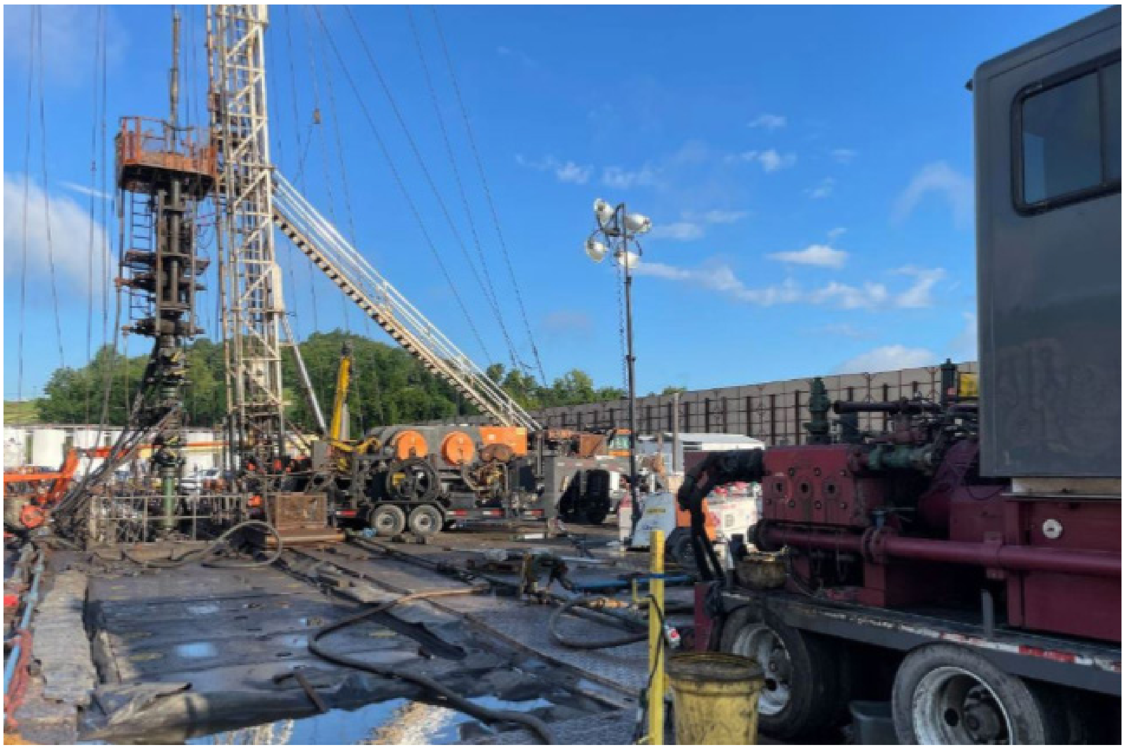

Figure 1. The Southwestern Energy site in West Virginia. (Credit: Southwestern Energy)

On the day of the incident, contractors worked to conduct a drill-out operation to recover a stuck pipe from an oil well. The equipment used in this operation included a return tank ("tank") that was open to the atmosphere (**Figure 2**). As the workers circulated drilling fluid through the well, natural gas and condensate entered the tank, which allowed natural gas to discharge into the air from the tank's opening. The duration of the drill-out operation and lack of wind at the well site allowed natural gas vapors to accumulate as a flammable vapor cloud in the area around the tank.

Figure 2. Post-incident image of the return tank. (Credit: Southwestern Energy)

At approximately 10:45 p.m., one worker's personal flammable gas detector alarmed, alerting the worker of the dangerous condition. Approximately five minutes later, a contract worker was shutting down a nearby electric generator when the generator ignited the natural gas, engulfing the contract worker. The fire traveled toward the tank, where another contractor was working. The contractor jumped over the tank's stairway railing to avoid the fireball and broke their foot from the fall. Both injured workers were transported and admitted to a hospital for treatment.

Southwestern Energy reported that 27.3 million cubic feet of natural gas were released. In its investigation, Southwestern Energy identified that the drill-out equipment did not effectively handle the natural gas, allowing the flammable vapor to accumulate around the area of the return tank. Southwestern Energy also found that stationary flammable gas detectors were removed from the site about three weeks before the incident when the company transitioned to personal devices for flammable gas detection. The company's investigation concluded that the stationary flammable gas detection and warning system could have provided workers with an earlier alert about the dangerous accumulation of natural gas, which should have allowed everyone to evacuate before the fire.

Probable Cause

Based on Southwestern Energy's investigation, the CSB determined that the probable cause of the incident was the uncontrolled release of natural gas during a drill-out operation. An operating electric generator ignited the flammable vapor. The lack of a fixed flammable gas detection and warning system contributed to the severity of the incident. An effective flammable gas detection and warning system could have alerted the workers to stop circulating the well and evacuate the area.

26. Dow

August 26, 2023

Texas City, Texas

Incident Summary

On August 26, 2023, at 6:10 a.m., approximately one gallon of vinyl acetate polymer residue ("vinyl acetate residue") was released at The Dow Chemical Company ("Dow") facility in Texas City, Texas. The Union Carbide Corporation, a Dow subsidiary, operates this facility. One employee, an operator, was seriously injured from skin exposure to the corrosive liquid.

Dow's investigation found that the operator used a loading hose to transfer vinyl acetate residue from a storage tank to a chemical trailer (**Figure 1**). After loading the chemical trailer, the operator introduced nitrogen gas through the hose and into the trailer to help remove the residual liquid in the hose. The operator then closed the isolation valve at the rear of the trailer and upstream from where the hose connects to the process, which resulted in the hose being pressurized with nitrogen. When the operator disconnected the hose from the chemical trailer, nitrogen gas and some residual liquid vinyl acetate residue were forcefully ejected. The force of this chemical release blew off some of the operator's personal protective equipment (PPE), leading to serious injuries from chemical burns.

After the operator isolated the hose, no instruments—such as a pressure gauge or other safety measures—were available to alert the operator or other employees of the danger that the hose was still under pressure from the nitrogen. The company's investigation revealed that the operator missed a step in the procedure. Before disconnecting the hose, the operator should have opened a valve to discharge the nitrogen to a safe location. After the nitrogen pressure was removed, it should have been safe for the operator to disconnect the hose from the chemical trailer.

Figure 1. Post-incident image showing the loading hose. (Credit: Dow)

Probable Cause

Based on Dow's investigation, the CSB determined that the probable cause of the incident was disconnecting the hose from the chemical trailer when the hose was pressurized with nitrogen. The lack of instrumentation or other safeguards to warn employees that the loading hose was under pressure contributed to the incident.

27. Sasol

March 13, 2024

Westlake, Louisiana

Incident Summary

On March 13, 2024, at 5:30 a.m., an accidental release of lubricating oil ignited at the Sasol Chemicals USA LLC ("Sasol") ethylene manufacturing facility in Westlake, Louisiana, resulting in a large fire at the facility. Sasol estimated that the incident resulted in $187 million in property damage.

On the morning of March 13, 2024, contract maintenance workers were preparing a compressor's lubricating ("lube") oil heat exchanger for cleaning by removing the end caps or "heads" when pressurized lube oil (300 pounds per square inch) sprayed out from the floating head cover. The lube oil contacted hot piping (900 degrees Fahrenheit) nearby and ignited (autoignition), resulting in a fire. The maintenance workers evacuated and notified Sasol Operations, who activated the fire suppression system and contained the fire within the process building (**Figure 1**).

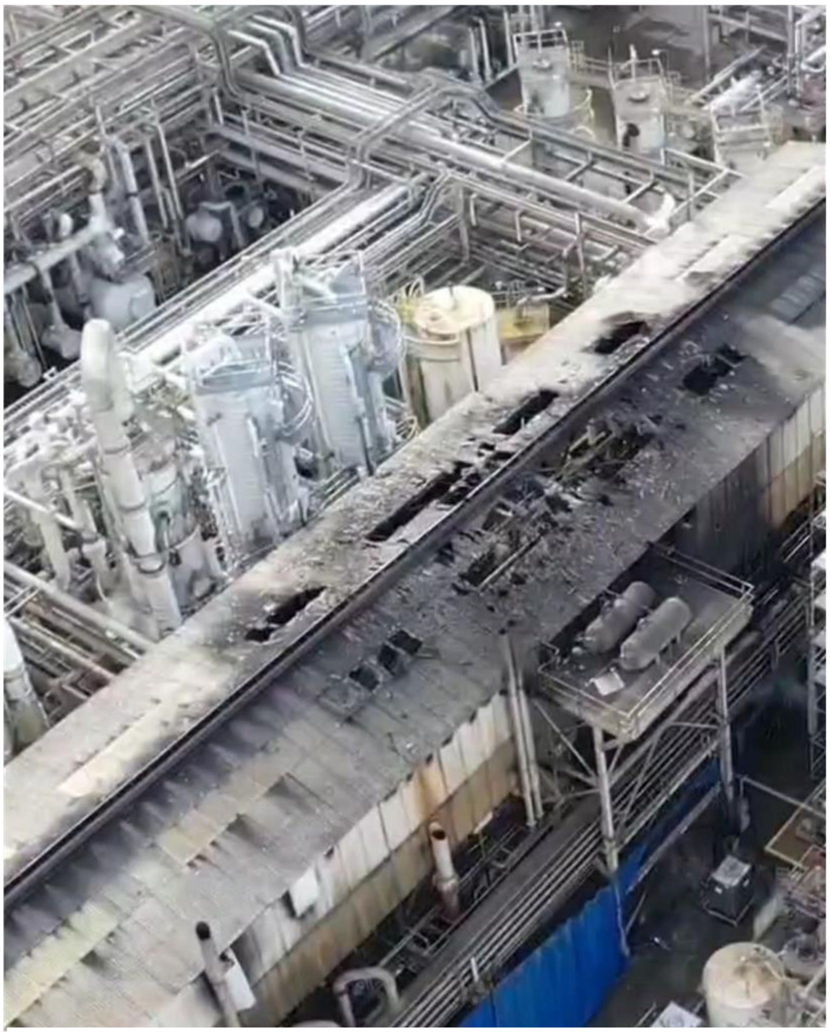

Figure 1. Overview of fire impact. (Credit: Sasol)

Sasol's investigation found that although the heat exchanger's supply and return valves were locked and the operations team issued a permit to have the maintenance workers remove the heat exchanger heads, the lube oil piping was not effectively isolated or drained. The lock-out relied on two three-way valves being in the correct position. Sasol's post-incident inspection revealed that the lube oil side of the exchanger was pressurized because one of the three-way valves was partially open (**Figure 2**).

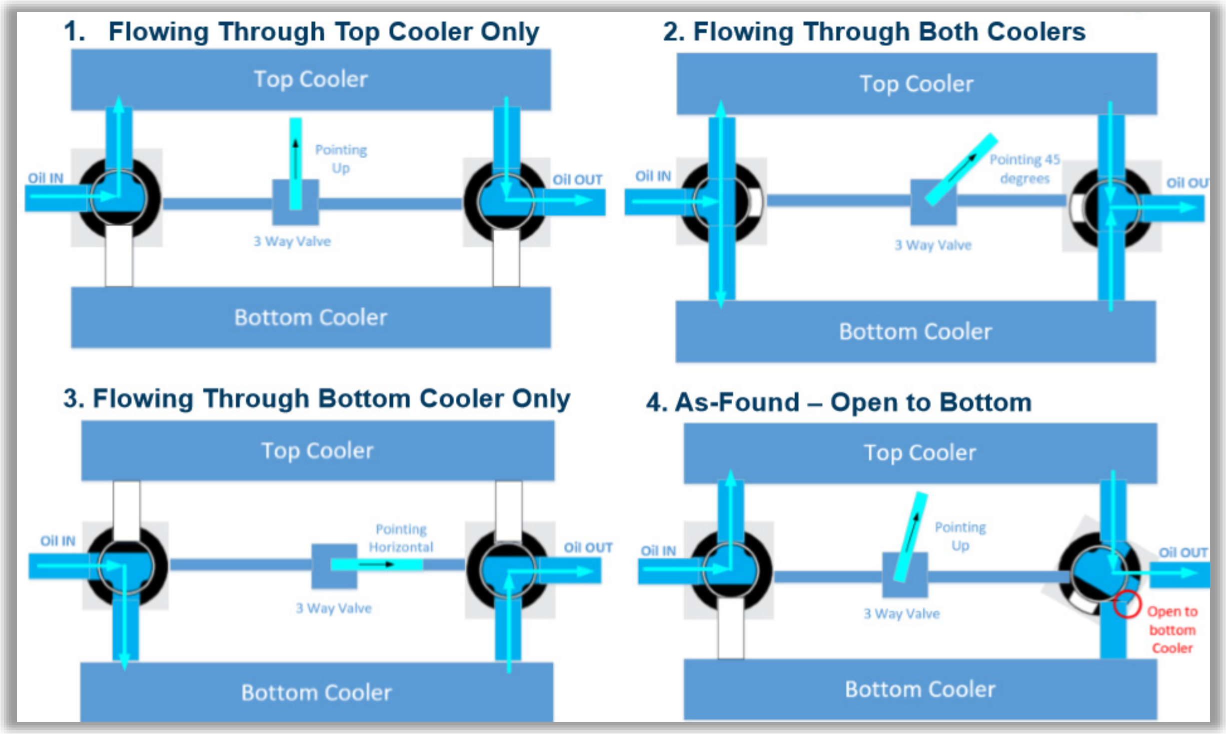

Figure 2. Three-way valve handle positions and "as-found" position (4). (Credit: Sasol)

Figure 3. Locked out valve handle position. (Credit: Sasol)

The handle for the three-way valve was locked out and oriented as shown in **Figure 3**, but it was not fully closed. Post-incident testing confirmed that the valve could fully close by removing the handle and using a wrench to close it. In addition, the vent and drain valves on the lube oil (shell) side of the exchanger remained closed. Sasol's investigation determined that a visual check was used to verify that there was no pressure within the exchanger and that the positions of the vent and drain valves were overlooked.

After the incident, Sasol installed instrumentation to display the pressure within the equipment and added position indicators for the three-way valve handle. Sasol reported that 9,400 pounds of lube oil were released. This lube oil was primarily comprised of (C15-C50) hydrocarbons.

Probable Cause

Based on Sasol's investigation, the CSB determined that the probable cause of the incident was that the heat exchanger was not effectively isolated and drained before the maintenance workers began disassembly. As a result, equipment containing pressurized lube oil was opened, which released lube oil into the ambient air. The lube oil was most likely ignited (autoignition) by contacting nearby high-temperature piping, resulting in a large fire.

28. Advantek

May 17, 2024

Westhoff, Texas

Incident Summary

On May 17, 2024, an explosion and fire occurred at the Advantek Eagleford LLC ("Advantek") oil and gas waste disposal facility in Westhoff, Texas (**Figure 1**). The explosion and fire fatally injured one Advantek employee and caused an estimated $6.94 million in property damage.

Figure 1. The fire at the Advantek facility in Westhoff, Texas (Credit: Advantek)

Advantek's facility receives fluids from oil field operations, such as drilling. These fluids are either disposed of in an injection well as waste or recovered and sold. At approximately 2:40 p.m., a truck transporting liquid entrained with solids ("mud") arrived at the facility. The truck was unloaded through shakers that removed large solids from the mud. The mud then flowed into a Mud Recovery Tank ("MRT"), which is open at the top and covered with a deck made from grating. Advantek's lead operator was stationed on the MRT deck, overseeing the pumps and valves required for unloading and processing the mud.

At 2:43 p.m., another truck parked next to the MRT in a lane designated for washing the truck's tank. At approximately 2:46 p.m., the truck driver signaled to the operator that the truck's engine was racing, prompting the operator and the driver to walk away from the vehicle. Shortly thereafter, flammable hydrocarbon vapor ignited and exploded in the truck's engine compartment. The explosion rapidly spread to the MRT deck, fatally injuring the lead operator and causing a fire that extended to the MRT and nearby storage tanks (**Figure 2**).

Figure 2. Progression of the fire and explosion at the Advantek facility (Credit: Advantek, modified by CSB)

Advantek's investigation revealed that the fluid unloaded from the truck at the facility had a higher concentration of hydrocarbons than anticipated, with over 92 percent of the material falling within the C4-C10 hydrocarbon range. Additionally, post-incident testing showed that this material had a flash point lower than -22 degrees Fahrenheit.

The CSB concluded that the unusually high hydrocarbon concentration was incompatible with Advantek's processes, which utilized open-top storage tanks. Nonetheless, the fluid was accepted and processed, allowing flammable vapors to escape into the atmosphere. This created a flammable vapor cloud that traveled toward the running truck engine.

After the incident, Advantek evaluated and enhanced the sampling process and procedures. The updated procedures emphasize that samples must pass a test to verify that the customer's shipment is not flammable.

Probable Cause

Based on Advantek's investigation, the CSB determined that the probable cause of the incident was unloading a truck of flammable hydrocarbons onto equipment designed to process non-flammable drilling fluids. When the hydrocarbon was processed through the shakers, flammable vapor was released into the air and ignited by a running truck engine.

29. Cornerstone

June 11, 2024

Waggaman, Louisiana

Incident Summary

On June 11, 2024, at about 6:30 a.m., a storage tank exploded, releasing approximately 5,300 pounds of hot urea at the Cornerstone Chemical Company ("Cornerstone") facility in Waggaman, Louisiana (**Figure 1**). The explosion and urea release seriously injured one Cornerstone employee and caused approximately $2.5 million in property damage.

Figure 1. The Cornerstone Chemical Company facility (Credit: Cornerstone)

On the day of the incident, Cornerstone operators were preparing to start up a reactor system. A step in the startup involved flushing high-viscosity material and accumulated solids from the bottom of a urea storage tank ("tank") because this material historically clogged the pump's strainer. Shortly after an operator opened the valve at the bottom of the tank, the pressure within the tank increased rapidly, and the top of the tank ruptured open (**Figure 2**). Hot urea liquid at about 280 degrees Fahrenheit erupted from the tank and contacted the operator, who had opened the valve. After rinsing in a safety shower, the injured operator was transported to a hospital and admitted for treatment.

Figure 2. The damaged tank at Cornerstone. (Credit: Cornerstone)

Cornerstone's investigation identified that the practice of flushing the high-viscosity material and solids from the bottom of the tank at startup was not covered by a written procedure. Cornerstone's investigation also determined that a valve was inadvertently left open, which allowed hot water to flow into the tank when the operator opened the tank's bottom valve. The water flashed to vapor when it contacted the tank's hot urea contents, rapidly increasing the pressure in the tank and ultimately rupturing the top of the tank. After the top of the tank had ripped open, the steam being generated propelled most (5,300 pounds) of the hot urea out of the tank's open top. Some of the hot liquid contacted and injured the operator.

The CSB found that the tank's pressure-relief system was not sized for this scenario, and the system lacked safeguards to control water from being inadvertently added to the tank containing hot urea.

Probable Cause

Based on Cornerstone's investigation, the CSB determined that the probable cause of the incident was adding water to a tank containing hot urea (280°F). The water flashed to steam, increasing the pressure inside the tank, resulting in an overpressure explosion. The insufficient capacity of the pressure-relief system and lack of safeguards contributed to this incident.

30. Georgia Pacific

January 16, 2025

Monticello, Mississippi

Incident Summary

On January 16, 2025, at approximately 5:00 p.m., an employee was seriously injured after being sprayed with very hot water at the Georgia Pacific Monticello, LLC ("Georgia Pacific") paper mill in Monticello, Mississippi (**Figure 1**).

Figure 1. The Georgia Pacific facility in Monticello, Mississippi. (Credit: DieselDucy)

On the day of the incident, one of the facility's paper machines that convert pulp into paper resumed operation after an outage to fix a leaking valve. During the restart, the refiner equipment used to process pulp slurry for the paper machine appeared to malfunction. Georgia Pacific's operators suspected that there was a clog in the system and used hot water to flush the refiners. One refiner's casing leaked and released approximately 100 gallons of hot water (**Figure 2**). Some of the hot water was sprayed onto an employee. After washing in a safety shower, the injured employee was transported and admitted to the hospital for medical treatment.

Figure 2. The refiner that leaked (left). (Credit: Georgia Pacific)

Georgia Pacific's investigation found that a misaligned valve (a closed valve that should have been open) had prevented flow through the refiners. The very hot water used for the flush overpressurized one refiner's casing, cracking it, and releasing hot water through its bolted seam, where seven casing bolts were not securely tightened. A high-pressure shutoff did not activate and protect the equipment because the set point exceeded the manufacturer's recommended pressure limit.

Georgia Pacific's investigation revealed that the misaligned valve was not detected during troubleshooting because the operators did not recognize that the refiner with the closed valve was operating. A recent upgrade to the computer control system changed the color indicators for the refiner's operating status. The previous colors, red for off and green for on, were replaced with gray for off and white for on. This new color scheme led to a misinterpretation and caused the operators to conclude that the equipment was plugged. As a result, the refiner's casing was overpressurized when hot water was injected into the closed (no flow) system.

Probable Cause

Based on Georgia Pacific's investigation, the CSB determined that the probable cause of the incident was the overpressurization of the refiner's casing under no-flow conditions. Introducing hot water to flush the refiner with a closed valve at the outlet created high-pressure conditions. A recent change in the facility's computer control system color scheme led to a misinterpretation of one refiner's operating status and valve position, contributing to the incident. Misunderstanding the control system information led to flushing the equipment with hot water after erroneously concluding that the pulp had clogged the system. In addition, an ineffective high-pressure shutdown system and the lack of a pressure-relief device to protect the refiner equipment contributed to the incident. Finally, the company's mechanical integrity program contributed to the incident by not securely tightening the refiner's casing bolts.

This page is intentionally blank.

U.S. Chemical Safety and
Hazard Investigation Board