VOLUME: 4
DATE: FEBRUARY 18, 2026

# 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:

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Chairperson

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# Summary

This volume of Incident Reports covers 13 accidental release events in seven states. These events resulted in 2 fatalities, 10 serious injuries, and approximately $1 billion in property damage.

| Accidental Release Events | | | | | | | |
|---|---|---|---|---|---|---|---|
| Number | Incident Date | Company | City | State | Fatality | Serious Injury | Substantial Property Damage ($ Million) |
| 1 | 2020-07-16 | ArcelorMittal | Burns Harbor | IN | | | 22 |
| 2 | 2020-11-29 | Eastman | Kingsport | TN | | | 1.1 |
| 3 | 2021-03-22 | Phillips 66 | Wilmington | CA | | 1 | |
| 4 | 2021-12-20 | AdvanSix | Chester | VA | | 1 | |
| 5 | 2022-02-14 | Diamond Green Diesel | Norco | LA | | 1 | |
| 6 | 2022-02-21 | Marathon | Garyville | LA | | | 54 |
| 7 | 2023-01-30 | Northrop Grumman | Magna | UT | 2 | | |
| 8 | 2023-02-06 | Atalco | Gramercy | LA | | 2 | |
| 9 | 2023-12-10 | SABIC | Mt. Vernon | IN | | | 3.5 |
| 10 | 2024-02-22 | PBF Energy | Chalmette | LA | | | 1.2 |
| 11 | 2024-10-08 | Formosa | Baton Rouge | LA | | 4 | |
| 12 | 2025-02-01 | PBF Energy | Martinez | CA | | | 924 |
| 13 | 2025-05-20 | Olin | Freeport | TX | | 1 | 23 |
| | | | | **Total** | **2** | **10** | **1,029** |

# 1. ArcelorMittal

**July 16, 2020**

**Burns Harbor, Indiana**

## Incident Summary

On July 16, 2020, at approximately 6:30 a.m., an explosion and fire occurred in a blast furnace at the ArcelorMittal steel mill in Burns Harbor, Indiana, which produced iron, steel, and other products (**Figure 1**). A few months after the incident, in December 2020, Cleveland-Cliffs Burns Harbor LLC ("Cleveland-Cliffs") purchased the Burns Harbor facility. Cleveland-Cliffs estimated that the incident resulted in approximately $22 million in property damage.

**Figure 1**. Blast furnaces at the Cleveland-Cliffs steel mill in Burns Harbor, Indiana. (Credit: Christian Thomas)

In iron manufacturing, a blast furnace operates at high temperatures to convert iron ore into molten iron. Hot, pressurized air enhances the blast furnace's efficiency and capacity. This hot air is heated in a pressure vessel known as a stove, and the top hemispherical part of the stove is referred to as the dome.

On July 16, 2020, a blast furnace at the Burns Harbor mill, Blast Furnace D ("Blast Furnace"), was operating normally when the dome on one of its stoves suddenly and catastrophically separated at approximately 6:30 a.m., resulting in a large explosion (**Figure 2**). Plant operators shut the unit down within minutes. The incident severely damaged portions of the mill.

**Figure 2**. Surveillance video image of the explosion (left) and post-incident picture of the incident stove (right). (Credit: Cleveland-Cliffs)

ArcelorMittal's investigation revealed that the rupture originated at a large repair patch on the stove's dome. The failure initiated where the dome's shell was thinnest due to internal corrosion, measuring approximately one-tenth of an inch. This thickness was only ten percent of the dome's original wall thickness of one inch. The investigation also found that the repair patch in this area was improperly welded and that the repair plate was only 0.25 inches thick, significantly less than the calculated minimum required thickness of 0.56 inches for the dome. The stove's normal operating pressure of 36 pounds per square inch caused the fracture to spread along the welds of the shell.

High-temperature oxidation corrosion had significantly reduced the thickness of the dome's shell over the years it was in operation. Several repair patches were applied throughout the dome's service life to address thinning and weld cracking. ArcelorMittal's investigation concluded that some of these repairs did not conform to the American Society of Mechanical Engineers (ASME) Pressure Vessel Code requirements. In fact, several repair patches were improperly welded, used dissimilar steel grades that did not match the original structural steel, and failed to meet the minimum thickness requirements for this type of pressure vessel. These deficiencies likely compromised the strength of the repaired areas, allowing the crack to propagate along the welds after the initial failure.

## Probable Cause

Based on ArcelorMittal's investigation, the CSB determined that the probable cause of the explosion was the catastrophic failure of the stove's dome. The dome failed at a repair patch that had been improperly welded and did not provide the minimum thickness needed to contain the dome's operating pressure. The steel mill's mechanical integrity program lacked effective inspection and weld repair practices, contributing to the incident.

## 2. Eastman

**November 29, 2020**

**Kingsport, Tennessee**

### Incident Summary

On November 29, 2020, at approximately 6:42 p.m., a major fire occurred at the Eastman Chemical Company ("Eastman") facility in Kingsport, Tennessee, after sections of piping supplying water to a coal gasification unit failed, releasing flammable chemicals that ignited (autoignition). Eastman estimated the property damage to be $1.1 million.

At the time of the incident, Eastman was feeding oxygen and a slurry of coal and water to one of its coal gasifiers to generate product gases, primarily hydrogen and carbon monoxide. The gasifier operated at a pressure of approximately 1,000 pounds per square inch. Pressurized water was injected into the gasifier to cool the hot product gases (**Figure 1**).

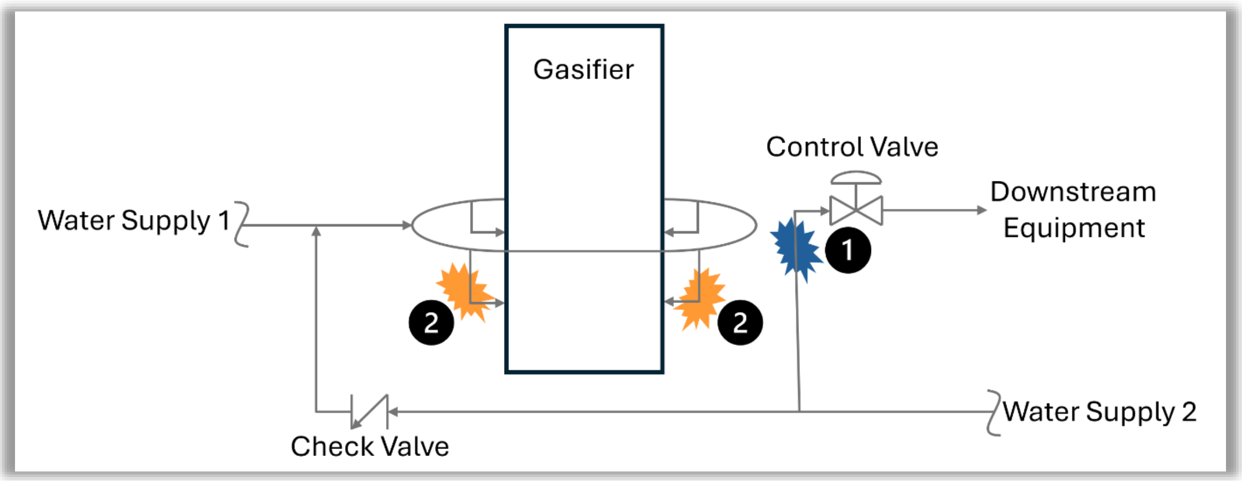


**Figure 1**. Simplified diagram of the water supply system involved in the incident. (Credit: CSB)

At approximately 6:41 p.m., a pipe support failed near the water supply control valve at location #1, shown in **Figure 1**. This pipe support was welded to the water supply piping, and its failure opened a large hole in the piping, releasing most of the available water supply. Roughly one minute later, two of the four water supply pipes to the gasifier ruptured at location #2, shown in **Figure 1**, releasing hot, flammable product gases that autoignited, resulting in a fire around the gasifier. Eastman operators shut down the gasifier, which stopped the release of product gases, extinguishing the fire.

Eastman's investigation found that fatigue cracking at the pipe support weld caused the initial water supply piping failure (**Figure 2**). The piping support had severely corroded over time and was no longer supporting the pipe, as it had lost contact with the structure. The company's last visual inspection of this piping system, which occurred in 2018, did not identify any problems with the pipe support.

With Water Supply 2 being released through the breached piping, Water Supply 1 should have been able to provide sufficient water flow to the gasifier. However, the check valve in the water supply piping had been stuck in the open position for an extended period prior to the incident and had not been inspected or otherwise tested. As a result, Water Supply 1 preferentially flowed through the open hole in the piping at location #1 (**Figure 1**).

**Figure 2**. Hole in water piping at location one (left), the piping support (center), and the top and bottom ends of the piping support (right). (Credit: Eastman, modified by CSB)

Without a steady water supply to the gasifier, hot product gases exited into the water piping, creating localized high-pressure and high-temperature conditions that ruptured two of the four water supply piping connections to the gasifier. Hot, flammable product gases were released from these two ruptured pipe locations, resulting in the fire.

Before the incident, Eastman's process hazard analysis (PHA) had not accurately assessed the potential for loss of water flow to the gasifier. The company's technical staff had mistakenly concluded that a loss of water flow would trigger a shutdown of the gasifier due to a low liquid level.

## Probable Cause

Based on Eastman's investigation, the CSB determined that the probable cause of the incident was the rupture of piping connected to the gasifier. The failure of the piping released hot, flammable material from the gasifier that ignited, resulting in the fire. The gasifier piping failure was caused by the loss of water flow through the piping, which occurred when a large hole developed in a different section of piping in the water system after a welded pipe support broke, and a check valve in the piping system did not close because it was stuck in the open position. Eastman's process safety management systems contributed to the incident. The company did not maintain the integrity of the piping support, which was severely corroded. Additionally, Eastman was not testing the integrity of the check valve, which had been inoperable for an extended period before the incident. Furthermore, not accurately assessing the loss of water flow in its PHA contributed to a lack of effective safeguards to protect the gasifier's piping.

## 3. Phillips 66

**March 22, 2021**

**Wilmington, California**

### Incident Summary

On March 22, 2021, at approximately 12:30 p.m., an explosion and fire occurred at the Phillips 66 Los Angeles Refinery ("Phillips 66") in Wilmington, California. The explosion and fire seriously injured one contract worker (**Figure 1**).


**Figure 1.** The Phillips 66 refinery in Wilmington, California. (Credit: Los Angeles Daily News)

Leading up to the incident, the Phillips 66 refinery was shut down for turnaround maintenance. The planned maintenance work included removing a section of carbon steel piping in the Fluidized Catalytic Cracking (FCC) unit that typically contained gasoline. Two days before the incident, on March 20, 2021, 50 gallons of chemical cleaning water containing hydrocarbons were released when workers opened a flange to install a blind (metal plate) to isolate a section of 18-inch piping (**Figure 2**).

On March 22, 2021, the day of the incident, the 18-inch piping was isolated with the blind at one end and the other end transitioning to a section of 10-inch piping open to the atmosphere with drain piping between the blind and the open 10-inch end. To remove the piping, Phillips 66 tasked a crew of contract workers to cut the 18-inch piping at the location shown in **Figure 2**.

Before the cutting began, an operator performed flammable gas testing at the work area, showing no flammable gas was present. Phillips 66 operators also walked the job with the contractor's supervisor. After this, the operators issued a work permit authorizing the contractors to use an electric angle grinder with a cutting wheel to cut the piping. The permit stated that the piping was isolated, vented, depressured, and chemically cleaned. Because the work area was elevated about 10 feet above ground, fire blankets were installed, creating an enclosure to contain sparks created during the pipe-cutting work.

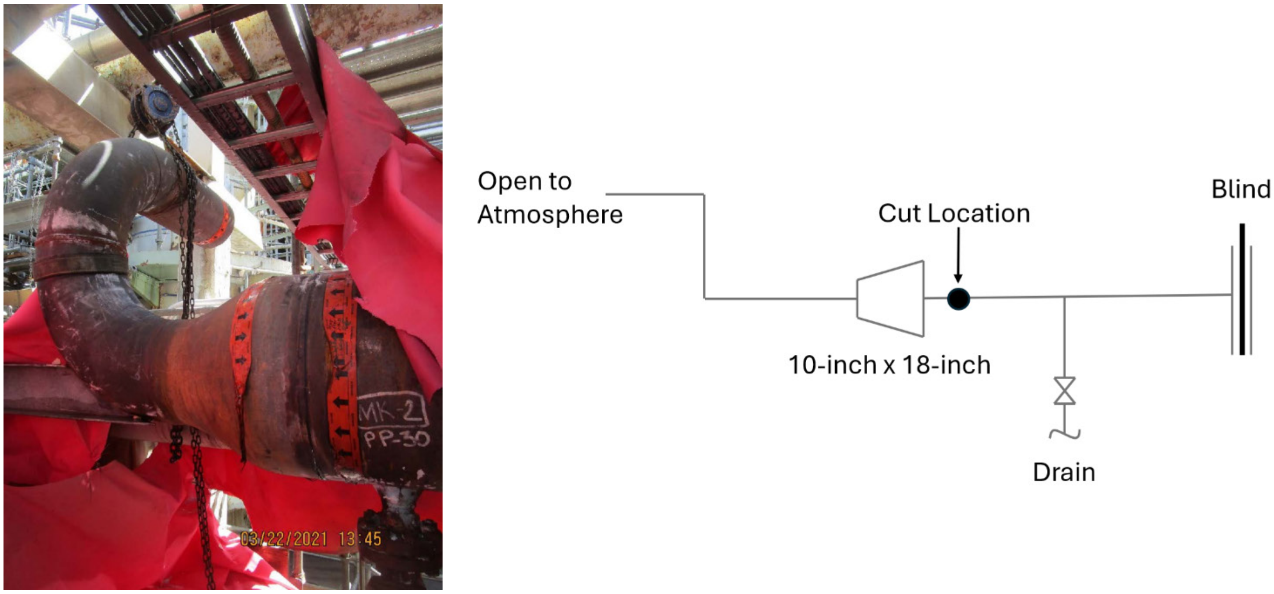


**Figure 2**. Photo (left) and simplified sketch (right) of the piping. Credit: (Phillips 66 (left), CSB (right))

As the lower portion (from the four to six o'clock position) of the piping was being cut, liquid flowed out, and the worker stopped cutting. The drain piping was unplugged using a wire, allowing the fluid to drain. The contractors contacted Phillips 66's operations personnel to evaluate the piping. The operators rechecked the piping and confirmed that no flammable gas was present. One of the contract workers invoked his stop-work authority and refused to continue cutting on this piping because the liquid smelled like gasoline. One of the operators described the odor as pine and attributed it to the substance used during chemical cleaning. Ultimately, two operators and a contractor supervisor agreed that the liquid was primarily water. At approximately 12:30 p.m., two hours after the work was stopped, another contract worker was sent to finish cutting the pipe. When the worker started the angle grinder, an explosion and fire occurred. The contractor suffered serious burn injuries from the combustion event and was transported and admitted to a hospital for treatment.

Phillips 66's investigation determined that the piping contained flammable hydrocarbons because the plugged drain prevented the piping from being flushed and cleared as intended. The flammable gas testing performed at the work area did not identify the flammable vapor inside the piping. In addition, the company's investigation concluded that when the contract worker used his stop-work authority and refused to cut the piping, his safety concerns should have been elevated to Phillips 66's operations and maintenance supervisors for help ensuring the job was safe before resuming work – but they were not. The company estimated that less than half a gallon of gasoline was released.

## Probable Cause

Based on Phillips 66's investigation, the CSB determined that the probable cause of the incident was that the piping segment was not effectively flushed and drained before the contract workers were authorized to cut the piping. Not recognizing the presence of flammable gas contributed to the incident.

## 4. AdvanSix

**December 20, 2021**

**Chester, Virginia**

## Incident Summary

On December 20, 2021, at approximately 9:30 a.m., a release of molten polymer caught fire, seriously injuring an employee at the AdvanSix, Inc. facility (“AdvanSix”) in Chester, Virginia (**Figure 1**).

**Figure 1**. The AdvanSix facility in Chester, Virginia. (Credit: Google Maps)

In December 2021, AdvanSix planned to perform maintenance work on a rupture disc used to protect one of its molten polymer positive displacement pumps from potential high-pressure conditions. On December 18, an operator prepared the equipment for maintenance. The preparation involved turning the pump off, locking and tagging its electrical switch, and closing, tagging, and locking the pump’s inlet and outlet isolation valves. The keys for the three locks were put into a lock box.

On December 20, 2021, the day of the incident, a different AdvanSix operator issued safe and hot work permits to two maintenance workers to perform the rupture disc maintenance. Each of the two maintenance workers applied their personal lock to the lock box. The work involved using a propane torch to heat the external surface of the equipment and melt the polymer inside so that the rupture disc could be removed. One of the maintenance employees removed the bolts from the rupture disc holder, while the second worker acted as a “standby” and observed the work. Both workers wore the standard personal protective equipment (PPE) used at the plant, plus a face shield and an aluminized jacket. When the maintenance worker used the propane torch before removing the last bolt, the rupture disc and the bolt were forcefully ejected, spraying the employee with hot (500 degrees Fahrenheit) molten polymer. The propane torch ignited the molten polymer, starting a fire.

The standby worker pulled the emergency alarm and used the plant radio system to call for help. Emergency responders extinguished the fire and transported the injured maintenance worker to a nearby hospital with a burn center. The worker was admitted for treatment of his injuries, which included third-degree burns. The most severe injuries were to the workers’ legs. The worker’s denim jeans did not offer the same level of protection as his aluminized jacket.

AdvanSix reported that approximately 50 pounds of molten polymer were released. The polymer primarily consisted of nylon 6 and some caprolactam.

AdvanSix's investigation found that the pump's outlet valve had been incorrectly locked in the open position when it should have been closed (**Figure 2**). On the day of the incident, the AdvanSix employees saw that the inlet and outlet valves had been tagged and locked. However, they did not verify that the valves were closed.

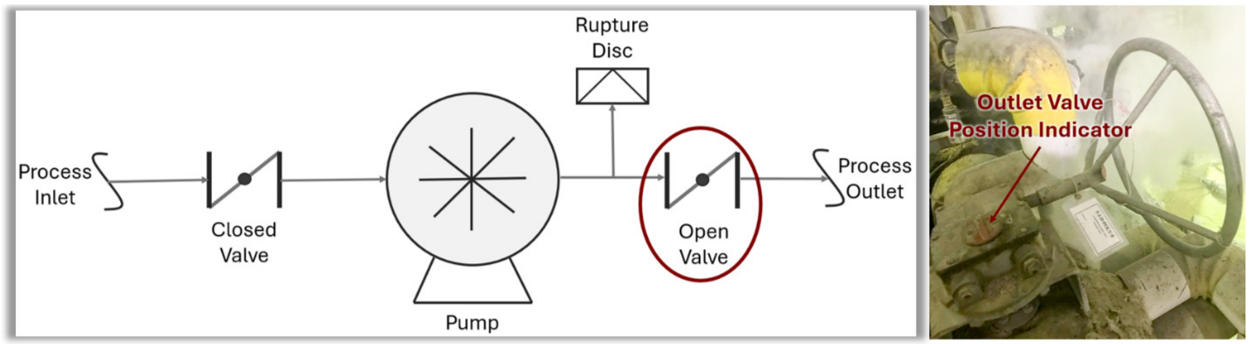


**Figure 2**. Simplified equipment drawing, highlighting the open outlet valve (left image), and a post-incident picture of the outlet valve's position indicator showing it was open (right image). (Credit: CSB (left), and AdvanSix (modified by CSB, right))

In response to the incident, AdvanSix upgraded the PPE requirements to include aluminized clothing for line opening work on its molten polymer equipment.

## Probable Cause

Based on AdvanSix's investigation, the CSB determined that the probable cause of the incident was not effectively isolating and draining the piping before having workers disassemble the rupture disc. As a result, after most of the rupture disc's flange bolts were removed, the pressurized piping caused molten polymer to spray out of the rupture disc's holder. The molten polymer ignited, leading to a fire that seriously injured one employee. Not verifying that the equipment was effectively isolated contributed to the incident. If any employee or supervisor had verified that the locked valves were closed, the incident could have been prevented. Not wearing aluminized pants with the aluminized jacket contributed to the severity of the incident.

# 5. Diamond Green Diesel

**February 14, 2022**

**Norco, Louisiana**

## Incident Summary

On February 14, 2022, at approximately 9:45 a.m., a release of steam and condensate seriously injured a contract worker at the Diamond Green Diesel LLC ("DGD") facility in Norco, Louisiana (**Figure 1**). DGD is a joint venture between subsidiaries of Valero and Darling Ingredients.


**Figure 1**. The Diamond Green Diesel Facility in Norco, Louisiana. (Credit: Valero)

On the day of the incident, a contract worker used steam to heat the contents of a railcar to facilitate its unloading into process equipment. After the railcar was unloaded, the worker needed to remove the steam and condensate hoses from the railcar (**Figure 2**). The contractor verified that the steam and condensate isolation valves were closed and that steam was no longer draining from the condensate drain valve. While removing the steam hose from under the railcar, the contractor was sprayed with steam and hot condensate. The contractor was transported and admitted to a hospital for treatment.

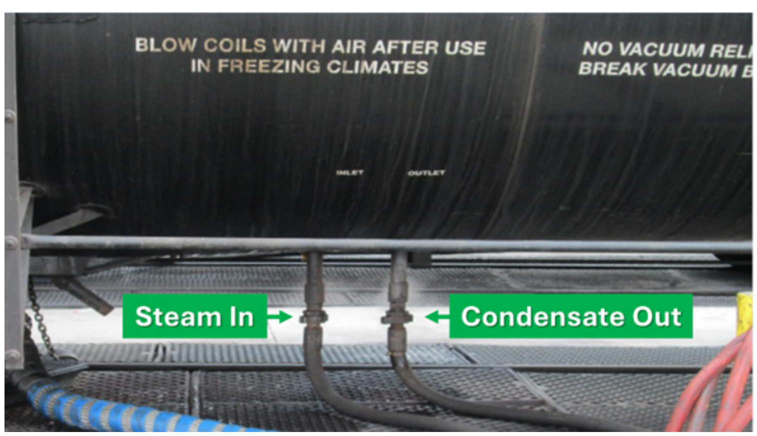


**Figure 2.** A photo showing the railcar's steam and condensate hose connections. (Credit: DGD, modified by the CSB)

DGD's investigation identified that the typical practice used at the facility to isolate and depressurize the steam hose was to close Valve A (**Figure 3**) while having Valve B (**Figure 3**) and Drain Valve 1 (**Figure 3**) open to allow residual steam to flow out of the hose (**Figure 3**). However, Valve A was broken in the open position and could not be closed. Instead, the contract worker closed Valve B, left Drain Valve 1 closed, and opened Drain Valve 2 (visually obstructed in **Figure 3** by the steam supply hose) to drain both the condensate hose and the steam hose. Because of how the heating coil was configured within the railcar, this configuration trapped condensate in the steam hose.

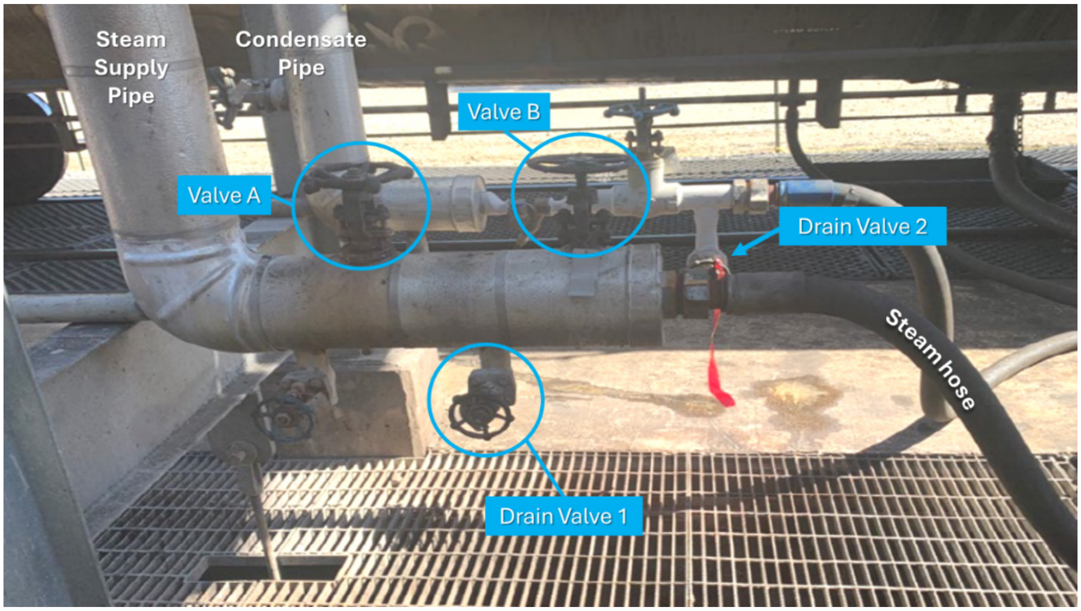


**Figure 3.** Valve configuration to isolate and depressurize the steam and condensate hoses. (Credit: DGD, modified by the CSB)

DGD's investigation found that when workers first identified the broken valve (Valve A), they should have used stop work authority to prevent the unloading equipment from being used until the valve was repaired. The company's investigation also concluded that its written operating procedure did not effectively describe the process of draining steam or hot condensate from the railcar. In addition, the procedure did not explain how to verify that there was no pressure on the steam or hot condensate hoses. No instruments (such as a pressure gauge) or other safeguards were available to warn workers that the steam hose contained a dangerous amount of condensate.

## Probable Cause

Based on DGD's investigation file, the CSB determined that the probable cause of the incident was disconnecting a hose from a railcar that contained steam and hot condensate. A broken isolation valve on the steam supply piping changed how the steam and condensate hoses were isolated and drained, contributing to the incident. The lack of instrumentation or other safeguards to warn employees that the loading hose held a dangerous amount of condensate contributed to the incident.

# 6. Marathon

**February 21, 2022**

**Garyville, Louisiana**

## Incident Summary

On February 21, 2022, at 9:22 a.m., a large jet fire occurred at the Marathon Petroleum Company LP ("Marathon") Refinery in Garyville, Louisiana, after a vacuum ejector ruptured within a hydrocracker unit at the refinery (**Figure 1**). Marathon estimated that the fire caused approximately $54 million in property damage.

**Figure 1.** Fire at the Marathon Refinery in Garyville, Louisiana. (Credit: Marathon)

On the day of the incident, Marathon restarted the hydrocracker unit following a maintenance turnaround. Marathon's pre-startup work included flowing nitrogen through the equipment to remove air (oxygen) that entered when the equipment was opened for maintenance. Marathon's equipment for removing air included a vacuum ejector (**Figure 2**). A vacuum ejector is a stationary device that utilizes a high-velocity fluid, such as steam, to create a low-pressure area at a specified location. Even though the vacuum ejector was not operating, nitrogen still was flowed through it to remove air from the equipment.

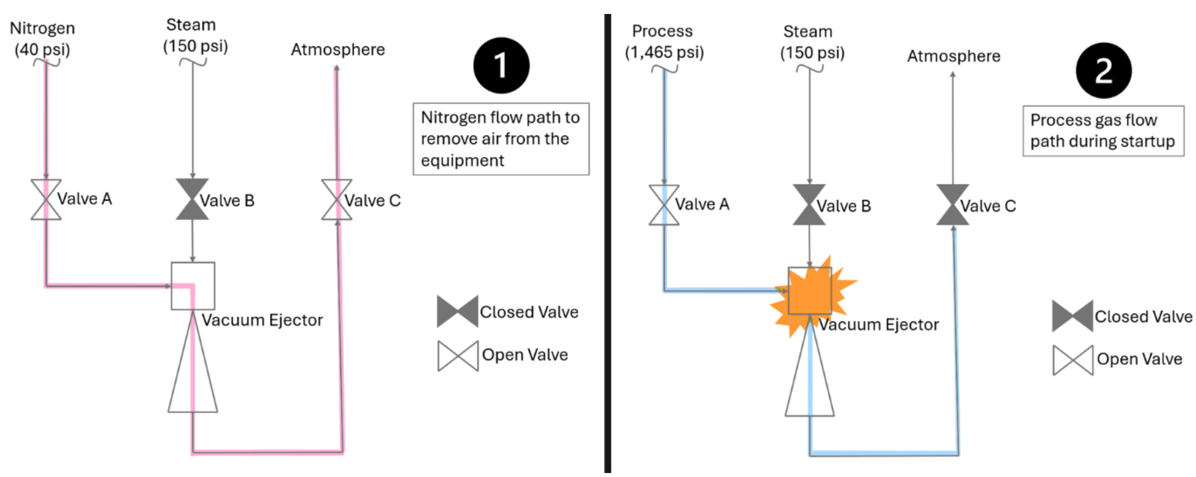


**Figure 2.** A simplified drawing of the vacuum ejector and relevant valve positions during air removal (1) and startup (2). (Credit: CSB)

After the operators completed the air removal step, the hydrogen and hydrocarbon flows were initiated, which increased the pressure inside the unit's equipment. At 9:22 a.m., the vacuum ejector ruptured, releasing a flammable gas mixture mainly composed of methane and hydrogen that ignited, resulting in a large fire. Emergency responders closed Valve A (**Figure 2**) to stop the release of flammable gas and successfully extinguished the fire at 12:27 p.m., roughly three hours after it began. Marathon estimated that approximately 7,000 pounds of flammable gas were released.

Marathon's investigation determined that after the air removal step was completed, an operator closed Valve C, but Valve A remained open. During the startup, this valve alignment allowed process gas to enter and pressurize the vacuum ejector to approximately 1,465 pounds per square inch (psi). The pressure ruptured the vacuum ejector, which had a design pressure of 360 psi. Marathon concluded that the flammable gas was ignited by a spark created when the vacuum ejector ruptured or from static electricity.

Marathon's investigation identified that the startup procedure did not include the necessary actions to protect the vacuum ejector from high-pressure conditions after operators completed the air removal step. In addition, Marathon found that the process hazard analysis had not identified the potential for overpressurizing the vacuum ejector.

## Probable Cause

Based on Marathon's investigation, the CSB determined that the probable cause of the incident was not isolating the vacuum ejector from the high-pressure process gas before startup. As a result, the flammable process gas overpressurized and ruptured the vacuum ejector, resulting in a large fire. Marathon could have prevented the incident by eliminating the vacuum ejector from the process since it was no longer in use, thereby avoiding the rupture, the flammable gas release, and ultimately the fire. Alternatively, the company could have installed a blind or a blind flange at the high-pressure isolation valve (Valve A) after the air removal step and before startup, which would have protected the vacuum ejector and prevented the incident.

# 7. Northrop Grumman

**January 30, 2023**

**Magna, Utah**

## Incident Summary

On January 30, 2023, at approximately 5:30 p.m., argon gas was released at the Northrop Grumman Systems Corporation ("Northrop Grumman") Bacchus Propulsion Systems facility in Magna, Utah (**Figure 1**). Exposure to the argon gas fatally injured two Northrop Grumman employees, who asphyxiated.

Northrop Grumman treated carbon fiber blocks at the Magna facility. As part of the treatment, a specialized vessel (autoclave) containing carbon fiber blocks was pressurized with argon gas. On the day of the incident, two employees were working to locate argon leaks and troubleshoot the vessel's pressure control system. During this work, the autoclave did not contain carbon fiber blocks. Throughout the workday, the vessel was pressurized with argon gas several times, but the task was not completed by the end of the employees' shift. The employees changed out of their work clothes and removed their personal oxygen monitors. However, before meeting with the oncoming shift workers, the two employees returned to the basement. The crew arriving for the next shift found their two coworkers unconscious in the basement's stairway. Emergency responders transported the two employees to the hospital, where they were declared deceased.


**Figure 1.** The Northrop Grumman Facility in Magna, Utah. (Credit: KSL News Utah)

Northrop Grumman's investigation found that argon had leaked through the seals of the pressurized vessel while the basement's ventilation system was off, which allowed the basement (about 4,500 cubic feet) to begin to fill with argon and create an oxygen-deficient atmosphere. The company's investigation did not determine why the two employees returned to the basement at the end of their shift, however. After the incident, Northrop Grumman classified the basement as a confined space and installed an oxygen monitoring system. The company also implemented safeguards to prevent entry into the basement when the oxygen concentration is unsafe, the exhaust ventilation fan is off, or the vessel is pressurized.

## Probable Cause

Based on Northrop Grumman's investigation, the CSB determined that the probable cause of the incident was the release of argon gas from the autoclave into a confined area. The two workers were fatally injured when they entered this oxygen-deficient environment. The lack of effective engineering controls, such as forced air ventilation and continual oxygen monitoring, contributed to the severity of the incident.

## 8. Atalco

**February 6, 2023**

**Gramercy, Louisiana**

### Incident Summary

On February 6, 2023, at 8:15 a.m., a release of a hot sodium hydroxide and water solution ("caustic slurry") seriously injured two employees at the Atalco Gramercy aluminum refinery ("Atalco") in Gramercy, Louisiana (**Figure 1**).

**Figure 1.** The Atalco facility in Gramercy, Louisiana. (Credit: Louisiana Illuminator)

On the morning of the incident, a team of operators was assigned to drain hot caustic slurry, at a temperature of approximately 195 degrees Fahrenheit (°F), from a tank with an open-top design. The operators closed the tank's steam injection control valve before beginning the draining operation. During their initial attempt to drain the tank, the operators determined that the drain piping was blocked. They used compressed air to blow through the drain piping to clear the blockage. However, when they directed the air into the piping, caustic slurry erupted from the tank's open top. The hot, corrosive liquid splashed onto two of the operators. After they washed off in a safety shower, the two operators were transported to a hospital, where they were admitted for treatment of their burn injuries. Atalco reported that approximately 80 gallons of caustic slurry had been released during the incident.

Atalco's investigation revealed that bauxite ore had accumulated in the tank and blocked the drain piping. Additionally, although the steam control valve was closed, it was leaking, which resulted in the tank's contents being heated beyond the target temperature of 180°F. The investigation also found that no isolation device was installed to prevent the air injected into the drain piping from entering the tank. Furthermore, it was noted that some operators were not wearing the required chemical suits while clearing the pipes. Among the injured operators, one wore the required chemical suit, goggles, and rubber gloves, while the other wore goggles and rubber gloves but not the chemical suit.

## Probable Cause

Based on Atalco's investigation, the CSB determined that the probable cause of the incident was flowing compressed air into the bottom of an open-top caustic slurry tank. The air created a geyser-like eruption of hot (195°F) caustic slurry that sprayed onto two operators, resulting in serious burn injuries. The lack of an isolation device between the tank and the air injection location, as well as the lack of an effective procedure to clear the drain piping, contributed to the incident.

## 9. SABIC

**December 10, 2023**

**Mt. Vernon, Indiana**

### Incident Summary

On December 10, 2023, at 3:38 p.m., two explosions and a fire occurred in a polymer reactor at the Saudi Basic Industries Corporation ("SABIC") facility in Mt. Vernon, Indiana. Property damage was estimated at $3.5 million.

Three months prior to the incident, on September 18, SABIC had shut down its polybutylene terephthalate resin unit for scheduled maintenance. On the day of the incident, the maintenance work was nearing completion, and SABIC was preparing the unit's reactor system for startup. At 3:38 p.m., a heat exchanger exploded, ejecting several equipment fragments, including one that landed approximately 505 feet away near the facility's boundary along the Ohio River (**Figure 1**). A second explosion and flash fire soon followed, rupturing a reactor (**Figure 2**).


**Figure 1.** Location of one equipment fragment after the initial explosion. (Credit: SABIC)

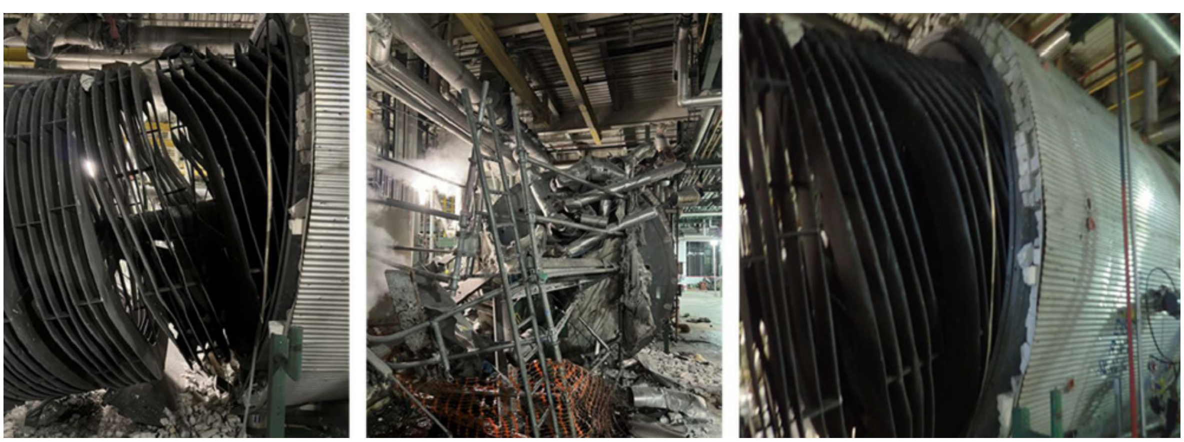

**Figure 2.** Post-incident images of the damaged reactor. (Credit: SABIC)

SABIC's investigation concluded that the initial explosion in the heat exchanger was caused by the rapid, energetic decomposition of unstable organic peroxide that had formed and accumulated inside the equipment. The second explosion and flash fire, which destroyed the reactor, was caused by heat from the first explosion igniting flammable tetrahydrofuran vapor inside the reactor.

The exchanger and reactor were interconnected, with no isolation between the two pressure vessels. The design of the reactor's outlet piping retained liquid in the piping. Because the piping could not fully drain, it contained polybutylene terephthalate polymer, butanediol, and tetrahydrofuran when the unit was shut down on September 18, 2023.

On December 10, SABIC began pre-startup activities. At 3:16 a.m., SABIC began flowing hot oil through the tracing used to heat the reactor's outlet piping. As the piping heated, the residual hydrocarbon material also heated, evolving tetrahydrofuran vapor that flowed into the reactor and the heat exchanger. A 3-inch nozzle on the heat exchanger remained open to ambient air, allowing oxygen into the reactor system. The tetrahydrofuran vapor reacted with available oxygen to form an organic peroxide compound. The organic peroxide continued to form for another 12 hours, until it exploded in a rapid decomposition reaction at 3:38 p.m. The heat from the explosion ignited additional flammable tetrahydrofuran inside the reactor, triggering the second explosion and a flash fire.

SABIC's investigation found that the company's historical practice of leaving residual hydrocarbon material in the reactor's outlet piping during shutdown created hazards that were neither recognized nor controlled. The reaction of tetrahydrofuran with oxygen produced the explosive organic peroxide. Before the incident, SABIC personnel had assumed that the cooled, solidified material could remain in the reactor's outlet piping because it was not hazardous, creating a false sense of safety.

SABIC's investigation also found that a change to the reactor's leak-testing procedure contributed to the incident. Previously, the reactor was leak-tested online under vacuum. SABIC switched to using pressurized nitrogen and moved the test into the maintenance outage. A management of change review had been approved to allow a leak test of the reactor during pre-startup activities. However, the review did not assess how the leak test might adversely affect those activities.

When the hot oil heated the reactor's outlet piping, the procedure required adding nitrogen to the reactor system. However, the nitrogen flow was omitted due to the modified leak test. The company's investigation concluded that the risk of performing simultaneous tasks during startup had not been evaluated.

## Probable Cause

Based on SABIC's investigation, the CSB determined that the probable cause of the incident was heating the reactor's outlet piping containing solidified polybutylene terephthalate polymer, butanediol, and tetrahydrofuran while a nozzle on an interconnected heat exchanger was open, allowing oxygen (air) to enter the equipment. These conditions generated tetrahydrofuran vapor, which reacted with oxygen to form an explosive organic peroxide, and also created a flammable atmosphere in the equipment, which then ignited and exploded after the organic peroxide energetically decomposed. The management of change review SABIC conducted for the reactor's leak testing did not assess how the leak testing might affect the simultaneous pre-startup tasks, contributing to the incident. As a result, there was no nitrogen flow through the reactor system, allowing unstable peroxide to form and developing flammable conditions within the equipment.

# 10. PBF Energy

**February 22, 2024**

**Chalmette, Louisiana**

## Incident Summary

On February 22, 2024, at 4:20 a.m., a valve leaked hot liquid hydrocarbon, which ignited, resulting in a fire at the Chalmette Refining, L.L.C. refinery, a subsidiary of PBF Energy, in Chalmette, Louisiana (**Figure 1**). PBF Energy estimated that the fire caused $1.2 million in property damage.

**Figure 1**. The PBF Energy refinery in Chalmette, Louisiana. (Credit: Petronoticias)

On the morning of the incident, unit operators saw a decrease in the crude unit's vacuum tower bottoms (VTB) flow. Field operators then found a fire near the flow control valve. Emergency responders extinguished the fire within minutes. PBF Energy reported that approximately 12,000 pounds of VTB material were released.

PBF Energy's investigation found that a recently installed 4-inch stainless steel globe valve in the VTB flow control station bypass piping had leaked at its pressure-retaining cover (bonnet). The valve had a Teflon (PTFE) bonnet gasket and Teflon packing, which were limited to 450 degrees Fahrenheit (°F), and were incompatible with the 650°F VTB material. The valve was ordered in August 2023 and installed during a unit outage on February 16, 2024, six days before the incident.

The valve was equipped with two tags that provided conflicting information (**Figure 2**). When PBF Energy ordered the valve from its preferred vendor, the order included the refinery's valve number, which specified a valve that met the process requirements by using graphite for the bonnet gasket and packing material. Teflon was not an acceptable material for this application.

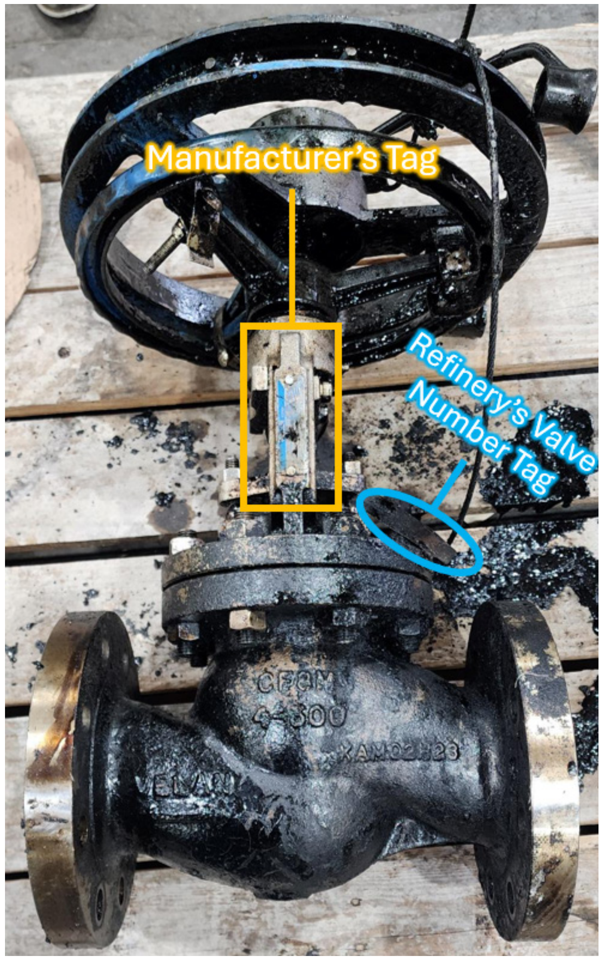


**Figure 2**. Tags on Incident Valve. (Credit: PBF Energy, modified by CSB)

PBF Energy's preferred vendor did not have this valve in its inventory, so it procured the valve from a third-party supplier. The manufacturer's tag attached to the valve correctly indicated that it was equipped with Teflon components and stated that the valve's maximum operating temperature was 450°F. However, the third-party supplier wired an additional tag stamped with the refinery's valve number to the valve, incorrectly identifying the valve as having graphite components. Refinery personnel accepted and installed the valve based on the order and receipt documentation, along with the valve's size, flange rating, and the refinery valve number.

## Probable Cause

Based on PBF Energy's investigation, the CSB determined that the probable cause of the incident was the installation of a valve with Teflon components that could not withstand the process temperature. PBF Energy could have prevented the incident by confirming that the manufacturer's tag indicated that the valve was assembled with the proper components and that the valve's design temperature was compatible with the vacuum tower bottoms temperature. Contributing to the incident was the third-party supplier's tag, which incorrectly identified the valve as having graphite components.

## 11. Formosa

October 8, 2024

### Baton Rouge, Louisiana

## Incident Summary

On October 8, 2024, at 8:15 p.m., a cylinder containing approximately 150 pounds of liquid anhydrous ammonia exploded, seriously injuring four employees at the Formosa Plastics Corporation's facility ("Formosa") in Baton Rouge, Louisiana.

On the day of the incident, Formosa planned to introduce anhydrous ammonia into equipment as part of a chemical treatment in preparation for turnaround maintenance work (**Figure 1**). To supply the ammonia, Formosa used a cylinder (DOT 4AA480) that contained approximately 150 pounds of liquid anhydrous ammonia ("cylinder"). The operations team wrapped the lower half of the cylinder with a rubber hose. This was done to allow steam to flow through the hose, enhancing heat transfer and preventing ice from forming on the cylinder's external surface as the liquid ammonia inside vaporized. The steam supply was approximately 300 degrees Fahrenheit and had a pressure of about 70 pounds per square inch (psi). While the valve on the cylinder remained closed, one of the operators opened the steam supply valve to initiate steam flow through the hose while continuing preparations for the chemical treatment. As the workers continued the equipment setup, the cylinder exploded, seriously injuring three operators and an operations supervisor (**Figure 2**). Emergency responders transported the four injured employees to a hospital, where they were admitted for treatment.

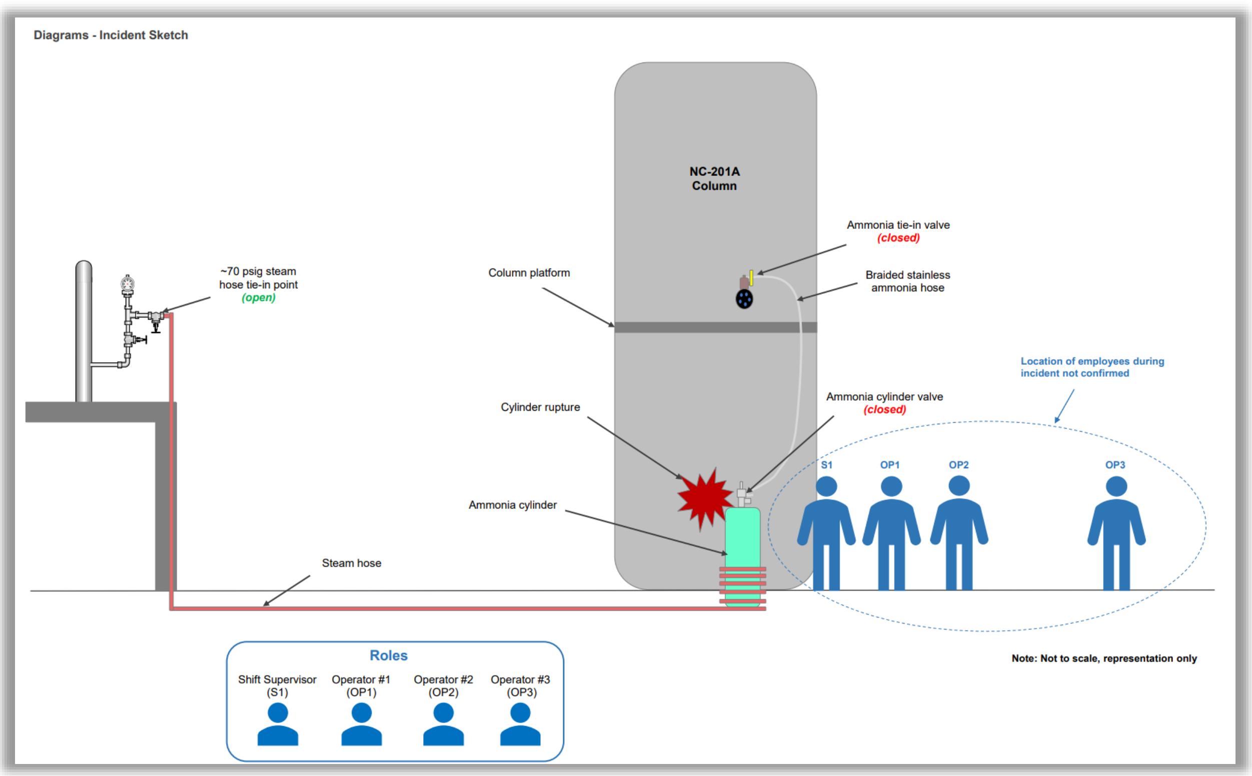


**Figure 1**. Sketch showing a simplified process diagram and the people injured by the explosion. (Credit: Formosa)


**Figure 2.** Photos showing damaged and exemplary cylinders. (Credit: Formosa)

Formosa's investigation determined that the procedure used for the chemical treatment did not cover critical safety details, such as not heating the cylinder when its outlet valve was closed. In addition, Formosa found that the cylinder was not protected by a pressure relief device. When the cylinder was heated, the pressure exerted by the liquid ammonia inside the cylinder significantly increased far above the cylinder's service pressure of 480 psi, resulting in a boiling liquid expanding vapor explosion (BLEVE).

## Probable Cause

Based on Formosa's investigation, the CSB determined that the probable cause of the incident was the uncontrolled external heating of a liquefied compressed gas cylinder without essential safeguards, including an emergency pressure-relief device. The uncontrolled heating generated tremendous internal pressure, causing the cylinder to explode. Formosa's process safety management systems contributed to the incident by not effectively evaluating and controlling the hazards presented by its anhydrous ammonia chemical treatment system.

## 12. PBF Energy

**February 1, 2025**

**Martinez, California**

### Incident Summary

On February 1, 2025, around 1:36 p.m., an explosion and fire occurred at the Martinez Refining Company refinery in Martinez, California (**Figure 1**), a subsidiary of PBF Holding Company LLC ("PBF Energy"). PBF Energy estimated that the incident caused approximately $924 million in property damage.

**Figure 1.** Fire at the Martinez Refining Company refinery in Martinez, California. (Credit: San Francisco Chronicle)

On February 1, 2025, PBF Energy tasked contract workers with installing an isolation blind at Flange A (**Figure 2**) to prepare a catalytic feed hydrotreater unit ("unit") for turnaround maintenance. A yellow tag was placed between Valve 2 and Valve 3 to indicate the location of the blind installation. After completing a field walkthrough to verify that the piping segment between Valve 1 and Valve 2 was empty, an operator issued a permit to the supervisor of the contractor work crew at 11:30 a.m.

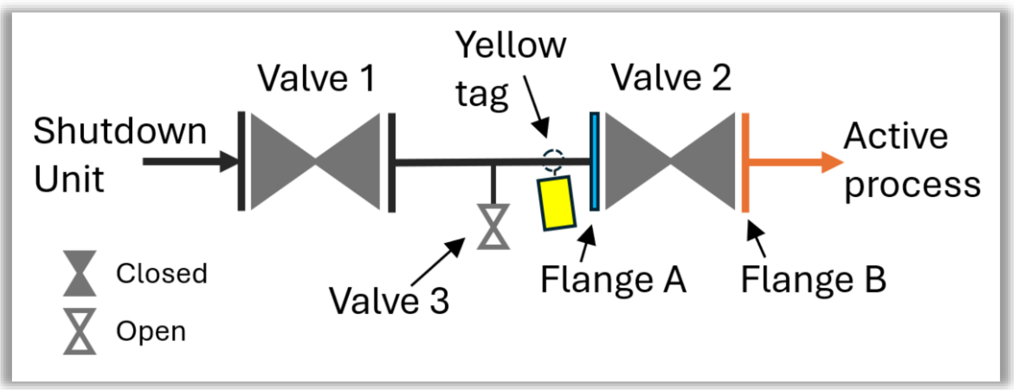


**Figure 2.** Existing isolation before blind installation (objects not to scale). (Credit: CSB)

When the work started, two contract workers were on a scaffold that provided access to the elevated equipment. In addition to their standard protective equipment, the two workers wore supplied-air respirators. Two standby workers from a different contract company were at ground level to monitor the breathing air equipment and observe the flange opening work. At approximately 1:25 p.m., the two contract workers began unbolting Flange B. At this time, neither the workers' supervisor nor the operator who issued the permit for the contractors to install the blind was present.

As Flange B was being unbolted, the contract workers' supervisor returned to the work area. From his vantage point, the supervisor could not see which flange the crew was working on. Shortly thereafter, the supervisor observed and heard a pressurized release and recognized that something was wrong. One of the standby workers activated an air horn to stop the work. The two contract workers disconnected from their supplied-air hoses, jumped from the scaffold, and evacuated the area. At about 1:30 p.m., the flammable material ignited and exploded with flames erupting from the area. Hot (above 600 degrees Fahrenheit) hydrocarbon material continued to be released from Flange B, fueling the fire. The extent of the fire escalated over three days and involved other equipment until emergency responders extinguished the fire on February 4, 2025. PBF Energy reported that approximately 50,000 gallons of flammable hydrocarbon material were released over three days.

PBF Energy's investigation found that the contract workers, hired specifically for the extra tasks during the turnaround, had not received training on the refinery's equipment opening policies and procedures. Consequently, these workers were not aware of PBF Energy's tagging system for identifying which flange should be opened. The company's investigation also revealed that installing this blind should have been treated as a "first break" (as written on the permit) under the refinery's policies, because this was the initial equipment opening for this system. First breaks required a qualified operator to be present during the work to ensure that maintenance workers open the proper equipment. However, because of a miscommunication between the workers, the operator was not present when the contract workers disassembled Flange B.

PBF Energy required maintenance crews to attach their personal locks or tags to all valves used for equipment isolation. The contractor crew did not apply locks or tags to Valve 1 or Valve 2. If the crew had done so, they could have had the opportunity to better understand the existing hazards by participating in the lockout/tagout process for these valves. The permit issued to the contractor supervisor stated that the equipment was out of service. The supervisor believed that all the equipment was empty and was unaware of the active (operating) process adjacent to Valve 2.

Because the work was on a scaffold, laser pointers were used to highlight Flange A during the field walk-throughs involving the operator, contract workers, and the contractor's supervisor. Although post-incident interviews with the operator and the contractor's supervisor revealed that two of the four walkdown participants understood that the blind should be installed in Flange A, it is evident that the contract workers believed that Flange B was the correct location.

Following the incident, PBF Energy revised its permitting procedure. For permits that require an operator to be present, operators must now issue one permit per isolation blind only after the workers are at the job site and prepared to start the task. This change was made to help ensure an operator is present to confirm that work is performed on the correct equipment.

## Probable Cause

Based on PBF Energy's investigation, the CSB determined that the probable cause of the incident was the opening of a flange that was connected to an active process containing pressurized flammable liquid hydrocarbon. When the flange was loosened, the flammable material was released and ignited (autoignition or static discharge), resulting in a large fire. PBF Energy could have prevented the incident by having a knowledgeable person present to ensure that workers unfamiliar with the equipment disassembled the correct flange and were aware of the existing hazards. Additionally, PBF Energy would benefit from improving its tagging practice to make it obvious which equipment workers should disassemble.

## 13. Olin

**May 20, 2025**

**Freeport, Texas**

### Incident Summary

On May 20, 2025, at approximately 8:15 a.m., approximately 8,000 pounds of toxic chlorine were released, seriously injuring one employee at the Olin Corporation ("Olin") facility in Freeport, Texas (**Figure 1**), operated by Blue Cube LLC, an Olin subsidiary. The community was ordered to shelter in place, and Olin estimated that the incident resulted in approximately $23 million in property damage.


**Figure 1**. Images of the Chlorine release at the Olin facility in Freeport, Texas. (Credit: KHOU)

On the day of the incident, Olin planned to replace a rupture disc (RD-217N) in the chlorine liquefication unit. This safety device protected the E-209A heat exchanger (**Figure 2**).

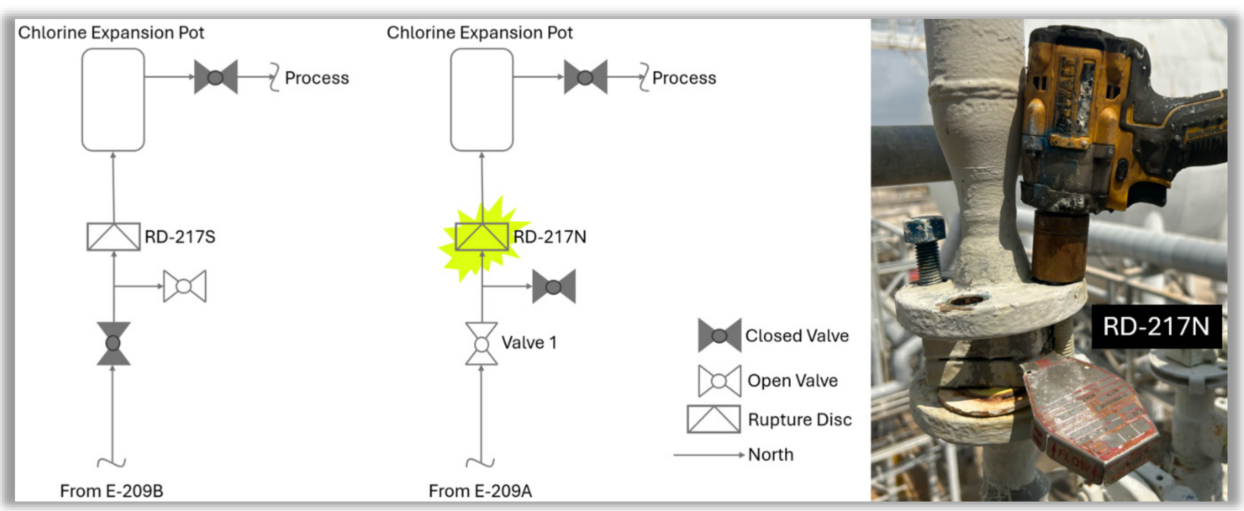


**Figure 2**. Simplified equipment drawing (left) showing the relevant equipment and valve positions before the rupture disc replacement work began, and a post-incident photo of RD-217N (right). (Credit: CSB (left), Olin (right).

Olin gave two contract maintenance workers the work package and a permit to replace the RD-217N rupture disc. At approximately 8:10 a.m., one of the maintenance workers began disassembling the RD-217N rupture disc holder using a battery-powered impact wrench. In addition to the standard protective equipment, the maintenance worker wore an air-supplying respirator with a 30-minute air bottle. At 8:15 a.m., liquid chlorine at a pressure of 100 pounds per square inch began releasing from the partially disassembled RD-217N rupture disc holder. The maintenance workers evacuated from the area. Alarm horns in the unit were activated after chlorine gas detectors identified the release. Local officials issued a shelter-in-place order for the cities of Clute and Lake Jackson. At 9:03 a.m., emergency responders closed Valve 1 to stop the release.

During the response to the incident, one emergency responder's 30-minute air supply depleted. He switched to a cartridge-style escape respirator to exit the area, but the respirator likely became saturated with chlorine, causing him to inhale the toxic vapor. Other emergency responders then transported him to a hospital, where he was admitted for treatment.

Olin's investigation found that although the work planning documents showed that RD-217N was to be replaced, Olin's operations team had mistakenly isolated, cleared, and tagged a different but nearly identical piping system—heat exchanger E-209B—to replace a different rupture disc, RD-217S. As a result, the Olin operations team did not isolate, clear, or tag the E-209A heat exchanger and the piping associated with RD-217N. This equipment was operating when Olin issued the contract workers a permit to replace the RD-217N rupture disc. The unit operator who issued the permit and the maintenance workers did not perform a field walk-through of the job. In addition, the contract workers did not review or sign the equipment isolation plan or the tag that identified the rupture disc holder to be opened. Seeking to do so should have revealed that RD-217N was in operation and had not been prepared for replacement.

## Probable Cause

Based on Olin's investigation, the CSB determined that the probable cause of the chlorine release was the mistaken disassembly of a rupture disc holder in an operating chlorine system. A breakdown in Olin's equipment opening and control of work programs contributed to the incident, including the absence of a pre-job site walkthrough that should have allowed plant operators and the maintenance crew to verify the rupture disc had been prepared for replacement.

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