U.S. Chemical Safety and Hazard Investigation Board

CSB Safety Alert

Hazards Posed by Dishcarges from Emergency Pressure-Relief Systems

Introduction

Effective emergency pressure-relief systems protect equipment from unexpected and undesired high-pressure events. These events can seriously harm or fatally injure workers, damage critical equipment, and cause significant off-site impacts. Emergency pressure-relief systems are the last line of defense to prevent equipment rupture by lowering internal pressure. This is accomplished by transferring material that is often flammable, toxic, or otherwise hazardous to a safe location.

Consistent with Occupational Health and Safety Administration (OSHA) rules,[1] employers must provide a safe workplace. As such, workers should reasonably expect that they are not in harm's way when working in the vicinity of pressurized equipment. Community members likewise should reasonably expect companies to have thoroughly evaluated the safety of the equipment at their facilities. The U.S. Chemical Safety and Hazard Investigation Board (CSB) has found, however, that harmful incidents involving the discharge of flammable and toxic chemicals from emergency pressure-relief systems are still occurring too frequently.

Ensuring that emergency pressure-relief systems discharge to a safe location is not a new safety lesson. Numerous chemical disasters involving the discharge of toxic or flammable materials from emergency pressure-relief systems have harmed or fatally injured people. These include the Union Carbide disaster in Bhopal, India in 1984, which ultimately resulted in thousands of fatalities, and the BASF tragedy in Cincinnati, Ohio, in 1990, which resulted in two fatalities and 41 injuries.

One of the worst industrial accidents in history, Bhopal involved the discharge of methyl isocyanate (MIC), a toxic chemical, from an emergency pressure-relief system that activated due to a runaway reaction that generated high-pressure conditions inside a storage tank. Hundreds of thousands of people were exposed to the dense lethal cloud that erupted from the storage tank's emergency pressure-relief system and drifted over the city of Bhopal. Following the toxic chemical release an estimated 3,800 people were killed almost instantly, and tens of thousands were injured. More than 20,000 people later died from illnesses attributed to the toxic gas exposure, while thousands more were injured.

The BASF incident occurred on July 19, 1990, when a release of flammable chemicals exploded, and a fire erupted, killing two workers and injuring 41 others at the BASF chemical manufacturing facility in Cincinnati, Ohio. The blast injured nearby residents and damaged more than 300 homes in the surrounding community. OSHA stated in its investigation that the explosion and fire followed a sequence of events where high-pressure conditions developed inside a reactor during

1. The General Duty Clause, Section 5(a)(1) of the Occupational Safety and Health Act, requires each employer to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm..."

a cleaning operation. Among other things, OSHA found that BASF failed to ensure that the reactor's emergency pressure-relief system discharged to a safe location. According to OSHA, when the emergency pressure-relief system was activated, it discharged a mixture of flammable chemicals into the plant, where it found an ignition source triggering a vapor cloud explosion.

Analyzing these past disasters to help inform present and future operations and prevent similar chemical disasters is extremely important. As process safety expert Trevor Kletz stated in his 1993 book *Lessons From Disaster: How Organizations Have no Memory and Accidents Recur*:

> **It might seem to an outsider that industrial accidents occur because we do not know how to prevent them. In fact, they occur because we do not use the knowledge that is available [1, p. 1].**

Several CSB investigations have also identified emergency pressure-relief systems that presented a safety hazard to both workers and the public. Some of these potential safety hazards existed for years and yet were never identified or corrected. This suggests that pressure-relief system discharge hazards may not be obvious to many workers, engineers, and managers.

This safety alert focuses on issues identified with emergency pressure-relief systems from four CSB investigations. These investigations are summarized herein to highlight recurring issues with discharge locations of pressure-relief systems. **These four chemical incidents alone resulted in 19 deaths and injuries to 207 people.**[2] Each of these incidents, while unique, was entirely preventable but resulted in worker deaths or severe injuries. As a result of its investigations of these incidents, the CSB issued 13 recommendations to address emergency pressure-relief system issues. As of the date of this publication, two of these recommendations remain open: one to Kuraray America, Inc. (issued in December 2022) and one to Veolia Environmental Services Technical Solutions (issued in July 2010). These recommendations, as well as those related to the 2010 Kleen Energy incident, are listed in Appendix A. Though not an emergency pressure-relief system incident, the Kleen Energy incident was a catastrophic natural gas explosion that occurred during the planned cleaning of fuel gas piping and resulted in six fatalities and at least 50 injuries. The Kleen Energy incident provides another stark example of the danger involved when flammable gas is not discharged to a safe location.

The CSB urges companies, regulators, and stakeholders to review these recommendations along with the key safety lessons at the end of this document. Site managers should thoroughly evaluate their emergency pressure-relief systems to ensure they **discharge to a safe location—where they will not harm people.** The CSB further urges companies to identify any emergency pressure-relief systems that are designed to discharge flammable or toxic materials into the air and consider directing these materials to a safer disposal system, such as a flare or scrubber.

2. While the 2014 incident at the DuPont La Porte facility contributed to these totals, that incident did not directly involve the discharge from an emergency pressure-relief system. The designs of emergency pressure-relief systems at the facility were identified as issues in the CSB's Interim Recommendations because the CSB's investigation found that a number of these systems were designed in such a way that endangered workers and the public.

These four chemical incidents alone resulted in

19 DEATHS

207 INJURIES

RELEVANT CSB INCIDENT INVESTIGATIONS

Kuraray Pasadena Release and Fire

PASADENA, TX | MAY 19, 2018

23 WORKERS INJURED

2 SERIOUSLY INJURED

On May 19, 2018, an ethylene release ignited (Figure 1), injuring 23 workers at the Kuraray America, Inc. (Kuraray) ethylene and vinyl alcohol copolymer plant in Pasadena, Texas. The CSB's animation of this event shows how this incident occurred during the startup of a chemical reactor system following a turnaround. High-pressure conditions developed inside the reactor and activated the reactor's emergency pressure-relief system, discharging flammable ethylene vapor horizontally into the ambient air in an area where a number of contractors were working (**Figure 2**). During the incident, approximately 2,350 pounds of ethylene were released in less than three minutes. Some workers in the immediate area of the discharge were forced to jump from the second or third story of the plant structure to escape. Others had to run from the area, suffering injuries while evacuating. Several workers were wearing fall protection equipment that physically attached them to structures in the area, delaying their escape from the fire and increasing the severity of their injuries.

The CSB determined the cause of the incident was Kuraray's long-standing emergency pressure-relief system design that discharged flammable ethylene vapor into the air through horizontally aimed piping that vented chemical vapors near workers. The CSB concluded that had Kuraray's emergency pressure-relief system discharged vapor from the reactor to a safe location, the flammable ethylene gas should not have harmed any workers. In addition, Kuraray's inconsistent practices for preventing nonessential personnel from being physically present in the unit during critical activities contributed to the injuries suffered.

CSB investigators also found that another emergency pressure-relief system from a different chemical reactor at the same Kuraray facility was designed to discharge reactor vapors, including ethylene, horizontally over a public road.

Learn more at https://www.csb.gov/kuraray-pasadena-release-and-fire/

Figure 2. Horizontally-aimed piping from Kuraray's emergency pressure-relief system.

Figure 1. Images from the CSB's animation of the ethylene release and fire at Kuraray.

DuPont La Porte Facility Toxic Chemical Release

LA PORTE, TX | NOVEMBER 15, 2014

4

WORKERS FATALLY INJURED

On November 15, 2014, approximately 24,000 pounds of highly toxic methyl mercaptan were released from an insecticide production unit at the E.I. du Pont de Nemours and Company (DuPont) chemical manufacturing facility in La Porte, Texas. The release fatally injured three operators and a shift supervisor inside a manufacturing building. During the early phases of the investigation, CSB investigators identified a number of worker safety issues—separate from the release scenario—that prompted the CSB to issue interim recommendations to the facility's management team. The CSB identified several emergency pressure-relief systems that were designed to discharge hazardous materials to areas that posed a risk to workers and the public. The CSB concluded that DuPont did not effectively evaluate relief valve scenarios and discharge location safety

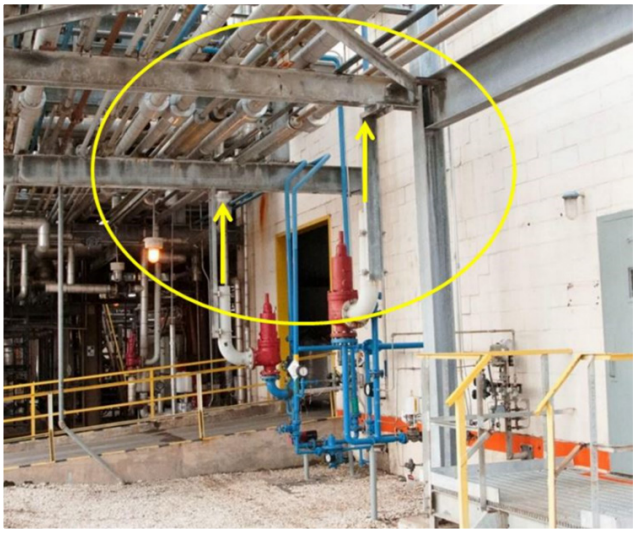

Figure 4. Overhead obstructions above nitrogen relief valves at DuPont. Pressure-relief valves relieving to the atmosphere, and the relief valve discharge path, are indicated by the yellow annotations.

Figure 3. DuPont's uninsulated methyl mercaptan storage tank. Pressure-relief valves relieving to the atmosphere are circled in yellow.

to ensure that the community, workers, and the environment were protected. For example:

- The CSB's Interim Recommendations documented that the emergency pressure-relief system for DuPont's 18,000-gallon methyl mercaptan storage tank exposed workers and the public to unacceptable risk (**Figure 3**). Had this safety system activated, a life-threatening concentration of methyl mercaptan could have endangered the neighboring community. To mitigate this risk, DuPont had insulated the tank to reduce the amount of toxic gas that would be released during a fire rather than installing a more costly scrubber system, but this protective insulation was later removed. The CSB found that DuPont lacked a technical basis or management approval for removing the insulation.
- CSB investigators identified nitrogen relief valves that discharged directly under a pipe rack in close proximity to worker entry and exit points for a building that workers frequently accessed (**Figure 4**). Structural supports and piping above the discharge point could impair dispersion of discharged nitrogen, potentially creating an asphyxiation hazard to workers as they approached or exited the building.

- CSB investigators identified that a methyl mercaptan pump, which fed the process, was equipped with a relief valve that enabled it to discharge highly toxic, highly flammable liquid that would readily vaporize near the ground in the immediate vicinity of where an operator would be located when starting this pump (**Figure 5**).
- On December 16, 2014, while the CSB was investigating the November incident, highly toxic chlorine gas was released from a caustic scrubber relief valve during a planned operation to vent chlorine and disconnect and relocate a chlorine railcar from the process. DuPont documentation indicated that the relief valve discharge piping was 10 feet above the work platform. The CSB noted that while this 10-foot vertical safety margin existed for the immediate work platform, there were several other adjacent work platforms above the relief valve discharge piping (**Figure 6**). These adjacent work platforms were not safe locations for workers because highly toxic gas could discharge toward them. Had workers been on these platforms at the time of the incident, they could have been exposed to toxic chlorine vapor.

The CSB concluded that DuPont did not effectively evaluate relief valve scenarios and discharge location safety to ensure that workers and the community were protected from process safety hazards. The CSB recommended that DuPont thoroughly evaluate the design and discharge locations of all emergency pressure-relief systems for safety. In 2016, DuPont notified the CSB that it made the decision not to restart the Insecticide and Herbicide Business Units, and this recommendation was closed as No Longer Applicable.

Learn more at https://www.csb.gov/dupont-la-porte-facility-toxic-chemical-release-/

Figure 5. Liquid methyl mercaptan relief valve designed to discharge to grade at DuPont. The relief valve and discharge path are indicated by the yellow annotations.

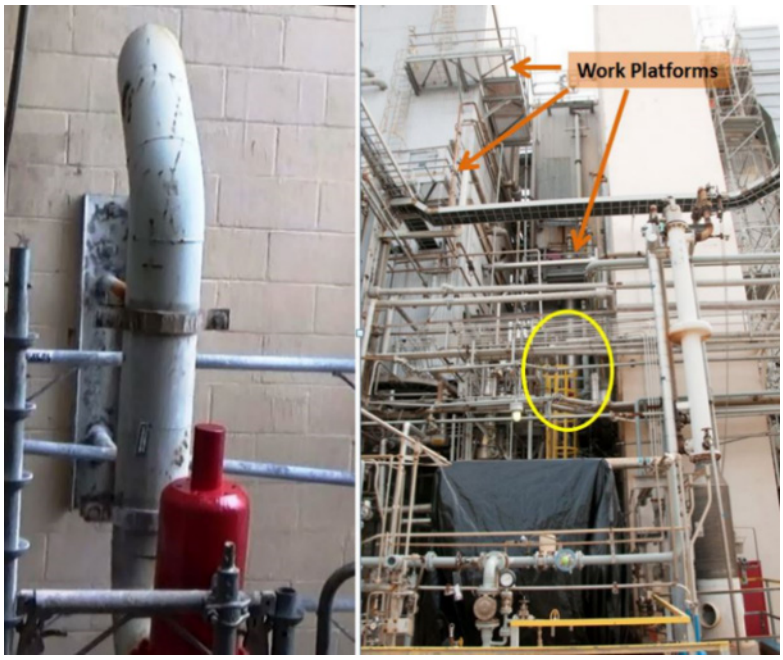

Figure 6. Chlorine gas discharged from this pressure-relief system below work platforms and in a congested area at DuPont. The relief valve location is circled in yellow.

Veolia Environmental Services Flammable Vapor Explosion and Fire

WEST CARROLLTON, OH | MAY 4, 2009

4 WORKERS INJURED

2 SERIOUSLY INJURED

On May 4, 2009, highly flammable vapor released from a waste recycling process, ignited, and violently exploded at Veolia ES Technical Solutions, LLC (Veolia), in West Carrollton, Ohio. The incident injured four employees, two seriously. The multiple explosions that occurred following the initial explosion significantly damaged every structure on the site. Residences and businesses in the surrounding community also sustained considerable damage. The CSB concluded that uncontrolled venting from relief valves to the atmosphere allowed tetrahydrofuran (THF) vapors to accumulate to explosive concentrations outside process equipment, and the vapors subsequently found an ignition source.

The CSB made a recommendation to Veolia to design and install a closed relief system during the facility's rebuilding process and develop a policy for safe venting (such as using a flare) of relief systems to the atmosphere. In response, Veolia informed the CSB that during the retrofit of the facility, vents and other relief devices were evaluated during the design process to ensure potential discharges were directed to safe locations. The CSB determined that the rebuild did not meet the CSB's recommendation, and the recommendation status is currently **"Open – Unacceptable Response/ No Response Received."**

Learn more at https://www.csb.gov/veolia-environmental-services-flammable-vapor-explosion-and-fire/

BP America Refinery Explosion

TEXAS CITY, TX | MARCH 23, 2005

15
WORKERS FATALLY INJURED

180
SERIOUSLY INJURED

On March 23, 2005, during the startup of an isomerization unit following a maintenance turnaround, a series of explosions occurred at the BP refinery in Texas City, Texas. The incident fatally injured 15 workers and injured an additional 180 workers. During the startup, a distillation tower flooded with flammable hydrocarbons and was over-pressurized, activating the tower's emergency pressure-relief system, which created a geyser-like release from the vent stack (**Figure 7**) and formed a flammable vapor cloud that soon ignited and exploded.

As a part of its investigation, the CSB evaluated the 1997 edition of American Petroleum Institute (API) Recommended Practice (RP) 521 (API 521), *Guide for Pressure-relieving and Depressuring Systems*, which was the generally accepted industry good practice guidance for pressure-relieving and disposal systems at the time. The CSB identified several gaps in the guidance and noted in its investigation report that the 1997 edition of API 521 did not address the potential overpressure hazard of vessel liquid overfill or the hazard of a large liquid release to a disposal drum that vents directly to the atmosphere. Additionally, API 521 did not address the safe siting of a vent stack or flare. API 521 also did not address the concept that a flare system is an inherently safer design than an atmospheric vent stack because it safely combusts flammable hydrocarbons before they are vented to the atmosphere, where they could become a serious fire or vapor cloud explosion hazard. The CSB recommended that API revise API 521 to, among other things, warn against the use of atmospheric blowdown drums and stacks attached to collection piping systems that receive flammable discharges from multiple relief valves. Following the CSB's recommendation, API strengthened API 521 from a recommended practice to a standard. API also issued updated versions of this industry standard in 2007 and again in 2014. The revisions included specifying what users must do to avoid or prevent a vapor cloud explosion scenario caused by emergency pressure-relief systems that discharge into the atmosphere.

Learn more at https://www.csb.gov/bp-america-refinery-explosion/

Figure 7. Image from the CSB's animation of the BP Texas City explosion.

KEY LESSONS

from incidents involving emergency pressure-relief systems

1. Follow existing good practice guidance.
API 521, *Pressure-relieving and Depressuring Systems*, is a Recognized and Generally Accepted Good Engineering Practice (RAGAGEP) standard that drives industry design of many emergency pressure-relief systems. API 521 addresses many concerns about releasing flammable vapor directly into the atmosphere and generally requires using inherently safer alternatives for toxic release scenarios or when the potential exists for a flammable vapor cloud explosion. API RP 14C, *Analysis, Design, Installation, and Testing of Safety Systems for Offshore Production Facilities*, follows API 521 and offers additional guidance unique to offshore oil and gas operations. The Center for Chemical Process Safety (CCPS) also addresses emergency pressure-relief systems for both flammable and toxic gases in two documents: (i) *Guidelines for Pressure-relief and Effluent Handling Systems* and (ii) *Safe Design and Operation of Process Vents and Emission Control Systems*. Additionally, the website of the American Institute of Chemical Engineers (AIChE) contains conference presentations and courses on Venting and Emergency Relief, which can be accessed here: **https://www.aiche.org/topics/process-safety-technical-areas/venting-emergency-relief**.

2. Evaluate whether the atmosphere is the appropriate discharge location or if there are safer alternatives.
As the CSB's BP Texas City and Veolia investigations noted, a flare system may be an inherently safer design than an atmospheric vent stack because it safely combusts flammable hydrocarbons before they are vented into the atmosphere, where they can become a serious fire or vapor cloud explosion hazard. Renowned process safety expert Trevor Kletz not only stressed the importance of discharging to a safe location, but also advocated against discharging material from emergency pressure-relief systems into the atmosphere altogether, unless there are exceptional circumstances that make it highly unlikely that the release could harm people. Although the CSB has recommended flaring as an inherently safer option than venting flammable vapor into the atmosphere, there are some applications where discharging into the atmosphere may be appropriate. If facilities have systems designed to discharge flammable or toxic vapor into the atmosphere[3], the CSB advises that they thoroughly evaluate these systems to ensure that releases will not harm workers or the public.

3. Ensure hazardous chemicals vented into the atmosphere discharge to a safe location.
As the CSB discussed in its Kuraray investigation report, if Kuraray's emergency pressure-relief system had discharged vapor from the reactor to a safe location, the flammable ethylene gas should not have harmed any workers. Ensuring no harm to people by discharging to a safe location is a basic emergency pressure-relief system design principle. As a general emergency pressure-relief system design philosophy, API 521 cautions that "...in no instance should the safety of a plant or its personnel be compromised" [2, p. 14]. API states that an unsafe location is one that may harm people. API defines an unsafe (hazardous) location for discharging flammable vapor from emergency pressure-relief systems in its industry guidance document, *Process Safety Performance Indicators for the Refining and Petrochemical*

3. The CSB recommended that API revise its RP 521 to, among other things, urge the use of appropriate inherently safer alternatives such as a flare system. CSB Recommendations Status Change Summary to API, Recommendation Number 2004-04-I-TX-R4.

Industries, API RP 754. According to API RP 754, an unsafe location is:

> An atmospheric pressure-relief device [emergency pressure-relief system] discharge point or downstream destructive device (e.g. flare, scrubber) discharge point that results in a potential hazard to personnel due to their proximity, such as the formation of flammable mixtures at ground level or on elevated work structures, presence of toxic or corrosive materials at ground or on elevated work structures, or thermal radiation effects from ignition of relief streams at the point of emission as specified in API 521 Section 5.8.4.4... [3, p. 10].

Companies should evaluate the discharge points from their emergency pressure-relief systems to ensure they discharge to a safe location, so they do not create a hazard for operators or maintenance personnel on walkways or platforms. Location of these discharge points also should be a safe distance from buildings' air intakes. Process Hazard Analyses (PHAs) present companies with one opportunity to periodically review and evaluate these systems. Field audits, relief studies, management of change (MOC), and incident investigations present additional opportunities to revisit and reassess these systems.

CSB CALL TO ACTION

The CSB continues to see incidents involving emergency pressure-relief systems far too frequently. This safety alert should serve as a call to action to companies to evaluate and, when appropriate, update their emergency pressure-relief systems to prevent future incidents and protect workers and surrounding communities from harm.

Appendix A:

PERTINENT RECOMMENDATIONS

INVESTIGATION	RECIPIENT	REC NO.	RECOMMENDATION STATUS
Ethylene Release and Fire at Kuraray America, Inc. EVAL Plant	Kuraray	2018-03-I-TX-R1	Open - Awaiting Response or Evaluation/Approval of Response

Recommendation Text:

Develop and implement an emergency pressure-relief system design standard to ensure that each of these safety systems will discharge to a safe location. Include a requirement to periodically evaluate the site's emergency pressure-relief systems and make appropriate modifications to ensure that each of these systems discharge to a safe location such that material that could discharge from these safety systems will not harm people.

[This CSB Recommendation was issued to Kuraray on December 16, 2022].

INVESTIGATION	RECIPIENT	REC NO.	RECOMMENDATION STATUS
Toxic Chemical Release at the DuPont La Porte Chemical Facility	DuPont La Porte	2015-01-I-TX-R1	Closed - No Longer Applicable

Recommendation Text:

Prior to resuming Insecticide Business Unit (IBU) manufacturing operations, conduct a comprehensive engineering analysis of the manufacturing building and the discharge of pressure-relief systems with toxic chemical scenarios to assess potential inherently safer design options. At a minimum, evaluate the use of an open building structure, and the direction of toxic chemical leaks and the discharge of pressure-relief systems with toxic chemical scenarios to a destruction system. Implement inherently safer design principles to the greatest extent feasible and effectively apply the hierarchy of controls such that neither workers nor the public are harmed from potential highly toxic chemical releases. Detail the analysis, findings, and corrective actions in a written report and make this report available to DuPont La Porte employees, their representatives, and the CSB.

[This CSB Recommendation was closed as 'No Longer Applicable' due to the decommissioning and permanent dismantling of their Insecticide Business Unit and Herbicide Business Unit as their resumption of production were determined to be no longer feasible for DuPont.]

INVESTIGATION	RECIPIENT	REC NO.	RECOMMENDATION STATUS
Toxic Chemical Release at the DuPont La Porte Chemical Facility	DuPont La Porte	2015-01-I-TX-R3	Closed - No Longer Applicable

Recommendation Text:

Prior to resuming manufacturing operations, ensure all Insecticides Business Unit (IBU) pressure-relief systems are routed to a safe location and effectively apply the hierarchy of controls to protect workers and the public. Commission a pressure-relief device analysis, consistent with API Standard 521 and the ASME Code, including a field review. Include an evaluation of relief system discharge location to ensure that relief systems are discharged to a safe location that will prevent toxic exposure, flammability, or asphyxiation hazards in order to ensure public and worker health and safety to the greatest extent feasible. Include an evaluation of relief scenarios consistent with API Standard 521.

[This CSB Recommendation was closed as 'No Longer Applicable' due to the decommissioning and permanent dismantling of their Insecticide Business Unit and Herbicide Business Unit as their resumption of production were determined to be no longer feasible for DuPont.]

INVESTIGATION	RECIPIENT	REC NO.	RECOMMENDATION STATUS
Toxic Chemical Release at the DuPont La Porte Chemical Facility	DuPont La Porte	2015-01-I-TX-R4	Closed - No Longer Applicable

Recommendation Text:

Develop and implement an expedited schedule to perform more robust process hazard analyses (PHAs) consistent with R1 **[above],** R2, and R3 **[above]** for all units within the Insecticides Business Unit (IBU). At a minimum, the PHAs must effectively identify and control the hazards referenced in this document utilizing the hierarchy of controls. The PHA schedule must be prioritized based on anticipated risks to the public and workers in order to ensure that the highest risk areas receive priority consideration. At a minimum, the more robust PHAs must be consistent with the approach applied to post-incident reviews described above in paragraph 10.

[This CSB Recommendation was closed as 'No Longer Applicable' due to the decommissioning and permanent dismantling of their Insecticide Business Unit and Herbicide Business Unit as their resumption of production were determined to be no longer feasible for DuPont.]

Appendix A:

PERTINENT RECOMMENDATIONS, CONTINUED

INVESTIGATION	RECIPIENT	REC NO.	RECOMMENDATION STATUS
Toxic Chemical Release at the DuPont La Porte Chemical Facility	DuPont La Porte	2015-01-I-TX-R5	Closed - No Longer Applicable

Recommendation Text:

Work together with the International Chemical Workers Union Council of the United Food and Commercial Workers (ICWUC/UFCW) Local 900C and the ICWUC/UFCW staff (at the request of the local) to develop and implement a plan to ensure active participation of the workforce and their representatives in the implementation of Recommendations R1 through R4 **[applicable to R1 and R3 above]**. In addition, provide a copy of DuPont's integrated plan for restart to La Porte workers and their local union representatives.

[This CSB Recommendation was closed as 'No Longer Applicable' due to the decommissioning and permanent dismantling of their Insecticide Business Unit and Herbicide Business Unit as their resumption of production were determined to be no longer feasible for DuPont.]

Toxic Chemical Release at the DuPont La Porte Chemical Facility	DuPont La Porte	2015-01-I-TX-R6	Closed – Acceptable Action

Recommendation Text:

Make publicly available (on a website) a summary of the DuPont November 15, 2014 incident investigation report, the integrated plan for restart, and actions to be taken for the implementation of Recommendations R1 through R5 **[applicable to R1 and R3 through R5 above]**. This website must be periodically updated to accurately reflect the integrated plan for restart and implementation of Recommendations R1 through R5.

Kleen Energy Natural Gas Explosion	Occupational Safety and Health Administration (OSHA)	2010-07-I-CT-UR1	Closed - Unacceptable Action/No Response Received

Recommendation Text:

Promulgate regulations that address fuel gas safety for both construction and general industry. At a minimum:

a. Prohibit the release of flammable gas to the atmosphere for the purpose of cleaning fuel gas piping
b. Prohibit flammable gas venting or purging indoors. Prohibit venting or purging outdoors where fuel gas may form a flammable atmosphere in the vicinity of workers and/or ignition sources.
c. Prohibit any work activity in areas where the concentration of flammable gas exceeds a fixed low percentage of the lower explosive limit (LEL) determined by appropriate combustible gas monitoring.
d. Require that companies develop flammable gas safety procedures and training that involves contractors, workers, and their representatives in decision-making.

Kleen Energy Natural Gas Explosion	National Fire Protection Association (NFPA)	2010-07-I-CT-UR2	Closed - Exceeds Recommended Action

Recommendation Text:

Enact a Tentative Interim Amendment and permanent changes to the National Fuel Gas Code (NFPA 54/ANSI Z223.1) that address the safe conduct of fuel gas piping cleaning operations. At a minimum:

a. Remove the existing NFPA 54 fuel gas piping exemptions for power plants and systems with an operating pressure of 125 pounds per square inch gauge (psig) or more.
b. For cleaning methodology, require the use of inherently safer alternatives such as air blows or pigging with air in lieu of flammable gas.

Appendix A:

PERTINENT RECOMMENDATIONS, CONTINUED

INVESTIGATION	RECIPIENT	REC NO.	RECOMMENDATION STATUS
Kleen Energy Natural Gas Explosion	American Society of Mechanical Engineers	2010-07-I-CT-UR3	Closed – Acceptable Action
Recommendation Text: Make appropriate changes to the 2012 version of Power Piping, ASME B31.1, to require the use of inherently safer fuel gas piping cleaning methodologies rather than natural gas blows. At a minimum, for the cleaning or flushing methods discussed in B31.1 paragraph 122.10, require the use of inherently safer alternatives such as air blows and pigging with air as the motive force in lieu of flammable gas.			
Kleen Energy Natural Gas Explosion	Governor and Legislature of the State of Connecticut	2010-07-I-CT-UR16	Closed – Acceptable Action
Recommendation Text: Enact legislation applicable to power plants in the state that prohibits the use of flammable gas that is released to the atmosphere to clean fuel gas piping.			
Kleen Energy Natural Gas Explosion	Governor and Legislature of the State of Connecticut	2010-07-I-CT-UR17	Closed - No Longer Applicable
Recommendation Text: Adopt the current version of NFPA 54 as amended pursuant to 2010-01-I-CT-UR2.			
BP America Refinery Explosion	American Petroleum Institute (API)	2005-4-I-TX-UR4	Closed – Acceptable Action
Recommendation Text: Revise API Recommended Practice 521, Guide for Pressure Relieving and Depressurizing Systems to ensure the guidelines: • Identifies overfilling vessels as a potential hazard for evaluation in selecting and designing pressure-relief and disposal systems; • Addresses the need to adequately size disposal drums for credible worse-case liquid relief scenarios, based on accurate relief valve and disposal collection piping studies; • Warns against the use of atmospheric blowdown drums and stacks attached to collection piping systems that receive flammable discharges from multiple relief valves and urges the use of appropriate inherently safer alternatives such as a flare system.			
Veolia Environmental Services Flammable Vapor Explosion and Fire	Veolia Environmental Services Technical Solutions	2009-10-I-OH-R2	Open - Unacceptable Response/ No Response Received
Recommendation Text: During the rebuild, design and install a closed relief system and develop a policy for safe venting (e.g., use of a flare) for relief systems to the atmosphere.			

REFERENCES

1. T. Kletz, Lessons From Disaster: How Organizations Have No Memory and Accidents Recur., Gulf Publishing Company, 1993.
2. American Petroleum Institute (API), "API Standard 521, Pressure-relieving and Depressuring Systems, Seventh edition," 2020.
3. American Petroleum Institute (API), "API, Process Safety Performance Indicators for the Refining and Petrochemical Industries: API Recommended Practice 754: Second Edition," April 2016.