U.S. Chemical Safety and Hazard Investigation Board

Trichloroisocyanuric Acid Reaction, Decomposition, and Toxic Gas Release at Bio-Lab, Inc.

Westlake, LA | *Incident Date: August 27, 2020* | **No. 2020-05-I-LA**

Investigation Report

Published: April 24, 2023

SAFETY ISSUES:

- **Extreme Weather Preparation**
- **Process Hazard Analyses Implementation**
- **Emergency Preparedness and Response**
- **Adherence to Applicable Hazardous Materials Codes**
- **Regulatory Coverage of Reactive Chemical Hazards**

U.S. Chemical Safety and Hazard Investigation Board

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The CSB is an independent federal agency charged with investigating, determining, and reporting to the public in writing the facts, conditions, and circumstances and the cause or probable cause of any accidental chemical release resulting in a fatality, serious injury, or substantial property damages.

The CSB issues safety recommendations based on data and analysis from investigations and safety studies. The CSB advocates for these changes to prevent the likelihood or minimize the consequences of accidental chemical releases.

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ABBREVIATIONS

ASPECT	Airborne Spectral Photometric Environmental Collection Technology
CCPS	Center for Chemical Process Safety
CFR	Code of Federal Regulations
CSB	U.S. Chemical Safety and Hazard Investigation Board
DEQ	Department of Environmental Quality (sometimes referenced as LDEQ)
EPA	U.S. Environmental Protection Agency
ESFR	early suppression fast response
GAO	U.S. Government Accountability Office
HESS	Health, Environmental, Safety, and Sustainability (sometimes referenced as EHS&S)
LSUCCC	Louisiana State Uniform Construction Code Council
MAQ	Maximum Allowable Quantity
METAR	meteorological aerodrome routine report
MOC	Management of Change
mph	miles per hour
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
PHA	process hazard analysis
PPM	parts per million
PSM	process safety management
RFI	requests for information
RMP	Risk Management Program (sometimes referenced as Risk Management Plan)
SCBA	self-contained breathing apparatus
SDS	safety data sheet
SRS	Specialized Response Solutions
TCCA	trichloroisocyanuric acid

Executive Summary

On August 27, 2020, extreme winds from Category 4 Hurricane Laura caused severe damage to buildings storing trichloroisocyanuric acid (TCCA) at the Bio-Lab, Inc. Lake Charles (Bio-Lab) facility in Westlake, Louisiana, located in the southwestern area of the state. TCCA is a chlorinating agent often used as a sanitizer to kill algae and bacteria in large volumes of water, predominantly swimming pools and hot tubs, and sold in tablet, stick, and granular forms. In large bodies of water, the TCCA is soluble and breaks down slowly, releasing chlorine in the water to sanitize contaminants. When TCCA instead comes in contact with or is wetted/moistened by a small amount of water and does not dissolve, it can experience a chemical reaction, generating heat and causing the decomposition of the chemical, which in turn produces toxic chlorine gas and can produce explosive nitrogen trichloride. After the buildings at the Bio-Lab facility were damaged by Hurricane Laura winds, rainwater contacted the TCCA stored inside, initiating a chemical reaction and subsequent decomposition of the TCCA. The heat produced from the reaction and decomposition initiated a fire, and the decomposition released a large plume of hazardous gases, including toxic chlorine, into the air. The plume of hazardous gases crossed the facility boundary and could be seen over a large portion of the nearby community.

The TCCA decomposition and fire destroyed a production building at the Bio-Lab facility and damaged additional structures. In addition, as a result of the incident, a portion of the nearby Interstate 10 was closed for over 28 hours, and the Calcasieu Parish Office of Homeland Security and Emergency Preparedness issued a shelter-in-place order due to the release of the hazardous gases. Following the incident, approximately $250 million was invested in redesigning and completely reconstructing the damaged Bio-Lab facility. The Bio-Lab facility resumed its production operations around March 2023. There were no reported injuries from this event.

Safety Issues

The CSB's investigation identified the safety issues below.

- **Extreme Weather Preparation.** Bio-Lab did not learn the importance of preparing for extreme weather after the 2017 Arkema incident in Crosby, Texas, which occurred after extensive flooding from Category 4 Hurricane Harvey caused an organic peroxide decomposition that led officials to institute a 1.5-mile evacuation zone during the incident. Bio-Lab did not implement industry guidance for extreme weather preparation that was updated and published after the Arkema incident and, as a result, was unprepared for the winds produced by Category 4 Hurricane Laura. (Section 4.1)

- **Process Hazard Analyses Implementation**. TCCA is not covered by the Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) Standard; however, Bio-Lab Lake Charles voluntarily implemented some elements of the PSM standard, including periodically conducting Process Hazard Analyses (PHAs). Bio-Lab's 2010 Process Hazard Analysis recommended the Lake Charles facility to "consider evaluating warehouse roof structure for hurricane conditions; verify warehouse is built to withstand high winds," but the company did not implement the recommendation. If Bio-Lab had implemented the 2010 PHA recommendation, it could have identified that the facility buildings were susceptible to damage from hurricane-strength winds. This might have led Bio-Lab to implement controls to prevent the TCCA from being exposed to hurricane rainwater, which could have prevented the incident. A lack of close-out documentation for the 2010 PHA recommendation indicates deficiencies in Bio-Lab's PHA action item management system. (Section 4.2)

- **Emergency Preparedness and Response**. Bio-Lab experienced serious delays in responding to the TCCA decomposition and fire due to an inadequate and largely nonfunctional fire protection system and the absence of automated sprinkler systems. The approximately five-and-a-half hour delay in responding to the decomposition likely led to an unnecessary increase in (1) the amount of TCCA that decomposed, (2) the quantity of toxic chlorine released, and (3) the extent of the facility damage. Bio-Lab did not adequately maintain its fire protection system to ensure its functionality and did not ensure that enough of its staff, including its assigned hurricane crew, knew how to activate the rental backup generator, which was necessary to operate electrically powered fire protection equipment during the power outage caused by Hurricane Laura. (Section 4.3)

- **Adherence to Applicable Hazardous Materials Codes**. The Bio-Lab Lake Charles facility, built in 1979, did not conform to the safeguards identified in the National Fire Protection Association (NFPA) 101 *Life Safety Code* for high-hazard industrial occupancies, which required automatic extinguishing systems or other protection to minimize danger to occupants before they have time to evacuate. Bio-Lab also did not conform to NFPA 400 *Hazardous Materials Code*, which required a fire detection system and an automatic fire sprinkler system, and which Louisiana requires adherence to for structures built or remodeled after July 1, 2017. Existing facilities in Louisiana, such as Bio-Lab, are grandfathered to the state-adopted codes and standards at the time of construction unless changes are made or if the State Fire Marshal receives a complaint. Had the Bio-Lab buildings involved in the incident been equipped with automatic extinguishing systems, it is likely that Bio-Lab would have begun applying large amounts of water to the decomposing TCCA earlier in the incident. (Section 4.4)

- **Regulatory Coverage of Reactive Chemical Hazards.** Although TCCA can decompose and release toxic chlorine gas,[a] TCCA is not regulated under the OSHA PSM Standard or the U.S. Environmental Protection Agency (EPA) Risk Management Program (RMP) Rule. As such, Bio-Lab was not required to implement baseline process safety management system elements to manage the safety of its TCCA-related operations under these regulations. OSHA and the EPA currently use predefined chemical lists to identify the processes subject to coverage under the PSM Standard and RMP Rule. The CSB's Reactive Hazard Study, published in 2002, concluded that solely using lists of chemicals is an inadequate approach for regulatory coverage of reactive hazards. Improving reactive hazard management requires regulators and industry to address the hazards from *combinations of chemicals* and *process-specific conditions* rather than focus exclusively on the inherent properties of individual chemicals. The CSB also found that OSHA and EPA did not adequately consider reactive chemical hazards when developing these chemical lists, and, as a result, many reactive chemicals, including TCCA, are not covered by these regulations. This regulatory coverage gap relating to reactive chemicals and their hazards (1) points to a weakness in relying on fixed chemical lists to determine regulatory coverage, (2) contributed to this incident, and (3) contributed to many other reactive chemical incidents over the past three decades. (Section 4.5)

[a] Chlorine is covered by both the OSHA Process Safety Management Standard and the EPA Risk Management Program Rule.

Cause

The CSB determined that the cause of the accidental release of chlorine gas from the Bio-Lab Lake Charles facility was rainwater contacting stored trichloroisocyanuric acid, which initiated a chemical reaction, decomposition, and fire after Category 4 Hurricane Laura winds damaged portions of the facility's building roofs that were not built to current wind design requirements. Contributing to the incident were Bio-Lab's inadequate preparation for extreme weather and Bio-Lab's deficient process hazard analysis action item management system. Also contributing to the incident was insufficient regulatory coverage of chemicals with reactive hazards. Contributing to the severity of the incident were Bio-Lab's inadequate and largely nonfunctional fire protection system and the absence of automatic extinguishing systems.

Recommendations

Previously Issued Recommendations Reiterated in This Report

To Occupational Safety and Health Administration (OSHA)

2001-01-H-R1 (from the 2002 CSB Reactive Hazard Study)

Amend the Process Safety Management (PSM) Standard, 29 CFR 1910.119, to achieve more comprehensive control of reactive hazards that could have catastrophic consequences.

- Broaden the application to cover reactive hazards resulting from process-specific conditions and combinations of chemicals. Additionally, broaden coverage of hazards from self-reactive chemicals. In expanding PSM coverage, use objective criteria. Consider criteria such as the North American Industry Classification System (NAICS), a reactive hazard classification system (e.g., based on heat of reaction or toxic gas evolution), incident history, or catastrophic potential.
- In the compilation of process safety information, require that multiple sources of information be sufficiently consulted to understand and control potential reactive hazards. Useful sources include:
  - Literature surveys (e.g., Bretherick's Handbook of Reactive Chemical Hazards, Sax's Dangerous Properties of Industrial Materials).
  - Information developed from computerized tools (e.g., ASTM's CHETAH, NOAA's The Chemical Reactivity Worksheet).
  - Chemical reactivity test data produced by employers or obtained from other sources (e.g., differential scanning calorimetry, thermogravimetric analysis, accelerating rate calorimetry).
  - Relevant incident reports from the plant, the corporation, industry, and government.
  - Chemical Abstracts Service.
- Augment the process hazard analysis element to explicitly require an evaluation of reactive hazards. In revising this element, evaluate the need to consider relevant factors, such as:
  - Rate and quantity of heat or gas generated.
  - Maximum operating temperature to avoid decomposition.
  - Thermal stability of reactants, reaction mixtures, byproducts, waste streams, and products.
  - Effect of variables such as charging rates, catalyst addition, and possible contaminants.
  - Understanding the consequences of runaway reactions or toxic gas evolution.

To U.S. Environmental Protection Agency (EPA)

2001-01-H-R3 (from the 2002 CSB Reactive Hazard Study)

Revise the Accidental Release Prevention Requirements, 40 CFR 68, to explicitly cover catastrophic reactive hazards that have the potential to seriously impact the public, including those resulting from self-reactive chemicals and combinations of chemicals and process-specific conditions. Take into account the recommendations of this report to OSHA on reactive hazard coverage. Seek congressional authority if necessary to amend the regulation.

New Recommendations

To Bio-Lab Lake Charles

2020-05-I-LA-R1

Evaluate the hazards to the Bio-Lab Lake Charles facility from hurricanes and accompanying wind, rainwater, floodwater, or storm surge forces. Implement processes and safeguards for protection against those hazards, such as through:

a. Constructing new and maintaining existing buildings and structures to withstand hurricane winds and flooding, with a particular focus on those containing hazardous materials;

b. Implementing safeguards and processes to ensure hazardous chemicals are not compromised and released during extreme weather events; and

c. Following the guidance presented in the Center for Chemical Process Safety Monograph *Assessment of and Planning for Natural Hazards*.

2020-05-I-LA-R2

Develop and implement an improved Process Hazard Analysis (PHA) action item management system. At a minimum the PHA action item management system should:

a. Ensure that each PHA action item or recommendation is assigned to an appropriate person with a deadline for initial evaluation;

b. Document and maintain the rationale if the action item or recommendation is modified or rejected; and

c. Track the status of all PHA action items or recommendations until they are resolved.

Additionally, periodic audits must be conducted on the PHA action item management system to ensure its effectiveness.

2020-05-I-LA-R3

Perform process hazard analyses (PHAs) on all buildings and units processing or storing trichloroisocyanuric acid. Ensure that the PHAs are revalidated at least every five years. Also include the building design basis as process safety information for the PHA team to reference during their analysis.

2020-05-I-LA-R4

Revise the Bio-Lab Lake Charles emergency response plan to require the following:

a. The site's fire protection system is properly maintained and routinely function-tested in accordance with published industry guidance and NFPA requirements. Require in the emergency response plan that any equipment identified as nonfunctional must be repaired in a timely manner in accordance with NFPA requirements;

b. Emergency and fire protection equipment (in particular fire water pumps) must be checked regularly to ensure that it is all in good working order one month before the start of the U.S. hurricane season, as recommended by the Center for Chemical Process Safety Monograph *Assessment of and Planning for Natural Hazards*; and

c. Site personnel must be trained on the use of all emergency generators and other emergency equipment at least one month before the start of the U.S. hurricane season.

To the Louisiana Governor and Louisiana State Legislature / Secretary of the Louisiana Department of Environmental Quality

2020-05-I-LA-R5

Under existing statutory or regulatory authority or through the establishment of new authority by executive or legislative action, for all existing chemical manufacturing and storage facilities that:

(1) Are located in a hurricane-prone region as defined by the International Building Code, and

(2) Manufacture or store or can inadvertently or otherwise produce (e.g., by chemical reaction) regulated substances inside equipment or building(s) built before more current wind design requirements came into effect

Require the facility operators to evaluate the hazards to their facilities from hurricanes and accompanying wind, rainwater, floodwater, or storm surge forces. Require the facility operators to implement processes and safeguards for protection against those hazards, such as through:

a. Ensuring that buildings and structures (both new and existing) can withstand hurricane winds and flooding, with a particular focus on buildings and structures containing hazardous materials;

b. Implementing safeguards and processes to ensure that hazardous chemicals are not compromised and released during extreme weather events; and/or

c. Following the guidance presented in the Center for Chemical Process Safety Monograph *Assessment of and Planning for Natural Hazards*.

To the U.S. Environmental Protection Agency (EPA)

2020-05-I-LA-R6

Implement the five open recommendations issued in the 2022 U.S. Government Accountability Office Report titled *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change*, which are:

a. The U.S. Environmental Protection Agency (EPA) should provide additional compliance assistance to Risk Management Plan (RMP) facilities related to risks from natural hazards and climate change;

b. The EPA should design an information system to track common deficiencies found during inspections, including any related to natural hazards and climate change, and use this information to target compliance assistance;

c. The EPA should issue regulations, guidance, or both, as appropriate, to clarify requirements and provide direction for RMP facilities on how to incorporate risks from natural hazards and climate change into their risk management programs;

d. The EPA should develop a method for inspectors to assess the sufficiency of RMP facilities' incorporation of risks from natural hazards and climate change into risk management programs and provide related guidance and training to inspectors; and

e. The EPA should incorporate the vulnerability of RMP facilities to natural hazards and climate change as criteria when selecting facilities for inspection.

1 BACKGROUND

1.1 BIO-LAB LAKE CHARLES

Bio-Lab, Inc. is a KIK Custom Products (KIK) subsidiary that manufactures and supplies pool and spa chemicals, including chlorinated isocyanurates. The Bio-Lab Lake Charles (Bio-Lab) facility was built in the late 1970s by Olin Chemical Corporation in the Calcasieu Parish in Westlake, Louisiana, located near Lake Charles, Louisiana, in the southwestern part of the state.[a,b] Trichloroisocyanuric acid (TCCA) is one of the chemicals manufactured at the facility. At the time of the incident, Bio-Lab had 111 employees.

A layout of the Bio-Lab Lake Charles facility is shown below in **Figure 1**.

Figure 1. Overhead view of a portion of the Bio-Lab facility with red denoting buildings involved in the incident. (Credit: Google Earth, annotations by U.S. Chemical Safety and Hazard Investigation Board (CSB))

[a] The Bio-Lab Lake Charles facility ownership has changed over time. KIK acquired Bio-Lab, Inc. as a separate corporate entity in 2013 and acquired the Lake Charles plant on March 24, 2017. Former owners before KIK include Lyondell Chemical Company, Great Lakes Chemical Corporation, and Chemtura Corporation.

[b] Multiple facilities in the U.S. produce, distribute, or package trichloroisocyanuric acid or similar chlorinated isocyanurates, including facilities operated by Bio-Lab (in Conyers, Georgia, and Westlake, Louisiana), Occidental Chemical Corporation (in Sauget, Illinois, and Luling, Louisiana), Solenis formerly known as Clearon Corporation (in South Charleston, West Virginia), and Haviland (in Grand Rapids, Michigan).

1.2 TRICHLOROISOCYANURIC ACID (TCCA)

Trichloroisocyanuric Acid (TCCA), a chlorinating agent,[a] is often used as a sanitizer for swimming pools and hot tubs. It is a white solid substance manufactured at the Bio-Lab facility and available as a powder, compacted tablets, and granules (**Figure 2**). In large bodies of water, such as pools, TCCA breaks down slowly to release hypochlorous acid (HClO),[b] as shown in **Figure 3**, which kills bacteria, algae, and other microorganisms as intended. When TCCA instead comes in contact with a small amount of water, it can experience a chemical reaction causing heat generation [1, pp. 2-3] and the decomposition of the TCCA.[c] When TCCA reacts and decomposes, it produces toxic chlorine gas [2, p. 2622] and can produce explosive nitrogen trichloride [3, p. 1]. According to the U.S. Environmental Protection Agency (EPA), “Even a small amount of water splashed on the [pool] chemical[d] may in some cases trigger a strong reaction” [1]. Water-reactive materials may violently react, produce toxic or other hazardous gases, or evolve enough heat to cause self-ignition or ignition of nearby combustibles upon water exposure [4, pp. 400-17]. TCCA is a Class 1 oxidizer,[e] and TCCA “[r]eacts with combustible materials, ammonia salts, or foreign substances, resulting in fire [5, pp. 49-148]. Bio-Lab’s TCCA safety data sheet (SDS) states that a fire involving TCCA should be flooded with water.

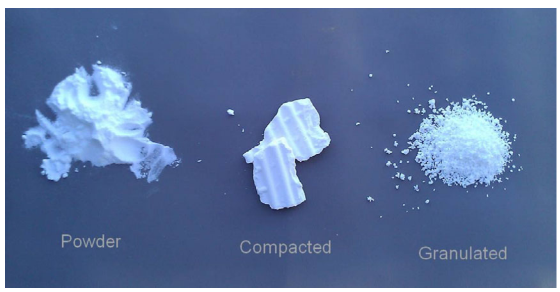

Figure 2. Forms of TCCA. (Credit: Bio-Lab)

[a] Bio-Lab refers to its TCCA product as BLC-90. The name BLC-90 is used to indicate there is 90% available chlorine in the product. Its safety data sheet states that the chemical is stable under recommended storage conditions, including tightly closed containers and in a dry and well-ventilated place.

[b] Hypochlorous acid is “an active form of chlorine in water” [73]. It is an unstable, weak acid existing only in solution [62, p. 7].

[c] TCCA decomposes when it reaches approximately 437°F (225°C).

[d] Chlorinated isocyanurates are included in the partial listing of pool chemicals provided in the EPA’s *Safe Storage and Handling of Swimming Pool Chemicals* safety alert [1].

[e] The National Fire Protection Association (NFPA) groups oxidizers into four classes. The four classes of oxidizers are defined as follows: “Class 1: An oxidizer that does not moderately increase the burning rate of combustible materials”; “Class 2: An oxidizer that causes a moderate increase in the burning rate of combustible materials”; “Class 3: An oxidizer that causes a severe increase in the burning rate of combustible materials”; and “Class 4: An oxidizer that can undergo an explosive reaction due to contamination or exposure to thermal or physical shock and that causes a severe increase in the burning rate of combustible materials” [4, pp. 400-18].

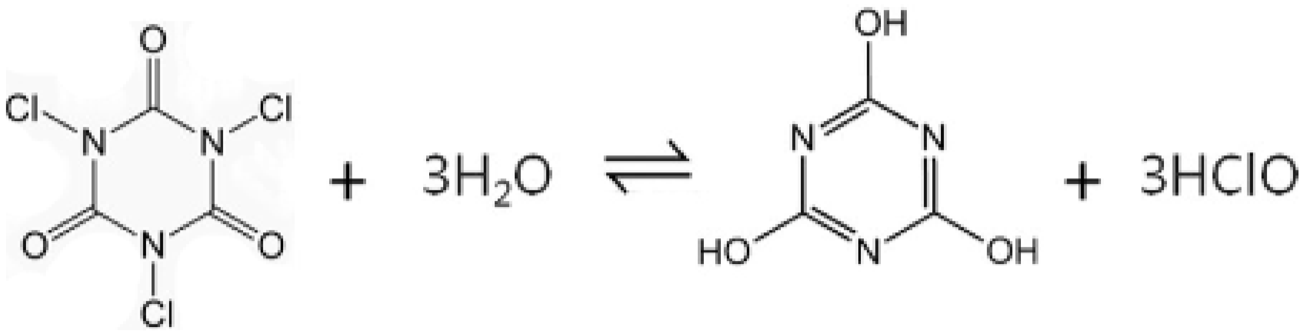

Figure 3. Depiction of intended reaction between TCCA and water. (Credit: Environment International [6])

According to the Bio-Lab SDS, "[e]xposure to the solid [TCCA] product or to free chlorine evolving from the product may cause irritation, redness of upper and lower airways, coughing, laryngospasm, and edema, shortness of breath, bronchoconstriction, and possible pulmonary edema. The pulmonary edema may develop several hours after severe acute exposure." Chlorine is a toxic substance immediately dangerous to life or health at a concentration of 10 parts per million (ppm) [7].

Numerous incidents involving TCCA decompositions have resulted in fires and chemical releases at facilities throughout the United States and Canada. At least three known toxic gas releases that occurred between 1988 and 2019 were related to rainwater contacting TCCA, resulting in evacuations and substantial property damage [8, pp. 8 - 9, 9, 8]. From 1998 to 2015, at least three additional TCCA incidents involved an explosion, release of vapors, or chemical fire, causing injuries, environmental impacts, and evacuations [10, p. 7, 11]. At least seven more incidents, including the incident at Bio-Lab Conyers, discussed in **Appendix C** of this report, occurred during 1999 and 2020 in warehouses or storage facilities, requiring company employees, responders, or others to be sent to the hospital, shelter indoors, or evacuate [10, p. 7, 12, 13].

Bio-Lab packaged its TCCA in a granulated form inside flexible bulk bags called "super sacks," each holding approximately 2,750 pounds of material.[a] Bio-Lab shipped its TCCA super sacks to other Bio-Lab, Inc. facilities, including the company's Conyers, Georgia, and Ontario, California, facilities, for final consumer tableting or formulation. At the time of the incident, Plant 4 held an estimated 70,000 to 100,000 pounds of TCCA,[b] and the Finished Goods Warehouse held over one million pounds of TCCA inventory (see building locations in **Figure 1**).

1.3 Description of Surrounding Area

Bio-Lab is one of approximately 37 industrial chemical/petrochemical facilities in the Cameron/Lake Charles, Louisiana area.[c] **Figure 4** shows the Bio-Lab facility and depicts the area within a one, three, and five-mile radius of the facility boundary. Summarized demographic data for the approximately one-mile vicinity of the Bio-Lab facility are shown below in **Table 1**. There are over 10,000 people residing in over 4,000 housing units, most of which are single units, within approximately one mile of the Bio-Lab facility. Detailed demographic

[a] The bags/super sacks are made of woven polypropylene fabric. A Bio-Lab employee described the bags as "watertight with the liner."

[b] The CSB is aware that some of the material was stored in drums and partially filled bags/super sacks.

[c] The surrounding Southwest Louisiana area industrial companies include refineries, liquefied natural gas plants, and chemical facilities.

data are included in **Appendix B**.

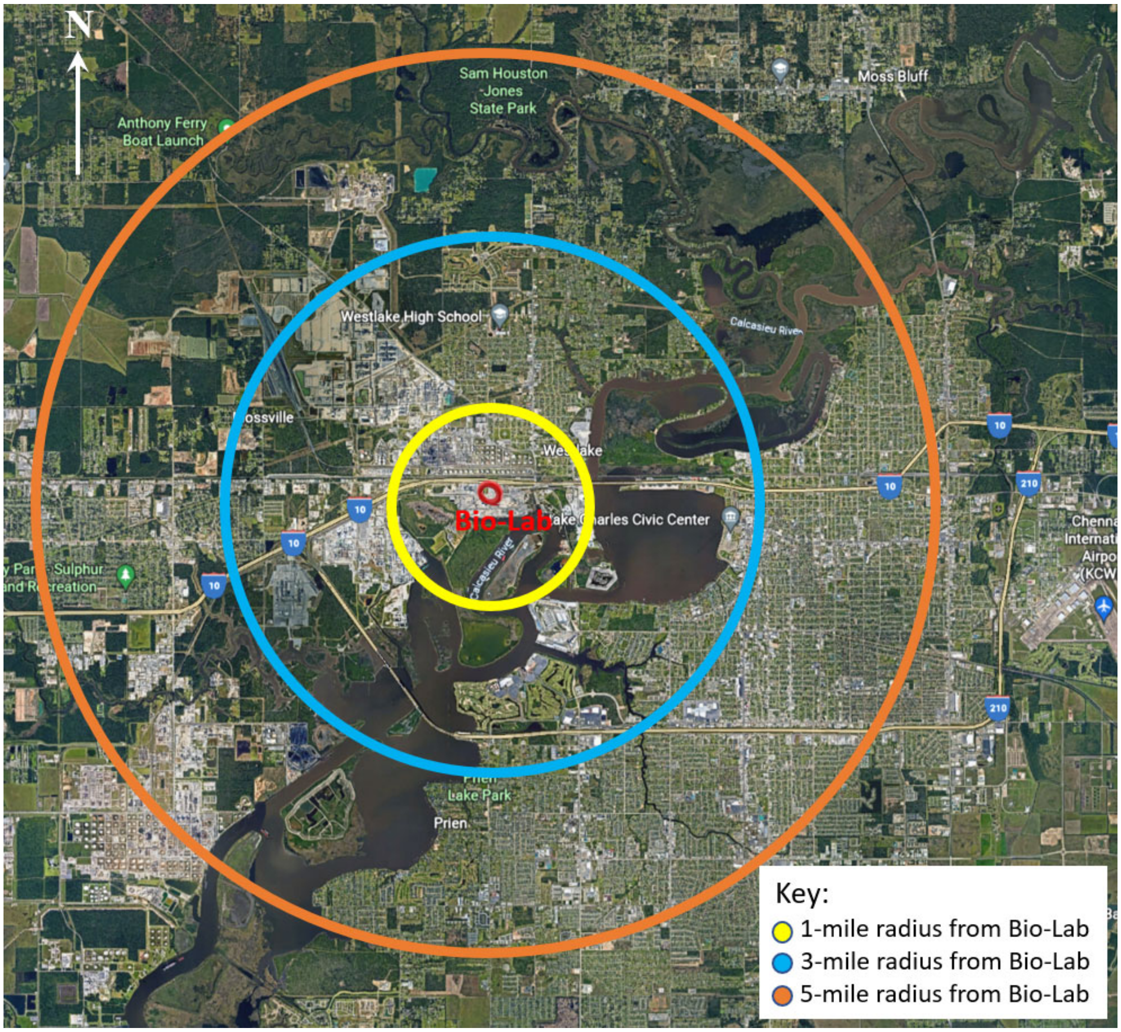

Figure 4. Overhead image of Bio-Lab and vicinity. (Credit: Google Earth, annotations by CSB)

Table 1. Summarized demographic data for the area within one mile of the Bio-Lab facility.

Population	Race & Ethnicity	Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Housing Units
10,297	• 85% White • 8% Black • 2% Asian • 1% Other • 2% Two+ • 1% Hispanic	$27,576	11%	4,235	• Single Unit 75% • Multi-Unit 11% • Mobile Home 14%

2 INCIDENT DESCRIPTION

2.1 BIO-LAB HURRICANE LAURA PREPARATION

On August 21, 2020, as Tropical Storm Laura moved north in the Gulf of Mexico toward Louisiana, Governor John Bel Edwards signed a proclamation declaring a Louisiana statewide state of emergency [14].

On Monday, August 24, 2020, the National Oceanic and Atmospheric Administration (NOAA) National Hurricane Center published an advisory forecasting that Tropical Storm Laura would become a hurricane on Tuesday, August 25, 2020. The advisory predicted the hurricane would continue to strengthen and "could be near major hurricane strength when it approaches the [U.S.] coast." The advisory also stated:

> Laura is expected to produce rainfall of 4 to 8 inches, with isolated maximum amounts of 12 inches across portions of the west-central U.S. Gulf Coast near the Texas and Louisiana border north into portions of the lower Mississippi Valley. This rainfall could cause widespread flash and urban flooding, small streams to overflow their banks, and minor to isolated moderate river flooding [15].

On August 24, 2020, in preparation for the hurricane, Bio-Lab began shutting down its Lake Charles operations using its Hurricane Plan. After a Bio-Lab, Inc. executive directed the site management to transport chemicals from the facility, the Bio-Lab team worked to secure trucks to remove TCCA from the facility before Hurricane Laura made landfall. Bio-Lab successfully transported about 825,000 pounds of TCCA from the Finished Goods Warehouse to the Bio-Lab facility in Conyers, Georgia.[a] However, two additional scheduled trucks never arrived at the facility, leaving over one million pounds of TCCA on-site as the hurricane approached.

Nine employees assigned to the Bio-Lab Hurricane Crew[b] reported to the facility on August 25, 2020, around 5:00 p.m. Each crew member had specific job assignments, including securing loose items that could become hazardous during the hurricane (e.g., by being propelled by wind), placing sandbags at entrances to prevent floodwater entry, and other tasks defined in the hurricane plan. To protect the remaining TCCA and other products from potential floodwater, the Hurricane Crew raised the materials above floor level by placing the material on triple-stacked pallets (**Figure 5**).[c]

On August 26, 2020, at approximately 7:00 a.m., Bio-Lab management announced its decision to evacuate the facility due to the approaching hurricane's strength.[d] At approximately 9:30 a.m., all employees left the facility after completing a final walk-around. The Bio-Lab facility had electrical power when the Bio-Lab employees evacuated the premises but lost its electrical power during the hurricane.

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[a] 247,500 pounds of TCCA was removed from the Lake Charles facility on August 24, 2020. On August 25, 2020, an additional 577,500 pounds of TCCA was removed from the site.

[b] The Hurricane Crew is a team of Bio-Lab employees designated to remain on-site in a safe location during a hurricane while maintaining continuity and ensuring critical infrastructure components are uninterrupted. One of the first two Bio-Lab employees, a supervisor, to arrive on-site on August 27, 2020, was also an assigned member of the Hurricane Crew for Hurricane Laura.

[c] Generally, a pallet is approximately five to seven inches tall. The triple-stacked pallets would have raised the super sacks approximately 15 to 21 inches above the floor level.

[d] The Bio-Lab Hurricane Plan includes a provision that allows supervision to evacuate the Hurricane Crew from the plant "with the intent to return to the site as soon as possible after the hurricane subsides and begin site evaluation and recovery operations."

Figure 5. TCCA product stacked as a precaution from floodwater. (Credit: CSB)

2.2 HURRICANE LAURA

Around 1:00 a.m. on August 27, 2020, Hurricane Laura made landfall in Cameron (Southwest Louisiana) as a Category 4 hurricane,[a] with maximum sustained winds reaching 150 miles per hour (mph) and a minimum central pressure of 939 millibars [16, 17] (**Figure 6**). The National Weather Service reported the following:

> Laura was the strongest hurricane to strike Southwest Louisiana since records began in 1851.[b] The eye and eyewall of Laura passed over the entire Lake Charles metropolitan area … while Laura was still a very powerful category 4 hurricane. [...] With this being the strongest hurricane to affect Southwest Louisiana, wind damage to buildings and trees and storm surge damage was major to catastrophic across Cameron and Calcasieu parishes… [16].

A National Weather Service station located at the Lake Charles Regional Airport, which is around eight miles from Bio-Lab, recorded a "station record highest peak wind gust of 133 mph at 1:42 a.m. Central Daylight Time just before the … equipment was destroyed" [16, 18, p. 5]. In downtown Lake Charles at the Calcasieu Parish Police Jury building, a maximum sustained wind of 101 mph with a peak gust of 137 mph was measured at 1:35 a.m., just before the instrument failed, leading to incomplete wind data for the area [16].[c] Hurricane Laura

[a] The Saffir-Simpson Scale classifies hurricanes into five categories (1–5) based on maximum sustained wind speed [59]. The wind speeds in miles per hour (mph) associated with each hurricane category are as follows: Category 1: 74–95 mph; Category 2: 96–110 mph; Category 3: 111–129 mph; Category 4: 130–156 mph; Category 5: greater than or equal to 157 mph. Major hurricanes, which fall into categories 3, 4, and 5 on the Saffir-Simpson Scale, can cause catastrophic wind damage and significant loss of life due to their wind strength [59, 60].

[b] The National Hurricane Center reported that Hurricane Laura "was the strongest hurricane to strike Louisiana since Hurricane Camille of 1969 (which produced category 5 conditions over the southeastern part of the state) [19, p. 4]."

[c] "Most of the METAR [Automated Surface/Weather Observing Systems] failures were due to power failures and destruction of the equipment" [16].

produced heavy rainfall, with maximum amounts of around 12 inches, over the southwestern part of Louisiana. Flooding also occurred in Calcasieu Parish from both rainfall and storm surge [19, p. 8].

Figure 6. Radar track of Hurricane Laura moving inland. (Credit: The Weather Channel [20])

Hurricane Laura also resulted in catastrophic damage to electrical power transmission and distribution systems, leaving some without power for almost a month.[a]

2.3 First Event: Early Morning August 27, 2020

On August 27, 2020, winds from Hurricane Laura caused portions of the roof of Bio-Lab Plant 4, which housed an estimated 70,000 - 100,000 pounds of TCCA material, to be torn off the building.[b] By 8:30 a.m., rainwater from Hurricane Laura had contacted the TCCA material in Plant 4, initiating a TCCA reaction that led to a decomposition that released toxic chlorine gas[c] and caused a fire. The decomposition and fire created a massive toxic gas and smoke plume that traveled over the local community (**Figure 7**, **Figure 8**). The fire quickly evolved, leaving a collapsed roof and severe structural damage to Plant 4 that ultimately destroyed the building (see descriptions of the damage in **Appendix D**, **Figure 9**). The massive fire also destroyed process equipment installed inside Plant 4. By this time, the Bio-Lab facility and surrounding area had also likely lost electrical power due to damage from the hurricane.

[a] Entergy Corporation issued a statement on September 22, 2020, that Hurricane Laura "resulted in approximately 600,000 outages at its peak and impacted more than 900,000 customers in total. Despite the extent of the damage, the teams have made significant progress and expect to restore power to all customers who can take power by Sept 30." [74]

[b] The drums and super sacks stored inside Plant 4 on the ground level included off-specification, floor sweep, unapproved, and recyclable TCCA, and damaged containers. Combustible materials, including wood or plastic pallets, cardboard slips, and new super sacks, were also left in Plant 4.

[c] As discussed in Section 2.3.3, Bio-Lab commissioned the Center for Toxicology & Environmental Health LLC to provide air monitoring and analytical air sampling support.

Figure 7. Photo of TCCA decomposition gases, including toxic chlorine, released from Bio-Lab Plant 4 after the building was severely damaged during Hurricane Laura and rainwater contacted the stored TCCA. (Credit: The Associated Press [21])

Figure 8. Photo of plume from TCCA decomposition in Bio-Lab Plant 4 approaching the Calcasieu River Bridge near the facility. (Credit: CBS 4WWL [22])

Figure 9. Decomposing TCCA in Plant 4 on August 27, 2020. (Credit: Louisiana State Police, annotations by CSB)

At approximately 8:32 a.m., the Calcasieu Parish Communications District E911 (9-1-1) received its first report from an employee at a nearby chemical facility of the release—described as a "very large … chemical-based cloud" that was "coming off of a tower" and "drifting towards the I-10 bridge"—that was suspected as coming from near the Bio-Lab facility. Around 8:54 a.m., within hours of Hurricane Laura passing through the area, the Louisiana State Police spoke with a Bio-Lab representative, who confirmed the release was likely chlorine vapors resulting from the decomposing product and that company personnel were attempting to access and enter the facility. At 9:54 a.m., the Louisiana State Police closed a portion of the nearby Interstate 10. At about 10:15 a.m., a shelter-in-place order was issued for the nearby community. At 10:38 a.m., there was a communication among three Bio-Lab leaders that US Fire Pump,[a] a third-party response resource, was coming to help.[b]

The below timeline (**Figure 10**) provides additional details of the associated events on August 27 and 28, 2020.

[a] This was about 55 minutes after Bio-Lab notified 9-1-1 that they were "trying to put out the fire."

[b] US Fire Pump was initially notified through the Louisiana State Police of a chemical fire at the Bio-Lab facility; after that, Bio-Lab management also contacted US Fire Pump.

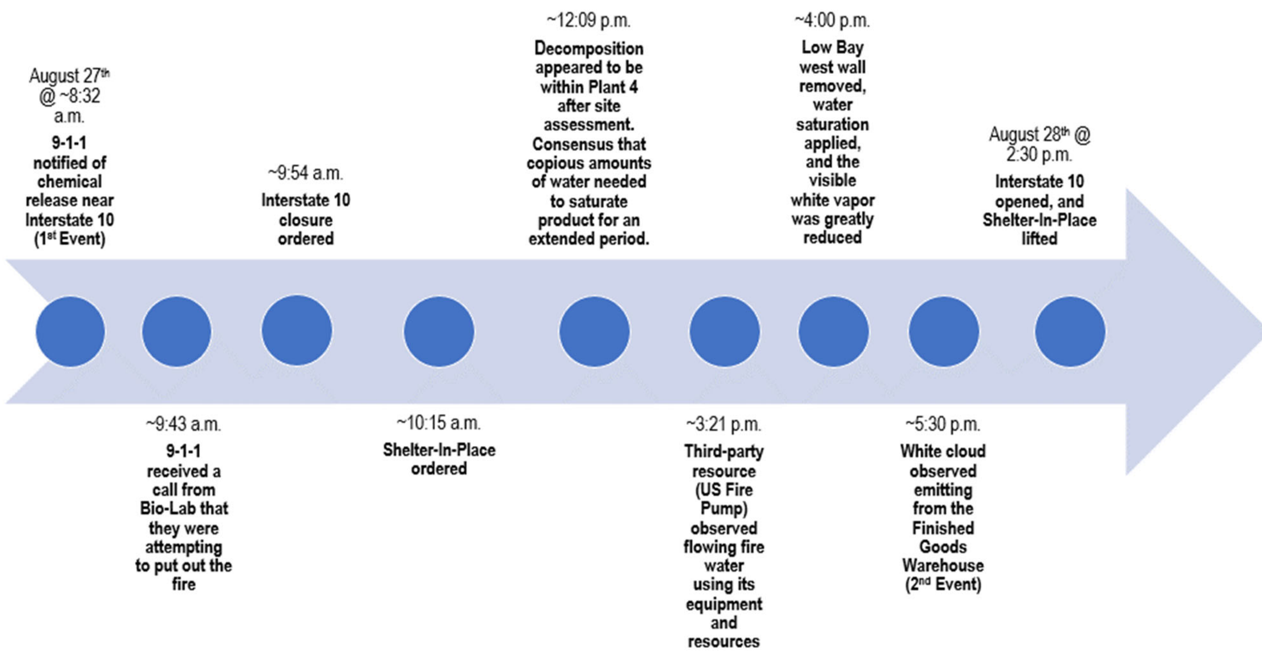

Figure 10. Timeline of events associated with the decomposition reactions. (Credit: CSB)

2.3.1 Bio-Lab Employees' Response

At approximately 9:00 a.m. on August 27, 2020, two Bio-Lab employees (a supervisor and a production operator) entered the Bio-Lab facility. There was no electrical power at the facility or the surrounding area due to catastrophic damage from the hurricane, as described in Section 2.2. Both employees told the CSB that they saw "smoke" when they entered the facility. They proceeded to obtain self-contained breathing apparatuses (SCBAs) for respiratory protection before attempting to assess the situation or control the TCCA decomposition.

The Bio-Lab facility had a fire protection system which included four fire water pumps, including two electric and two diesel pumps that started sequentially (see Section 4.3.1.1). A backup generator was required to provide electrical power to the electric pumps during a power outage. One of the employees attempted to turn on a rental backup generator secured during the site's preparation for Hurricane Laura[a] to energize the large electric fire water pump. Without this generator, there was no way to operate this pump since the facility did not have electrical power, and Bio-Lab's backup emergency generator was not functional. The employee, who was unfamiliar with the rental generator, was unable to start it.[b] As a result, he was unable to begin efforts to stop the TCCA decomposition.

Additional Bio-Lab employees arrived at the facility, including the Health, Environmental, Safety, and Sustainability (HESS) manager, a maintenance supervisor, wastewater treatment employees, and a second production operator. A wastewater treatment operator familiar with the fire protection equipment attempted to start the rental backup generator and energize the electric fire pump without success. He was, however, successful in manually starting one diesel fire water pump. By around 11:40 a.m., with the sole diesel fire water

[a] A Bio-Lab employee told the CSB that he arranged for the rental backup generator to be brought on-site "at the last minute."

[b] A representative for the rental backup generator came on-site, set it up, and showed some Bio-Lab employees how to start it. The CSB understands that the rental backup generator was brought on-site in the days before Hurricane Laura.

pump pressurizing the fire water system, the supervisor, two production operators, and the maintenance supervisor began turning on fire water monitors and attempted to spray water on the Plant 4 building or in the air to "knock down some of the smoke." The supervisor quickly realized there was inadequate water pressure at the monitor. The Bio-Lab employees then examined the fire water system piping[a] and discovered a leak in the fire water system at the adjacent Lonza Arch Chemicals (Lonza) facility, to which Bio-Lab provides fire water.[b] The employees successfully stopped the water leak, turned off Lonza's deluge system,[c] and isolated the area. These actions, however, did not significantly increase the water pressure within Bio-Lab's fire water system (**Figure 11**). By this time, the fire had worsened and was beyond the capability of the Bio-Lab responding employees.

Figure 11. Available water pressure at an exterior fire monitor near Plant 4. (Credit: Louisiana State Police, annotations by CSB)

[a] Bio-Lab's fire water loop extends to the property of others.

[b] The CSB was told that a cooling tower at Lonza collapsed during the passing of Hurricane Laura, breaking a post indicator device that was spewing water. In addition, Lonza's deluge system had been activated and was also spraying water.

[c] Lonza's deluge system also appeared to have been damaged and spraying water near a truck wash-down area. Bio-Lab contacted Lonza and was given permission to turn off the deluge system.

2.3.2 FIRE AND VAPOR CONTROL

At approximately 11:03 a.m., the Lake Charles Fire Department arrived at the Bio-Lab facility. External emergency responders—Specialized Response Solutions (SRS)[a] and Haz Mat Special Services, LLC[b]—also arrived to assist with environmental and hazardous material response.

Around 12:09 p.m., emergency responders entered the facility wearing personal protective equipment. Following the emergency responders' on-site assessment, a meeting was held with Bio-Lab, the Louisiana State Police, and other responders, reaching a consensus that "copious amounts of water would be necessary to saturate the product" to reduce and/or control the decomposition reaction.

The Fire Department attempted to use its equipment to draft water from the Bio-Lab freshwater reservoir and experienced technical difficulties with priming their pump, delaying their efforts to get water to the fire. Bio-Lab had contracted US Fire Pump to provide fire water, emergency response equipment, suppression capabilities, and support services at the facility for the incident following Hurricane Laura. By approximately 3:21 p.m., US Fire Pump was on-site and flowing fire water to Plant 4 with its firefighting equipment.

Haz Mat Special Services' main focus was to control/stop the further spread of the fire and the large vapor (gas plume) release from Plant 4 and provide equipment for the emergency response, including track hoes, pumps, and large steel frac tanks for storing liquids or solids. Haz Mat Special Services determined that the Plant 4 Low Bay west wall (**Figure 12**) and a roof between the 24-hour Storage and 30-day Warehouse prevented fire water access to the decomposing TCCA stored on the ground level and required removal.[c] Once Haz Mat Special Services demolished the wall and roof, they accessed the TCCA and saturated it with water,[d] significantly reducing the visible white cloud emitting from the building.

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[a] National Response Corporation acquired Specialized Response Solutions (SRS) services in 2014 [63]. SRS services reported to the Bio-Lab facility after communicating with the Louisiana State Police.

[b] Haz Mat Special Services, LLC (Haz Mat Special Services) was initially part of the Louisiana Emergency Response Task Force for the hurricane response, originally in Beaumont, Texas, on August 26, then in Lafayette, Louisiana, and finally at Chennault Airport on August 27, before being contracted by Bio-Lab for Environment Emergency Response. While at Chennault Airport around 9:45 a.m., a smoke cloud was observed coming from the Sulphur and Westlake area. A Haz Mat Special Services responder went to the Bio-Lab incident with Lake Charles HAZMAT.

[c] The decomposing TCCA drums and super sacks included floor sweep, recyclable, and off-specification material.

[d] US Fire Pump deployed various firefighting equipment, including pumps, monitors, submersibles, and hoses, to Bio-Lab to control the release and fire.

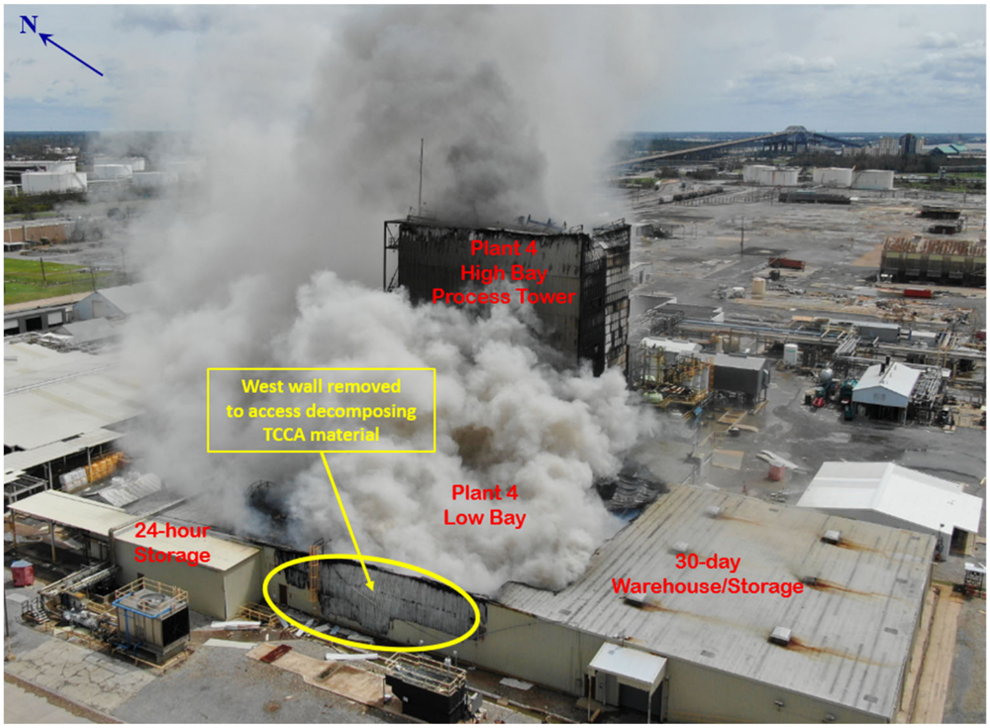

Figure 12. Decomposing TCCA stored in Plant 4. (Credit: Louisiana State Police, annotations by CSB)

2.3.3 AIR MONITORING

The Louisiana Department of Environmental Quality (LDEQ) arrived at the facility around 12:05 p.m. on August 27, 2020, and began coordinating air monitoring efforts. The EPA Airborne Spectral Photometric Environmental Collection Technology (ASPECT) aircraft arrived at approximately 2:00 p.m.[a] EPA technical contractors also arrived at 3:00 p.m. to support air monitoring within the residential community northeast of the facility. The EPA conducted handheld air monitoring for chlorine gas in multiple ground locations.[b] The EPA measured chlorine gas "slightly" exceeding the EPA Acute Exposure Guideline Level (AEGL-1) of 0.5 ppm in two locations on August 27, 2020: 0.9 ppm of chlorine measured at 5:38 p.m., and 0.7 ppm of chlorine measured at 9:54 p.m. [23].[c,d] The EPA completed its air monitoring support and demobilized at 4:00 p.m. on August 28, 2020.

Bio-Lab also requested that the Center for Toxicology & Environmental Health LLC provide air monitoring and analytical air sampling support. Real-time ground-level air monitoring started at 4:00 p.m. on August 27, 2020. The Center for Toxicology & Environmental Health LLC real-time air monitoring included community

[a] ASPECT data showed ammonia, dichloroethane, and tetrachloroethylene at maximum concentrations of 10.10 ppm, 0.70 ppm, and 1.58 ppm, respectively [64].

[b] The EPA conducted handheld air monitoring at 41 locations in Westlake, Louisiana, and chlorine gas was reported above the detection limit at nine locations [23]. The Center for Toxicology & Environmental Health LLC conducted air monitoring at 86 locations in Lake Charles and Westlake, Louisiana, and chlorine gas was reported above the detection limit at three locations [23].

[c] The EPA "AEGL-1 level is intended for exposure up to 8 hours and is a level that people could experience notable irritation and changes in lung function; however, these effects are not disabling and go away upon stopping exposure" [23].

[d] The EPA informed the CSB that the results were shared with responding entities, including LDEQ, Louisiana State Police, and the Center for Toxicology & Environmental Health LLC.

monitoring and on-site work area monitoring. Analytical air sampling equipment for chlorine, volatile organic compounds, and other chemicals was stationed at ground-level upwind and downwind locations. One out of 40 community readings measured 0.5 ppm of chlorine between 4:00 p.m. on August 27, 2020, and 6:00 a.m. on August 28, 2020. One out of 16 work area readings measured 1.2 ppm of chlorine, exceeding chlorine's 1 ppm Occupational Safety and Health Administration (OSHA)-permissible exposure limit, between 4:00 p.m. on August 27, 2020, and 6:00 a.m. on August 28, 2020.

Bio-Lab told the CSB that neither it nor anyone on its behalf calculated the amount of chlorine that could have been released from Plant 4 or the Finished Goods Warehouse after Hurricane Laura, explaining that it was difficult due to several atypical circumstances, including "the amount of trichlor material unaccounted for in inventory and shipping records, [unknown] source term parameters such as reaction kinetics…, and meteorological data such as rate of rainfall and windspeed during the decomposition event." The CSB calculated that one million pounds of TCCA, the approximate amount within Plant 4 and the Finished Goods Warehouse at the time of the incident, could theoretically produce over 450,000 pounds of chlorine (maximum).

There were no reported injuries from the event.

2.4 SECOND EVENT: LATE AFTERNOON AUGUST 27, 2020

Later in the afternoon, at approximately 5:30 p.m., a first responder working from Interstate 10 near the Bio-Lab facility observed a white cloud emitting from the Finished Goods Warehouse (**Figure 13**),[a] which Hurricane Laura's wind had also severely damaged. The warehouse contained TCCA inventory and partially filled super sacks, among other raw materials. **Figure 14** depicts a portion of the Finished Goods Warehouse and some of its inventory following the second decomposition and release.

[a] The Bio-Lab Finished Goods Warehouse was divided into three bays for storing raw materials, TCCA finished product, and off-specification materials. It was a single-story pre-engineered "Butler" style steel-framed building built around 1979. The Finished Goods Warehouse had tapered steel moment frames supporting the lightweight steel roof purlins, wall girts, and screw-attached steel or fiberglass exterior sheathing.

Figure 13. Damaged Finished Goods Warehouse roof emitting white fumes. (Credit: Bio-Lab)

Figure 14. Inventory and storage areas inside the Finished Goods Warehouse following the second event. (Credit: CSB)

As part of the response to the second event, incident responders removed a back wall of the Finished Goods Warehouse to spray water inside the area containing the decomposing super sacks. In addition, they removed the damaged or compromised TCCA super sacks from the Finished Goods Warehouse to saturate them with water and extinguish the decomposition. At 7:30 a.m. on August 28, 2020, the vapors emitting from the facility were considerably reduced and determined to be controlled. There were no reported injuries from the second decomposition event.

2.5 Incident End

On August 28, 2020, at approximately 2:30 p.m., the incident was sufficiently controlled, and the Louisiana State Police reopened Interstate 10 after it had been closed for 28 hours and lifted the shelter-in-place order. After the incident, Bio-Lab invested approximately $250 million to reconstruct the damaged facility. Bio-Lab reported that the new facility includes enhanced safety features surpassing those of the damaged facility [24].

3 PREVIOUS CHEMICAL RELEASE INCIDENT FOLLOWING HURRICANE FLOODING

On August 31, 2017, the Arkema Inc. chemical plant in Crosby, Texas, experienced an organic peroxide decomposition, release, and fire following Category 4 Hurricane Harvey flooding.[a] The CSB concluded that the company did not consider flooding of its safety systems to be a credible risk and included the following guidance in its final report [25] to companies with chemical manufacturing, handling, or storage facilities in areas that are susceptible to extreme weather events, such as flooding:

- "Such facilities should perform an analysis to determine their susceptibility to extreme weather events…consider the risk of other extreme weather such as high-wind events."
- "Companies should evaluate risk assessments and the adequacy of relevant safeguards by applying facility process safety management programs, such as process hazard analyses or facility siting programs. Facilities should strive to apply a sufficiently conservative risk management approach when evaluating and mitigating the potential effects of extreme weather scenarios."
- "Facilities should ensure that critical safeguards and equipment are not susceptible to common mode failures."

The CSB also issued multiple safety recommendations.

[a] Arkema Inc. Chemical Plant Fire | CSB

4 Safety Issues

The following sections discuss the safety issues the CSB identified in its investigation, which include:

- Extreme Weather Preparation
- Process Hazard Analyses Implementation
- Emergency Preparedness and Response
- Adherence to Applicable Hazardous Materials Codes
- Regulatory Coverage of Reactive Chemical Hazards

The Bio-Lab graphical causal analysis (AcciMap) is in **Appendix A**.

4.1 Extreme Weather Preparation

4.1.1 Factual Information

4.1.1.1 Lake Charles Area Wind Load Requirements at Time of Construction

The Bio-Lab facility was built in 1979[a]. For buildings constructed between 1975 and 1979, the Louisiana State Fire Marshal's Office required building construction to adhere to the 1973 edition of NFPA 101 *Life Safety Code* and Chapter 4[b] and Section 518[c] of the Standard Building Code (1974 revisions to the 1973 edition) [26, p. 264]. Taken together, these documents addressed fire protection, egress requirements, stairs and ladders, hazardous material processing and storage, and other construction aspects closely related to building life-safety systems. General design standards requirements, including design wind loads, were not part of the State Fire Marshal oversight during this period (see **Appendix D**).

The CSB's discussions with building officials in the Calcasieu Parish and the Cities of Westlake and Lake Charles, Louisiana, suggest that general design standards in the area during the 1970s were largely deferred to the architects and engineers involved. Representatives from the Calcasieu Parish told the CSB that licensed designers in the Parish would potentially look to standard engineering practices, including the prevailing Standard Building Code, for design guidance in the absence of official state adoption of the code. The Standard Building Code in use in 1979 was the 1974 revision of the 1973 edition. Basic design wind speeds are shown in Chapter 12 of that Code, with the Westlake / Lake Charles area falling close to the 100-mph wind speed contour for building design (see **Figure 15** and **Appendix D**).

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[a] The Bio-Lab facility was designed in 1978.

[b] Chapter 4 of the Standard Building Code pertained to the separation between townhouses (see **Appendix D**).

[c] Section 518 of the Standard Building Code pertained to life-safety provisions of high-rise buildings (see **Appendix D**).

Annual Extreme Fastest-Mile Speed 30 Feet Above Ground,
100-Year Mean Recurrence Interval

Figure 15. Basic design wind speeds in the prevailing Standard Building Code in 1979, the year the Bio-Lab facility was constructed. (Credit: 1974 Standard Building Code, annotations by CSB)

4.1.1.2 Lake Charles Area Current Wind Load Requirements

Currently, the Louisiana State Uniform Construction Code Council (LSUCCC) reviews and adopts the state uniform construction code as part of Louisiana's efforts to "maintain reasonable standards of construction in buildings and other structures in the state consistent with the public health, safety, and welfare of its citizens [27].” At the time of the incident (and at present), the LSUCCC adopted the 2015 version of the International Building Code, with amendments,[a] as the Louisiana State Uniform Construction Code [28]. Under the 2015 International Building Code requirements for Risk Category IV buildings, the Bio-Lab facility would be required to withstand 145 mph winds (see **Figure 16** and **Appendix D**).

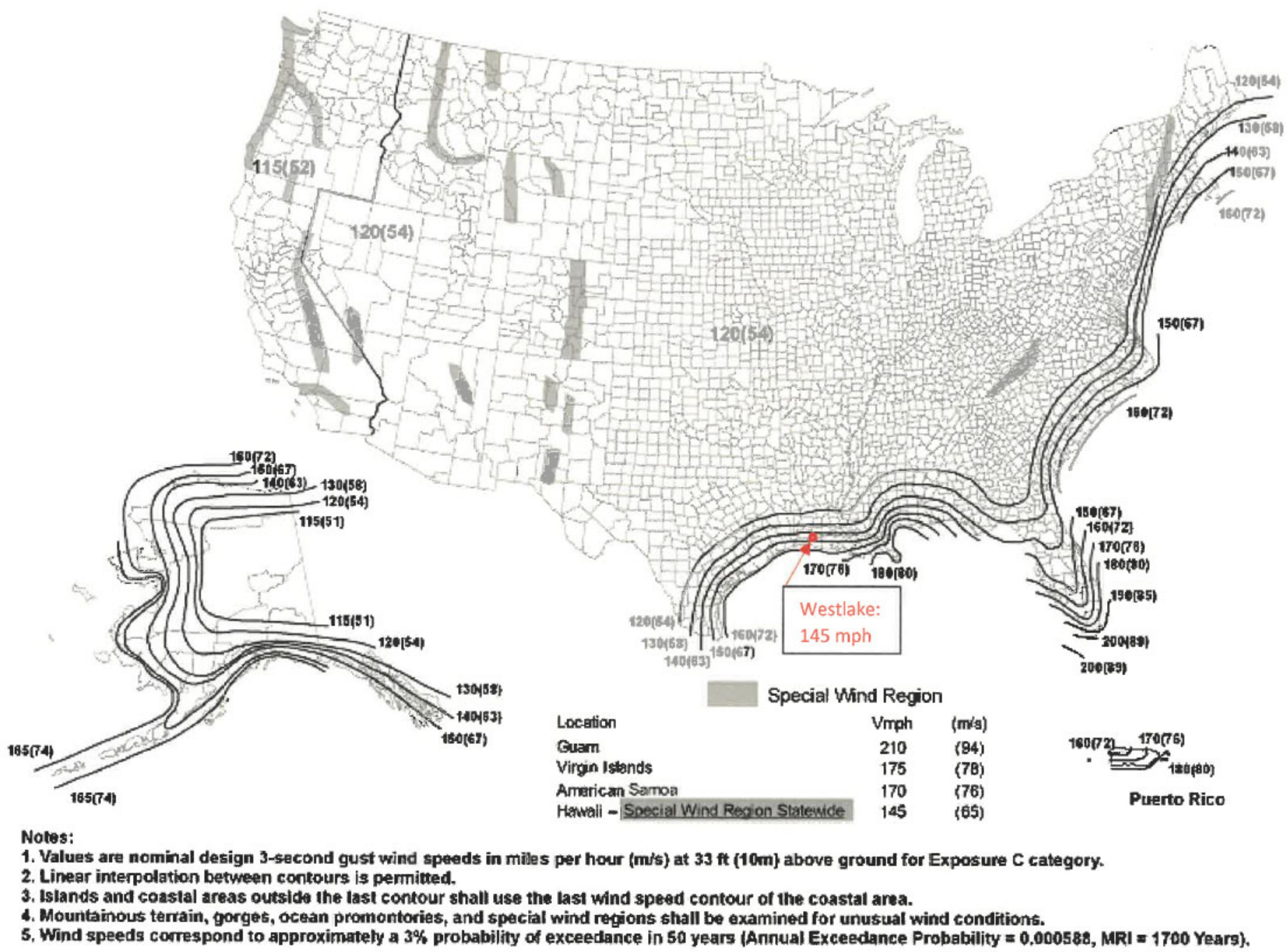


Figure 16. 2015 International Building Code Fig 1609.3(2), Design Wind Speeds for Risk Category III and IV Buildings. (Credit: 2015 International Building Code, annotations by CSB)

The Standard Building Code 1974 design wind speed of 100 mph and the 2015 International Building Code design wind speeds of 145 mph cannot be compared directly. The 2015 International Building Code design wind speeds are coupled with extensive refinements in building codes since 1974, including:

- 41 years of additional climate data;
- use of three-second gust instead of fastest mile wind speed measurement;
- a different basis for storm return periods;

[a] Louisiana’s adoption of the International Building Code includes the deletion of chapters 1, 11, and 27, and the inclusion of 69 amendments. None of these deletions or amendments alter the International Building Code design wind speeds. See **Appendix D**.

- increased design wind speed for high-risk buildings; and
- refined calculation methods for wind pressure.

An analysis commissioned by the CSB (**Appendix D**) determined that a better way to compare the 1974 Standard Building Code and the 2015 International Building Code wind design requirements is by comparing the resulting wind pressures. The 2015 International Building Code requires Risk Category IV structures, such as those at Bio-Lab, to successfully resist substantially higher wind pressures than the 1974 Standard Building Code, as shown in **Table 2**:

Table 2. Comparison of 1974 Standard Building Code and 2015 International Building Code Design Wind Pressures.

Building Component	**Required Design Wind Pressure (in pounds per square foot (psf))**	
	1974 Standard Building Code	**2015 International Building Code**
Windward wall, 0-30 ft height	26 psf	31 psf
Roof edge, flat roof, 30 ft height	20 psf (up)	57 psf (up)
Rolling door, 0-30 ft height	26 psf	45 psf

Although there are additional calculation refinements in the 2015 International Building Code that affect design, the above data from the 2015 code leads to substantial increases in building strength and resilience. The CSB-commissioned analysis determined that buildings meeting 2015 International Building Code requirements are significantly stronger and better able to survive high wind events than those meeting the 1974 Standard Building Code requirements. As such, structures in the Westlake / Lake Charles, Louisiana, area meeting the 2015 International Building Code design requirements for Risk Category IV buildings would be expected to better withstand higher winds, such as those experienced from Hurricane Laura (**Appendix D**).

4.1.1.3 Previous Hurricanes Impacting Louisiana

Table 3 below lists Category 3, Category 4, and Category 5 hurricanes that have impacted Louisiana between 1964 and 2020. According to the National Weather Service, "Laura was the strongest hurricane to strike Southwest Louisiana since records began in 1851" [16], with maximum sustained winds reaching 150 mph while approaching the coast of southwestern Louisiana.[a] The highest wind gust speed recorded in the Lake Charles area during Hurricane Laura was 137 mph, just before the instrument failed.

[a] 130 kt = 150 mph

Table 3. Category 3, Category 4, and Category 5 hurricanes impacting Louisiana 1964–2020 [29, 30].

Year	Name	Landfall	Winds (mph)	Category
1964	Hilda	Salt Point, LA	115	3
1965	Betsy	Grand Isle, LA	125	3
1969	Camille	Pass Christian, MS	190	5
1974	Carmen	Point Au Fer, LA	120	3
1985	Elena	Gulfport, MS	115	3
1992	Andrew	Atchafalaya, LA	115	3
1995	Opal	Pensacola, FL	115	3
2005	Katrina	Mouth of the Mississippi River, LA	125	3
2005	Rita	Johnson's Bayou, LA	115	3
2020	Laura	Cameron, LA	150	4
2020	Ida	Port Fourchon, LA	150	4
2020	Zeta	Cocodrie, LA	115	3

4.1.1.4 Bio-Lab Hurricane Plan

The Bio-Lab Hurricane Plan[a] defines six hurricane preparation and response phases starting 50 hours before tropical storm-force winds are expected in the area (**Table 4**). To protect chemicals from hurricane rainwater and floodwater, the plan requires employees to "sandbag identified entrances to prevent floodwater entry," "move finished product… to higher storage or place empty pallet under the product," "survey areas for other materials vulnerable to flood damage as well as material that could become hazardous during flooding," and "close/secure all warehouse doors." These actions could not protect chemicals from any unintentional movement from hurricane winds or exposure to rainwater in the event hurricane-force winds damaged the buildings.

[a] The Hurricane Plan is distributed annually to Bio-Lab employees to provide refresher training, establish hurricane staffing volunteers, and ensure that area plans are current. It was also discussed at monthly meetings and daily safety talks. The Hurricane Plan was sent to Bio-Lab employees in May 2020, three months before the incident. The Plant Manager is responsible for initiating actions based on available resources or information, including from the National Weather Service and the Calcasieu Parish Office of Homeland Security and Emergency Preparedness.

Table 4. Bio-Lab hurricane preparation guidance for pre-hurricane and Phase I Through Phase VI.

Pre-hurricane Actions ***(Before hurricane season starts)***	**Phase I Actions** ***(50 hours before 39 mph winds are expected in the area)***	**Phase II Actions** ***(36 hours before 39 mph winds are expected in the area)***
• Check doors • Secure or remove temporary buildings and construction material • Check drainage ditches • Review hurricane procedures at the start of hurricane season • Confirm availability of emergency food and water • Contact area electrical contractors for any post-hurricane electrician assistance • Maximize diesel and gasoline storage • Confirm information technology backups • Obtain re-entry criteria • Establish a block of hotel rooms • Increase identified hurricane supplies inventory	• Check hurricane supplies • Fill diesel and gasoline storage tanks • Verify adequate sandbagging material availability • Review staffing arrangements and shutdown procedures—Plant 1, 4, 5, 6, and Wastewater Treatment Instructions • Survey areas for material that could become hazardous during a hurricane and prepare a check-off list of items to be removed or secured • Check scaffolding, secure or remove dumpsters, and perform general securing of areas per checklist • Coordinate pre-hurricane work • Monitor hurricane tracking and developments • Implement plant shutdown plans • Sandbag identified entrances to prevent floodwater entry	• Verify completion of the check-off list • Relocate important files in Administration to elevated storage • Complete plant shutdown in an orderly fashion and begin to secure units • Dismiss hurricane staffing crew to cover details and preparation at home • Arrange removal of all unnecessary trailers from the plant • Move finished product on first floor of Plant 4 to higher storage or place empty pallet under the product • Survey areas for other materials vulnerable to flood damage as well as material that could become hazardous during flooding • Order rental pumping equipment as needed • Holdover off-going shift and craftsmen to finalize preparation • Secure hoses, fire extinguishers, breathing air boxes, and all doors against high wind or move indoors • Move correspondence files, charts, and drawings to a higher location wherever possible or place them on blocks and cover with Visqueen
Phase III Actions ***(24 hours before 39 mph winds are expected in the area)***	**Phase IV Actions** ***(12 hours before winds are expected to reach 39 mph in the area)***	**Phase V Actions** ***(Winds reach 45 mph in the area)***

• Hurricane crew completes personal preparations and prepares to report to the plant, ready to remain for the duration of the emergency
• Verify check-off list is completed or will be completed on time
• Shut down warehouse activities
• Close/secure all warehouse doors
• Release all personnel not needed for emergency staffing
	• Hurricane crew reports to plant:
	  o Holds brief meeting to coordinate impending activities
	  o Store two forklifts in Plant 4 and all other forklifts in Finished Product Warehouse
	  o Move company trucks at the maintenance shop
	  o Make final area survey
		• Hurricane crew remains in Control Rooms, monitors damage, if possible, and maintains radio contact between Control Rooms
		Phase VI Actions
		(Winds below 45 mph)
		• Check for damage and unsafe conditions
		  o All motor control centers; downed electrical lines; fiberglass vessels and piping; wet product in Plant 4 and warehouse; and all motors and other electrical equipment before energizing
		• Generate list to be completed for startup

4.1.2 Analysis

Hurricane Laura, a Category 4 hurricane, produced wind gusts in the Westlake / Lake Charles area exceeding 130 mph. It led to an estimated $10 billion in insured damages in Louisiana [31]. The CSB concludes that the strong winds from Hurricane Laura damaged Bio-Lab's Plant 4 and the Finished Goods Warehouse, which allowed rainwater to intrude into these buildings, contact the TCCA, and initiate a chemical reaction, TCCA decomposition, chlorine release, and fire.

4.1.2.1 Industry Guidance on Protecting Chemicals from Extreme Weather

After the August 2017 organic peroxide decomposition incident at the Arkema facility in Crosby, Texas, which occurred after extensive flooding was caused by Category 4 Hurricane Harvey, the CSB recommended to the Center for Chemical Process Safety (CCPS) the following:

> Develop broad and comprehensive guidance to help companies assess their U.S. facility risk from all types of potential extreme weather events. Guidance should address the issues identified in this [CSB investigation report on the Arkema incident] and cover actions required to prepare for extreme weather, resiliency, and protection of physical infrastructure and personnel during extreme weather, as well as recovery operations following an extreme weather event, where appropriate. Include guidance for each of the following:
>
> - Addressing common mode failures of critical safeguards or equipment that could be caused by extreme weather events, including but not limited to flooding. For flooding scenarios, sufficient independent layers of protection should be available if floodwater heights reach the facility.
> - Evaluating facility susceptibility to potential extreme weather events. Relevant safety information, such as flood maps, should be incorporated as process safety information.
> - Involving relevant professional disciplines, including engineering disciplines, to help ensure risk assessments and process hazard analyses are as robust as practicable for any given facility [32, p. 127].

KEY LESSON

Extreme weather can present serious hazards to facilities that manufacture, process, or store hazardous chemicals. Facilities should evaluate the hazards to processes from extreme weather and implement safeguards to protect from those hazards. The CCPS Monograph *Assessment of and Planning for Natural Hazards* provides guidance on how to evaluate, risk assess, and protect facilities from natural hazards.

In response to this recommendation, CCPS updated its CCPS Monograph *Assessment of and Planning for Natural Hazards*.[a] The Monograph outlines six steps for preparing for a natural disaster, including (1) Identify Hazards; (2) Gather Data; (3) Identify Equipment to be Addressed in Natural Hazards Assessment; (4) Evaluate Against Design Criteria; (5) Recovery; and (6) Recommissioning [33]. As part of the third step, "Identify Equipment to be Addressed in Natural Hazards Assessment," the Monograph specifically addresses how to evaluate wind hazards, stating, "For wind hazards, document the equipment/operation potentially impacted, the required wind design per local building code, and the existing wind design basis [33, p. 3]." The Monograph provides a Wind Hazard Table for documenting the current wind design requirements per code, the existing wind design basis of buildings/equipment, the wind design gap, safeguards, and actions (**Table 5**).

[a] Monograph Assessment of and Planning for Natural Hazards | CCPS The CCPS updated and published this Monograph in 2019 as an updated edition of its previous pamphlet, "Recovery from Natural Disasters."

Table 5. Wind hazard table in CCPS Monograph *Assessment of and Planning for Natural Hazards* [33].

Wind Hazard Table					
Critical Equipment / Building Impacted	Wind Design Required per code (kph)(mph)	Existing Wind Design Basis (kph)(mph)	Wind Design Gap: (kph)(mph)	Safeguards	Action: (one or more) • Close Gap • Assess Risk • Emergency Response

The Monograph also states:

> Where the current or planned design falls below the design criteria, then there is a gap that should be addressed. One or more of the following approaches may be taken in addressing a gap.
>
> 1. Bring the equipment/operation up to the design criteria
> 2. Conduct a risk assessment to understand the risk and develop safeguards
> 3. Address the gap through emergency response plans.
>
> […] The process safety hierarchy should be kept in mind when deciding how best to close a gap. It is better to first eliminate the gap, then to engineer a solution, and then to provide emergency response. […]
>
> For meteorological hazards including wind (including hurricane), earthquake, tornado, snow/ice storm, and [lightning], local building codes should be consulted for design criteria. For example, wind or seismic designs should be evaluated for tall structures […] [33, p. 3].

Per the CCPS Monograph guidance, Bio-Lab should have (1) determined the current building wind design requirements per code, (2) determined the actual/existing wind design basis of its facility buildings, (3) determined the wind design gap, (4) identified existing safeguards, and (5) identified and addressed corrective actions to protect its chemicals from hurricane hazards. Bio-Lab never conducted these activities. The CSB concludes that Bio-Lab did not learn the importance of preparing for extreme weather after the 2017 Arkema incident, did not adequately implement industry guidance for preparing for extreme weather, and, as a result, was unprepared for the winds produced by Category 4 Hurricane Laura. As a result, much of the facility was severely damaged, one production building was destroyed, and the local community was put at risk of being exposed to toxic chlorine. The CSB also concludes that had Bio-Lab adhered to the guidance published in the CCPS Monograph *Assessment of and Planning for Natural Hazards*, it would have identified that the buildings housing water-reactive TCCA were not built to current wind design code requirements, which could have led to Bio-Lab taking action to protect its chemicals during hurricanes, thereby preventing the incident.

The CSB recommends that Bio-Lab evaluate the hazards to the Bio-Lab Lake Charles facility from hurricanes and accompanying wind, rainwater, floodwater, or storm surge forces. Implement processes and safeguards for protection against those hazards, such as through:

- Constructing new and maintaining existing buildings and structures to withstand hurricane winds and flooding, with a particular focus on those containing hazardous materials;
- Implementing safeguards and processes to ensure hazardous chemicals are not compromised and released during extreme weather events; and
- Following the guidance presented in the CCPS Monograph *Assessment of and Planning for Natural Hazards*.

4.1.2.2 Need for Improved Hurricane Preparation in Aging Facilities

As will be described in Section 4.5 of this report, there are currently no federal process safety regulations that cover the Bio-Lab facility and require it to evaluate its process safety hazards and implement safeguards to protect from those hazards (e.g., implementing safeguards to protect its chemicals from hurricane-strength winds and water intrusion). While the CSB is recommending in this report that the Bio-Lab facility be covered by federal process safety regulations, the CSB concludes that additional measures are needed to ensure that aging Louisiana facilities do not have hazardous chemical releases during hurricanes. The Louisiana Department of Environmental Quality (LDEQ) is the primary agency in the state concerned with environmental protection and regulation.[a] The Louisiana Environmental Quality Act[b] provides that "[i]n order to prevent accidental releases of regulated substances," the Secretary of LDEQ is authorized to "adopt and promulgate regulations governing release prevention, detection, and correction requirements."[c] LDEQ has issued regulations adopting the requirements of the EPA RMP Rule, with some modifications,[d] and as such, chlorine, which was released in the Bio-Lab incident, is regulated under both the EPA RMP Rule and LDEQ regulations.[e] Additionally, the Governor of Louisiana has the authority to issue executive orders and otherwise direct action by executive agencies in the state, and the Louisiana State Legislature can enact new laws to prevent releases of hazardous materials, as it did with the Louisiana Environmental Quality Act. The CSB therefore recommends the following to the Governor of Louisiana, Louisiana State Legislature, and Secretary of the LDEQ:

Under existing statutory or regulatory authority or through the establishment of new authority by executive or legislative action, for all existing chemical manufacturing and storage facilities that:

(1) Are located in a hurricane-prone region as defined by the International Building Code, and

(2) Manufacture or store or can inadvertently or otherwise produce (e.g., by chemical reaction) regulated substances inside equipment or building(s) built before more current wind design requirements came into effect

[a] Louisiana Revised Statute Title 30 Subtitle II § 2011
[b] Louisiana Revised Statute Title 30 Subtitle II
[c] Louisiana Revised Statute Title 30 Subtitle II § 2063(G)
[d] Louisiana Administrative Code (LAC) Title 33, Part III, Chapter 59 § 5901 (A)
[e] 40 CFR § 68.130

Require the facility operators to evaluate the hazards to their facilities from hurricanes and accompanying wind, rainwater, floodwater, or storm surge forces. Require the facility operators to implement processes and safeguards for protection against those hazards, such as through:

a. Ensuring that buildings and structures (both new and existing) can withstand hurricane winds and flooding, with a particular focus on buildings and structures containing hazardous materials;

b. Implementing safeguards and processes to ensure that hazardous chemicals are not compromised and released during extreme weather events; and/or

c. Following the guidance presented in the CCPS Monograph *Assessment of and Planning for Natural Hazards*.

4.1.2.3 Need for EPA Action to Ensure Regulated Facilities Consider Risks from Climate Change

In 2022, the U.S. Government Accountability Office (GAO)[a] issued a report, *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change* [34]. The GAO stated the following about the report:

> **Why GAO Did This Study**. Over 11,000 [U.S. EPA-covered Risk Management Program] facilities across the nation have extremely hazardous chemicals in amounts that could harm people, property, or the environment if accidentally released. Risks to these facilities include those posed by natural hazards, which may damage facilities and potentially release the chemicals into surrounding communities. Climate change may make some natural hazards more frequent or intense, according to the Fourth National Climate Assessment.
>
> GAO was asked to review climate change risks at RMP facilities. This report examines, among other things, (1) what available federal data indicate about RMP facilities in areas with natural hazards that may be exacerbated by climate change; and (2) challenges RMP facilities face in managing risks from natural hazards and climate change, and opportunities for EPA to address these challenges. GAO analyzed federal data on RMP facilities and four natural hazards [flooding, storm surge from hurricanes, wildfires, and sea level rise] that may be exacerbated by climate change, reviewed agency documents, and interviewed agency officials and stakeholders, such as industry representatives.
>
> **What GAO Recommends**. GAO is making six recommendations, including that EPA issue regulations, guidance, or both to clarify requirements and provide direction to facilities on incorporating natural hazards and climate change into risk management programs. EPA agreed with our recommendations [34].

The GAO report also referenced Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*, which was issued on January 27, 2021, by President Joseph R. Biden, and calls for a government-wide approach

[a] The GAO provides non-partisan, fact-based information to Congress, the public, and executive agencies at the request of congressional committees/subcommittees or by statutory requirement [71].

to “drive assessment, disclosure, and mitigation of … climate-related risks in every sector of our economy….” [35].

The GAO report found that “[t]he RMP Rule does not explicitly require a facility to consider natural hazards or climate change as part of its risk management program. However, EPA guidance says that an RMP facility should consider external hazards, such as natural hazards, as part of the hazards review or process hazard analysis conducted for its prevention program [34, p. 33].” The report goes on to say that “[b]y issuing regulations, guidance, or both, as appropriate, to clarify requirements and provide RMP facilities with direction on how to incorporate [natural hazard] risks into their risk management programs, EPA could better ensure that RMP facilities are managing risks from all relevant hazards, including natural hazards and climate change [34, p. 38].”

In the report, GAO issued six recommendations to EPA:

1. The EPA should provide additional compliance assistance to RMP facilities related to risks from natural hazards and climate change;
2. The EPA should design an information system to track common deficiencies found during inspections, including any related to natural hazards and climate change, and use this information to target compliance assistance;
3. The EPA should issue regulations, guidance, or both, as appropriate, to clarify requirements and provide direction for RMP facilities on how to incorporate risks from natural hazards and climate change into their risk management programs;
4. The EPA should develop a method for inspectors to assess the sufficiency of RMP facilities’ incorporation of risks from natural hazards and climate change into risk management programs and provide related guidance and training to inspectors;
5. The EPA should incorporate the vulnerability of RMP facilities to natural hazards and climate change as criteria when selecting facilities for inspection; and
6. The EPA should incorporate the relative social vulnerability of communities that could be impacted by an accidental release when selecting RMP facilities for inspection [34, pp. 45-46]. As of March 2023, the GAO’s website shows this recommendation as “closed-implemented,” indicating “actions that satisfy the intent of the recommendation have been taken.”

The CSB concludes that the findings and recommendations of the 2022 GAO report *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change* identify critical actions that EPA should take to ensure that facilities evaluate risks from natural hazards and climate change and identify corrective safeguards. The CSB recommends that the EPA implement the five open recommended actions from the GAO report.

4.2 Process Hazard Analyses Implementation

4.2.1 Factual Information

4.2.1.1 TCCA Operating Safety Reviews and Process Hazard Analyses

In 2019, Bio-Lab voluntarily established a process safety management program for its facility modeled after some of OSHA's Process Safety Management (PSM) elements. According to the site's process safety documents:

> The Lake Charles site is not subject to Process Safety Management regulations (OSHA 1910.119) because it does not have any process chemicals above the threshold limits set in the OSHA regulation. The Lake Charles site recognizes Process Safety Management (PSM) is a comprehensive system for the management of chemical process[es] and has chosen to be PSM compliant.

Before Bio-Lab procedurally established its facility process safety management program in 2019, a previous owner conducted "Operating Safety and Hazard Reviews" in 1988 covering the hazards associated with Plant 2 and Plant 4 (which was involved in the incident), and Bio-Lab conducted process hazard analyses (PHAs) in 2010 and 2016 of the operations within Plant 2 only (which was not involved in the incident). These reviews are discussed below.

1988 TCCA Operating Safety and Hazard Reviews

The 1988 *TCCA Operating Safety and Hazard Reviews* document covered operations in both Plant 2 and Plant 4. The document states, "[p]roduct decompositions create the greatest environmental and safety hazard in Plant 4." The 1988 hazard review document identified that wet product from Plant 2 entering the dry system in Plant 4 could trigger a decomposition event. The hazard review did not identify that extreme weather events could also lead to decomposition events in Plant 4. The site did not conduct any additional hazard reviews or PHAs for Plant 4 after this 1988 hazard review.

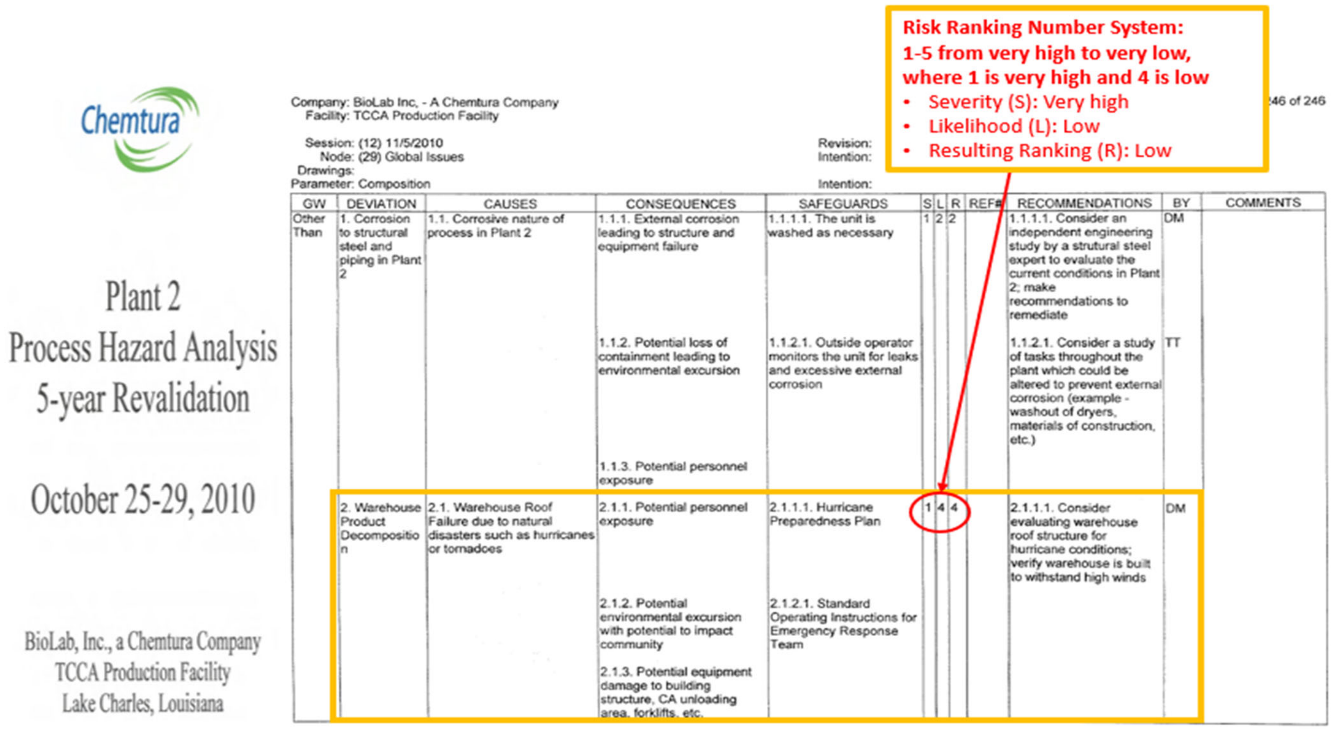
2010 Plant 2 Process Hazard Analysis

In 2010, Bio-Lab conducted a process hazard analysis (PHA) for Plant 2 (which was not impacted by Hurricane Laura or involved in the incident, thus not the subject of this report).[a] That PHA evaluated a node called "global issues" (**Figure 17**). For that node, the PHA team identified a deviation called "warehouse product decomposition," with an identified potential cause of "warehouse roof failure due to natural disasters such as hurricanes or tornados." The PHA team classified this deviation as having a very high severity, low likelihood, and low overall risk.[b] The PHA team recommended that the site "consider evaluating warehouse roof structure for hurricane conditions; verify warehouse is built to withstand high winds." According to Bio-Lab's 2010 PHA

[a] The 2010 Bio-Lab PHA was conducted prior to KIK's acquisition of Bio-Lab.

[b] Bio-Lab uses a matrix that, from the combination of severity (S) and likelihood (L), identifies the overall risk (R). A number 1 overall risk ranking level is "Very High" and must be mitigated with engineering and administrative controls before continued operation. A number 4 overall risk ranking level is "Low" and the mitigation is optional depending on cost-benefit.

documentation, for deviations such as this one classified as having a low overall risk, "mitigation is optional depending on cost-benefit."



Company: BioLab Inc, - A Chemtura Company
Facility: TCCA Production Facility
Session: (12) 11/5/2010
Node: (29) Global Issues
Drawings:
Parameter: Composition
Revision:
Intention:
Intention:
246 of 246

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS	BY	COMMENTS
Other Than	1. Corrosion to structural steel and piping in Plant 2	1.1. Corrosive nature of process in Plant 2	1.1.1. External corrosion leading to structure and equipment failure	1.1.1.1. The unit is washed as necessary	1	2	2		1.1.1.1. Consider an independent engineering study by a strutural steel expert to evaluate the current conditions in Plant 2; make recommendations to remediate	DM	
			1.1.2. Potential loss of containment leading to environmental excursion	1.1.2.1. Outside operator monitors the unit for leaks and excessive external corrosion					1.1.2.1. Consider a study of tasks throughout the plant which could be altered to prevent external corrosion (example - washout of dryers, materials of construction, etc.)	TT	
			1.1.3. Potential personnel exposure								
	2. Warehouse Product Decomposition	2.1. Warehouse Roof Failure due to natural disasters such as hurricanes or tornadoes	2.1.1. Potential personnel exposure	2.1.1.1. Hurricane Preparedness Plan	1	4	4		2.1.1.1. Consider evaluating warehouse roof structure for hurricane conditions; verify warehouse is built to withstand high winds	DM	
			2.1.2. Potential environmental excursion with potential to impact community	2.1.2.1. Standard Operating Instructions for Emergency Response Team							
			2.1.3. Potential equipment damage to building structure, CA unloading area, forklifts, etc.								

Figure 17. Excerpt from 2010 Plant 2 PHA. (Credit: Bio-Lab, annotations by CSB)

The CSB asked Bio-Lab if this recommendation had been implemented and closed out. Bio-Lab responded with the following information:

> Bio-Lab performs routine evaluations and maintenance of the warehouse, including recent repairs to the steel in the warehouse structure. As part of its Hurricane Plan, Bio-Lab also assesses the warehouse for damage or unsafe conditions following hurricane events. In the time following Hurricane Laura, Bio-Lab has been unable to identify documentation on the close-out status of the Node 29 Global Issues Action Item.

Bio-Lab has no documentation that this 2010 PHA recommendation was ever implemented.[a] In addition, Bio-Lab told the CSB that it was unaware of any evaluations of its facility buildings' design basis to understand wind speeds at which the buildings could be susceptible to damage.

---

[a] Bio-Lab communicated the following information to the CSB regarding its PHA action item closeout process: [T]he Lake Charles Site is not subject to Process Safety Management regulations (OSHA 1910.119) because it does not have any process chemicals above the threshold limits set in the OSHA regulation.[] The company has nonetheless made an effort to incorporate PSM principles into its processes and operations…. For PHA action items related to Management of Change ("MOC"), Bio-Lab uses [a] Lake Charles Plant Safety Policy and Procedure [called] Management of Change, to implement MOC action items. … Beyond MOC recommendations, as a general practice, Bio-Lab reviews the recommendations from a PHA and evaluates which recommendations are suitable for entry into SAP [software system]. Once entered in the SAP system, work orders are created to implement the PHA recommendations. Completed work orders are closed out in SAP.

In addition, there is no evidence that Bio-Lab conducted a PHA of the storage of TCCA in Plant 4 to assess possible hazards or risks during extreme weather conditions.

4.2.1.2 Bio-Lab Post-Incident PHAs

Post-incident, Bio-Lab has conducted two additional PHAs. The first PHA focused on Plant 2 operations and was completed in July 2021. A second PHA focused on Plant 2 and Plant 4 operations and was completed in August 2022. This PHA included building and facility siting evaluations in addition to the evaluations of control rooms' susceptibility to extreme weather. The PHAs did not specifically cover the Finished Goods Warehouse or Plant 4 areas that store TCCA.

Bio-Lab communicated that it does not have a PHA action item management system. Bio-Lab's implementation of the CSB's recommendations issued in this report will help improve Bio-Lab's facility process safety management program.

KEY LESSON

It is important to ensure that (1) PHA recommendations are assigned to an appropriate person with a deadline for initial evaluation, (2) the rationale for recommendation modification or rejection is documented, and (3) the status of all action items or recommendations are tracked until completion. Such a process will help ensure that findings and recommendations from PHAs are effectively acted upon.

4.2.2 Analysis

While the Bio-Lab facility voluntarily chooses to follow some of OSHA's PSM elements, improvement of the facility's process safety management program to match the PSM Standard requirements could help to prevent future similar incidents at the facility. Because no closeout documentation was provided for the 2010 warehouse product decomposition deviation described above, the CSB could not determine whether Bio-Lab decided not to implement the recommendation because of the "Low" risk assigned to the deviation or if Bio-Lab's action item closeout management system was deficient. The CSB concludes that had Bio-Lab implemented its 2010 PHA recommendation by evaluating whether the warehouse was built to withstand high winds, it could have identified that the facility buildings were susceptible to damage from hurricane-strength winds. This might have led to Bio-Lab implementing controls to prevent the TCCA from being exposed to hurricane rainwater, which could have prevented the incident.

The CSB also concludes that the lack of closeout documentation for the 2010 PHA recommendation points to deficiencies in Bio-Lab's PHA action item management system. The Center for Chemical Process Safety (CCPS) book *Guidelines for Risk Based Process Safety* provides the following guidance relating to PHA action item closeout:

> ***Resolve recommendations and track completion of actions.*** All recommendations resulting from risk assessments should be resolved in a timely manner. Each recommendation should be assigned to an appropriate person, with a deadline for initial evaluation. That evaluation should consider the costs and

> benefits of the recommendation, its complexity, and its difficulty of implementation. If the recommendation is modified or rejected, the rationale should be documented. Specific action plans should be developed for accepted recommendations. (Note that resolution of a single recommendation may require multiple action plans, and a single action plan may address multiple recommendations.) The action plan should establish responsibilities and implementation deadlines. The management system should track the status of all actions until they are resolved, and should periodically audit the system to ensure compliance [36, p. 220].

The CSB concludes that improving the Bio-Lab PHA action item management system to ensure that each PHA recommendation is assigned to an appropriate person with a deadline for initial evaluation—so that the rationale for recommendation modification or rejection is documented and the status of all action items or recommendations are tracked—can help ensure that future PHA recommendations are appropriately managed.

Additionally, the lack of regularly performed PHAs may be due to Bio-Lab not formally establishing its process safety program until 2019. The CSB concludes that conducting PHAs on all TCCA processes and storage facilities every five years following the CCPS *Guidelines for Risk Based Process Safety* elements and OSHA PSM Standard requirements, could have led to Bio-Lab identifying the potential for the TCCA stored in Plant 4 and the Finished Goods Warehouse to become wet and decompose during hurricanes. This could have led Bio-Lab to implement controls to prevent this event.

The CSB recommends that Bio-Lab develop and implement an improved PHA action item management system. At a minimum the PHA action item management system should:

a. Ensure that each PHA action item or recommendation is assigned to an appropriate person with a deadline for initial evaluation;

b. Document and maintain the rationale if the action item or recommendation is modified or rejected; and

c. Track the status of all PHA action items or recommendations until they are resolved.

Additionally, periodic audits must be conducted on the PHA action item management system to ensure its effectiveness.

The CSB also recommends that Bio-Lab perform PHAs on all buildings and units processing or storing TCCA. Ensure that the PHAs are revalidated at least every five years. Also include the building design basis as process safety information for the PHA team to reference during their analysis.

4.3 Emergency Preparedness and Response

4.3.1 Factual Information

4.3.1.1 Fire Protection System

The Bio-Lab fire protection system included a freshwater reservoir[a] that provided water to four fire water pumps, which pressurized the water for use via hose stations,[b] fire hydrants, and fire monitors.[c] The fire protection system distribution loop extended into a nearby property owned by another company, to which Bio-Lab provided fire water.

Bio-Lab's four fire water pumps consisted of two diesel pumps, one electric jockey pump,[d] and a large electric pump, with a total pumping capacity of 8,000 gallons per minute with all four pumps running.[e] Each pump had a control cabinet with a selector switch, which dictated its mode and sequence of operation, allowing the pumps to start either automatically, based on the system's water pressure, or manually.[f] When the selector switches were set to run automatically, the pumps were designed to begin sequentially when the water pressure dropped below 100 pounds per square inch (psi) (**Figure 18**).[g] In the event of a power outage, Bio-Lab required using a generator to provide electricity to power the electric pumps. Bio-Lab's backup generator was not working before the hurricane. During the site's preparation for Hurricane Laura, Bio-Lab acquired a rental backup generator that could be used to operate the electric fire water pumps.[h]

[a] The Bio-Lab freshwater reservoir is around 18 million gallons.

[b] Each High Bay process tower level, including the ground floor, was equipped with two manually operated hose stations. The hose system typically contained a reel, hose, valve, and cabinet connected to the fire water loop. The Low Bay area contained additional hose reels.

[c] Fire monitors, sometimes referred to as firefighting cannons, are high-capacity jets that shoot a high-velocity stream of firefighting water or other fire-extinguishing agents manually or automatically.

[d] Jockey pumps are typically small electric pumps that maintain pressure in a fire protection piping system, so the larger fire pump does not have to run or cycle on and off at short intervals. A jockey pump often does not provide much flow and does not contribute to the actual firefighting operation [61, p. 366].

[e] The jockey pump is rated 500 gallons per minute (gpm) at 134 pounds per square inch gauge (psig) and 1,800 revolutions per minute (rpm). The large electric and diesel fire water pumps are each rated 2,500 gpm at 134 psig and 1,725 rpm.

[f] The system's water pressure is not connected to the facility's Distributed Control System. Its instrumentation includes local gauges and pneumatically operated pressure transmitters, switches, and other equipment.

[g] Bio-Lab told the CSB that its electric jockey pump would operate continuously once started and would not shut off when the system's other fire water pumps started.

[h] Post-incident, the rental backup generator was also used to provide electricity at the facility as needed.

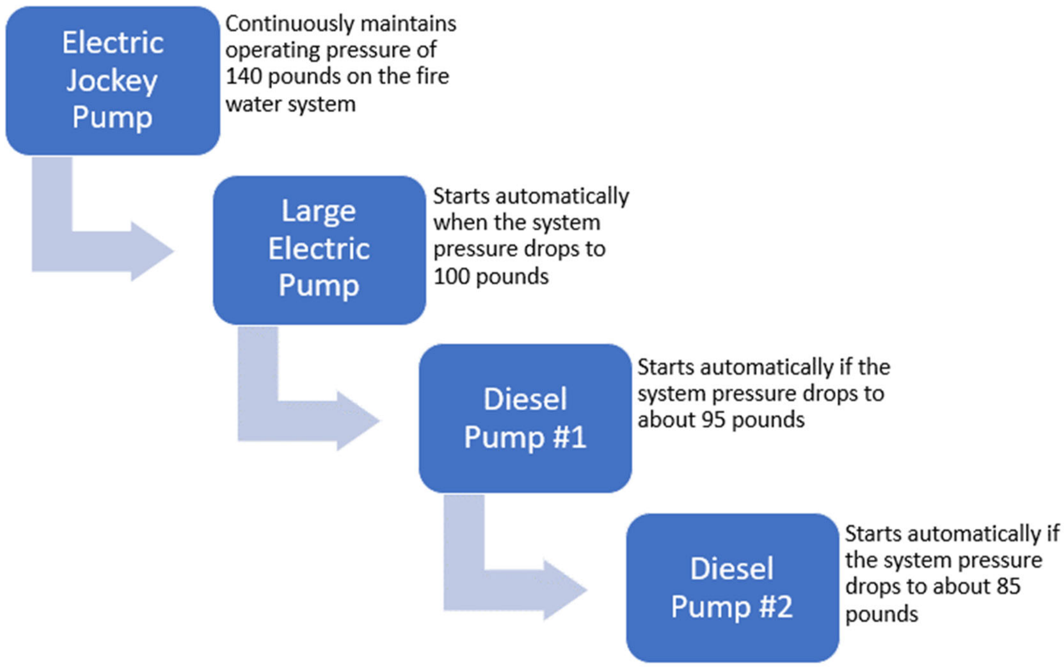


Figure 18. Bio-Lab's fire water pumps automatic start-up sequence. (Credit: Bio-Lab, illustration by CSB)

Hurricane Laura damaged a power grid, causing the Bio-Lab facility and the surrounding area to lose electrical power. Bio-Lab personnel attempted to turn on the rental backup generator to operate the fire protection system. Initially, they could not activate the rental generator, and as a result, neither the electric jockey pump nor the large electric pump could be operated. Later, another employee successfully turned on the generator, but it still could not supply power to the electric pumps. The employees did not have a manual or operating procedure to reference for the rental generator. In addition, one of the diesel pumps was nonfunctional before the hurricane made landfall, resulting in only one fire water pump—a diesel pump—available for use to respond to the decomposition and fire. Once the Fire Department arrived, they also experienced difficulties priming their pump, as discussed in Section 2.3.2. With only one fire water pump, the facility could not achieve adequate pressure to apply water to the decomposing TCCA. The incident could not be controlled until the contracted third-party emergency responders arrived, set up their equipment, and successfully flowed sufficient water to the decomposing TCCA. The problems with the Bio-Lab fire protection system resulted in a lengthy delay of around five and a half hours before productive emergency response operations began. During this delay, the TCCA continued to decompose, releasing large clouds of decomposition products, including chlorine.

4.3.1.2 Lack of Automated Fire Sprinklers

Bio-Lab did not have automated fire sprinklers in Plant 4 or the Finished Goods Warehouse,[a] which stored TCCA and experienced decomposition events due to the hurricane. The Bio-Lab employees were left to rely on external fire monitors to attempt to control the accidental release and prevent the fire from spreading.

[a] The Bio-Lab post-incident rebuild investment includes the installation of a new automatic sprinkler system monitored by a remote supervising station (by others) throughout the new production building that replaced the destroyed Plant 4.

4.3.1.3 Nonfunctional Diesel Fire Water Pump

As will be described in Section 4.4.1.1, NFPA 101 requires fire protection equipment to continuously be in proper operating condition. Bio-Lab routinely checked its diesel fire water pumps for operability. A third-party company also tested the performance of the electric and diesel fire water pumps to NFPA 25 *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. The diesel fire water pump that was not functional at the time of the incident had failed its annual performance test in 2015, 2016, 2017, and 2020. A Bio-Lab manager communicated to the CSB that the pump "didn't work and it hasn't for some years." Bio-Lab did not provide performance test reports to the CSB for 2018 and 2019.

The NFPA 25 standard includes the following general requirements:

- "The property owner or designated representative shall correct or repair deficiencies or impairments [37, pp. 25-14]."
- "Records shall be made for all inspections, tests, and maintenance of the system and its components [37, pp. 25-15]."
- "Records shall be made available to the authority having jurisdiction upon request [37, pp. 25-15]."
- "Maintenance shall be performed to keep the system equipment operable [37, pp. 25-16]."

4.3.1.4 Industry Guidance

Published industry guidance describes the importance of quickly applying copious amounts of water to decomposing pool chemicals, including TCCA:

- "If swimming pool chemicals are involved in a fire or reaction, use large quantities of water." Source: NFPA 400 *Hazardous Materials Code* [4, pp. 400-208]
- "[T]richlor can react with small amounts of water over a period of time and form NCl_3 [nitrogen trichloride], a potentially explosive compound.…water should continue to be added. Water in sufficient quantities is still the best method to control an oxidizer in a fire." Source: NFPA 400 *Hazardous Materials Code* [4, pp. 400-207]

The guidance also describes that it is critical to call for outside support by the fire department in the event of a TCCA or pool chemical fire:

- "In the event of any fire, you should immediately call your local fire department–even if the building has a sprinkler system…An oxidizer fire probably will not be contained by the sprinkler system alone. The fire department must be called." Source: *Guidelines for Safe Handling & Storage of Calcium Hypochlorite and Chlorinated Isocyanurate Pool Chemicals* [38, p. 2 and 14]
- "…If there is a fire or if the pool chemical product is contaminated with another chemical [including water], the area should be evacuated and the fire department called immediately, even if the building has a sprinkler system." Source: NFPA 400 *Hazardous Materials Code* [4, pp. 400-208]

Having an emergency response plan for natural disasters or chemical emergencies is also extremely important according to industry guidance, which states the following:

- "[D]eveloping, training, and testing an emergency response plan for natural disasters is just as important as doing the same for other potential site emergencies." Source: CCPS Monograph *Assessment of and Planning for Natural Hazards* [39, p. 7]
- "[Emergency response] equipment should be checked to make sure it is in good working order. Checks may include refreshing battery packs and testing equipment that is not in routine use. Checks should be scheduled, for example, two weeks before the beginning of the monsoon season in South Asia, one month before the official start of the hurricane season in the US Gulf coast and Atlantic coast, and two times a year for earthquake prone regions." Source: CCPS Monograph *Assessment of and Planning for Natural Hazards* [39, p. 25]
- "The emergency action plan shall include … maintenance of fire protection equipment." Source: NFPA 400 *Hazardous Materials Code* [4, pp. 400-49]
- "Fire protection and life safety systems shall be maintained in an operative condition at all times, and shall be replaced or repaired where defective." Source: International Fire Code [40]
- Under the Hazardous Waste Operations and Emergency Response standard (29 CFR § 1910.120), an emergency response plan must address emergency equipment [41].

4.3.2 Analysis

It is essential that emergency and fire protection equipment operate as intended when needed. Companies need to develop and adhere to regular maintenance schedules to ensure the reliability of emergency and fire protection equipment. The CSB concludes that Bio-Lab experienced serious delays in its response to the TCCA decomposition and fire (roughly five and a half hours), due to an inadequate and largely nonfunctional fire protection system and the absence of automated extinguishing systems. This significant delay in responding to the decomposition likely led to an unnecessary increase in (1) the amount of TCCA that decomposed, (2) the quantity of toxic chlorine released, and (3) the extent of the facility damage. An adequately designed and functional fire protection system with appropriate detection and activation features that have been properly assessed for risk could have provided a critical early response to reduce the size of the event. Companies also need to ensure they can respond to emergencies even with loss of commercial electrical power, such as through on-site backup power sources, to foster resiliency and reliability. Bio-Lab's post-incident reconstruction investment of approximately $250 million includes upgrades to its fire protection system, including new fire water pumps, automatic sprinklers, thermal cameras in the rebuilt Plant 4, and other safety features.

The CSB also concludes that Bio-Lab did not adequately maintain its fire protection system to protect against fire hazards and ensure its functionality during an emergency. The CSB notes that Louisiana has adopted the NFPA 101 *Life Safety Code* under the State Fire Marshal's authority, which requires the maintenance of any necessary equipment [42, pp. 101-38]. Bio-Lab also did not ensure that personnel could activate its rental backup generator, which was necessary to operate fire protection equipment during the power outage caused by Hurricane Laura.

The CSB recommends the following to Bio-Lab Lake Charles:

Revise the Bio-Lab Lake Charles emergency response plan to require the following:

a. The site's fire protection system is properly maintained and routinely function-tested in accordance with published industry guidance and NFPA requirements. Require in the emergency response plan that any equipment identified as nonfunctional must be repaired in a timely manner in accordance with NFPA requirements;

b. Emergency and fire protection equipment (in particular fire water pumps) must be checked regularly to ensure it is all in good working order one month before the start of the hurricane season, as recommended by the CCPS Monograph *Assessment of and Planning for Natural Hazards*; and

c. Site personnel must be trained on the use of all emergency generators and other emergency equipment at least one month before the start of the U.S. hurricane season.

KEY LESSON

Companies must ensure that emergency response equipment is fully operational and can function when needed during emergencies. Companies should conduct routine evaluations of the functionality of fire protection systems in accordance with industry guidance and NFPA requirements, adequately maintain the equipment, and repair or replace equipment as appropriate in a timely manner. Companies must ensure that personnel are trained on how to use emergency response equipment.

4.4 Adherence to Applicable Hazardous Materials Codes

4.4.1 Factual Information

4.4.1.1 NFPA 101 *Life Safety Code*

The 1973 edition of the NFPA 101 *Life Safety Code*, as adopted by Louisiana when Bio-Lab was constructed in 1979, states,

> Every required automatic sprinkler system, fire detection and alarm system, exit lighting, fire door, and other item of equipment required by this Code shall be continuously in proper operating condition [43, pp. 101-6].
>
> High hazard contents shall be classified as those which are liable to burn with extreme rapidity or from which poisonous [toxic] fumes or explosions are to be feared in the event of fire [43, pp. 101-15].
>
> *High Hazard Industrial Occupancy*. Includes those buildings having contents which are liable to burn with extreme rapidity or from which poisonous [toxic] fumes or explosions are to be feared in the event of fire [43, pp. 101-167].

> Every high hazard [industrial] occupancy shall have automatic sprinkler protection or such other protection as may be appropriate to the particular hazard, including explosion venting for any area subject to an explosion hazard, designed to minimize danger to occupants in case of fire or other emergency before they have time to utilize exits to escape [43, pp. 101-174].

TCCA is a high hazard, as defined above and described in Section 1.2. In addition, buildings storing TCCA, such as Bio-Lab's Plant 4 and the Finished Goods Warehouse, are high-hazard industrial occupancies. The fire protection equipment at the facility must be in proper operating condition. Existing facilities in Louisiana are grandfathered to the state-adopted codes and standards at the time of construction unless changes are made or if the State Fire Marshal receives a complaint.

4.4.1.2 NFPA 400 *Hazardous Materials Code*

NFPA 400 *Hazardous Materials Code* "provide[s] fundamental safeguards for the storage, use, and handling of hazardous materials [44, pp. 400-7]," including ammonium nitrate solids and liquids, corrosive solids and liquids, flammable solids, organic peroxide formulations, oxidizers, pyrophoric solids and liquids, toxic and highly toxic solids and liquids, unstable (reactive) solids and liquids, water-reactive solids and liquids, and compressed gases and cryogenic fluids. The Louisiana Administrative Code requires, as of July 1, 2017, that all new and remodeled structures in the state of Louisiana adhere to the requirements of NFPA 400 [45, pp. 265-266].

TCCA falls under the NFPA 400 hazard classifications shown in **Table 6**. Also indicated in **Table 6** are the associated Maximum Allowable Quantity (MAQ) limits of TCCA allowed to be stored per control area based on the hazard classification. At Bio-Lab, control areas were the individual buildings holding TCCA at the time of the hurricane. During the hurricane, Plant 4 held an estimated 70,000 to 100,000 pounds of TCCA, and the Finished Goods Warehouse held over one million pounds of TCCA.

Table 6. NFPA 400 Hazard Classification and MAQ for TCCA (see **Appendix E**).

TCCA Hazard Classifications	MAQ	High Hazard Protection Level[a]
Oxidizer Class 1	4,000 pounds	N/A
Water Reactive Class 1	Not Limited	N/A
Toxic	500 pounds	4
Corrosive	5,000 pounds	4

For facilities storing, using, or handling hazardous materials exceeding the quantities listed in **Table 6**, including the Bio-Lab facility, NFPA 400 includes additional protection requirements. As described in **Appendix E** of this report, those required protections include a fire detection system and an automatic fire sprinkler system, among

[a] High hazard protection reflects increased building safety requirements exceeding the construction requirements for control areas to accommodate quantities of hazardous materials in excess of those permitted using the control area concept [4, pp. 400-18, 400-27, & 400-28].

other requirements. Bio-Lab had neither a fire detection system nor an automatic fire sprinkler system in either Plant 4 or the Finished Goods Warehouse, where the TCCA decompositions occurred.

4.4.2 Analysis

The CSB concludes that the Bio-Lab facility did not adequately conform to the safeguards identified in the NFPA 101 *Life Safety Code* for high-hazard industrial occupancy (Plant 4 and the Finished Goods Warehouse), which required automatic sprinkler protection or other protection to minimize danger to occupants before they have time to evacuate. Bio-Lab may have conformed to the 1973 edition of NFPA 101 requirements when the facility was originally built in 1979 under former ownership based on drawings provided to the CSB. In addition, the CSB concludes that Bio-Lab did not conform to NFPA 400 *Hazardous Materials Code*, which required a fire detection system and an automatic fire sprinkler system in Plant 4 and the Finished Goods Warehouse. Louisiana requires adherence to NFPA 400 code requirements only for structures built or remodeled after July 1, 2017. The CSB also concludes that had the Bio-Lab facility adhered to the NFPA 101 *Life Safety Code* requirements for high-hazard industrial occupancies and the NFPA 400 *Hazardous Materials Code* requirements, it could have begun applying large amounts of water to the decomposing TCCA earlier in the incident.

Since the incident, Bio-Lab has rebuilt its destroyed production building and resumed production operations. Because Louisiana requires new facilities to adhere to NFPA 101 (2015 edition) and NFPA 400 requirements, Bio-Lab is required to incorporate fire detection systems and automatic fire sprinkler systems in its new buildings storing, using, or handling TCCA at quantities exceeding the MAQ limits. Bio-Lab's new production building is equipped with an automatic sprinkler system. The CSB concludes that designing any new Bio-Lab facility buildings or remodeling existing ones to NFPA 101 *Life Safety Code* (2015 edition) and NFPA 400 *Hazardous Materials Code* requirements, as current Louisiana regulation requires, could help prevent or reduce the severity of future decomposition events.

4.5 Regulatory Coverage of Reactive Chemical Hazards

Chemical reactions can rapidly release heat, energy, and hazardous byproducts. *Uncontrolled* chemical reactions—like the one experienced in the Bio-Lab incident—can lead to toxic releases, fires, or explosions that can cause death, injury, property damage, and negative effects in the environment.

To manage chemical process safety and to help prevent major incidents, in 1992, OSHA promulgated the PSM Standard (29 CFR § 1910.119), and in 1996 the EPA promulgated its RMP Rule (40 CFR § 68). These regulations require some chemical facilities to manage process safety to protect workers, members of the public, and the environment. Each regulation covers facilities that process certain chemicals. The OSHA PSM Standard covers processes using flammable materials and individually listed chemicals that present a range of hazards, and the EPA RMP Rule identifies covered substances based on flammability and toxicity.

While these regulations achieve improved process safety for many chemical processing facilities in the United States, they have a critical coverage gap: neither standard adequately covers facilities processing chemicals that could undergo hazardous chemical reactions. Significantly, while TCCA is capable of undergoing a highly hazardous chemical reaction that can release toxic chlorine, as happened during the Bio-Lab incident, the chemical is not covered in either the OSHA PSM or EPA RMP regulations. As such, Bio-Lab was not required to implement baseline process safety management system elements to manage the safety of its TCCA-related operations under these regulations. OSHA and the EPA currently use predefined chemical lists to identify the processes subject to coverage under the PSM Standard and RMP Rule. The CSB found that OSHA and EPA did not adequately consider reactive chemical hazards when developing these chemical lists, and, as a result, many reactive chemicals, including TCCA, are not covered by these regulations. This regulatory coverage gap relating to reactive chemicals and their hazards (1) points to a weakness with relying on fixed chemical lists to determine regulatory coverage, (2) contributed to this incident, and (3) contributed to many other reactive chemical incidents over the past three decades.

4.5.1 Controlling Hazards through Effective Process Safety Management Systems

The OSHA PSM Standard includes 14 elements, which together constitute a *process safety management system*. The EPA RMP Rule has elements similar to those of the OSHA PSM Standard. OSHA states that "the key provision of PSM is process hazard analysis (PHA)—a careful review of what could go wrong and what safeguards must be implemented to prevent releases of hazardous chemicals" [46]. The PSM Standard states,

> "the process hazard analysis shall be performed by a team with expertise in engineering and process operations…. The employer shall establish a system to promptly address the team's findings and recommendations; assure that the recommendations are resolved in a timely manner and that the resolution is documented; document what actions are to be taken; complete actions as soon as possible; develop a written schedule of when these actions are to be completed; [and] communicate the actions to operating, maintenance and other employees whose work assignments are in the process and who may be affected by the recommendations or actions."[a]

As described in Section 4.2.1, Bio-Lab established a written voluntary process safety management program at its facility. The CSB concludes that had Bio-Lab been required to conduct PHAs and action item resolution processes according to the requirements in the OSHA PSM and EPA RMP regulations, it might have implemented the 2010 hazard analysis recommendation (see Section 4.2), which could have led to the determination that facility buildings were susceptible to damage from hurricane-strength winds. Bio-Lab also would have been required to conduct a revalidation PHA in 2015, presenting another opportunity to address the issues and recommendations. This could have led to Bio-Lab implementing controls to prevent the TCCA from being exposed to hurricane rainwater, which could have prevented the incident.

4.5.2 CSB Reactive Hazard Study

In 2002, the CSB published a hazard investigation report called *Improving Reactive Hazard Management* (known as the Reactive Hazard Study). In that study, the CSB examined the process safety of chemical reactivity hazards in the United States and analyzed 167 known reactive chemical incidents that occurred

[a] 29 CFR § 1910.119(e)

between 1980 and 2001. The study's objectives included determining the impacts of reactive chemical incidents; examining how industry, OSHA, and the EPA address reactive chemical hazards; and developing recommendations for reducing the number and severity of reactive chemical incidents [47, p. 3].

The CSB Reactive Hazard Study found that while the OSHA PSM Standard covers some reactive chemicals, many other reactive chemicals that could contribute to catastrophic incidents are not covered. The PSM Standard covers flammable chemicals (based on flashpoint) and a specified list of 137 toxic and reactive chemicals at facilities that process certain threshold quantities of those chemicals. Of the 137 toxic and reactive chemicals covered by the OSHA PSM Standard, the Standard considers only 38 to be highly reactive. These 38 chemicals were selected for coverage by the PSM Standard from an existing list of chemicals identified and rated by the NFPA because of their instability rating (formerly reactivity rating) of 3 or 4 on a scale of 0 to 4. The CSB found that this coverage technique is inadequate because, of the 167 incidents studied in the Reactive Hazard Study, only about 10% involved chemicals with an NFPA instability rating of 3 or 4. The CSB then examined the effect if the PSM Standard coverage were expanded to also include NFPA instability ratings of 1 and 2 but found that this approach would still address fewer than half of the chemicals involved in the 167 incidents studied (**Figure 19**) [47, pp. 48-49]. Because TCCA has an instability rating of 2, it is not listed as a covered chemical either by the OSHA PSM or EPA RMP regulation.

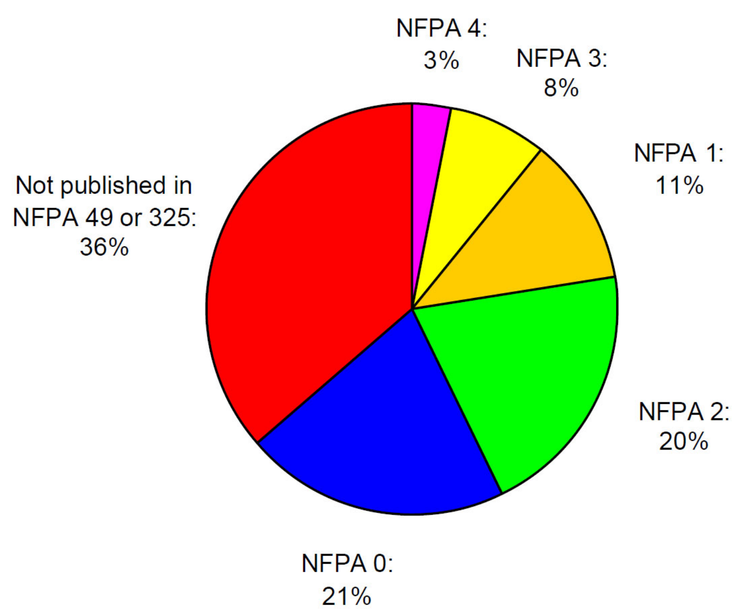


Figure 19. NFPA instability rating analysis of substances in incident data from 1980 to 2001 examined in the CSB Reactive Hazard Study. (Credit: CSB [47, p. 48])

The CSB Reactive Hazard Study critiqued the use of the NFPA classification system to determine regulatory coverage of reactive hazards:

> For the purpose of the OSHA PSM Standard, NFPA instability ratings have the following limitations with respect to identifying reactive hazards:
>
> - They were originally designed for initial emergency response purposes, not for application to chemical process safety.

- They address inherent instability only, not reactivity with other chemical substances (with the exception of water) or chemical behavior under nonambient conditions.
- NFPA Standard 49—on which the OSHA PSM-listed highly reactive chemicals are based—covers only 325 chemical substances, a very small percentage of the chemicals used in industry.
- The OSHA PSM Standard lists 137 highly hazardous chemicals—only 38 of which are considered highly reactive based on NFPA instability ratings of "3" or "4."
- The NFPA ratings were established by a system that relies, in part, on subjective criteria and judgment. [47, p. 6]

The CSB concluded in the Reactive Hazard Study that "[t]he OSHA PSM Standard has significant gaps in coverage of reactive hazards because it is based on a limited list of individual chemicals with inherently reactive properties" and "NFPA instability ratings are insufficient as the sole basis for determining coverage of reactive hazards in the OSHA PSM Standard" [47, p. 10].

The CSB also found significant gaps with the EPA RMP Rule. The CSB found that the EPA RMP Rule does not specifically target reactive chemicals. Regarding the EPA RMP Rule, the CSB Reactive Hazard Study stated:

> When developing the [EPA RMP] list of [covered] substances, EPA considered only the inherent characteristics of a chemical that indicate a severe threat due to exposure. Well-defined criteria were used for toxicity and flammability. However, because of the complexities of site-specific factors and process conditions, EPA was unable to determine any inherent characteristic as an indicator of reactivity. EPA concluded that there was "insufficient technical information for developing criteria for identifying reactive substances." Consequently, the January 1994 list of 130 chemicals does not contain any substances listed due to reactive hazards. [47, p. 60]

Similar to the gap in the OSHA PSM Standard, TCCA is not covered by the EPA RMP regulation. The CSB concluded in the Reactive Hazard Study that "the EPA RMP has significant gaps in coverage of reactive hazards" [47, p. 61].

Based on the shortcomings of predefining reactive chemicals to be covered by the PSM Standard and RMP Rule, the CSB concluded in the Reactive Hazard Study that solely "[u]sing lists of chemicals is an inadequate approach for regulatory coverage of reactive hazards. Improving reactive hazard management requires that both regulators and industry address the hazards from *combinations of chemicals* and *process-specific conditions* rather than focus exclusively on the inherent properties of individual chemicals" [47, p. 10]. The CSB re-emphasizes that conclusion in this report.

In the Reactive Hazard Study, the CSB recommended to OSHA:

> Amend the Process Safety Management Standard (PSM), 29 CFR 1910.119, to achieve more comprehensive control of reactive hazards that could have

> catastrophic consequences. Broaden the application to cover reactive hazards resulting from process-specific conditions and combinations of chemicals. Additionally, broaden coverage of hazards from self-reactive chemicals. In expanding PSM coverage, use objective criteria. Consider criteria such as the North American Industry Classification System (NAICS), a reactive hazard classification system (e.g., based on heat of reaction or toxic gas evolution), incident history, or catastrophic potential. [47, p. 89]

The CSB also issued a recommendation to the EPA:

> Revise the Accidental Release Prevention Requirements, 40 CFR 68, to explicitly cover catastrophic reactive hazards that have the potential to seriously impact the public, including those resulting from self-reactive chemicals and combinations of chemicals and process-specific conditions. [47, p. 91]

Neither OSHA nor the EPA has implemented these recommendations [48], and reactive chemicals still are not adequately covered by either regulatory standard.

4.5.2.1 Reactive Chemical Incidents Investigated by the CSB after the Reactive Hazard Study

After the publication of the CSB Reactive Hazard Study, the CSB investigated an additional eight reactive process incidents between 2002 and 2020 in which the chemicals involved were not covered by the OSHA PSM and EPA RMP regulations. Those incidents are summarized below:

- ***First Chemical Corporation reactive chemical explosion (October 13, 2002).***[a] Steam caused mononitrotoluene (MNT) in a distillation tower to decompose and explode. The force of the explosion blew off the upper 35 feet of the tower and sent tons of debris flying up to a mile away. One piece of the tower punctured a storage tank approximately 500 feet away that contained more than 100,000 gallons of MNT, igniting a fire that burned for about three hours. Another piece of debris, weighing six tons, narrowly missed hitting a crude oil tank at an adjacent refinery. A third fragment struck a pipe rack directly above a tank containing 500,000 pounds of toxic anhydrous ammonia, but the tank was spared. Three workers were injured [49]. MNT is not covered by either the OSHA PSM or the EPA RMP regulations.

- ***T2 Laboratories Inc. reactive chemical explosion (December 19, 2007).***[b] A runaway exothermic reaction occurred during a batch operation producing methylcyclopentadienyl manganese tricarbonyl (MCMT), due to a loss of cooling. The reactor burst, and the reactor contents ignited, creating an explosion equivalent to 1,400 pounds of TNT. Four employees were killed, the facility was destroyed, and 32 people were injured—including 4 employees and 28 members of the public. Debris from the reactor was found up to one mile away [50]. The MCMT and other chemicals involved in the incident,

[a] First Chemical Corporation Reactive Chemical Explosion | CSB Investigation
[b] T2 Laboratories Inc. Reactive Chemical Explosion | CSB Investigation

including methylcyclopentadiene and diglyme, are not covered by either the OSHA PSM or the EPA RMP regulations.

- ***Airgas nitrous oxide explosion (August 28, 2016).***[a] The CSB determined that a pump likely lost its prime or ran dry during a nitrous oxide transfer, causing a temperature increase that likely initiated a nitrous oxide decomposition reaction, causing an explosion. One worker was killed [51]. Nitrous oxide is not covered by either the OSHA PSM or EPA RMP regulations.

- ***MGPI Processing Inc. gas leak (October 21, 2016).***[b] During a chemical delivery to a processing plant, sulfuric acid was inadvertently charged to a tank containing sodium hypochlorite. These chemicals reacted to produce a gas cloud containing chlorine gas and other compounds. Four MGPI employees, the chemical delivery driver, and over 140 community members sought medical attention after exposure to the toxic gas cloud [52]. Neither sulfuric acid nor sodium hypochlorite is covered by the OSHA PSM or EPA RMP regulations. Although chlorine is covered by both regulations, because it was a reaction product, it did not trigger coverage by these regulations.

- ***Midland Resource Recovery explosions (May 24, 2017, and June 20, 2017).***[c] Reactive, unstable chemicals exploded when workers tried to drain uncharacterized, chemically treated liquid from natural gas odorizer equipment. Two workers were killed, and one worker was severely injured [53]. The amount of sodium hypochlorite and tertiary butyl mercaptan used in the Midland Resource Recovery deodorizing process and involved in the explosions are not covered by the OSHA PSM and EPA RMP regulations.

- ***AB Specialty chemical reaction, explosion, and fire (May 3, 2019).***[d] Operators at the AB Specialty manufacturing facility were performing a batch operation that involved manually adding and mixing chemicals in a tank inside a production building. During the operation, an operator pumped an incorrect chemical into the tank, which was incompatible with another chemical that was added to the tank. The incorrect, incompatible chemical was stored in an identical drum to one of the correct chemicals, the only differentiating markings being small labels on the drums, and bung caps. After the incompatible chemicals were mixed, the tank contents underwent a chemical reaction, producing hydrogen gas that was released inside the building. The hydrogen ignited, causing a massive explosion and fire. Four workers were killed, and the production building was destroyed [54]. The potassium hydroxide and AB Specialty's XL 10 (methylhydrogensiloxane dimethylsiloxane copolymer) involved in the incident are not covered by the OSHA PSM and EPA RMP regulations.[e]

- ***Bio-Lab Chemical Reaction, Decomposition, and Chlorine Release (August 27, 2020).*** This incident is the subject of this report. The chemical involved in the incident, TCCA, is not covered by the OSHA PSM and EPA RMP regulations.

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[a] Airgas nitrous oxide explosion | CSB Investigation

[b] MGPI Processing Inc. gas leak | CSB Investigation

[c] Midland Resource Recovery explosion | CSB Investigation

[d] AB Specialty chemical reaction, explosion, and fire | CSB Investigation

[e] Hydrogen is on the EPA's List of Regulated Substances under the RMP regulation. Hydrogen is not on OSHA's list of Highly Hazardous Chemicals.

- ***Bio-Lab Chemical Reaction, Decomposition, and Chlorine Release (September 14, 2020).*** This incident is described in **Appendix C** of this report. The TCCA involved in the incident is not covered by the OSHA PSM and EPA RMP regulations.

4.5.3 Need for Coverage of Reactive Chemical Hazards in the PSM and RMP Regulations

Reactive chemical incidents at chemical processing facilities continue to occur, at times with serious consequences. The CSB concludes that improved coverage of reactive chemicals by the OSHA PSM and EPA RMP regulations would help prevent future highly hazardous chemical reactivity incidents. Despite the CSB issuing recommendations in the Reactive Hazard Study to OSHA and EPA to cover reactive hazards and reiterating them in other investigation reports, the recommendations have not been implemented.[a] Neither OSHA nor the EPA has improved the PSM Standard or RMP Rule to increase coverage of reactive chemicals.

Significantly, in 2013 and 2014, respectively, both OSHA and the EPA published requests for information (RFIs) for public input on potential changes to the PSM and RMP regulations, including expanding coverage requirements for reactivity hazards [55, 56]. OSHA's RFI stated, "OSHA has long been aware of the need to update the PSM Standard to address hazards associated with reactive chemicals" [55]. The CSB responded to the RFIs, strongly encouraging both OSHA and the EPA to expand their regulations to cover reactivity hazards [57, 58]. Neither agency, however, has implemented changes to cover reactivity hazards.

In 2022, both the EPA and OSHA took actions relating to revising the RMP and PSM regulations, and the CSB provided comments on each in October and November 2022, respectively. The CSB's comments addressed some new issues and supplemented the agency's previous comments and applicable recommendations.

The CSB concludes that both the OSHA PSM and EPA RMP regulations should be amended to cover reactive hazards that could have catastrophic consequences. The CSB reiterates a recommendation to OSHA from the CSB Reactive Hazard Study to amend the PSM Standard, 29 CFR § 1910.119, to achieve more comprehensive control of reactive hazards that could have catastrophic consequences. The CSB also reiterates a recommendation to the EPA from the CSB Reactive Hazard Study to revise the Accidental Release Prevention Requirements, 40 CFR § 68, to explicitly cover catastrophic reactive hazards that have the potential to seriously impact the public, including those resulting from self-reactive chemicals and combinations of chemicals and process-specific conditions.

[a] These recommendations are listed as "Open—Unacceptable Response / No Response Received" on the CSB website [67].

5 CONCLUSIONS

5.1 FINDINGS

Extreme Weather Preparation

1. The strong winds from Hurricane Laura damaged Bio-Lab's Plant 4 and the Finished Goods Warehouse, which allowed rainwater to intrude into these buildings, contact the TCCA, and initiate a chemical reaction, TCCA decomposition, chlorine release, and fire.
2. Bio-Lab did not learn the importance of preparing for extreme weather after the 2017 Arkema incident, did not adequately implement industry guidance for preparing for extreme weather, and, as a result, was unprepared for the winds produced by Category 4 Hurricane Laura. As a result, much of the facility was severely damaged, one production building was destroyed, and the local community was put at risk of being exposed to toxic chlorine.
3. Had Bio-Lab adhered to the guidance published in the CCPS Monograph *Assessment of and Planning for Natural Hazards*, it would have identified that the buildings housing water-reactive TCCA were not built to current wind design code requirements, which could have led to Bio-Lab taking action to protect its chemicals during hurricanes, thereby preventing the incident.
4. Additional measures are needed to ensure that aging Louisiana facilities do not have hazardous chemical releases during hurricanes.
5. The findings and recommendations of the 2022 GAO report *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change* identify critical actions that EPA should take to ensure that facilities evaluate risks from natural hazards and climate change and identify corrective safeguards.

Process Hazard Analyses Implementation

6. Had Bio-Lab implemented its 2010 PHA recommendation by evaluating whether the warehouse was built to withstand high winds, it could have identified that the facility buildings were susceptible to damage from hurricane-strength winds. This might have led to Bio-Lab implementing controls to prevent the TCCA from being exposed to hurricane rainwater, which could have prevented the incident.
7. The lack of close-out documentation for the 2010 PHA recommendation points to deficiencies in Bio-Lab's PHA action item management system.
8. Improving the Bio-Lab PHA action item management system to ensure that each PHA recommendation is assigned to an appropriate person with a deadline for initial evaluation—so that the rationale for recommendation modification or rejection is documented and the status of all action items or recommendations is tracked—can help ensure that future PHA recommendations are appropriately managed.

9. Conducting PHAs on all TCCA processes and storage facilities every five years following the CCPS *Guidelines for Risk Based Process Safety* elements and OSHA PSM Standard requirements, could have led to Bio-Lab identifying the potential for the TCCA stored in Plant 4 and the Finished Goods Warehouse to become wet and decompose during hurricanes. This could have led Bio-Lab to implement controls to prevent this event.

Emergency Preparedness and Response

10. Bio-Lab experienced serious delays in its response to the TCCA decomposition and fire (roughly five and a half hours), due to an inadequate and largely nonfunctional fire protection system and the absence of automated extinguishing systems. This significant delay in responding to the decomposition likely led to an unnecessary increase in (1) the amount of TCCA that decomposed, (2) the quantity of toxic chlorine released, and (3) the extent of the facility damage. An adequately designed and functional fire protection system with appropriate detection and activation features that have been properly assessed for risk could have provided a critical early response to reduce the size of the event.

11. Bio-Lab did not adequately maintain its fire protection system to protect against fire hazards and ensure its functionality during an emergency. Bio-Lab also did not ensure that personnel could activate its rental backup generator, which was necessary to operate fire protection equipment during the power outage caused by Hurricane Laura.

Adherence to Applicable Hazardous Materials Codes

12. The Bio-Lab facility did not adequately conform to the safeguards identified in the NFPA 101 *Life Safety Code* for high-hazard industrial occupancy (Plant 4 and the Finished Goods Warehouse), which required automatic sprinkler protection or other protection to minimize danger to occupants before they have time to evacuate. Bio-Lab may have conformed to the 1973 edition of NFPA 101 *Life Safety Code* requirements when the facility was originally designed and constructed in the late 1970s under former ownership based on drawings provided to the CSB.

13. Bio-Lab did not conform to NFPA 400 *Hazardous Materials Code*, which required a fire detection system and an automatic fire sprinkler system in Plant 4 and the Finished Goods Warehouse. Louisiana requires adherence to NFPA 400 requirements only for structures built or remodeled after July 1, 2017.

14. Had the Bio-Lab facility adhered to the NFPA 101 *Life Safety Code* requirements for high-hazard industrial occupancies and the NFPA 400 *Hazardous Materials Code* requirements, it could have begun applying large amounts of water to the decomposing TCCA earlier in the incident.

15. Designing any new Bio-Lab facility buildings or remodeling existing ones to NFPA 101 *Life Safety Code* (2015 edition) and NFPA 400 *Hazardous Materials Code* requirements, as current Louisiana regulation requires, could help prevent or reduce the severity of future decomposition events.

Regulatory Coverage of Reactive Chemical Hazards

16. Had Bio-Lab been required to conduct PHAs and action item resolution processes according to the requirements in the OSHA PSM and EPA RMP regulations, it might have implemented the 2010 hazard analysis recommendation, which could have led to the determination that facility buildings were susceptible to damage from hurricane-strength winds. Bio-Lab also would have been required to conduct a revalidation PHA in 2015, presenting another opportunity to address the issues and recommendations. This could have led to Bio-Lab implementing controls to prevent the TCCA from being exposed to hurricane rainwater, which could have prevented the incident.
17. The OSHA PSM Standard has significant gaps in coverage of reactive hazards because it is based on a limited list of individual chemicals with inherently reactive properties.
18. NFPA instability ratings are insufficient as the sole basis for determining coverage of reactive hazards in the OSHA PSM Standard.
19. The EPA RMP Rule has significant gaps in coverage of reactive hazards.
20. Solely using lists of chemicals is an inadequate approach for regulatory coverage of reactive hazards. Improving reactive hazard management requires that both regulators and industry address the hazards from *combinations of chemicals* and *process-specific conditions* rather than focus exclusively on the inherent properties of individual chemicals.
21. Improved coverage of reactive chemicals by the OSHA PSM and EPA RMP regulations would help prevent future highly hazardous chemical reactivity incidents.
22. Both the OSHA PSM and EPA RMP regulations should be amended to cover reactive hazards that could have catastrophic consequences.

5.2 Cause

The CSB determined that the cause of the accidental release of chlorine gas from the Bio-Lab Lake Charles facility was rainwater contacting stored trichloroisocyanuric acid, which initiated a chemical reaction, decomposition, and fire after Category 4 Hurricane Laura winds damaged portions of the facility's building roofs that were not built to current wind design requirements. Contributing to the incident were Bio-Lab's inadequate preparation for extreme weather and Bio-Lab's deficient process hazard analysis action item management system. Also contributing to the incident was insufficient regulatory coverage of chemicals with reactive hazards. Contributing to the severity of the incident were Bio-Lab's inadequate and largely nonfunctional fire protection system and the absence of automatic extinguishing systems.

6 RECOMMENDATIONS

To prevent future chemical incidents, and in the interest of driving chemical safety change to protect communities, workers, and the environment, the CSB makes the following safety recommendations:

6.1 PREVIOUSLY ISSUED RECOMMENDATIONS REITERATED IN THIS REPORT

6.1.1 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

2001-01-H-R1 (from the 2002 CSB Reactive Hazard Study)

Amend the Process Safety Management Standard (PSM), 29 CFR 1910.119, to achieve more comprehensive control of reactive hazards that could have catastrophic consequences.

- Broaden the application to cover reactive hazards resulting from process-specific conditions and combinations of chemicals. Additionally, broaden coverage of hazards from self-reactive chemicals. In expanding PSM coverage, use objective criteria. Consider criteria such as the North American Industry Classification System (NAICS), a reactive hazard classification system (e.g., based on heat of reaction or toxic gas evolution), incident history, or catastrophic potential.
- In the compilation of process safety information, require that multiple sources of information be sufficiently consulted to understand and control potential reactive hazards. Useful sources include:
  - Literature surveys (e.g., Bretherick's Handbook of Reactive Chemical Hazards, Sax's Dangerous Properties of Industrial Materials).
  - Information developed from computerized tools (e.g., ASTM's CHETAH, NOAA's The Chemical Reactivity Worksheet).
  - Chemical reactivity test data produced by employers or obtained from other sources (e.g., differential scanning calorimetry, thermogravimetric analysis, accelerating rate calorimetry).
  - Relevant incident reports from the plant, the corporation, industry, and government.
  - Chemical Abstracts Service.
- Augment the process hazard analysis (PHA) element to explicitly require an evaluation of reactive hazards. In revising this element, evaluate the need to consider relevant factors, such as:
  - Rate and quantity of heat or gas generated.
  - Maximum operating temperature to avoid decomposition.
  - Thermal stability of reactants, reaction mixtures, byproducts, waste streams, and products.
  - Effect of variables such as charging rates, catalyst addition, and possible contaminants.
  - Understanding the consequences of runaway reactions or toxic gas evolution.

6.1.2 U.S. Environmental Protection Agency (EPA)

2001-01-H-R3 (from the 2002 CSB Reactive Hazard Study)

Revise the Accidental Release Prevention Requirements, 40 CFR 68, to explicitly cover catastrophic reactive hazards that have the potential to seriously impact the public, including those resulting from self-reactive chemicals and combinations of chemicals and process-specific conditions. Take into account the recommendations of this report to OSHA on reactive hazard coverage. Seek congressional authority if necessary to amend the regulation.

6.2 New Recommendations

6.2.1 Bio-Lab Lake Charles

2020-05-I-LA-R1

Evaluate the hazards to the Bio-Lab Lake Charles facility from hurricanes and accompanying wind, rainwater, floodwater, or storm surge forces. Implement processes and safeguards for protection against those hazards, such as through:

a. Constructing new and maintaining existing buildings and structures to withstand hurricane winds and flooding, with a particular focus on those containing hazardous materials;

b. Implementing safeguards and processes to ensure hazardous chemicals are not compromised and released during extreme weather events; and

c. Following the guidance presented in the Center for Chemical Process Safety Monograph *Assessment of and Planning for Natural Hazards*.

2020-05-I-LA-R2

Develop and implement an improved Process Hazard Analysis (PHA) action item management system. At a minimum the PHA action item management system should:

a. Ensure that each PHA action item or recommendation is assigned to an appropriate person with a deadline for initial evaluation;

b. Document and maintain the rationale if the action item or recommendation is modified or rejected; and

c. Track the status of all PHA action items or recommendations until they are resolved.

Additionally, periodic audits must be conducted on the PHA action item management system to ensure its effectiveness.

2020-05-I-LA-R3

Perform process hazard analyses (PHAs) on all buildings and units processing or storing trichloroisocyanuric acid. Ensure that the PHAs are revalidated at least every five years. Also include the building design basis as process safety information for the PHA team to reference during their analysis.

2020-05-I-LA-R4

Revise the Bio-Lab Lake Charles emergency response plan to require the following:

a. The site's fire protection system is properly maintained and routinely function-tested in accordance with published industry guidance and NFPA requirements. Require in the emergency response plan that any equipment identified as nonfunctional must be repaired in a timely manner in accordance with NFPA requirements;

b. Emergency and fire protection equipment (in particular fire water pumps) must be checked regularly to ensure it is in good working order one month before the start of the U.S. hurricane season, as recommended by the Center for Chemical Process Safety Monograph *Assessment of and Planning for Natural Hazards*; and

c. Site personnel must be trained on the use of all emergency generators and other emergency equipment at least one month before the start of the U.S. hurricane season.

6.2.2 Louisiana Governor and Louisiana State Legislature / Secretary of the Louisiana Department of Environmental Quality

2020-05-I-LA-R5

Under existing statutory or regulatory authority or through the establishment of new authority by executive or legislative action, for all existing chemical manufacturing and storage facilities that:

(1) Are located in a hurricane-prone region as defined by the International Building Code, and

(2) Manufacture or store or can inadvertently or otherwise produce (e.g., by chemical reaction) regulated substances inside equipment or building(s) built before more current wind design requirements came into effect

Require the facility operators to evaluate the hazards to their facilities from hurricanes and accompanying wind, rainwater, floodwater, or storm surge forces. Require the facility operators to implement processes and safeguards for protection against those hazards, such as through:

a. Ensuring that buildings and structures (both new and existing) can withstand hurricane winds and flooding, with a particular focus on buildings and structures containing hazardous materials;

b. Implementing safeguards and processes to ensure that hazardous chemicals are not compromised and released during extreme weather events; and/or

c. Following the guidance presented in the Center for Chemical Process Safety Monograph *Assessment of and Planning for Natural Hazards*.

6.2.3 U.S. Environmental Protection Agency (EPA)

2020-05-I-LA-R6

Implement the five open recommendations issued in the 2022 U.S. Government Accountability Office Report titled *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change*, which are:

a. The U.S. Environmental Protection Agency (EPA) should provide additional compliance assistance to Risk Management Program (RMP) facilities related to risks from natural hazards and climate change;

b. The EPA should design an information system to track common deficiencies found during inspections, including any related to natural hazards and climate change, and use this information to target compliance assistance;

c. The EPA should issue regulations, guidance, or both, as appropriate, to clarify requirements and provide direction for RMP facilities on how to incorporate risks from natural hazards and climate change into their risk management programs;

d. The EPA should develop a method for inspectors to assess the sufficiency of RMP facilities' incorporation of risks from natural hazards and climate change into risk management programs and provide related guidance and training to inspectors; and

e. The EPA should incorporate the vulnerability of RMP facilities to natural hazards and climate change as criteria when selecting facilities for inspection.

7 KEY LESSONS FOR THE INDUSTRY

To prevent future chemical incidents, and in the interest of driving chemical safety change to protect communities, workers, and the environment, the CSB urges companies to review these key lessons:

1. Extreme weather can present serious hazards to facilities that manufacture, process, or store hazardous chemicals. Facilities should evaluate the hazards to processes from extreme weather and implement safeguards to protect from those hazards. The CCPS Monograph *Assessment of and Planning for Natural Hazards* provides guidance on how to evaluate, risk assess, and protect facilities from natural hazards.

2. It is important to ensure that (1) PHA recommendations are assigned to an appropriate person with a deadline for initial evaluation, (2) the rationale for recommendation modification or rejection is documented, and (3) the status of all action items or recommendations are tracked until completion. Such a process will help ensure that findings and recommendations from PHAs are effectively acted upon.

3. Companies must ensure that emergency response equipment is fully operational and can function when needed during emergencies. Companies should conduct routine evaluations of the fire protection system's functionality in accordance with industry guidance and NFPA requirements, adequately maintain the equipment, and repair or replace equipment as appropriate in a timely manner. Companies must ensure that personnel are trained on how to use emergency response equipment.

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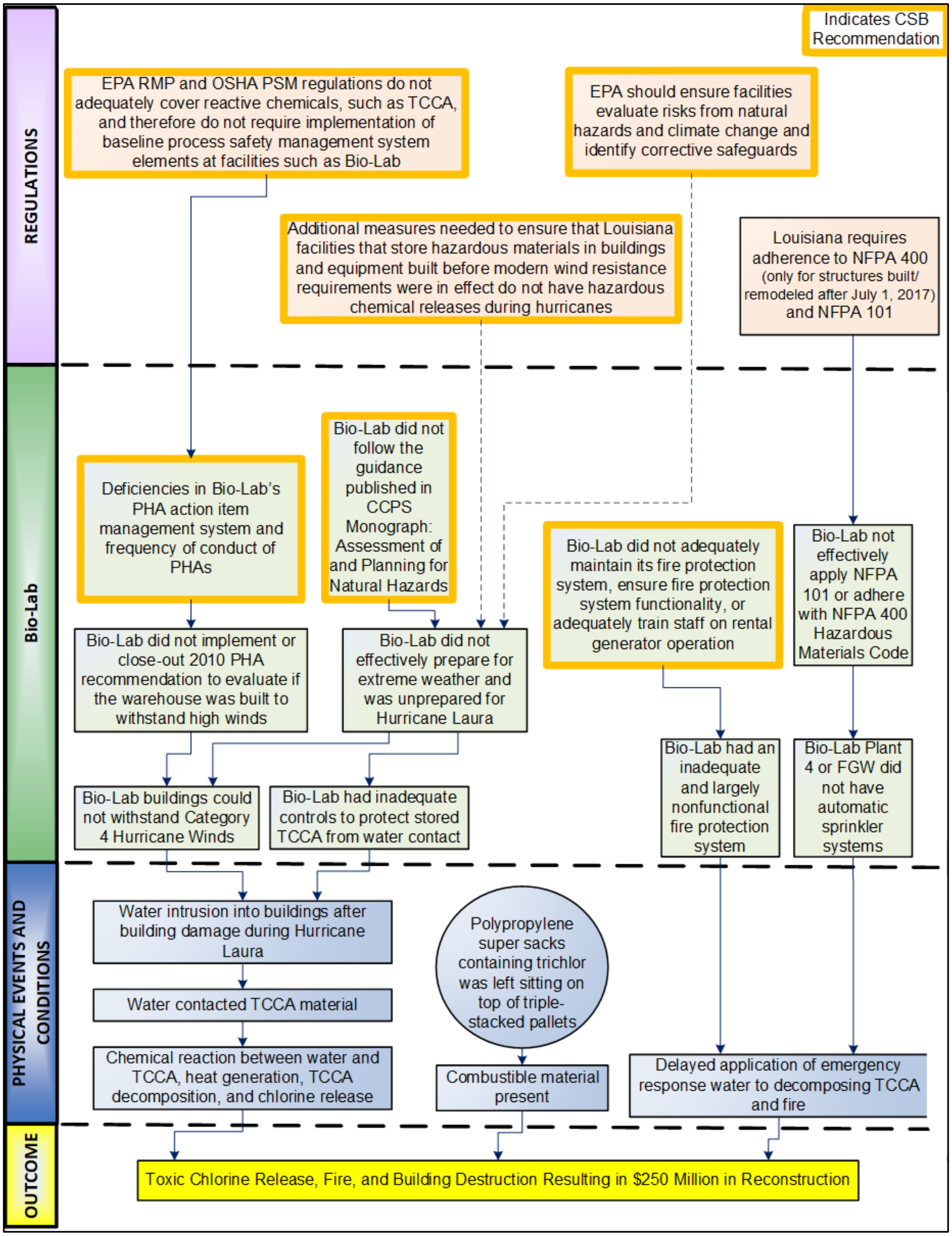
APPENDIX A—BIO-LAB LAKE CHARLES CAUSAL ANALYSIS (ACCIMAP)



APPENDIX B—DEMOGRAPHIC INFORMATION FOR BIO-LAB LAKE CHARLES SURROUNDING AREA

The demographic information of the population residing within about one mile of the Bio-Lab Lake Charles facility is contained below in **Figure 20** and **Table 7**:[a]

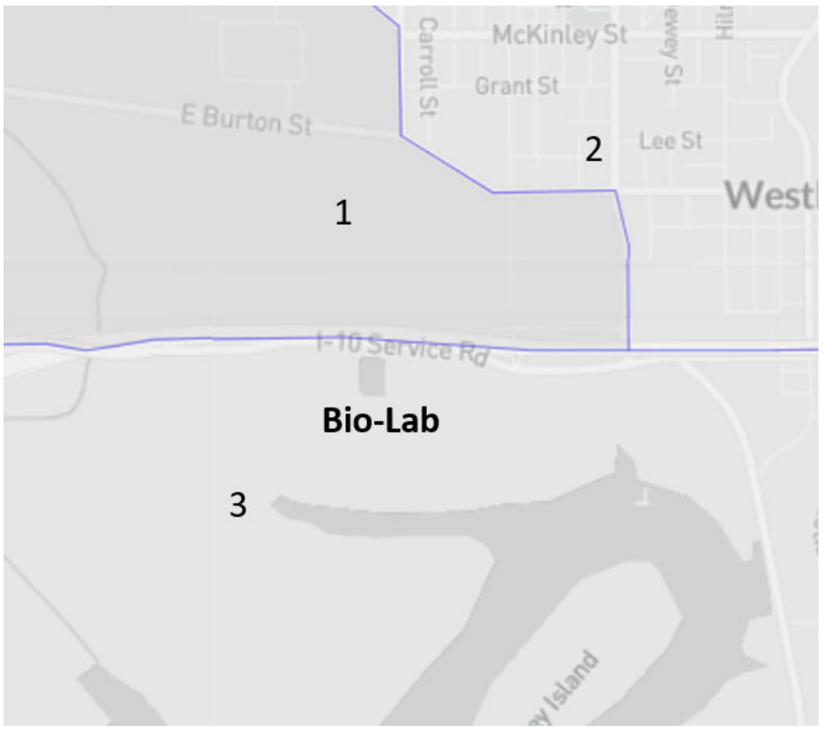


Figure 20. Census tracts in the vicinity of the Bio-Lab Lake Charles facility. (Credit: Census Reporter, annotations by CSB)

[a] This information was compiled using 2020 Census data as presented by Census Reporter [68]. "Census Reporter is an independent project to make data from the American Community Survey easier to use. [It is] unaffiliated with the U.S. Census Bureau. A News Challenge grant from the Knight Foundation funded the initial build-out of the site. … Support for [Census Reporter's] 2020 Decennial Census features was provided by the Google News Initiative. … [T]he Medill School of Journalism at Northwestern University, home of the Knight Lab, [] provides in-kind support for some of Census Reporter's ongoing development. Most of [Census Reporter's] server hosting infrastructure is [] provided by the Oregon State University Open Source Lab [69]."

Table 7. Tabulation of demographic data for the populations within the census tracts shown in **Figure 20**.

Tract Number	Population	Median Age	Race and Ethnicity	Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Structures
1	3,487	42.2	• 86% White • 2% Black • 1% Native • 5% Asian • 1% Other • 2% Two+ • 3% Hispanic	$ 25,998	14.6%	1,606	• 75% Single Unit • 2% Multi-Unit • 23% Mobile Home
2	4,679	33.1	• 81% White • 15% Black • 1% Other • 2% Two+ • 1% Hispanic	$ 27,108	7.3%	1,837	• 81% Single Unit • 7% Multi-Unit • 12% Mobile Home
3	2,131	38.4	• 94% White • 4% Black • 2% Two+	$ 31,186	15.1%	792	• 62% Single Unit • 38% Mobile Home

APPENDIX C—BIO-LAB CONYERS FACILITY INCIDENT

On September 14, 2020, a TCCA reaction and decomposition occurred at a Bio-Lab, Inc. facility in Conyers, Georgia. A plume of hazardous chemicals was released, exposing Bio-Lab Conyers personnel and nine firefighters to dangerous fumes, and caused a portion of Interstate 20 near the facility to be closed for approximately six hours. Surrounding businesses in the area were evacuated. The resulting estimated property damage was over $1,007,000. Four days later, on September 18, 2020, a second decomposition involving TCCA occurred with no reported injuries.

Bio-Lab Conyers Facility

The Bio-Lab Conyers facility in Conyers, Georgia, opened in 1973. Among other operations, the site received, blended, and packaged TCCA material into finished consumer products. In September 2020, it had 222 full-time employees. The Bio-Lab Conyers incident occurred in a building (**Figure 21**), referred to by the company as Plant 6, which had warehousing and chemical blending activities. The building also had offices for administrative functions.

The Bio-Lab Conyers facility received dry TCCA from the Bio-Lab Lake Charles facility inside "super sacks," each typically holding approximately 2,750 pounds of material. Once received, the TCCA was stored inside Plant 6 until it was used in finishing operations. At the time of the incident, the building held over 345,000 pounds of TCCA material,[a,b] much of which sat on top of wood or plastic pallets on the floor in super sacks, double stacked, as shown in **Figure 22**. At the time of the incident, the building also contained off-specification materials and other chemicals. The configuration of a section of the Bio-Lab Conyers Plant 6 building is shown in **Figure 23**.

Figure 21. Bio-Lab Conyers Plant 6, where the incident occurred. (Credit: CSB)

Figure 22. TCCA super sacks storage method inside the Bio-Lab Conyers Plant 6. (Credit: CSB)

[a] The TCCA inventory included at least 70 super sacks from Bio-Lab Lake Charles.

[b] The warehouse also contained over 44,470 pounds of compressed consumer TCCA, referred to as pucks or compressed tablets.

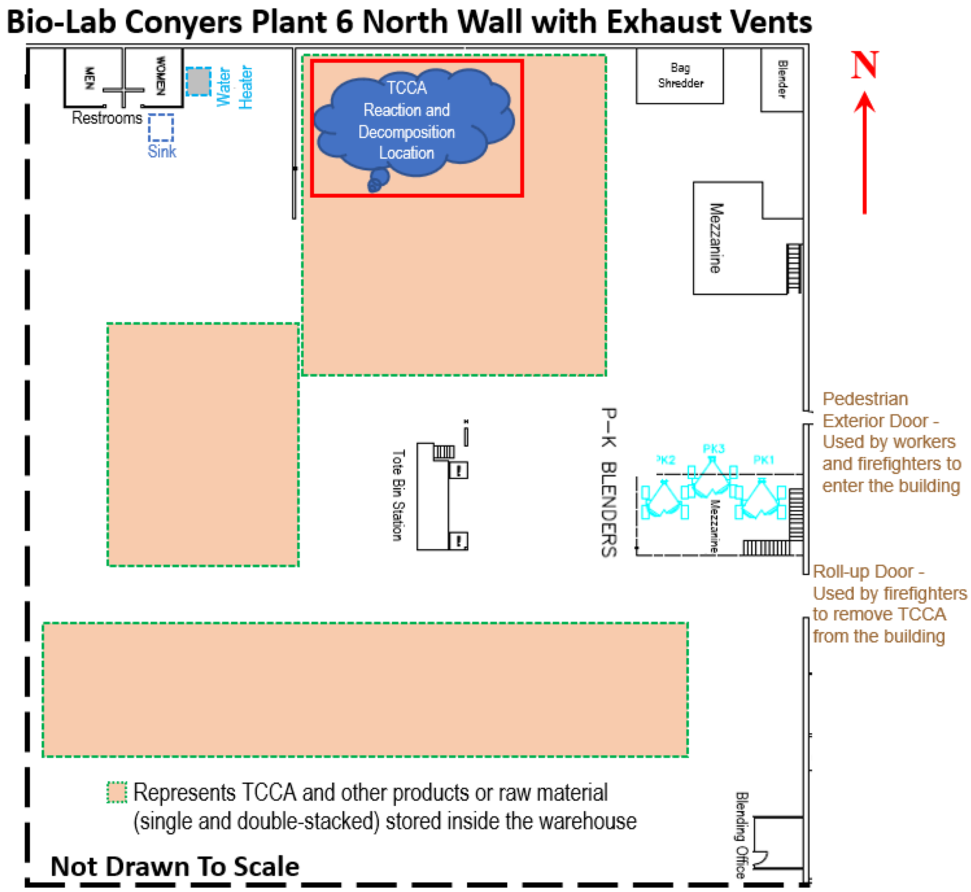


Figure 23. The configuration of a section of Plant 6 and the incident location (red box). (Credit: Bio-Lab Conyers, annotations by CSB)

Installed in the building were two separate water systems: (1) an early suppression fast response (ESFR) wet sprinkler system[a] and (2) a potable water system used for employee restrooms and sinks, as well as a water heater used for heating the water used in the restrooms and sinks. The building was not equipped with an automated water detector or alarm system to alert employees of a water leak. Post-incident, Bio-Lab Conyers employees communicated to the CSB that the building storage areas did not have "active" floor drains, and facility staff could not locate drawings detailing the structural design of floor drains or the floor slope.

[a] ESFR sprinklers are high-volume and "designed to react to a fire by automatically releasing a stream of water and distributing it in a specified pattern and density over a designated area so as to promptly reduce the fire to an acceptable level" [70, p. 128]. They have been "used in warehouses to protect high-piled inventory or palletized inventory" [65].

Incident Description

First Event: September 14, 2020

Between the close of business on Saturday, September 12, 2020, and the normal arrival of employees on Monday, September 14, 2020, a 3/8-inch polyethylene water line leaked in the Bio-Lab Conyers Plant 6, flooding a portion of the building. At approximately 4:50 a.m. on Monday, September 14, 2020, while Worker #1, a production lead, was in the building office preparing for the shift, Worker #2, a blending operator, entered the office and reported seeing water on the building floor. Worker #1 proceeded to the area to assess the situation and saw that water covered approximately 75% of the floor. Worker #1 estimated that the floodwater was about two or three inches deep in some areas but lower than the top of the wood pallets used to store TCCA near the building's north wall (**Figure 23**).[a] He then walked near the employee restrooms (**Figure 23**) and saw water releasing from a polyethylene line connected to the water heater (**Figure 24**). Worker #1 immediately closed the water heater's hot water outlet valve, which stopped the water leak. After stopping the water leak, Worker #1 contacted the Maintenance Department to report the damaged line and notified management of the flooded warehouse.

Figure 24. Location of polyethylene line that leaked, causing an area in the Bio-Lab Conyers Plant 6 to flood. (Credit: CSB)

At approximately 5:00 a.m., Worker #3, another blending operator, met Worker #1 in front of the office and told him that "there was powder on the floor, in the water." Worker #1 returned to the flooded area and observed the water on the warehouse floor turning a "milky white" color, which was concerning to him because he realized that meant TCCA was on the floor and could react with the water. While Worker #1 was observing the flooded area, the milky white water began to fume.[b] He started clearing the personnel from the area to the rally point and then removing the forklifts with propane tanks attached from the area.

During this early stage of the incident, Worker #4, a maintenance technician lead, met Worker #1 near the leak location. After assessing the leaking line,[c] Worker #4 left the building to retrieve the tools required to repair the line. The conditions inside the warehouse worsened before Worker #4 could return to perform the repair. The production of fumes intensified, and Worker #5 quickly recognized that a TCCA decomposition was occurring.

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[a] Bio-Lab stores the TCCA product on wood or plastic pallets inside Plant 6. Worker #1 told the CSB that the TCCA stored in the area was sitting on wood pallets, similar to exemplar stacked bags shown in **Figure 22** where the reaction and decomposition occurred. The CSB confirmed the height of two wood pallets. One measured approximately seven inches high, and the other was about five inches.

[b] The witnesses described their observations as smoke. This smoke would have contained toxic vapors or by-products generated from the TCCA decomposition.

[c] Worker #4 explained to the CSB that upon his arrival at Plant 6, they (Worker #4 and Worker #1) turned on the water to verify the leak's location, then turned it off when their assessment was completed.

He reported the decomposition to Management and called 9-1-1 at approximately 5:50 a.m.

Wearing a respirator, Worker #5 used a forklift to move non-decomposing super sacks of material stored in the northeast section of the building to other areas inside the warehouse to isolate them from the decomposing TCCA super sacks. The Rockdale County Fire Department arrived on-site at 5:54 a.m. but did not immediately enter the building because the Bio-Lab emergency responders believed they could isolate the decomposing product by relocating storage bags using forklifts. After Bio-Lab personnel moved approximately 10 pallets of the super sacks, they determined conditions were no longer safe to continue the work. The forklifts used to move the materials were sliding on the wet floor, and the continued fume formation was causing visibility in the warehouse to worsen (**Figure 25**).

Figure 25. September 14 TCCA decomposition. (Credit: Bio-Lab Conyers)

The Rockdale County Fire Department then led the emergency response operations, assisted by Dekalb County mutual aid. Responders sprayed water to control temperatures of the decomposing TCCA to prevent adjacent combustible materials from getting "hot enough to combust," and they continued moving unaffected material away from decomposing materials. At approximately 11:47 a.m., air monitoring stations were established in the Conyers parking lot and within residential areas and business properties surrounding the facility using the EPA's Viper wireless remote monitoring system. Chlorine concentrations were measured at a nearby business property approximately one-quarter of a mile from the Bio-Lab Conyers facility at concentrations as high as 12 ppm, which greatly exceeded OSHA's chlorine permissible exposure limit of 1 ppm [7].

According to the Rockdale County Fire Department, "access to the decomposing pallets was hindered by other surrounding poorly stacked pallets of materials." The Fire Department also established an external decontamination area (**Figure 26**) and moved decomposing materials to this area using forklifts and skid steers[a] to stop the chemical reactions inside the building.[b]

[a] Skid steers are small, construction-type powered machines used for various tasks, including material handling, debris removal, and demolition. They are often referred to as "*bobcats.*"

[b] The Monsanto Industrial Chemicals Company published a technical bulletin, *Storage and Handling of ACL Compounds* (Technical Bulletin IC / SCS-310) [66], which discusses the extinguishing of chlorinated chemical decompositions. The publication explains, "[i]n some cases, it may be possible to isolate the decomposition by moving the decomposing product to an open area. This should only be attempted if the decomposition is small, and the material is easily accessible" [66, p. 7].

Figure 26. External decontamination area outside the Bio-Lab Conyers Plant 6. (Credit: Bio-Lab Conyers)

The Fire Department temporarily closed a portion of Georgia Interstate 20 (I-20) from approximately 7:00 a.m. to 1:00 p.m. while chemical plumes were emitting from the Bio-Lab Conyers facility (**Figure 27**). Post-incident, nine firefighters were taken to the hospital for evaluation after inhaling hazardous vapors, and were subsequently released.

Figure 27. TCCA decomposition products, including chlorine, releasing from the Bio-Lab Conyers facility on September 14. (Credit: WSB-TV Channel 2 Atlanta)

Second Event: September 18, 2020

Bio-Lab Conyers facility employees relocated some of the TCCA inventory in Plant 6 into trailers after the first event. The Fire Department had remained on-site performing fire watch activities as a precaution at the request of Bio-Lab Conyers when, on September 18, 2020, a second decomposition occurred in one of the trailers (**Figure 28**). The probable cause of this second event was the decomposition of TCCA that had gotten wet or heated during the September 14, 2020, event. There were no reported injuries.

Figure 28. TCCA decomposition on a rental trailer at Bio-Lab Conyers. (Credit: Bio-Lab Conyers)

APPENDIX D—CONSULTANT REPORT, BIO-LAB SITE STRUCTURAL DAMAGE

Report on Site Structural Damage

Bio-Lab Chemical Processing Facility at Westlake, Louisiana
Hurricane and Fire Event of August 27, 2020

Prepared for the **U.S. Chemical Safety Board**
CSB Investigation 2020-05-I-LA
1700 Pennsylvania Avenue, NW, Suite 910
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551A Pylon Drive, Raleigh, NC 27606

Report date: February 8, 2023

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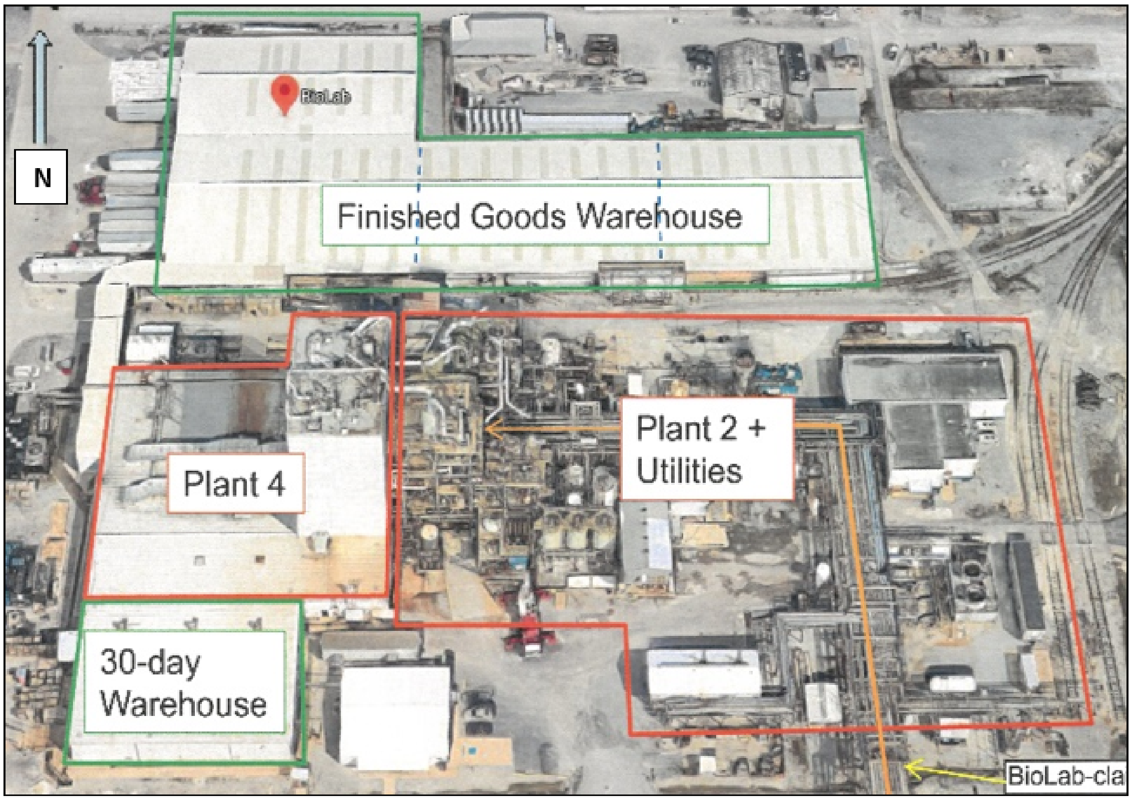
Introduction and Scope of Work



Bio-Lab photo/diagram by CSB

The Bio-Lab facility in the Calcasieu Parish in Westlake LA produces trichloroisocyanuric acid (TCCA), a feedstock chemical used in manufacturing, cleaning, and pool-chlorination products. The facility includes several single-story industrial buildings, an enclosed "High Bay" processing tower, and exterior structures that support chemical process equipment and piping.

The facility was severely damaged during the passage of Hurricane Laura on August 27, 2020. Wind forces collapsed walls and stripped roofs at several buildings. Fires subsequently broke out at two buildings and destroyed them. Smoke from the fires and the possible release of airborne chlorine compounds required substantial emergency measures by local authorities including road closures, evacuations, and shelter-in-place orders. The U.S. Chemical Safety Board (CSB) is investigating this event.

The CSB asked our firm to assess building damage at the site, assist the investigators with safe access to damaged areas, provide UAV aerial video photography, and prepare this report on structural damage at the site.

Executive Summary

Production and storage buildings at the Bio-Lab facility were hit with 100 mph sustained winds with gusts up to 137 mph during Hurricane Laura's passage through the area on August 27, 2020.

Hurricane winds damaged several buildings at the facility. Wind forces blew in rolling doors, collapsed exterior walls, and stripped roof panels and roof-top ductwork. Further damage occurred as these openings in walls and roofs let wind-driven rain into the building interiors.

A massive fire started at the Plant 4 production/packaging buildings known as Low Bay and High Bay. Fire destroyed these two structures. At a section of the southern Finished Goods Warehouse (FGW), wood pallets were charred and storage bags were melted, adjacent to stored chemicals.

We understand from the CSB that the chemical produced at Bio-Lab, trichloroisocyanuric acid (TCCA), undergoes an exothermic reaction when in contact with water, and that the heat output from the reaction can be intense enough to cause thermal damage or start fires. The facility produces and stores the chemical in large quantities. It appears likely that fire broke out when the buildings' enclosures were torn open by wind forces and the chemical inside was flooded with rainwater, starting the exothermic reaction and the structural fire.

We observed conditions at five damaged buildings at the facility soon after the event. The A-Z Building and the two FGW structures suffered substantial wind damage but were repairable. The Plant 4 Low Bay was destroyed by fire and had been demolished at the time of our site visit. The Plant 4 High Bay tower had severe structural damage. The High Bay was not safe to enter, and was not repairable.

Overview, looking north (Atlas UAV, 9/30/2020)

Overview of Site and Buildings

The Bio-Lab facility is in southwestern Louisiana, 30 miles north of the Gulf Coast. The facility is sited in an industrially developed tract of land roughly one mile wide east-west by a half-mile north-south. The site and surrounding terrain are flat and the ground elevation is about 15 feet above sea level.

The buildings at the site were steel-framed with concrete slab-on-grade ground floors. All were single-story except for the High Bay tower at Plant 4. Several buildings including the A-Z Building and the FGW structures were pre-engineered "Butler" style buildings, with tapered moment frames that support light-weight steel roof purlins and wall girts and steel or fiberglass exterior sheathing.

The single-story Plant 4 Low Bay Building was steel-framed with wide-flange columns and beams and a corrugated steel roof deck topped with insulation and a membrane. The roof supported large ductwork and other roof-top equipment. The Plant 4 High Bay tower was 110' tall with a heavy braced frame of steel wide-flange members with bolted connections. The tower had substantial roof framing that supported ductwork and heavy roof-top equipment. The exterior walls were finished with insulated metal wall panels.

Eastern bay of south FGW, looking SW. Wrecked framing has been removed (Atlas, 9/29/2020)

<u>Hurricane Laura - Wind Speeds</u>

We found the following windspeed data for Hurricane Laura's passage across the Bio-Lab site:

- Hurricane Laura came ashore at Cameron, Louisiana at 0100 CDT on August 27, 2020. Cameron is 30 miles due south of the Bio-Lab facility in Westlake. Hurricane Laura made landfall with a reported windspeed of 150 mph (NOAA bulletin).

- The Weather Underground website reports that at 0200 CDT, winds near the Bio-Lab site were from the ESE at 90 mph. Other local weather records reported wind gusts to 137 mph.

- NOAA reported that at 0700 CDT the hurricane was centered over Fort Polk, 60 miles north of Lake Charles, with a maximum reported wind speed of 100 mph.

- CSB provided us with information from the NIST National Windstorm Impact Reduction Program, which uses a combination of observed and modeled data to calculate windspeeds at grid points. The NIST data indicate that the Bio-Lab facility experienced maximum sustained winds of 103 mph.

The above figures support maximum windspeeds of <u>100 mph sustained</u> at the Bio-Lab site during the passage of the hurricane, with wind gusts up to 137 mph.

We have no data on the storm's wind directions at the Bio-Lab site. However, since hurricanes spin CCW and Laura's eye tracked north almost directly over Westlake, it is likely that the maximum windspeeds would come from the east as the storm approached, and then from the west as the storm moved away.

Hurricane Laura eye track (NOAA)

Site Structures and Damage Assessments

We made detailed observations at five buildings at the Bio-Lab site:

- A-Z Building
- Southern Finished Goods Warehouse (FGW)
- Northern Finished Goods Warehouse (FGW)
- Low Bay at Plant 4
- High Bay at Plant 4

Our site observations and aerial videos were made on September 29-30, 2020, after some parts of the damaged buildings had been demolished and/or cleaned up.

A-Z Building – 600' Southwest of Plant 4

Description – We did not review any drawings for this building. Based on site observations, this was a pre-engineered steel-framed building with a concrete slab-on-grade floor, and a footprint of about 100' square. It had three single-story bays that were oriented east-west. The north and south bays had roof heights of about 12', while the center bay had a roof height of about 24' with large roll-up doors at its east and west ends. The framing was of tapered steel moment frames spanning north-south, with X-braces running east-west. The frames supported light-weight purlins and girts, and the building was sheathed with 22g corrugated steel panels attached with screws.

Wind Damage – High winds collapsed both large rolling doors at the central bay, and most of the central bay's roof panels were torn off their purlins. Several roof sections also tore free at the north and south bays, and ceilings in these bays collapsed.

We observed debris from the roof and found that the metal roof panels tore free around the screw heads. At the roof areas that had been stripped, the purlins and structural frames appeared undamaged.

A-Z Building (Atlas UAV, 9/30/2020)

Post-Incident Condition – This building was substantially damaged but the structure was relatively stable. Hazards included loose overhead panel debris, hanging wires, and trip hazards. It was feasible to repair this building.

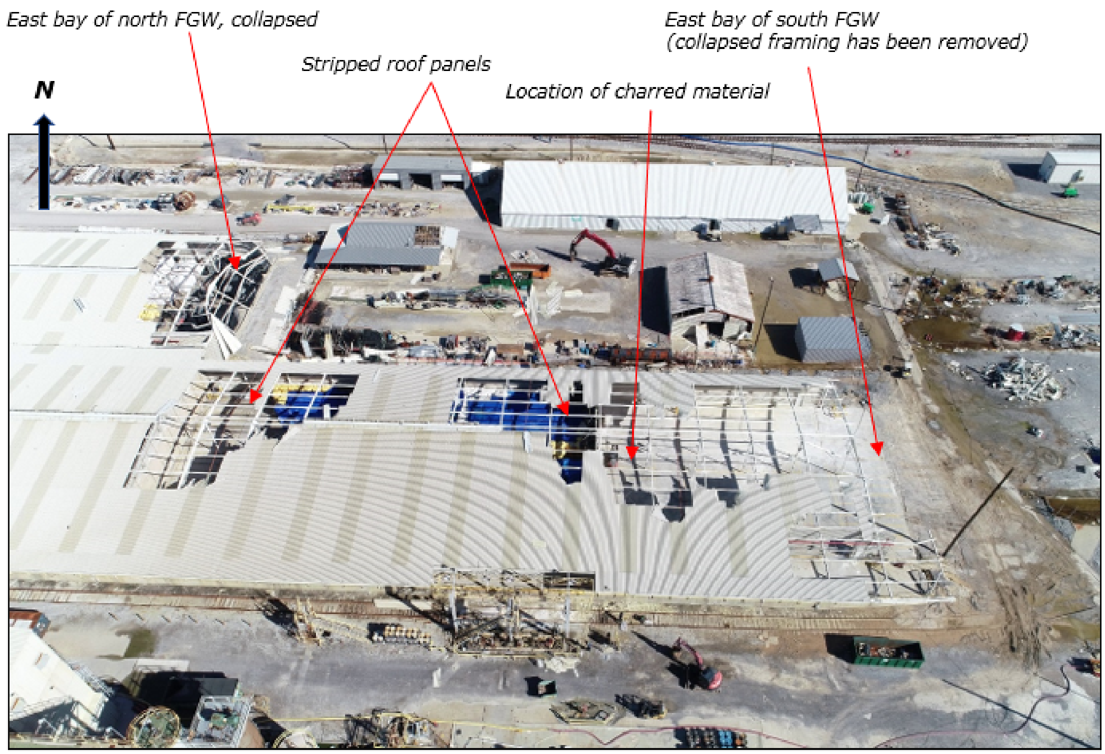
Site Structures and Damage Assessments (cont.)

Finished Goods Warehouses (FGW) – 100' North of Plant 4

Description – The CSB provided us with a partial set of construction drawings for the FGW's, dated 1977-78. Based on these drawings and our observations, they were single-story pre-engineered steel-framed structures with concrete slab-on-grade floors.

The roofs were about 14' high. The southern FGW was about 460' long east-west; the northern, 160' long; both were about 110' wide north-south.

They appeared to have identical framing consisting of tapered steel moment frames that spanned north-south over mid-span columns, supporting light-weight steel purlins and girts. The walls and roofs were sheathed with corrugated fiberglass panels attached with screws.



Finished Goods Warehouses (Atlas UAV, 9/30/2020)

Site Structures and Damage Assessments (cont.)

Finished Goods Warehouses (cont.)

Wind Damage – At both FGW's, the columns at the eastern end-walls collapsed to the west, falling into the eastern building bay and buckling roof purlins and wall girts as they fell. We examined the column bases at these end-walls and found severe corrosion at the anchor bolts. Several anchor bolts had corroded in two, leaving the end-wall columns unattached to the slab, and less able to resist wind loads.

Eastern bay of north FGW, looking SW, & close-up of column base and anchor bolts (Atlas 9/29/2020)

At building bays farther west, large areas of roof panels had been torn away by wind forces. The southern FGW lost about 40% of its roof panels, while the northern FGW lost about 20%. The fiberglass roof panels tore around the screw heads. Except for the eastern bays, the remaining steel frames, purlins, and girts appeared undamaged.

Fire Damage – Most debris had been cleared away at the time of our site visit. Photos taken earlier by CSB show a pile of debris on the southern FGW floor that included charred wood pallets, wall panels with char marks, and melted storage bags. The CSB documented that heavy white smoke emerged from this area soon after the storm. The charring, melted bags, and smoke likely resulted from an exothermic reaction between the stored chemical and the rainwater that entered the FGW through the breached roof and wall. At the time of our site visit, we saw no sign of fire damage to structural members at the FGW's.

Post-Incident Condition – The buildings were damaged but the structures were relatively stable. Hazards included loose overhead panel debris, damaged framing at the eastern bays, and hanging wires. It was feasible to repair these buildings.

Site Structures and Damage Assessments (cont.)

Low Bay at Plant 4

Our information on the Low Bay building is limited. The CSB supplied us with two foundation drawings dated 1977-78, but no other structural plans were available. Most of the Low Bay collapsed during the fire and had been demolished by the time of our site visit. Our understanding of the building is based on earlier photos made by the CSB, and our observations of nearby structures that remained standing, including a small northern section of the Low Bay and the 30-Day Warehouse to the south.

Location of demolished Low Bay building

View from High Bay stair, looking SW (Atlas, 9/29/2020)

View looking west (Atlas UAV, 9/30/2020)

Description – The Low Bay was a single-story structure with a footprint of 160′ north-south by 150′ east-west and a roof height of about 20′. The Low Bay wrapped around and attached to the High Bay tower on the tower's north, west, and south sides. The Low Bay adjoined the 30-Day Warehouse to the south.

The Low Bay had steel columns on a 20′ x 20′ grid that supported steel roof beams and sub-beams. The columns bore on caisson footings and the building had a concrete floor slab. The exterior walls were concrete block masonry. The roof included corrugated steel decking topped with insulation and what appeared to be a modified bitumen roofing membrane.

Site Structures and Damage Assessments (cont.)

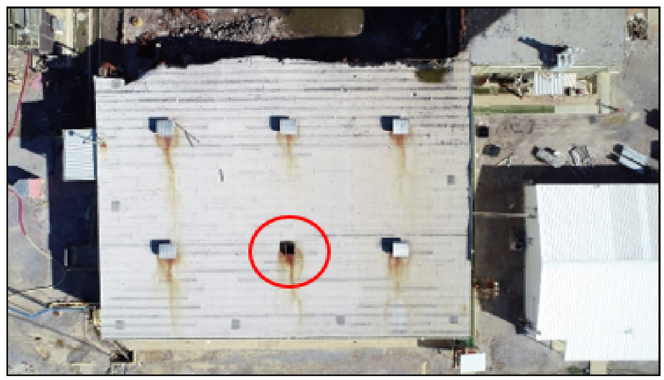
Plant 4 Low Bay (cont.)

Wind Damage – Most of the Low Bay building was severely damaged by fire, had collapsed, and been demolished by the time of our site visit. At a small part of Low Bay remaining at the north end, and at the 30-Day Warehouse just to the south, the roofs appeared mostly intact, but there were large openings where roof-top ducts or vent-heads had blown off.

Based on this damage and on roof damage seen at other buildings at the site, it appears likely that the roof or roof-top ductwork at Low Bay were broken open by storm winds. Roof breaches would allow wind-driven rain to enter the building during the storm.

Roof-top ductwork torn away, at two roof areas adjacent to Low Bay

Roof opening at broken duct, Low Bay roof north of High Bay tower (Atlas 9/29/2020)



Open roof duct at 30-day Warehouse, just south of Low Bay (Atlas UAV 9/30/2020)

Fire Damage – According to the site demolition contractor, the heat from the fire buckled the building columns and the roof collapsed. At the time of our site visit the debris had been cleared from the building footprint.

Post-Incident Condition – We did not enter the small remaining portion of Low Bay at the north end, or the 30-Day Warehouse to the south. We suspect these areas had substantial structural damage and were damaged beyond repair.

Site Structures and Damage Assessments (cont.)

High Bay tower at Plant 4

Description –The CSB supplied us with a partial set of original structural plans for the High Bay tower from 1978, along with drawings for equipment and framing alterations from 1996. Our understanding of the structure was based on these and on our observations at the site. The High Bay was an enclosed industrial-process tower with a footprint of 80′ north-south by 50′ east-west. It was steel-framed, with five column lines spaced at 20′ north-south, and three column lines spaced at 25′ east-west. The columns bore on large combination spread footings. Lateral resistance was provided by chevron braces. The framing connections were bolted.

The ground floor was a concrete slab-on-grade. There were four elevated floor levels, and the roof was 110′ above the ground. The floors were steel-framed and supported hoppers, bins, ducts, baghouses, crane rails, and other process equipment, some of which spanned vertically through floor levels. Most of the elevated floors were topped with steel decking but there were many openings in the floor levels. Level 4 included a mezzanine that supported heavy baghouse equipment.

The walls were sheathed with inner and outer panels of corrugated steel that sandwiched a layer of insulation. Both panels were mechanically attached to horizontal girts that spanned between the columns. There was ductwork and ten blowers on the roof. The blowers rested on large concrete slab bases that bore on the corrugated steel roof decking and the steel framing underneath. It appeared that the roof areas between the concrete bases were insulated and topped with a membrane.

Views of High Bay tower, looking northeast

Pre-event (GoogleEarth)

Firefighting (late August, A/P News)

Wind Damage – At the south exterior wall, most of the outer layer of corrugated steel wall paneling had been torn away, as well as the insulation. The inner layer of paneling remained largely intact. Both layers of the wall paneling remained generally intact at the other three sides of the tower. Possible wind damage to the roof and upper wall panels could not be ascertained, as these parts had been destroyed by fire.

Site Structures and Damage Assessments (cont.)

Plant 4 High Bay (cont.)

Fire Damage – The fire had severely damaged the tower's structural framing. The fire's heat softened the steel, leading to deformation and collapse of the building columns above the Level 4. These columns folded inward, funneling the roof-top blowers, their concrete roof slabs, and the mezzanine equipment toward the center of the building and dropping this debris onto the Level 4 floor. The middle of the Level 4 floor system failed and some of this equipment dropped below onto Level 3. Part of the Level 3 floor system also failed. We found heat-deformed out-of-line columns, beams, and bracing at every floor level. The fire destroyed all the internal process equipment. Many machines fell loose from their moorings, and tons of debris fell to floor areas not designed for concentrated loading.

Upper 35' of tower looking NW, after fire & demo work (Atlas UAV, 9/30/2020)

4th floor level, from north stair (Atlas 9/29/2020)

3rd floor level from north stair, showing heat-deformed columns & bracing (Atlas, 9/29/2020)

Ground floor level looking east, showing heat-deformed brace & spandrel (Atlas, 9/29/2020)

Post-Incident Condition – The High Bay tower was standing but had been severely damaged by fire. The floor levels were damaged, overloaded, and liable to collapse at any time. While at the site, we advised the CSB, the Bio-Lab Plant Manager, and the site contractor not to enter the tower or allow anyone to do so. The High Bay tower was damaged beyond repair. We recommended that demolition be accomplished using stand-off methods.

Building Codes and Design Wind Speeds

At Time of Construction

The construction drawings we reviewed were not complete sets but the available sheets indicated that the FGW's and the Low Bay and High Bay structures at Plant 4 were built in 1978. Older buildings are not normally required to meet the current building code, but instead are expected to meet the code in force at the time of their construction.

Based on information CSB received from local officials, Louisiana did not establish a state-wide building code until 2006. Prior to this, the State Fire Marshal's (SFM) Office set standards for building life-safety systems. From 1975 to 1980, the SFM's life-safety requirements were based on the following documents (see Attachment 1) –

- NFPA 101 Life Safety Code, 1973 edition
- Chapter 4 and Section 518 of the Standard Building Code (SBC), 1974 revisions to 1973 edition. *(Chapter 4 pertains to separation between townhouses, and Section 518 covers life-safety provisions for high-rise buildings. No other SBC sections are cited.)*

Taken together, these documents address fire protection, egress requirements, stairs and ladders, hazardous material processing and storage, and other construction aspects closely related to building life-safety systems. Other design standards, including design wind loads, were apparently not part of the SFM oversight during this period.

CSB's recent discussions with building officials in the Calcasieu Parrish suggest that general design standards in the area during the 1970's were largely left up to the architects and engineers involved. Licensed designers of that time would potentially look to best industry practices and the prevailing SBC for design wind loads in the absence of official state adoption of the code.

The SBC in use in 1978 was the 1974 revision of the 1973 edition. Basic design wind speeds are shown in Chapter 12, on figure 1205.1, with the Westlake area falling close to the 100 mph wind speed contour (see Attachment 2).

Building code design wind speeds at this time were defined in terms of "fastest mile". At 100 mph it takes 36 seconds for a mile of wind to pass through an anemometer. A 100 mph wind speed defined this way represents the average wind speed during a measurement period of 36 seconds.

Note that the "fastest mile" wind speed definition is not directly comparable to how wind speeds are defined or used in modern codes, or to how hurricane wind are currently reported by weather stations.

Building Codes and Design Wind Speeds (cont.)

Hurricane Laura's Wind Speed vs 1974 SBC Design Wind Speed

How wind speeds are reported depends on the duration of measurement. Hurricane Laura's sustained wind speed of 100 mph over the Westlake area is based on weather station reports, which use the maximum average speed measured over a 60 second interval. The 1974 SBC 100 mph design windspeed is based on the average over 36 seconds.

The two measurement criteria can be compared using a chart from ASCE 7-10, Figure C26.5-1, which relates reported windspeeds averaged over different durations (see Attachment 3). Applying the chart indicates that Hurricane Laura's sustained wind speed was within about 4% of the 1974 SBC wind code. This difference is likely within the margin of error in reading code wind maps or measuring wind speed.

It is reasonable to conclude that Hurricane Laura's sustained wind speed in the Westlake area was approximately equal to the 1974 SBC design wind speed. Since the plant suffered substantial wind damage during the storm, it can be inferred that its design and construction either just barely met the 1974 SBC wind code requirements, or fell somewhere below them.

Design Wind Speed in 2020

At the time of Hurricane Laura's passage, Louisiana's building code was based on the state's adoption of the 2015 International Building Code (IBC), which included ASCE 7-10 by reference. Louisiana did not adopt the 2015 IBC in its entirety, deleting IBC chapters 1, 11, and 27, and adding 69 amendments. None of these deletions or amendments altered the 2015 IBC design wind speeds.

The 2015 IBC design wind speeds were based on a building's location, and on its Risk Category (IBC Table 1604.5). These categories can be summarized as follows –

Risk Category I: Agricultural, storage

Risk Category II: Most buildings

Risk Category III: High occupancy, medical, or toxic/dangerous materials

Risk Category IV: Essential facilities or highly toxic/very dangerous materials

CSB's fire safety consultant Terp Consulting prepared a report characterizing the danger and toxicity of TCCA, and the quantities of TCCA present at the Bio-Lab facility. Based on our review of the report, these factors closely fit the criteria for Risk Category IV in the 2015 IBC.

For Risk Category IV buildings like those at the Bio-Lab site, the 2015 IBC design windspeed is 145 mph, in accordance with IBC Figure 1609.3(2) (see attachment 4).

Building Codes and Design Wind Speeds (cont.)

Design Wind Loads – 2015 IBC vs 1974 SBC

The SBC 1974 design wind speed of 100 mph and the 2015 IBC figure of 145 mph cannot be compared directly. The 2015 IBC wind speeds are coupled with extensive refinements in building codes since 1974, including –

- 41 years of additional climate data
- Use of 3-second gust instead of fastest mile wind speed measurement
- A different basis for storm return periods
- Increased design wind speed for high-risk buildings
- Refined calculation methods for wind pressure

A better way to compare the two codes is the resulting wind pressures. Design wind speeds are used to calculate the wind pressures and the forces acting against buildings. Higher wind pressures, as calculated per code, require designers to design stronger buildings.

The 2015 IBC code required Risk Category IV structures to successfully resist substantially higher wind pressures than required by the 1974 SBC, as shown in these examples:

	Required Design Wind Pressure	
Building Component	1974 SBC	2015 IBC
Windward wall, 0-30’ height	26 psf	31 psf
Roof edge, flat roof, 30’ height	20 psf (up)	57 psf (up)
Rolling door, 0-30’ height	26 psf	45 psf

Although there are additional calculation refinements in the 2015 code that affect design, the above wind pressure figures for the 2015 IBC would lead designers to build in substantial increases in building strength and resilience. Buildings meeting the 2015 IBC are significantly stronger and better able to survive high wind events than those meeting the 1974 SBC.

Hurricane Laura, Bio-Lab, and the 2015 IBC

Hurricane Laura’s 100 mph sustained winds scale up to 122 mph, when adjusted for a 3-second measurement duration (see Attachment 3).

This is substantially less than the 145 mph 3-second design windspeed required by the 2015 IBC for Risk Category IV buildings. Had the Bio-Lab facility met this code, the buildings at that site would be expected to survive the passage of Hurricane Laura without major wind damage.

Summary of Report

1. Hurricane Laura passed almost directly over the Bio-Lab facility on August 27, 2020. The facility experienced sustained windspeeds up to 100 mph, with gusts up to 137 mph. The storm substantially damaged several major buildings at the site, including production, packaging, and storage buildings. Hurricane winds collapsed doors and walls and tore off roofs and roof-top equipment. These openings led to subsequent damage from wind-driven rain that flooded building interiors.

2. Just after the storm, a massive and intense fire broke out at Low Bay and High Bay, the production/packaging buildings at Plant 4. The fire destroyed both buildings. Later in the day an area within the Finished Goods Warehouse (FGW) suffered thermal damage and emitted white smoke.

3. Bio-Lab's product was trichloroisocyanuric acid (TCCA), a chemical that reacts exothermically with water. We understand the reaction can generate enough heat to cause thermal damage or start fires. Many tons of TCCA were stored in Plant 4 and in the FGW.

4. It appears likely that rainwater entered the buildings through wind-torn openings and flooded the building interiors. The flooding reacted with the TCCA stored inside, causing a chemical reaction that caused thermal damages and started the fires.

5. The following summarizes the damage and post-incident condition of the buildings we observed at the Bio-Lab facility –

   a. A-Z Building: Loss of roof panels and interior water damage. Repairable.

   b. North & South FGW's: Collapse at eastern bays and loss of roof panels. Repairable.

   c. Low Bay at Plant 4: Destroyed by fire. Remains have been demolished.

   d. High Bay at Plant 4: Severe structural damage due to fire, leaving the tower unsafe to enter and unsalvageable.

The facts and opinions included in this report are based on our observations at the site on September 29-30, 2020, and on information provided to us. If any new information comes to light, please forward it to our office for our additional consideration.

ATLAS ENGINEERING, INC.

Report attachments

Attachment 1: Louisiana Administrative Code, page 264

Attachment 2: Wind map, 1974 Standard Building Code (SBC)

Attachment 3: ASCE 7-10, Fig C26.5-1, wind speeds vs duration of measurement

Attachment 4: Wind map, 2015 International Building Code Fig 1609.3(2)

Attachment 1: Louisiana Administrative Code, page 264

PUBLIC SAFETY

NFPA 664	2012 Edition	Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
NFPA 820	2016 Edition	Standard for Fire Protection in Wastewater Treatment and Collection Facilities
NFPA 901	2016 Edition	Standard Classifications for Incident Reporting and Fire Protection Data
NFPA 1123	2014 Edition	Code for Fireworks Display
NFPA 1124	2017 Edition	Code for the Manufacture, Transportation, Storage, and Retail Sales of Fireworks and Pyrotechnic Articles
NFPA 1221	2013 Edition	Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems
NFPA 1402	2012 Edition	Guide to Building Fire Service Training Centers
NFPA 1403	2012 Edition	Standard on Live Fire Training Evolutions
NFPA 1961	2013 Edition	Standard on Fire Hose
NFPA 1962	2013 Edition	Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose

B. All inspections and other evaluations of buildings constructed or remodeled pursuant to plans submitted to the Office of State Fire Marshal for review shall be made utilizing new construction requirements set forth in the *Life Safety Code* published by the National Fire Protection Association, the *NFPA 1 Fire Code* published by the National Fire Protection Association, the special provisions for high-rise building section of the *Standard Building Code* published by the Southern Building Code Congress International, the fire protection and life safety provisions of the *International Building Code* published by the International Code Council, and the *FGI Guidelines* published by the Facilities Guidelines Institute for facilities evaluated on behalf of the Department of Health as follows.

Building Constructed or Remodeled	NFPA Life Safety Code Edition	NFPA 1 Fire Code Edition	SBC Section/ Building Code Edition	Sections/ International Building Code Edition	FGI Guidelines
prior to 1/1/1975	1967		-	-	
1/1/1975 to 12/31/1979	1973		518 / 1974 Chapter 4 revisions to 1973	-	
1/1/1980 to 8/31/1981	1976		518 / 1974 Chapter 4 revisions to 1973	-	
9/1/1981 to 8/31/1986	1981		506 / 1979	-	
9/1/1986 to 2/18/1989	1985		506 / 1985	-	
2/19/1989 to 5/31/1992	1988		506 / 1985	-	
6/1/1992 to 1/4/1995	1991		506 / 1988	-	
1/5/1995 to 5/31/1998	1994		506 / 1991	-	
6/1/1998 to 6/30/2001	1997		412 / 1994	-	
7/1/2001 to 12/31/2001	2000		412 / 1994	-	
1/1/2002 to 6/30/2004	2000		412 / 1997	-	
7/1/2004 to 9/30/2007	2003		-	-	
10/1/2007 to 6/30/2010	2006		-	-	
7/1/2010 to 12/31/2013	2009		-	-	
1/1/2014 to 6/30/2017	2012		-	9 and 10/2012	
after 7/1/2017	2015	2015		9 and 10/2015	2014

C. All references to performance based criteria in the *Life Safety Code* shall only be considered by the Office of State Fire Marshal after an appeal of a decision has been timely made.

AUTHORITY NOTE: Promulgated in accordance with R.S. 40:1563(F), R.S. 40:1563(L), R.S. 40:1578.6(A), and R.S. 40:1578.7(E).

HISTORICAL NOTE: Promulgated by the Department of Public Safety, Office of Fire Protection, LR 1:145 (February 1975), amended LR 5:468 (December 1979), LR 6:71 (February 1980), amended by the Office of State Fire Marshal, LR 7:588 (November 1981), LR 9:417 (June 1983), amended by the Department of Public Safety and Corrections, Office of State Fire Marshal, LR 15:96 (February 1989), LR 17:1114 (November 1991), LR 23:1688 (December 1997), LR 27:857 (June 2001), LR 27:2257 (December 2001), repromulgated LR 29:183 (February 2003), amended LR 30:1303 (June 2004), LR 33:671 (April 2007), LR 36:1564 (July 2010), LR 39:1478 (June 2013), LR 43:969 (May 2017).

§105. Required Inspections of Wiring, Gas Piping and Fire Extinguishers

A. In order to assure that the electrical wiring in any structure or movable will not cause a fire or explosion, the electrical wiring in any structure, watercraft or movable shall be inspected and, if necessary, repaired by a licensed electrical contractor in accordance with the *National Electrical Code*.

B. In order to assure that any structure, watercraft or movable is safe from hazards caused by gas piping, all gas piping shall be inspected and, if necessary, repaired by a licensed plumber or mechanical contractor in accordance with the applicable *National Fuel Gas Code* of the National Fire Protection Association and the provisions of the Louisiana Revised Statutes.

C. The inspections required by this regulation for electrical wiring and gas piping shall be made at the time of the initial installation and thereafter as required based upon a visual inspection by the fire marshal or his designated representative.

AUTHORITY NOTE: Promulgated in accordance with R.S. 40:1651(B).

HISTORICAL NOTE: Promulgated by the Department of Public Safety, Office of State Fire Marshal, LR 8:145 (March 1982), amended by the Department of Public Safety and

Attachment 2: Wind map, 1974 Standard Building Code (SBC)

FIGURE 1205.1 - BASIC WIND SPEEDS IN MILES PER HOUR

Annual Extreme Fastest-Mile Speed 30 Feet Above Ground,
100-Year Mean Recurrence Interval

Source: 1974 Amendments to 1973 Standard Building Code

Attachment 3: Wind Speed Adjustments for Duration of Measurement

Source: Figure C26.5-1 of ASCE 7-10 (Included by reference in the 2015 IBC)

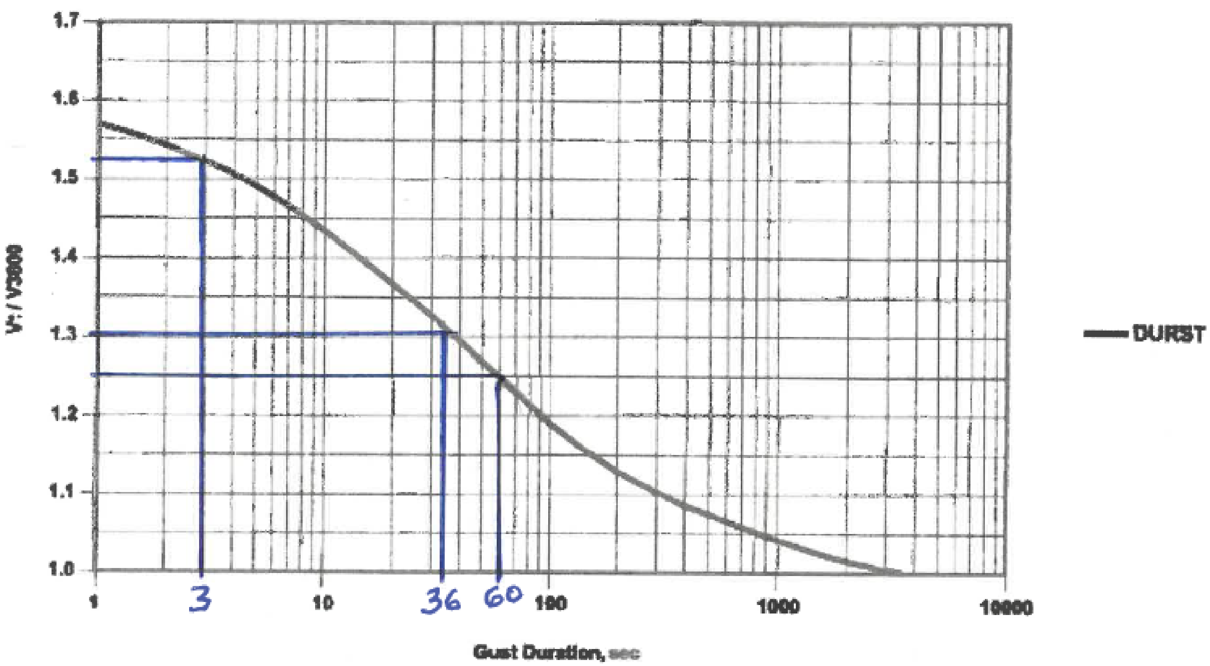


FIGURE C26.5-1 Maximum Speed Averaged over *t* s to Hourly Mean Speed.

Factors taken from C26.5-1

3-second factor	1.52
36-second factor	1.30
60-second factor	1.25

Adjustment Examples

Example 1 – Express 2020 weather station reporting of 100 mph, 60-second speed - In terms of the the 1974 SBC 36-second speed basis

36-second speed / 60-second speed = 1.30/1.25 = 1.04

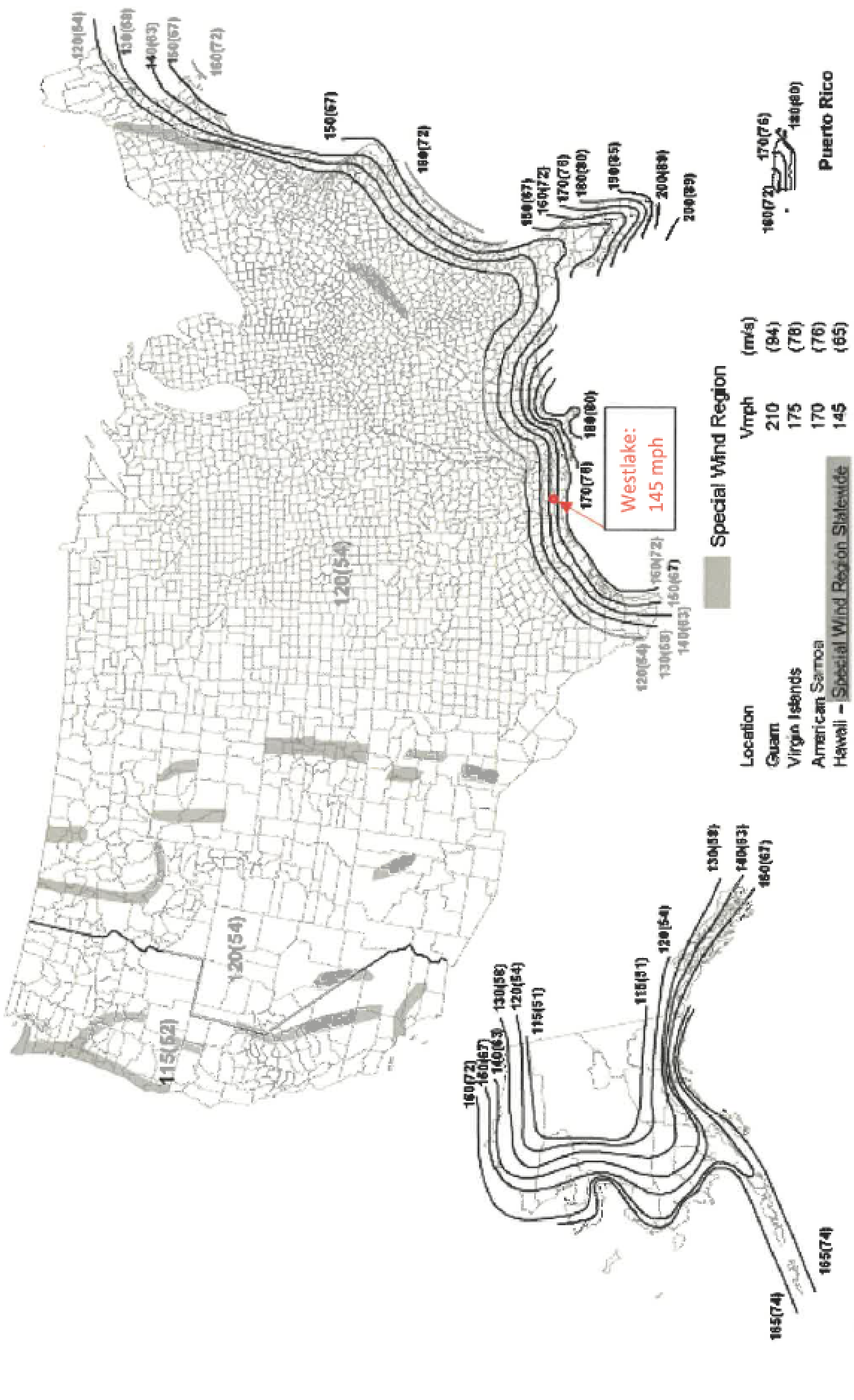
100 mph, 60-second speed *compares to* a 104 mph, 36-second speed

Example 2 – Express 2020 weather station reporting of 100 mph, 60-second speed - In terms of the 2015 IBC 3-second speed basis

3-second speed / 60-second speed = 1.52/1.25 = 1.22

100 mph, 60-second speed *compares to* a 122 mph, 3-second speed

Attachment 4: Wind map, 2015 International Building Code Fig 1609.3(2)



Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1700 Years).

FIGURE 1609.3(2) ULTIMATE DESIGN WIND SPEEDS, V_{ult}, FOR RISK CATEGORY III AND IV BUILDINGS AND OTHER STRUCTURES: **2015 IBC**

APPENDIX E—CONSULTANT REPORT, FIRE PROTECTION CODE REVIEW

TERPconsulting
fire + life safety

BIOLAB LAKE CHARLES
Code Analysis

code consulting | fire protection engineering
construction management | fire protection system and testing

Prepared for:

Citrine LLC

Prepared by:

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1604 S. Maryland Parkway
Las Vegas, NV 89104

TC #22.0612

26 January 2023

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INTRODUCTION

TERPconsulting has conducted a review of the code requirements relative to the BioLab facility located at Lake Charles, Louisiana. It is our understanding that the BioLab facility experienced a release of Trichloroisocyanuric Acid (TCCA) on 27 August 2020, during the passage of Hurricane Laura, a Category 4 hurricane. The TCCA reaction and decomposition emitted visible smoke, released hazardous chlorinated compounds, and resulted in a fire.

TERPconsulting has been engaged to review the quantity and code requirements for the storage of TCCA. The findings of the review presented herein focus on the minimum code requirements applicable to the facility regarding the storage and handling of TCCA prior to the incident.

DOCUMENT REVIEW

TERPconsulting has prepared the following review of the incident based on discussions with the U.S. Chemical Safety and Hazard Investigation Board (CSB) and the following information:

- "BLC-90" – Safety Data Sheet (SDS) - Attached for reference as Appendix A
- Intertape Polymer Corp. – FIBC specifications
- Email correspondence from the Louisiana Office of the State Fire Marshal
- Bio-Lab Response to U.S. Chemical Safety and Hazard Investigation Board's Twenty-Seventh Records and Information Request to Bio-Lab, Inc.
- Bio-Lab Response to U.S. Chemical Safety and Hazard Investigation Board's Twenty-Seventh Records and Information Request to Bio-Lab, Inc.

APPLICABLE CODES & STANDARDS

- 1973 Standard Building Code (SBC)
- NFPA 72 – *National Fire Alarm and Signaling Code* (2019 edition)
- NFPA 101 – *Life Safety Code* (1973 edition)
- NFPA 400 – *Hazardous Materials Code* (2019 edition)
- NFPA 704 – *Standard System for the Identification of the Hazards of Materials for Emergency Response* (2022 edition)
- NFPA Fire Protection Guide to Hazardous Materials (14th edition)
- 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

FACILITY BACKGROUND

The BioLab facility processed and stored TCCA in Plant 4 and the Finished Goods Warehouse (FGW). Plant 4 was utilized for dry blending and packaging of TCCA. The FGW was divided into three (3) bays for storing raw materials, storing TCCA finished product, and storage of off-specification material.

1

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BUILDING DESCRIPTION

The Plant 4 building is a five-story process tower with steel framing and a concrete floor. The building was originally designed and built in the late 1970s. The tower consisted of a high-bay tower and a single-story low-bay enclosed structure. The high-bay process tower was 110' tall with a footprint of 80' by 50'. The low-bay was approximately 20' tall with a 20' by 20' footprint.

Each level of the high-bay, including the ground floor, was provided with two manually operated fire hose stations. The low-bay was also provided with fire hose reels. As of 2020, neither Plant 4 nor the FGW were provided with automatic fire sprinklers.

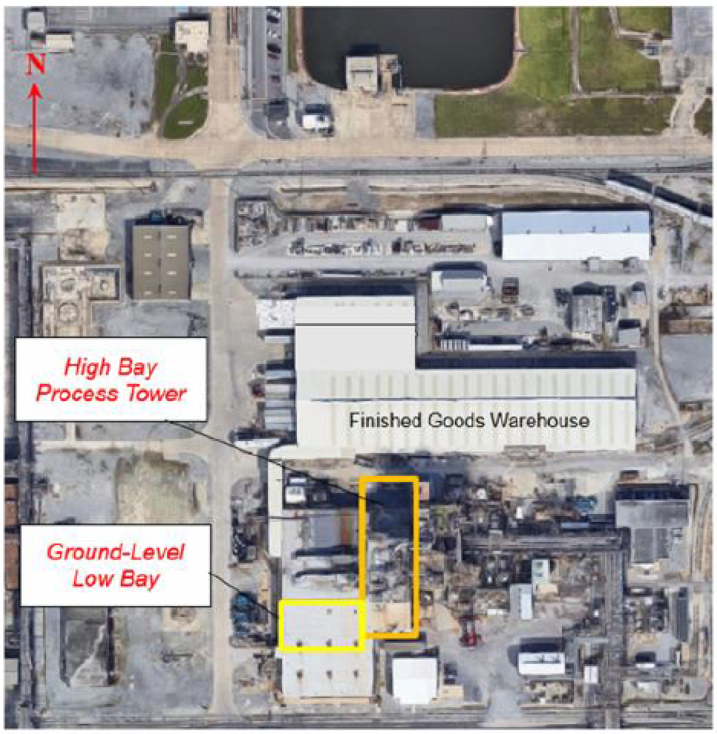

Figure 1: *Plant 4 and Finished Goods Warehouse*

STORAGE DESCRIPTION

The finished product was stored in polypropylene Flexible Intermediate Bulk Containers (FIBCs). An estimated 70,000 to 100,000 pounds of TCCA was stored in Plant 4 on the ground level. The FGW contained over one million pounds (500 tons) of TCCA on August 25, 2020, before the hurricane.

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The TCCA final product was stored inside FIBCs each holding approximately 2,750 pounds of material. The FIBCs consisted of a polypropylene outer bag and a polyethylene inner liner. The FIBCs were sealed/secured with a metal clamp. The FIBCs were placed on pallets and stacked up to two (2) high within the FGW.

HAZARD DESCRIPTION

TCCA is a white powder with an odor similar to chlorine and is utilized as a disinfecting agent in swimming pools. The TCCA SDS, NFPA Fire Protection Guide to Hazardous Materials, and the chemical classification criteria from NFPA 400 were utilized to assign multiple hazard classifications to the TCCA. The NFPA 400 hazard classifications and classification criteria are summarized below.

Table 1: Hazard Classification Summary

Hazard Classification	Classification Criteria	NFPA 400 reference
Oxidizer Class 1	See NFPA 400 Section G.4.1.4	Section 3.3.73.1
Water-Reactive Class 1	Wet material may generate nitrogen trichloride (SDS pg. 3) & NFPA Fire Protection Guide to Hazardous Materials	Section 3.3.62.11
Toxic	Oral LD50 = 406 mg/kg (SDS pg. 6)	Section 3.3.62.9
Corrosive	Causes skin burns (SDS pg. 1) & OSHA Hazard Communication Standard (29 CFR 1910.1200)	Section 3.3.62.2

OXIDIZER

NFPA 400 Section 3.3.73.1 (pg. 400-18) provides the classification criteria and definition of a Class 1 Oxidizer. It states:

> *"An oxidizer that does not moderately increase the burning rate of combustible materials with which it comes into contact or a solid oxidizer classified as Class 1 when tested in accordance with the test protocol set forth in Section G.1."*

Page 1 of the attached SDS indicates that the TCCA is an Oxidizer. NFPA 400 Section G.4.1.4 (pg. 400-192) states that TCCA is classified by NFPA as a Class 1 oxidizer; as such, the SDS and NFPA 400 were utilized to determine the Oxidizer Class 1 hazard classification.

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WATER REACTIVE

NFPA 400 Section A.3.3.62.11 (pg. 400-112) classifies water-reactive materials based on their heat of mixing. It states:

> *"Class 1 water-reactive materials are materials whose heat of mixing is at or above 30 cal/g and less than 100 cal/g. Class 2 water-reactive materials are materials whose heat of mixing is at or above 100 cal/g and less than 600 cal/g. Class 3 water-reactive materials are materials whose heat of mixing is greater or equal to 600 cal/g."*

Since the heat of mixing was not available for TCCA, NFPA 704, and the NFPA Fire Protection Guide to Hazardous Materials were utilized to classify the TCCA as Water Reactive.

Page 3 of the attached SDS indicates that the TCCA "may generate nitrogen trichloride, an explosion hazard" when wet. The attached page 49-148 of the NFPA Fire Protection Guide to Hazardous Materials specifically states that the trichloroisocyanuric acid is water reactive. The reference further indicates that the material reacts with small amounts of water, releasing chlorine gas and nitrogen trichloride. See the Instability and Reactivity Hazards Section excerpt below:

INSTABILITY AND REACTIVITY HAZARDS: Water reactive. Reacts with small amounts of water, releasing chlorine gas and nitrogen trichloride, which is a highly explosive compound when concentrated. Reaction with ammonia or amines produces nitrogen trichloride. Reacts with most reducing agents. Reacts explosively with calcium hypochlorite and water.

Figure 2: *NFPA Fire Protection Guide to Hazardous Materials – Trichloroisocyanuric Acid Instability and Reactivity Hazards pg. 49-148.*

NFPA 704 Table F.2 (pg. 704-22) lists the degree of hazard and specific criteria for classification. Although the degree of hazard is a separate 0-4 classification, the classification criteria is consistent with the NFPA 400 water-reactive criteria. In accordance with Table F.2, materials that produce toxic or flammable gas hazards are assigned the same classification as materials whose heat of mixing is at or above 30 cal/g and less than 100 cal/g. This is consistent with the NFPA 400 classification for Water-Reactive Class 1. See Figure 3 below:

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1 — Does NOT require a ~~W~~ to be displayed in the special hazards	Materials that react vigorously with water, but not violently (criterion most applicable when assigning water reactivity rating to solids because the heat of mixing is determined by physical characteristics and the degree to which the material has dissolved) Materials whose heat of mixing is at or above 30 cal/g and less than 100 cal/g Materials that react with water, producing either heat or gas leading to pressurization or toxic or flammable gas hazards

Figure 3: *NFPA 704 Table F.2 (pg. 704-22) – Degrees of Water Reactivity Hazards*

TOXIC

Page 6 of the SDS indicates that the TCCA has an Oral LD50 = 406 mg/kg. NFPA 400 Section 3.3.62.9 (pg. 400-16) indicates that toxic materials have "a median lethal dose (LD50) of more than 50 mg/kg but not more than 500 mg/kg of body weight when administered orally to albino rats weighing between 200 g and 300 g each"; as such, the TCCA is classified as Toxic in accordance with NFPA 400.

CORROSIVE

Page 1 of the SDS indicates that the chemical "Causes severe skin burns" and indicates that the chemical is classified in accordance with OSHA as Category 1 Sub-Category C.

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Acute toxicity - Oral	Category 4
Acute toxicity - Inhalation (Dusts/Mists)	Category 2
Skin corrosion/irritation	Category 1 Sub-category C
Serious eye damage/eye irritation	Category 1
Reproductive toxicity	Category 2
Specific target organ toxicity (single exposure)	Category 3
Oxidizing solids	Category 2

Label elements

Emergency Overview

Danger

Hazard statements
Harmful if swallowed
Causes severe skin burns and eye damage
Suspected of damaging fertility or the unborn child
May cause respiratory irritation
Fatal if inhaled **
May intensify fire; oxidizer

Figure 4: *SDS Hazard Identification Section*

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Appendix A of OSHA Hazard Communication Standard (29 CFR 1910.1200) identifies Category 1 materials as corrosive and provides additional sub-categories: See Table A.2.1 below:

A.2.2.1 Corrosion

A.2.2.1.1 A corrosive substance is a chemical that produces destruction of skin tissue, namely, visible necrosis through the epidermis and into the dermis, in at least 1 of 3 tested animals after exposure up to a 4-hour duration. Corrosive reactions are typified by ulcers, bleeding, bloody scabs and, by the end of observation at 14 days, by discoloration due to blanching of the skin, complete areas of alopecia and scars. Histopathology should be considered to discern questionable lesions.

A.2.2.1.2 Three sub-categories of Category 1 are provided in Table A.2.1, all of which shall be regulated as Category 1.

Table A.2.1 - Skin Corrosion Category and Sub-Categories

Category 1: corrosive	Corrosive sub-categories	Corrosive in ≥1 of 3 animals	
		Exposure	Observation
	1A	≤3 min	≤1 h.
	1B	>3 min ≤1 h	≤14 days.
	1C	>1 h ≤4 h	≤14 days.

Figure 5: *OSHA Hazard Communication Standard (29 CFR 1910.1200) Section A.2.2.1*

NFPA 400 Section 3.3.62.2 (pg. 400-16) defines a corrosive material as "a chemical that causes visible destruction of, or irreversible alternations in, living tissue by chemical action at the site of contact". Mayoclinic.org defines a chemical burn as tissue damage caused by strong acids or other substances.

The TCCA is classified as Corrosive based on the OSHA Hazard Communication Standard (29 CFR 1910.1200) and NFPA 400.

MAXIMUM ALLOWABLE QUANTITY

The Maximum Allowable Quantity (MAQ) per control area is identified in NFPA 400 Table 5.2.1.1.3 (pg.400-22). The FGW and Plant 4 are considered a single control area. When the threshold quantity of a material in a specific hazard class is exceeded within the control area, additional construction features and engineering controls are required.

The TCCA hazard classifications and MAQ are shown below:

Table 2: Hazard Classification MAQ

TCCA Hazard Classifications	MAQ	High Hazard Protection Level
Oxidizer Class 1	4,000 pounds	N/A
Water Reactive Class 1	Not Limited	N/A
Toxic	500 pounds	4
Corrosive	5,000 pounds	4

The MAQs shown above are allowed to be increased with the presence of automatic fire sprinklers; however, the BioLab facility was not provided with automatic fire sprinklers. The applicable requirements for each specific hazard classification would have applied to the storage of TCCA.

Since the BioLab facility exceeded the MAQ for Toxic and Corrosive materials at the time of the hurricane, high hazard level 4 protection would have been required in accordance with NFPA 400 Table 5.2.1.1.3 (pg. 400-22). High hazard protection reflects increased building safety requirements exceeding the construction requirements for control areas to accommodate quantities of hazardous materials in excess of those permitted using the control area concept.

FIRE ALARM/DETECTION

NFPA 400 Section 15.1.1 (pg. 400-63) requires compliance with Chapter 15 when the amount of oxidizer solids exceed the MAQ. In accordance with NFPA 400 Section 15.3.1.1 (pg. 400-65) a fire detection system would have been required for the indoor storage of TCCA. The system would be required to be installed in accordance with NFPA 72 – *National Fire Alarm and Signaling Code*, as required by NFPA 400 Section 6.1.20 (pg. 400-33). Based on Bio-Lab response provided to the CSB it appears that the FGW was provided with smoke detectors that were not being utilized prior to the hurricane.

FIRE SUPPRESSION

An automatic fire sprinkler system would have been required for the storage of TCCA within the BioLab Plant 4 and FGW in accordance with the following NFPA 400 Sections.

- Storage of Corrosive solids exceeding the MAQ – Section 12.5.5 (pg. 400-57)
- Storage of Toxic solids exceeding the MAQ – Section 18.2.6 (pg. 400-75)
- High hazard level 4 protection – Section 6.2.1.1. High hazard level 4 protection is required in accordance with NFPA 400 Table 5.2.1.1.3 (pg. 400-22) when the MAQ is exceeded for Toxic and Corrosive materials.

Since hose streams were provided at the BioLab facility, a minimum water supply of 750 gpm for 2 hours would have been required in accordance with NFPA 400 Section 15.2.5.2. The required hose stream water supply is reduced to 500 gpm when used in conjunction with automatic fire sprinklers.

Section 14-4321 of the 1973 NFPA 101 Life Safety Code (pg. 101-174) also requires automatic sprinkler protection or other protection as may be appropriate to the particular hazard, designed to minimize danger to occupants in case of fire or other emergency before they can evacuate, for high hazard occupancies.

SECONDARY CONTAINMENT

Secondary containment is intended for both solids and liquids and serves to contain a spill from the largest vessel plus the water discharged from the fire sprinkler system as required by NFPA 400 Section 6.2.1.9.3.6 (pg. 400-37).

A secondary containment system would have been required for the storage of TCCA within the BioLab Plant 4 and FGW in accordance with the following NFPA 400 Sections:

- Storage of Oxidizer solids exceeding the MAQ – Section 15.2.3 (pg. 400-64)
- Storage of Toxic solids exceeding the MAQ – Section 18.2.3 (pg. 400-75)
- Aggregate storage over 10,000 lbs. – Section 6.2.1.9.3.1(2) (pg. 400-37).

The building or area containing the TCCA should have been provided with one of the following methods (NFPA 400 Section 6.2.1.9.3.4) (pg. 37):

1. Liquid-tight sloped or recessed floors
2. Liquid-tight floors provided with raised or recessed sills or dikes
3. Sumps or collection systems
4. Drainage systems leading to an approved location.

The secondary containment system should have been sized to contain a spill from the largest container plus the design flow volume of the fire protection water calculated to discharge from the fire-extinguishing for a period of 20 minutes.

VENTILATION

NFPA 400 Section 6.2.1.5 (pg. 400-35) requires buildings or portions of buildings to be provided with mechanical ventilation where corrosive dusts/mists are present or might be emitted. Additionally, page 4 Section 7 of the SDS for TCCA indicates to use local exhaust ventilation.

Mechanical ventilation would have been required for the Plant 4 process building. NFPA 400 Section 6.2.1.5.3 requires a mechanical ventilation rate of not less than 1 $ft^3/min/ft^2$ of floor area.

Mechanical ventilation is not required as allowed by NFPA 400 Section 6.2.1.5.1 (pg. 400-35) when solids are stored in closed containers; as such, the FGW building would not have required mechanical ventilation for areas storing FIBCs containing final TCCA product. The FIBCs are packaged within the Plant 4 building and sealed/secured with a metal clamp before moving to the FGW.

TCCA STORAGE CONFIGURATION

NFPA 400 Table 15.3.2.2.2.2(A)(a) outlines the storage configuration for Class 1 Oxidizers in a nonsprinklered building. The FIBCs were 46-52" high and stacked on pallets. FIBCs stacked two (2) high on pallets would have been approximately 8-9' high. NFPA 400 Table 15.3.2.2.2.2(A)(a) (pg. 400-66) limits storage height in nonsprinklered buildings to 8' (see Appendix C regarding NFPA reference clarification).

The storage of TCCA in the FGW was approximately 500 tons. NFPA 400 Table 15.3.2.2.2.2(A)(a) limits each pile to 20 tons and limits pile width and provides requirements for aisles between piles. The exact pile configuration before the incident was not known.

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NFPA 400 Section 15.3.2.2.2.2(E) (pg. 400-66) requires the TCCA to be separated from ordinary combustibles and incompatible materials by a solid noncombustible barrier. The FGW was separated into three (3) bays; however, the specific barrier construction material is not known.

STANDBY AND EMERGENCY POWER

NFPA 400 Section 6.2.1.8 (pg. 400-36) requires standby or emergency power for mechanical ventilation systems and alarm/detection systems for occupancies storing quantities of hazardous materials exceeding the MAQ. This section would have been applicable since the MAQ was exceeded for Toxic and Corrosive materials.

The standby and emergency power requirements would have been applicable to the Plant 4 mechanical ventilation system and the fire detection system that would have been required in both the FGW and Plant 4.

Based on information provided by the CSB an emergency generator was onsite but was not functioning properly at the time of hurricane Laura. A portable emergency generator was provided but was unusable at the time of the incident.

LIFE SAFETY CODE & STANDARD BUILDING CODE

According to the Office of the State Fire Marshal and the Louisiana Administrative Code, the 1973 edition of NFPA 101 Life Safety Code and the high-rise provisions of the 1973 edition of the Standard Building Code would have been applicable during the construction of the FGW and Plant 4; however, based on the use of the building the SBC provisions were not applicable.

The 1973 NFPA 101 Life Safety Code (pg. 101-167) indicates that buildings that contain contents which poisonous fumes are to be feared in the event of a fire are considered *High Hazard Industrial Occupancies* as outlined below:

> (c)* *High Hazard Industrial Occupancy.* Includes those buildings having contents which are liable to burn with extreme rapidity or from which poisonous fumes or explosions are to be feared in the event of fire.

Figure 6: *1973 NFPA 101 Life Safety Code – High Hazard Industrial Occupancy*

The TCCA SDS (pg. 3) indicates that thermal decomposition can lead to release of toxic/corrosive gases and vapors; as such, both the FGW and Plant 4 would have been considered High Hazard Industrial Occupancies under the 1973 NFPA 101 Life Safety Code.

In accordance with the 1973 NFPA 101 Life Safety Code Section 14-4321 (pg. 101-174) every high hazard industrial occupancy shall have automatic sprinkler protection, or such protection as may be appropriate to the particular hazard. In addition, Section 14-2183 (pg. 101-172) would have required a manual fire alarm system; however, Exception No. 3 allows omission of the manual fire alarm system when the building is provided with automatic sprinklers.

CONCLUSION

Based on the analysis documented in this report, TERPconsulting concludes that the BioLab facility was not in compliance with NFPA 400 in its handling and storage of Trichloroisocyanuric Acid prior to the damage caused by Hurricane Laura on 27 August 2020.

The storage of over one million pounds of TCCA exceeded the MAQ of 500 pounds and 5,000 pounds for Toxic and Corrosive materials, respectively. As a result of exceeding the MAQ and hazard specific requirements, the following was required but was not present or not functional at the facility:

- Fire detection system
- Automatic fire sprinklers
- Secondary containment system
- Mechanical ventilation system
- Standby/emergency power.

TERPconsulting reserves the right to supplement this report and to submit revised opinions and conclusions if additional information and documents are made available. If you have any questions regarding the information included in the report above, please do not hesitate to contact our office.

TERPconsulting

APPENDIX A

TCCA Safety Data Sheet (SDS)

SAFETY DATA SHEET

Revision Date 29-Feb-2016 **Version** 3

1. IDENTIFICATION

Product identifier
Product Name BLC-90

Other means of identification
Product Code R10807LC
UN/ID no. UN2468

Recommended use of the chemical and restrictions on use
Recommended Use Swimming pool sanitizer.
Uses advised against Do not mix with other chemicals

Details of the supplier of the safety data sheet
Supplier Address
Bio-Lab, Inc.
P.O. Box 300002
Lawrenceville, GA 30049-1002
Telephone 800-859-7946

Emergency telephone number
Emergency Telephone Chemtrec (Transportation) 1-800-424-9300, 703-527-3887
Poison Control Center (Medical) : (877) 800-5553

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Acute toxicity - Oral	Category 4
Acute toxicity - Inhalation (Dusts/Mists)	Category 2
Skin corrosion/irritation	Category 1 Sub-category C
Serious eye damage/eye irritation	Category 1
Reproductive toxicity	Category 2
Specific target organ toxicity (single exposure)	Category 3
Oxidizing solids	Category 2

Label elements

Emergency Overview

Danger

Hazard statements
Harmful if swallowed
Causes severe skin burns and eye damage
Suspected of damaging fertility or the unborn child
May cause respiratory irritation
Fatal if inhaled **
May intensify fire; oxidizer

BLC-90 **Revision Date** 29-Feb-2016

Color white **Physical state** Solid **Odor** Chlorine

** **Product as sold is not expected to produce respiratory effects. See Section 11 (Toxicological Information) for additional details on inhalation.**

Precautionary Statements - Prevention
Obtain special instructions before use
Do not handle until all safety precautions have been read and understood
Use personal protective equipment as required
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product
Do not breathe dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Wear respiratory protection
Keep away from heat/sparks/open flames/hot surfaces. — No smoking
Keep/Store away from clothing/ combustible materials

Precautionary Statements - Response
Immediately call a POISON CENTER or doctor/physician
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Immediately call a POISON CENTER or doctor/physician
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower. Wash contaminated clothing before reuse
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CENTER or doctor/physician
IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell. Rinse mouth. Do NOT induce vomiting.
Water only; no dry chemical, CO_2 or Halon

Precautionary Statements - Storage
Store locked up. Store in a well-ventilated place. Keep container tightly closed

Precautionary Statements - Disposal
Dispose of contents/container to an approved waste disposal plant

Hazards not otherwise classified (HNOC)
Not applicable

Other Information
0% of the mixture consists of ingredient(s) of unknown toxicity

3. COMPOSITION/INFORMATION ON INGREDIENTS

Mixture

Chemical Name	CAS No.	Weight-%
Trichloro-s-triazinetrione	87-90-1	99
boric acid	10043-35-3	0.5-1*

4. FIRST AID MEASURES

Description of first aid measures

General advice	If symptoms persist, call a physician. Do not breathe dust/fume/gas/mist/vapors/spray. Do not get in eyes, on skin, or on clothing.
Eye contact	Immediately flush with plenty of water. After initial flushing, remove any contact lenses and continue flushing for at least 15 minutes. Keep eye wide open while rinsing. If symptoms persist, call a physician.
Skin contact	Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Wash contaminated clothing before reuse. If skin irritation persists, call a physician. Immediate medical attention is not required.
Inhalation	Remove to fresh air. If breathing is irregular or stopped, administer artificial respiration. Avoid direct contact with skin. Use barrier to give mouth-to-mouth resuscitation. Artificial respiration and/or oxygen may be necessary. If symptoms persist, call a physician.
Ingestion	Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Have person sip a glass of water if able to swallow. Call a physician immediately.
Self-protection of the first aider	Use personal protective equipment as required.

Most important symptoms and effects, both acute and delayed

Symptoms No information available.

Indication of any immediate medical attention and special treatment needed

Note to physicians Treat symptomatically. Probable mucosal damage may contraindicate the use of gastric lavage.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media
Flood fire area with water from a distance.

Unsuitable extinguishing media Do not use dry chemicals, carbon dioxide, or halogenated extinguishing agents.

Specific hazards arising from the chemical
Do not let the fire burn. Thermal decomposition can lead to release of toxic/corrosive gases and vapors. Wet material may generate nitrogen trichloride, an explosion hazard.

Explosion data
Sensitivity to Mechanical Impact None.
Sensitivity to Static Discharge None.

Protective equipment and precautions for firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Personal precautions Use personal protective equipment as required. Evacuate personnel to safe areas. Keep people away from and upwind of spill/leak.

Environmental precautions

Environmental precautions Prevent entry into waterways, sewers, basements or confined areas. Do not flush into surface water or sanitary sewer system. Prevent further leakage or spillage if safe to do so. Prevent product from entering drains. See Section 12 for additional ecological information.

Methods and material for containment and cleaning up

Methods for containment Prevent further leakage or spillage if safe to do so. Do not add water to spilled material. Using clean dedicated equipment, sweep and scoop all spilled material, contaminated soil, and other contaminated material and place into clean dry containers for disposal. Do not close containers containing wet or damp material. They should be left open to disperse any hazardous gases that may form.

Methods for cleaning up Use personal protective equipment as required. Cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry. Take up mechanically, placing in appropriate containers for disposal. Avoid creating dust. Clean contaminated surface thoroughly. Pick up and transfer to properly labeled containers. Sweep up and shovel into suitable containers for disposal. After cleaning, flush away traces with water. Do not use floor sweeping compounds to clean up spills. Do not transport wet or damp material. Contact supplier in Section 1 for instructions, especially for damp or contaminated material.

7. HANDLING AND STORAGE

Precautions for safe handling

Advice on safe handling Use personal protective equipment as required. Avoid contact with skin, eyes or clothing. Wash contaminated clothing before reuse. Do not breathe dust/fume/gas/mist/vapors/spray. Do not eat, drink or smoke when using this product. Use with local exhaust ventilation. Do not mix with other chemicals. Keep/Store away from clothing/ combustible materials. Wash thoroughly after handling. Use only in well-ventilated areas.

Conditions for safe storage, including any incompatibilities

Storage Conditions Keep container tightly closed in a dry and well-ventilated place. Keep out of the reach of children. Keep containers tightly closed in a cool, well-ventilated place. Keep in properly labeled containers.

Incompatible materials Incompatible with strong acids and bases. Ammonia. Calcium hypochlorite. Combustible material. Do not mix with other swimming pool/spa chemicals in their concentrated forms. Reducing agent.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines .

Chemical Name	ACGIH TLV	OSHA PEL	NIOSH IDLH
boric acid 10043-35-3	STEL: 6 mg/m³ inhalable fraction TWA: 2 mg/m³ inhalable fraction	-	-

Appropriate engineering controls

Engineering Controls Showers
Eyewash stations
Ventilation systems.

Individual protection measures, such as personal protective equipment

Eye/face protection Wear safety glasses with side shields (or goggles).

Skin and body protection Wear protective gloves and protective clothing.

Respiratory protection If exposure limits are exceeded or irritation is experienced, NIOSH/MSHA approved respiratory protection should be worn. Positive-pressure supplied air respirators may be required for high airborne contaminant concentrations. Respiratory protection must be provided in accordance with current local regulations.

General Hygiene Considerations When using do not eat, drink or smoke. Wash contaminated clothing before reuse. Regular cleaning of equipment, work area and clothing is recommended.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Physical state	Solid		
Appearance	granules	**Odor**	Chlorine
Color	white	**Odor threshold**	No information available

Property	**Values**	**Remarks • Method**
pH	3-3.5	in 1% Solution
Melting point/freezing point	248 °C	Decomposes on heating
Boiling point / boiling range	No information available	
Flash point	No information available	
Evaporation rate	No information available	
Flammability (solid, gas)	No information available	
Flammability Limit in Air		
Upper flammability limit:	No information available	
Lower flammability limit:	No information available	
Vapor pressure	No information available	
Vapor density	No information available	
Specific Gravity	No information available	
Water solubility	Soluble in water	
Solubility in other solvents	No information available	
Partition coefficient	No information available	
Autoignition temperature	No information available	
Decomposition temperature	No information available	
Kinematic viscosity	No information available	
Dynamic viscosity	No information available	
Density	0.88-0.96	g/cm3
Bulk density	No information available	
Explosive properties	No information available	
Oxidizing properties	May intensify fire; oxidizer	

Other Information

Softening point	No information available
Molecular weight	No information available
VOC Content (%)	No information available

10. STABILITY AND REACTIVITY

Reactivity
No data available
Chemical stability
Stable under recommended storage conditions.
Possibility of Hazardous Reactions
None under normal processing.
Conditions to avoid
Extremes of temperature and direct sunlight. Protect from moisture. Do not mix with other chemicals.
Incompatible materials
Incompatible with strong acids and bases. Ammonia. Calcium hypochlorite. Combustible material. Do not mix with other swimming pool/spa chemicals in their concentrated forms. Reducing agent.
Hazardous Decomposition Products
Chlorine gas.

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

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Inhalation This material in the form as sold is not expected to produce repiratory effects. Particles of respirable size are generally not encountered. The respirable fraction is typically less than 0.1% by weight. If ground or otherwise in a powdered form, effects similar to a corrosive substance may occur. Exposure to the solid product or to free chlorine evolving from the product may cause irritation, redness of upper and lower airways, coughing, laryngospasm and edema, shortness of breath, bronchoconstriction, and possible pulmonary edema. The pulmonary edema may develop several hours after a severe acute exposure.

Eye contact Risk of serious damage to eyes. Causes burns.

Skin contact Irritating to skin. Contact with moist skin may cause skin burns. Causes burns. May be fatal if absorbed through skin.

Ingestion Harmful if swallowed. May be fatal if swallowed.

Chemical Name	Oral LD50	Dermal LD50	Inhalation LC50
Trichloro-s-triazinetrione 87-90-1	= 406 mg/kg (Rat)	> 2000 mg/kg (Rabbit)	>50 mg/L (Rat) 4 h
boric acid 10043-35-3	= 2660 mg/kg (Rat)	> 2000 mg/kg (Rabbit)	> 0.16 mg/L (Rat) 4 h

Information on toxicological effects

Symptoms No information available.

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Sensitization No information available.
Germ cell mutagenicity No information available.
Carcinogenicity No information available.

Reproductive toxicity This product contains a boron compound. This boron compound when fed to test animals at very high doses has shown reproductive and developmental toxicity. When this product is used according to label directions, the boron compound in this product does not represent a practical risk to humans.
STOT - single exposure No information available.
STOT - repeated exposure No information available.
Chronic toxicity Avoid repeated exposure.
Aspiration hazard No information available.

Numerical measures of toxicity - Product Information

The following values are calculated based on chapter 3.1 of the GHS document .
Oral LD50 809 mg/kg (rat)
Dermal LD50 > 2000 mg/kg (rabbit)

12. ECOLOGICAL INFORMATION

Ecotoxicity

Very toxic to aquatic life with long lasting effects

0% of the mixture consists of components(s) of unknown hazards to the aquatic environment

Chemical Name	Algae/aquatic plants	Fish	Crustacea
Trichloro-s-triazinetrione 87-90-1	-	0.13 - 0.5: 96 h Lepomis macrochirus mg/L LC50 static 0.06 - 0.11: 96 h Oncorhynchus mykiss mg/L LC50 static	0.21: 48 h Daphnia magna mg/L EC50 0.16 - 0.18: 48 h Daphnia magna mg/L EC50 Static
boric acid 10043-35-3	-	1020: 72 h Carassius auratus mg/L LC50 flow-through	115 - 153: 48 h Daphnia magna mg/L EC50

Persistence and degradability

No information available.

Bioaccumulation
No information available.

Mobility
No information available.

Chemical Name	Partition coefficient
boric acid 10043-35-3	-0.757

Other adverse effects No information available

13. DISPOSAL CONSIDERATIONS

Waste treatment methods

Disposal of wastes Disposal should be in accordance with applicable regional, national and local laws and regulations.

Contaminated packaging Do not reuse container. Refer to all federal, state and local regulations prior to disposal of container and unused contents by reuse, recycle or disposal.

14. TRANSPORT INFORMATION

Note: Limited quantity (LQ) exception is possible

DOT

UN/ID no.	UN2468
Proper shipping name	Trichloroisocyanuric acid, dry
Hazard Class	5.1
Packing Group	II
Description	UN2468, Trichloroisocyanuric acid, dry, 5.1, II
Emergency Response Guide Number	140

TDG

UN/ID no.	UN2468
Proper shipping name	Trichloroisocyanuric acid, dry
Hazard Class	5.1
Packing Group	II
Description	UN2468, Trichloroisocyanuric acid, dry, 5.1, II

IATA

UN/ID no.	UN2468
Proper shipping name	Trichloroisocyanuric acid, dry
Hazard Class	5.1
Packing Group	II
Description	UN2468, Trichloroisocyanuric acid, dry, 5.1, II

IMDG

UN/ID no.	UN2468
Proper shipping name	Trichloroisocyanuric acid, dry
Hazard Class	5.1
Packing Group	II
EmS-No.	F-A, S-Q
Description	UN2468, Trichloroisocyanuric acid, dry, 5.1, II
Marine pollutant	This material meets the definition of a marine pollutant

15. REGULATORY INFORMATION

International Inventories

TSCA	Complies
DSL/NDSL	Complies

Legend:
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List

US Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories

Acute health hazard	Yes
Chronic Health Hazard	No
Fire hazard	No
Sudden release of pressure hazard	No
Reactive Hazard	No

CWA (Clean Water Act)
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

US State Regulations

California Proposition 65
This product does not contain any Proposition 65 chemicals

U.S. State Right-to-Know Regulations

Chemical Name	New Jersey	Massachusetts	Pennsylvania
Trichloro-s-triazinetrione 87-90-1	X	X	X

U.S. EPA Label Information
EPA Pesticide Registration Number 5185-442
EPA Statement
This chemical is a pesticide product registered by the Environmental Protection Agency and is subject to certain labeling requirements under federal pesticide law. These requirements differ from the classification criteria and hazard information required for safety data sheets, and for workplace labels of non-pesticide chemicals. Following is the hazard information as required on the pesticide label:
Difference between SDS and EPA Pesticide label
DANGER: CORROSIVE: Causes irreversible eye damage and skin burns. May be fatal if absorbed through skin. May be fatal if inhaled. Do not breathe dust or fumes. Irritating to nose and throat. Harmful if swallowed. Do not get in eyes, on skin, or on clothing. Wear goggles or face shield, protective clothing and rubber gloves when handling this product. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash before reuse.

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16. OTHER INFORMATION, INCLUDING DATE OF PREPARATION OF THE LAST REVISION

NFPA	**Health hazards** 3	**Flammability** 0	**Instability** 1	**Physical and Chemical Properties** OX
HMIS	**Health hazards** 3	**Flammability** 0	**Physical hazards** 1	**Personal protection** X

Prepared By Regulatory Affairs
Revision Date 29-Feb-2016
Revision Note No information available
Disclaimer
The information provided in this Material Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

End of Safety Data Sheet

APPENDIX B

NFPA Guide Page 49-148

SOLUBILITY IN WATER: not soluble

VAPOR PRESSURE: 19 mm Hg @ 20°C 40 mm Hg @ 35°C

NAME: **TRICHLOROETHYLENE**

SYNONYMS: ethylene trichloride; trichlor

FORMULA: $ClCH=CCl_2$

NFPA 30/OSHA CLASSIFICATION:

DOT CLASS: Class 6.1, Poisonous material

SHIPPING LABEL: KEEP AWAY FROM FOOD

ID NO.: UN 1710

CAS NO.: 79-01-6

MOL. WT.: 131.4

STATEMENT OF HAZARDS: Moderate health hazard. Combustion by-products may include hydrogen chloride and phosgene.

EMERGENCY RESPONSE PERSONAL PROTECTIVE EQUIPMENT: Wear full protective clothing and positive pressure self-contained breathing apparatus. Polyvinyl alcohol or Viton® barrier recommended.

SPILL OR LEAK PROCEDURES: Approach release from upwind. Stop or control the leak, if this can be done without undue risk. Control runoff and isolate discharged material for proper disposal.

FIRE FIGHTING PROCEDURES: Approach fire from upwind to avoid hazardous vapors and toxic decomposition products. Use water spray to keep fire-exposed containers cool. Extinguish fire using agent suitable for surrounding fire.

HEALTH HAZARDS: Moderate health hazard. May be harmful if inhaled. Irritating to skin, eyes, and respiratory system. Symptoms of exposure include dizziness and loss of consciousness. Combustion by-products may include hydrogen chloride and phosgene.

FIRE AND EXPLOSION HAZARDS: No flash point in conventional closed tester; however, vapors in containers can explode if subjected to a high energy source. Combustion may produce irritants and toxic gases including hydrogen chloride.

AUTOIGNITION TEMPERATURE: 788°F (420°C)

FLAMMABLE LIMITS: LOWER: 8% UPPER: 10.5%

INSTABILITY AND REACTIVITY HAZARDS: Reacts with active metals.

STORAGE RECOMMENDATIONS: Store in a cool, dry, well-ventilated location. Separate from active metals. Isolate from open flames and combustibles.

USUAL SHIPPING CONTAINERS: Bottles, cans, drums; tanks on trucks, rail cars, barges.

PHYSICAL PROPERTIES: Colorless liquid with mild odor like chloroform.

MELTING POINT: −121°F (−85°C)

BOILING POINT: 189°F (87°C)

SPECIFIC GRAVITY: 1.46

SOLUBILITY IN WATER: not soluble

VAPOR PRESSURE: 58 mm Hg @ 20°C

NAME: **TRICHLOROISOCYANURIC ACID, dry**

SYNONYMS: TCCA; trichloro; tri-chloroimino-cyanuric acid; trichloro-s-triazinetrione; symclosene

FORMULA: $C_3Cl_3N_3O_3$

NFPA 30/OSHA CLASSIFICATION:

DOT CLASS: Class 5.1, Oxidizer

SHIPPING LABEL: OXIDIZER

ID NO.: UN 2468

CAS NO.: 87-90-1

MOL. WT.: 232.4

STATEMENT OF HAZARDS: Moderate health hazard. Oxidizer. Reacts with combustible materials or ammonium salts resulting in fire. Reacts with small amounts of water, releasing chlorine gas and nitrogen trichloride, which is a highly explosive compound when concentrated. Thermally unstable. Decomposes at 437°F (225°C).

EMERGENCY RESPONSE PERSONAL PROTECTIVE EQUIPMENT: Wear special protective clothing and positive pressure self-contained breathing apparatus.

SPILL OR LEAK PROCEDURES: Keep water away from release. Approach release from upwind. Isolate leaking containers, if this can be done without undue risk. Prompt cleanup and removal is necessary. Shovel into suitable dry container. Control runoff and isolate discharged material for proper disposal.

FIRE FIGHTING PROCEDURES: Approach fire from upwind to avoid hazardous vapors and toxic decomposition products. Fight fire from protected location or maximum possible distance. Use flooding quantities of water on fire-involved containers. If necessary use water spray to keep fire-exposed containers cool. Avoid use of water on non-involved material wherever possible.

HEALTH HAZARDS: Moderate health hazard. May be harmful if or inhaled. Irritating to skin, eyes, and respiratory system. Water reactive. Releases chlorine gas and nitrogen chloride on contact with water.

FIRE AND EXPLOSION HAZARDS: Not combustible. Reacts with combustible materials, ammonium salts, or foreign substances, resulting in fire. Closed containers may rupture violently when heated. Thermally unstable. Decomposes at 437°F (225°C).

INSTABILITY AND REACTIVITY HAZARDS: Water reactive. Reacts with small amounts of water, releasing chlorine gas and nitrogen trichloride, which is a highly explosive compound when concentrated. Reaction with ammonia or amines produces nitrogen trichloride. Reacts with most reducing agents. Reacts explosively with calcium hypochlorite and water.

STORAGE RECOMMENDATIONS: Store in a cool, dry, well-ventilated location. Outside or detached storage is preferred. Must be stored in a dry location on pallets arranged according to NFPA 430, Code for Storage of Liquid and Solid Oxidizers. Separate from combustibles, oxidizables, ammonia, sodium carbonate (soda ash), calcium hypochlorite, hydrogen peroxide.

USUAL SHIPPING CONTAINERS: Moisture-excluding fiber drums with polyethylene bag liners and lined pails. Unlined

[redacted]

From: NFPA Haz Chem <techqueshazchem@nfpa.org>
Sent: Monday, January 9, 2023 6:03 AM
To: [redacted]
Subject: NFPA Technical Question Response ref# [ref:_00D5077Vx._5001T1nBbqd:ref]

NFPA

TECHNICAL QUESTIONS

Thank you for your question on NFPA 400 *Hazardous Materials Code*, 2019 edition.

It appears that you have identified an item in NFPA 400 that should be corrected to align with the formatting in the similar tables found in Chapter 15 for oxidizer solids and liquids. In Table 15.3.2.2.2.2(A)(a) the third row 'storage limit' does refer to storage height. That row should be amended to say 'storage height' to better clarify what that row applies to.

Important Notice: Any opinion expressed in this correspondence is the personal opinion of the author and does not necessarily represent the official position of the NFPA or its Technical Committees. In addition, this correspondence is neither intended, nor should it be relied upon, to provide professional consultation or services.

Respectfully,

Matt Barker
NFPA

If you have a follow-up question directly related to this inquiry, please reply to this email. If you have another question on either a separate topic or different document please return to the document information pages and submit your new question by clicking on the "Technical Questions" tab.

Contact: [redacted]
Create Date: 1/4/2023

Document Number: 400
Edition: 2019

U.S. Chemical Safety and Hazard Investigation Board

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