U.S. Chemical Safety and
Hazard Investigation Board

Chemical Decomposition, Fires, and Toxic Gas Release at KIK Consumer Products / Bio-Lab Conyers Facility

Conyers, Georgia | *Incident Date: September 29, 2024* | **No. 2024-04-I-GA**

Investigation Report

Published: July 2026

Safety Issues:

- **Run To Failure**
- **Identification of Storage Hazards**
- **Risk Management and Oversight**
- **NFPA Guidance for Pool-Treatment Chemicals**
- **PSM and RMP Coverage of Reactive Hazards**

U.S. Chemical Safety and Hazard Investigation Board

The mission of the U.S. Chemical Safety and Hazard Investigation Board (CSB) is to *drive chemical safety excellence through independent investigations to protect communities, workers, and the environment.*

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.

More information about the CSB and CSB products can be accessed at www.csb.gov or obtained by contacting:

U.S. Chemical Safety and Hazard Investigation Board
470 L'Enfant Plaza SW, Suite 604 #23278
Washington, DC 20026
(202) 261-7600

The CSB was created by the Clean Air Act Amendments of 1990, and the CSB was first funded and commenced operations in 1998. The CSB is not an enforcement or regulatory body. No part of the conclusions, findings, or recommendations of the Board relating to any accidental release or the investigation thereof shall be admitted as evidence or used in any action or suit for damages arising out of any matter mentioned in such report. 42 U.S.C. § 7412(r)(6)(G).

CONTENTS

ABBREVIATIONS

AEGL	Acute Exposure Guideline Level
AHJ	Authority Having Jurisdiction
AIChE	American Institute of Chemical Engineers
ARCO	ARCO Design/Build
ASTM	American Society for Testing and Materials
BCDMH	Bromochloro-5,5-dimethylimidazolidine-2,4-dione / Bromochlorodimethylhydantoin
CCPS	Center for Chemical Process Safety
CFM	Cubic Feet per Minute (unit of measurement)
CFR	Code of Federal Regulations
CHETAH	Chemical Thermodynamic and Energy Release Evaluation
Cl_2	Chlorine Gas
CSB	U.S. Chemical Safety and Hazard Investigation Board
EHS	Environment, Health, and Safety
EPA	U.S. Environmental Protection Agency
ERT	Emergency Response Team
ESFR	Early Suppression Fast Response
FIBC	Flexible Intermediate Bulk Container
FT	Feet (unit of measurement)
FTIR	Fourier Transform Infrared Spectroscopy
GC-MS	Gas Chromatography-Mass Spectrometry
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
HCl	Hydrogen Chloride and Hydrochloric Acid
IBC	International Building Code
ICC	International Code Council
IFC	International Fire Code
ISO	Polyisocyanurate
KIK	KIK Custom Products, Inc. d/b/a KIK Consumer Products
LBS	Pounds (unit of measurement)
MAQ	Maximum Allowable Quantity
MPH	Miles Per Hour
NaDCC (or DCCA)	Sodium Dichloroisocyanurate
NCl_3	Nitrogen Trichloride
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
NRC	National Response Center
OSHA	U.S. Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PSI	Pounds per Square Inch (unit of measurement)
PSM	Process Safety Management
RBPS	Risk-Based Process Safety
RCFR	Rockdale County Fire Rescue
RMP	Risk Management Program
RTF	Run To Failure
RTI	Response Time Index
SDS	Safety Data Sheet
SME	Subject Matter Expert
TCCA	Trichloroisocyanuric Acid
TPO	Thermoplastic Polyolefin
TPQ	Threshold Planning Quantities

EXECUTIVE SUMMARY

On the morning of September 29, 2024, Bio-Lab, Inc., a subsidiary of KIK Custom Products, Inc. d/b/a KIK Consumer Products (“KIK”), experienced a chemical reaction involving hazardous chemicals inside a warehouse at its Conyers, Georgia, facility (“Bio-Lab Conyers”). The reaction caused extensive off-gassing, excessive heat generation, multiple fires, and a massive plume of toxic smoke containing chlorine, hydrogen chloride, and bromine (as well as other substances). These conditions prompted shelter-in-place orders, evacuations, and road closures by local authorities. Roughly 17,000 people in the surrounding community were reportedly evacuated, and local media also reported that 90,000 people in the Atlanta metropolitan area were advised to shelter in place due to toxic smoke from the fires.

Bio-Lab, Inc. (“Bio-Lab”) is the swimming pool and spa water care division of KIK [1]. On the morning of September 29, a decomposition reaction was initiated in Bio-Lab’s Plant 12 Storage Warehouse at the Conyers facility when water from a failed sprinkler system component contacted chlorinated isocyanurates stored in the warehouse. Chlorinated isocyanurates are chemicals used in products for treating pools and spas. The reaction generated heat and activated other sprinkler heads in the warehouse, wetting more chlorinated isocyanurates and other chemicals, including cyanuric acid, aluminum sulfate, and sodium bromide, some of which also reacted. The multiple reactions generated substantial additional heat, which further led to the decomposition of products and, subsequently, caused significant plumes of smoke, toxic vapors, and fires within the building. The Plant 12 Storage Warehouse contained four primary chemicals: trichloroisocyanuric acid (TCCA) (and formulations thereof), sodium dichloroisocyanurate (NaDCC) (anhydrous and dihydrate), and Bromochloro-5,5-dimethylimidazolidine-2,4-dione (BCDMH), which are National Fire Protection Association (NFPA) Class 1 and Class 2 oxidizers. The warehouse also contained various commodities and packaging materials, such as corrugated cardboard, plastic bottles, containers, and labeling supplies.

The Plant 12 Storage Warehouse was constructed in 2019. In June 2019, prior to the construction of the warehouse, Bio-Lab Conyers’ design-build contractor, ARCO Design/Build (ARCO),[a] prepared and submitted documentation to local authorities on behalf of Bio-Lab, Inc./KIK, stating that they anticipated storing an “average inventory” of approximately 6.2 million pounds of raw materials, including oxidizers, in the warehouse. At the time of the incident in September 2024, however, the warehouse contained nearly 14 million pounds of various formulations of TCCA, NaDCC, NaDCC dihydrate, and BCDMH combined, more than twice the amount initially indicated to local officials.

Inventory records indicate that at the time of the incident, approximately 5,000 “super sacks” containing between 2,205 to 2,805 pounds of chlorinated isocyanurates each were present inside the Plant 12 Storage Warehouse. There also were numerous other bags of BCDMH in the warehouse, each weighing approximately 200 pounds.

Components of the sprinkler system in the Plant 12 Storage Warehouse had been experiencing significant corrosion and leaking since shortly after Bio-Lab Conyers began storing chlorinated isocyanurates there in 2019. The warehouse was not air-conditioned, and its ventilation system was insufficient to effectively manage

[a] The permit drawings for the Plant 12 Bio-Lab Storage Warehouse list “Bio-Lab c/o Republic Property Company” as the Owner/Developer.

humidity (moisture) levels inside the building in light of the large quantities of oxidizer chemicals in the building.

Sprinkler inspection reports conducted in 2021 and 2022 identified hundreds of “deficiencies” each year due to corroded or rusty sprinkler system heads in an area of the warehouse called the “Powder Storage”, also referred to as “the bunker,” where most of the chlorinated isocyanurates were being stored at the time. In November 2022, following these observed deficiencies, Bio-Lab Conyers replaced the original brass-finish sprinkler heads inside the bunker with wax-coated corrosion-resistant sprinkler heads. The facility also upgraded the bolts and couplings in the bunker in 2023. Sprinkler heads outside the bunker were replaced in-kind with brass-finish heads, not wax-coated corrosion-resistant heads.

During 2023, Bio-Lab Conyers started storing chlorinated isocyanurates outside of the bunker (in addition to inside the bunker) as the company increased the volume of material in the warehouse. A subsequent inspection conducted in December 2023 did not identify any deficiencies in the bunker (which now had corrosion-resistant sprinklers), but a large number of deficiencies were found in the sprinkler system outside the bunker, which had brass-finish sprinkler heads. Overall, 1,124 sprinkler heads outside the bunker were visually observed to be corroded during the December 2023 Annual Sprinkler Inspection.

Although Bio-Lab Conyers had replaced the corrosion-prone brass-finish sprinkler heads in the bunker with the corrosion-resistant heads, it did not do so outside the bunker. Instead, Bio-Lab chose to replace corroded/leaking brass-finish sprinkler heads outside the bunker with similar brass-finish sprinkler heads, even though Bio-Lab Conyers had begun to store significant amounts of chlorinated isocyanurates outside the bunker. The corrosion damage to the sprinkler system components at the Plant 12 Storage Warehouse resulted in a high number of abnormal events recorded by the building’s fire protection alarm monitoring system. Between January 1, 2023, and September 29, 2024, the fire protection system registered abnormal status in at least 60 of the 637 calendar days, or 9.6 percent. At the time of the incident in September 2024, most of the sprinkler heads outside the bunker were still brass-finish heads.

The first off-gassing and initial fire during the incident occurred in an area just outside the bunker where chlorinated isocyanurates were being stored. A large number of super sacks containing chlorinated isocyanurates in the warehouse were double-stacked in multiple rows against the wall outside the bunker (in addition to elsewhere throughout the warehouse). Because of this multiple-row, double-stack storage configuration, neither KIK employees[a] (nor emergency responders later) were able to gain access to the super sacks where the first off-gassing occurred, which were situated behind multiple other super sacks. A KIK emergency responder was able to move four super sacks located in front of the off-gassing area, but while the employee was attempting to move additional sacks to gain access to and remove the off-gassing sacks, the vapor cloud intensified and visibility deteriorated, forcing the employee to leave the building. Because the off-gassing super sacks could not be removed, the initial fire started.

Before the Conyers incident in September 2024, KIK did not effectively institutionalize lessons learned from prior incidents, observations, and sprinkler system component failures to prevent similar failures across its organization. Although these events highlighted vulnerabilities related to corrosion, KIK did not provide

[a] At the time of the incident, all employees at the Bio-Lab Conyers facility were employees of KIK International LLC, which uses the trade name “KIK Consumer Products”.

adequate organizational oversight to ensure that corrective actions were systematically evaluated at Bio-Lab Conyers and implemented across all locations with similar conditions. As a result, safeguards to prevent or mitigate the corrosion of sprinkler system components were not consistently applied across the organization. This lack of organizational learning and the failure to integrate knowledge gained from past experiences into company-wide practices likely allowed known deficiencies to persist, increasing the risk of recurring incidents involving similar failure mechanisms.

The Rockdale County Fire Rescue responded to the incident, along with 14 additional mutual aid units from neighboring counties and cities. Although the first building fire was extinguished at approximately 8:10 a.m., the elevated temperatures inside the building from additional decomposing super sacks of materials continued to affect other areas of the warehouse. The heat emitted by the decomposing oxidizers also activated the sprinklers in other areas (zones) of the warehouse. The water from the sprinklers, in turn, caused decomposition of materials in these other areas, generating even more heat. The volume of decomposing material stored outside the bunker, both in racks and on the floor, continued generating sufficient heat to ignite combustible materials (wooden pallets and packing materials) throughout the warehouse, resulting in a second fire that ignited at approximately 12:00 p.m. Portions of the warehouse roof and several walls started collapsing at approximately 12:40 p.m. Although the fire was extinguished around 4:00 p.m., the remaining roof and wall sections collapsed that evening by 8:00 p.m.

The emergency response phase lasted 17 days, during which nightly shelter-in-place warnings for a 12-hour period from 7:00 p.m. to 7:00 a.m. were issued to residents and the surrounding community within a 2-mile radius. There also were school closures for nearly two weeks.

Ultimately, the warehouse was destroyed. No injuries were reported during the incident or in the subsequent emergency response. The estimated property damage was $50.5 million. As a result of the incident, on May 15, 2025, after completing remediation of the facility, KIK decided to cease operations at the Bio-Lab Conyers facility and subsequently listed the property for sale on January 27, 2026. As of June 2026, the property was still available for sale. Operations previously conducted at the Conyers facility have been moved to Bio-Lab's facility in Ontario, California, and third-party manufacturing facilities and warehouses.

SAFETY ISSUES

The CSB's investigation identified the safety issues below.

- **Run To Failure.** Most incidents are preceded by warning signs related to asset integrity. The Bio-Lab Conyers facility did not proactively maintain its corroding sprinkler system in the warehouse. Instead, the facility replaced or repaired corroded sprinkler heads and piping after they had failed and begun to leak. The leaking water posed a risk of coming into contact with the chlorinated isocyanurate materials stored in the Plant 12 Storage Warehouse. The company upgraded some, but not all, of the sprinkler system components in the warehouse from brass-finished sprinkler heads to wax-coated corrosion-resistant sprinkler heads in late 2022; however, corroded sprinkler heads were documented in the 2021 and 2022 Annual Sprinkler Inspections. In 2023, other sprinkler heads were replaced in kind with brass-finish heads. A subsequent inspection in December 2023 identified multiple deficiencies in areas of the warehouse where the sprinkler heads had not been upgraded to corrosion-resistant and remained brass-finished. At the time of the September 2024 incident, these bass-finished sprinkler heads had not been upgraded and were replaced as necessary. Had Bio-Lab Conyers taken steps to proactively prevent sprinkler system leaks instead of allowing the system to run to failure, the incident likely would not have occurred. (Section 4.1)

- **Identification of Storage Hazards.** Failure to identify hazards in chemical manufacturing facilities can result in fatalities, injuries, operational incidents, significant property damage, and negative environmental impacts. Early hazard identification enables a structured evaluation of potential safeguards to prevent accidental releases, fires, or other serious incidents. The Bio-Lab Conyers facility did not identify the hazards associated with storing chlorinated isocyanurates with multiple hazardous characteristics and other oxidizers, including the consideration of environmental conditions inside the building, inventory quantities, and storage configuration. Therefore, the Bio-Lab Conyers Plant 12 Storage Warehouse was not compliant with the NFPA standards, including NFPA 400 *Hazardous Materials Code* (NFPA 400) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (NFPA 13). The large quantities and storage configuration of pool-treatment chemicals stored in the Plant 12 Storage Warehouse on September 29, 2024, also did not allow proper access to the materials at all times and hindered the emergency response to the reacting material that morning. These deficiencies contributed to the incident that occurred in the Bio-Lab Conyers Plant 12 Storage Warehouse. (Section 4.2)

- **Risk Management and Oversight.** KIK had an obligation as an organization to thoroughly understand the hazards and risks associated with the stored chlorinated isocyanurates and to effectively assess and manage the risks inherent in Bio-Lab's storage and handling of these materials to prevent incidents. Despite having the potential to learn lessons from two other incidents involving Bio-Lab within five years of the Conyers 2024 incident, KIK failed to acknowledge and address the risks inherent in storing large quantities of chlorinated isocyanurates, failed to ensure that lessons learned from previous events were incorporated across KIK's organization, and missed opportunities to either prevent future incidents involving chlorinated isocyanurate decomposition reactions or minimize the extent of its impacts to the surrounding communities. Additionally, KIK was aware of the water-reactive and corrosive characteristics of the materials it handled and stored but did not require its Bio-Lab facilities to address corrosion at the time of its observation or to adopt a proactive approach to consistently manage corrosion across its facilities. Furthermore, KIK did not fully implement or enforce its corporate guidance, such as its "Process Safety Management (PSM) Lite" procedure, the requirement to conduct hazard analyses, and the investigation of fire protection system impairments across the company, to promote the safe handling and storage of chlorinated isocyanurate materials. (Section 4.3)

- **NFPA Guidance for Pool-Treatment Chemicals.** Clear and comprehensive guidance is essential when storing materials with multiple hazardous properties, especially pool-treatment chemicals such as TCCA, NaDCC, and BCDMH, which are known to be corrosive and water-reactive under certain conditions. It is vital to assess and consider all hazard categories when designing warehouses and fire protection sprinkler systems for these materials. NFPA 400 and NFPA 13 are among the NFPA standards that applied to the design and construction of the Plant 12 Storage Warehouse in 2019. While NFPA 13 acknowledges that chlorinated chemicals can corrode sprinkler components, it does not specifically associate this hazard with pool-treatment chemical storage or establish related design requirements. NFPA 400 primarily focuses on TCCA, NaDCC, and BCDMH as typical oxidizers but does not mention their corrosive and water-reactive characteristics, which are well documented in safety data sheets and prior incidents. The corrosive environment created by pool-treatment chemicals like TCCA can lead to the failure of fire sprinkler system components, as seen at Bio-Lab Conyers and ultimately the fire on September 29, 2024. (Section 4.4)

- **PSM and RMP Coverage of Reactive Hazards.** TCCA, TCCA-based formulations, NaDCC, and NaDCC dihydrate are chlorinated isocyanurate compounds that can undergo a decomposition reaction when heated or exposed to water/moisture. These reactions may release toxic vapors and lead to fires with severe impacts on people, property, and the environment. Yet, these and many other such reactive chemicals are not regulated under the Occupational Safety and Health Administration's (OSHA's) Process Safety Management (PSM) Standard or the U.S. Environmental Protection Agency's (EPA's) Risk Management Program (RMP) Rule. Had TCCA, NaDCC, and NaDCC dihydrate been covered under PSM or RMP, Bio-Lab Conyers and KIK would have been required to implement safeguards that may have prevented -- or mitigated the severity of -- this incident. (Section 4.5)

Cause

The CSB determined that the cause of the incident was a corroded sprinkler system component that failed, allowing water to contact the stored pool-treatment chemicals (chlorinated isocyanurates) inside the warehouse, initiating a decomposition reaction and generating significant amounts of dense toxic smoke and heat that started fires, ultimately leading to the building's destruction and closure of the site. The corrosion resulted from the corrosive environment created by stored chlorine-based chemicals in the building, an issue that was not proactively addressed.

The discrepancy between the design of the warehouse and the hazardous categories and large volumes of the materials stored inside, the lack of corporate implementation of risk mitigation strategies across all facilities, including the Conyers site, and gaps in NFPA guidance regarding the storage and handling of pool-treatment chemicals with multiple hazardous characteristics all contributed to this incident. Also contributing to the incident was the insufficient regulatory coverage of reactive hazards.

Contributing to the severity of the incident were inadequate storage configurations for the large quantities of hazardous material in the warehouse that hindered emergency response access to the initial reacting material early that morning, which led to the activation of additional sprinklers, wetting more materials, which resulted in further decomposition reactions, increased heat generation throughout the warehouse, and fires within the building.

RECOMMENDATIONS[a]

<u>Previously Issued Recommendations Reiterated in This Report</u>

To Occupational Safety and Health Administration (OSHA)

2021-02-I-WV-R13 (from the 2020 CSB Optima Belle Investigation)

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 hazardous 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 but are not limited to:
    - Literature surveys (e.g., Bretherick's Handbook of Reactive Chemical Hazards, Sax's Dangerous Properties of Industrial Materials, CAS SciFinder).
    - Information developed from computerized tools (e.g., ASTM's CHETAH, CCPS's Chemical Reactivity Worksheet).
    - Chemical property data compiled in PubChem and the REACH (Registration, Evaluation, and Authorization of Chemicals) dossiers maintained by the European Chemicals Agency (ECHA).
    - Chemical reactivity test data produced by employers or obtained from other sources following established standards, such as:
        - ASTM E537-20, Standard Test Method for Chemicals by Differential Scanning Calorimetry;
        - ASTM E1981-22, Standard Guide for Assessing Thermal Stability of Materials by Methods of Accelerating Rate Calorimetry;
        - ASTM E2550-21, Standard Test Method for Thermal Stability by Thermogravity; and
        - ASTM E1231-19, Standard Practice for Calculation of Hazard Potential Figures of Merit for Thermally Unstable Materials.

[a] The CSB is not issuing any recommendations specifically to Bio-Lab Conyers because KIK has ceased operations at the facility. Additionally, the CSB is not issuing any recommendations to the State of Georgia or Rockdale County. However, the CSB urges both the State of Georgia and Rockdale County to establish a new process or to maintain an existing one that routinely reviews and updates its minimum fire safety standards and requirements to ensure that they remain aligned with future editions of relevant National Fire Protection Association (NFPA) standards, such as NFPA 400, and incorporate applicable regulatory requirements as they become effective.

- Relevant incident data from the plant, the corporation, industry, and government.

- 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 a runaway reaction from decomposition.
  - Time to Maximum Rate under Adiabatic Conditions (TMR_{ad}).
  - 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 KIK Consumer Products

2024-04-I-GA-R1

Develop and implement a corporate standard for the storage (including storage configuration) and handling of bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements), and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

2024-04-I-GA-R2

Develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that manufacture and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements). The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that manufacture and/or store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standards.

2024-04-I-GA-R3

Contract a third party to audit the implementation of the *PSM Lite* program within KIK's Pool Division, including all facilities that handle and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH. Address all identified deficiencies resulting from the audit within a specified timeframe.

2024-04-I-GA-R4

Contract a third party to audit the implementation of the corporate standards developed in recommendations 2024-04-I-GA-R1 and 2024-04-I-GA-R2 at KIK Consumer Products / Bio-Lab, Inc. Pool Division facilities and third-party facilities that manufacture and/or store bulk pool-treatment chemicals. Address all identified deficiencies resulting from the audit within a specified timeframe.

To National Fire Protection Association

2024-04-I-GA-R5

Revise NFPA 400 *Hazardous Materials Code*, Section 4.1 *Hazardous Material Classification*, or a more appropriate section, to clarify that materials are required to be assessed and a determination reached for each of the categories of hazardous materials (1) through (14).

2024-04-I-GA-R6

Revise NFPA 400 *Hazardous Materials Code*, Section G.4 *Safety Information on Oxidizers Used in Swimming Pools*, to address the potential for pool-treatment chemicals to demonstrate characteristics of hazard classifications other than those of oxidizers, and that each additional hazard classification must conform to the code requirements for each applicable hazardous material classification in accordance with Section 4.4 *Multiple Hazards*.

2024-04-I-GA-R7

Revise NFPA 400 *Hazardous Materials Code*, Section G.4 *Safety Information on Oxidizers Used in Swimming Pools*, to include information regarding the potential for oxidizers to corrode metals such as sprinkler components and reference NFPA 13 *Standard for the Installation of Sprinklers*.

1 BACKGROUND

1.1 BIO-LAB, INC.

The Bio-Lab, Inc. facility involved in the September 29, 2024, incident is located in Conyers, Georgia, an incorporated city within Rockdale County, approximately 24 miles from Atlanta. The Conyers facility received, blended, and packaged chlorinated isocyanurates[a] and other raw materials to produce finished consumer products for swimming pool and spa treatment chemicals. The Conyers facility has changed ownership several times since it opened in 1973. In 2013, KIK Custom Products, Inc. d/b/a KIK Consumer Products ("KIK") acquired Bio-Lab, Inc., which included the Bio-Lab Conyers manufacturing facility ("Bio-Lab Conyers").[b] At the time of the incident, Bio-Lab. Inc. was a subsidiary of KIK. **Figure 1** depicts KIK's organizational structure.

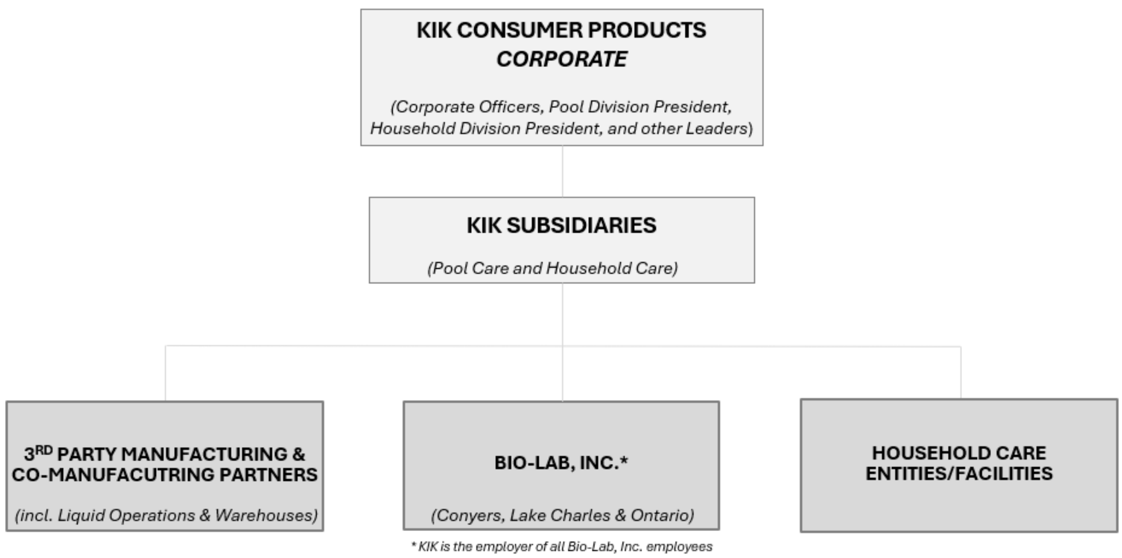


Figure 1. KIK's organizational structure. (Credit: CSB)

Bio-Lab Conyers had approximately 241 full-time KIK employees assigned to the facility at the time of the incident on September 29, 2024.[c] Following the incident, the Conyers facility ceased all operations.[d] The site contained several buildings, as shown in **Figure 2**, used for various operations and for the storage of swimming pool and spa treatment chemicals. Bio-Lab Conyers typically operated on a one-shift schedule, with fire watch personnel working during nights and weekends,[e] except in the "busy season".[f] A warehouse, referred to as the

[a] *See* **Section 1.2.1** for additional information on chlorinated isocyanurates.

[b] KIK Consumer Products, Inc. acquired Bio-Lab, Inc. in 2013.

[c] KIK International LLC, which uses the trade name "KIK Consumer Products," is the employer of all US-based employees, including those at Bio-Lab facilities such as Bio-Lab Conyers.

[d] The Conyers facility was listed for sale on January 27, 2026. Operations previously conducted at the facility have been moved to Bio-Lab's facility in Ontario, California, and third-party manufacturing facilities and warehouses.

[e] Bio-Lab Conyers had a 24-hour weekend fire watch split into two 12-hour shifts.

[f] During the busy season, a second (night) shift was added to run specific products. *See* **Section 2.1** for more details on the fire watch shift during Hurricane Helene.

Plant 12 Storage Warehouse, was involved in the incident on September 29, 2024. In addition to the swimming pool and spa treatment chemicals, the warehouse also stored combustible materials, including corrugated cardboard, plastic bottles, containers, and labeling supplies.

Figure 2. Overhead view of Bio-Lab Conyers with property line outlined in blue and red denoting the building involved in the incident. (Credit: KIK, annotated by CSB)

1.2 KEY CHEMICALS INVOLVED

The Plant 12 Storage Warehouse primarily stored oxidizers, as classified by the National Fire Protection Association (NFPA), as well as smaller quantities of other chemicals and combustible materials, including packaging supplies. The inventory in the warehouse included approximately 14 million pounds (lbs.) of chlorinated isocyanurates and Bromochlorodimethylhydantoin (BCDMH),[a] which were involved in the September 2024 incident.[b] Bio-Lab Conyers considered these products to be raw materials, and many were contained in very large bulk bags or flexible intermediate bulk containers (FIBCs), known as "super sacks." As discussed in **Section 1.3.4**, the super sacks used in the Plant 12 Storage Warehouse consisted of a woven polypropylene outer bag and an internal polyethylene liner (plastic insert) that was closed at the top with a sewn drawcord. Most of these super sacks contained approximately 2,200 to 2,800 lbs. of oxidizers.

Several published standards and codes,[c] including NFPA 400 define the classifications of hazardous materials, such as oxidizers. NFPA 400 defines an oxidizer as:

> Any solid or liquid material that readily yields oxygen or other oxidizing gas, or that readily reacts to promote or initiate combustion of combustible materials,

[a] Although many of the key raw materials stored in the Plant 12 Storage Warehouse are classified as chlorinated isocyanurates, the BCDMH is classified as halogenated hydantoin. BCDMH is also known as bromochloro-5,5-dimethylimidazolidine-2,4-dione.

[b] Out of the approximately 14 million lbs. of inventory, over 13 million lbs. were chlorinated isocyanurates, including trichloroisocyanuric acid and sodium dichloroisocyanurate (anhydrous and dihydrate).

[c] These standards and codes also include the International Code Council's (ICC's) International Fire Code, OSHA's Hazard Communication Standard, and the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

> and that can, under some circumstances, undergo a vigorous self-sustained decomposition due to contamination or heat exposure [2, pp. 400-18].

NFPA 400 also groups oxidizers into four classes.[a] **Table 1** lists the definitions for Class 1, Class 2, Class 3, and Class 4 NFPA oxidizers.

Table 1. Definitions for each NFPA-classified oxidizer [2, pp. 400-18].

NFPA Oxidizer Class	Description
1	"An oxidizer that does not moderately increase the burning rate of combustible materials." This is the lowest level of oxidizers.
2	"An oxidizer that causes a moderate increase in the burning rate of combustible materials."
3	"An oxidizer that causes a severe increase in the burning rate of combustible materials."
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." This is the highest level of oxidizers.

1.2.1 Chlorinated Isocyanurates

Chlorinated isocyanurates are chlorine-based dry solid disinfectants available in tablet or granular form. These compounds are commonly used as sanitizers for swimming pools, spas, and industrial water applications. Their strong disinfection properties make them an important component in dishwashing detergents, bleaches, and cleaning products. Chlorinated isocyanurates are excellent sanitizers due to their available chlorine content [3, p. 2].[b] However, high chlorine content in these compounds can also make them hazardous to handle and store [3, p. 3]. In 2013, Arch Chemicals, Inc.,[c] a manufacturer of chlorinated isocyanurates and similar chemicals, created a guide "to provide good and accurate information" about the storage and handling of its products.[d] The guide provided recommendations, including temperature monitoring systems and climate-controlled storage, and outlined warnings such as:

> Pool and spa chemicals are stable when stored in a cool, dry, well-ventilated area and not contaminated by other materials, such as acids, bases, or easily oxidizable materials. They can become unstable and dangerous if mishandled,

[a] The definitions were the same in the 2022 Edition (effective April 8, 2021) when the incident occurred in September 2024.

[b] Available chlorine is "the amount of free chlorine that a substance (such as bleaching powder) yields when treated with an acid in the presence of a chloride" [153].

[c] Arch Chemicals, Inc., a Lonza Company, was the copyright owner of the Lonza "*Pool and Spa Chemicals Storage & Handling Guide*," first published in 2013. In 2011, Lonza acquired Arch Chemicals, Inc.

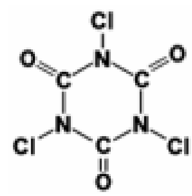
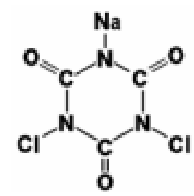
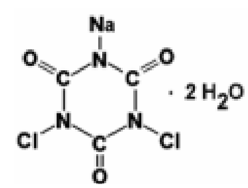
[d] Lonza/Arch Chemicals, Inc. created its "*Pool and Spa Chemicals Storage & Handling Guide*" as part of the company's "Product Stewardship."

improperly stored or contaminated. They can undergo a decomposition reaction, which could produce intense heat, hazardous gases, fire or explosion. [4][a]

Improper storage of pool and spa chemicals in volume or manner can result in a fire of great intensity, causing property damage, personal injury or death. [4]

Three primary chemical compositions of chlorinated isocyanurates -- trichloroisocyanuric acid (TCCA), anhydrous sodium dichloroisocyanurate (NaDCC), and NaDCC dihydrate [5, p. 6] -- as listed in **Table 2**, were stored in the Plant 12 Storage Warehouse. These compounds can be in various forms, such as powder, granular, tablet, and stick.

Table 2. Physical and chemical properties of three primary chlorinated isocyanurates [3, p. 2].

Name	TCCA	NaDCC	NaDCC dihydrate
Chemical Structure			
Chemical Nomenclature	trichloroisocyanuric acid	anhydrous sodium dichloroisocyanurate	sodium dichloroisocyanurate dihydrate
Formula	$Cl_3(NCO)_3$	$NaCl_2(NCO)_3$	$NaCl_2NCO_3{\cdot}2H_2O$
CAS Registry Number[b]	87-90-1	2893-78-9	51580-86-0
NFPA Oxidizer Class[c]	1	2	1
Available chlorine content (w/w)	~ 90%	~ 60%	~ 56%

Anhydrous denotes "a chemical compound lacking water: applied particularly to salts lacking their water of crystallization" [6, p. 37]. Dihydrate is defined as a "crystalline hydrate containing two moles of water per mole of compound" [6, p. 176]. In the Plant 12 Storage Warehouse, the NaDCC had moisture levels below 3 percent,[d] and the NaDCC dihydrate had moisture levels of 11 to 14 percent. Additionally, NaDCC and NaDCC dihydrate present different thermal hazards.

[a] These decomposition byproducts can include chlorine gas, nitrogen trichloride, nitrogen, cyanogen chloride, oxides of carbon, phosgene, and chloramines.

[b] A CAS Registry Number is a unique and unambiguous identifier for a specific substance that allows clear communication and, with the help of CAS scientists, links together all available data and research about that substance. Governmental agencies rely on CAS Registry Numbers for substance identification in regulatory applications because they are unique, easy easily validated, and internationally recognized.

[c] NFPA 400 (2025 Edition)

[d] KIK and Bio-Lab Conyers often referred to sodium dichloroisocyanurate as DCCA.

1.2.1.1 TCCA

TCCA is a chlorinating agent often used as a sanitizer for swimming pools and hot tubs.[a] It is classified as an NFPA Class 1 oxidizer [2, pp. 400-204] and under OSHA's Hazard Communication Standard, it is categorized as a corrosive, causing "skin corrosion/irritation." When TCCA is heated to its decomposition temperature, it undergoes an exothermic breakdown that liberates chlorine gas (Cl_2) as a primary decomposition product [7, p. 13 and 14].[b,c] Chlorine gas is a respiratory irritant and is toxic [8, p. 11, 9, p. 95]. Thermal decomposition of TCCA can lead to the release of toxic/corrosive gases and vapors (*see* **Section 1.2.3**). Wet material may generate nitrogen trichloride (NCl_3), an explosion hazard. Bio-Lab's safety data sheet (SDS) for TCCA warns not to mix it with other chemicals and to store it away from combustibles.

1.2.1.2 NaDCC

NaDCC is a white granular substance with a bleach-like or slight chlorine odor. It is classified as an NFPA Class 2 oxidizer [2, pp. 400-205]. NaDCC is corrosive to skin and eyes and when heated can decompose and emit toxic fumes, including chlorine, nitrogen oxides, and sodium oxide (*see* **Section 1.2.3**) [10, p. 13]. There is a risk of fire and explosion upon contact with water. Contamination with moisture may start a decomposition reaction (*see* **Section 1.2.3**), releasing Cl_2 and NCl_3 [10, p. 51]. According to Oxy's SDS for NaDCC, the containers should be closed and stored in a cool, dry space with adequate ventilation.

1.2.1.3 NaDCC dihydrate

NaDCC dihydrate is a white powder or granular solid with a chlorine odor. It is classified as an NFPA Class 1 oxidizer [2, pp. 400-204] and is known to be corrosive and an irritant, and can undergo a decomposition reaction that releases chlorine gas, NCl_3,[d] and other byproducts when heated to its decomposition temperature. Wet NaDCC dihydrate may also generate NCl_3. There is a risk of fire and explosion when NaDCC dihydrate comes into contact with small quantities of water [11, p. 17]. Additionally, the compound may intensify fire. When storing NaDCC dihydrate, it should be separated from incompatible materials [11, p. 19].

1.2.2 BCDMH

BCDMH is an organobromide compound [12, p. 2] with antimicrobial properties.[e] It is used in various water applications, including the treatment of drinking water and pools/spas, and is classified as an NFPA Class 2 oxidizer. BCDMH is added to water to disinfect it or control microbial growth on the surfaces of water distribution system components. The compound is white with a slight odor of bromine and acetone. When

---

[a] Bio-Lab, Inc. refers to its trichloroisocyanuric acid product, manufactured at Bio-Lab Lake Charles, as BLC-90. The safety data sheet for BLC-90 powder indicates that it has a composition of 99 percent by weight trichloroisocyanuric acid (CAS No. 87-90-1). The name BLC-90 indicates that the product contains 90 percent available chlorine.

[b] *see* **Section 1.2.3**. Trichloroisocyanuric acid is a synonym for symclosene [7]. The decomposition temperature of TCCA according to PubChem is greater than 225°C [7].

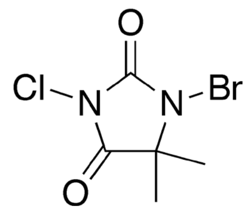
[c] Exothermic activity can occur at temperatures lower than the decomposition temperatures, especially when the TCCA is exposed to moisture, including high humidity, "a technique in which a substance is heated in stages until very slow decomposition [or other reaction] is detected" [148].

[d] Nitrogen trichloride (NCl_3) is explosive, and upon decomposition it emits toxic fumes [162, p. 11].

[e] "Organobromine chemicals are produced naturally by an array of biological and other chemical processes in our environment. Some of these compounds are identical to man-made organobromine compounds, such as methyl bromide, bromoform, and bromophenols, but many others are entirely new molecular entities, often possessing extraordinary and important biological properties" [130].

BCDMH is heated to decomposition, it emits toxic vapors of nitrogen oxides, hydrogen bromide, and hydrogen chloride. Some chemical and physical properties of BCDMH are listed in **Table 3**. Additionally, at high concentrations, BCDMH "may be corrosive to most metals at high concentrations" [12, p. 11]. When BCDMH is introduced to water, chlorine and bromine are released, forming hypochlorous and hypobromous acid, which are active antimicrobial agents.[a]

Table 3. Physical and chemical properties of BCDMH [12].

Chemical Molecule	
Chemical Nomenclature[b]	1-Bromo-3-chloro-5,5-dimethyl-2,4-imidazaolidinedione
Formula	$C_5H_6BrClN_2O_2$
CAS Registry Number[c]	16079-88-2
NFPA Oxidizer Class	2
Available Chlorine Content (w/w)[d]	~14.4%

1.2.3 Decomposition of Oxidizers

Exposure of oxidizers to heat or to small amounts of water or moisture can initiate a decomposition reaction that generates significant heat and releases toxic and corrosive vapors (i.e., hydrogen chloride (HCl), chlorine gas (Cl_2), and bromine (Br_2)) [13, p. 5, 10, p. 13, 14, p. 1]. Because chlorine-based oxidizers, including chlorinated isocyanurates, react readily with water (*see* **Section 3.2**), humidity in the air[e] can also cause them to react and release HCl vapor, which can "cause corrosive injury to all exposed body tissues" and is "corrosive to metals" [15, p. 4, 16, pp. 1-2]. HCl can also irritate the eyes and respiratory system [16]. Test data generated in 2025 by a third party for the CSB (*see* **Appendix E**) show that oxidizers undergoing decomposition can reach high temperatures and generate significant heat.[f] **Section 3.3** further details the

[a] Hypochlorous acid is "a weak, unstable acid, it is an active form of chlorine in water…a member of reactive oxygen species and a chlorine oxoacid…. Found only in aqueous solution" [143].

[b] BCDMH chemical structure [163]

[c] A CAS Registry Number is a unique and unambiguous identifier for a specific substance that allows clear communication and, with the help of CAS scientists, links together all available data and research about that substance. Governmental agencies rely on CAS Registry Numbers for substance identification in regulatory applications because they are unique, easily validated, and internationally recognized [154].

[d] https://envirotech.com/wp-content/uploads/2020/03/BCDMH-Tech-Booklet.pdf

[e] Relative humidity is "the amount of water vapor present in the air, expressed as a percentage of the amount needed for saturation at the same temperature" [164, p. 1].

[f] In 2025, the CSB contracted a third party to conduct analytical tests to better characterize the behavior of oxidizers stored in the Bio-Lab Plant 12 Storage Warehouse (*see* **Section 3.2**).

sequence of events that followed the onset of oxidizer decomposition at the Plant 12 Storage Warehouse during the September 2024 incident.

1.3 Plant 12 Storage Warehouse

The Georgia State Office of the Commissioner of Insurance and Safety Fire[a] provided the U.S. Chemical Safety and Hazard Investigation Board (CSB) with the *Rules and Regulations of the State of Georgia*,[b] specifically Chapter 120-3-3, *State Minimum Fire Safety Standard*,[c] that were in effect in 2019 when the Plant 12 Storage Warehouse was constructed.[d] These rules and regulations include the adopted codes and standards applicable to buildings constructed at that time, which included, but were not limited to:

- NFPA 400, 2013 Edition;
- International Building Code;[e]
- International Fire Code, 2012 Edition; and
- NFPA13, 2013 Edition.

1.3.1 Design and Construction

The Plant 12 Storage Warehouse was designed for Bio-Lab Conyers by a design-build contractor, ARCO Design/Build (ARCO), and constructed in 2019 as a single-story, Type IIB non-combustible building.[f,g] The warehouse roof system installed during the original building construction consisted of a white 0.045-inch thermoplastic polyolefin (TPO) membrane[h] and two 2.2-inch polyisocyanurate (ISO) insulation layers mechanically attached to a steel roof deck, as is common for industrial building construction. Type IIB construction type is not required to include any fire resistance ratings for the primary and secondary structural elements [17]; therefore, the columns, joints, and other structural steel are usually uncovered and unprotected from fire. The Plant 12 Storage Warehouse (**Figure 3**) was 42 feet tall and covered 275,125 square feet, nearly

---

[a] The official website of the State of Georgia includes the terms "Office of Commissioner of Insurance and Safety Fire" and the "Office of Insurance and Safety Fire Commissioner".

[b] The Georgia State Safety Fire Commissioner's *Rules and Regulations for the State Minimum Fire Safety Standards* is "promulgated to establish the State's minimum fire safety standards…" [141].

[c] The CSB is not issuing any recommendations to the State of Georgia or Rockdale County. However, the CSB urges both the State of Georgia and Rockdale County to establish a new process or to maintain an existing one that routinely reviews and updates its minimum fire safety standards and requirements to ensure they remain aligned with future editions of relevant NFPA standards, such as NFPA 400, and incorporate applicable regulatory requirements as they become effective.

[d] The Official Code of Georgia Annotated Title 25, Section 25-2-13 includes the state's minimum fire safety requirements.

[e] The IBC edition is not listed in the Georgia rules and regulations provided to the CSB, which were effective in 2019.

[f] The ICC's International Building Code (IBC) defines five construction types. Types I and II construction are types of construction in which the building elements specified are of noncombustible materials, except as permitted under certain specified conditions [17].

[g] Chapter 6 from the 2024 ICC's IBC classifies Type II buildings into A or B sub-categories, depending on the extent to which the building's elements, such as the roof, building frame, wall, and floor, can resist fire [17, p. Chapter 6]. For a Type IIA building, one-hour fire-resistance ratings are required for primary structural elements. For a Type IIB building, zero-hour fire-resistance ratings are required for primary structural elements, meaning that they are not required to provide any fire-containment duration under standard fire tests.

[h] The TPO membrane is "a single-ply sheet made from polypropylene and ethylene-propylene rubber reinforced with polyester" that "comes in thicknesses from 45-mil to 80-mil" [144]. Single-ply roofing is common on low-slope commercial buildings [145].

equal to the total square footage of five football fields combined.[a] Additionally, the warehouse floor plan (**Figure 4**) included several support areas, including offices, a break area, and the firewater pump room. **Figure 3** shows the Plant 12 Storage Warehouse in 2019.[b]

Figure 3. The Bio-Lab Conyers Plant 12 Storage Warehouse. (Credit: ARCO, annotated by CSB)

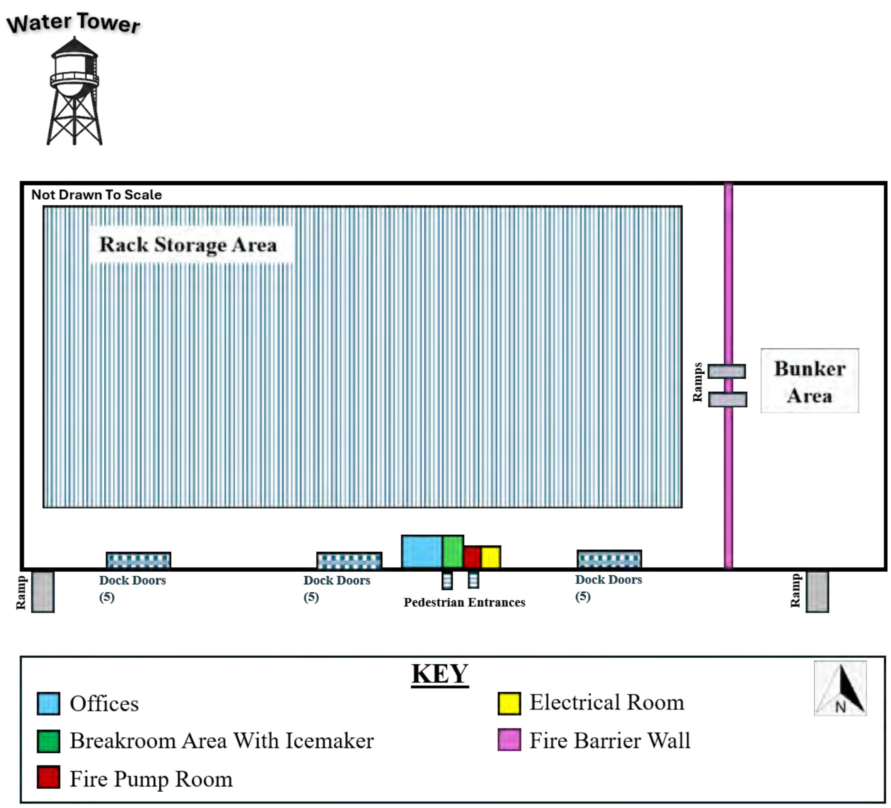


Figure 4. The Bio-Lab Conyers Plant 12 Storage Warehouse floor plan. (Credit: CSB)

[a] The standard size of a football field is 57,600 square feet [167]. Five football fields equal 288,000 square feet. The warehouse building area was 275,125 square feet.

[b] ARCO's website: https://arcodb.com/projects/biolab-warehouse-conyers-ga/

1.3.2 BUILDING OCCUPANCY CLASSIFICATION

The building occupancy classification is a formal designation by the International Building Code (IBC) that categorizes a structure based on its primary purpose [17].[a] In June 2019, prior to the construction of the Plant 12 Storage Warehouse, Bio-Lab Conyers' design-build contractor, ARCO, submitted commercial building permit application documents to Rockdale County on behalf of Bio-Lab, Inc./KIK,[b] which included a list of materials intended to be stored in the warehouse. The documents did not discuss the corrosiveness of the materials to be stored there (*see* **Section 4.2**).[c] Moreover, the presence of BCDMH, a Class 2 oxidizer, was not included in the permit documentation provided by Bio-Lab, Inc./KIK.

Rockdale County approved the Plant 12 Storage Warehouse's occupancy classification as a storage building Group S (S-1), moderate hazard storage, consistent with the storage of Class 1 oxidizers.[d]

1.3.3 FIRE PROTECTION SYSTEM

A fire protection system is defined as "any fire alarm device or system or fire-extinguishing device or system, or combination thereof, that is designed and installed for detecting, controlling, or extinguishing a fire or otherwise alerting occupants, or the fire department, or both, that a fire has occurred" [2, pp. 400-14]. These systems may operate automatically or manually and include components such as sprinklers, alarms, suppression systems, and fire-resistive construction (i.e., fire resistance-rated walls). While all of these components are not always required, many often are used together for the fire protection strategy of a building.

The design of a sprinkler system is influenced by several factors, including the building's height, the hazard classification of the materials being stored, the planned quantities of hazardous materials, and the anticipated commodity classification. Additionally, the sprinkler system design should consider the storage configuration and storage height for non-hazardous commodities. The *Fire Code* (NFPA 1) also requires an automatic sprinkler system throughout all occupancies containing areas greater than 2,500 square feet for a high-piled storage of combustibles and greater than 12,000 square feet for the general storage of combustibles [18, pp. 1-115].[e] As stated in **Section 1.3.1**, the Plant 12 Storage Warehouse area was 275,125 square feet.

The "wet pipe" system is the most common type of sprinkler system due to its reliability and cost-effectiveness. In a wet pipe system, the sprinkler piping is filled and pressurized with water, and when the temperature at the ceiling surpasses the sprinkler's temperature threshold, the glass bulb or fusible link in a sprinkler breaks and releases the water. A common example of a wet pipe system is the Early Suppression Fast Response (ESFR) sprinkler system, widely used in storage occupancies for its rapid, high-volume fire suppression capabilities [19, p. 1 and 3, 20, p. 4]. ESFR sprinklers are designed for full suppression rather than

[a] Building Occupancy is the overall hazard level of a protected space.

[b] The permit drawings for the Plant 12 Bio-Lab Storage Warehouse list "Bio-Lab c/o Republic Property Company" as the Owner/Developer.

[c] Although BCDMH was not included on the permit documentation, in December 2019, a third-party fire and risk consultant determined that "In order to store these [BCDMH] Class 2 Oxidizers in excess of the permitted Maximum Allowable Quantity of 500 pounds, storage is required in a separate (cut-off) area classified as a Group H-3 Occupancy."

[d] S-1 storage allows for the storage of combustible materials [128]. This can facilitate the development and spread of fire at a moderate rate [133]. The S-1 occupancy classification aligns with the building's Commercial Certificate of Occupancy and building drawings.

[e] NFPA 13 identifies several types of automatic sprinkler systems, including wet pipe, dry pipe, preaction, deluge, and combined dry pipe and preaction [21, pp. 13-56].

mere control, delivering sufficient water directly onto the burning fuel during the early stages of a fire and penetrating the developing plume to achieve suppression. These sprinklers are known for their ability to suppress “specific high-challenge fire hazards” [20, p. 4].[a] NFPA 13 specifies an “ordinary or intermediate” temperature rating for ESFR sprinklers [21, pp. 13-122], which range from 135°F and 200°F (57°C and 93°C) [21, pp. 13-51].[b]

Sprinkler System Design

The Plant 12 Storage Warehouse was equipped with an automatic ESFR wet pipe sprinkler system with brass-finish sprinkler heads (**Figure 5D**),[c,d] during the construction of the building in 2019.[e] The system was designed to operate using the municipal water supply at a minimum water pressure of 52 pounds per square inch gauge (psig),[f] and included an additional electric booster fire pump (**Figure 5E**).[g]

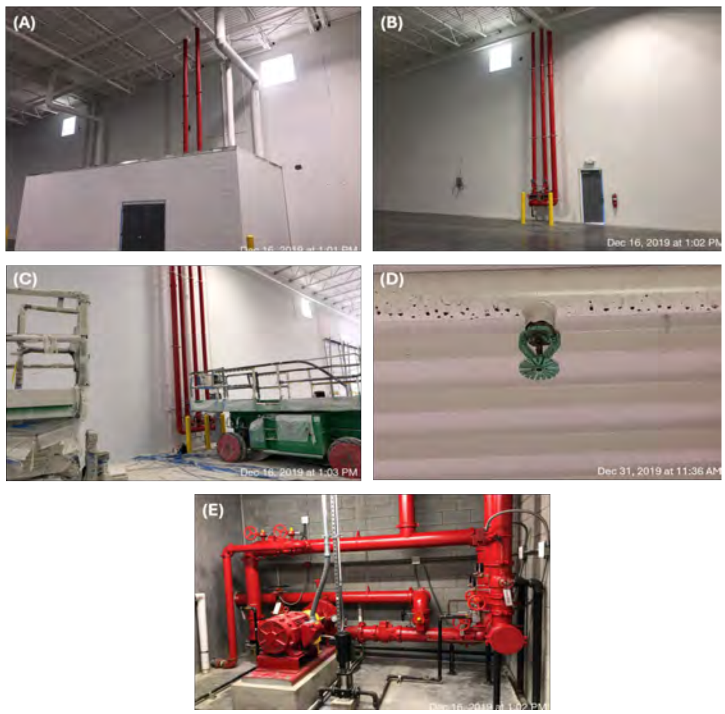


Figure 5. ESFR sprinkler system installed in the Plant 12 Storage Warehouse, including (A-C) piping in different locations, (D) a corroded brass-sprinkler head, and (E) the fire pump. (Credit: ARCO, annotated by CSB)

[a] These sprinklers have a response time index (RTI) of “50 (meters-seconds)$^{1/2}$ or less” [20, p. 4].

[b] The ordinary or intermediate temperature rating ranges from 135°F to 225°F (57°C to 107°C) for fusible links.

[c] The ESFR sprinkler system in the Plant 12 Storage Warehouse was K-16.8 (K-factor) per NFPA specifications. A K-factor of 16.8 is a measure of the sprinkler’s discharge coefficient (how much water it can flow at a given pressure).

[d] 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” [129, p. 128]. They are “predominately used to protect storage occupancies” [21] and also have been “high-piled inventory or palletized inventory” [131].

[e] A third-party fire and risk consultant, Haines Fire & Risk Consulting, hired by Bio-Lab Conyers’ design-built contractor (ARCO), determined that the provided automatic sprinkler protection was “adequate for the protection of the solid-piled storage of [super-sacks of] Class 1 Oxidizers in accordance with Section 6304.1.4 of the International Fire Code (2012 Edition).”

[f] Bio-Lab management was involved in the specification of the Plant 12 Storage Warehouse fire system.

[g] The electric fire pump was designed for 1,500 gallons per minute at 65 psi, which enhanced the pressure and increased water flow of the municipal water supply to the fire protection sprinkler system.

The warehouse also included a 2-hour rated fire barrier wall (**Figure 6A**) and two 90-minute automatic fire shutters[a] (**Figure 6B**) to prevent the spread of fire and to divide the warehouse into two distinct storage areas. Employees at Bio-Lab Conyers referred to the area behind the fire barrier wall as the "bunker." The fire barrier wall separated the bunker area from the rest of the warehouse's storage area. The entire warehouse was divided into seven sprinkler system zones (**Figure 6**).

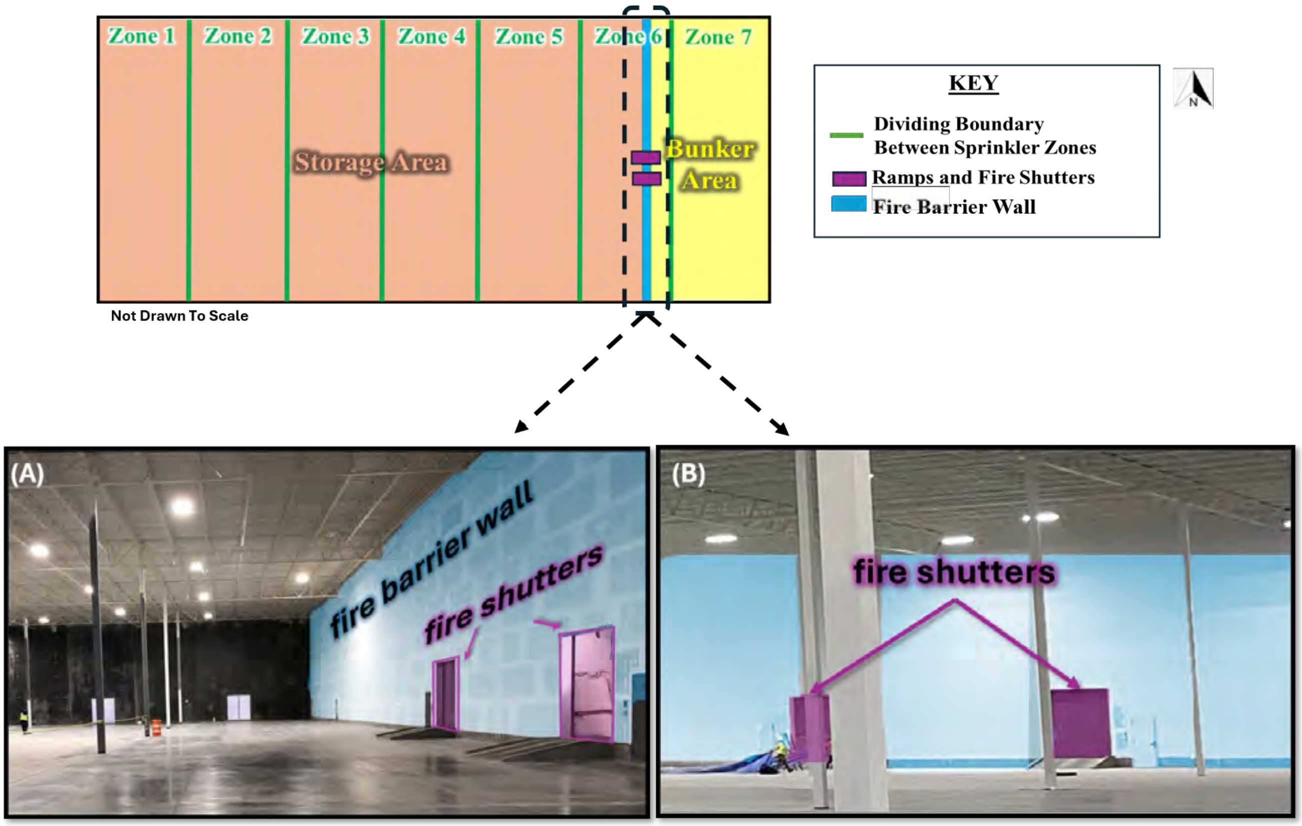


Figure 6. Plant 12 Storage Warehouse floor plan showing different views of the fire barrier wall location and fire shutters. (A) Northwest view of the warehouse showing the fire barrier wall (2-hour rated) and 90-minute fire shutters, and (B) Front view of the fire barrier wall and fire shutters. (Credit: ARCO, annotated by CSB)

Ramps were installed at both entrances to the bunker, with fire shutters to allow forklifts to transport super sacks inside and outside the bunker. On the day of the incident, the fire shutters in the bunker were open.

Single-Ignition-Point Fire Versus Multi-Ignition-Point Fire

Sprinkler systems are generally designed to protect only against a single fire origin within a building [21, pp. 13-16]. Each heat-sensitive sprinkler head operates independently and activates only when the temperature at that specific head reaches its rated threshold (typically 135°F – 175°F) [22, pp. 13-367, 23]. This localized activation allows water to be discharged directly over the fire area while preventing unnecessary water damage in unaffected parts of the building. When a fire involves multiple ignition points, however, several sprinkler

[a] "Fire shutters are used as structural barriers to compartmentalize and prevent the spread of fire" [137].

heads may activate simultaneously. The sudden increase in water demand can reduce the system water pressure, which in turn diminishes overall suppression effectiveness [21, pp. 13-367].

1.3.4 SUPER SACKS

An FIBC, commonly referred to as a super sack, is an intermediate bulk container constructed from flexible woven material, typically polypropylene [24, p. 1]. Super sacks are commonly used in the food, pharmaceutical, agricultural, and chemical industries to store "dry flowable products such as, but not limited to, grains, seeds, salts, powdered coatings, sands, clays, cement, ferroalloys," resins, and oxidizers [25]. They are designed for the "shipment of solid materials in powder, flake, or granular form" [26, pp. 448-449] and may be used to store hazardous materials when specifically approved for the intended product. The super sack and its contents must be compatible and fully comply with all the requirements in the applicable regulatory code.[a]

FIBCs (super sacks) generally hold between 1,000 and 4,000 pounds (500 and 2,000 kilograms) of product. The super sacks used to store chlorinated isocyanurates in Plant 12 Storage Warehouse contained approximately 2,200 to 2,800 pounds of these materials, as shown in **Figure 7**.

Figure 7. Photo of super sacks used in Plant 12 Storage Warehouse. (Credit: ARCO)

Super sack liners serve as an internal barrier that protects the product from moisture, oxygen, and contamination, and are commonly manufactured from polyethylene variants such as low-density polyethylene,

[a] Regulatory codes might include: the United Nations Recommendations on the Transport of Dangerous Goods, the U.S. Department of Transportation's Title 49 Code of Federal Regulations, the Canadian General Standards Board, among others, depending on shipping origination and destination.

linear low-density polyethylene, or high-density polyethylene [27]. **Figure 8** shows a photo of a commercially available super sack with a liner for visual purposes only.

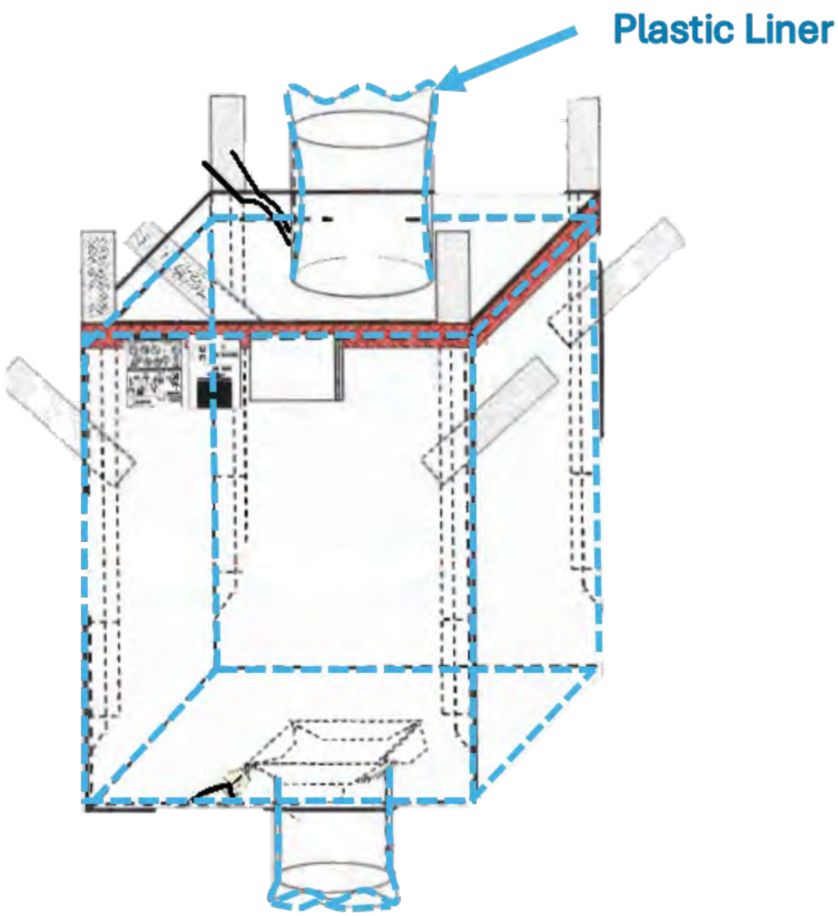


Figure 8. Diagram showing plastic liner (dashed lines in blue) inside the super sacks used in the Plant 12 Storage Warehouse. (Credit: Bio-Lab, annotated by the CSB)

The super sacks used in the Plant 12 Storage Warehouse, as shown in **Figure 7**, consisted of a woven polypropylene outer bag and an internal polyethylene liner (plastic insert) with a "ribbon tie" to close the top.[a] The woven polypropylene fabric did not include any interior or exterior polypropylene coating to reduce moisture transmission. As a result, the outer bag itself was not waterproof. Woven polypropylene is a permeable, tape-yarn fabric that allows measurable water flow through its inter-yarn pores. Consequently, the moisture protection of each super sack depended primarily on the condition and integrity of its polyethylene liner.

[a] The ribbon tie is for the top spout and discharge chute, which are used for filling and discharging.

1.3.5 INVENTORY AND STORAGE CONFIGURATION

As stated in **Section 1.1** and **Section 1.2**, the Plant 12 Storage Warehouse was used to store various commodities, chemicals, and pool/spa treatment chemicals, specifically chlorinated isocyanurates and BCDMH. The manufacturing operations at Bio-Lab Conyers included both "pure" TCCA (99%) and various formulation blends ranging from 50% to 95% TCCA. Additionally, the facility stored NaDCC in both anhydrous and dihydrate forms, along with BCDMH and other chemicals used in production. Both liquid and solid chemicals were kept on-site, with most solid materials, such as chlorinated isocyanurates and BCDMH, stored in super sacks.

According to Bio-Lab Conyers management, super sacks containing approximately 2,200 to 2,800 pounds of chlorinated isocyanurates were stored on the floor on wood pallets, stacked two-high (**Figure 7F**) to an approximate height of 7 feet. In 2021, Bio-Lab Conyers installed storage racks (**Figure 9**) in the area outside the bunker to increase storage capacity. The Rockdale County Fire Marshal's Office approved the installation in April 2021.[a]

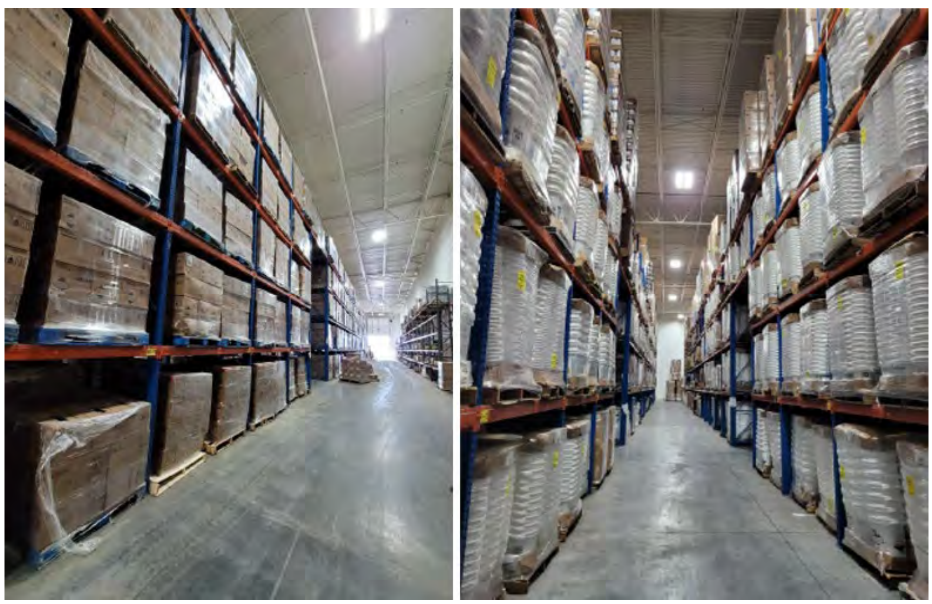


Figure 9. Bio-Lab Conyers Plant 12 Storage Warehouse racks installed in 2021. (Credit: KIK)

This area also stored various commodities, including pails, cardboard, and bottles [21, pp. 13-22], up to a height of 25 feet, and was protected by the ceiling-mounted ESFR fire protection sprinkler system. The documents approved by the Rockdale County Fire Marshal's Office in 2021 specified that "[t]he commodity being stored [in the racks] are Class III Commodities consisting of group A plastics (empty pails and bottles) and corrugate stored on wooden pallets."

The NFPA defines a commodity as "[t]he combination of products, packing materials, and containers that determines commodity classification" [21, pp. 13-22] and indicates that Class III may also include paper,

[a] Rockdale County Fire Marshal approved the new rack system on April 6, 2021.

natural fibers, or Group C plastics, with or without cartons, boxes, or crates, and may contain limited amounts of Group B plastics [28, pp. 3-4].

At the time of the incident on September 29, 2024, approximately 14 million pounds of Class 1 and Class 2 oxidizers were stored in the Plant 12 Storage Warehouse.[a] As **Table 4** shows nearly 11 million pounds of these materials were stored inside the bunker, which included approximately 4,000 super sacks of chlorinated isocyanurates and over 2,800 bags of BCDMH.[b] An additional approximately 3 million pounds of chlorinated isocyanurates (approximately 1,100 more super sacks) were stored outside the bunker. Altogether, there were approximately 5,000 super sacks of chlorinated isocyanurates, each containing between 2,205 to 2,805 pounds of the substance, stored in the warehouse (inside and outside the bunkers) at the time of the incident.

In June 2019, prior to the construction of the warehouse, in response to inquiries from Rockdale County, Bio-Lab Conyers' design-build contractor, ARCO, prepared and submitted documents on behalf of Bio-Lab, Inc./KIK stating that an anticipated "average inventory" of approximately 6.2 million pounds of raw materials, including oxidizers, would be stored in the storage warehouse (**Table 4)**. The documents were prepared based on information provided to ARCO by Bio-Lab, Inc./KIK representatives.[c] The volume of oxidizers in the warehouse at the time of the incident was more than double this amount.

Table 4. Summary of oxidizers inventory: Anticipated in 2019 and actual 2024 storage amounts.

Plant 12 Storage Warehouse Inventory (in millions of pounds)				
Oxidizer Class	**Material Name**	**2019 Permit Submission Anticipated Average****	**2024 During Incident**	
			Inside Bunker	**Outside Bunker**
Class 1	TCCA NaDCC Dihydrate	5.06	9.94	2.86
Class 2	NaDCC BCDMH*	1.14	1.11	0.08
Chemicals Total:		**6.20**	**11.05**	**2.94**

*All BCDMH was stored inside the bunker.

** The Rockdale County Commercial Building Application documentation.

Figure 10 is a representation of the approximate locations of the oxidizers stored inside and outside the bunker, in storage racks alongside other dry chemicals, and on the floor on wood pallets, stacked two high.

[a] The approximately 14 million lbs. of Class 1 and Class 2 oxidizers, including TCCA, NaDCC, NaDCC dihydrate, and BCDMH, do not represent the entire inventory in the Plant 12 Storage Warehouse at the time of the incident.

[b] The BCDMH was packaged in 95-kg (approximately 209-lb) bags.

[c] The permit drawings for the Plant 12 Bio-Lab Storage Warehouse list "Bio-Lab c/o Republic Property Company" as the Owner/Developer.

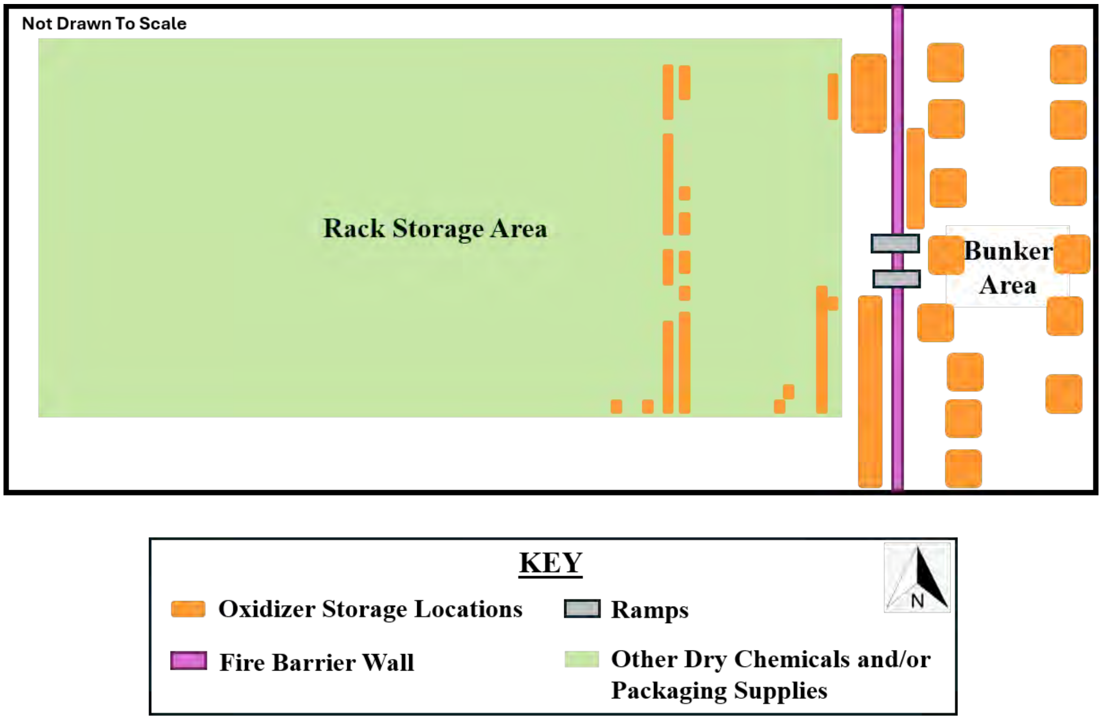


Figure 10. Sketch of the Plant 12 Storage Warehouse floor plan showing the fire barrier wall, rack storage, and the bunker. (Credit: CSB)

1.4 Previous Incidents Involving Pool-Treatment Chemicals

There have been several other incidents in recent years involving pool-treatment chemicals, such as TCCA or similar chlorinated isocyanurates, which resulted in the release of chlorine gas or other potentially toxic by-products.

1.4.1 Previous Bio-Lab Incidents Involving Pool-Treatment Chemicals

Since the Conyers facility opened in 1973, it has experienced several chemical decomposition reactions involving oxidizers that have water-reactive characteristics. Local responders in Rockdale County responded to at least four of these incidents over the years, specifically on April 17, 2004, June 14, 2015, June 4, 2016, and September 14, 2020. One responder specifically told the CSB that “we’ve been here [Bio-Lab Conyers] many times.” Some of these incidents have been reported in various news media and investigated by the CSB. Below is a summary of three additional previous decomposition reaction incidents: two occurring at Bio-Lab Conyers and one at Bio-Lab Lake Charles, located in West Lake, Louisiana.

1. On May 25, 2004, a 260,000 square foot warehouse at Bio-Lab Conyers, located where the Plant 12 Storage Warehouse would later be built, was also destroyed.[a] At that time, Bio-Lab was not owned by

[a] The National Response Center (NRC) report number for the Conyers 2004 fire is 722896. The NRC is “the designated federal point of contact for reporting all oil, chemical, radiological, biological and etiological discharges into the environment, as well as railroad incidents, anywhere in the United States and its territories” [134].

KIK. The 2004 incident involved approximately 12.5 million lbs. of pool-treatment chemicals and oxidizers, a release of HCl gas/vapor,[a] and a fire. The effect "of the plume was felt more than 50 miles away" [29]. Published news media reported that "the three main chemicals stored in the warehouse were trichloroisocyanuric acid, dichloroisocyanuric acid, and calcium hypochlorite" and that 28 people were admitted to hospitals, "but none was injured seriously" [30]. The community was impacted by road closures, including U.S. Interstate 20 ("I-20"), and a mandatory evacuation. Large plumes of smoke from the incident were visible in the surrounding area, as shown in **Figure 11**.

Figure 11. Chemical release and fire at Bio-Lab Conyers on May 25, 2004. (Credit: U.S. Environmental Protection Agency [29])

2. On September 14, 2020, Bio-Lab Conyers experienced a chemical reaction and decomposition involving TCCA-based formulations stored in Plant 6, a different building from the one where the 2024 incident occurred.[b] Much of the material in Plant 6 was stored in lined super sacks that sat on top of wood or plastic pallets on the floor. A 3/8-inch polyethylene water line connected to the water heater developed a leak, causing flooding in the building. The floodwater came into contact with TCCA-based formulation material on the floor, causing a decomposition event (**Figure 12**), which released a plume of hazardous chemicals. As a result, KIK employees assigned to Bio-Lab Conyers and nine firefighters were exposed to dangerous fumes, and the interstate highway near the facility was closed for approximately 6 hours. Following the incident, the TCCA-based formulation inventory was relocated from Plant 6 into trailers. The relocated inventory was exposed to moisture during the September 14, 2020, incident. Four days later, on September 18, 2020, a second decomposition occurred in one of the trailers involving the inventory that had been relocated from Plant 6.[c]

[a] The CERCLA Emergency Response Action Report for Bio-Lab, Inc. prepared for the U.S. Environmental Protection Agency, indicate "that possible airborne contaminants were chlorine, hydrochloric acid, and hydrogen bromide".

[b] The CSB investigated the 2020 incident. *See* https://www.csb.gov/bio-lab-conyers-chemical-release-/

[c] The CSB investigated the 2020 incident at Conyers. Further details can be found in Appendix D of the CSB's final report published on the Bio-Lab Lake Charles incident, which occurred on August 27, 2020.

Figure 12. TCCA material decomposition reaction at Bio-Lab Conyers in 2020. (Credit: KIK)

3. On the morning of August 27, 2020, at the Bio-Lab Lake Charles facility in Westlake, Louisiana, rainwater from Hurricane Laura, a Category 4 hurricane, came into contact with TCCA-based formulation materials stored inside a Production Building at the facility, initiating a chemical reaction and subsequent decomposition that led to a fire that destroyed the building.[a] Hurricane Laura produced heavy rainfall and winds of 101 miles per hour (mph), with a peak gust of 137 mph recorded in downtown Lake Charles. Later in the afternoon, a second decomposition reaction and release occurred in the Finished Goods Warehouse at the Bio-Lab Lake Charles facility, which had also been severely damaged by the hurricane's winds. At the time of the incident, the warehouse was storing TCCA-based formulation material. The decomposition reactions released large plumes of hazardous gases, including toxic chlorine, into the air, crossing the facility boundary. The plumes were visible over a substantial portion of the nearby community (**Figure 13**), resulting in the closure of part of a nearby interstate for over 28 hours and the issuance of a shelter-in-place order.

[a] The CSB investigated this incident too. *See* https://www.csb.gov/biolabLakeCharles

Figure 13. A large plume of hazardous gas from the decomposition at the Bio-Lab Lake Charles facility approaching the Calcasieu River Bridge in Louisiana, located between Westlake and Lake Charles. (Credit: 4WWL-TV [31])

1.4.2 Other Previous Incidents Involving Pool-Treatment Chemicals

For more than two decades, incidents involving pool-treatment chemicals or chlorinated compounds have occurred at various warehouses, manufacturing facilities, and other locations, releasing chlorine vapors and other potentially toxic substances. These incidents often led to fires, injuries, the need for medical treatment, and the evacuation of residents and surrounding areas. **Table 5** provides a summary of three such incidents. A summary of 10 more incidents can be found in **Appendix B**.

Table 5. Summary of three previous incidents involving pool chemical fires and toxic gas releases.

Date	Incident Location	Description	Impact*
June 17, 1988	Advance Laboratories, Inc. Springfield, Massachusetts	Two fires occurred inside a two-story building used to manufacture TCCA tablets and produce other chemicals, resulting in the partial collapse of the roof and significant structural damage. The first fire occurred in the morning and involved rainwater contacting chlorine compounds. The reaction released chlorine, generated heat, and led to the ignition of ordinary combustibles. The second occurred later that night, likely after rainwater entered the building through open windows and also came into contact with chlorine compounds [32].	~ 6,000 people, and schools, evacuated
October 2, 2013	Clearon Corp. South Charleston, West Virginia	A chlorinated dry bleach chemical release, which "resulted in a small fire inside the plant, along with a chlorine gas cloud that hovered over the western part of the county" [33].	3 people required medical treatment, and a shelter-in-place was issued
December 8, 2020	Optima Belle Belle, West Virginia	A toxic chlorine release and fire after a pressure-rated rotary double cone dryer containing a "chlorinated isocyanurate compound (sodium dichloroisocyanurate dihydrate, or NaDCC dihydrate) exploded" [34].[a]	1 person fatally injured, 1 injury, 2 medically evaluated, and shelter-in-place

*Some incidents necessitated a building evacuation, and others required an evacuation of the surrounding area(s).

1.5 Regulatory Coverage

In 1992, OSHA promulgated the Process Safety Management (PSM) Standard (29 CFR § 1910.119), and in 1996, the U.S. Environmental Protection Agency (EPA) promulgated its Risk Management Program (RMP) Rule (40 CFR § 68). Both the OSHA PSM standard and the EPA RMP rule are intended to manage chemical process safety and help prevent incidents. These regulations require chemical facilities to implement process safety requirements 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 covers facilities with specifically listed flammable or toxic substances present above threshold quantities. The chlorinated isocyanurates and BCDMH involved in the Bio-Lab Conyers incident in 2024 are not included on the OSHA PSM or EPA RMP lists. Consequently, the Bio-Lab Conyers Plant 12 Storage Warehouse was not covered by either of these regulations.

OSHA's General Duty Clause under Section 5(a)(1) of the Occupational Safety and Health Act states that each employer "shall furnish to each of his employees employment and a place of employment which are free from

[a] The CSB investigated this incident. *See* https://www.csb.gov/OptimaBelle

recognized hazards that are causing or are likely to cause death or serious physical harm to his employees" [35]. Although not covered by the PSM standard, the storage and handling of chlorinated isocyanurates and BCDMH are subject to OSHA's General Duty clause. In addition, these materials can generate chlorine, bromine, and explosive compounds such as nitrogen trichloride, which can cause serious physical harm and even death to employees.

After the September 2024 incident, OSHA cited Bio-Lab, Inc. for violating Section 5(a)(1) General Duty Clause based upon OSHA's finding that:

> [E]mployees were exposed to toxic chemicals and fire hazards when performing fire watch and material handling tasks in that, hazardous chemicals such as, but not limited to, Trichloroisocyanuric acid, (TCCA), 99% Sodium Dichloroisocyanurate (DCCA), and Bromochloro-5,5-dimethylimidazolidine-2,4-dione (BCDMH) were not stored properly [36].

OSHA also cited Bio-Lab, Inc. for violations of 29 CFR §1910.120 *Hazardous Waste Operations and Emergency Response* and 29 CFR §1910.134 *Respiratory Protection* standards with respect to personal protective equipment (PPE). These asserted violations pertained to PPE and respiratory use, including failure to produce records of medical surveillance and fit testing associated with respirator use. OSHA issued six citations to the company, with penalties totaling $61,473. According to OSHA, these penalties had been paid in full by the time this report was published.

1.6 Description of Surrounding Area

Figure 14 shows Bio-Lab Conyers and depicts the areas within approximately 1, 3, and 5 miles of the facility boundary. Summarized demographic data for the surrounding vicinity in an approximately 1-mile radius of Bio-Lab Conyers and Rockdale County are shown below in **Table 6** and **Table 7**, respectively. At the time of the incident, there were over 15,424 people residing in over 6,286 housing units, most of which are single units, within the census blocks in which a portion of the block(s) are within 1 mile of Bio-Lab Conyers. Detailed demographic information is included in **Appendix C**.

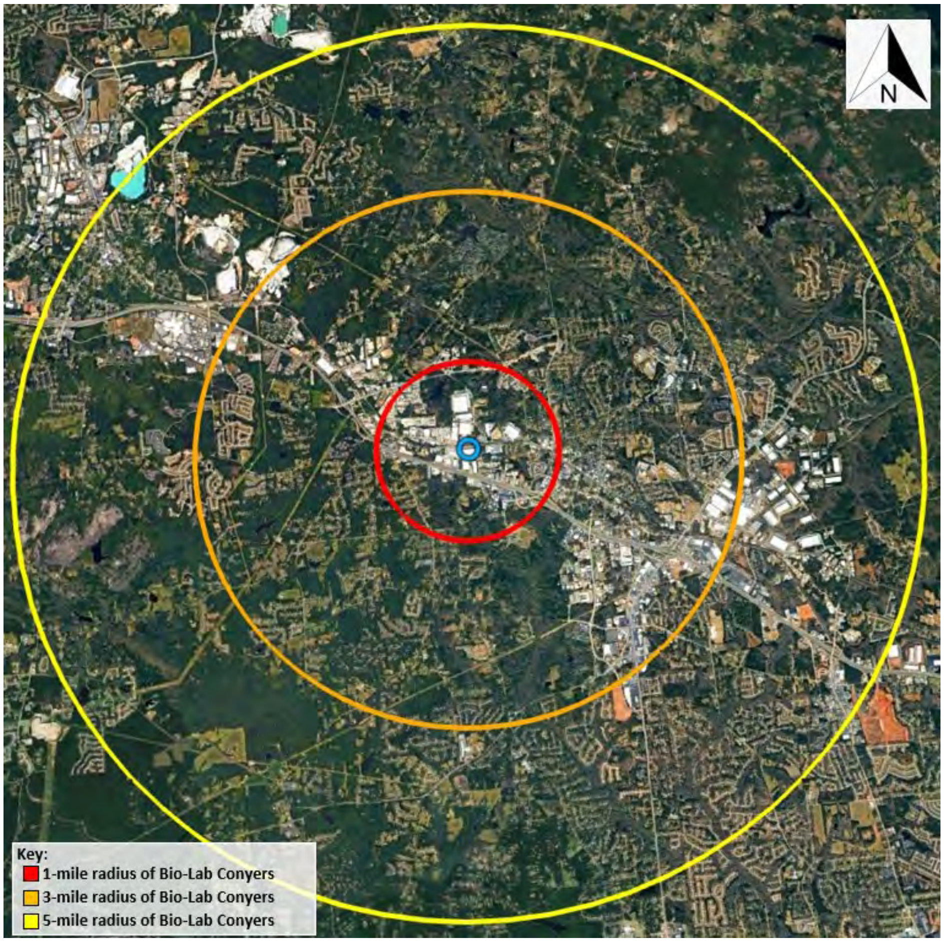


Figure 14. Overhead satellite image of Bio-Lab Conyers and the surrounding area. (Credit: Google Earth, annotated by CSB)

Table 6. Summarized demographic data for approximately 1-mile vicinity of Bio-Lab Conyers.[a]

Population	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Housing Units	
15,424	White	24%	$ 31,498	15%	6,286	Single Unit	78.1%
	Black	53%				Multi-Unit	21.2%
	Native	0%				Mobile Home	0.7%
	Asian	2%				Boat, RV, Van, etc.	0.0%
	Islander	0%					
	Other	1%					
	Two+	5%					
	Hispanic	14%					

[a] Census Reporter reports that Georgia's per capita income was $39,685 [135] and that the overall per capita income for the United States was $43,313 [136].

Table 7. Summarized demographic data for Rockdale County, Georgia.

Population	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Housing Units	
95,987	White	22%	$ 35,034	12%	35,459	Single Unit	83.0%
	Black	58%				Multi-Unit	13.0%
	Native	0%				Mobile Home	4.0%
	Asian	2%				Boat, RV, Van, etc.	0.0%
	Islander	0%					
	Other	1%					
	Two+	6%					
	Hispanic	11%					

2 INCIDENT DESCRIPTION

2.1 PRE-INCIDENT HURRICANE PREPAREDNESS

On Thursday, September 26, 2024, three days before the incident, Bio-Lab Conyers ceased all on-site operations after Georgia's governor declared a State of Emergency in preparation for Hurricane Helene. In anticipation of potential hurricane impacts, Bio-Lab Conyers closed early on Thursday and communicated to its employees that the site would remain shut down on Friday. Although normal operations were shut down, the facility maintained its rotating 12-hour fire watch[a] shifts to ensure continuous facility surveillance, consisting of regular walkthroughs at each of the site's buildings.

Bio-Lab Conyers leadership told the CSB that two or three months prior to the incident, the facility had established a permanent fire watch to mitigate the risk of potential thermal decomposition after detecting strong odors from oxidizers in the warehouse and another storage building. The responsibilities of fire watch employees included identifying and managing hazards, detecting early signs of product decomposition or fire hazards, notifying site leadership of any observed leaks or other water intrusions, and contacting the third-party sprinkler company if a sprinkler head was leaking. Although fire watch typically consisted of two individuals providing coverage for the entire facility, Bio-Lab Conyers increased staffing to three employees during the 12:00 a.m. to noon shift on Friday, September 27, 2024, to provide additional support and walkthrough coverage during Hurricane Helene's passage through the region. Normal operations remained shut down after the hurricane's passage, although the facility returned to two employees per fire watch shift effective with the noon to midnight shift on Friday, September 27, 2024.

Due to the eastward track of the hurricane through Georgia, the Atlanta metropolitan region was spared the higher winds of 70-100 mph recorded throughout the eastern half of the state [37]. The nearest wind monitoring station to the site registered a maximum wind speed of 41 mph during the most intense portion of the storm on September 27, 2024, with a daily average speed of 26 mph [38].[b] The National Oceanic and Atmospheric Administration (NOAA) rain gauging station closest to the Bio-Lab Conyers facility registered 10 inches of rainfall between September 26 and 27, 2024,[c] with no additional rainfall occurring in the 36 hours prior to the incident, the morning of September 29, 2024.[d]

2.2 INITIAL OFF-GASSING EVENT

At approximately 5:00 a.m. on September 29, 2024, one of the two employees onsite at Bio-Lab Conyers (Employee A),[e] assigned to fire watch in the Plant 12 Storage Warehouse, reported hearing a popping sound as

[a] The NFPA *Life Safety Code* (NFPA 101) 2012 Edition defines fire watch as "The assignment of a person or persons to an area for the express purpose of notifying the fire department, the building occupants, or both of an emergency; preventing a fire from occurring; extinguishing small fires; or protecting the public from fire or life safety dangers" [70, pp. 13-101 to 13-34].

[b] Windspeed data are from the joint National Weather Service and Federal Aviation Administration official station located at the Dekalb Peachtree Airport in Dekalb County.

[c] The referenced weather station in Conyers measures rainfall only and is considered more representative of conditions experienced at the Bio-Lab facility.

[d] The rain ended on the morning of Friday, September 27, 2024.

[e] At the time of the incident, all employees at the Bio-Lab Conyers facility were employees of KIK International LLC, which uses the trade name "KIK Consumer Products".

they stepped out of the breakroom to begin their surveillance round. Employee A initially attributed the sound to the nearby ice maker in the warehouse. However, based on previous experience and training, Employee A immediately concluded that product in the warehouse was wet and called the other employee (Employee B) on fire watch on-site, who also was a member of the Bio-Lab Conyers Emergency Response Team (ERT). Employee A then notified offsite management by phone.[a,b]

At 5:04 a.m., Employee B arrived at the warehouse and donned a full-face respirator before entering the warehouse building.[c] Employee A left the building to retrieve their respirator from their vehicle and returned to the warehouse to assist Employee B in attempting to remove super sacks that were off-gassing. Neither employee reported seeing fire, but both observed several super sacks "putting off" dense white fumes, referred to as "off-gassing."[d] The off-gassing super sacks were located immediately outside the bunker adjacent to the fire barrier wall, with three rows of double-stacked super sacks stored in front of them. **Figure 15** shows the location of Employee A at the time they first heard the popping sound (person-shaped symbol) relative to the area where they observed the initial off-gassing super sacks (red circle).

[a] Employee A contacted Employee B and the facility management using the Telegram App on their mobile device. Telegram is a mobile messaging program that can be used on mobile devices. Bio-Lab managed its site communications through separate "channels" on the Telegram App, such as for fire watch and ERT.

[b] Employee A also placed "Code red plant 12" in the Telegram App ERT channel. The Bio-Lab Conyers *Emergency Response Plan* defines Code Red as "Emergency requiring plant evacuation."

[c] Employee B's 5:04 a.m. arrival is based on the fire alarm log, as their first action at the building was to enter through the fire pump room to shut the pump off. When the fire pump was shut off manually, it generated an alarm with the remote monitoring company whose dispatchers respond by calling multiple facility contacts to notify them of the system status. Employee B received and answered the phone call from the remote monitoring company at 5:10 a.m.

[d] Off-gassing "is defined as the "emanation of volatile matter of any kind from materials into habitable areas" [138, p. 282], with "volatile matter" defined as "[p]roducts given off by a material as gas or vapor" [138, p. 428].

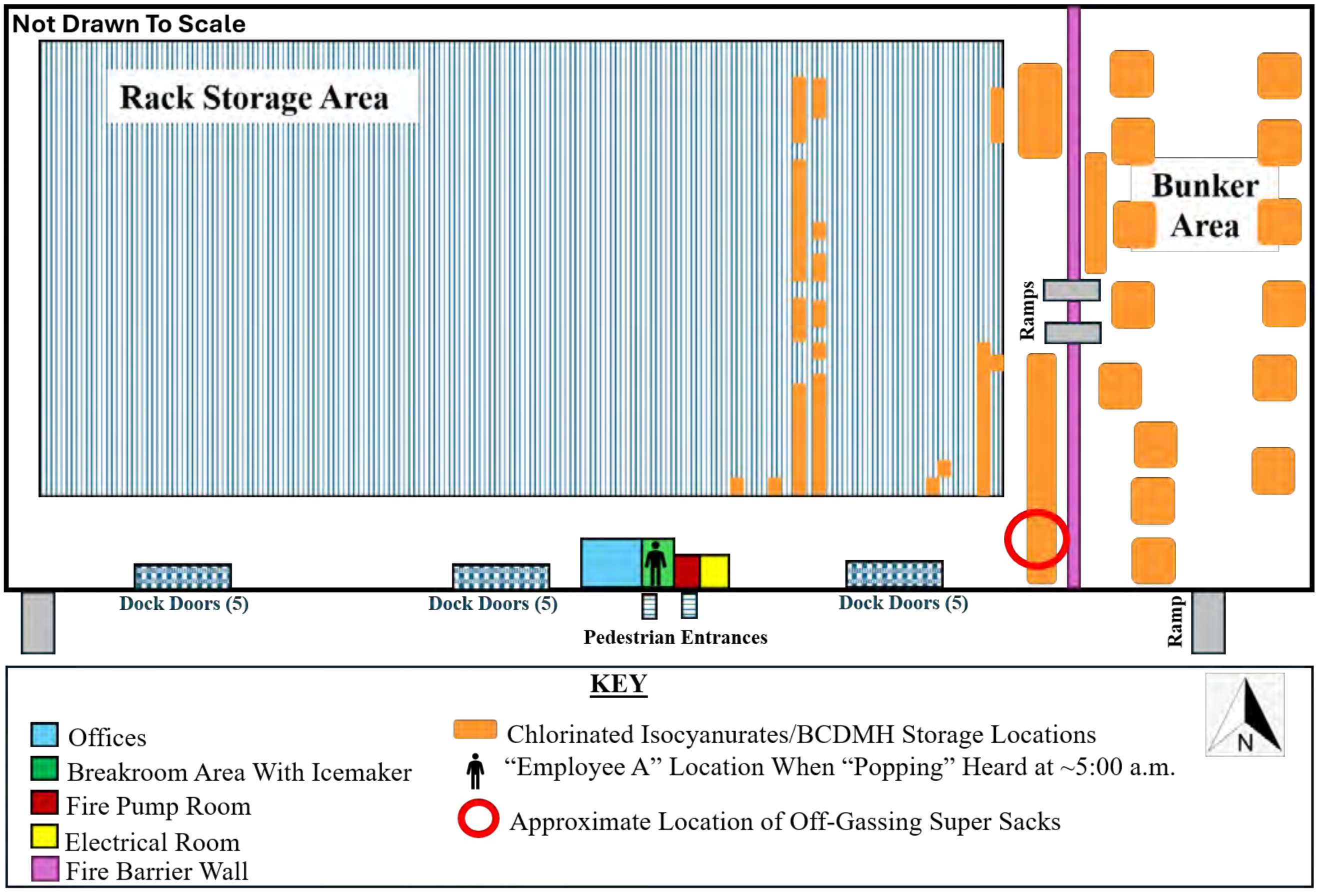


Figure 15. Depiction of the Plant 12 Storage Warehouse floor plan showing Employee A's location when they heard "popping." (Credit: CSB)

After assessing the situation, Employee B directed Employee A to call 9-1-1. Employee A did not report a fire when they called 9-1-1 at approximately 5:10 a.m., but they reported that a "sprinkler head burst" and that "chemical smoke is everywhere." On October 3, 2024, four days later, the employee later told the CSB,

> "I think it could've been water off the ceiling. I don't know…but I know water…"

Employee B was able to remove only four super sacks of material from the area in front of the off-gassing super sacks before both employees had to leave the building due to the increasing fume density affecting visibility. Employee B also encountered difficulty moving the super sacks because there was "[n]o visibility and floors [were] too slick for forklift" due to the water from the sprinkler flow. Employee B took a picture and video of the dense white fumes before leaving the building (**Figure 17**).[a] **Figure 16** depicts the path of travel that Employee B took when entering the building to shut off the fire pump, the general location of the off-gassing material, and where Employee B was standing when they took the picture (**Figure 17**).

[a] The metadata for the photo and video file did not include a timestamp for when the photo was taken.

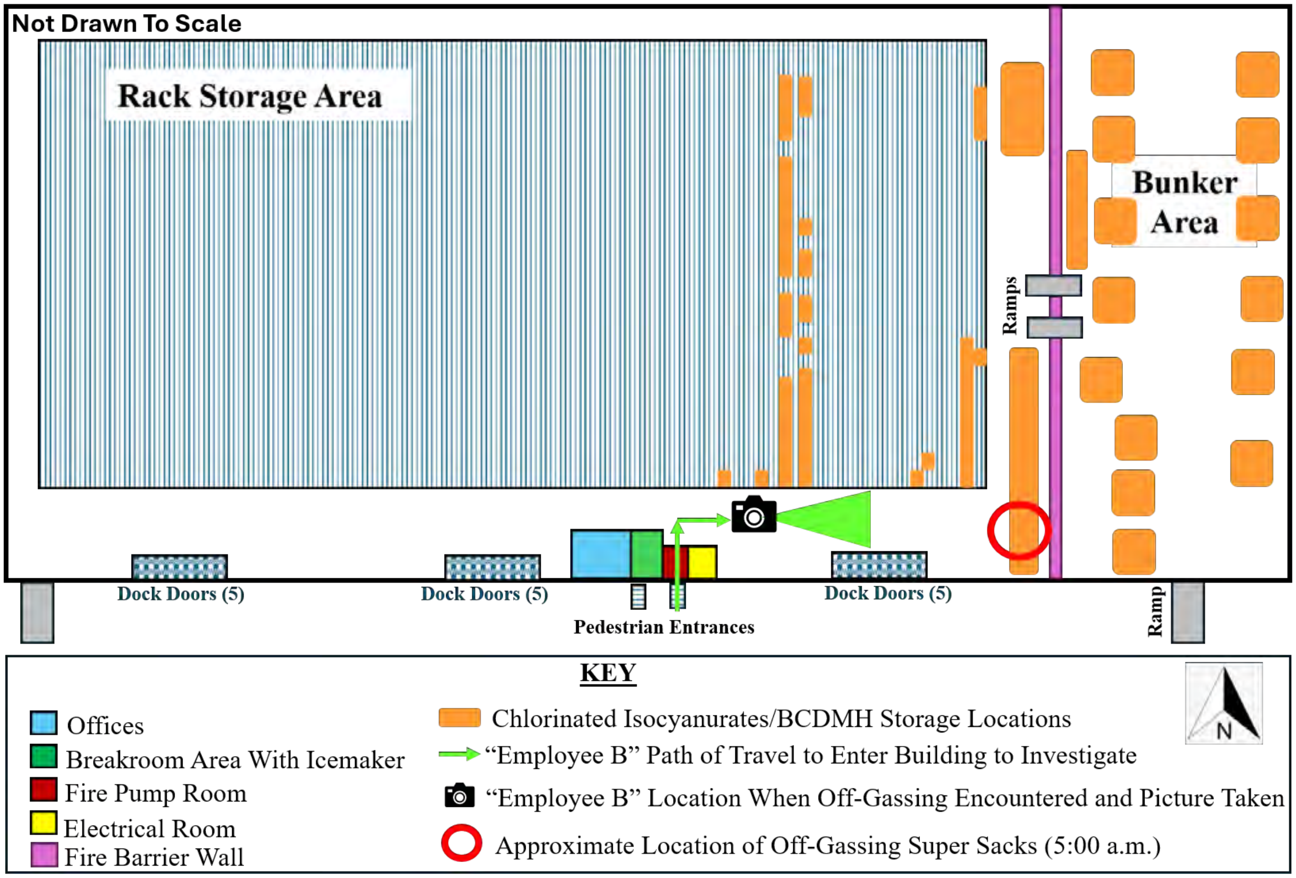


Figure 16. Depiction of the Plant 12 Storage Warehouse floor plan showing Employee B's path of travel into the warehouse and the location where the off-gassing picture was taken. (Credit: CSB)

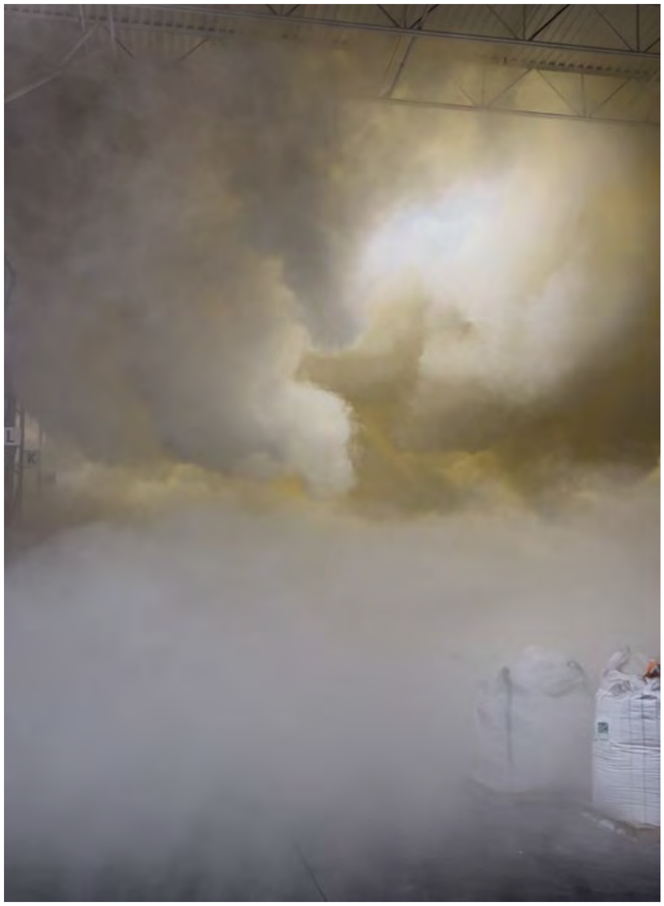


Figure 17. Initial off-gassing observed in the warehouse outside the bunker by a KIK employee assigned to fire watch. (Credit: KIK)[a]

Rockdale County Fire Rescue (RCFR) first responders and additional KIK employees arrived at the Plant 12 Storage Warehouse by approximately 5:30 a.m., within 30 minutes of the event's discovery. Both KIK and RCFR personnel recounted to the CSB that upon arrival, they observed large volumes of water running out of the dock doors before RCFR had sprayed any water, indicating that the fire protection system had been activated before the RCFR personnel arrived. However, the timing and extent of fire protection system activations cannot be determined from alarm system logs because the heat generated by the off-gassing event exposed and shorted wiring, causing system status communication loss at 5:32 a.m. and full system failure at 5:37 a.m. **Figure 18** shows the large volume of water flowing out from the warehouse interior through all the dock doors along the full length of the building, except the bunker. An RCFR responder also told the CSB that they "got a good view in [the bunker]," no sprinklers were going off in there, and "[they] could see all the way to the fire barrier wall and saw no involvement in there at all." In **Figure 18**, the location of the bunker within the warehouse is outlined in yellow, and its external vehicle access ramp is highlighted in aqua.

[a] The photo and video metadata do not include the original timestamp.

Figure 18. Water flow from the Bio-Lab Plant 12 Storage Warehouse's interior through dock doors at 8:41 a.m., with the bunker area outlined in yellow and its exterior ramp outlined in aqua. (Credit: RCFR, annotated by CSB)[a]

At approximately 6:00 a.m., Employee B accompanied RCFR personnel for reconnaissance in an attempt to take them to where the initial off-gassing super sacks were located. The RCFR reconnaissance attempt was limited, however, due to the thick fumes that hindered visibility and rendered RCFR's thermal imaging cameras unusable. The RCFR team and Employee B had to physically feel their way back out of the building after becoming "disoriented and lost for a few minutes" because they could not see the exit doors through the fumes.

[a] RCFR used its drone to take the picture at 8:41 a.m., showing water still flowing from the dock doors 30 minutes after the morning roof fire was extinguished.

2.3 First Visible Building Fire at 6:30 a.m.

At approximately 6:30 a.m., shortly after the reconnaissance attempts, RCFR personnel observed small flames inside the building near the area where the two KIK employees had first observed the material popping and off-gassing. RCFR personnel described the fire to the CSB as "very small… very contained," and located up against the concrete wall separating the bunker from the main warehouse area.

The heat from the fire inside the building was intense enough to initiate a fire on the roof of the building (**Figure 19**). RCFR informed the CSB that the fire on the roof was contained and limited to the roof membrane, which overlayed the metal roof decking. The fire charred and burned the roof membrane, but did create a hole in the underlaying metal roof decking. In **Figure 19**, the bunker is shown outlined in aqua, and the location of the roof fire is circled in red. In the drone thermal image at right, the bunker area is darker in coloration, indicating that the bunker is cooler in temperature than the main warehouse area. **Figure 20** shows the location of the 6:30 a.m. roof fire relative to the interior layout of the warehouse building.

Figure 19. Two images showing the roof membrane damage at 8:11 a.m. after the first was extinguished, with the bunker outlined in aqua and the roof damage circled in red. (Credit: RCFR, annotated by CSB)[a]

[a] File metadata indicates that this drone image was taken at 8:11 a.m. (both normal and thermal exposure). The drone had not arrived at the scene prior to this time.

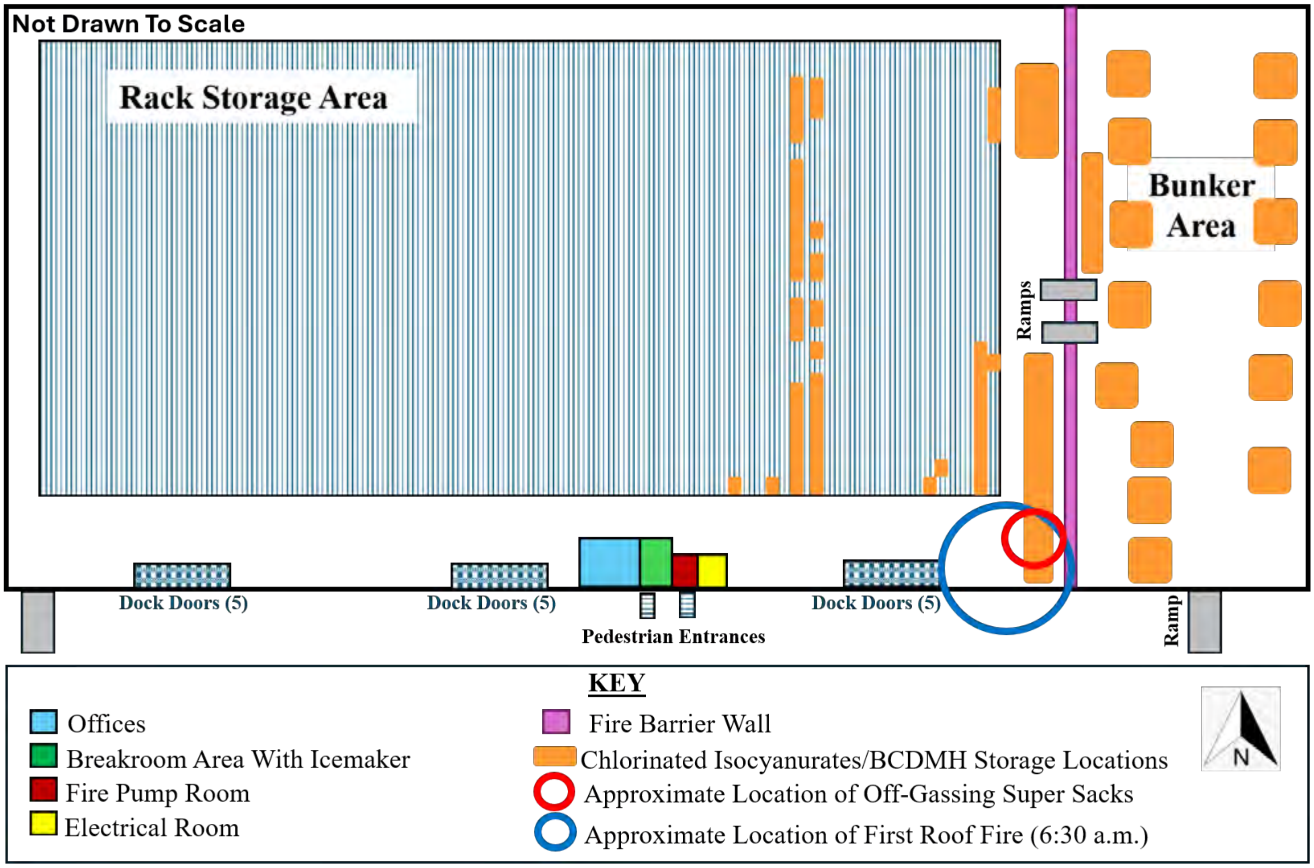


Figure 20. Approximate location of first roof fire relative to building interior layout. (Credit: CSB)

Although the flames on the roof were first observed at 6:30 a.m., it was not until approximately 8:10 a.m. that the responders extinguished the roof membrane fire by applying a relatively small stream of water, estimated by fire rescue personnel as only a "couple gallons." RCFR personnel told the CSB they wanted to use the minimum amount of water necessary and not wet additional material based on their experience with previous TCCA (TCCA-based formulation) incidents at Bio-Lab Conyers, such as the 2020 Plant 6 decompositions.[a] The RCFR responders performing external reconnaissance also looked into the bunker through the open dock door and reported minimal fumes and no signs of sprinkler activation within the bunker area.

After RCFR extinguished the roof fire, KIK employees were allowed to safely enter the bunker area, which was reported to have no fuming/off-gassing material and no signs of sprinkler activation. In the several hours after the roof membrane fire was extinguished, RCFR personnel focused on increasing ventilation to the rack storage area in the warehouse to remove fumes, improve visibility, and reduce exposure hazards enough to allow KIK employees to safely reenter the bunker area with forklifts to remove super sacks. RCFR personnel coordinated with KIK employees, who opened the bay doors and removed ground-level exhaust fans with forklifts, while the fire department's ladder trucks removed plexiglass windows along the top of the building on the wall with the dock doors in an attempt to clear fumes/vapors from inside the building.

[a] The CSB investigated the 2020 Conyers incident in connection with its investigation of the 2020 Bio-Lab Lake Charles. *See* Bio-Lab 2020 Lake Charles Chemical Fire and Release Investigation Report, April 2023.

KIK employees entered the bunker to remove super sacks of material to reduce the potential for additional off-gassing events in the building. However, only 59 out of the approximately 4,000 super sacks containing chlorinated isocyanurates stored inside the bunker could be removed from the bunker [a] before RCFR noticed a second fire on the roof of the building and ordered everyone to evacuate the building immediately. Inventory records indicate that approximately 5,000 super sacks, each containing between 2,205 to 2,800 pounds of chlorinated isocyanurates, were present inside the Plant 12 Storage Warehouse, in both the bunker and the rack storage area. Additionally, there were a large number of smaller bags containing BCDMH inside the Plant 12 Storage Warehouse bunker.[b]

2.4 Second Fire at Noon

The second roof fire occurred at approximately 12:00 p.m., with black smoke initially observed rising from the center of the Plant 12 Storage Warehouse. When an RCFR responder went up in the aerial ladder of a firetruck to investigate the extent of the second fire, they described seeing:

> a gigantic hole… the entire center, almost dead center of th[e] building had vented through the fire. And if I had to estimate it, it probably was 100 ft by 100 ft… and shooting 40-50-foot flames in the air.

Because the building was constructed from concrete slabs raised into place and supported by a roof and truss system, the walls lacked the support to remain standing once the roof began collapsing shortly after the second larger fire broke out. By 12:40 p.m., some of the warehouse's exterior had already collapsed from the loss of roof support. **Figure 21** shows the second fire and the large roof hole at the building center, taken with a drone approximately 10 minutes after the fire was first observed by witnesses on the ground. **Figure 22** shows the location of the second fire, relative to the first fire at 6:30 a.m., and the interior layout of the warehouse building.

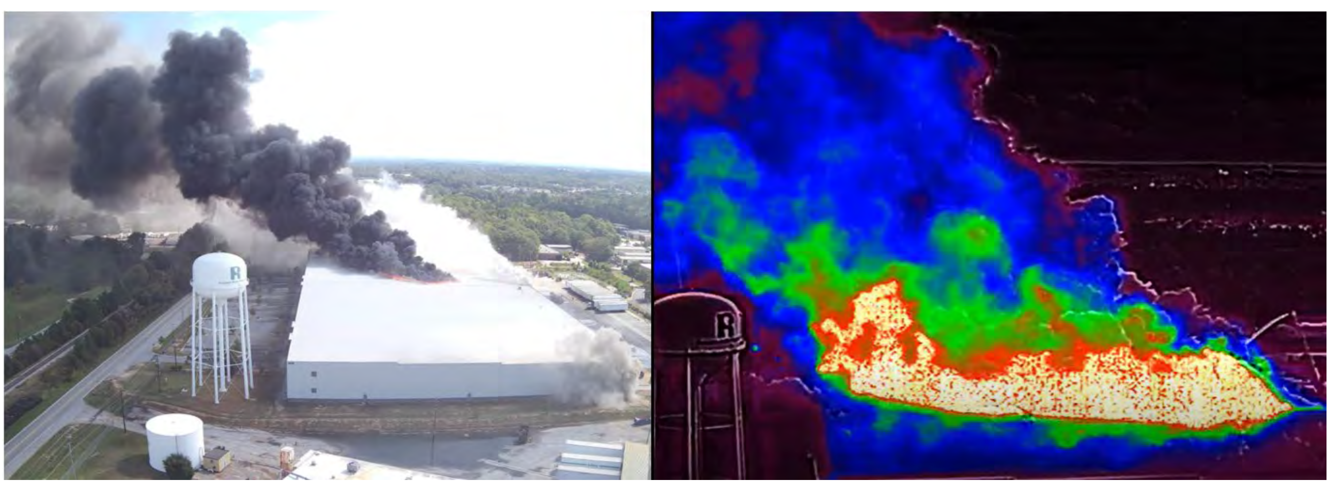


Figure 21. Black plume of smoke and fire venting through a large hole in the center of the building's roof (left) and thermal image of building (right) at 12:13 p.m. (Credit: RCFR)[c]

---

[a] KIK management directed its employees to start removing material from the building since "it wasn't smoking too bad."

[b] At the time of the incident, over 2,800 bags of BCDMH, each weighing 95 kg (approximately 209 lbs.), were also in the bunker.

[c] Although the thermal picture at right is a zoomed-in view, the metadata for both photos indicates a timestamp of 12:13 p.m.

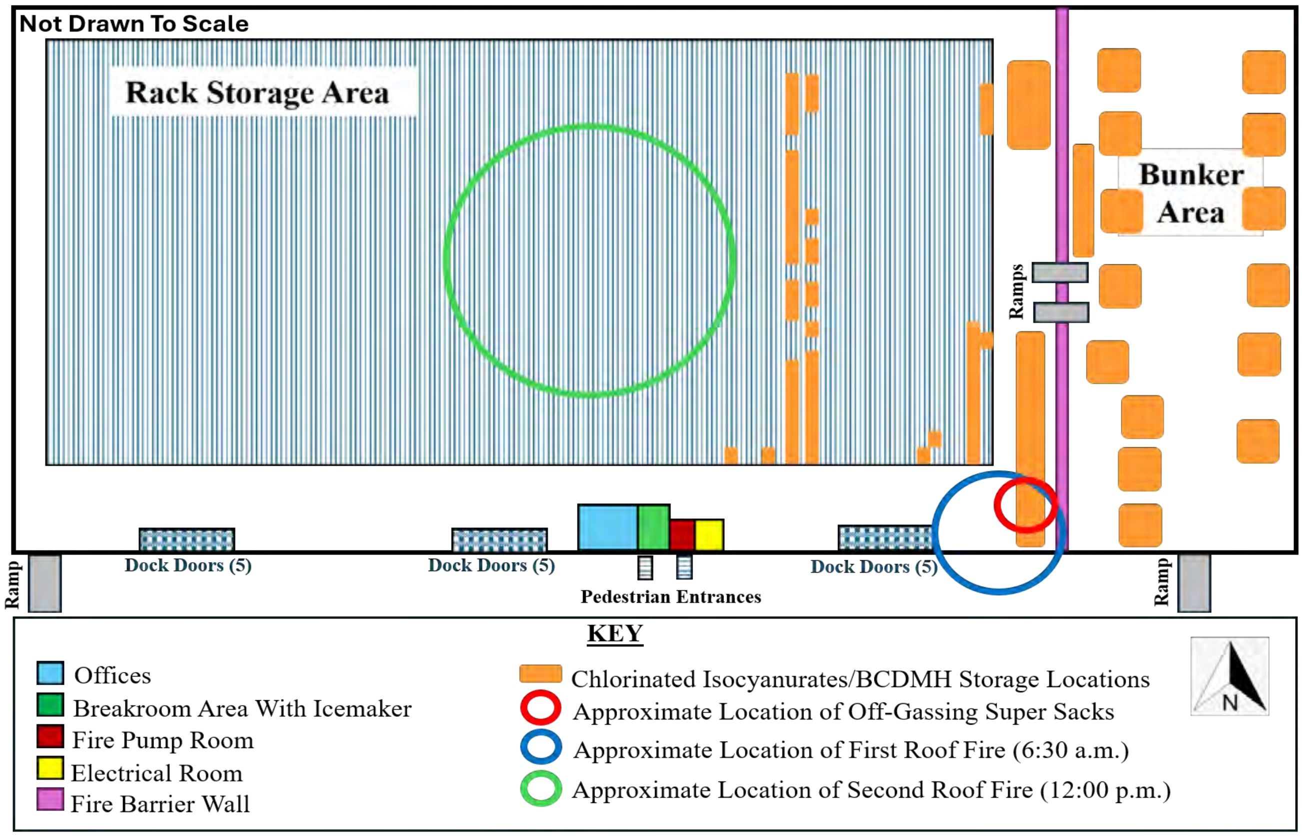


Figure 22. Location of second roof fire relative to first fire and building interior layout. (Credit: CSB)

RCFR personnel described that the second fire as initially consisting of a large plume of black smoke, thick white fumes and large flames, before changing over to multicolored plumes of smoke, as shown in **Figure 23**.

Figure 23. Multicolor plumes of smoke observed during the second fire at Bio-Lab Conyers on September 29, 2024. (Credit: Ross/11Alive)

In total, 14 mutual aid response units from four counties and one city assisted with firefighting efforts, as 4 units were already at the facility after the first fire, and 10 additional units arrived between 1:00 p.m. and 2:30 p.m.[a] The multiple RCFR and mutual aid units engaged in firefighting "flow[ed] water for hours" to fight the fire and fumes.[b]

At approximately 1:22 p.m., one of the collapsing walls struck and damaged the supports of the adjacent water tower. When the walls of the bunker collapsed at approximately 3:00 p.m. onto the material that was stored within it, the reacting materials "spill[ed] out" onto the roadway behind the building where the main fire hydrants in use were located, complicating firefighting efforts. RCFR responders in this vicinity reported observing chemical reactions in the form of "small explosions" with product physically shooting out from the building, as well as hearing "popping" sounds. An RCFR responder tasked with retrieving an engine truck parked at a hydrant on the east side of the building adjacent to the bunker area described that:

> [T]he whole reason we moved [the engine truck was] because it was getting pummeled. I mean, it literally felt like…it sounded like shotguns going off. Almost like you're at the gun range. You know, it sounded like you literally were at the gun range with pow, pow, pow, pow, pow. And you could just see

[a] Responding mutual aid units were from neighboring Dekalb, Henry, Newton, and Walton counties, as well as from the city of Social Circle located in Walton County.

[b] NFPA 400 explains that "trichlor, can react with small amounts of water over a period of time and form NCl_3, 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" [2, pp. 400-210]. Additionally, "[i]f swimming pool chemicals are involved in a fire or reaction, use large quantities of water" [2, pp. 400-211].

just whatever shooting out… [chemical material] that was pelt[ing] me when I was trying to get the hydrant taken off.

Figure 24 shows the damaged water tower and building debris (left), and the reacting “popping” chemical materials that spilled out of the collapsed bunker (right).

Figure 24. Damaged water tower supports struck by falling building walls (left) and reacting chemical material that spilled out after the bunker wall collapsed (right). (Credit: CSB [left], RCFR [right])

The Rockdale County Fire Chief reported the fire was extinguished at approximately 4:00 p.m. By approximately 8:00 p.m., the Plant 12 Storage Warehouse roof and most of its walls had collapsed, and firefighting efforts transitioned to extinguishing smaller fire hot spots within the building footprint. These activities focused on controlling the impacts on the community from the ongoing release of fumes and decomposition products from within the building debris. **Figure 25** depicts the hot spots of fire and off-gassing from the super sacks and materials trapped under the building debris during the evening of September 29, 2024.

Figure 25. Hotspots of fire and off-gassing from super sacks and materials trapped under building debris on the evening of September 29, 2024. (Credit: RCFR)

2.5 Impacts and Consequences of Incident

2.5.1 Emergency Response Phase

After the immediate firefighting phase of the incident concluded on the evening of September 29, 2024, the emergency response transitioned to a phase of establishing and implementing a controlled demolition of the Plant 12 Storage Warehouse that lasted through October 17, 2024. Under a Unified Incident Command, the remaining chemicals and the structural components of the building were removed for safety and environmental concerns. No injuries were reported at the site during the incident or in the extended emergency response that followed.

Throughout the response period, off-gassing from the site occurred because residual products remained trapped beneath the collapsed walls and structural debris, requiring heavy equipment to access and remove the material for treatment. **Figure 26** shows the continued off-gassing conditions from the building site during response activities in the days after the incident.

Figure 26. Ongoing off-gassing observed from the site during cleanup operations on October 2, 2024, several days after the incident. (Credit: CSB)

2.5.2 IMPACTS TO SURROUNDING COMMUNITY

The toxic vapor plume released from the site both during the active fire and throughout the extended emergency response phase of the incident significantly impacted the surrounding community, resulting in evacuations, multiple road closures, and shelter-in-place orders.

On September 29, 2024, at approximately 5:25 a.m., RCFR closed the first public roads around Bio-Lab Conyers due to the wind carrying white fumes off-site towards the northwest, with additional perimeter road closures occurring within 30 minutes after the first RCFR responders arrived at the facility. At approximately 6:00 a.m., local emergency services personnel began going door-to-door in Conyers, issuing the first shelter-in-place and evacuation orders directly to residents within the neighborhoods adjacent to the facility.

Interstate highway I-20, which runs parallel to the facility, was shut down at 12:57 p.m. on September 29, 2024, shortly after the building collapsed, and was reopened to the public at approximately 7:00 a.m. on September 30, 2024. Smaller state roads in the vicinity of the facility remained closed for several weeks after the incident, and local officials later told the CSB that the train tracks adjacent to the facility also were closed to rail traffic for an extended period. As a result of the incident, local officials reported that approximately 17,000 people in the local community were evacuated [39].[a] On September 29, 2024, at 8:30 p.m., Rockdale County issued a county-wide shelter-in-place order, affecting a population of approximately 90,000 county residents, including many in the Atlanta metropolitan area, who were ordered to stay indoors and turn off ventilation systems such as air conditioning. Although the warehouse was destroyed on the day of the incident,

[a] Rockdale County's Update (Facebook video)

shelter-in-place notifications were issued nightly for a 12-hour period from 7:00 p.m. to 7:00 a.m. throughout the duration of the active emergency response phase at the incident site. The final shelter-in-place order issued to the surrounding community was communicated on October 16, 2024, effective at 7:00 p.m. that evening and expiring the morning of October 17, 2024.

Rockdale County Public Schools were closed the week of September 30 through October 4, 2024, for fall break, and the schools conducted virtual remote learning from October 10 through 18, 2024, because of the incident. The schools did not return to in-person learning until October 21, 2024 [40, 41]. The school closures affected over 16,500 students attending 11 elementary, 4 middle, 3 high, and 4 non-traditional schools in Rockdale County [42]. Newton County also closed its schools on September 30, 2024, due to potential impacts from the chemical plume [43]. **Figure 27** shows the proximity of Bio-Lab Conyers to Rockdale County Schools.[a]

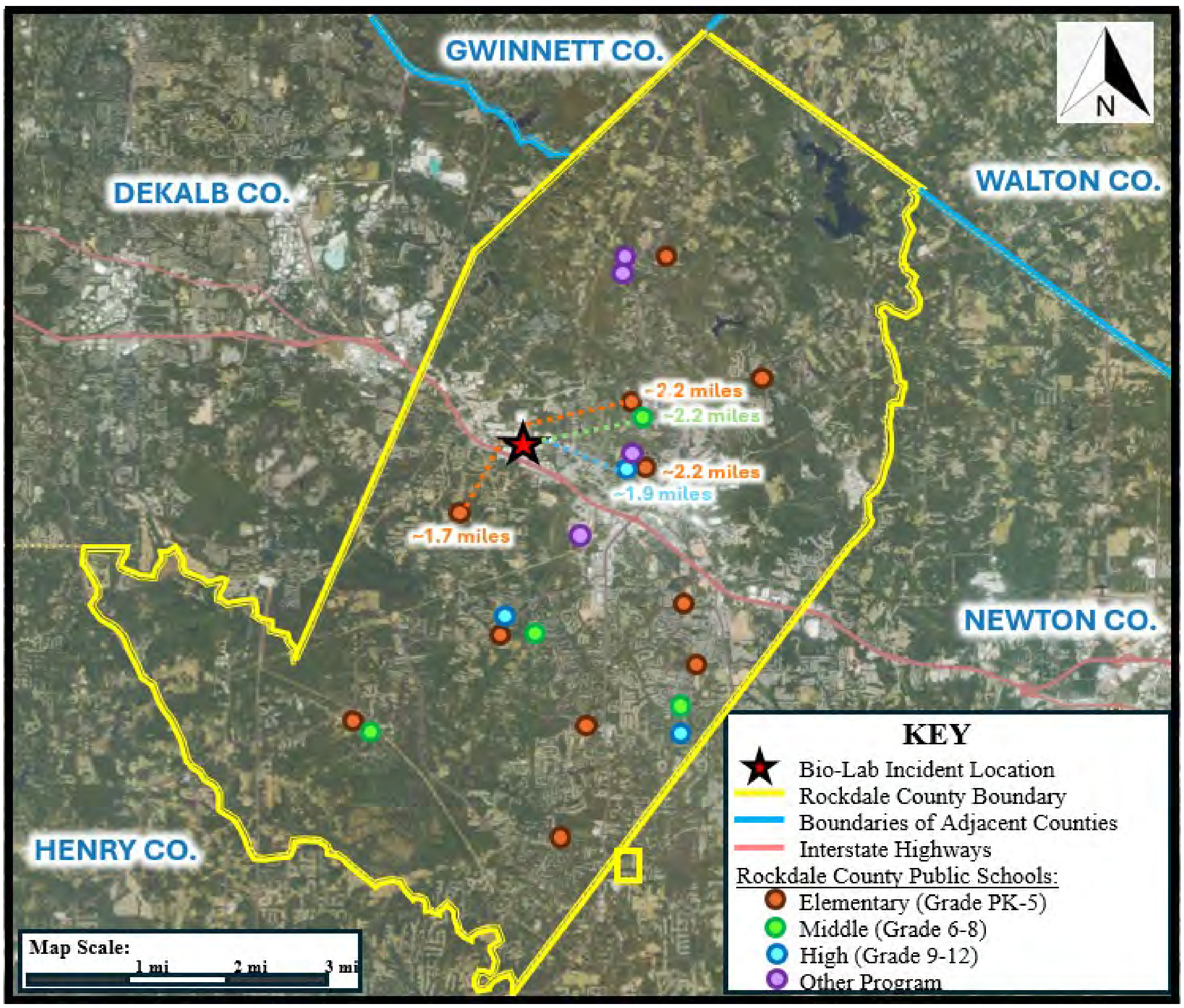


Figure 27. Location of Bio-Lab Conyers relative to Rockdale County Schools. At least five of these are within 2 miles of the facility. (Credit: CSB)[b]

[a] Additionally, other academic facilities were also within 2 miles of Bio-Lab Conyers.

[b] Locations and categorization of schools based on information available on individual school profile pages at: [Home - Rockdale County Public Schools](#).

After the incident, multiple Conyers community members reported "black, charred" material on their properties consistent with "burned structural debris" that was dispersed as far as approximately 2 miles from the site during the fire [44]. In 2025, independent analytical testing conducted by Apex Laboratories, LLC, for a non-CSB investigation of the Conyers incident confirmed the presence of multiple volatile organic compounds, semi-volatile compounds, dioxins, and furans that may be associated with potential adverse human health implications.[a,b]

EPA also performed community air monitoring from September 30, 2024 through October 17, 2024, and shared the collected data with the public on a dedicated webpage for the incident response.[c] Based on the EPA 12-hour air monitoring results from the duration of the emergency response phase, chlorine and hydrogen chloride were detected at concentrations above their respective Level 1 Acute Exposure Guideline Level (AEGL-1) intermittently during overnight 5:00 p.m. to 5:00 a.m. periods on September 30 to October 1, 2024, and from October 1 to October 2, 2024.[d]

The AEGL-1 is a screening value developed by EPA for use by emergency responders during active release events to help predict potential impacts on the public, including sensitive and vulnerable populations. The highest chlorine detections were recorded the night of September 30 to October 1, 2024, between 12:00 a.m. and 3:00 a.m. at a monitoring station located immediately southeast and downwind of the site, with a maximum detection of 31.20 parts per million (ppm) and an hourly average concentration of 10.7 ppm during this period, versus the 0.5 ppm AEGL-1 hourly average action level.[e] The maximum hydrogen chloride detection for this same air monitoring station was 15.5 ppm measured at 12:45 a.m. and an hourly average of 2.15 ppm (measured between 1:00 and 2:00 a.m.), versus an hourly average AEGL-1 action level of 1.8 ppm. During the final day of air monitoring conducted by EPA on October 17, 2024, low-level chlorine detections were observed at all 11 monitoring stations in the site vicinity. At the conclusion of the emergency response phase, 1-hour average chlorine concentrations at all monitoring sites remained well below the AEGL-1 action level of 0.5 ppm as 1-hour average.

An independent study conducted by the Georgia Institute of Technology (Georgia Tech) from September 30 to October 15, 2024, used chemical ionization mass spectrometry in Conyers and Midtown Atlanta, approximately 21 miles from Conyers, to characterize the gas phase composition of the plume initiated by the decompositions and fires at Bio-Lab Conyers [45].[f] According to the study report released by Georgia Tech,

---

[a] The 2025 Apex Lab analytical testing was conducted and retained by an external third-party to assist in their non-CSB "investigation into the explosion/fire." The CSB did not commission or participate in this work.

[b] One of the dioxins detected was 2,3,7,8-TCDD, which is a chlorinated dibenzo-p-dioxin (CDD) recognized by the Agency for Toxic Substances and Disease Registry (ATSDR) as "the most toxic of the CDDs and is the one most studied" and commonly released into the air in emissions from incineration of municipal and industrial solid waste. Dioxins are mainly formed during incomplete combustion and are commonly detected in the air emissions from most fires, with the amounts produced depending on the type and amount of material involved in the fire.

[c] EPA's Bio-Lab Fire website can be found at: [Conyers, GA: Bio-Lab Fire | US EPA]

[d] EPA defines three levels of AEGL. Level 1 is the concentration resulting in "[n]otable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure." Additional information is available at: https://www.epa.gov/aegl/about-acute-exposure-guideline-levels-aegls.

[e] Chlorine is recognized as "potent irritant in humans to the eyes, the upper respiratory tract, and the lungs" with "itching of the nose and cough, stinging, or dryness of the nose and throat [occurring] at 0.06 to 0.3 ppm" [6, p. 1].

[f] "[H]igh-resolution time-of -flight chemical ionization mass spectrometry (HR-TOF-CIMS)" was used in Midtown Atlanta from September 30 to October 9, 2024, and a quadrupole chemical ionization mass spectrometry was used in Conyers from October 3 to October 15, 2024.

"Twenty-six species were identified, including reactive nitrogen-containing compounds (e.g., HNCO, cyanoacetic acid, and cyanamide) and oxygenated volatile organic compounds," many having potentially adverse health effects. The study also found "unexpectedly high" concentrations of bromine and elevated levels of isocyanic acid, cyanic acid, fulminic acid, and numerous other compounds were observed by the study [45].

2.5.3 SITE CLEAN-UP AND REMEDIATION

In the months following the incident, KIK continued to clean up and remediate the incident scene to eliminate associated environmental risks, including metals and other chemicals released from the debris (**Figure 28**).[a] The company implemented on-site containment, collection, sampling, and disposal measures for water generated or present as a result of firefighting and weather events, per the requirements of the Georgia Environmental Protection Division to prevent off-site migration. The concrete building pad was the only remaining portion of the warehouse at the completion of site clean-up activities (**Figure 29**). Bio-Lab, Inc./KIK estimated approximately $50,500,000 in losses of inventory and fixed assets resulting from the incident.

Figure 28. Surface water runoff of metals from rusting structural debris (left) and residual chemicals (right) on the former warehouse's concrete slab. (Credit: KIK)[b]

[a] This site cleanup and remediation began immediately.

[b] KIK managed the collection, sampling, and disposal of surface water runoff at the site.

Figure 29. Concrete slab where the Plant 12 Storage Warehouse was located before the 2024 Bio-Lab Conyers incident. (Credit: KIK, annotated by CSB)

On May 15, 2025, KIK publicly announced that it had completed remediation of the Conyers site affected by the September 2024 incident and was ceasing all storage and manufacturing operations of the Bio-Lab Conyers manufacturing facility, where the Plant 12 Storage Warehouse was located (**Figure 2**) [46].[a] However, according to the company's public announcement, the Bio-Lab Conyers distribution centers located less than a mile from the main facility where the September 2024 incident occurred would continue to operate. Following KIK's decision to close the Bio-Lab Conyers manufacturing facility, the company listed the entire facility for sale on January 27, 2026.[b] According to KIK, the facility remains listed for sale as of the date of this report. Although some of the Conyers facility's operational capacity was picked up by another Bio-Lab facility (Bio-Lab On-Cal, located in California), which has similar processes, some of the site's former blending and packaging operations have been outsourced to multiple tolling facilities located in California, Georgia, Michigan, and West Virginia.

[a] https://biolabcommunityresources.com/updates/

[b] The distribution centers near the manufacturing facility are not included in the sale.

3 Technical Analysis

3.1 Identifying the Initiating Water Source

Both fire watch employees (Employees A and B) onsite at the time of the September 29, 2024, incident stated to RCFR dispatchers and first responders that the source of the water that initiated the off-gassing was a sprinkler head that sprinkler head that burst, which is consistent with their communications to Bio-Lab management at the time of the incident. However, as described in **Section 2.2**, Employee A later informed the CSB that the water could have been coming from the ceiling, and KIK asserted that the company believed the water source was a roof leak from the rainfall from the hurricane that had recently passed through the region. The CSB did not agree with this view and conducted an analysis to determine the most likely source of the water that initiated the incident.

3.1.1 Roof Leaks

As described in **Section 1.3.1**, the Plant 12 Storage Warehouse roof system, installed in late 2019 during the original building construction, consisted of a three-layer system of waterproof plastic membrane and insulation board installed over a metal roof deck. The building owner coordinated annual inspections and routine preventative maintenance in accordance with the requirements of the 15-year roof warranty, and maintained documentation of the roof's service and performance history. Roof penetrations represent areas of elevated risk for potential leaks because these are locations where the three-layer roof system was deliberately compromised to allow the installation of supporting utilities. Penetrations throughout the 274,750-square-foot Plant 12 metal roof deck, representing potential points of elevated risk for leaks, included one Heating, Ventilation, and Air Conditioning unit, two small exhaust fans, 10 heater vent pipes, and one standing plumbing pipe. **Figure 30** shows a typical roof penetration associated with heater vent outlet piping at the Plant 12 Storage Warehouse.

Figure 30. Roof penetration at the Plant 12 Storage Warehouse. (Credit: ARCO)

There were five documented instances of roof leaks between the completion of the Bio-Lab Conyers Plant 12 Storage Warehouse's construction in late 2019 and the September 2024 incident. **Table 8** summarizes the previous roof leaks at the storage warehouse.

Table 8. Summary of documented roof leaks at the storage warehouse

Date	Leak Description	Location
April 6, 2022	Leak reported to the building owner and repair service requested. A service technician repaired the leak with a heat-welded patch on the membrane.	Back wall at end of building opposite from bunker end
March 7, 2024	A "couple of leaks" reported, which the building owner repaired on March 11, 2024.	Not specified
Sept. 15, 2024[a]	Employee reported to the plant Telegram App ERT channel[b] that they discovered a roof leak.	Near dock door #5
Sept. 26, 2024	Leak discovered during fire watch during Hurricane Helene's passage through the region.	"In front of recv2," which is outside bunker
Sept. 27, 2024	Leak discovered during fire watch during Hurricane Helene's passage through the region.	"By door P3"

Figure 31 shows the location of the roof leaks documented in September 2024, with the adjacent storage area containing super sacks of inert raw materials indicated in aqua. **Figure 32** show the location and severity of each of the three roof leaks documented in September 2024, with the puddle extent of each outlined in blue.

[a] KIK did not produce any documentation demonstrating that the roof leak discovered on September 15 was either reported to or repaired by the building owner.

[b] *See* **Section 2.2** for information on Bio-Lab Conyers use of Telegram.

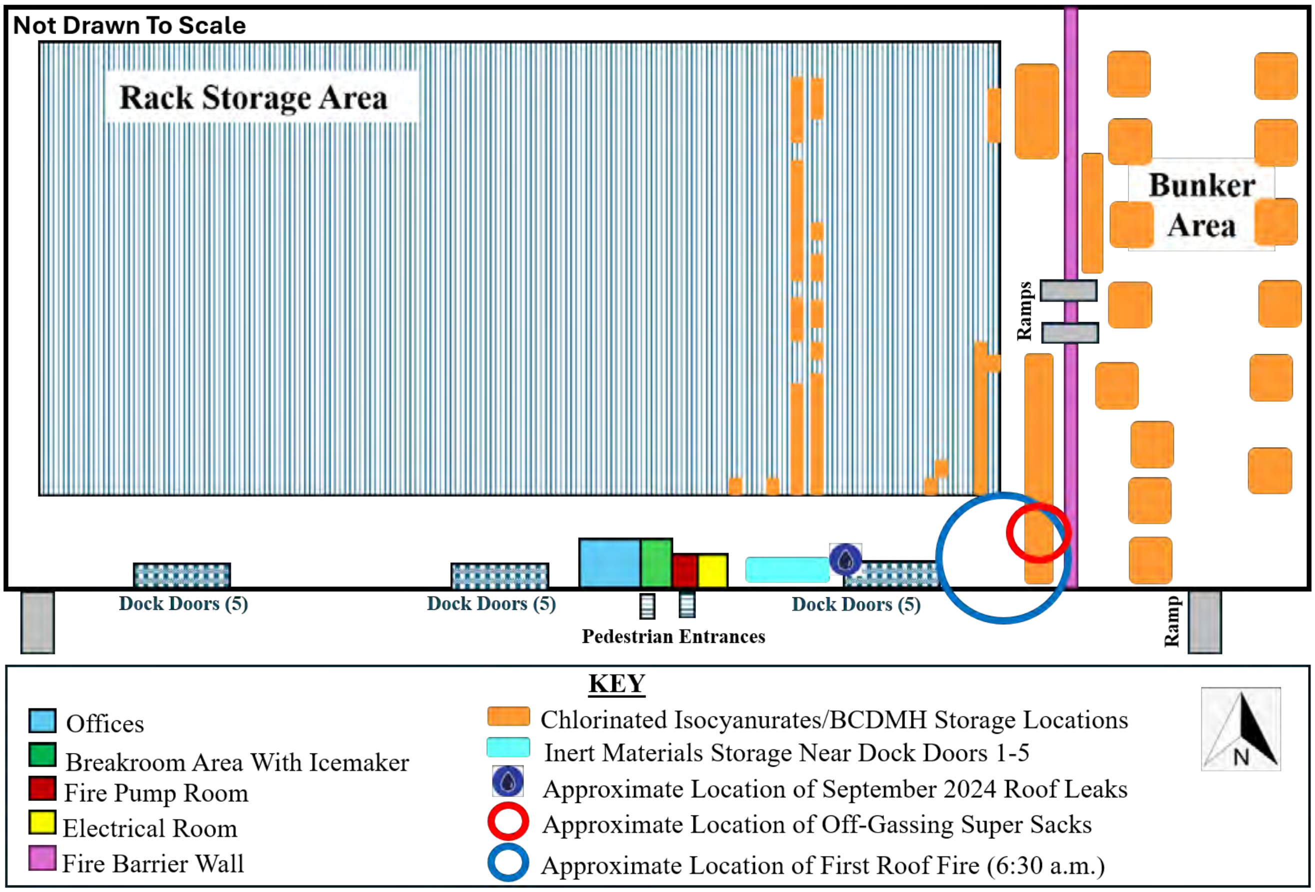


Figure 31. Location of roof leaks discovered in the Plant 12 Storage Warehouse on September 15, 26, and 27, 2024. (Credit: CSB)

Figure 32. Roof leaks discovered in the Plant 12 Storage Warehouse on September 15, 26, and 27, 2024, with each puddle extent outlined in blue. (Credit: KIK, annotated by CSB)

Based on KIK employees' descriptions, the leaks discovered in September 2024 were located at the roof penetrations associated with the exhaust piping from two roof-mounted heaters located near the easternmost set of dock doors. The super sacks (**Figure 32**) located in the bulk storage area near the dock doors (**Figure 31**, shown in aqua) contained materials such as sodium bicarbonate and soda ash, and did not contain any chlorinated isocyanurates, according to building inventory records. If these materials had been chlorinated isocyanurates, the heat from the fire and associated fire water usage by RCFR would have also off-gassed during the extended emergency response phase, along with the other chlorinated isocyanurates (*see* **Section 1.2.1**). That did not happen. **Figure 33** shows the inert material super sacks adjacent to the dock doors (aqua box) and interior building heater (yellow box) associated with the September 2024 roof leaks. Although the super sacks containing sodium bicarbonate, soda ash, and other inert materials experienced some external damage from the fire, as shown in the **Figure 33** photo, which was taken on October 14, 2024, they remained largely intact post-incident.

Figure 33. Super sacks located adjacent to the dock door (indicated by aqua box) and heater (indicated by yellow box) with the leaking vent penetration post-incident on October 14, 2024. (Credit: CSB)

Ten inches of rainfall were recorded between September 26 and 27, 2024,[a] yet the KIK employees assigned to onsite fire watch during the storm described the leaks as consisting only of small quantities of water controlled in 5-gallon buckets and producing a low volume of water. KIK employees told the CSB that these leaks were minor enough that it "took a while for it just to cover the bottom of the bucket." No other roof leaks at the warehouse were documented during Hurricane Helene, and there was no additional rainfall within the 36 hours prior to the incident on September 29, 2024.[b] Large volumes of water running out of the dock doors were also observed by KIK employees and responders prior to the application of firefighting water by RCFR (*see* **Section 2.2**).

The CSB concludes that although minor roof leaks, as described by KIK employees, were documented during Hurricane Helene, it is unlikely that the leaks provided the water source that initiated the incident. Rainfall had also ceased over 36 hours before the incident occurred.

3.1.2 Sprinkler System Failures as Water Source

Closed super sacks of bulk chlorinated isocyanurates will allow natural off-gassing of chlorine fumes under ambient conditions in storage, with higher rates under hot or humid conditions. The average relative humidity in Conyers, Georgia, from May to October generally ranges between 64% and 70%, indicating high moisture

[a] The previously referenced weather station in Conyers measures rainfall only and is considered more representative of conditions experienced at Bio-Lab Conyers.

[b] The rain ended on the morning of Friday, September 27, 2024.

levels.[a] Oxidizers combined with moisture cause metal corrosion. In this case, chlorine fumes combine with the ambient moisture in the air to produce highly corrosive droplets of hydrochloric acid (HCl) [47], which condense onto the metal surfaces in the building. HCl is not only reactive with water (*see* **Section 3.2**) but can "cause corrosive injury to all exposed body tissues" and is also "corrosive to metals," including brass and other materials [15, p. 4, 16]. The production of HCl condensate damages building components such as the fire protection system in the Plant 12 Storage Warehouse, resulting in the premature corrosion of these systems even after short periods of chlorinated isocyanurates storage (*see* **Section 3.1.2.1**). As a result of these processes, the Plant 12 Storage Warehouse at the Bio-Lab Conyers facility regularly experienced corrosion damage and the resulting failure of its fire protection system components (*see* **Section 3.1.2.2** and **Section 3.1.2.3**). Multiple fire protection system component failures occurred at the warehouse in the weeks leading up to the September 29, 2024, incident, and a sprinkler head failure was reported as the water source that initiated the incident (*see* **Section 3.1.2.4**).

3.1.2.1 Corrosion Damage to the Sprinkle System

The impact of storing chlorinated isocyanurates in the storage warehouse became visible shortly after Bio-Lab Conyers started using the new warehouse building in 2019, nearly five years before the September 2024 incident. TCCA storage began in the Plant 12 Storage Warehouse bunker on November 5, 2019. Building construction personnel observed corroded sprinkler heads in the warehouse by December 31, 2019. They also observed leaks from piping when the bolts supporting the sprinkler system became "prematurely rusted" after only 2 months of storage. Specification sheets for the fire protection system construction indicate that the sprinkler heads were constructed of brass and steel, and the fire protection system piping was steel. As described previously, chlorine fumes that are naturally off-gassed through super sacks of chlorinated isocyanurates combine with ambient humidity and condense as hydrochloric acid (HCl) droplets on metal surfaces. HCl causes severe corrosion of most common metals, resulting in pitting corrosion and stress corrosion cracking of stainless steel [48, p. 2]. Such premature corrosion resulted in the first sprinkler system component failure at the warehouse on December 30, 2019, when bolts on the fire water piping corroded through, as shown in **Figure 34**.

[a] The EPA recommends keeping indoor relative humidity below 60%.

Figure 34. Failed fire protection piping coupling, pictured on December 30, 2019, due to bolt failure [left], and corroded cross-section of failed bolt [right]. (Credit: ARCO)

The 2021 risk assessment, performed on behalf of KIK's insurance company[a], observed widespread and extensive fire protection piping and sprinkler system corrosion in four other Bio-Lab Conyers buildings at the facility, including Plant 6, which involved TCCA-based formulations that the CSB investigated in 2020 (*see* **Section 1.4.1**). The 2021 risk assessment indicated that Plant 6's building's fire protection system was completely out of service and required complete replacement of sprinklers and branch lines due to corrosion damage at that time. It is unknown how long Plant 6's building's sprinkler system was out of service in total. At the time of an ensuing 2022 insurance risk assessment, Plant 6 was empty in preparation for the upcoming replacement of the corrosion-damaged sprinkler system and the roofing.

After the September 2024 incident, Bio-Lab Conyers began removing all remaining oxidizer from the facility and storing the material in a third-party warehouse in Texas as of November 2024. In February 2025, CSB investigators visited the third-party warehouse in Texas, where they noted a strong chlorine smell in the building and observed visible corrosion on the fire protection system piping at the facility, including rusty drip marks from the piping's exterior on the floor and super sacks below. Employees of the third-party warehouse told the CSB that the corrosion observed was a "very recent issue" at the building.

[a] The 2021 and 2022 insurance risk assessments are independent reports, separate from the required NFPA 25 annual inspections.

The CSB concludes that the natural off-gassing of chlorine fumes from the storage of chlorinated isocyanurates reacted with the ambient moisture in the air to produce hydrochloric acid droplets, which condensed on metal surfaces, such as sprinklers and fire protection system piping. As hydrochloric acid caused severe corrosion of most common metals, this process resulted in damage to the fire protection system components within a few months after the start of chlorinated isocyanurates storage in a building.

3.1.2.2 Sprinkler Corrosion Deficiency Observations

Bio-Lab Conyers experienced frequent recurrent failures associated with corroding components of the Plant 12 Storage Warehouse's fire protection system (*see* **Section 3.1.2.3**). NFPA 25 *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* (NFPA 25) provides the inspection requirements for sprinkler systems installed in accordance with NFPA 13 *Standard for the Installation of Sprinkler Systems* (NFPA 13) [49, pp. 25-18 and 25-19]. NFPA 25 requires annual inspection of sprinklers, pipes and fittings, and hangers/braces/supports for water-based fire protection systems installed per NFPA 13 to ensure that these systems are maintained in good working order [49, pp. 25-18].

Corroded sprinkler heads were documented by the Bio-Lab Conyers fire protection contractor as deficiencies in both the 2021 and 2022 Annual Sprinkler Inspection reports, where the chlorinated isocyanurates were stored.[a] NFPA defines deficiencies as "a condition that will or has the potential to adversely impact the performance of a system or portion thereof, but does not rise to the level of an impairment" [49, pp. 25-9]. **Figure 35** shows the sprinkler deficiencies observed during the annual fire protection system inspections performed in 2021 and 2022, where "Powder Storage" refers to the bunker area.[b] The CSB was informed that the oxidizers were previously stored in the bunker. Both the 2021 and 2022 inspection reports identified more than 500 corroded or rusty heads in "Powder Storage".

[a] Corroded or rusty heads were documented in Powder Storage in the 2021 and 2022 inspection reports.
[b] Management at Bio-Lab Conyers referred to the TCCA as "powder."

Sprinkler Deficiencies **Date: 11/9/2021**

STE/FLR	QTY	ISSUE	DESCRIPTION
Powder Storage	560	CH	VK503 ESFR 30' AFF
Head Cabinet			There are no ESFR installed.
Fire Protection Vault	2		

Sprinkler Deficiencies **Date: 12/7/2022**

STE/FLR	QTY	ISSUE	DESCRIPTION
Powder Storage	560	CH	VK503 ESFR 30' AFF These heads appear to be corroded. A closer
			inspection is needed for an accurate found and severity of corrosion.
Fire Protection Vault	2		OS&Y control valves are unsecured.

LEGEND

PH= Painted Head	TH= Taped Head	OR= Orientation
PP= Painted or Caulked Plate	CH= Corroded or Rusty Head	DH= Damaged Head
RP= Replacement Program Head	LH= Loaded Head	MR= Mixed Response
RE= Recut Head	MT= Mixed Temperature	OB= Obstructed Head

Figure 35. Sprinkler deficiencies documented in the 2021 and 2022 Annual Fire Sprinkler Inspection reports. (Credit: KIK, date annotation and image composited by CSB)

During both 2021 and 2022 Annual Sprinkler Inspections (**Figure 35**), corrosion was visually observed by the inspector on 560 sprinkler heads within the bunker,[a] as documented on the inspection reports, and no deficiencies were documented outside of the bunker at that time. Following these observed deficiencies, Bio-Lab Conyers replaced the original brass-finish sprinkler heads installed inside the bunker with wax-coated corrosion-resistant sprinkler heads in November 2022. In 2023, the original fire protection piping couplings and bolts within the bunker were also replaced. Additionally, over 300 brass-finished K17 ESFR sprinkler heads outside the bunker were replaced in-kind around August/September 2023.

Bio-Lab Conyers management stated that no further leaks were reported in the bunker after the replacement with corrosion-resistant sprinkler heads. However, KIK employees on-site reported observing corrosion in other areas of the warehouse when the facility began storing chlorinated isocyanurates outside the bunker, which led to multiple sprinkler head failures and leaks where the fire protection piping and pipe couplings were corroded. **Figure 36** shows the sprinkler deficiencies observed during the December 28, 2023 annual fire protection system inspection after the sprinkler system component upgrades in the bunker and K17 ESFR sprinkler head replacements outside the bunker. The location of these deficiencies is shown by the yellow shading in **Figure 37**. These deficiencies are depicted as vertical bands, as the sprinkler inspector identified the row where the deficiencies were observed, but the specific sprinkler head was not identified within the row. All of the deficiencies were outside the bunker in locations where the oxidizers were stored.

[a] Noted as "Powder Storage" in the Annual Sprinkler Inspection reports

STE/FLR	QTY	ISSUE	DESCRIPTION
Risers 7&6	384	CH	Corroded chr pendent heads 3/4" 286 east end warehouse
Risers 7&6	112	CH	Corroded br Upright heads 3/4" 286 east end warehouse
Riser 6	1	CH	Corroded 3/4" 286 br ESFR pendent head aisle A
Riser 5	486	CH	Corroded and painted 3/4" 286 br ESFR pendent heads aisles E-P
Riser 4	141	CH	Corroded and painted 3/4" 286 br ESFR pendent heads aisles Q-S-T
Riser 3	1	PH	Painted 3/4" 286 br ESFR pendent head aisle DD
Riser 2	1	PH	Painted 3/4" 286 br ESFR pendent head aisle UU

Sprinkler Deficiencies Date: 12/28/2023

LEGEND

PH= Painted Head
PP= Painted or Caulked Plate
RP= Replacement Program Head
RE= Recut Head
TH= Taped Head
CH= Corroded or Rusty Head
LH= Loaded Head
MT= Mixed Temperature
OR= Orientation
DH= Damaged Head
MR= Mixed Response
OB= Obstructed Head

Figure 36. Sprinkler deficiencies documented in the 2023 Annual Fire Sprinkler Inspection report. (Credit: KIK, date annotation and image composited by CSB)

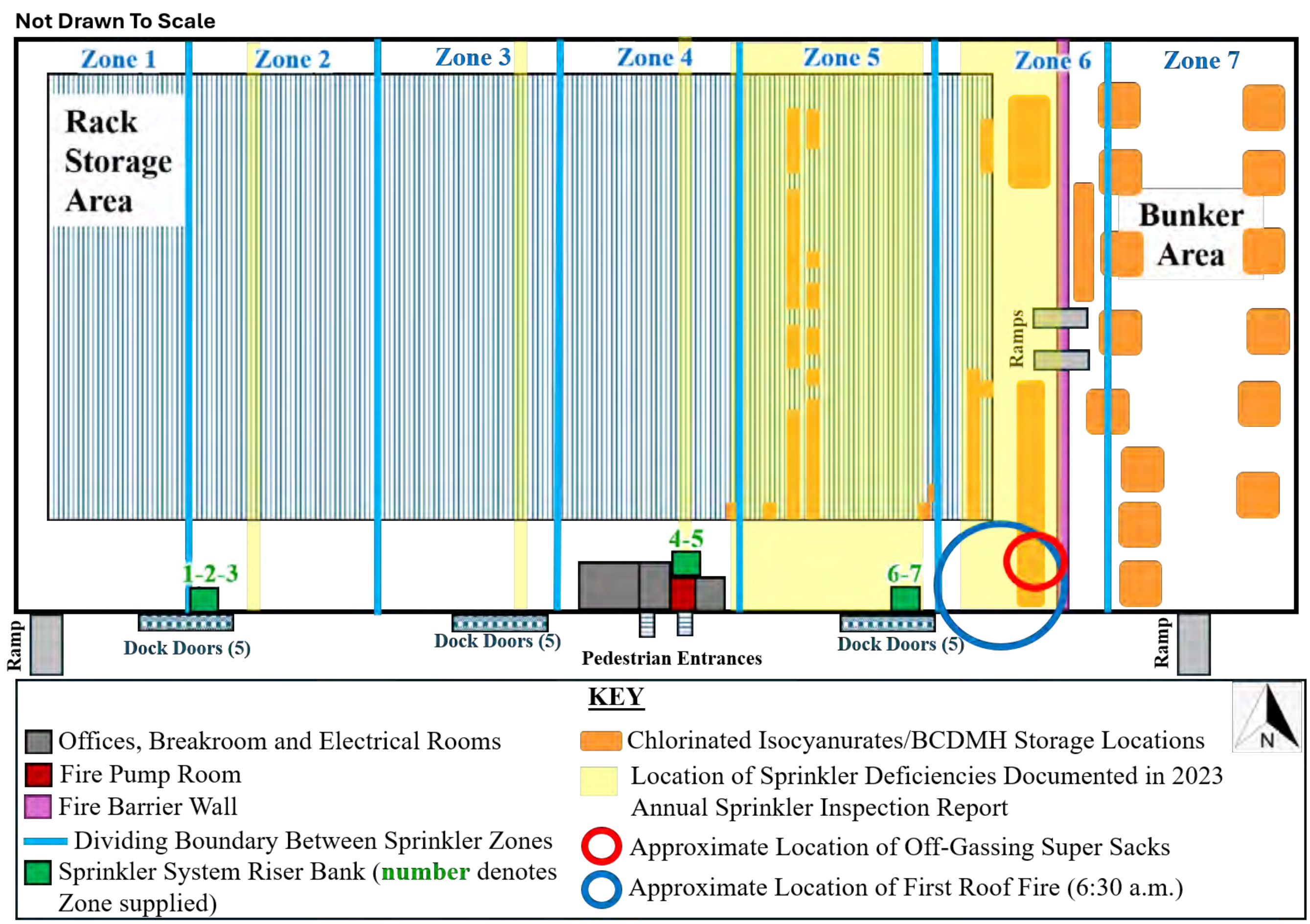


Figure 37. Fire protection zone locations and illustration of 2023 sprinkler deficiencies. (Credit: CSB)

During the December 28, 2023, annual fire protection system inspection performed for the building, no deficiencies were documented in 2023 within the bunker following the sprinkler upgrades to improve corrosion resistance. Although corrosion associated with "Risers 7&6" was documented due to the side-by-side location of these two pipes, the location of the corroded heads was documented as the "east end of warehouse" and not "powder storage" bunker, as in the previous year. The riser is the above-ground horizontal or vertical pipe between the water supply and the fire piping and sprinkler zone it supplies with water [49, pp. 25-12]. All sprinkler heads outside the bunker were ceiling-mounted. Overall, widespread corrosion of 1,124 sprinkler heads outside the bunker was visually observed across four of the seven zones of the fire protection system.

At the time of the incident, most of the sprinkler heads outside the bunker were still brass-finish heads, as specified and installed during the construction of the storage warehouse in 2019 and in 2023. According to Bio-Lab Conyers, the corrosion-resistant sprinkler heads would not provide adequate fire protection for the warehouse rack storage. Therefore, corroded sprinkler heads outside the bunker were replaced in-kind as they developed a leak. As shown in **Figure 37**, the locations of chlorinated isocyanurates and BCDMH storage at the time of the event and the sprinkler deficiencies observed in 2023 are closely correlated. Prior to the December 2023 annual sprinkler inspection, all sprinkler deficiencies identified during the required annual inspection were listed as "Powder Storage." The December 2023 annual inspection of the storage warehouse was the first time that the inspector observed and documented sprinkler deficiencies, specifically outside of the bunker (**Figure 36**).

3.1.2.3 Sprinkler System Failure Frequency

The corrosion damage to the sprinkler system at the Plant 12 Storage Warehouse resulted in a high number of abnormal events recorded by the building's fire protection alarm monitoring system. Between January 1, 2023, and September 29, 2024, the fire protection system registered abnormal status in at least 60 of the 637 calendar days, or 9.6 percent. **Figure 38** shows the status of the fire protection system for the warehouse building from January 1, 2023, through the incident on September 29, 2024. No fire alarm monitoring logs were available for the period prior to January 1, 2023. In **Figure 38**, each block is color-coded to depict the first registered alarm code on each calendar day, and a white box indicates that the only alarm log entry is a normal system self-test confirmation.[a]

[a] For days with multiple alarm codes registered, the status shown is the first alarm code generated for the calendar day.

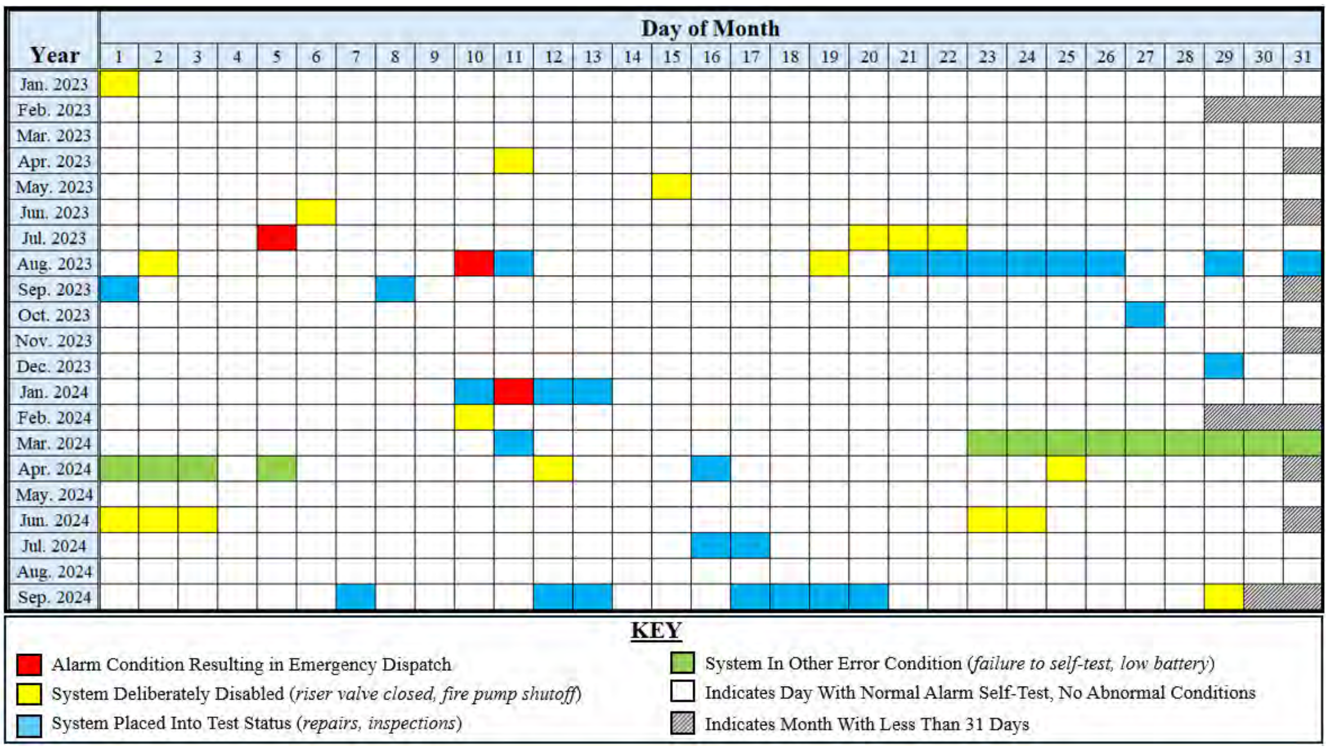


Figure 38. Daily fire alarm monitoring system status from January 1, 2023, through September 29, 2024. (Credit: CSB)

For 17 days, including the day of the September 29, 2024, incident, the fire protection system was deliberately disabled by an employee, either manually shutting off power to the fire pump or closing the riser valves. Risers are the above-ground horizontal or vertical pipes between the water supply and the fire piping and sprinkler zone it supplies with water [49, pp. 25-12]. The location of the risers relative to the seven sprinkler system zones is shown in **Figure 37**. KIK employees explained to the CSB that their standard practice for responding to a sprinkler system leak at the facility was to manually shut the riser valve to the sprinkler zone containing the leak, which was unsuccessful when the ERT personnel attempted to do so on September 29, 2024, as they were unable to access the riser. This approach was known to and approved of by Bio-Lab Conyers management and environmental and safety personnel, as indicated in the ERT's Telegram app chat logs.[a]

The system was placed into test status on 27 days for activities such as sprinkler system repairs or inspections. Placing the system into test status also occurred in situations where sprinkler leaks were identified, but Bio-Lab Conyers did not choose to shut off the fire pump and drain the system on September 29, 2024.

On 3 days, July 5, 2023, August 10, 2023, and January 17, 2024, the alarm condition resulted in the alarm monitoring system's supervisory dispatcher notifying the fire department to respond to an emergency based on a flow alarm. The alarm on July 5, 2023, was caused by the riser flow detection to Zone 6 of the warehouse, which was the first full fire protection zone immediately outside of the bunker. Although the supervisory dispatcher notified the fire department because they could not reach any of Bio-Lab Conyers' contacts, a Bio-Lab Conyers supervisor, who contacted the alarm system dispatcher 30 minutes after the initial alarm told them that a sprinkler system pipe failed. On August 10, 2023, a sprinkler head leak caused by the blowout of a 2-

[a] Telegram is a cloud-based messaging app with a focus on security and speed.

inch pipe coupling resulted in a water flow alarm to Fire Protection Zone 6. The alarm monitoring dispatcher was able to successfully contact a Bio-Lab Conyers supervisor to inquire whether assistance was required, and the resolution to the alarm was that the monitoring system dispatcher notified the local fire department to respond and assist. The event on January 17, 2024, was triggered by flow detection on the riser piping that supplied the zone, which protected both the bunker and the warehouse area immediately outside of the bunker (Zone 6). This event was caused by issues with a frozen 1-inch inspector's valve.

Not all sprinkler system leaks resulted in Bio-Lab employees turning off the fire pump or closing the riser valves, and this information would not have been captured in the fire alarm system monitoring logs and included in the analysis presented in **Figure 38**. For example, internal communications document that Bio-Lab employees and supervision decided not to disable the fire protection system during the sprinkler leak discovered the evening of September 17, 2024, at 5:57 p.m., and instead controlled the leaking water with a bucket. The test status shown in **Figure 38** for September 17, 2024, was associated with sprinkler repair work conducted during the workday hours, and the new failure was discovered after sprinkler technicians had departed the facility. Based on these observations, the frequency of fire protection system failures may have been higher than what is indicated by the sprinkler system alarm monitoring history.

3.1.2.4 Recent Sprinkler System Component Failures

In addition to the multiple sprinkler system component failures that occurred at the Plant 12 Storage Warehouse in the months leading up to the September 29, 2024, incident due to the corrosion of sprinkler system components, several failures occurred within just 2 weeks of the incident. Emergency repairs were performed to replace multiple corroded sprinkler heads on September 13, 2024, and again from September 17 through 20, 2024. The specific locations of the leaks caused by the corroded sprinkler heads on September 17, 18, and 20, 2024, inside the Plant 12 Storage Warehouse were not detailed on the provided replacement work ticket or other documentation. The sprinkler head leak on September 19 was communicated at 2:50 a.m. to the ERT as "another sprinkler head leaking in plant 12… [b]y dock door 1 in front of the ventilation fan." However, on September 17, 2024, at 5:57 p.m., a "Minor Sprinkler leak in bunker right by roll up door" was also documented in the telegram chat, although Bio-Lab Conyers stated that no further leaks were reported in the bunker after the replacement with corrosion-resistant sprinkler heads,[a] and it remains unclear if the leak was related to corrosion. **Figure 39** shows the location of the September 17 and 19 sprinkler leaks within the Plant 12 Storage Warehouse.

[a] On September 17, 2024, a KIK employee stated in the Telegram app ERT channel that they identified a "[m]inor leak in the bunker, right by [the] roll up door," and an ERT member placed a bucket in place to capture the "drip". No information is available on the proximity between this "Small leak" and the nearest chlorinated isocyanurate or BCDMH super sacks, or whether corrosion caused the leak.

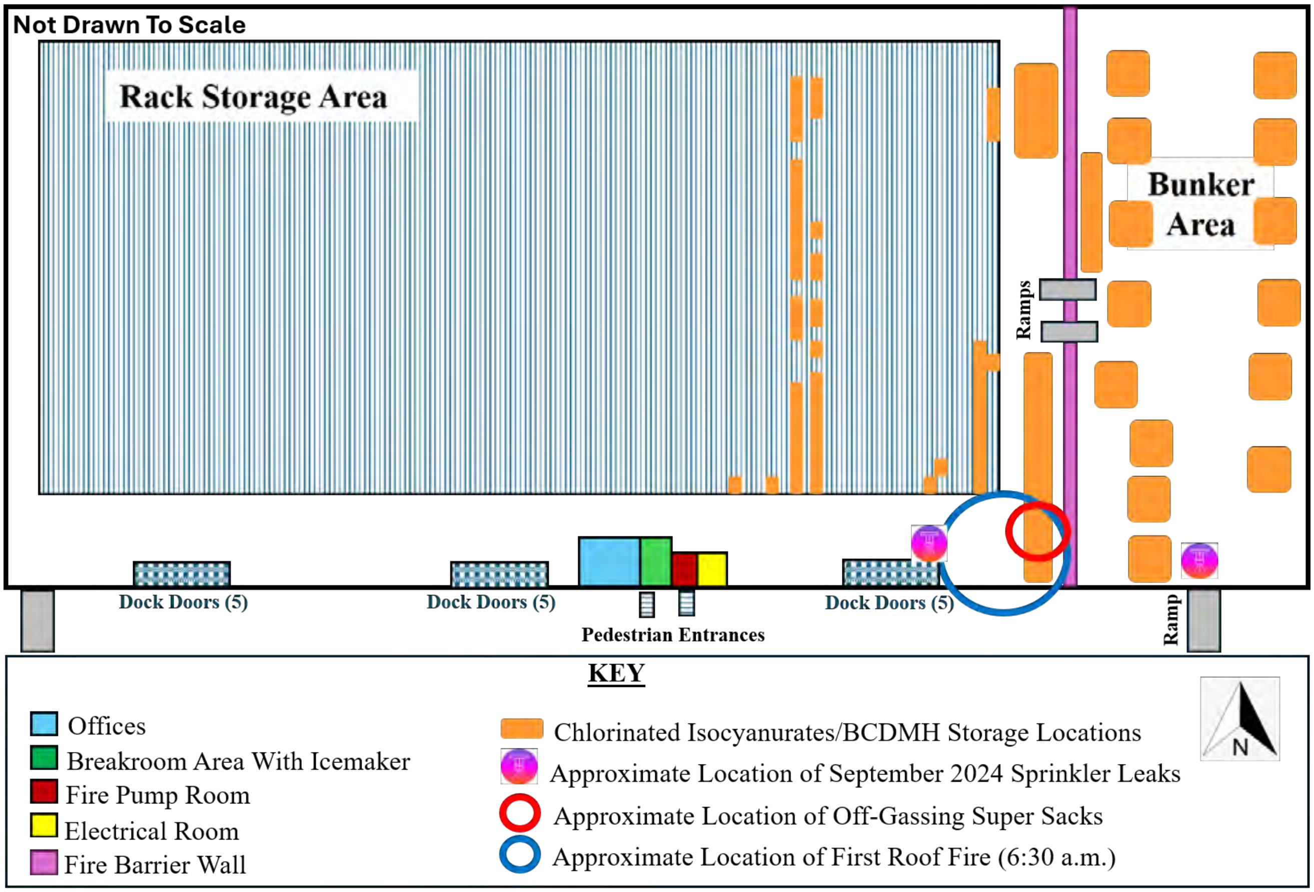


Figure 39. Location of sprinkler system leaks in the warehouse on September 17 and 19, 2024. (Credit: CSB)

The September 29, 2024, incident itself was initially reported to the 9-1-1 dispatcher at 5:12 a.m., as a "sprinkler head burst" and that "chemical smoke is everywhere." Then, at 6:19 a.m., Bio-Lab Conyers management notified KIK's Corporate EHS about the "Sprinkler head burst in plant 12. Over TCCA outside bunker…" The company's internal communications also documented that at 6: 31 a.m., "Smoker in PL12. Sprinkler head and water….", and at 8:05 a.m., as the "Root cause is sprinkler head rupture." At 8:57 a.m., the KIK's Leadership reported that the cause of the incident was "Unclear at this point." As described in **Section 2.2**, the KIK employee who called 9-1-1 later told the CSB that it could have been water off the ceiling.

The CSB concludes that, based on the initial KIK fire watch employee report to multiple parties and the well-established history of failures due to corrosion damage, and the flow of water observed before any firefighting water was applied, a sprinkler system component failure represents the most likely water source scenario for initiating the incident.

3.2 Reaction Byproducts of Chlorinated Isocyanurates

Although Bio-Lab Conyers managed the chlorinated isocyanurates stored in its warehouse solely based on their oxidizer characteristics, both the 2024 Bio-Lab Conyers incident and the previous incident history of these materials demonstrate that they also display other hazardous characteristics. Additionally, Bio-Lab, Inc. has been aware of TCCA's corrosive properties since at least 2010, as documented in one of its process hazard analyses.[a] Bio-Lab, Inc.'s SDS for TCCA, dated May 2015 and November 2020, also indicates that chlorinated isocyanurate is a corrosive hazard. Both revisions of the SDS occurred after KIK acquired Bio-Lab, Inc. in 2013.

In addition to reviewing hazard testing data collected by KIK, both before and after the 2024 incident, the CSB conducted its own testing program to further characterize the behavior of chlorinated isocyanurates when exposed to water.[b] Although KIK's testing in 2025 only analyzed dry materials, the CSB's testing characterized the time, temperature, and pressure relationships of exothermic events across a range of material-to-water concentration ratios. The CSB's full test reports are included in **Appendix E**.

Although the NFPA 400 heat of mixing water reactivity criteria in its Annex A requires a 1:1 ratio for comparison,[c] the Annex material is "informational" and not required [2, pp. 400-117].[d] The formal NFPA 400 definition of a water-reactive material is one that "explodes, violently reacts, produces flammable, toxic, or other hazardous gases or evolves enough heat to cause self-ignition or ignition of nearby combustibles upon exposure to water or moisture required" [2, pp. 400-17].[e]

When common chlorinated isocyanurates, such as TCCA and NaDCC, are exposed to small amounts of water or other contaminants, they can undergo a decomposition reaction, generate excess heat, and release toxic chlorine gas [50, 51] along with other hazardous gases.[f] Chlorine is a toxic substance immediately dangerous to life or health at a concentration of 10 parts per million (ppm) [52] and is "highly corrosive to all metals in the presence of any humidity factor" [9, p. 18]. NFPA 400 defines a corrosive material as "A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact" [2, pp. 400-16].[g] However, the details in the NFPA 400 informational Annex A state, "For purposes of this code, this term does not refer to action on inanimate surfaces (e.g., steel or aluminum)" [2, pp. 400-116].[h]

The CSB's testing program included characterizing the reaction products of chlorinated isocyanurates stored in the Bio-Lab Conyers warehouse upon exposure to water to determine the properties of the gases generated during material decomposition.[i] Gas Chromatography-Mass Spectrometry (GC-MS) and Fourier Transform Infrared Spectroscopy (FTIR) methodologies were used to identify and quantify the reaction products from the

[a] A Bio-Lab, Inc. Process Safety Analysis dated October 25 - 29, 2010 for the "TCCA Production Facility" at Lake Charles, Louisiana, identified "Corrosion to structural steel and piping" as a deviation under its global issues with the potential consequence of "external corrosion leading to structure and equipment failure." *See* **Section 1.2.1.1** for additional information on TCCA.

[b] The CSB commissioned a third party to conduct the analytical testing for its 2025 testing program.

[c] The NFPA 704 *Standard System for the Identification of the Hazards of Materials for Emergency Response*, states that "[t]he heat of mixing should be determined using a Two Drop Mixing Calorimeter… or "equivalent technique" using a 1:1 wt/wt [weight to weight] ratio of chemical to water" [146, pp. 704-21], although NFPA 400 does not specify a method for determining the water reactivity classification.

[d] The NFPA 400 Annex A definition for water-reactive materials is the same in the 2019 and 2025 editions.

[e] The NFPA 400 definition for water-reactive materials is the same in the 2019 and 2025 editions

[f] Confinement, including closed vessels, closed containers, or self-confinement by bulk mass, may exacerbate decomposition reactions involving chlorinated isocyanurates.

[g] The NFPA 400 definition for a corrosive material is the same in the 2013 and 2025 editions.

[h] The NFPA 400 informational Annex A details for a corrosive material are the same in the 2013 and 2025 editions.

[i] As discussed in **Section 2.5.2**, an additional independent study has also been conducted of the plume released from the Bio-Lab 2024 incident.

"worst-case" test run.[a] The worst-case scenario in which the highest temperature rises occurred typically corresponded to a 2:1 material-to-water ratio for the 100% TCCA formulation, but was 2.5 g:0.5 g for the other four materials tested. The GC-MS and FTIR data also detected at least seven released reaction gases, including HCl and carbon monoxide.[b] Both colorless gases are either toxic or flammable. HCl is particularly corrosive to metals and body tissues [15, p. 4, 16] and can irritate the eyes and respiratory system [16]. **Table 9** and **Table 10** summarize these results for the two TCCA formulations, NaDCC, and NaDCC dihydrate, by GC-MS and FTIR methodologies, respectively. Expanded versions of these tables, including the full test reports for the characterization of the resulting reaction gases, and all detections below the 5 percent threshold are included in **Appendix E** and **Appendix F**.

Table 9. Summary of constituents detected by GC-MS analysis in gases generated during the reaction of TCCA (94% and 100%), NaDCC, and NaDCC dihydrate with water.[c]

Constituents Detected Post-Reaction in Sampled Gas	Sample Material				Characteristics of Gases Detected and Source
	TCCA (~94%)	TCCA (~100%)	NaDCC	NaDCC Dihydrate	
Results for Gas Analysis Conducted by GC-MS (% of total peak area for sample)[1]					
• Acetone	—	—	◈ (Gray)	◈ (Blue)	**Flammable** [53, p. 1]
Carbon dioxide, and adjacent peaks[2]					
• Carbon Dioxide, Dimethylamine, Methyl-hydrazine	◈ (Purple)	—	—	—	**Flammable** [54, p. 1] **Poison/Toxic**, **Flammable** [55, p. 1]
• Carbon Dioxide, Dimethylamine, 2-hydroxy-Propanamide	—	◈ (Orange)	—	—	**Flammable** [54, p. 1] **Poison/Toxic** [56, p. 12]
• Carbon Dioxide, Ethanolamine, Methyl-hydrazine	—	—	◈ (Purple)	—	**Poison/Toxic** [57, p. 1] **Poison/Toxic**, **Flammable** [55, p. 1]
• Carbon Dioxide, Methyl-hydrazine, Nitrous Oxide	—	—	—	◈ (Purple)	**Poison/Toxic**, **Flammable** [55, p. 1]
Carbon monoxide, and adjacent peaks[2]					
• Carbon monoxide, Nitrogen	◈ (Blue)	—	—	—	**Poison/Toxic**, **Flammable** [58, p. 1]
• Carbon monoxide, Nitrogen, Ethylene	—	◈ (Purple)	◈ (Purple)	◈ (Blue)	**Poison/Toxic**, **Flammable** [58, p. 1] **Flammable** [59, p. 1]
• Hydrogen chloride	◈ (Purple)	◈ (Purple)	—	—	**Poison/Toxic**; **Corrosive** [16, p. 1]
• L-Homoserine	◈ (Orange)	—	—	—	**Skin/Eye/Respiratory Irritation** [60, p. 32]
• Propane, 2-chloro-2-nitro-	—	◈ (Orange)	—	—	**Flammable** [61, p. 1]

[1] Peak areas for the individual constituent, relative to total peak areas measured for sample (%): Purple diamond (◈) denotes percentages >20% of total for sample; Blue diamond (◈) denotes 10-20% of total for sample; Orange diamond (◈) denotes 5-10% of total for sample; and Gray diamond (◈) denotes <5% of total for sample.

[2] Indicates where multiple constituents were identified, but individual peak areas could not be determined for each due to the presence of multiple peaks in close proximity.

---

[a] For all materials tested in 2025, one test run was performed at a weight ratio of 1:1 (1.5 grams of chemical to 1.5 grams of water), to allow for a comparison with the NFPA's water reactivity criterion.

[b] The detected released reaction gases also included acetone, dimethylamine, methyl-hydrazine, ethanolamine, ethylene, l-homoserine, and methane.

[c] The CSB compiled **Table 9** from its third party's "Gas Analysis" reports, which can be found in **Appendix E**.

Table 10. Summary of constituents detected by FTIR analysis in gases generated during the reaction of TCCA (94% and 100%), NaDCC, and NaDCC dihydrate with water.[a]

Constituents Detected Post-Reaction in Sampled Gas[1]	Sample Material				Characteristics of Gases Detected and Source
	TCCA (~94%)	TCCA (~100%)	NaDCC	NaDCC Dihydrate	
Acetone	○	○	○	●	**Flammable** [53, p. 1]
Carbon Dioxide (CO_2)	●	●	●	●	Nontoxic [62, p. 1]
Carbon Monoxide (CO)	●	●	●	●	**Poison/Toxic**, **Flammable** [58, p. 1]
Ethylene	○	○	○	●	**Flammable** [59, p. 1]
Hydrogen Chloride	●	●	●	○	**Poison/Toxic**; **Corrosive** [16, p. 1]
Methane (CH_4)	●	○	○	●	**Flammable** [63, p. 1]
Water	●	●	●	●	Nontoxic [64, p. 1]

[1] Detections are denoted by the filled circle symbol (●) and non-detections by the empty circle symbol (○).

The CSB concludes:

1. Chlorinated isocyanurates stored inside the Bio-Lab Conyers Plant 12 Storage Warehouse generated significant heat and released hazardous gases when mixed with small amounts of water; therefore, these materials met the formal qualitative definition of water-reactive materials as defined by NFPA 400, and
2. When those chlorinated isocyanurates come into contact with water, they release several hazardous gases, including HCl, which is not only corrosive upon physical contact but can also create a corrosive atmosphere.[b]

The CSB also concludes that the chlorinated isocyanurates stored in the Plant 12 Storage Warehouse released corrosive HCl gas when they come into contact with water. As a result, when these materials are exposed to water/moisture under ambient conditions, they emit corrosive HCl vapors, which create a corrosive atmosphere that can corrode metal surfaces.

3.3 Incident Progression

Several factors that occurred at Bio-Lab Conyers on September 29, 2024, contributed to the development of the incident.

As discussed in **Section 1.3.4**, in the Plant 12 Storage Warehouse, oxidizers were stored in woven propylene super sacks with a top and bottom neck for filling and discharge and were equipped with a polyethylene liner (also known as a plastic insert) closed on top with a sewn cord (**Figure 40**).

[a] The CSB compiled **Table 10** from its third party's "Gas Analysis" reports, which can be found in **Appendix E**.

[b] NFPA 70 states that a corrosive atmosphere includes the presence of corrosive gases or vapors, or other corrosive conditions [93, pp. 70-566].

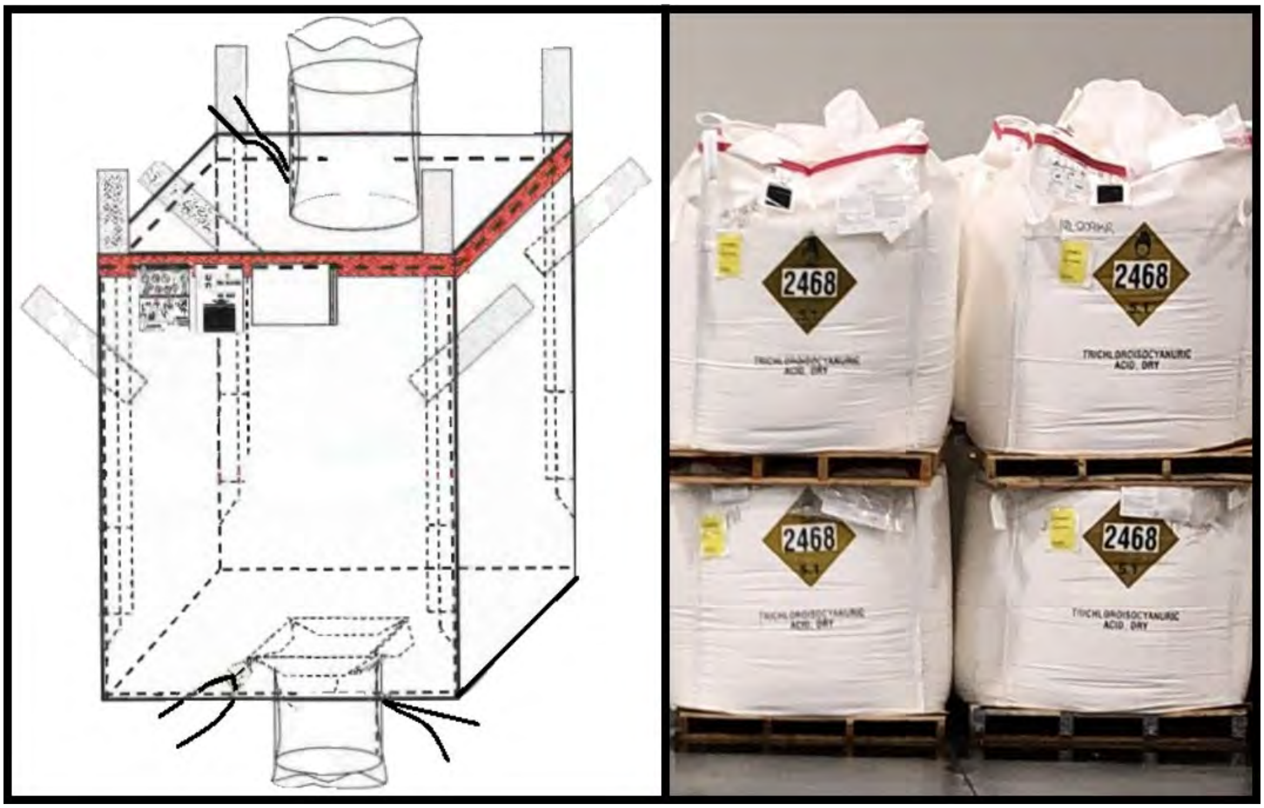


Figure 40. Design of the super sacks used in Plant 12 Storage Warehouse (left), and exemplar super sack used at Plant 12 Storage Warehouse (right). (Credit: Bio-Lab and ARCO, modified by CSB)

However, the outer super sack fabric (woven polypropylene) is not waterproof. Because the bags are not sealed, there's an opportunity for moisture in the air to enter the bags, contact the chlorinated isocyanurates, and cause them to release corrosive vapors, such as HCl, as stated in **Section 1.2.3**. These corrosive vapors create a corrosive atmosphere that can corrode metals in the area, such as the sprinkler system. Corrosion of a sprinkler system can cause failures, resulting in water leaking onto bags stored below it. Once wetted, the material in the super sacks underwent a decomposition reaction, producing toxic vapors described by employees as "dense white clouds" coming from the "off-gassing bags" (*see* **Section 2.2**).

Subsequently, the heat generated by the decomposing chlorinated isocyanurates initiated the decomposition of the adjacent super sacks, which also contained chlorinated isocyanurates, and ignited the wood pallets used to support them (**Figure 44**). Once the wood pallets ignited, a "single-point-heat-source" fire developed (**Figure 44**).[a] The heat generated from the fire and decomposing materials was enough to ignite the roof membrane, resulting in the first visible building fire on the roof around 6:30 a.m. (**Figure 41**).[b]

[a] RCFR confirmed seeing a fire inside the building outside the bunker before the first roof fire and "a little glow coming from the roof."

[b] Based on experimental test performed on TPO roof membranes [155, pp. 15-16].

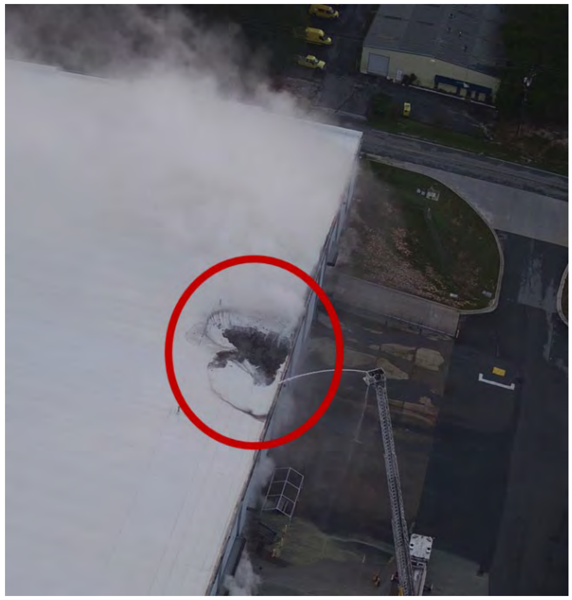


Figure 41. Location of the roof fire (red circle) resulting from the single-point heat source developed outside the bunker, in front of the fire barrier wall at Plant 12 Storage Warehouse. (Credit: CSB)

The heat generated by the decomposing materials and fire inside the building triggered additional sprinklers, wetting more super sacks and causing them to decompose and generate more heat. The resultant heat activated even more sprinklers, wetting additional super sacks throughout the building, and initiating the transition from a single-point to a multiple-point heat source (**Figure 42**).

Although the first building fire was extinguished at approximately 8:10 a.m., the elevated temperatures inside the building from additional decomposing super sacks of materials continued to affect other areas of the warehouse. As shown in steps 1 through 3 of **Figure 42**, the heat emitted by decomposing oxidizers also activated the sprinklers in additional zones of the warehouse (*see* **Section 2.2**).

Additionally, once the sprinkler system was activated by temperature, water would continue to flow until the water supply to the fire protection system was shut off.

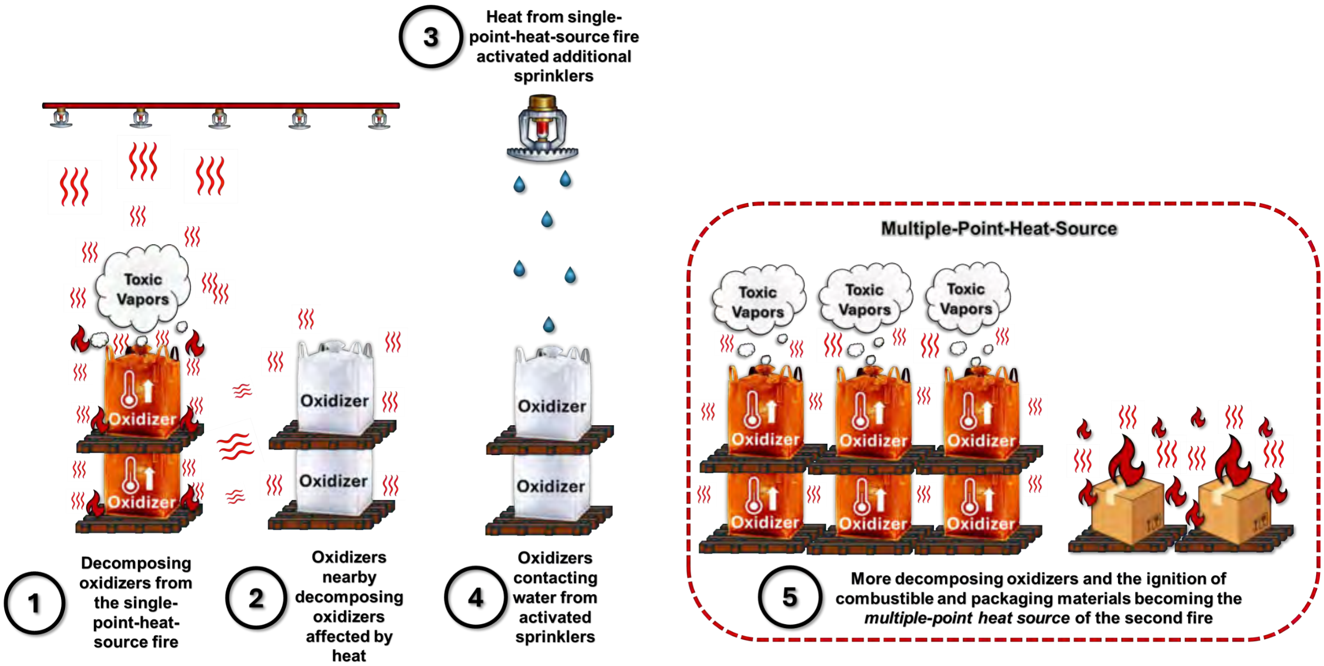


Figure 42. Depiction of the progression of the second fire in Plant 12 Storage Warehouse caused by a multiple-point heat source. (Credit: CSB)

The volume of decomposing material stored outside the bunker, both in racks and on the floor, continued generating sufficient heat to ignite combustible materials (wooden pallets and packing materials) throughout the warehouse, resulting in the second building fire that ignited at approximately 12:00 p.m., as shown in **Figure 43**.

Figure 43. Aerial shot of the second building fire at Bio-Lab Conyers 12 Storage Warehouse on September 29, 2024, resulting from the multiple-point heat source generated by decomposing oxidizers and combustible materials. (Credit: RCFR, annotated by CSB)

Portions of the roof and several walls started collapsing at approximately 12:40 p.m. RCFR extinguished the fire at 4:00 p.m., and by 8:00 p.m., the remaining roof and wall sections had collapsed.

Figure 44 presents a timeline of the incident that outlines the chronological sequence of events from the initial fire started by a “single-point-heat-source” on the morning of September 29, 2024, through the transition to a “multiple-point-heat-source” fire [65, pp. 13-367], the subsequent roof collapse, and its impact on the community.

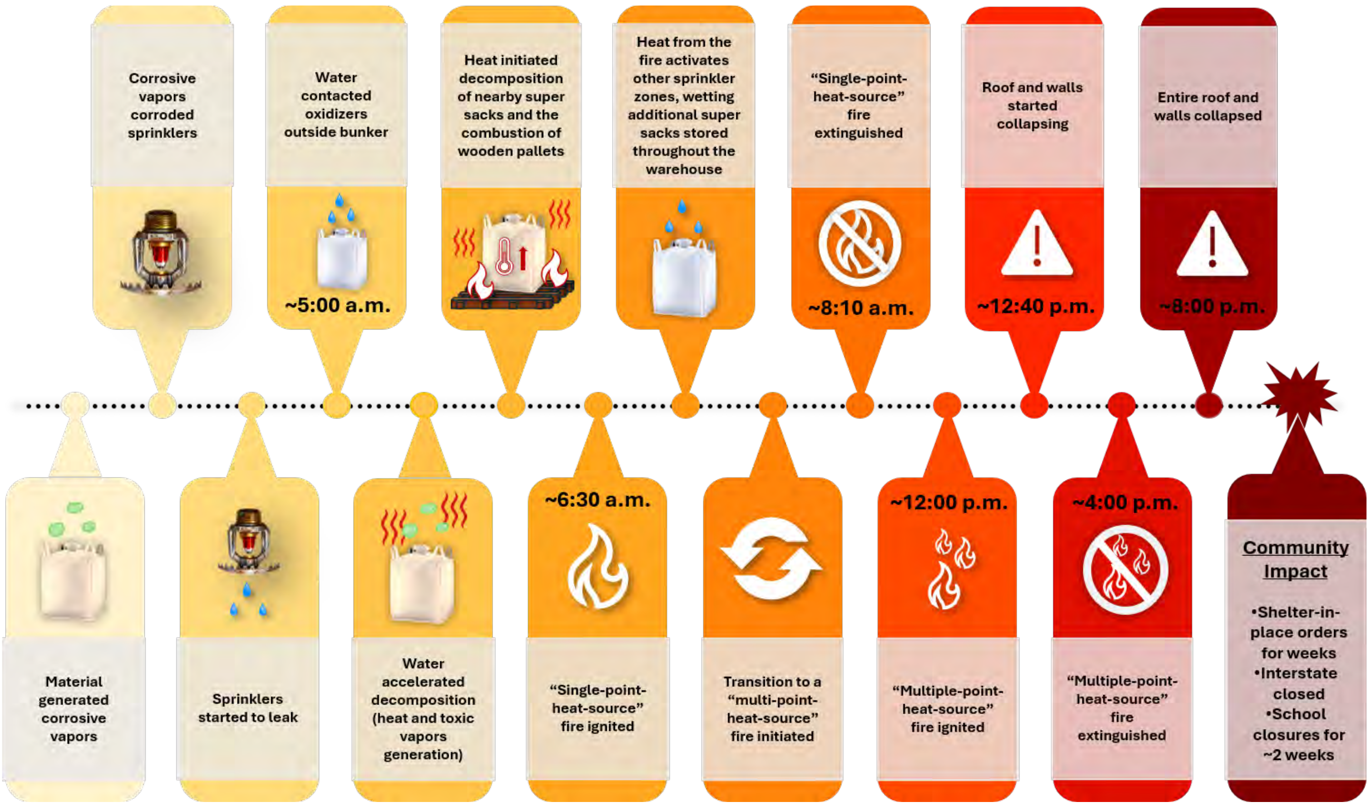


Figure 44. Timeline of the incident at Bio-Lab Conyers on September 29, 2024. (Credit: CSB)

4 Safety Issues

The following sections discuss the safety issues contributing to the incident, which are:

- Run to Failure
- Identification of Storage Hazards
- Risk Management and Oversight
- NFPA Guidance for Pool-Treatment Chemicals
- PSM and RMP Coverage of Reactive Hazards

Appendix A contains the accident map (AcciMap), which provides a graphical analysis of this incident.

4.1 RUN TO FAILURE

In the book, *Recognizing Catastrophic Incident Warning Signs in the Process Industries*, the Center for Chemical Process Safety (CCPS), a non-profit, corporate membership organization within the American Institute of Chemical Engineers (AIChE), states that "most if not all incidents were preceded by warning signs" [66, p. 1]. Warning signs related to asset integrity[a] include run to failure (RTF), corrosion, and frequent leaks—all of which have been observed at Bio-Lab Conyers.

Although fire protection sprinkler systems are not associated with traditional processes, they fall within the definition of "asset integrity" as they prevent or mitigate the consequences of a release of hazardous materials. As discussed in **Section 3.2**, when the chlorinated isocyanurates stored in the Bio-Lab Plant 12 warehouse are exposed to water or moisture, including humidity in the air, they can decompose, releasing corrosive gases. Additionally, employees at the Bio-Lab Conyers facility observed leaks in the warehouse due to observed corrosion on the fire protection sprinkler system piping and sprinkler heads in the warehouse, which led to failures of the system (leaks) due to corrosive vapors present inside the building. Bio-Lab Conyers did not proactively maintain the corroding sprinkler system in the warehouse. Instead, the Conyers facility replaced or repaired the corroded sprinkler heads and piping as they failed and leaked water. The leaking water posed a known risk of contact with stored chlorinated isocyanurates, which was known to lead to decomposition reactions and product off-gassing.

The CSB requested the annual fire sprinkler inspection reports and insurance risk assessments that had been prepared for the Plant 12 Storage Warehouse, specifically those conducted within 5 years prior to the 2024 incident. Bio-Lab Conyers provided the annual fire sprinkler inspection reports for 2020, 2021, 2022, and 2023,[b] along with the 2024 fifth-year inspection and the insurance risk assessments for 2021 and 2022. Of the eight documents provided, only the 2020 Annual Sprinkler Report and the September 7, 2023 Annual Sprinkler Report, indicated no signs of visual corrosion. The other three sprinkler inspection reports from 2021, 2022, and December 28, 2023 noted corrosion on the sprinkler heads. The 2024 fifth-year inspection conducted on September 12, 2024, did not record any corrosion. However, "corroded heads in Plant 12" had to be replaced on September 17, 18, and 2024. As discussed in **Section 3.1.2**, the insurance risk assessments conducted in 2021 and 2022 both indicated extensive corrosion on the fire protection piping and sprinkler system in multiple buildings at the Conyers facility, which handled, blended, or stored chlorinated isocyanurates and BCDMH.

Below are some of the corrosion incidents and related failures observed at Bio-Lab Conyers.

Plant 12 Storage Warehouse

- Photographs, such as those shown in **Section 3.1.2.1** and **Figure 33**, indicated that corrosion was observed on the Plant 12 Storage Warehouse fire protection sprinkler system piping less than 2 months after the storage of TCCA began inside the bunker in 2019. The corrosion resulted in a sprinkler system component failure and a subsequent water leak when the bolts on the fire piping corroded through.

---

[a] Asset integrity is the reliable performance of equipment designed to safely contain, prevent, or mitigate the consequences of a release of hazardous materials [66, p. 97].

[b] The CSB reviewed two 2023 Annual Fire Sprinkler Inspections conducted in 2023: one was completed on September 7, 2023 and the other on December 28, 2023.

- Bio-Lab Conyers experienced frequent recurrent failures associated with corroding components of the Plant 12 Storage Warehouse's fire protection system, which were also documented in the 2021 and 2022 Annual Inspection reports, particularly in the bunker where the majority of the chlorinated isocyanurates were located. Based on these observations, in late 2022 and 2023, the facility replaced the original brass-finish fire protection system components, including sprinkler heads, piping couplings, and bolts installed inside the bunker, with corrosion-resistant materials.
- In December 2023, corrosion was visually observed on 1,124 sprinkler heads located outside the bunker, across four of the seven zones of the fire protection system. The corroded sprinkler heads outside the bunker were replaced in-kind (brass-finish heads) as they failed.
- Multiple sprinkler system component failures also occurred outside the bunker in the months leading up to the September 2024 incident in the storage warehouse. On July 16 and 17, 2024, emergency repairs were performed to repair a hole in the fire protection piping in the storage warehouse. In September 2024, several leaking sprinkler heads were reported at the warehouse, and emergency repairs were performed to replace multiple corroded sprinkler heads on September 13 and from September 17 through 20, 2024.

Other Buildings across Bio-Lab Conyers

- As mentioned in **Section 3.1.2**, widespread and extensive corrosion was observed on fire protection piping and sprinkler systems in four buildings at the facility in 2021. One building's fire protection system was completely out of service due to corrosion damage. KIK confirmed that three of the four buildings contained solid oxidizers as of October 2024.
- A 2022 Risk Assessment conducted by a third party, on behalf of the insurance company, also identified corroded ceiling sprinklers and piping in multiple buildings.

As discussed in **Section 3.1**, Bio-Lab Conyers recognized the need for corrosion-resistant coatings for the sprinkler system in the Plant 12 Storage Warehouse due to frequent corrosion-related failures. After these upgrades inside the bunker, the majority of sprinkler system failures occurred outside the bunker on the non-corrosion-resistant components (*see* **Figure 36**). Bio-Lab Conyers management discussed upgrading some of the sprinkler heads outside the bunker; however, only investigative work had begun at the time of the September 29, 2024, incident.[a] Therefore, at the time of the incident, most of the sprinkler heads outside the bunker area in the warehouse still had a brass finish. Bio-Lab Conyers decided that when corroded sprinkler heads failed and leaked outside the bunker, they were to be replaced in-kind, as the sprinkler system in that area had not been upgraded to corrosion-resistant heads.

The *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* (NFPA 25) requires that maintenance be performed to keep sprinkler systems operable [67, pp. 25-17].[b] Chapters 5 and 13 of the standard specify the minimum requirements and frequency for the inspection, testing, and maintenance of sprinkler systems, including valves and other components [67, pp. 25-19, 25-20, 25-72, and 25-

[a] The Bio-Lab Conyers facility had not implemented a project to upgrade to corrosion-resistant sprinkler heads outside the bunker, such as purchasing corrosion-resistant heads, as of September 2024.

[b] The same maintenance requirements were also included in the 2017, 2020, and 2023 editions of NFPA 25.

73].[a] Examples of these specifications are listed in **Table 11** below. NFPA 25 requires that any sprinkler showing signs of "corrosion detrimental to sprinkler performance" must be replaced [67, pp. 25-18].[b]

Table 11. Examples of NFPA 25 sprinkler system inspection, testing, and maintenance requirements.

Item	**Frequency** [67, pp. 25-19, 25-20, 25-72, and 25-73]
Inspection	
Hangers/braces/supports	Annually
Pipe and fittings	Annually
Sprinklers	Annually
Waterflow alarm devices	Quarterly
Test	
Sprinklers *(harsh environments)*	5 years
Waterflow alarm devices *(mechanical)*	Quarterly
Valve supervisory signal initiating device	Semiannually
Waterflow alarms	Quarterly / Semiannually
Maintenance	
Replacement of sprinklers	Removed for any reason

Bio-Lab Conyers commissioned a third-party vendor to conduct annual inspections of its sprinkler system, as required by NFPA 25. This same vendor would also replace sprinkler heads and components post-inspection that were found to be inadequate. Additionally, Bio-Lab Conyers would contact the vendor for repairs and replacements when components of its sprinkler system failed and leaked. However, despite Bio-Lab Conyers utilizing a third-party vendor for these replacements, repairs, and annual inspections, the CSB does not have evidence that the company engaged in proactive preventive maintenance of its sprinkler system to prevent corrosion.

For several consecutive years, Bio-Lab experienced multiple sprinkler system failures throughout the year and had significant corrosion findings at its 2021 (November), 2022 (December), and 2023 (December) annual sprinkler system inspections. The 2023 inspection report also documented two "Painted ¾" 286 br ESFR pendent head[s]" outside the bunker (**Figure 36**), the type of paint used is unknown, and whether it complied with NFPA 13. There is no evidence that Bio-Lab requested or implemented additional safeguards, such as: 1) increasing the frequency of inspection or maintenance [67, pp. 25-19 and 25-20] on the fire protection sprinkler system to reduce the risk of water leaking onto the chlorinated isocyanurates stored below, or 2) improving ventilation in the warehouse [68, pp. 400-35].[c] Bio-Lab could have also installed a "protective coating of high-quality" as suggested in the Annex of NFPA 13, where "exposure to corrosive fumes is severe" [69, pp. 13-345, 70, pp. 13-306]. High-quality protective coatings include, but are not limited to, commercial acid-resisting paint, provided the manufacturer's instructions are followed [69, pp. 13-345, 71, pp. 13-377], and hot-dip galvanized steel [69, pp. 13-248, 71, pp. 13-282]. Over multiple years of experiencing sprinkler system failures in the Plant 12 Storage Warehouse and other buildings at the facility, Bio-Lab Conyers failed to

[a] The same summary table was included in the 2017, 2020, and 2023 editions of NFPA 25.

[b] The requirement has remained the same in the 2017, 2020, 2023, and 2026 editions of NFPA 25.

[c] NFPA 400 has provided ventilation guidance regarding buildings where "corrosive or highly toxic dusts, mists, fumes, vapors, or gases are, or might be emitted" for over a decade.

identify and implement additional safeguards to prevent such failures, which ultimately led to the incident on September 29, 2024.

The CSB concludes that Bio-Lab adopted a practice of replacing the fire protection sprinkler heads only after they had corroded, failed, and begun to leak. Had Bio-Lab Conyers implemented a proactive preventive maintenance program for the fire protection sprinkler system, the sprinkler heads, couplings, or other components outside the bunker area could have been replaced before they failed, reducing the risk of wetting the material stored below, which was known to initiate a decomposition reaction.

The CSB also concludes that had Bio-Lab Conyers taken steps to proactively prevent sprinkler system leaks instead of allowing the system to run to failure, the incident likely would not have occurred.

The CSB recommends KIK develop and implement a corporate standard for the storage of bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 *Hazardous Materials Code* and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements), and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

The CSB also recommends KIK develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that manufacture and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials Code* and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements). The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that manufacture and/or store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

4.2 IDENTIFICATION OF STORAGE HAZARDS

Failure to identify storage hazards in warehouse storage facilities can result in injuries, operational incidents, significant property damage, and negative environmental impacts. Industry practices emphasize the importance of conducting hazard assessments to identify such hazards in facilities that handle large quantities of hazardous chemicals, including pool-treatment chemical storage warehouses. For example, the CCPS identifies hazard identification as an essential first step in any process hazard analysis, noting that "hazards that are not identified cannot be further studied" [72, p. 16]. The CCPS further reinforces this principle in its *Guidelines for Risk Based*

Process Safety, where "Hazard Identification and Risk Analysis" is one of the 20 foundational elements of chemical process safety management. Early hazard identification enables a structured evaluation of potential safeguards to prevent accidental releases, fires, explosions, or other serious incidents.

Bio-Lab Conyers failed to identify the hazards associated with storing these hazardous materials, a deficiency that contributed to the initiation and inability to mitigate the consequences of this incident.

Additionally, the large quantities and storage configuration of the pool-treatment chemicals stored in the Plant 12 Storage Warehouse on September 29, 2024, did not allow proper access to the materials at all times and hindered the emergency response to the reacting material that morning.

KEY LESSON

Chlorinated isocyanurates (pool-treatment chemicals) can naturally off-gas corrosive vapors, creating a corrosive environment inside buildings that can corrode sprinkler system components, leading to failures and decomposition reactions that can result in fires. Users who handle and store pool-treatment chemicals should be aware of their corrosive properties to ensure that structures are properly designed and that an appropriate sprinkler system is selected to proactively prevent incidents, and to ensure compliance with NFPA 400 and NFPA 13 standards.

4.2.1 Corrosive Environment

As seen at Bio-Lab Conyers, corrosion can lead to leaks and compromised sprinkler systems, posing a significant threat to their longevity. The NFPA 70 *National Electrical Code* (NFPA 70) Article 680 *Swimming Pools, Foundations, and Similar Installations* (2017 Edition) defines "corrosive environment" as:

> Areas where pool sanitation chemicals are stored…shall be considered corrosive environments. The air in such areas shall be considered to be laden with acid, chlorine, and bromine vapors, or any combination of acid, chlorine, or bromine vapors, and any liquids or condensation in those areas shall be considered to be laden with acids, chlorine, and bromine vapors, or any combination of acid, chlorine, or bromine vapors. [73, pp. 70-545]

NFPA 13 mandates that, in such environments, the sprinkler system be corrosion-resistant [70, pp. 13-28][a] and requires users to identify corrosive environments [70, pp. 13-243, 74].[b] Additionally, NFPA 400 requires piping and other components to withstand the exposure to which they are subjected [75, pp. 400-34, 70, pp. 13-93].[c] Failure to meet the corrosion-resistance and materials requirements renders a facility non-compliant with NFPA standards for the storage of chlorinated isocyanurate oxidizers.

From the construction of the Bio-Lab Conyers Plant 12 Storage Warehouse in 2019 until sometime in 2023, it was standard practice for the facility to store Class 1 and Class 2 oxidizers only in the bunker (**Figure 10**),

[a] NFPA 13 Editions 2013, 2016, 2019, 2022, and 2025 have the same requirement [70, pp. 13-28, 69, pp. 13-30, 71, pp. 13-116, 160, pp. 13-127, 21, pp. 13-51].

[b] NFPA 13 succeeding editions, including the 2025 edition [21, pp. 13-38], all include the same requirements. See **Section 4.1** for more information on protective coatings.

[c] The same language appeared in the 2013 Edition, 2016 Edition, 2019 Edition, and 2022 Edition of NFPA 400 [75, pp. 400-34, 68, pp. 400-30, 142, pp. 400-34, 161, pp. 400-32, 2, pp. 400-32].

while the remainder of the warehouse was used to store other commodities. Despite being aware of the various hazardous characteristics of the TCCA and other Class 1 and Class 2 oxidizers it stores, Bio-Lab or KIK did not provide the CSB with evidence that it conducted an adequate hazard assessment before deciding to store the chlorinated isocyanurate and other oxidizers outside the bunker.

As discussed in **Section 3.2**, previous knowledge and experience in manufacturing TCCA should have ensured that Bio-Lab, Inc. and KIK were familiar with the corrosive effects of chlorinated isocyanurates on structural steel and piping, including sprinkler systems, which could lead to failures, before the Bio-Lab Conyers warehouse was designed. However, the corrosive characteristic of these materials was not communicated to the parties involved in the design and construction phases of the Bio-Lab Conyers storage warehouse. Instead, the materials were consistently represented to the authority having jurisdiction (AHJ) throughout all phases of construction as solely oxidizers. As a result, from 2019 until approximately November 2022, the original brass finish sprinkler system in the Bio-Lab Conyers Plant 12 Storage Warehouse was not in compliance with NFPA 13, which mandates corrosion-resistant material or a "protective coating" for sprinkler systems in corrosive environments [70, pp. 13-93 and 13-118].[a,b]

In late 2022, Bio-Lab Conyers replaced the original brass finish sprinkler heads in the bunker with wax-coated, corrosion-resistant heads. However, the replacement heads inside the bunker did not meet NFPA 400's requirement for ceiling sprinklers to be high temperature-rated when protecting Class 2 oxidizers that exceed the maximum threshold quantity per control area.[c] Moreover, the sprinkler heads outside the bunker were never replaced with corrosion-resistant heads. Because Class 1 and Class 2 oxidizers were stored in this unprotected area, Bio-Lab Conyers was non-compliant with NFPA 13 at the time of the incident.

NFPA 13 also requires users to evaluate environmental conditions and identify corrosive environments during the design phase to ensure the proper selection of resistant components based on the intensity and accessibility of the corrosive environments [70, pp. 13-243, 74].[d] The CSB does not have evidence that such an evaluation was conducted and documented for the Bio-Lab Conyers Plant 12 Storage Warehouse during its design.

The CSB concludes that Bio-Lab Conyers and KIK were not compliant with NFPA standards for the storage and handling of hazardous materials in corrosive environments within the Plant 12 Storage Warehouse. Had Bio-Lab Conyers and KIK followed the NFPA corrosion-resistance requirements for managing corrosive environments, such as: 1) installing corrosion-resistant pipes, fittings, and hangers; 2) regularly inspecting and maintaining areas susceptible to corrosion; and 3) applying protective coatings that are resistant to corrosion in accordance with the specific requirements set by the sprinkler manufacturer, the severity of the incident involving water contacting the stored chlorinated isocyanurates could have been mitigated.

[a] As stated in **Section 1.3**, the 2013 Edition of NFPA 13 was effective in 2019.

[b] The last five editions of NFPA 13, including 2013, have the same requirement [70, pp. 13-93, 69, pp. 13-99, 71, pp. 13-118, 160, pp. 13-129, 21, pp. 13-131].

[c] A control area is defined in NFPA 400 as "[A] building or portion of a building or outdoor area within which hazardous materials are allowed to be stored, dispensed, used, or handled in quantities not exceeding the MAQ" [2, pp. 400-12].

[d] NFPA 13 succeeding editions, including the 2025 Edition [21, pp. 13-38], include the same requirements. *See* **Section 4.1** for more information on protective coatings.

Ventilation System

In addition, the warehouse's ventilation system also failed to meet the conditions of the corrosive environment. The Bio-Lab Conyers Plant 12 Storage Warehouse had a mechanical ventilation system that provided two air exchanges per hour, based on the building's design documents provided by the design-build contractor. NFPA 400 requires that the actual required ventilation rate be "determined by calculations based on anticipated fugitive emissions or by sampling of the actual vapor concentration levels under normal operating conditions" [2, pp. 400-37].[a] Additionally, the ventilation system should prevent the accumulation of vapors.[b] The CSB estimated the Bio-Lab Conyers ventilation system's airflow rate, by cubic feet per minute (CFM/ft^2),[c] to be approximately 1.4 CFM/ft^2, based on a ceiling height of 42 feet.[d,e] **Table 12** summarizes the ventilation requirements for corrosive environments and compares them with the CSB's estimated airflow rate for the Bio-Lab Conyers Plant 12 Storage Warehouse ventilation system at the time of the incident.

Table 12. NFPA 400 ventilation requirements for corrosive environments [75, pp. 400-39].

Oxidizer Class	**Ventilation Requirements** ***(minimum allowable design rate)***	**Bio-Lab Conyers Plant 12 Storage Warehouse*[e]**
Class 1	$\geq$ 1 CFM/ft^2 of floor area over areas required to comply with protection level 1 through protection level 5[f]	2 air exchanges per hour = 1.4 CFM/ft^2
Class 2		

* Ventilation airflow rate at the time of the incident

NFPA 400 requires that storage areas in which corrosive vapors or gases are emitted or may be emitted have "mechanical exhaust ventilation or natural ventilation where natural ventilation can be shown to be acceptable for the materials as stored" [2, pp. 400-37].[g] Although the Bio-Lab Conyers' ventilation system could provide 1.4 CFM/ft^2 of exhaust airflow, its capacity was still insufficient to effectively manage humidity (moisture) levels inside the building.[h,i] Additionally, the warehouse as built did not qualify for the exception applicable to closed containers storage [2, pp. 400-37],[j] since the super sacks containing the bulk chlorinated isocyanurates allowed natural off-gassing (*see* **Section 3.1**).

The CSB concludes that the Bio-Lab Conyers Plant 12 Storage Warehouse's ventilation system was inadequate to remove the corrosive vapors generated by the large quantities of corrosive oxidizers stored in the building.

[a] NFPA 400, Section 6.2.1.5.4. Additionally, NFPA 400 Sections 6.2.1.5.5 and 6.2.1.5.12, along with its subsections, require that the design and layout of the ventilation system's make-up air and exhaust locations be arranged to prevent short-circuiting and effectively capture and remove vapors [2, pp. 400-37].

[b] NFPA 400, Section 6.2.1.5.12.3.

[c] CFM/ft^2 denotes CFM per square foot, i.e., the cubic feet per minute of airflow required for every square foot of a space.

[d] ft^2 denotes square feet.

[e] CFM/ft^2 = ACH (air changes per hour) x ceiling height (ft) / 60 (min/hr) = 2*42/60 = 1.4 CFM/ft^2

[f] NFPA 5000 *Building Construction and Safety Code* [159, pp. 5000-340]. The NFPA requirement has not changed in the succeeding editions, including the 2024 Edition [158, pp. 5000-370].

[g] This ventilation requirement has not changed in the last five editions of NFPA 400: 2013, 2016, 2019, 2022, and 2025.

[h] Air and water are the two most important components in nature that induce corrosion [165]. "Atmospheric corrosion is the attack of a metal (or an alloy) by the atmospheric environment to which it is exposed. This corrosion is caused by the simultaneous attack by…or condensing water, oxygen contained in the air, and atmospheric pollutants" [165].

[i] The Plant 12 Storage Warehouse, where chlorinated isocyanurates were stored, was not air-conditioned. Summers in North and Central Georgia, where Conyers is located, typically consistent of "lengthy spells of warm and humid weather" [166].

[j] NFPA 400, Section 6.2.1.5.1

Had the ventilation been sufficient, the accumulation of corrosive vapors could have been prevented, likely avoiding the degradation of the sprinkler system components that initiated the incident.

The CSB also concludes that the warehouse's ventilation system was insufficient for handling the quantities of corrosive oxidizers present in the ambient air humidity/moisture in Conyers, Georgia. Had the warehouse's ventilation system been designed for increased airflow, the sprinkler system might not have corroded, failed, or leaked water inside the building.

KEY LESSON

It is important for all users of chemicals, especially users of pool-treatment chemicals, to understand the ability of the chemicals used or stored to create a corrosive environment due to the material evolving vapors during normal storage conditions. As such, users of these chemicals must ensure the correct safeguards are implemented to reduce the impact of the corrosive environment, such as the materials of construction used for infrastructure inside the building and adequate ventilation to reduce the corrosivity of the environment.

4.2.2 Storage Quantity Requirements

Effective storage and inventory management of chemicals is a critical component of safe warehouse operations [76, p. 29]. The CCPS emphasizes the importance of inventory control, particularly for hazardous chemicals such as the materials stored in the Bio-Lab Conyers storage warehouse [77, pp. 173-176], through its Risk-Based Process Safety (RBPS) framework. The CCPS also "identifies and addresses process safety needs for a variety of facilities involved with handling, storing, using or processing, and transporting hazardous materials" [78]. To effectively mitigate risks in these operations, particularly in handling and storing hazardous materials, it is essential to implement robust policies and procedures for managing risk and maintaining inventory controls [76].[a]

NFPA 400 assigns high-hazard levels to various classifications of materials stored in buildings [2, pp. 400-16], containing levels 1 through 4, with 1 being the highest hazard and 4 being the lowest. NFPA 400 also lists Class 2 solid oxidizers as high-hazard level 3 contents, which "include materials that readily support combustion or present a physical hazard" [2, pp. 400-21]. However, Class 1 oxidizers are not categorized as high-hazard contents.

The established high-hazard levels correspond to the Protection Level, "a term used to describe a tier of building safety that exceeds the construction requirements for control areas to accommodate quantities of hazardous materials in excess of those permitted using the control area concept" [2, pp. 400-18].[b] "Where the quantity of hazardous materials in storage or use exceeds the MAQ[c] …, the occupancy shall comply with the requirements for protection level 1, protection level 2, protection level 3, or protection level 4, as required for the

[a] "Without written procedures, a facility can have no assurance that the intended procedures and methods are used…consistently execute a particular task in the intended manner" [77, p. 246].

[b] An alternative to protection level storage is detached storage, which is defined as "Storage in a separate building or in an outside area located away from all structures" [2, pp. 400-19] and meet the additional specific conditions stated in NFPA 400 Section 15.3.2.2.3 and Section 15.3.2.3.5.1 [2, pp. 400-72 and 400-73].

[c] MAQ is defined as the "maximum allowable quantity". MAQ per control area is defined as "A threshold quantity of hazardous material in a specific hazard class that once exceeded requires the application of additional administrative procedures, construction features or engineering controls" [2, pp. 400-17]. A control area is defined in **Section 4.2.2**.

material in storage or use ...” [2, pp. 400-27 and 400-28]. The warehouse was not designed in accordance with the requirements for a Protection Level 3 storage building.[a]

The Plant 12 Storage Warehouse appeared to have been designed based solely on the storage of Class 1 oxidizers and was classified as a Group S (S-1), moderate hazard storage, occupancy (*see* **Section 1.3.2**), despite Bio-Lab Conyers being aware that the warehouse would store at least BCDMH, which is an NFPA Class 2 oxidizer,[b] the company failed to share the other hazard characteristics of these materials with the design-build contractor.

The chlorinated isocyanurates stored in the Bio-Lab Plant 12 Warehouse also meet the NFPA 400 definition of a corrosive solid, and therefore, in accordance with NFPA 400 Section 4.4 [75, pp. 400-19],[c] the design of the warehouse must address the requirements applicable to all applicable hazard categories. Furthermore, Bio-Lab Inc. and KIK were also aware of the corrosivity of the chlorinated isocyanurate materials before the Plant 12 Storage Warehouse was built, based on their internal knowledge and previous experience within the company (*see* **Section 3.2** and **Section 4.2.1**). Additionally, Bio-Lab Conyers intended to store commodities in the Plant 12 Storage Warehouse. **Table 13** below compares some NFPA requirements for Class 1 and Class 2 oxidizers.

[a] The design requirements for Protection Level storage in NFPA’s terms would have had to meet the requirements for the storage of Class 2 oxidizers, as that’s the most stringent requirement. Thus, the building design would have required additional fire protections/resistance for the building structure.

[b] NFPA 400 (2013 Edition) informational Annex G identified BCDMH as a “Typical Class 2 Oxidizer” [75, pp. 400-175]; this classification remains unchanged in the 2025 Edition [2, pp. 400-205].

[c] The same “multiple hazards” requirement is stated in NFPA 400, Section 1.1.1.2 [75, pp. 400-5].

Table 13. Some of the storage requirements based on NFPA chemical hazard categories.

	Requirements for Class 1 Oxidizers	Requirements for Class 2 Oxidizers	Plant 12 Storage Warehouse (actual at time of incident)
High-hazard Level	N/A	3	N/A
Protection Level	N/A	3	N/A
Occupancy Classification (*per IBC/IFC**)	Storage 1 (S-1)[1]	High Hazard 3 (H-3)[2] Protected structural steel[3] 2-hr fire-rated (minimum) separation barriers Storage rooms limited to ≤10% of overall building size Exhaust ventilation	Storage 1 (S-1)
Quantities for Protection Level Storage Buildings (Building Limit)[4]	Not Limited	2000 tons	~7000 tons total (~14 million lbs.) ~6400 tons Class 1 Oxidizers ~600 tons Class 2 Oxidizers
Pile Size Limit[5]	200 tons 4–8 ft aisle width 8 rows of 8 bags stacked 2 high	100 tons[6] 4–8 ft aisle width[7] 4 rows of 8 bags stacked 2 high	Unknown
Corrosion-Resistant Sprinkler System per NFPA 13[8]	Required in locations susceptible to corrosion	Required in locations susceptible to corrosion	In bunker only

* International Fire Code (IFC)

1 Buildings for moderate-hazard storage (i.e., books and paper in rolls or packs, furniture, glues, photo engravings, soaps, sugar, upholstery and mattresses, among others) [17, pp. Chapter 3, Section 311.2].

2 "Buildings and structures that readily support combustion or that pose a physical hazard shall be classified as Group H-3…materials shall include, but not be limited to…Oxidizers, Class 2…Water-reactive materials, Class 2" [17].

3 Structural steel protected with fire-resistance rated construction.

4 Maximum quantities in Protection Level Storage of Class 1 and Class 2 oxidizers all found in NFPA 400.

5 Values used for piles: A super sack is ~3 ft wide x 3 ft deep x 4ft high; holds ~2,750 lbs. each. Class 1 oxidizer pile limit = 200 tons; max width = 24 ft; max height = 20 ft. Calculations were done based on bags stacked 2 high, not the height to align with Bio-Lab Conyers configuration. Class 2 oxidizer pile limit = 100 tons; max width = 25 ft; max height = 8 ft.

6 Additionally, Class 2 Oxidizers can be stored up to 16 ft high in racks with in-rack sprinkler systems designed in accordance with NFPA 400 Chapter 15 [2, pp. 400-73].

7 The maximum distance from any container to an aisle is 12 ft.

8 The approved automatic fire sprinkler system must comply with Section 55.3 of NFPA 5000, *Building Construction and Safety Code*.

The Plant 12 Storage Warehouse initially contained approximately 6.2 million lbs. of oxidizers inside the bunker, based on the average quantity that Bio-Lab Conyers' design-build contractor reported to Rockdale County on behalf of the company during the building permit process. Bio-Lab Conyers management told the CSB that oxidizer quantities in the warehouse gradually increased over time. By 2022, the bunker was storing approximately 8 million lbs. of oxidizers. When the CSB inquired about the increase in the oxidizer inventory, Bio-Lab management stated that "Bio-Lab's swimming pool product business is cyclical. The amount of product that Bio-Lab stores in a facility at any given time depends on logistics and supply factors for seasonal business cycles, which are themselves based on customer demand." By the time of the incident, the Bio-Lab Conyers Plant 12 Storage Warehouse contained approximately 14 million lbs. of oxidizers, approximately 12.8 million lbs. of Class 1 oxidizers, and approximately 1.2 million lbs. of Class 2 oxidizers, stored both inside and outside the bunker, as shown in **Table 4** (*see* **Section 1.3.5**).

The CSB concludes:

- The increased inventory quantities in the Plant 12 Storage Warehouse forced the facility to store chlorinated isocyanurates (NFPA Class 1 and Class 2 oxidizers) outside the bunker, resulting in the corrosion of sprinkler heads in the area. The corroded heads failed, allowing water to leak onto the super sacks containing the oxidizer, resulting in off-gassing, decomposition reactions, and fires, and

- Had the Bio-Lab Conyers Plant 12 Storage Warehouse been designed to meet High-Hazard / Protection Level 3 storage requirements, the company would have been allowed to: 1) store unlimited quantities of Class 1 oxidizers and up to 2,000 tons (4 million pounds) of Class 2 oxidizers, and 2) likely store Class 2 oxidizers outside the bunker in accordance with the NFPA standards.

The CSB also concludes that the Bio-Lab Conyers Plant 12 Storage Warehouse, as designed in 2019, did not comply with NFPA standards. Based on the building's design, Class 1 oxidizers would have unlimited storage, whereas Class 2 oxidizers would be limited to 500 lbs. per control area. Constructing a compliant H-3 (Protection Level 3) building with a mechanical ventilation system designed per code would have properly addressed the corrosive vapors and, therefore, may have prevented the incident on September 29, 2024. Smoke detection in the warehouse (i.e., wherever Class 2 oxidizers are stored) would enable much earlier detection of smoke/fire and possibly lead to earlier fire department intervention. Also, the proper sprinkler system design (including in-rack sprinklers for rack storage) may have kept the incident to a single fire location.

The CSB recommends KIK develop and implement a corporate standard for the storage and handling of bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements), and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

The CSB also recommends KIK develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials* Code (for storage and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements). The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

4.2.3 STORAGE CONFIGURATION

When storage configurations or large inventory amounts obstruct access in a warehouse, they can: 1) allow early signs of product decomposition to go unnoticed, and 2) delay or prevent an effective response to a developing hazard, increasing the likelihood that a manageable event escalates into a more serious incident.

Early Detection of Potential Hazard

As described in **Section 2**, at the time of the incident, Bio-Lab Conyers had reinstated its rotating fire watch shifts to detect early signs of potential safety hazards and fulfill other responsibilities. Those assigned to fire watch conducted a walkthrough of each building every hour, and that information was "normally" communicated verbally at shift change. Management relied entirely on human intervention for early detection of potential safety hazards in the Plant 12 Storage Warehouse and provided handheld devices to scan the exterior of super sacks containing chlorinated isocyanurates to detect hot spots[a] or elevated temperatures.[b] This approach required the employees to access the super sacks, including those stacked two high in multiple rows, those alongside the fire barrier wall, and those in racks, while standing in an aisle or sitting on a golf cart.

Because of the size of the warehouse and individual walk-through descriptions shared with the CSB, the employees likely could not effectively monitor super sacks that were obstructed or inaccessible. An alternative proactive approach to manually detecting hotspots would have been for KIK to require the installation of thermal cameras that automatically send notifications when hotspots are detected in all buildings with bulk solid oxidizers, as KIK installed at Bio-Lab On-Cal and Bio-Lab Lake Charles. As the Bio-Lab Conyers Plant 12 Storage Warehouse was destroyed during the incident, the CSB is unable to confirm the building's exact storage configurations and whether they complied with the NFPA standards, some of which are noted in **Table 13**.

The CSB concludes that the storage configuration at the Bio-Lab Conyers Plant 12 Storage Warehouse at the time of the 2024 incident likely hindered the facility's ability to effectively monitor large quantities of inventory for early warning signs of product decomposition or a fire in the warehouse.

ERT Response

KIK employees, including local management assigned to the Conyers facility, informed the CSB of an unwritten practice regarding the response of trained ERT personnel[c] to material inside a building identified as "hot" (having a temperature reading above 90 degrees) or that emitted strong odors. As part of the response, the material would be removed from the building and isolated for further observation and appropriate action.[d] However, this emergency response could only be executed if the materials were accessible to the ERT. Therefore, ERT personnel need to be aware of a building's storage configuration and the volume of stored materials, as these factors may impede access to addressing a hazard, as was exemplified on the morning of

[a] A hot spot refers to the highest temperature(s) recorded in a localized area, although these highest temperatures remain within a specified temperature range [127, p. 19]. Checking for hot spots offers early warning signs of potential safety hazards.

[b] The KIK employee on fire watch also ensured there were no leaks and verified that there were no abnormal odors, none of which required documentation.

[c] It is crucial that "all affected employees," including ERT personnel, wear the appropriately identified personal protective equipment [150].

[d] Bags removed from the building were either taken to a "wash down" building, located in an area behind Plant 4 and Plant 6, for monitoring or moved to the emergency dike.

September 29, 2024, when the ERT personnel were unable to reach the off-gassing material located adjacent to the fire barrier wall with three rows of double-stacked super sacks[a] stored in front of it. (*see* **Section 2.2**).

The Bio-Lab Conyers Plant 12 Storage Warehouse stored Class 1 and Class 2 oxidizers outside the bunker area, in front of the fire barrier wall, utilizing both 25-foot-tall storage racks and floor storage. Single- and double-stacked super sacks were used for floor storage. The warehouse storage configuration for the large quantities of pool-treatment chemicals inside the building did not allow proper access to the reacting material at the time of the incident.

KEY LESSON

Facilities must ensure that storage layouts provide unobstructed access to always allow effective monitoring of hazardous materials, particularly those that can undergo exothermic decomposition under normal storage conditions. This includes establishing clear storage configurations such as adequate aisle widths and product pile sizes. Additionally, facilities should implement continuous automated systems, such as the installation of thermal cameras, to detect potential safety hazards early rather than rely solely on manual intermittent monitoring.

On the morning of September 29, 2024, approximately 3 million lbs. of chlorinated isocyanurates were stored outside the bunker area. As mentioned in **Section 2.2**, at the onset of the incident, visibility was clear, and Employee B, an ERT member, was able to see inside the warehouse, including the location of the off-gassing super sacks, the number of bags, and the rows in front of them. Employee B moved four super sacks located in front of the off-gassing area. However, while attempting to remove additional super sacks and retrieve the initially off-gassing super sacks, the vapor cloud intensified and visibility deteriorated, forcing the employee to leave the building and preventing the material from being retrieved before it initiated the first fire that ultimately led to the complete destruction of the Bio-Lab Conyers Plant 12 Storage Warehouse. The storage configuration of multiple rows of double-stacked super sacks in front of the fire barrier wall further impeded access and prevented the retrieval of all the reacting material, ultimately resulting in a fire in the warehouse. Bio-Lab Employee A informed the CSB, “We tried to move the contaminated bag out of the warehouse, but…we couldn’t get to the bag.”

The CSB concludes that Bio-Lab Conyers’ ERT personnel’s ability to successfully respond to the off-gassing super sack(s) early on the morning of the incident, while visibility was still clear, was hindered by the storage configurations of the large quantities of material. Had Bio-Lab Conyers considered the potential for off-gassing super sacks and ensured unobstructed emergency access in their storage configurations, such as by using storage racks with properly designed sprinkler systems and in-rack sprinklers, the ERT may have been able to respond effectively before the material ignited and prevented further spread of the fire within the building on September 29, 2024.

The CSB also concludes that the use of single- and double-row storage racks, along with properly designed sprinkler systems, including in-rack sprinklers, may allow quicker access to an off-gassing container than three-row deep floor storage.

The CSB recommends KIK develop and implement a corporate standard for the storage (including storage configuration) and handling of bulk pool-treatment chemicals, including but not limited to chlorinated

[a] Double-stacked super sacks refer to the arrangement of two bags placed one on top of the other (*see* **Figure 40 Right**).

isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems*, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

The CSB also recommends KIK develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that manufacture and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials Code* and NFPA 13 *Standard for the Installation of Sprinkler Systems*. The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that manufacture and/or store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

Additionally, the CSB recommends KIK contract a third party to audit the implementation of the corporate standards developed in recommendations 2024-04-I-GA-R1 and 2024-04-I-GA-R2 at the KIK Consumer Products / Bio-Lab, Inc. Pool Division facilities and third-party facilities that manufacture and/or store bulk pool-treatment chemicals. Address all identified deficiencies resulting from the audit within a specified timeframe.

4.3 Risk Management and Oversight

The three stages of risk management involve "identifying what the risks are, [a]ssessing the significance of each risk in terms of its possible impact(s) and probability, [and] devising the responses to the risks and identifying risk owners who will carry these out" [79, p. 181]. Recognizing the importance of these concepts to process owners, the CCPS's RBPS approach encompasses 20 elements divided into 4 "pillars," with "Understand Hazards and Risk" and "Manage Risk" as two of these pillars [80, p. 42]. An organization that prioritizes not only identifying (*see* **Section 4.2.1**) but fully understanding their hazards and risks (*see* **Section 4.2.2**), can then use this information to implement mitigation (*see* **Section 4.2.3**) necessary for either preventing incidents or reducing their severity in accordance with the organization's risk tolerance. As such, KIK had an obligation as an organization not only to understand the full hazards and risks associated with its stored chlorinated isocyanurates, but to effectively assess and manage the risks inherent in the storage and handling of these materials to avoid the occurrence of an incident. Despite having the potential to learn lessons from two other major incidents in the 5 years prior to this incident,[a] KIK failed to acknowledge and address the risks inherent in storing chlorinated isocyanurates and missed opportunities to either prevent the 2024 Bio-Lab Conyers incident or minimize the extent of its impacts to the surrounding communities.

[a] Each of these incidents involved water coming in contact with chlorinated isocyanurates, particularly TCCA and/or TCCA formulations, stored inside a building.

4.3.1 IDENTIFICATION OF RISKS

> **KEY LESSON**
>
> Even in the absence of regulatory requirements for risk assessments, organizations should ensure that all hazards of using and storing hazardous chemicals be assessed and properly mitigated.
>
> Additionally, any risks, including worst-case scenarios identified, that can have community impact should also be evaluated and mitigated appropriately to reduce the severity and likelihood of community impacts due to incidents at the site.

Hazard and risk identification is the first step in the risk assessment management process [79, p. 181]. Before a hazard or risk can be effectively evaluated and mitigated, an organization must first ensure that its hazards and risks are fully and accurately identified, acknowledged, and understood. The "identification of areas of vulnerability and of specific hazards is of fundamental importance" to risk management and catastrophic incident prevention [81, p. 205]. A risk register is one example of a tool that organizations frequently use to understand, document, and manage their overall risk program and profile so that subsequent analyses can be performed at both the facility and organizational levels. Companies in the process industry have shared their experiences using risk registers for identifying, managing, and tracking both the inherent and emergent risks associated with their processes at multiple CCPS *Global Congress on Process Safety* conferences [82, 83, 84]. Risk registers provide records of an organization's identified hazards and associated safeguards, as well as information on how and where the hazard was identified, whether through a hazard analysis or other source, "such as incident investigations or employee observations" [85, pp. 217-218].

On a company-wide basis with respect to hazard and risk identification, KIK managed its materials solely as oxidizers. In the second quarter of 2024, prior to the Bio-Lab Conyers incident, KIK established a formal Oxidizer Task Force with the objectives to "identify how to lower the risk probability of an event" and ensure that the company was storing material in such a way as to protect itself from incidents. One of the Task Force's key priorities was establishing a company-wide Oxidizer Training program to instruct workers on how to monitor the material to identify hot spots, high-temperature areas,[a] within the super sacks, and the importance of eliminating water sources, such as removing sinks from the building where solid oxidizers were stored. Additionally, in June 2025, KIK management told the CSB that when the Oxidizer Task Force was established before the September 2024 incident, the only material it focused on was TCCA, not NaDCC, NaDCC dihydrate, or BCDMH, because the company's previous incidents involved only TCCA. The scope of the Oxidizer Task Force may have expanded to other solids according to a "Pool Division Safety Enhancements" presentation shared with the CSB in February 2026.

KIK's internal oxidizer subject matter expert (SME) told the CSB that the company had never performed water reactivity testing on any of its chlorinated isocyanurate raw materials or TCCA formulations. KIK's Research & Development SME stated that NFPA's water reactivity testing method "would not be applicable" for considering the chlorinated isocyanurates as water reactive, as it requires a one-to-one ratio of material to water when determining the heat of mixing necessary to assign an NFPA classification. KIK's SME explained that the

[a] *See* **Section 4.2.3**

company performed hazard testing in 2021 (*see* **Appendix D**) and determined that TCCA only exhibited significant reactivity and temperature increases at water proportions between 7.5 percent and 10 percent, but would not at the 1:1 ratio required for NFPA water reactivity determination. Although the CSB's material testing confirmed that the chlorinated isocyanurates reacted more vigorously at the lower water ratios, test results indicated that these materials were also capable of exhibiting heats of decomposition consistent with NFPA 400's criteria for Class 2 water-reactive materials, even at the higher 1:1 material-to-water ratio. KIK failed to identify the full water reactivity hazard characteristics of their chlorinated isocyanurate material, and the potential for water contacting these materials to result in a major building fire loss, despite the company's previous experience with the 2020 Bio-Lab Lake Charles incident (*see* **Section 1.4.1**).

KIK was also familiar with the corrosivity of its materials based on its experiences with recurring fire protection system component failures, both at the Plant 12 Storage Warehouse and in other buildings at Bio-Lab Conyers, as an employee explained to the CSB that "we are working with corrosive material that doesn't like metals." KIK management was also aware that the Bio-Lab Ontario facility (On-Cal)[a] employed multiple measures to prevent and counteract the effects of corrosion, both by the facility's own initiative and in response to inputs from its AHJ (as discussed in **Section 4.2.3**). During the insurer risk assessments in 2021 at the Bio-Lab Conyers facility, "ceiling sprinklers in [four] Plants were found to be corroded," with one manufacturing plant's sprinkler system completely out of service as "most sprinklers and branch lines are corroded and the overall system is in poor condition and will be replaced in the near future." A year later, during the insurer risk assessment in 2022, the same corrosion observations were documented.

Evidence of widespread corrosion in multiple buildings at Bio-Lab Conyers was not only known to plant-level management but was directly addressed to KIK corporate employees at the vice president and manager level in annual insurance risk assessment reports. Even though KIK management would have been aware of the corrosion deficiencies identified in the Bio-Lab Conyers insurer risk assessment reports, no corrective actions were taken between the 2021 and 2022 insurance reports in response to the observed corrosion. KIK did not impose any requirements on its Bio-Lab facilities to prevent corrosion or implement a proactive approach to manage corrosion. Instead, Bio-Lab Conyers was allowed to respond reactively to corrosion issues by repairing leaking sprinkler heads and structural corrosion on the fire protection piping as they failed, and only replacing the bunker sprinkler heads at the Plant 12 Storage Warehouse after several years of inspection-documented corrosion deficiencies.

The CSB concludes that KIK recognized the physical hazards of its stored chlorinated isocyanurates, which are NFPA-classified oxidizers with water-reactive and corrosive characteristics. However, the company did not adequately address the risk of treating these materials as oxidizers only during storage, such as the possibility that corroded fire protection systems could release sufficient water to initiate a reaction capable of resulting in total building fire loss. Had KIK effectively managed the risk of not incorporating the other hazard characteristics into its operations, it may have required its component facilities, such as Bio-Lab Conyers, to have implemented more proactive actions to prevent fire protection system corrosion damage that might cause water-reactive chlorinated isocyanurates to become wet enough to cause a catastrophic building fire.

[a] As shown in **Figure 1**, KIK's On-Cal facility is one of the several Bio-Lab pool business unit manufacturing facilities, along with Lake Charles and Conyers.

As previously mentioned, KIK has decided to cease all storage and manufacturing operations at Bio-Lab Conyers [46].[a] To make up for the lost manufacturing and warehousing capacity, it has moved some manufacturing and warehousing to other KIK internal sites and identified third-party contract manufacturing, also known as toll manufacturing or tolling,[b] and warehousing companies to maintain its production capacity and continue its supply chain.

The CSB recommends that KIK develop and implement a corporate standard for the storage (including storage configuration) and handling of bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements), and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

The CSB also recommends that KIK develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that manufacture and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements). The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that manufacture and/or store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

4.3.2 Assessing Risk

During the process of risk analysis and assessment, four main actions are available to organizations to address their identified hazards and risks as a company:

- "Avoidance (lowering the probability of the hazard occurring);
- Mitigation (reducing the scale of impact of the hazard if avoidance is not possible);
- Transference (shifting the impact of the hazard to someone else); or
- Acceptance" [79, p. 182].

Risk analyses are typically performed by organizations to assess, document, and manage their risks as a business, even in the absence of regulatory requirements for them to do so [86, pp. 28-29], as "good safety means good business" [87, p. 1]. KIK was not required to perform a hazard analysis for Bio-Lab Conyers because it was not subject to either OSHA PSM or EPA RMP, or any other regulation or code that specifically

[a] https://biolabcommunityresources.com/updates/

[b] Tolling is defined as "Providing manufacturing services for a fee by a contractor (the toller), to a company issuing (letting) a contract for those services. Tolled services can include, reaction processes, formulation, blending, mixing or size reduction, separation, agglomeration, packaging/repackaging, and others or a combination [thereof]" [139].

required a hazard analysis. Had KIK performed risk analyses for the storage of BCDMH and the chlorinated isocyanurates, the organization may have better understood and "take[n] account of other risk measures such as business interruption, environmental impact, [and] loss of production" [87, p. 3].

Although a former Bio-Lab Conyers safety employee had considered voluntarily applying "PSM LITE, which was taking some of the best components of that to [use] from a best practice standpoint," according to KIK management, the company was not applying that at the time of the incident because it was focused on other priorities and was "not ready for PSM LITE yet." However, at the time of the September 29, 2024, incident, the company considered "Process Safety Management (PSM) LITE" an active corporate procedure with the latest revision dated February 2024 and approved by the KIK's Vice President of Environment, Health, and Safety (EHS), as shown in **Figure 45**.

KIK CONSUMER PRODUCTS	TITLE: PROCESS SAFETY MANAGEMENT (PSM) LITE	DOCUMENT NO. EHS-6001.00			
		OWNER	VERSION	DATE	PAGE
		EHS	1.0	20-Feb-2024	1
PREPARED BY: [redacted]	REVIEWED BY: [redacted]	APPROVED BY: [redacted] VP of EHS			

Table of Contents

Figure 45. Header and List of Requirements from KIK's PSM LITE Procedure, approved by KIK in February 2024 (Credit: KIK, redacted by CSB)

The *Process Hazard Analysis* section of this procedure stated that a hazard analysis "must be conducted initially and then upon significant changes to the equipment design or process" using a standard methodology such as "What-If" or "Checklist." Although KIK's procedure required a hazard analysis, no formal risk assessment was performed for the Plant 12 Storage Warehouse because Bio-Lab Conyers was not actively following this procedure. Post-incident, KIK management told the CSB that the company intended to perform process hazard analyses as part of its Oxidizer Task Force's initiatives, as no "formal" hazard analyses had previously been performed.[a]

Multiple KIK employees at Bio-Lab Conyers communicated to the CSB that, along with the knowledge and involvement of KIK's senior management and the recently formed Oxidizer Task Force, Bio-Lab Conyers and EHS management planned to reduce the bunker inventory from approximately 11 million to 6 million lbs. maximum inventory. The purpose of this reduction plan was to allow all chlorinated isocyanurates to be stored within the bunker and mitigate the impacts of a potential incident. However, KIK employees knowledgeable about the leadership team's directive for the warehouse did not understand the impetus for the sudden focus on reducing inventory, other than that it was for "safety reasons." KIK was not able to provide the CSB with any documentation for any risk analysis, assessment, or other basis associated with these inventory reduction plans.

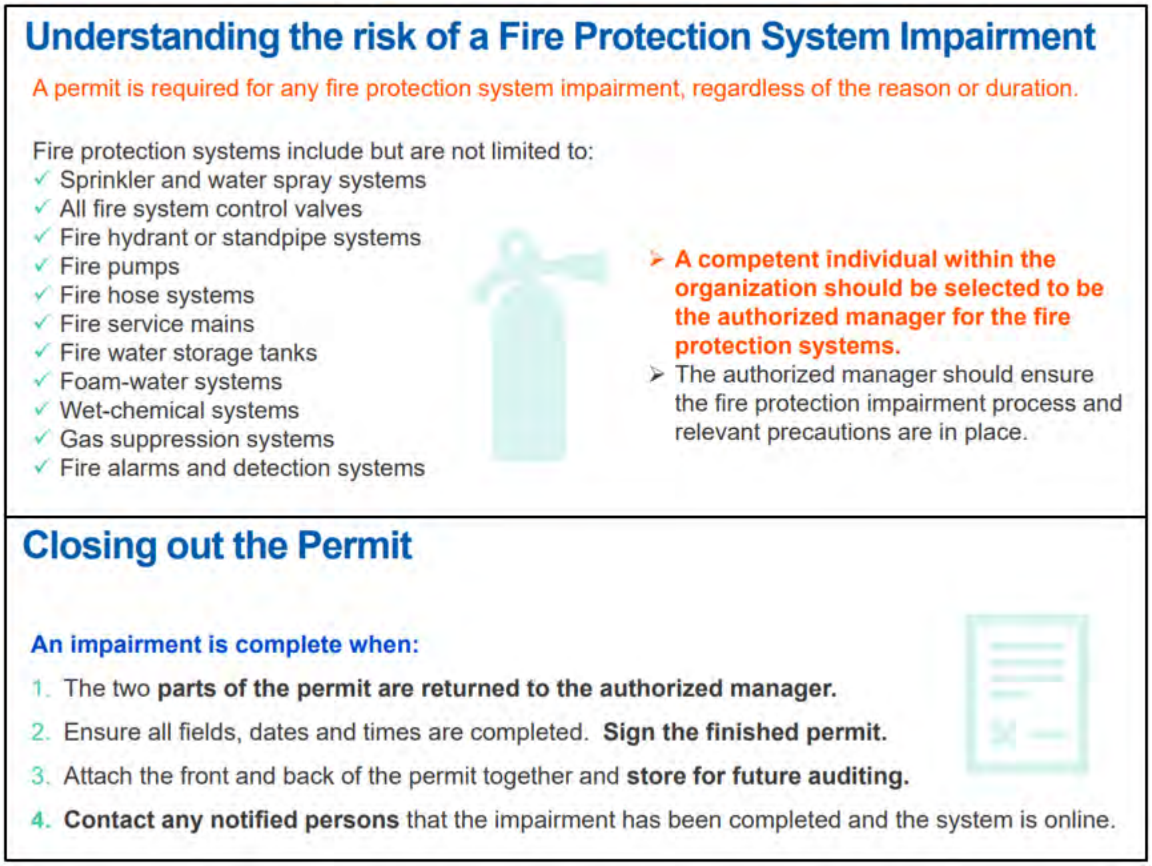
The CCPS's book *Recognizing Catastrophic Incident Warning Signs in the Process Industries* identifies weak process hazard analysis and the lack of a baseline risk profile as two indicators of risk [88, p. 122 and 131]. Although the lack of a hazard analysis "may result in new hazards not being identified or known hazards being assumed controlled, static and unchanging," [88, p. 122] failure to develop a baseline risk profile "may suggest that management does not really understand risk" [88, p. 131]. As part of risk analysis, KIK was responsible not only for assessing the significance of each risk in terms of its possible impact(s) and probability, but also for determining the degree of tolerance and acceptance for each risk.

Prior to the 2024 Bio-Lab Conyers incident, KIK had established procedures to document and track fire impairments and off-gassing incidents at its facilities, which would have enabled it to understand the actual frequency of these events. As discussed in the following subsections, KIK's failure to fully implement and enforce these corporate procedures represents a lost opportunity to understand and assess the risks that these frequent events pose to the organization as a whole.

Fire Protection System Deficiencies

In March 2024, KIK developed and implemented a corporate-level Fire Impairment Procedure to "ensure that fire protection system impairment management exists to minimize the impairment extent, duration, and the potential sources of fire" and "to also outline the requirements for reporting an impairment… to KIK's risk insurance carrier." Based on this procedure, KIK considered periods where fire protection systems were out of service due to leaks or ruptured pipes to be "emergency" or "unplanned" impairments, and periods of maintenance or repair to be "preplanned" impairments. Additionally, this procedure states that a "KIK facility shall notify KIK's risk insurance carrier of a fire protection system impairment that will last more than four (4) hours," and that "unplanned fire protection system impairments should be considered an incident, should be reported, and investigated to prevent reoccurrence." As shown below in **Figure 46**, KIK's March 2024 corporate guidance also required its facilities to document and track each fire system impairment via a permit.

[a] Although KIK management was not aware of it and did not take credit for it during the September 2024 incident investigation, Bio-Lab Lake Charles did conduct process hazard analyses after the 2020 incident in 2021 and 2022 per the CSB's recommendation (2020-05-I-LA-R3) in that previous report (https://www.csb.gov/bio-lab-lake-charles-chemical-fire-and-release).



Understanding the risk of a Fire Protection System Impairment

A permit is required for any fire protection system impairment, regardless of the reason or duration.

Fire protection systems include but are not limited to:
- ✓ Sprinkler and water spray systems
- ✓ All fire system control valves
- ✓ Fire hydrant or standpipe systems
- ✓ Fire pumps
- ✓ Fire hose systems
- ✓ Fire service mains
- ✓ Fire water storage tanks
- ✓ Foam-water systems
- ✓ Wet-chemical systems
- ✓ Gas suppression systems
- ✓ Fire alarms and detection systems

- ➢ **A competent individual within the organization should be selected to be the authorized manager for the fire protection systems.**
- ➢ The authorized manager should ensure the fire protection impairment process and relevant precautions are in place.

Closing out the Permit

An impairment is complete when:

1. The two **parts of the permit are returned to the authorized manager.**
2. Ensure all fields, dates and times are completed. **Sign the finished permit.**
3. Attach the front and back of the permit together and **store for future auditing.**
4. **Contact any notified persons** that the impairment has been completed and the system is online.

Figure 46. Excerpt from KIK Corporate G*uide to manage Fire Protection System Impairment*. (Credit: KIK)

Despite these documented corporate requirements, the CSB identified 13 days in the period between March 19, 2024, when KIK's Fire Impairment Procedure went into effect, and the September 29, 2024, Bio-Lab Conyers incident, during which the warehouse's fire protection system was impaired for more than 4 hours. Bio-Lab Conyers was unable to produce notification records for any of the 13 impairments, the longest of which lasted for 44 hours. Although the CSB requested all impairment records since the issuance of the procedure in February 2024, KIK only "produced fire protection system impairment notifications for the Conyers facility since August 2024," as its procedure states, "Copies of impairment notifications and restoration notifications shall be kept for 12 months." All six of which were issued in calendar year 2025.

Although Bio-Lab Conyers failed to complete documentation of fire protection impairments as required by corporate procedure, KIK's failure to enforce implementation of these procedure requirements demonstrates the company's risk tolerance or acceptance. Although local Bio-Lab Conyers EHS on-site was responsible for implementation, they should also have communicated the hazards and risks associated with frequent fire protection impairments to its corporate KIK leadership (**Figure 1**).

The CSB concludes that if KIK had enforced its fire protection impairment procedures, the company would have had stronger oversight of the issues and risks at the site level. With better knowledge of the frequency and severity of fire protection impairments, KIK could have assessed the level of risk for continuing operations at Bio-Lab Conyers without first implementing significant fire protection system improvements. As the

September 2024 Bio-Lab Conyers incident was most likely initiated by a fire protection system failure, KIK's failure to understand and assess the significance of a high frequency of fire impairments contributed to the Plant 12 Storage Warehouse's fire.

Learning from Previous Incidents

In addition to KIK's previous experience with significant incidents such as those previously investigated by the CSB at the Conyers and Lake Charles facilities in 2020 (*see* **Section 1.4.1**), at least three smaller-scale off-gassing incidents have occurred at the Conyers facility, some of which were serious enough to require external aid from RCFR. As the off-gassing incidents at the facility were considered routine and accepted as business-as-usual,[a] the approach at Bio-Lab Conyers was described by an employee who worked in the facility's safety organization as "react, take care of it, get back to work." When asked whether Bio-Lab Conyers considered an off-gassing event to be an incident or a near-miss, a manager at the Conyers facility told the CSB that "Probably outside of KIK it would be an incident, but here it's more of a near miss because it's something we're trained in being able to handle so quickly… yeah, the rest of the world sure looks at that as an incident."

KIK issued an Incident Reporting and Investigation procedure to its facilities on January 8, 2024, in which it defined an incident as "an unplanned event, not necessarily injurious or damaging to property, interrupting the activity in progress, including, but not limited to, accidents, illnesses, near misses, evacuation alarms, spills, and exceedances." The company also utilized a software suite for its facilities to access and input "incident details and associated investigations records, including supporting attachments." Based on records from this system, although two separate super sack off-gassing events occurred in November 2023, one of which caused a wooden pallet to catch fire, the associated incident tracking records for these events were still listed as "open" at the time of the September 2024 incident, nearly a year later. Although these Conyers incidents would have had visibility within the software system at the KIK corporate level, the system entries were allowed to remain open for nearly a year with no additional investigation conducted or corrective/preventative actions implemented. The lack of urgency or follow-up by KIK regarding these incidents suggests a high risk tolerance or acceptance.

According to the CCPS's *Recognizing Catastrophic Incident Warning Signs in the Process Industries*,

> Failure to learn is often evident by the fact that operations tend to repeat the same mistakes… [T]his warning sign may suggest the need for a complete process safety management upgrade…. Unless the causes are systematically analyzed and addressed with follow-up actions, there is a finite probability that the incident will recur…. A major incident provides an opportunity to explore the root causes and take action. It also represents an opportunity to transform a site or company culture in a fundamental way [88, p. 151].

Common reasons why organizations fail to learn from experience include an incomplete understanding of hazards or a loss of a sense of vulnerability [89, p. 32]. Bio-Lab Conyers considered off-gassing events to be intrinsic to the characteristics of the chlorinated isocyanurates rather than a potential opportunity to investigate and determine how to prevent or minimize such incidents. However, Bio-Lab's On-Cal facility provided an example that off-gassing did not have to be regarded as a routine and expected event, as the facility had never

[a] *See* **Section 4.2.3** for information on the Bio-Lab Conyers wash down area and emergency dike that are used when ERT personnel respond to decomposition or off-gassing incidents.

experienced an off-gassing incident in its 13 years of operation. However, a KIK-level manager who reported directly to the company's Chief Executive Officer told the CSB that the organization as a whole "[does not] have a lot of formality" associated with process hazard risk and its management overall.

Additionally, a KIK corporate Vice President acknowledged to the CSB that, despite being with the company for less than 2 years, they had personally witnessed multiple chlorinated isocyanurate decompositions, both "small and large… probably four or five." Bio-Lab Conyers's approach of "take care of it, get back to work" indicates that the facility did not completely understand the hazards of and had no sense of vulnerability to an off-gassing event, including within the safety organization.

The CSB concludes that KIK, as a company, was aware of and accepted the risk of storing large quantities of bulk chlorinated isocyanurates and regarded off-gassing events as routine business-as-usual occurrences. KIK also failed to voluntarily conduct formal risk analyses or assessments at each of its storage facilities and practices before the Conyers 2024 incident, despite its awareness of prior internal and external incidents involving these pool-treatment chemicals. Had KIK done so, or effectively implemented existing corporate procedures such as PSM LITE, Fire Project Impairment, or Incident Investigation, the company may have had an opportunity to determine whether its existing practices were inadequate for the risks involved in the storage and handling of its bulk materials in the Plant 12 Storage Warehouse.

The CSB recommends that KIK contract a third party to audit the implementation of the PSM Lite program within KIK's Pool Division, including all facilities that handle and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH. Address all identified deficiencies resulting from the audit within a specified timeframe.

4.3.3 MITIGATION OF RISK

The final stage of organization risk management consists of mitigation or treatment, which is the process of implementing actions to reduce the impact and severity of a hazard if avoiding it is not possible [79, p. 181]. Although risk mitigation may involve potential approaches such as avoiding, eliminating, or substituting the hazard, the most common approach in the process industries consists of identifying the controls and control management systems needed to address the risks by either preventing unwanted events or mitigating their consequences to an acceptable level [86, p. 21]. The CCPS's *Recognizing Catastrophic Incident Warning Signs in the Process Industries* book states that

> Senior management is responsible for knowing the risks posed by their operations, setting objectives to control those risks, and ensuring that action is taken. This includes potential risks to the environment, the community, and workers. Senior management also needs to understand how a catastrophic loss could potentially affect the business, both upstream and downstream of the operation…. Senior management should maintain a sense of vulnerability and communicate its support for risk-reduction and risk-management practices [88, pp. 180-181].

KIK's risk mitigation approach was inconsistent between its sites, and good practices that were implemented at the company's other sites had not been applied to Bio-Lab Conyers at the time of the incident.

Bio-Lab Conyers' primary method for detecting elevated temperatures that could lead to a decomposition incident or fire hazard involved employees manually scanning super sacks with either a compact thermal camera or an infrared laser thermometer that produces a single-point reading to identify hotspots (*see* **Section 4.2.1**). Due to the large size of the Conyers facility, employees conducted this screening while riding around on golf carts to manually scan each oxidizer super sack. However, at the time of the incident, the Plant 12 Storage Warehouse alone contained over 5,000 individual oxidizer super sacks, some of which were located on the second or third shelf of the storage racks (closer to the water source), and others that were in the middle of a pile of super sacks multiple rows deep, where they would not have been physically accessible for scanning.

Although the Bio-Lab Conyers facility installed two thermal cameras inside its Plant 6 building, where the 2020 incident had occurred, as a response to that event (*see* **Section 1.4.1**),[a] the only cameras installed at the Plant 12 Storage Warehouse at the time of the incident were two exterior surveillance cameras. KIK management told the CSB that, in its understanding, thermal cameras had been purchased for the interior of the Plant 12 Storage Warehouse and had arrived on site, but their installation was not prioritized or completed prior to the incident. However, according to Bio-Lab Conyers documentation, the Plant 12 Storage Warehouse thermal cameras were purchased in July 2024 but were backordered, preventing their delivery as of August 16, 2024, and installation before the incident.[b]

In contrast to the Conyers facility, the Bio-Lab On-Cal facility monitors its oxidizer super sacks using an array of thermal cameras positioned to provide continuous active temperature monitoring. When the thermal camera system detects an area of elevated temperatures, it automatically sends facility management an alert and a picture of the location where the heat-up is occurring. Based on the requirements of the facility's monitoring procedure, on-facility employees respond by manually verifying with a handheld temperature scanner whether the elevated reading is correct and determining whether action needs to be taken. Employees at On-Cal explained to the CSB that they had verified the ability of the thermal camera system to identify small areas of elevated temperature in a bag by placing a small hand-warmer pad between the pallets, which the camera system successfully detected. The On-Cal thermal camera system was already in place in its storage area prior to the Conyers 2024 incident, as "part of being more robust, more proactive" as a facility. Despite Bio-Lab Conyers and On-Cal having the same parent company and corporate structure, their methods of monitoring bulk chlorinated isocyanurates demonstrate a highly variable risk tolerance between individual sites.

The On-Cal facility also instituted multiple safeguards to address and mitigate impacts from the water-reactive and corrosive characteristics of the company's materials. Although a water-based fire protection system was installed at the On-Cal facility, the site did not experience any of the corrosion and leaks that occurred at the Conyers facility. For approximately 10 years, at least since 2016, all sprinkler system piping components at the On-Cal facility have been repainted annually with a corrosion-resistant epoxy paint as part of preventive maintenance to protect against external corrosion damage. Sprinkler heads in the building were not only wax-coated to prevent corrosion, but the facility also covered every individual head with a plastic bag. The bags on the sprinkler heads protected them from corrosive fumes and also were intended to prevent any small drips of water from contacting super sacks of chlorinated isocyanurates if a sprinkler head developed a leak. Installing plastic bags over the sprinkler heads was implemented at the recommendation of the fire engineer for the local

[a] According to Bio-Lab, "Thermal cameras were installed in Plant 6 in or around late 2022, early 2023, and 2024." Thermal cameras were also installed in Plant 22 "in or around 2021."

[b] A representative from the camera supplier informed Bio-Lab Conyers management that the last update they received regarding the camera's delivery was on July 29, 2024, with an estimated arrival of 6 weeks.

AHJ, as the facility maintained a strong working relationship with its local fire marshal's office. As site-level management reported directly to KIK executive leadership (**Figure 1**), KIK corporate would have been aware of Bio-Lab On-Cal's proactive measures and had an opportunity to encourage adoption of these mitigation approaches at its other Bio-Lab facilities to also prevent incidents.

Bio-Lab On-Cal also used a vacuum system to draw fumes from floor level and exhaust them from the building, as required by its local AHJ and NFPA 400, because of the building's prior High-hazard Group H-4 classification, which includes the storage of corrosive materials.[a] This vacuum ventilation system was required by the AHJ to remain operational at all times, and to meet this requirement, the On-Cal facility had an emergency generator to ensure that the system would operate even during power failures. The system reduced the corrosive fumes produced from normal super sack off-gassing, minimizing the potential for corrosion damage to building infrastructure. By comparison, rather than having a dedicated fume vacuum system as at On-Cal, Bio-Lab Conyers used only large floor-level exhaust fans to turn over air in the building.

As a company, KIK's risk mitigation approach was inconsistent between its sites, with Bio-Lab On-Cal's practices not consistently applied to its other sites. The mitigation methods implemented at Bio-Lab On-Cal may have reduced the likelihood of an incident occurring, as the facility has never experienced an off-gassing incident in its 13 years of operation. Comparatively, the Bio-Lab Conyers and Bio-Lab Lake Charles facilities experienced multiple large-scale to catastrophic events, some of which were previously investigated by the CSB. Although corrosion resulting from the super sacks' natural off-gassing losses during storage of chlorinated isocyanurates was normalized at Bio-Lab Conyers, the On-Cal facility's proactive mitigation measures prevented observable external corrosion from occurring. Even when preventive or mitigation measures, such as thermal camera installation, were planned for Conyers, management did not prioritize and implement them in a timely manner. At the time of the incident, Bio-Lab Conyer used 24/7 Fire Watch and handheld temperature devices to detect early warning hazards, as described in **Section 4.2.3**.

KIK management informed the CSB that before the company established the Oxidizer Task Force, as described in **Section 4.2.1**, the "pool sites" met within KIK's *Health, Environmental, Safety, and Security* group to discuss various topics, such as concerns, safety, quality, production, and updates, and also met with KIK's VP of Operations. However, it is unclear why the Bio-Lab On-Cal practices were not proactively and consistently implemented at the company's other locations. In fact, KIK corporate personnel described to the CSB that "the company just doesn't have the formality associated with it in a lot of places, not just risk, not just risk rates or…or process hazard." Therefore, it is likely that some of the failure to share and implement risk mitigation practices at other facilities may stem in part from a lack of formal risk or effective safety management systems or structures at the company. Had KIK corporate management communicated and supported the adoption of proactive risk-reduction and risk-management practices across its Bio-Lab sites, Bio-Lab Conyers may have also become aware of and implemented some of the approaches employed at Bio-Lab On-Cal.

The CSB concludes that had Bio-Lab Conyers installed thermal cameras to enable early identification of super sack hot spots, rather than relying on human intervention, or implemented measures to prevent or reduce the impact of the corrosive fumes produced during the normal storage of chlorinated isocyanurates, the September 2024 incident may have been prevented.

[a] High-hazard Group H-4 buildings and structures contain materials that are health hazards, such as "corrosives, highly toxic materials, and toxic materials" [17].

Whereas Bio-Lab On-Cal has implemented practices that have mitigated the occurrence of chlorinated isocyanurates incidents and prevented structural corrosion from vapors, these measures were inconsistently rolled out to other facilities, despite the company's SDS for TCCA stating, "Thermal decomposition can lead to release of toxic and corrosive gases/vapors." Although the Bio-Lab On-Cal's practices predominantly originated from the need to comply with more stringent California state regulations and direct recommendations provided by the AHJ, these practices were effective at preventing incidents. Risk-reduction and risk-management mitigation measures not only improve safety but also provide benefits to the business by preventing operational disruption and catastrophic losses. By failing to force the implementation of Bio-Lab On-Cal's practices at its other facilities, Bio-Lab, Inc./KIK management signaled its risk acceptance and tolerance for catastrophic incidents such as those that occurred at its Lake Charles and Conyers facilities in 2020 (*see* **Section 1.4.1**). KIK failed to maintain a sense of vulnerability, communicate its support for risk-reduction and risk-management practices, and employ effective mitigation at the Conyers facility, which resulted in the loss of the storage warehouse in 2024. Ultimately, the loss of the warehouse resulted in the company closing the site following the incident.

The CSB concludes that KIK, as a company, did not maintain a sense of vulnerability as an organization or proactively communicate its support for risk-reduction and risk-management practices to its component sites. As a result, risk mitigation approaches were inconsistent between its sites, with multiple Bio-Lab On-Cal preventive and mitigation practices not consistently applied to other Bio-Lab facilities, such as Bio-Lab Conyers. Had KIK required Bio-Lab Conyers to implement measures such as those employed at Bio-Lab On-Cal to prevent corrosion of the fire protection system, the September 2024 incident may have been prevented or its severity mitigated by enabling earlier detection of super sack hot spots.

KEY LESSON

Users of NFPA standards are responsible for properly identifying each applicable hazard classification associated with the chemicals they are using and storing. All relevant NFPA hazard classification requirements should be applied, ensuring the implementation of the most stringent requirements, to ensure safe handling and storage.

The CSB recommends that KIK develop and implement a corporate standard for the storage (including storage configuration) and handling of bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 Hazardous Materials Code (for storage, construction, and other requirements) and NFPA 13 Standard for the Installation of Sprinkler Systems (for corrosion resistance and other requirements), and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

The CSB also recommends that KIK develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that manufacture and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements). The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that manufacture and/or store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standards.

4.4 NFPA Guidance for Pool-Treatment Chemicals

The primary purpose of NFPA standards is "to help protect people, property, businesses, and communities by establishing minimum safety requirements that reduce risk from fire, electrical, and other related hazards. NFPA standards address a wide range of critical safety topics, such as… inspection, testing, and maintenance of … fire protection systems…" [90].

In this section, we will discuss several significant gaps in NFPA guidance regarding the storage and behavior of certain pool-treatment chemicals stored in the Plant 12 Storage Warehouse, which ultimately contributed to the incident in September 2024 (see **Section 4.1** and **Section 4.2.1**).

4.4.1 Material Hazard Classification

The chemical industry heavily relies on the NFPA standard when handling hazardous materials. These standards cover a broad set of safety considerations, including inspection and maintenance of fire protection systems [90], and the safeguards associated with the storage, use, and handling of hazardous materials [2, pp. 400-7]. Determining the appropriate fire protection system and hazardous materials safeguards, however, requires a comprehensive code analysis incorporating multiple regulations, codes, and standards.

In Georgia, the IBC works in conjunction with the International Fire Code (IFC). Georgia law (O.C.G.A. § 25-2-13 (g)) establishes that, in the event of a conflict, NFPA codes and standards take precedence over other building codes:

> "Notwithstanding any other provision of law… the code or standard of the National Fire Protection Association shall prevail.… The order of precedence… shall apply to all buildings and structures" [91].

Because NFPA standards govern hazardous chemical storage and fire protection system installation in Georgia,[a] several NFPA standards, including NFPA 400 and NFPA 13, served as the basis of design for Plant 12 Storage Warehouse storage arrangements, quantity limits, and certain elements of the fire protection system (**Figure 47 -** blue rounded rectangles), as shown in the facility's architectural plans.

[a] Although the CSB is not issuing any recommendations to the State of Georgia or Rockdale County, the CSB urges both the State of Georgia and Rockdale County to establish a new process or to maintain an existing one that routinely reviews and updates of its minimum fire safety standards and requirements to ensure they remain aligned with future editions of relevant NFPA standards and incorporate applicable regulatory requirements as they become effective.

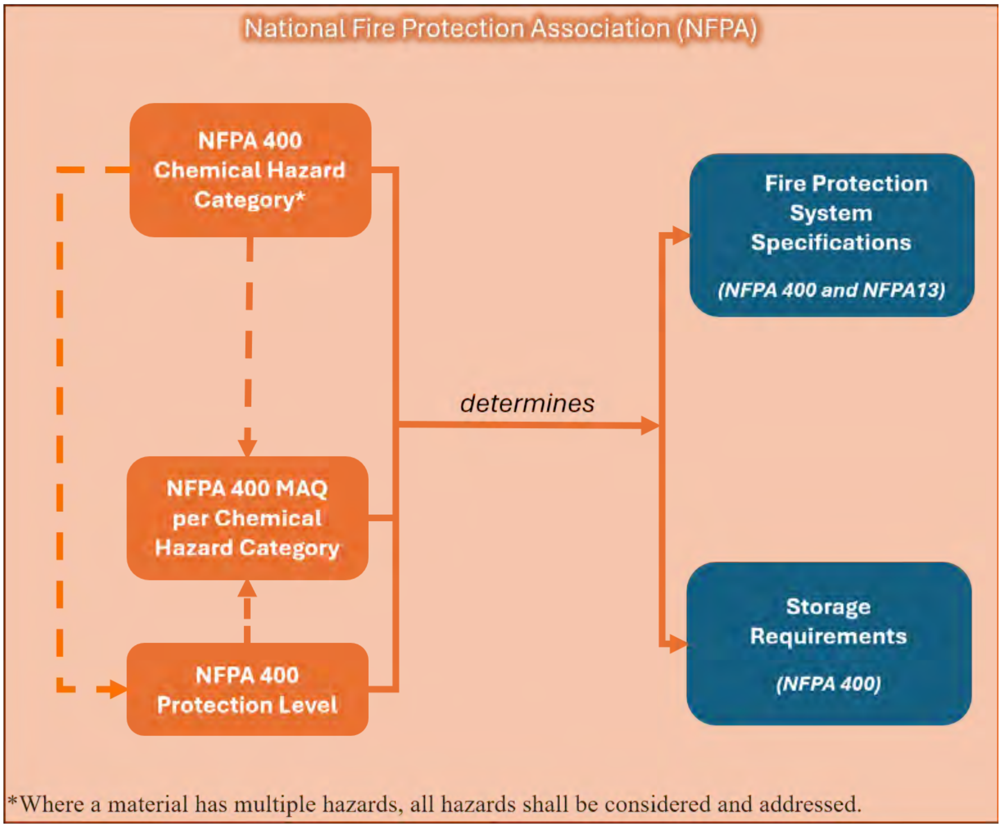


Figure 47. Influence of chemical hazard category on fire protection and storage requirements. (Credit: CSB)

Three main elements determine the applicable NFPA safety requirements:

1. Chemical Hazard Category[a]
2. Maximum Allowable Quantity (MAQ)
3. Protection Level[b]

NFPA 400 assigns high-hazard levels to various classifications of materials stored in buildings. Once the high-hazard category of a material has been determined, NFPA guidelines require users to utilize that information to determine the building design requirements for structures, such as warehouses. As illustrated in **Figure 47**, the hazard category influences both the MAQ and the required Protection Level storage. As mentioned in **Section 4.2.2**, NFPA 400 defines Protection Level storage as "a tier of building safety that exceeds the construction requirements for control areas"[c] to accommodate quantities of hazardous materials that exceed the MAQ [2, pp. 400-18]. MAQs function as thresholds above which additional safeguards are required [92].

[a] NFPA 400 specifies 14 categories of hazardous materials, including corrosive solids, oxidizer solids, and water-reactive solids [2, pp. 400-20], and that "materials shall be classified into one or more" of these categories.

[b] NFPA Protection Level corresponds to IBC/IFC Occupancy Classification. It is a safety classification used when more hazardous materials are present than what standard control areas allow, requiring enhanced safety measures.

[c] A control area is defined in NFPA 400 as "[A] building or portion of a building or outdoor area within which hazardous materials are allowed to be stored, dispensed, used, or handled in quantities not exceeding the MAQ" [2, pp. 400-12].

Chapter 15 of NFPA 400, titled *Oxidizer Solids and Liquids*,[a] is the only hazard material category in the standard that includes detailed tables in an annex (i.e., Annex G "*Oxidizers*") listing specific chemicals and their "typical" oxidizer class. Annex G also includes a section titled "*Safety Information on Oxidizers Used in Swimming Pools*." **Figure 48** and **Figure 49** show typical Class 1 and Class 2 oxidizers from Table G.2.2 and Table G.2.3 in NFPA 400, including TCCA, NaDCC, NaDCC dihydrate, and BCDMH, pool-treatment chemicals, stored in the Plant 12 Storage Warehouse. These same compounds also exhibit additional hazardous properties, not only as documented in multiple SDSs, but also as demonstrated in the independent third-party testing (*see* **Appendix D** and **Appendix E**) and previous incidents involving the same materials (*see* **Section 1.4**). However, these additional hazard characteristics are not mentioned in NFPA 400 or its annex.

[a] The title of Chapter 15 in NFPA 400, Oxidizer Solids and Liquids, has remained unchanged over the last five editions: 2013, 2016, 2019, 2022, and 2025.

Table G.2.2 Typical Class 1 Oxidizers

Class 1 Oxidizer	CAS Number
All inorganic nitrates (unless otherwise classified)	
All inorganic nitrites (unless otherwise classified)	
Ammonium persulfate	7727-54-0
Barium peroxide	1304-29-6
Calcium hypochlorite (nominal 80 percent, maximum 81 percent) blended with magnesium sulfate heptahydrate (nominal 20 percent, minimum 19 percent) having an available chlorine of less than or equal to 66 percent and a total water content of at least 17 percent	
Calcium peroxide	1305-79-9
Hydrogen peroxide solutions (greater than 8 percent up to 27.5 percent)	7722-84-1
Lead dioxide	1309-60-0
Lithium hypochlorite (39 percent or less available chlorine)	13840-33-0
Lithium peroxide	12031-80-0
Magnesium peroxide	1335-26-8
Manganese dioxide	1313-13-9
Nitric acid (40 percent concentration or less)	7697-37-2
Perchloric acid solutions (less than 50 percent by weight)	7601-90-3
Potassium dichromate	7778-50-9
Potassium monopersulfate (45 percent KHSO5 or 90 percent triple salt)**	70693-62-8
Potassium percarbonate	589-97-9
Potassium persulfate	7727-21-1
Sodium carbonate peroxide	15630-89-4
Sodium dichloro-s-triazinetrione dihydrate (sodium dichloroisocyanurate dihydrate)	51580-86-0
Sodium dichromate	10588-01-9
Sodium perborate (anhydrous)	7632-04-4
Sodium perborate monohydrate	10332-33-9
Sodium perborate tetrahydrate	10486-00-7
Sodium percarbonate	15630-89-4
Sodium persulfate	7775-27-1
Strontium peroxide	1314-18-7
Trichloro-s-triazinetrione [trichloroisocyanuric acid (TCCA; trichlor), all physical forms]	87-90-1
Zinc peroxide	1314-22-3

Figure 48. NFPA 400 list of typical Class 1 oxidizers in Annex G (NaDCC dihydrate and TCCA highlighted). (Credit: NFPA 400, annotated by CSB)

Table G.2.3 Typical Class 2 Oxidizers

Class 2 Oxidizer	CAS Number
Ammonium nitrate prill (99 percent)**	31432-46-9
Barium bromate	13967-90-3
Barium chlorate	13477-00-4
Barium hypochlorite	13477-10-6
Barium perchlorate	13465-95-7
Barium permanganate	7787-36-2
1-Bromo-3-chloro-5,5-dimethylhydantoin (BCDMH)	16079-88-2
Calcium chlorate	10137-74-3
Calcium chlorite	14674-72-7
Calcium hypochlorite (48 percent or less by weight unless covered by other formulations in G.1.2)**	7778-54-3
Calcium hypochlorite (50 percent or less by weight unless covered by other formulations in Section G.2)	7778-54-3
Calcium perchlorate	13477-36-6
Calcium permanganate	10118-76-0
Calcium peroxide (75 percent)**	1305-79-9
Chromium trioxide (chromic acid)	1333-82-0
Copper chlorate	135821-00-0
Halane (1,3-dichloro-5,5-dimethylhydantoin)	118-52-5
Hydrogen peroxide (greater than 27.5 percent up to 52 percent)	7722-84-1
Lead perchlorate	13637-76-8
Lithium chlorate	13453-71-9
Lithium hypochlorite (more than 39 percent available chlorine)	13840-33-0
Lithium perchlorate	7791-03-9
Magnesium bromate	14519-17-6
Magnesium chlorate	10326-21-3
Magnesium perchlorate	10034-81-8
Mercurous chlorate	10294-44-7
Nitric acid (more than 40 percent but less than 86 percent)	7697-37-2
Nitrogen tetroxide	10544-72-6
Perchloric acid solutions (more than 50 percent but less than 60 percent)	7601-90-3
Potassium perchlorate	7778-74-7
Potassium permanganate	7722-64-7
Potassium peroxide	17014-71-0
Potassium superoxide	12030-88-5
Silver peroxide	1301-96-8
Sodium dichloro-s-triazinetrione anhydrous (sodium dichlorocyanurate anhydrous)**	51580-86-0
Sodium chlorite (40 percent or less by weight)	7758-19-2

(continues)

Figure 49. A partial list NFPA 400 typical Class 2 oxidizers in Annex G (BCDMH and NaDCC highlighted). (Credit: NFPA 400, annotated by CSB)

Primarily focusing on the oxidizing properties of these pool-treatment chemicals in NFPA 400 Annex G, without specifically noting their additional hazardous categories, could possibly lead a user to overlook their corrosivity and water reactivity. As illustrated in **Figure 50**, misclassification of the chemical hazard category or failure to properly assess each hazard category and appropriately address the most restrictive requirements directly affects MAQ determinations and Protection Level requirements, which, in turn, impact storage requirements and fire protection system design (black round rectangles).

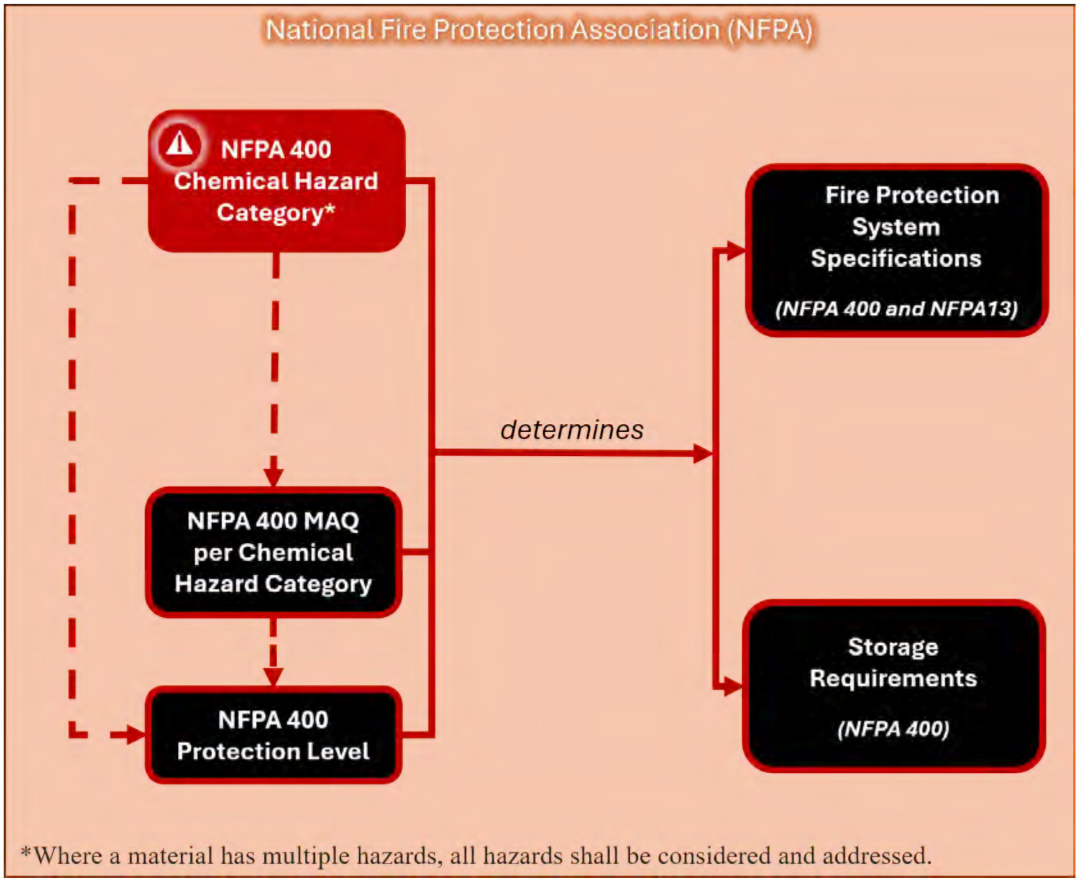


Figure 50. Impact of incomplete hazard classification on NFPA 400 and NFPA 13 requirements. (Credit: CSB)

For example, a material classified and managed only as a Class 1 oxidizer has an MAQ that is "not limited," with no Protection Level required. If the same material is also considered corrosive, an MAQ of 10,000 lbs. applies, and the corrosive environment must be addressed, causing additional code requirements. **Table 14** summarizes some significant differences between assigning a chemical to a single versus multiple hazard categories. These differences materially impact storage, handling, and fire protection system design.

Table 14. Some of the storage and fire protection system requirements based on the NFPA 400 chemical hazard categories: Class 1 oxidizer and corrosive solids [2, p. 23] (**Appendix G**).

Requirements	Class 1 Oxidizer	Class 1 Oxidizer + Corrosive
Building Storage Limit	Not Limited	Not Limited⁑
Protection Level	N/A	4
Occupancy Classification (*by IBC/IFC*)	Storage 1 (S-1)[a]	High Hazard 4 (H-4)[†b]
Ventilation	At least 1 CFM/SF across the entire floor of the room according to the Mechanical Code for a standard warehouse.	At least 1 CFM/SF across the entire floor of the room and enough to remove anticipated amount of fugitive vapors.
Sprinkler System	ESFR	• OH2[c] with 3,000 square feet design area or ESFR • Corrosion protection
Other Fire Protection System Requirements	Smoke/heat vents only if not using ESFR	• Add exhaust ventilation with backup power and emergency alarm • Smoke/heat vents only if not using ESFR
Fire Rated Barriers	N/A	1-hr fire barrier separation from adjacent spaces

*These requirements are a compilation of information obtained from IBC, IFC, and several NFPA standards.

⁑Provided the building is compliant with the rules for Group H-4 (Protection Level 4).

†Also classified as Protection Level 4 in accordance with NFPA 400.

The failure to proactively and appropriately address the most restrictive requirements of the pool-treatment chemicals in Plant 12 Storage Warehouse contributed to the accumulation of corrosive vapors that corroded the sprinkler system component, which failed on September 29, 2024, and allowed water to contact stored material outside the bunker (*see* **Section 3.1.2**). This interaction initiated the fire that destroyed the warehouse.

The CSB concludes that NFPA 400 primarily classifies pool-treatment chemicals as oxidizers and fails to address other hazardous categories or properties of these compounds, which are important for their safe storage. The NFPA should update its guidance to explicitly warn users about the additional hazard categories of pool-treatment chemicals and provide specific guidance on managing these materials with multiple hazardous characteristics. This update could enhance awareness, leading to thorough hazard assessments for their storage and management, and potentially reduce incidents like the fire at Bio-Lab Conyers.

---

[a] *See* **Section 1.3.2** and **Section 4.2.2**.

[b] "Buildings and structures containing materials that are health hazards shall be classified as Group H-4. Such materials shall include, but not be limited to, the following: corrosives, highly toxic materials, toxic materials" [17].

[c] "OH2" stands for "Ordinary Hazard (Group 2)" in NFPA 13 *Standard for the Installation of Sprinkler Systems*. It refers to "occupancies or portions of other occupancies where the quantity and combustibility of contents are moderate to high…" [21, pp. 13-26].

4.4.2 Definition of Corrosive Materials and Corrosive Environment

As discussed in **Section 4.2.1**, a misalignment exists among NFPA 400, NFPA 13, and NFPA 70 (key standards governing the design and construction of the Plant 12 Storage Warehouse and storage and handling of the oxidizers within it) regarding the context in which the term "corrosion" is applied. Each standard addresses corrosion only within the boundaries of its own scope. **Table 15** summarizes and compares the scope of these three NFPA standards as they relate to the Plant 12 Storage Warehouse.

Table 15. Comparison of code scopes for NFPA 400, NFPA 13, and NFPA 70.

Code	Primary Focus	What It Regulates	References
NFPA 400	Hazardous materials safety	Storage, use, and handling of hazardous materials, including oxidizers, corrosive solids and liquids, organic peroxides, flammable solids, toxic/pyrophoric/water-reactive materials, and compressed gases	Section 1.1 [2, pp. 400-7]
NFPA 13	Automatic sprinkler systems	Design, installation, and acceptance testing of automatic fire sprinkler systems; system types; hazard classifications; hydraulic design; water supply	Section 1.1 [21, pp. 13-16]
NFPA 70	Electrical installations	Installation of electrical conductors, equipment, raceways, signaling, communications, and optical-fiber systems	Article 90, Section 90.2 [93, pp. 70-24]

The resulting safety requirements are not harmonized across the standards, leading to differing interpretations of how corrosion should be addressed. **Figure 51** illustrates how each NFPA standard targets a distinct aspect of corrosion within its respective scope.

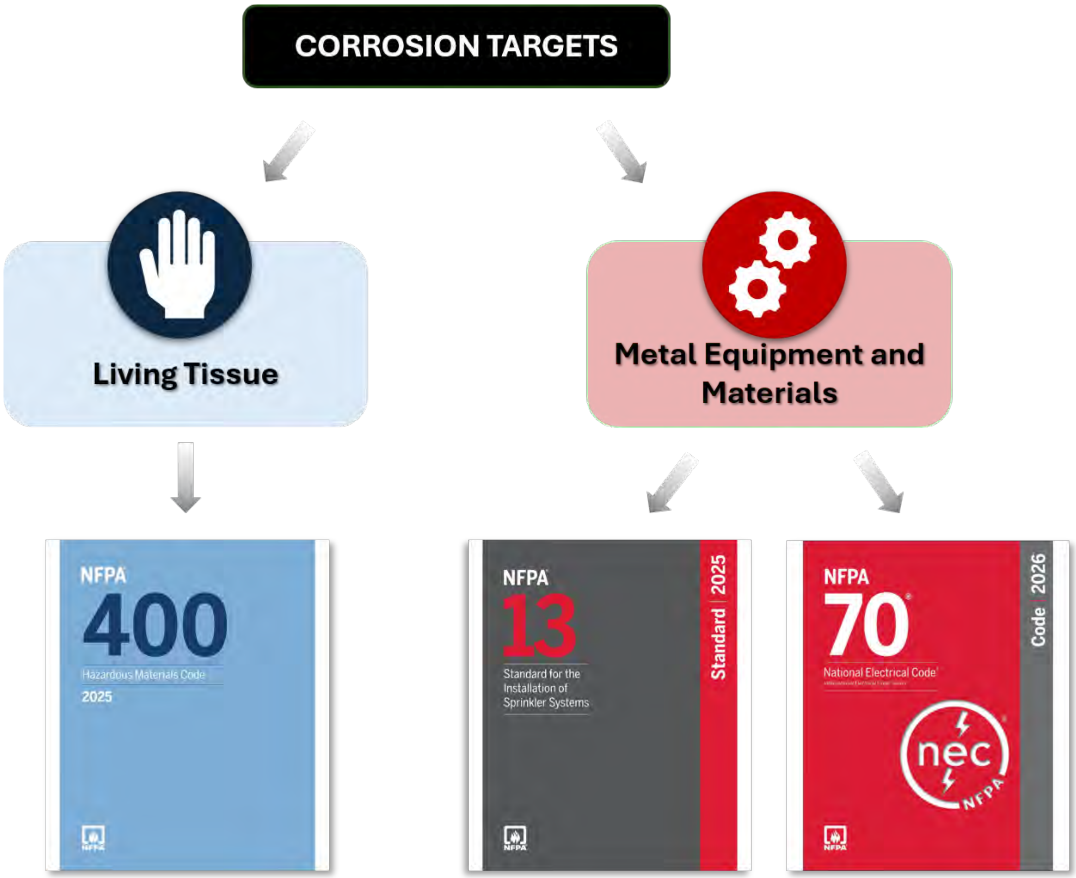


Figure 51. Corrosion targets for NFPA 400, NFPA 13, and NFPA 70 [94]. (Credit: CSB)

NFPA 400 addresses corrosion strictly as a chemical hazard affecting living tissue. It defines a corrosive material as "a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact" [2, pp. 400-16][a] (*see* **Section 3.2**). Annex A in NFPA 400 further clarifies that "For purposes of this code, this term [corrosive] does not refer to action on inanimate surfaces (e.g., steel or aluminum)" [2, pp. 400-116].[b] Thus, the safety requirements in NFPA 400 are based solely on corrosion effects to human health, not materials or equipment.

In contrast, NFPA 13 and NFPA 70 treat corrosion as a degradation mechanism affecting inanimate materials such as metal components in sprinkler or electrical systems. As summarized in **Table 15**, the scope of NFPA 13 is to "…provide the minimum requirements for the design and installation of automatic fire sprinkler systems and exposure protection sprinkler systems covered within this standard" [65, pp. 13-16]. Therefore, the definition of corrosion is related to the physical deterioration of sprinkler system piping and components. It does not address any human health–based corrosion criteria.

NFPA 70 defines corrosive environments as "areas or enclosures without adequate ventilation, where electrical equipment is located and pool sanitation chemicals are stored, handled, or dispensed" [93, pp. 70-37]. The standard notes that chemicals such as chlorine cause "severe corrosive and deteriorating effects on electrical

[a] The NFPA 400 definition for a corrosive material is the same in the 2013 and 2025 editions.

[b] The NFPA 400 informational Annex A details for a corrosive material are the same in the 2013 and 2025 editions.

equipment when stored nearby." Thus, NFPA 70 evaluates corrosion based on the potential to create corrosive atmospheres, not on direct effects to human tissue.

As explained above and in **Section 4.2.1**, although the three standards address the same chemical hazard (corrosion), their safety requirements differ because they evaluate corrosion through entirely different lenses. For example, NFPA 400 refers users to NFPA 13 for sprinkler system requirements: "The design of the sprinkler system shall [be]… in accordance with NFPA 13…" [2, pp. 400-35]. NFPA 13, in turn, requires corrosion-resistant sprinkler systems in corrosive environments [70, pp. 13-28][a] and obligates users to identify such environments [70, pp. 70-243, 74].[b]

NFPA 70 explicitly recognizes pool-treatment chemicals as corrosive, defining corrosive environments as locations where these chemicals are stored or dispensed and where inadequate ventilation is present [93, pp. 70-37]. This definition acknowledges corrosive effects on electrical equipment, but similar effects on building components, including sprinkler systems, are not addressed in NFPA 400 or NFPA 13. NFPA 13 addresses the corrosivity effect of these oxidizers on sprinkler systems but not as the result of the storage and handling of pool-treatment chemicals. Therefore, NFPA 400 or NFPA 13 alerts users about the corrosive characteristics of pool-treatment chemicals and their effect on sprinkler systems, besides their health effect component.

NFPA 400 does not address the potential for oxidizers to create corrosive environments that damage metal components such as sprinkler piping or sprinkler heads. As a result, corrosion hazards associated with oxidizers—particularly pool-treatment chemicals—are not captured in the safety requirements for facilities storing even Class 1 oxidizers, which currently fall under occupancy S-1, which have no additional protection levels, and require only minimal protection (e.g., a "typical NFPA 13" warehouse ESFR system; *see* **Appendix G**). No reference is made to the specific corrosion-related guidance of NFPA 70. A user must know to consult NFPA 70 to understand that pool-treatment chemicals can create significantly corrosive environments, which require additional safeguards [93, pp. 70-657].

The CSB concludes that the three NFPA standards address corrosion from fundamentally different perspectives: human health (NFPA 400), material degradation of sprinkler systems (NFPA 13), and corrosive atmospheres affecting electrical equipment (NFPA 70). Thus, facilities storing pool-treatment chemicals may not know to consult NFPA 70 and to implement fire protection systems that account for the corrosive environments these chemicals create, which could result in failure and lead to a decomposition reaction.

The CSB recommends that the NFPA:

1. Revise NFPA 400 *Hazardous Materials Code*, Section 4.1 *Hazardous Material Classification*, or a more appropriate section, to clarify that materials are required to be assessed and a determination reached for each of the categories of hazardous materials (1) through (14).
2. Revise NFPA 400 *Hazardous Materials Code*, Section G.4 *Safety Information on Oxidizers Used in Swimming Pools*, to address the potential for pool-treatment chemicals to demonstrate characteristics of hazard classifications other than those of oxidizers, and that each additional hazard classification

[a] NFPA 13 Editions 2013, 2016, 2019, 2022, and 2025 have the same requirement [70, pp. 13-28, 69, pp. 13-30, 71, pp. 13-116, 160, pp. 13-127, 21, pp. 13-51].

[b] NFPA 13 succeeding editions, including the 2025 Edition [21, pp. 13-38], all include the same requirements. *See* **Section 4.1** for more information on protective coatings.

must conform to the code requirements for each applicable hazardous material classification in accordance with Section 4.4 *Multiple Hazards.*

3. Revise NFPA 400 *Hazardous Materials Code*, Section G.4 *Safety Information on Oxidizers Used in Swimming Pools*, to include information regarding the potential for oxidizers to corrode metals such as sprinkler components and reference NFPA 13 *Standard for the Installation of Sprinklers*.

4.5 OSHA PSM AND EPA RMP COVERAGE OF REACTIVE HAZARDS

OSHA describes Process Safety Management (PSM) as “the proactive identification, evaluation, and mitigation or prevention of chemical releases that could occur as a result of failures in process, procedures, or equipment” [95]. The 14 elements included in OSHA’s PSM standard are intended to establish and maintain primary and secondary lines of defense that work in tandem to “operate and maintain the process as designed, and to keep the chemicals contained” while also ensuring systems such as fire protection systems work to “control or mitigate hazardous chemicals once an unwanted release occurs.”

While the OSHA PSM standard is oriented towards protecting onsite workers from the hazards associated with highly hazardous chemicals, the primary focus of the EPA Risk Management Program (RMP) rule is on preventing impacts to the public and the environment. To accomplish this objective, although the EPA RMP rule incorporates the same 14 elements that comprise OSHA’s PSM standard, the EPA RMP rule also includes Offsite Consequences Analysis to assess the impact of a potential release to “areas beyond the property boundary of the stationary source, and areas within the property boundary to which the public has routine and unrestricted access during or outside business hours” [96]. A facility that is subject to the OSHA PSM standard or the EPA RMP rule is required to have:

1) Conducted a hazard assessment that details the potential effects of an accidental release, an accident history of the last 5 years, and an evaluation of worst-case and alternative accidental release scenarios;
2) Implemented a prevention program that includes safety precautions, including engineering controls, operating procedures, maintenance, monitoring, and employee training measures; and
3) Maintained an emergency response program with requirements tied to whether or not the facility will rely on local emergency responders to respond to accidental releases [96].

Had Bio-Lab Conyers been subject to the OSHA PSM standard or the EPA RMP rule, the facility would have been regulatorily required to have identified, evaluated, and implemented mitigation or prevention programs that may have reduced the likelihood, extent, and severity of the September 2024 incident at the Plant 12 Storage Warehouse.

4.5.1 OSHA PROCESS SAFETY MANAGEMENT STANDARD

OSHA’s PSM standard [29 CFR §1910.119] provides regulatory requirements intended to:

> [P]reven[t] or minimiz[e] the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. These releases may result in toxic, fire or explosion hazards [95].

Despite the stated purpose of the statute and its focus on "toxic, reactive… or explosive chemicals" [95], coverage under the OSHA PSM standard is determined solely on the basis of a chemical's inclusion in a list of individual Highly Hazardous Chemicals, enumerated in Appendix A of the standard" [95], not on the inherent hazardous characteristics of materials. None of the chlorinated isocyanurates or BCDMH are included in OSHA PSM's *List of Highly Hazardous Chemicals, Toxics and Reactives (Mandatory)* despite these materials displaying reactive and corrosive characteristics (*see* **Section 3.2**) as demonstrated through the CSB's hazard testing. Therefore, Bio-Lab Conyers did not have and was not required to have a PSM program as of September 29, 2024.

Additionally, although chlorine, hydrogen chloride, and bromine are individually subject to the PSM standard, chlorinated isocyanurates and BCDMH are not, despite the fact that when these materials react upon exposure to water, they generate chlorine, hydrogen chloride, and bromine. Chlorine and bromine both have an OSHA PSM standard threshold quantity of 1,500 lbs., and the threshold quantity of hydrogen chloride (HCl) is 5,000 lbs. As an example, the decomposition of 15,000 lbs. of NaDCC would evolve approximately 1,500 lbs. of chlorine, based on available technical literature data.[a] The actual amount of NaDCC present at the warehouse at the time of the incident was approximately 588,000 lbs.

The CSB concludes that the quantities of chlorinated isocyanurates stored at the building, the Bio-Lab Conyers incident likely resulted in a release of chlorine, bromine, and/or hydrogen chloride that exceeded the OSHA PSM standard's threshold quantities for these chemicals. Although chlorinated isocyanurates are not currently subject to the OSHA PSM standard, incidents involving these materials are capable of releasing large quantities of reaction products, which are explicitly covered by the OSHA PSM standard.

Although the OSHA PSM standard applies to flammable gases and liquids such that any aggregated combination of these materials "on site in one location, in a quantity of 10,000 lbs. or more" is a covered process subject to the PSM standard, no such aggregate rule applies to substances such as toxics or materials that readily release toxics to the surrounding environment as a result of a decomposition reaction. The Bio-Lab Conyers warehouse contained nearly 14 million lbs. of chlorinated isocyanurates and BCDMH, capable of releasing immense quantities of toxic bromine, chlorine, and hydrogen chloride, but those materials were not in any way regulated under the OSHA PSM standard, even though a substantially lower quantity of flammables would have been covered under the standard. **Table 16** provides examples of requirements from OSHA's PSM standard that, if applied to Bio-Lab Conyers at the time of the incident, might have either prevented the incident from occurring or mitigated its severity.

[a] NaDCC presented as a representative example because it was the only chlorinated isocyanurate with a gas evolution rate value available in the technical literature.

Table 16. Applicability of OSHA's PSM standard and EPA's RMP rule to factors involved in the 2024 incident.

OSHA PSM language [95]	**EPA RMP Language** [97]	**Applicability to Incident**
Process Safety Information		
29 CFR §1910.119(d) [T]he employer shall complete a compilation of written process safety information before conducting any process hazard analysis required by the standard. The compilation of written process safety information is to enable the employer and the employees involved in operating the process to identify and understand the hazards posed by those processes involving highly hazardous chemicals. [Information shall include]… Reactivity data,… Corrosivity data,… Thermal and chemical stability data… maximum intended inventory.	*40 CFR §68.65* The owner or operator shall complete a compilation of written process safety information before conducting any process hazard analysis required by this part and shall keep process safety information up to date. The compilation of written process safety information is to enable the owner or operator and the employees involved in operating the process to identify and understand the hazards posed by those processes involving regulated substances. [Information shall include]… Reactivity data,… Corrosivity data,… Thermal and chemical stability data… maximum intended inventory.	Had the OSHA PSM standard and EPA RMP rule applied to the stored chlorinated isocyanurates and BCDMH, Bio-Lab Conyers and KIK would have been required to develop and document a full hazard characteristics profile of its materials, which they could have used for developing safeguards for the Plant 12 Storage Warehouse, or have passed this information along to Bio-Lab Conyers' design-build contractor or AHJ so these characteristics could be taken into account in its construction. Additionally, Bio-Lab Conyers would have been required to establish and control its material quantities within a maximum inventory threshold for the storage warehouse. At the time of the incident, Bio-Lab Conyers considered its materials to be solely oxidizers and did not have established maximum inventories for the warehouse.
Process Hazard Analysis		
29 CFR §1910.119(e) "The employer shall perform an initial process hazard analysis (hazard evaluation) on processes covered by this standard. The process hazard analysis shall be appropriate to the complexity of the process and shall identify, evaluate, and control the hazards involved in the process…." Conduct a hazard assessment every five (5) years that identifies, evaluates, and controls the hazards involved in the process, including details of the potential effects of an accidental release and previous incidents, and an evaluation of worst-case and alternative accidental release scenarios.	*40 CFR §68.67* The owner or operator shall perform an initial process hazard analysis (hazard evaluation) on processes covered by this part. The process hazard analysis shall be appropriate to the complexity of the process and shall identify, evaluate, and control the hazards involved in the process…shall determine and document the priority order for conducting process hazard analyses … includes such considerations as extent of the process hazards, number of potentially affected employees, age of the process, and operating history of the process.…(f) At least every five (5) years after the completion of the initial process hazard analysis, the process hazard analysis shall be updated and revalidated …to assure that the process hazard analysis is consistent with the current process.	Had the OSHA PSM standard and EPA RMP rule applied to stored chlorinated isocyanurates and BCDMH, Bio-Lab Conyers would have been required to have performed a Process Hazard Analysis to identify, evaluate, and control the hazards involved in the process prior to first storing chlorinated isocyanurates at the warehouse building. As described in **Section 4.3.2**, Bio-Lab had never performed any formal hazard analyses of the storage warehouse at any point in its life cycle.

OSHA PSM language [95]	**EPA RMP Language** [97]	**Applicability to Incident**
Mechanical Integrity: Equipment Deficiencies		
29 CFR §1910.119(j) The employer shall correct deficiencies in equipment that are outside acceptable limits before further use or in a safe and timely manner when necessary means are taken to assure safe operation.	*40 CFR §68.73* The owner or operator shall correct deficiencies in equipment that are outside acceptable limits before further use or in a safe and timely manner when necessary means are taken to assure safe operation.	Had the OSHA PSM standard and EPA RMP rule applied to stored chlorinated isocyanurates and BCDMH, Bio-Lab Conyers would have been required to establish and maintain a mechanical integrity program, inclusive of the fire protection system, that would have more effectively managed and resolved equipment failures and deficiencies. These deficiencies were the most likely initiation factor in the September 29, 2024, incident, as previously described in **Section 3.1.2**.
Incident Investigation		
29 CFR§1910.119(m) The employer shall investigate each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace. …. The employer shall establish a system to promptly address and resolve the incident report findings and recommendations. Resolutions and corrective actions shall be documented.	*40 CFR §68.81.* The owner or operator shall investigate each incident which resulted in, or could reasonably have resulted in a catastrophic release… The owner or operator shall promptly address and resolve the investigation findings and recommendations. Resolutions and corrective actions shall be documented.	Had the OSHA PSM standard and EPA RMP rule applied to stored chlorinated isocyanurates and BCDMH, Bio-Lab Conyers would have been required to conduct incident investigations on previous off-gassing incidents at the facility and implement any identified corrective actions resulting from these investigations. Despite frequent previous off-gassing events and near-misses, Bio-Lab did not perform any previous incident investigations of these events, as described in **Section 1.4.1**.

The CSB concludes that the PSM standard has significant gaps in coverage of reactive hazards because it is based on a limited and static list of individual chemicals and does not apply to materials such as the chlorinated isocyanurates or BCDMH, despite their reactive and explosive characteristics and inherent ability to evolve toxic gases. Had these materials been covered based on their reactive characteristics and had Bio-Lab Conyers and KIK been required to implement the elements of the OSHA PSM standard, the September 2024 incident may have either been prevented or its severity mitigated.

The CSB reiterates its previous recommendation (2021-02-I-WV-13) to OSHA to 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 hazardous 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 but are not limited to:
    - Literature surveys (e.g., Bretherick's Handbook of Reactive Chemical Hazards, Sax's Dangerous Properties of Industrial Materials, CAS SciFinder).
    - Information developed from computerized tools (e.g., ASTM's CHETAH, CCPS's Chemical Reactivity Worksheet).
    - Chemical property data compiled in PubChem and the REACH (Registration, Evaluation, and Authorization of Chemicals) dossiers maintained by the European Chemicals Agency (ECHA).
    - Chemical reactivity test data produced by employers or obtained from other sources following established standards, such as:
        - ASTM E537-20, Standard Test Method for Chemicals by Differential Scanning Calorimetry;
        - ASTM E1981-22, Standard Guide for Assessing Thermal Stability of Materials by Methods of Accelerating Rate Calorimetry;
        - ASTM E2550-21, Standard Test Method for Thermal Stability by Thermogravity; and
        - ASTM E1231-19, Standard Practice for Calculation of Hazard Potential Figures of Merit for Thermally Unstable Materials.
    - Relevant incident data from the plant, the corporation, industry, and government.
- 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 a runaway reaction from decomposition.
    - Time to Maximum Rate under Adiabatic Conditions (TMRad).
    - 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 hazardous gas evolution.

4.5.2 EPA Risk Management Program Rule

Similar to OSHA PSM's approach, the applicability of the EPA RMP rule is also determined entirely on the basis of a chemical's inclusion in a list of regulated toxic and flammable substances and their associated threshold planning quantities (TPQ) enumerated at 40 CFR §68.130 [96]. A facility is subject to the RMP rule if the "stationary source… has more than a threshold quantity of a regulated substance in a process." Although chlorine, hydrogen chloride, and bromine are individually subject to the RMP rule, chlorinated isocyanurates and BCDMH are not, despite the fact that these materials can generate large quantities of chlorine, hydrogen chloride, and bromine upon exposure to water, leading to a decomposition reaction. Therefore, Bio-Lab Conyers and KIK were not subject to the EPA RMP rule as of September 29, 2024.

Under the EPA RMP rule, chlorine has a threshold quantity of 2,500 lbs., and bromine has a TPQ of 10,000 lbs. In addition to the TPQ, the 40 CFR §68.130 list of substances includes a column identifying the "basis of listing" for each chemical that is subject to the RMP rule. For example, the basis code provided for cyanogen chloride, which can be released during decomposition of chlorinated isocyanurates (**Appendix F**) is "toxic gas" [96]. For HCl, the associated basis code is "[t]oxicity of hydrogen chloride, potential to release hydrogen chloride, and history of accidents" [96]. The significance of these codes is associated with the RMP rule's focus on off-site consequences analysis, which requires dispersion modeling to determine whether and to what extent impacts from a release will extend to off-site receptors such as the surrounding community. As discussed previously in **Section 1.4**, numerous previous industry incidents have involved the chlorinated isocyanurates and other pool-treatment chemicals that release chlorine and bromine gases upon during a decomposition reaction.

The CSB concludes that the large quantities of chlorinated isocyanurates stored at the building, the Bio-Lab Conyers incident likely resulted in a release of chlorine, bromine, and/or hydrogen chloride that exceeded the EPA RMP rule's threshold planning quantities for these chemicals, even though these reaction products themselves were not stored at the building in those forms.

As part of dispersion modeling, the EPA RMP rule dictates that the facility owner "shall ensure that…dispersion analysis of regulated toxic substances appropriately account for gas density," considering the special hazards associated with "dense or neutrally buoyant gases." Vapor plumes are classified according to whether they are lighter than air (positively buoyant), denser than air (negatively buoyant), or of the same density as air (neutrally buoyant) [98, pp. 34 - 36 and 40]. These characteristics determine their behavior when a hazardous release occurs [98, p. 40], such as whether they rise above or remain close to the ground and impact off-site receptors such as the neighboring community.[a] Chlorine vapor is considered a dense gas for the purposes of the EPA RMP rule off-site consequences modeling, as these vapors are heavier than air and will not loft or disperse as readily, which increases their potential severity of impact to off-site receptors [99, pp. 4 - 3].

Air monitoring by EPA following the September 2024 Conyers incident indicated that the observed plume from the site contained bromine, chlorine, and hydrogen chloride.[b] Per EPA's *Risk Management Program Guidance for Offsite Consequences Analysis*, bromine, chlorine, and hydrogen chloride are all classified as dense gases for EPA RMP off-site consequences modeling [100, pp. B-2 and B-4]. **Figure 52** shows the dense gas behavior of the plume during the incident, where a significant portion of the gas plume remained close to the ground, where it would have a greater impact at the ground level compared with a lighter buoyant plume. The light blue line in **Figure 52** shows the point at which the dense plume slumps to the ground, and the red circle shows the RCFR fire truck inundated by the thick ground-level plume.

[a] Although upon release a dense vapor may first travel upward, once initial momentum is lost it will start to descend toward the ground due to "gravity slumping" since it is heavier than the surrounding air. "When dense gases are initially released, these gases slump toward the ground and move both upwind and downwind..." [156, p. 284].

[b] Air monitoring by EPA was conducted at multiple stations downwind of the site throughout the 17 days of off-gassing from the building footprint. EPA 12-hour air monitoring results included detections of chlorine and hydrogen chloride, and low detections of phosgene. Air sampling performed by Georgia Tech's Atmospheric Science and Chemistry Measurement Network in Decatur, Georgia, detected a 1,400-times increase in the amount of chlorine-containing particles and a 170-times increase in the amount of bromine-containing particles in the air on September 30, 2024, the day after the incident.

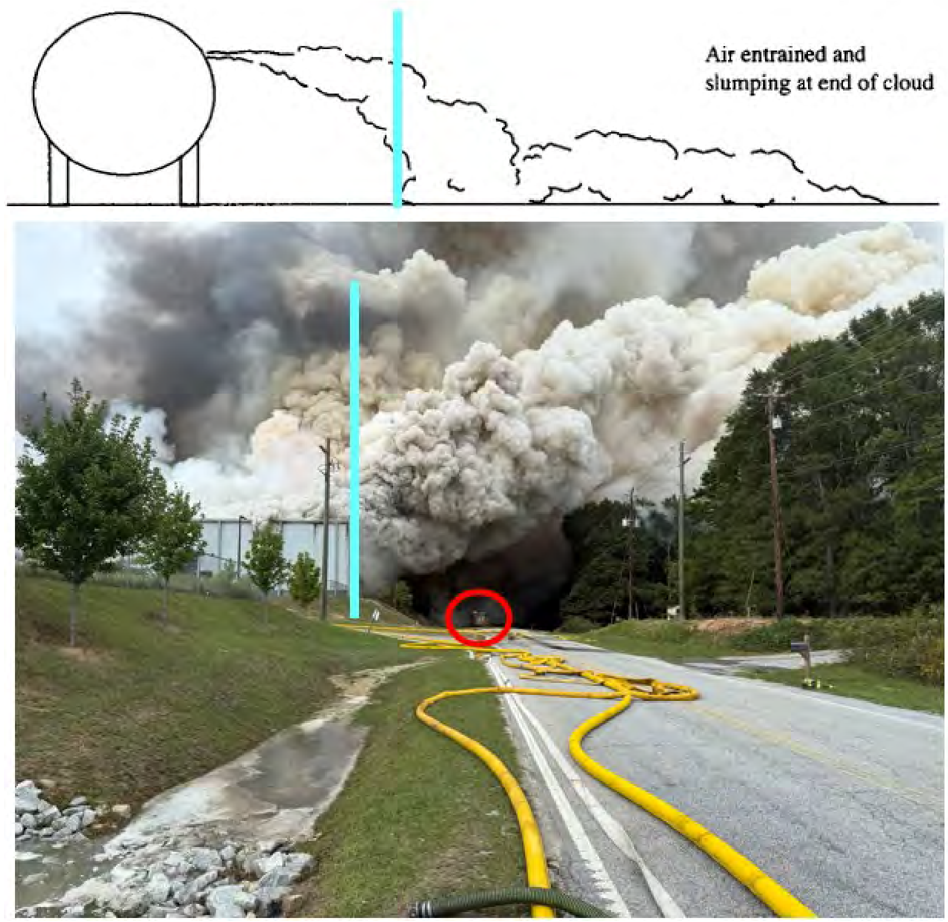


Figure 52. Comparison of expected dense gas behavior to plume behavior observed during the Bio-Lab Conyers 2024 incident. (Credit: Wells [98, p. 40], at top; RCFR at bottom; annotated by CSB)

As with the OSHA PSM standard, **Table 16** in **Section 4.5.1** above also provides examples of requirements from the EPA RMP rule that, if applied to Bio-Lab Conyers and KIK at the time of the incident, might have either prevented the incident from occurring or mitigated its severity.

The CSB concludes that the EPA's RMP rule does not adequately confer regulatory coverage to require stationary sources to address and abate reactive chemical hazards, such as the chlorinated isocyanurates and BCDMH stored in the Bio-Lab warehouse, despite their previous incident history in industry and their potential to evolve reaction gases known to be toxic and that exhibit dense gas behavior that increases off-site consequences. Had Bio-Lab and KIK been subject to the EPA RMP rule and therefore required to conduct a hazard assessment, implement a prevention program, and maintain an emergency response program, these measures could have prevented or mitigated the severity of the incident.

The CSB reiterates its previous recommendation (2001-01-H-3) to EPA 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. Take into account the recommendations of this report to OSHA on reactive hazard coverage. Seek congressional authority if necessary to amend the regulation.

5 Conclusions

5.1 Findings

Technical Analysis

1. Although minor roof leaks, as described by KIK employees, were documented during Hurricane Helene, it is unlikely that the leaks provided the water source that initiated the incident. Rainfall had also ceased over 36 hours before the incident occurred.

2. The natural off-gassing of chlorine fumes from the storage of chlorinated isocyanurates reacted with the ambient moisture in the air to produce hydrochloric acid droplets, which condensed on metal surfaces, such as sprinklers and fire protection system piping. As hydrochloric acid caused severe corrosion of most common metals, this process resulted in damage to the fire protection system components within a few months after the start of chlorinated isocyanurate storage in a building.

3. Based on the initial KIK fire watch employee report to multiple parties and the well-established history of failures due to corrosion damage, and the flow of water observed before any firefighting water was applied, a sprinkler system component failure represents the most likely water source scenario for initiating the incident.

4. Chlorinated isocyanurates stored inside the Bio-Lab Conyers Plant 12 Storage Warehouse generated significant heat and released hazardous gases when mixed with small amounts of water; therefore, these materials met the formal qualitative definition of water-reactive materials as defined by NFPA 400 and when those chlorinated isocyanurates come into contact with water, they release several hazardous gases, including HCl, which is not only corrosive upon physical contact but can also create a corrosive atmosphere.

5. The chlorinated isocyanurates stored in the Plant 12 Storage Warehouse released corrosive HCl gas when they come into contact with water. As a result, when these materials are exposed to water/moisture under ambient conditions, they emit corrosive HCl vapors, which create a corrosive atmosphere that can corrode metal surfaces.

Safety Issue: Run To Failure

6. Bio-Lab adopted a practice of replacing the fire protection sprinkler heads only after they had corroded, failed, and begun to leak. Had Bio-Lab Conyers implemented a proactive preventive maintenance program for the fire protection sprinkler system, the sprinkler heads, couplings, or other components outside the bunker area could have been replaced before they failed, reducing the risk of wetting the material stored below, which was known to initiate a decomposition reaction.

7. Had Bio-Lab Conyers taken steps to proactively prevent sprinkler system leaks instead of allowing the system to run to failure, the incident likely would not have occurred.

Safety Issue: Identification of Storage Hazards

8. Bio-Lab Conyers and KIK were not compliant with NFPA standards for the storage and handling of hazardous materials in corrosive environments within the Plant 12 Storage Warehouse. Had Bio-Lab Conyers and KIK followed the NFPA corrosion-resistance requirements for managing corrosive environments, such as: 1) installing corrosion-resistant pipes, fittings, and hangers; 2) regularly inspecting and maintaining areas susceptible to corrosion; and 3) applying protective coatings that are resistant to corrosion in accordance with the specific requirements set by the sprinkler manufacturer, the severity of the incident involving water contacting the stored chlorinated isocyanurates could have been mitigated.

9. The Bio-Lab Conyers Plant 12 Storage Warehouse's ventilation system was inadequate to remove the corrosive vapors generated by the large quantities of corrosive oxidizers stored in the building. Had the ventilation been sufficient, the accumulation of corrosive vapors could have been prevented, likely avoiding the degradation of the sprinkler system components that initiated the incident.

10. The Bio-Lab Conyers Plant 12 Storage Warehouse's ventilation system was insufficient for handling the quantities of corrosive oxidizers present in the ambient air humidity/moisture in Conyers, Georgia. Had the warehouse's ventilation system been designed for increased airflow, the sprinkler system might not have corroded, failed, or leaked water inside the building.

11. The increased inventory quantities in the Plant 12 Storage Warehouse forced the facility to store chlorinated isocyanurates (NFPA Class 1 and Class 2 oxidizers) outside the bunker, resulting in the corrosion of sprinkler heads in the area. The corroded heads failed, allowing water to leak onto the super sacks containing the oxidizer, resulting in off-gassing, decomposition reactions, and fires.

12. Had the Bio-Lab Conyers Plant 12 Storage Warehouse been designed to meet High-Hazard / Protection Level 3 storage requirements, the company would have been allowed to: 1) store unlimited quantities of Class 1 oxidizers and up to 2,000 tons (4 million pounds) of Class 2 oxidizers, and 2) likely store Class 2 oxidizers outside the bunker in accordance with the NFPA standards.

13. The Bio-Lab Conyers Plant 12 Storage Warehouse, as designed in 2019, did not comply with NFPA standards. Based on the building's design, Class 1 oxidizers would have unlimited storage, whereas Class 2 oxidizers would be limited to 500 lbs. per control area. Constructing a compliant H-3 (Protection Level 3) building with a mechanical ventilation system designed per code would have properly addressed the corrosive vapors and, therefore, may have prevented the incident on September 29, 2024. Smoke detection in the warehouse (i.e., wherever Class 2 oxidizers are stored) would enable much earlier detection of smoke/fire and possibly lead to earlier fire department intervention. Also, the proper sprinkler system design (including in-rack sprinklers for rack storage) may have kept the incident to a single fire location.

14. The storage configuration at the Bio-Lab Conyers Plant 12 Storage Warehouse at the time of the 2024 incident likely hindered the facility's ability to effectively monitor large quantities of inventory for early warning signs of product decomposition or a fire in the warehouse.

15. Bio-Lab Conyers' ERT personnel's ability to successfully respond to the off-gassing super sack(s) early on the morning of the incident, while visibility was still clear, was hindered by the storage

configurations of the large quantities of material. Had Bio-Lab Conyers considered the potential for off-gassing super sacks and ensured unobstructed emergency access in their storage configurations, such as by using storage racks with properly designed sprinkler systems and in-rack sprinklers, the ERT may have been able to respond effectively before the material ignited and prevented further spread of the fire within the building on September 29, 2024.

16. The use of single- and double-row storage racks, along with properly designed sprinkler systems, including in-rack sprinklers, may allow quicker access to an off-gassing container than three-row deep floor storage.

Safety Issue: Risk Management and Oversight

17. KIK recognized the physical hazards of its stored chlorinated isocyanurates, which are NFPA-classified oxidizers with water-reactive and corrosive characteristics. However, the company did not adequately address the risk of treating these materials as oxidizers only during storage, such as the possibility that corroded fire protection systems could release sufficient water to initiate a reaction capable of resulting in total building fire loss. Had KIK effectively managed the risk of not incorporating the other hazard characteristics into its operations, it may have required its component facilities, such as Bio-Lab Conyers, to have implemented more proactive actions to prevent fire protection system corrosion damage that might cause water-reactive chlorinated isocyanurates to become wet enough to cause a catastrophic building fire.

18. If KIK had enforced its fire protection impairment procedures, the company would have had stronger oversight of the issues and risks at the site level. With better knowledge of the frequency and severity of fire protection impairments, KIK could have assessed the level of risk for continuing operations at Bio-Lab Conyers without first implementing significant fire protection system improvements. As the September 2024 Bio-Lab Conyers incident was most likely initiated by a fire protection system failure, KIK's failure to understand and assess the significance of a high frequency of fire impairments contributed to the Plant 12 Storage Warehouse's fire.

19. KIK, as a company, was aware of and accepted the risk of storing large quantities of bulk chlorinated isocyanurates and regarded off-gassing events as routine business-as-usual occurrences. KIK also failed to voluntarily conduct formal risk analyses or assessments at each of its storage facilities and practices before the Conyers 2024 incident, despite its awareness of prior internal and external incidents involving these pool-treatment chemicals. Had KIK done so, or effectively implemented existing corporate procedures such as *PSM LITE*, *Fire Project Impairment*, or *Incident Investigation*, the company may have had an opportunity to determine whether its existing practices were inadequate for the risks involved in the storage and handling of its bulk materials in the Plant 12 Storage Warehouse.

20. Had Bio-Lab Conyers installed thermal cameras to enable early identification of super sack hot spots, rather than relying on human intervention, or implemented measures to prevent or reduce the impact of the corrosive fumes produced during the normal storage of chlorinated isocyanurates, the September 2024 incident may have been prevented.

21. KIK, as a company, did not maintain a sense of vulnerability as an organization or proactively communicate its support for risk-reduction and risk-management practices to its component sites. As a result, risk mitigation approaches were inconsistent between its sites, with multiple Bio-Lab On-Cal preventive and mitigation practices not consistently applied to other Bio-Lab facilities, such as Bio-Lab Conyers. Had KIK required Bio-Lab Conyers to implement measures such as those employed at Bio-Lab On-Cal to prevent corrosion of the fire protection system, the September 2024 incident may have been prevented or its severity mitigated by enabling earlier detection of super sack hot spots.

Safety Issue: NFPA Guidance for Pool-Treatment Chemicals

22. NFPA 400 primarily classifies pool-treatment chemicals as oxidizers and fails to address other hazardous categories or properties of these compounds, which are important for their safe storage. The NFPA should update its guidance explicitly to warn users about the additional hazard categories of pool-treatment chemicals and provide specific guidance on managing these materials with multiple hazardous characteristics. This update could enhance awareness, leading to thorough hazard assessments for their storage and management, and potentially reduce incidents like the fire at Bio-Lab Conyer.

23. The three NFPA standards address corrosion from fundamentally different perspectives: human health (NFPA 400), material degradation of sprinkler systems (NFPA 13), and corrosive atmospheres affecting electrical equipment (NFPA 70). Thus, facilities storing pool-treatment chemicals may not know to consult NFPA 70 and to implement fire protection systems that account for the corrosive environments these chemicals create, which could result in failure and lead to a decomposition reaction.

Safety Issue: PSM and RMP Coverage of Reactive Hazards

24. The quantities of chlorinated isocyanurates stored at the building, the Bio-Lab Conyers incident likely resulted in a release of chlorine, bromine, and/or hydrogen chloride that exceeded the OSHA PSM standard's threshold quantities for these chemicals. Although chlorinated isocyanurates are not currently subject to the OSHA PSM standard, incidents involving these materials are capable of releasing large quantities of reaction products, which are explicitly covered by the OSHA PSM standard.

25. The PSM standard has significant gaps in coverage of reactive hazards because it is based on a limited and static list of individual chemicals and does not apply to materials such as the chlorinated isocyanurates or BCDMH, despite their reactive and explosive characteristics and inherent ability to evolve toxic gases. Had these materials been covered based on their reactive characteristics and had Bio-Lab Conyers and KIK been required to implement the elements of the OSHA PSM standard, the September 2024 incident may have either been prevented or its severity mitigated.

26. The large quantities of chlorinated isocyanurates stored at the building, the Bio-Lab Conyers incident likely resulted in a release of chlorine, bromine, and/or hydrogen chloride that exceeded the EPA RMP rule's threshold planning quantities for these chemicals, even though these reaction products themselves were not stored at the building in those forms.

27. The EPA's RMP rule does not adequately confer regulatory coverage to require stationary sources to address and abate reactive chemical hazards, such as the chlorinated isocyanurates and BCDMH stored in the Bio-Lab warehouse, despite their previous incident history in industry and their potential to evolve reaction gases known to be toxic and that exhibit dense gas behavior that increases off-site consequences. Had Bio-Lab and KIK been subject to the RMP rule and therefore required to conduct a hazard assessment, implement a prevention program, and maintain an emergency response program, these measures could have prevented or mitigated the severity of the incident.

5.2 CAUSE

The CSB determined that the cause of the incident was a corroded sprinkler system component that failed, allowing water to contact the stored pool-treatment chemicals (chlorinated isocyanurates) inside the warehouse, initiating a decomposition reaction and generating significant amounts of dense toxic smoke and heat that started fires, ultimately leading to the building's destruction and closure of the site. The corrosion resulted from the corrosive environment created by stored chlorine-based chemicals in the building, an issue that was not proactively addressed.

The discrepancy between the design of the warehouse and the hazardous categories and large volumes of the materials stored inside, the lack of corporate implementation of risk mitigation strategies across all facilities, including the Conyers site, and gaps in NFPA guidance regarding the storage and handling of pool-treatment chemicals with multiple hazardous characteristics all contributed to this incident. Also contributing to the incident was the insufficient regulatory coverage of reactive hazards.

Contributing to the severity of the incident were inadequate storage configurations for the large quantities of hazardous material in the warehouse that hindered emergency response access to the initial reacting material early that morning, which led to the activation of additional sprinklers, wetting more materials, which resulted in further decomposition reactions, increased heat generation throughout the warehouse, and fires within the building.

6 RECOMMENDATIONS

To prevent future chemical incidents, and in the interest of driving chemical safety excellence 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 TO OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

2021-02-I-WV-R13 (from the 2020 CSB Optima Belle Investigation)

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 hazardous 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 but are not limited to:
    - Literature surveys (e.g., Bretherick's Handbook of Reactive Chemical Hazards, Sax's Dangerous Properties of Industrial Materials, CAS SciFinder).
    - Information developed from computerized tools (e.g., ASTM's CHETAH, CCPS's Chemical Reactivity Worksheet).
    - Chemical property data in PubChem and the REACH (Registration, Evaluation, and Authorization of Chemicals) dossiers maintained by the European Chemicals Agency (ECHA).
    - Chemical reactivity test data produced by employers or obtained from other sources following established standards, such as:
        - ASTM E537-20, Standard Test Method for Chemicals by Differential Scanning Calorimetry;
        - ASTM E1981-22, Standard Guide for Assessing Thermal Stability of Materials by Methods of Accelerating Rate Calorimetry;
        - ASTM E2550-21, Standard Test Method for Thermal Stability by Thermogravity; and

- ASTM E1231-19, Standard Practice for Calculation of Hazard Potential Figures of Merit for Thermally Unstable Materials.

- Relevant incident data from the plant, the corporation, industry, and government.

- 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 a runaway reaction from decomposition.
  - Time to Maximum Rate under Adiabatic Conditions (TMR_{ad}).
  - 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 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.

6.2 New Recommendations[a]

6.2.1 KIK Consumer Products

2024-04-I-GA-R1

Develop and implement a corporate standard for the storage (including storage configuration) and handling of bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, at facilities in the company's Pool Division. At a minimum, the standard shall ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements), and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product

[a] The CSB is not issuing any recommendations specifically to Bio-Lab Conyers because KIK has ceased operations at the facility. Additionally, the CSB is not issuing any recommendations to the State of Georgia or Rockdale County. However, the CSB urges both the State of Georgia and Rockdale County to establish a new process or to maintain an existing one that routinely reviews and updates its minimum fire safety standards and requirements to ensure that they remain aligned with future editions of relevant National Fire Protection Association (NFPA) standards, such as NFPA 400, and incorporate applicable regulatory requirements as they become effective.

facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standard.

2024-04-I-GA-R2

Develop and implement a corporate standard that requires an assessment of all KIK Consumer Products / Bio-Lab, Inc. third-party facilities that manufacture and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH, to ensure compliance with NFPA 400 *Hazardous Materials Code* (for storage, construction, and other requirements) and NFPA 13 *Standard for the Installation of Sprinkler Systems* (for corrosion resistance and other requirements). The standard shall ensure that any non-compliance with NFPA 400 and NFPA 13 is appropriately addressed prior to operations. The standard shall ensure that existing third-party facilities that manufacture and/or store bulk chlorinated isocyanurates and BCDMH are assessed for compliance with NFPA 400 and NFPA 13, and that any non-compliance is addressed within a specified timeframe. The incident history of KIK Consumer Product facilities, including the Bio-Lab Lake Charles and Bio-Lab Conyers sites, shall be used to guide the development of the standards.

2024-04-I-GA-R3

Contract a third party to audit the implementation of the *PSM Lite* program within KIK's Pool Division, including all facilities that handle and/or store bulk pool-treatment chemicals, including but not limited to chlorinated isocyanurates and BCDMH. Address all identified deficiencies resulting from the audit within a specified timeframe.

2024-04-I-GA-R4

Contract a third party to audit the implementation of the corporate standards developed in recommendations 2024-04-I-GA-R1 and 2024-04-I-GA-R2 at KIK Consumer Products / Bio-Lab, Inc. Pool Division facilities and third-party facilities that manufacture and/or store bulk pool-treatment chemicals. Address all identified deficiencies resulting from the audit within a specified timeframe.

6.2.2 National Fire Protection Association

2024-04-I-GA-R5

Revise NFPA 400 *Hazardous Materials Code*, Section 4.1 *Hazardous Material Classification*, or a more appropriate section, to clarify that materials are required to be assessed and a determination reached for each of the categories of hazardous materials (1) through (14).

2024-04-I-GA-R6

Revise NFPA 400 *Hazardous Materials Code*, Section G.4 *Safety Information on Oxidizers Used in Swimming Pools*, to address the potential for pool-treatment chemicals to demonstrate characteristics of hazard classifications other than those of oxidizers, and that each additional hazard classification must conform to the code requirements for each applicable hazardous material classification in accordance with Section 4.4 *Multiple Hazards*.

2024-04-I-GA-R7

Revise NFPA 400 *Hazardous Materials Code*, Section G.4 *Safety Information on Oxidizers Used in Swimming Pools*, to include information regarding the potential for oxidizers to corrode metals such as sprinkler components and reference NFPA 13 *Standard for the Installation of Sprinklers*.

7 Key Lessons for the Industry

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

1. Chlorinated isocyanurates (pool-treatment chemicals) can naturally off-gas corrosive vapors, creating a corrosive environment inside buildings that can corrode sprinkler system components, leading to failures and decomposition reactions that can result in fires. Users who handle and store pool-treatment chemicals should be aware of their corrosive properties to ensure that structures are properly designed and that an appropriate sprinkler system is selected to proactively prevent incidents, and to ensure compliance with NFPA 400 and NFPA 13 standards.

2. It is important for all users of chemicals, especially users of pool-treatment chemicals, to understand the ability of the chemicals used or stored to create a corrosive environment due to the material evolving vapors during normal storage conditions. As such, users of these chemicals must ensure the correct safeguards are implemented to reduce the impact of the corrosive environment, such as the materials of construction used for infrastructure inside the building and adequate ventilation to reduce the corrosivity of the environment.

3. Facilities must ensure that storage layouts provide unobstructed access to always allow effective monitoring of hazardous materials, particularly those that can undergo exothermic decomposition under normal storage conditions. This includes establishing clear storage configurations such as adequate aisle widths and product pile sizes. Additionally, facilities should implement continuous automated systems, such as the installation of thermal cameras, to detect potential safety hazards early rather than rely solely on manual intermittent monitoring.

4. Even in the absence of regulatory requirements for risk assessments, organizations should ensure that all hazards of using and storing hazardous chemicals be assessed and properly mitigated. Additionally, any risks, including worst-case scenarios identified, that can have community impact should also be evaluated and mitigated appropriately to reduce the severity and likelihood of community impacts due to incidents at the site.

5. Users of NFPA standards are responsible for properly identifying each applicable hazard classification associated with the chemicals they are using and storing. All relevant NFPA hazard classification requirements should be applied, ensuring the implementation of the most stringent requirements, to ensure safe handling and storage.

8 REFERENCES

[1] KIK Consumer Products Inc., "What is BioLab?," [Online]. Available: https://www.biolabinc.com/. [Accessed 8 July 2026].

[2] National Fire Protection Association, "NFPA 400: Hazardous Materials Code (2025 Edition)," 2024.

[3] Occidental Chemical Corporation, "Occidental Chemical Corporation ACL Chlorinated Isocyanurates Product Details," [Online]. Available: https://www.oxy.com/siteassets/documents/chemicals/products/other-essentials/chlorinated-isocyanurates---product-details.pdf. [Accessed 20 June 2025].

[4] LONZA, Pool and Spa Chemicals, Storage & Handling Guide, 2013.

[5] U. S. I. T. Commission, "Chlorinated Isocyanurates," 7 April 2020. [Online]. Available: https://www.usitc.gov/keywords/chlorinated_isocyanurates. [Accessed 20 June 2025].

[6] J. Daintith, Dictionary of Chemistry (6th Edition), Oxford University Press, 2008.

[7] PubChem, "Symclosene," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Trichloroisocyanuric-acid. [Accessed 29 May 2025].

[8] National Center for Biotechnology Information, "PubChem Element Summary for AtomicNumber 17, Chlorine," [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/element/Chlorine. [Accessed 29 May 2025].

[9] National Center for Biotechnology Information, "PubChem Compound Summary for CID 24526, Chlorine," [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Chlorine. [Accessed 29 May 2025].

[10] National Center for Biotechnology Information, "PubChem Compound Summary for CID 517202, Troclosene sodium," [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Troclosene-sodium. [Accessed 29 May 2025].

[11] National Center for Biotechnology Information, "PubChem Compound Summary for CID 23667638, Sodium dichloroisocyanurate dihydrate," [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Sodium-dichloroisocyanurate-dihydrate. [Accessed 29 May 2025].

[12] National Center for Biotechnology Information, "PubChem Compound Summary for CID 61828, 1-Bromo-3-chloro-5,5-dimethyl-2,4-imidazolidinedione," 2025. [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/1-Bromo-3-chloro-5_5-dimethylhydantoin. [Accessed 20 June 2025].

[13] EnviroTech, "BCDMH Tabs: Water Treatment Biocide," [Online]. Available: https://envirotech.com/wp-content/uploads/2016/01/BCDMH-Tech-Booklet.pdf. [Accessed 12 May 2026].

[14] Y. Wang, J. Meng, X. Tian, C. Sun, L. Liu and X. Sun, "Chlorine gas poisoning by trichloroisocyanuric acid and respiratory failure: a case report of a 49-year-old patient.," *Front Med (Lausanne),* vol. 12, no. 1676596, p. 11, 2025.

[15] Agency for Toxic Substances and Disease Registry | Division of Toxicology and Human Health Sciences, "Medical Management Guidelines for Hydrogen Chloride," [Online]. Available: https://wwwn.cdc.gov/TSP/MMG/MMGDetails.aspx?mmgid=758&toxid=147#:~:text=High%20concentrations%20of%20hydrogen%20chloride,throat%2C%20esophagus%2C%20and%20stomach.. [Accessed 2 May 2026].

[16] CAMEO Chemicals, "Hydrogen Chloride, Anhydrous," National Oceanic and Atmospheric Association (NOAA) , Version 3.1.0 rev 2.. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8731. [Accessed December 2025].

[17] International Code Council, "International Building Code, 2024," [Online]. Available: https://codes.iccsafe.org/content/IBC2024V1.0/chapter-6-types-of-construction. [Accessed 24 June 2025].

[18] National Fire Protection Association, NFPA 1 Fire Code (2024 edition).

[19] American Fire Protection Group, "Comparing the Different Types of Fire Sprinkler," 2026. [Online]. Available: https://www.afpgusa.com/blog/comparing-the-different-types-of-fire-sprinkler-systems/. [Accessed 13 May 2026].

[20] B. O'Connor, "Types of Sprinklers," National Fire Protection Association (NFPA), 2022.

[21] National Fire Protection Association, "NFPA 13: Standard for the Installation of Sprinkler Systems (2025 Edition)," 2024.

[22] National Fire Protection Association, "Enhanced content, Annex A (A.1.1.3): Commentary on multiple ignition sources.," in *NFPA 13: Installation of Sprinkler Systems*, Quincy, MA, 2025.

[23] Kimble & Company, "What Triggers a Fire Sprinkler System? 5 Activation Scenarios Explained," Huntington Beach, CA.

[24] Flexible Intermediate Bulk Containers Association (FIBCA), "Frequently Asked Questions," 2026. [Online]. Available: https://fibca.com/faq-page-1/. [Accessed 04 May 2026].

[25] Flexible Intermediate Bulk Containers (FIBCs), "Flexible Intermediate Bulk Containers Association (FIBCA)," 2026. [Online]. Available: https://fibca.com/faq-page-1/. [Accessed 04 May 2026].

[26] A. Brody and K. Marsh, "Flexible Intermediate Bulk Contains," in *The Wiley Encyclopedia of Packaging Technology*, New York, 1997, pp. 448-449.

[27] FlexSack, "FIBC Liner Selection Guide: How to Choose the Right Liner for Bulk Packaging Protection," 2026. [Online]. Available: https://flexsack.com/fibc-liner-selection-guide/. [Accessed 6 May 2026].

[28] National Fire Protection Association®, "Commodity Classifications in NFPA 13," 18 January 2022. [Online]. Available: https://www.nfpa.org/news-blogs-and-articles/blogs/2022/01/18/commodity-classifications-in-nfpa-13. [Accessed 9 April 2025].

[29] United States Environmental Protection Agency, "BioLab Fire - On-Scene Coordinator," [Online]. Available: https://www.epaosc.org/site/site_profile.aspx?site_id=A4EY. [Accessed 30 June 2025].

[30] 2005 Cable News Network LP, LLLP. │cnn.com, "Intense chemical blaze 'very difficult fire to fight'," 25 May 2004. [Online]. Available: https://www.cnn.com/2004/US/South/05/25/fire/index.html. [Accessed June 30 2025].

[31] CSB 4WWL, "Large chemical fire reported in Lake Charles after Hurricane Laura," 27 August 2020. [Online]. Available: https://www.wwltv.com/article/weather/hurricane/large-chemical-fire-reported-in-lake-charles-after-hurricane-laura/289-0de1b0bc-2a9c-4bea-be9d-e2813c7a8df8. [Accessed 1 July 2025].

[32] United States Fire Administration Technical Report Series, Federal Emergency Management Agency, "Swimming Pool Chemical Plant Fire Springfield, Massachusetts".

[33] The State Journal, "Clearon Corp. issues statement following leak in South Charleston, WV," 18 January 2024. [Online]. Available: https://www.wvnews.com/statejournal/news/clearon-corp-issues-statement-following-leak-in-south-charleston-wv/article_c9ed5112-c415-5cc6-a5b8-3261d5b4d429.html. [Accessed 17 July 2025].

[34] U.S. Chemical Safety and Hazard Investigation Board, "Fatal Chemical Decomposition Reaction and Explosion at Optima Belle LLC," 6 July 2023. [Online]. Available: https://www.csb.gov/file.aspx?DocumentId=6238. [Accessed 6 May 2026].

[35] United States Code, "§654. Duties of employers and employees," [Online]. Available: https://uscode.house.gov/view.xhtml?req=(title:29%20section:654%20edition:prelim). [Accessed 4 August 2025].

[36] U.S. Department of Labor, Occupational Safety and Health Administration, "Violation Detail (Inspection Nr: 1778326.015, Report ID: 0418100)," [Online]. Available: https://www.osha.gov/ords/imis/establishment.violation_detail?id=1778326.015&citation_id=01001. [Accessed 15 January 2026].

[37] National Weather Service, Atlanta, GA, "Hurricane Helene, September 27-29, 2024: Hurricane Helene Brings Major Impacts to Much of Central and North Georgia," [Online]. Available: https://storymaps.arcgis.com/stories/f58c7544cb7f4068be1a9e7d03c629b3. [Accessed 7 July 2025].

[38] National Weather Service | National Oceanic and Atmospheric Administration, "WFO Monthly/Daily Climate Data: Preliminary Local Climatological Data, Dekalb Peachtree Airport, September 2024.," [Online]. Available: https://forecast.weather.gov/product.php?site=FFC&issuedby=PDK&product=CF6&format=CI&version=11&glossary=0. [Accessed 22 July 2025].

[39] Rockdale County Government Facebook, "Update: Press Conference regarding to [sic] today's incident at Bio-Lab," Rockdale County Government Rockdale County Sheriff's Office Rockdale County Emergency Management Agency - RC EMA City of Conyers, GA, 29 September 2024. [Online]. Available: https://www.facebook.com/RockdaleGov/videos/update-press-conference-regarding-to-todays-incident-at-bio-labrockdale-county-g/506209848917302/. [Accessed 21 April 2025].

[40] Rockdale County Public Schools, "BioLab Fire Independent Learning Virtual Extended," 8 October 2024. [Online]. Available: https://www.rockdaleschools.org/about/news-and-announcements/district-announcements/biolab-fire-independent-learning-virtual-extended. [Accessed 22 July 2025].

[41] J. Nussman, "Rockdale County Schools extend virtual learning days following BioLab chemical incident," 11Alive News, 8 October 2024. [Online]. Available: https://www.11alive.com/article/news/local/rockdale-county-schools-virtual-biolab-chemical/85-732ec0d6-b563-41b6-9496-27fd5ce669af. [Accessed 22 July 2025].

[42] Rockdale County Public Schools, "About Rockdale County Public Schools," [Online]. Available: https://business.conyers-rockdale.com/list/member/rockdale-county-public-schools-506. [Accessed 22 July 2025].

[43] WSB-TV Atlanta, "Rockdale County chemical fire: Newton Co. Schools closed Monday due to potential Biolab impact," WSB-TV Atlanta, 29 September 2024. [Online]. Available: https://www.wsbtv.com/news/local/newton-county/rockdale-county-chemical-fire-newton-co-schools-closed-monday-due-potential-biolab-impact/RJCCRV6MN5HPFHW3AV4JB3V24Y/. [Accessed July 22 2025].

[44] M. N. D. P. Savannah Levins, "What independent test results after Georgia's BioLab fire reveal," 11Alive News, 2 January 2025. [Online]. Available: https://www.11alive.com/article/news/investigations/11alive-news-investigates/conyers-biolab-sampling-results/85-16beaeae-5c51-4dc3-ad97-0a384ee3f126. [Accessed 22 July 2025].

[45] C. A. Harper, L. Arterburn, K. Paredero, R. E. Asmar, M. L. Stewart, D. J. Tanner, J. M. Roberts, J. J. Orlando, J. Sadighi, R. J. Weber and G. L. Huey, "Observations of the Gas Phase Composition of the 2024 BioLab Industrial Plume in the Atlanta Metropolitan Area," *Environmental Science & Technology Letters*, vol. 13, no. 5, pp. 664 - 669, 2026.

[46] BioLab, "May 15, 2025 12:00 PM BioLab Provides Update on Site Remediation and Manufacturing Operations," 15 May 2025. [Online]. Available: https://biolabcommunityresources.com/updates/. [Accessed 19 May 2025].

[47] Office of Research and Development, U.S. Environmental Protection Agency, "CHLORINE AND HYDROGEN CHLORIDE | EPA-600/1-76-020," 1976.

[48] R. Fan, W. Zhang, Y. Wang, D. Chen and Y. Zhang, "Metal Material Resistant to Hydrochloric Acid," *Journal of Physics: Conference Series,* vol. 1732, no. 012134, p. 8, 2021.

[49] National Fire Protection Association, "NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (2026 Edition)," 2025.

[50] PubChem, "Trichloroisocyanuric Acid," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Trichloroisocyanuric-Acid. [Accessed 22 April 2026].

[51] PubChem, "Troclosene sodium," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Troclosene-sodium. [Accessed 29 May 2025].

[52] Center for Disease Control and Prevention. The National Institute for Occupational Safety and Health (NIOSH), "Chlorine," [Online]. Available: https://www.cdc.gov/niosh/npg/npgd0115.html. [Accessed 1 May 2026].

[53] CAMEO Chemicals, "Acetone," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8. [Accessed 22 December 2025].

[54] CAMEO Chemicals, "Dimethylamine, Anhydrous," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8562. [Accessed 22 December 2025].

[55] CAMEO Chemicals, "Methylhydrazine," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/1110. [Accessed 22 December 2025].

[56] PubChem, "2-hydroxypropanamide," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/2S_-2-hydroxypropanamide. [Accessed 22 December 2025].

[57] CAMEO Chemicals, "Ethanolamine," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/1146. [Accessed 22 Decenber 2025].

[58] CAMEO Chemicals, "Carbon Monoxide," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/335. [Accessed 22 December 2025].

[59] CAMEO Chemicals, "Ethylene," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8655. [Accessed 22 December 2025].

[60] PubChem, "L-Homoserine," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/L-homoserine. [Accessed 23 December 2025].

[61] CAMEO Chemicals, "2-Chloro-2-nitropropane," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/20008. [Accessed 23 December 2025].

[62] CAMEO Chemicals, "Carbon Dioxide," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/330. [Accessed 22 December 2025].

[63] CAMEO Chemicals, "Methane," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8823. [Accessed 23 December 2025].

[64] CAMEO Chemicals, "Water," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/30024. [Accessed 23 December 2025].

[65] National Fire Protection Association, "NFPA 13: Standard for the Installation of Sprinkler Systems," 2025. [Online]. Available: https://link.nfpa.org/publications/13/2025/annexes/A/groups/1. [Accessed 13 March 2026].

[66] Center for Chemical Process Safety | American Institute of Chemical Engineers, Recognizing Catastrophic Incident Warning Signs in the Process Industries, Wiley, 2012.

[67] National Fire Protection Association, "NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (2026 Edition)," 2025.

[68] National Fire Protection Association, "NFPA 400: Hazardous Material Code (2019)," 2018.

[69] National Fire Protection Association, "NFPA 13: Standard for the Installation of Sprinkler Systems (2016 Edition)," 2015.

[70] National Fire Protection Association, "NFPA 13: Standard for the Installation of Sprinkler Systems (2013 Edition)," 2012.

[71] National Fire Protection Association, "NFPA 13: Standard on the Installation of Sprinkler Systems (2019 Edition)," 2018.

[72] Center for Chemical Process Safety (CCPS) | AIChE, Guidelines for Hazard Evaluation Procedures (3rd Edition), John Wiley & Sons, Inc., 2008.

[73] National Fire Protection Association, "NFPA 70: National Electrical Code (2017 Edition)," 2016.

[74] National Fire Protection Association, "NFPA LiNK® | CASI™".

[75] National Fire Protection Association, "NFPA 400: Hazardous Material Code (2013 Edition)," 2012.

[76] Center of Chemical Process Safety (CCPS), "Inventory Management," in *Guidelines for Safe Warehousing of Chemicals*, 1998, pp. 29-31.

[77] Center for Chemical Process Safety (CCPS), Guidelines for Risk Based Process Safety, Hoboken: John Wiley & Sons, Inc., 2007, pp. 245-316.

[78] Center of Chemical Process Safety (CCPS), "About CCPS," [Online]. Available: https://www.aiche.org/ccps/about. [Accessed 2 April 2026].

[79] J. Cadle, D. Paul and P. Turner, Business Analysis Techniques - 99 Essential Tools for Success (2nd Edition), BCS , 2014.

[80] Center for Chemical Process Safety/AiChE (CCPS), More Incidents That Define Process Safety, Center for Chemical Process Safety, 2020.

[81] S. Mannam, Lees' Loss Prevention in the Process Industries, Vol. 1-3 - Hazard Identification, Assessment and Control (4th Ed), Elsevier, 2012.

[82] T. Whipple and R. Pitblado, "Applied Risk-Based Process Safety: A consolidated risk register and focus on risk communication," in *Center for Chemical Process Safety/AIChE 2008 International Conference and Workshop*, 2008.

[83] A. Boyd, "Utilizing Process Hazard Analysis to Manage Risk in Pilot Scale Designs," in *AiCHE 2025 Spring Meeting and 21st Global Congress on Process Safety*, Dallas, TX, 2025.

[84] N. Turner, E. Akhavan, K. Metwally and M. Hause, "Case Study in Organizational Risk Profiling – Bridging the Gap Between Risk and Decision Making," in *American Institute of Chemical Engineers 2018 Spring Meeting and 14th Global Congress on Process Safety*, Orlando, Florida, 2018.

[85] I. Sutton, "Process Risk and Reliability Management (2nd Ed.)," Elsevier, 2015.

[86] M. Hassall and P. Lant, Fundamentals of Risk Management for Process Industry Engineers, 1st Ed., Elsevier, 2023.

[87] N. Cavanagh and J. Linn, "Process Business Risk: A methodology for assessing and mitigating the financial impact of process plant accidents," in *Center for Chemical Process Safety/AIChE (CCPS) 2006 International Conference and Workshop* , 2006.

[88] Center for Chemical Process Safety, Recognizing Catastrophic Incident Warning Signs in the Process Industries, Wiley, 2012.

[89] P. Nelson and K. Robbins, "Denials Delusions and Bias," in *2023 Spring Meeting and 19th Global Congress on Process Safety, 12th Process Safety Management Mentoring (PSMM) Forum*, Center for Chemical Process Safety/AiChE, 2023.

[90] National Fire Protection Association®, "Why NFPA Codes and Standards Matter," [Online]. Available: https://www.nfpa.org/about-nfpa/why-nfpa-codes-and-standards-matter. [Accessed 2026 March 31].

[91] Official Code of Georgia Annotated, "O.C.G.A. § 25-2-13(g)," 2026.

[92] G. R. Colonna and L. E. Moreno, "Role of Fire Codes and Standards in Hazard Management for Fire, Explosion and Reactivity Hazards," in *Center for Chemical Process Safety/AIChE 2019 Spring Meeting and 15th Global Congress on Process Safety Proceedings, 53rd Annual Loss Prevention Symposium (LPS), March 31 - April 3, 2019*, New Orleans, LA, 2019.

[93] National Fire Protection Association, "NFPA 70: National Electrical Code," Quincy, 2026.

[94] National Fire Protection Association, "List of Codes and Standards," 2026. [Online]. Available: https://www.nfpa.org/for-professionals/codes-and-standards/list-of-codes-and-standards?page=1&sort=code&dir=asc. [Accessed 27 May 2026].

[95] Code of Federal Regulations, "§ 1910.119 Process safety management of highly hazardous chemicals," National Archives, [Online]. Available: https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-H/section-1910.119. [Accessed 16 January 2026].

[96] Code of Federal Regulations, "PART 68—CHEMICAL ACCIDENT PREVENTION PROVISIONS," National Archives, [Online]. Available: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-68. [Accessed 16 January 2026].

[97] Electronic Code of Federal Regulations, "40 CFR §68 Chemical Accident Prevention Provisions," National Archives, [Online]. Available: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-68?toc=1. [Accessed 19 May 2026].

[98] G. Wells, Major Hazards and Their Management, Institution of Chemical Engineers (ICHEME), 1997.

[99] U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Risk Management Program Guidance for Offsite Consequences Analysis (EPA 550B99009)," March 2009.

[100] U.S. Environmental Protection Agency, Risk Program Management Guidance for Offsite Consequences Analysis (EPA-550-B-99-09), 2009.

[101] United States Environmental Protection Agency | CEPP, "Chemical Safety Alert: Safe Storage and Handling of Swimming Pool Chemicals," [Online]. Available: https://www.epa.gov/rmp/chemical-safety-alert-safe-storage-and-handling-swimming-pool-chemicals.

[102] CBC News, "Port Metro Vancouver Chemical Fire Under Control," 5 March 2015. [Online]. Available: https://www.cbc.ca/news/canada/british-columbia/port-metro-vancouver-chemical-fire-under-control-1.2982024. [Accessed 17 July 2025].

[103] "Enforcement Notice Kassouni Manufacturing Inc.," 26 September 2019. [Online]. Available: https://www.egle.state.mi.us/aps/downloads/SRN/a1702/A1702_ENFN_20190925.pdf. [Accessed 17 July 2025].

[104] MLive Media Group | Michael Kransz, "Some residents frustrated after another chemical fire at Belding plant," 22 July 2019. [Online]. Available: https://www.mlive.com/news/grand-rapids/2019/07/some-residents-frustrated-after-further-chemical-fires-at-belding-plant.html. [Accessed 18 July 2025].

[105] WCHSTV | 8abc FOX, "Crews clean up chlorine incident at Clearon in South Charleston," 19 February 2020. [Online]. Available: https://wchstv.com/news/local/crews-cleaning-up-chlorine-spill-at-clearon-in-south-charleston. [Accessed 18 July 2025].

[106] "Small explosion and chemical release contained at OxyChem chemical plant," 28 January 2022. [Online]. Available: https://www.kristv.com/news/chemical-release-being-contained?_amp=true. [Accessed 17 July 2025].

[107] Fox 4 KDFW | Shannon Murray, "Fort Worth pool supply warehouse fire causes concern," July 6 2023. [Online]. Available: https://www.fox4news.com/news/fort-worth-pool-supply-warehouse-fire-causes-concern. [Accessed 17 July 2025].

[108] LINK nky | Danielle Goodman | WCPO, "Chemical leak interrupts workday at Florence manufacturing plant," 11 June 2025. [Online]. Available: https://linknky.com/news/2025/06/11/chemical-leak-florence-manufacturing-plant/. [Accessed 17 July 2025].

[109] "Clayton firefighters return to pool supply store after hazmat situation, no threat or injuries," 2 July 2025. [Online]. Available: https://www.wral.com/news/local/hazmat-smoke-incident-baystate-pool-clayton-july-2025/. [Accessed 17 July 2025].

[110] US Environmental Protection Agency, "Chemical Safety Alert: Safe Storage and Handling of Swimming Pool Chemicals," March 2001. [Online]. Available: https://19january2017snapshot.epa.gov/rmp/chemical-safety-alert-safe-storage-and-handling-swimming-pool-chemicals_.html. [Accessed 30 March 2026].

[111] National Fire Protection Research Foundation, "National Oxidizing Pool Chemicals Storage Fire Test Project," August 1998. [Online]. Available: https://nfpa.access.preservica.com/uncategorized/IO_1808bd2a-f5dc-49ef-bac9-75e790f5dd47/. [Accessed 30 March 2026].

[112] CAMEO Chemicals, "Acetic Acid," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/2272. [Accessed 22 December 2025].

[113] CAMEO Chemicals, "Acetonitrile," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/11. [Accessed 22 December 2025].

[114] PubChem, "Methyl isocyanide," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Methyl-isocyanide. [Accessed 22 December 2025].

[115] CAMEO Chemicals, "Nitrogen," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8898. [Accessed 22 December 2025].

[116] CAMEO Chemicals, "Chloroacetic Acid," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/374. [Accessed 22 December 2025].

[117] CAMEO Chemicals, "Chloroacetaldehyde," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/2867. [Accessed 22 December 2025].

[118] CAMEO Chemicals, "Methyl Chloride," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/1094. [Accessed 22 December 2025].

[119] CAMEO Chemicals, "Cyanogen Chloride, Stabilized," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8479. [Accessed 22 December 2025].

[120] CAMEO Chemicals, "Cyanogen," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/490#section6. [Accessed 2025 December 23].

[121] PubChem, "2-Ethylfuran," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/2-Ethylfuran. [Accessed 23 December 2025].

[122] CAMEO Chemicals, "Nitrous Oxide," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/8909. [Accessed 23 December 2025].

[123] PubChem, "1,2-Dichloro-2-methylpropane," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/1_2-dichloro-2-methylpropane. [Accessed 23 December 2025].

[124] CAMEO Chemicals, "Chloroform," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/2893. [Accessed 23 December 2025].

[125] PubChem, "Dichloronitromethane," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Dichloronitromethane. [Accessed 23 December 2025].

[126] CAMEO Chemicals, "Dichloroacetyl chloride," National Oceanic and Atmospheric Association (NOAA), Version 3.1.0 rev 2. [Online]. Available: https://cameochemicals.noaa.gov/chemical/533. [Accessed 23 December 2025].

[127] World Health Organization, "Temperature mapping of storage areas | Technical supplement to WHO Technical Report Series, No. 961, 2011, Annex 9," May 2015. [Online]. Available: https://cdn.who.int/media/docs/default-source/medicines/norms-and-standards/. [Accessed 11 February 2026].

[128] National Fire Sprinkler Association, "Occupancy Classifications in the International Building Code," 8 January 2024. [Online]. Available: https://nfsa.org/2024/01/08/occupancy-classifications-in-the-ibc/. [Accessed 27 February 2026].

[129] Hodgson, Peter and Donnell Christian, F is for Fire: A Dictionary of Key Fire Terminology, BSI Standards, 2007.

[130] G. Gribble, "The natural production of organobromine compounds," *Environmental Science and Pollution Research,* vol. 7, pp. 37 - 49, 2000.

[131] "Comparing the Different Types of Fire Sprinkler Systems," American Fire Protection Group, Inc., [Online]. Available: https://www.afpgusa.com/blog/comparing-the-different-types-of-fire-sprinkler-systems/. [Accessed 16 December 2025].

[132] Alex Post, "Pallet Racking System Design Factors, Pallet Positions," arkerwarehouse.com, 22 October 2020. [Online]. Available: https://arkerwarehouse.com/designing-pallet-racking-system/. [Accessed 2 July 2025].

[133] American Legal Publishing | Code Library, "311.2 Moderate-hazard storage, Group S-1," [Online]. Available: https://codelibrary.amlegal.com/codes/newyorkcity/latest/NYCadmin/0-0-0-166406. [Accessed 27 February 2026].

[134] United States Environmental Protection Agency, "National Response Center," [Online]. Available: https://www.epa.gov/emergency-response/national-response-center#:~:text=It%20is%20the%20designated%20federal,United%20States%20and%20its%20territories.. [Accessed 30 June 2025].

[135] Census Reporter, "Georgia," [Online]. Available: https://censusreporter.org/profiles/04000US13-georgia/. [Accessed 17 March 2025].

[136] Census Reporter, "United States," [Online]. Available: https://censusreporter.org/profiles/01000US-united-states/. [Accessed 17 March 2025].

[137] Fire Curtain Technology®, "Fire Curtain VS Fire Shuttle," 6 July 2020. [Online]. Available: https://firecurtaintechnologies.com/blog/fire-curtain-vs-fire-shutter/. [Accessed 27 March 2026].

[138] J. Tomac, Dictionary of Materials and Testing, 2nd Edition, SAE International, 2000.

[139] Center for Chemical Process Safety | American Institute of Chemical Engineers, "Tolling," [Online]. Available: https://www.aiche.org/ccps/resources/glossary. [Accessed 5 May 2026].

[140] KOMOL Plastics, "Bulk Bags (FIBC)," 2026. [Online]. Available: https://www.komolplastics.com/fibc-bulk-bags/. [Accessed 6 May 2026].

[141] Rules and Regulations of the State of Georgia, "Ga. Comp. R. & Regs. r. 120-3-3-.04 State Minimum Fire Safety Standards with Modifications Georgia Administrative Code," State of Georgia Secretary of State Brad Raffensperger, https://rules.sos.ga.gov/gac/120-3-3.

[142] National Fire Protection Association, "NFPA 400: Hazardous Materials Code (2016 Edition)," 2015.

[143] National Center for Biotechnology Information, "PubChem Compound Summary for CID 24341, Hypochlorous acid," National Library of Medicine, [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Hypochlorous-Acid. [Accessed 12 May 2026].

[144] Chaffee Industrial Roofing, "Understanding TPO Roofing Systems," 18 September 2025. [Online]. Available: https://chaffeeroofing.com/what-is-tpo-roofing/. [Accessed 14 May 2026].

[145] Single Ply Roofing Industry | SPRI, "Single-Ply Roofing 101," 9 January 2019. [Online]. Available: https://www.spri.org/2019/01/single-ply-roofing-101/. [Accessed 14 May 2026].

[146] National Fire Protection Association, "NFPA 704: Standard System for the Identification of the Hazards of Materials for Emergency Response (2022 Edition)," 2020.

[147] Sigma-HSE Process Safety Experts, " Thermal Screening and Adiabatic Calorimetry Testing Methods," 4 December 2024. [Online]. Available: https://sigma-hse.com/news-insights/thermal-screening-adiabatic-calorimetry/. [Accessed 15 May 2026].

[148] American Institute of Chemical Engineers Center for Chemical Process Safety, "Accelerating Rate Calorimetry (ARC)," [Online]. Available: https://www.aiche.org/ccps/resources/glossary/process-safety-glossary/accelerating-rate-calorimetry-arc. [Accessed 15 May 2026].

[149] Center for Chemical Process Safety | American Institute of Chemical Engineers, "Onset Temperature," [Online]. Available: https://www.aiche.org/ccps/resources/glossary. [Accessed 18 May 2026].

[150] U.S. Department of Labor Occupational Safety and Health Administration, "eCFR :: 29 CFR 1910.132 - General Requirements," [Online]. Available: https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-I/section-1910.132. [Accessed 22 May 2026].

[151] U.S. Chemical Safety and Hazard Investigation Board (USCSB), "Board Order 40: Investigation Program," [Online]. Available: https://www.csb.gov/assets/record/board_order_040_approved_2_14_17.pdf.

[152] U.S. Chemical Safety and Hazard Investigation Board (USCSB), "Board Order 22: Recommendations Program," [Online]. Available: https://www.csb.gov/assets/record/csb_board_order_022_final_20161.pdf.

[153] Merriam-Webster.com Dictionary, "Available chlorine," Merriam-Webster, [Online]. Available: https://www.merriam-webster.com/dictionary/available%20chlorine. [Accessed 30 April 2025].

[154] CAS a Division of the American Chemical Society, "What is a CAS Registry Number®?," [Online]. Available: https://www.cas.org/cas-data/cas-registry. [Accessed 29 May 2026].

[155] D. J. d. Paula, J. P. C. Rodrigues and A. L. Camargo, "Experimental tests on fire behavior of roof covering systems," *Fire Safety Journal,* vol. 162, p. 27, 2026.

[156] Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers (AIChE), Process Safety for Engineers - An Introduction (2nd edition), Wiley-AIChE, 2022.

[157] National Fire Protection Association, "NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (2020 Edition)," 2019.

[158] National Fire Protection Association, "NFPA 5000: Building Construction and Safety Code (2024 Edition)," Quincy, 2023.

[159] National Fire Protection Association, "NFPA 5000: Building Construction and Safety Code® (2012 Edition)," 2011.

[160] National Fire Protection Association, "NFPA 13: Standard on the Installation of Sprinkler Systems (2022 Edition)," 2021.

[161] National Fire Protection Association, "NFPA 400: Hazardous Materials Code (2022 Edition)," 2021.

[162] National Center for Biotechnology Information, "PubChem Compound Summary for CID 61437, Nitrogen trichloride," [Online]. Available: https://pubchem.ncbi.nlm.nih.gov/compound/Nitrogen-trichloride. [Accessed 29 May 2025].

[163] Molekula Group, "1-Bromo-3-chloro-5,5-dimethylhydantoin (BCDMH)," 2025. [Online]. Available: https://molekula.com/catalog/16079-88-2/75611742-1-bromo-3-chloro-55-dimethylhydantoin-bcdmh?locale=en. [Accessed 23 June 2025].

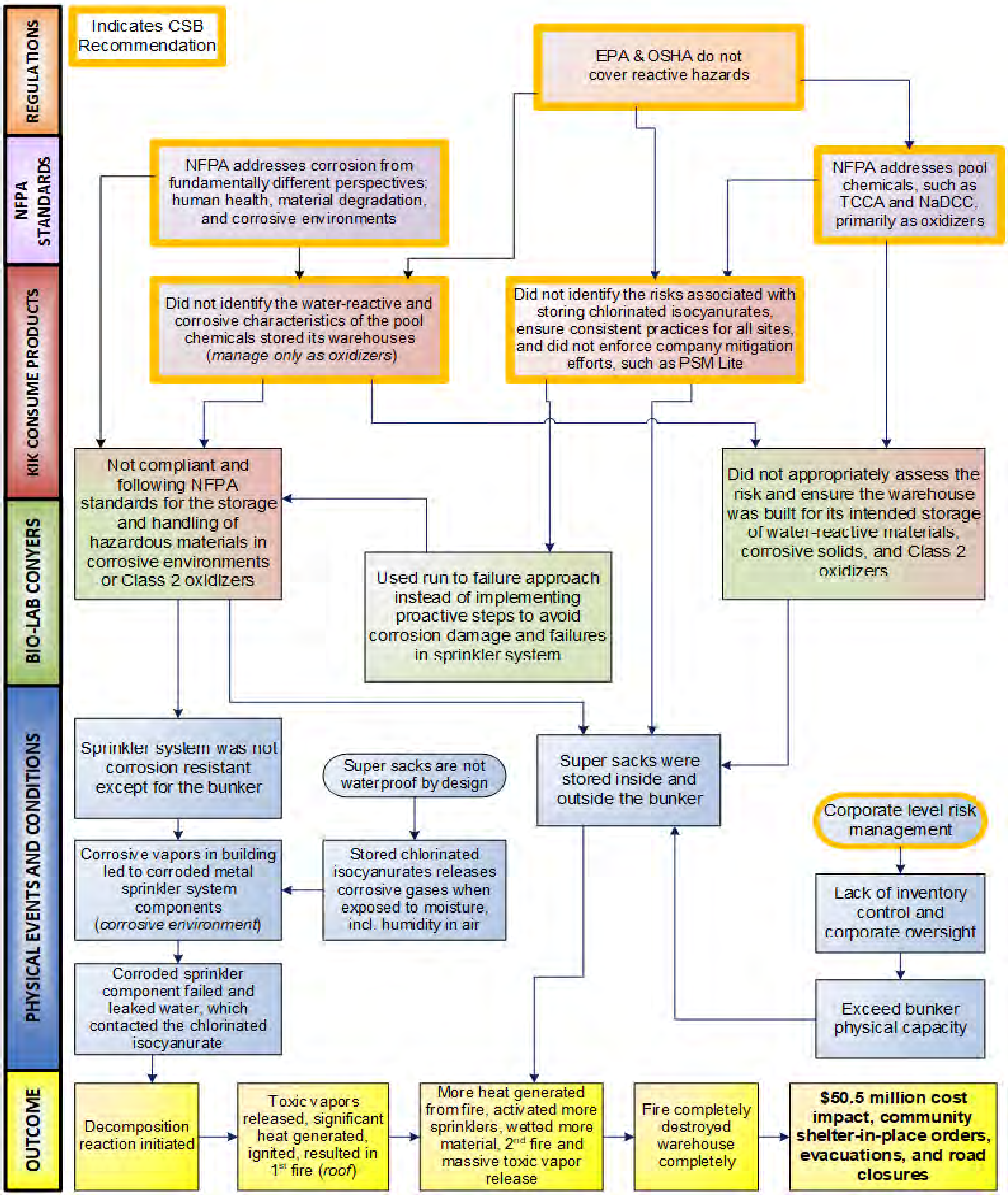
[164] G. Guarnieri, B. Olivieri, G. Senna and A. Vianello, "Relative Humidity and Its Impact on the Immune System and Infections," *International Journal of Molecular Science,* p. 11, 29 May 2023.

[165] C. Vargel, Corrosion of Aluminium, Elsevier Science, 2004.

[166] National Weather Service | National Oceanic and Atmospheric Administration, "What's Typical in North and Central Georgia?," [Online]. Available: https://www.weather.gov/ffc/clisumlst. [Accessed 10 June 2026].

[167] CoverSports, "NFL Football Field Dimensions Guide," 21 July 2025. [Online]. Available: https://coversports.com/resources/field-guides/professional-football-field-dimensions-guide. [Accessed 2 July 2026].

APPENDIX A—SIMPLIFIED CAUSAL ANALYSIS (ACCIMAP)



APPENDIX B—PREVIOUS POOL-TREATMENT CHEMICAL INCIDENTS

Date	Incident Location	Description	Impact*
August 21, 1988	Advanced Laboratories, Inc. Glendale, Arizona	A warehouse storing swimming pool-treatment chemicals was destroyed after rainstorms passed through the area. The roof collapsed, heavy red-brown smoke was observed, and explosions were heard inside the structure. [32]	~200–300 people evacuated
August 17, 1999	Federal warehouse Burlington, New Jersey	Calcium hypochlorite spilled in a federal warehouse. “The spill was caused by the corrosion of steel shelving on which the material was stored. The spilled material mixed with other incompatible materials, resulting in fire and release of products of combustion and decomposition including chlorine gas” [101].	24 injured
March 4, 2011	Centerm Container Terminal Port Metro Vancouver	Fire in a single shipping container at the Centerm Container Terminal on the south shore of Burrard Inlet. “Vancouver Coastal Health said trichloroisocyanuric acid, a hazardous organic compound that can be used as an industrial disinfectant, fueled the fire at the container terminal…the chemical is an oxidizer, which means it produces oxygen and adds to a fire…it was either contaminated or disrupted, so it heated up and caught fire…Smoke from the fire was foul-smelling and irritating to the eyes and lungs” [102].	shelter-in-place and downtown core shutdown
June 22, 2019	Kassouni Manufacturing, Inc. Belding, Michigan	A fire that resulted in chlorine gas being released into the ambient air. The incident was included in an Enforcement Notice issued by the State of Michigan Department of Environment, Great Lakes, and Energy. [103]	evacuation
July 19, 2019	Kassouni Manufacturing, Inc. Belding, Michigan	The company uses trichloroisocyanuric acid in the production of tablets for chlorinating pools. Firefighters responded to a dumpster fire that state officials say was “caused by a manufacturer continuing to mishandle a volatile chemical…toxic chlorine gas releases” [104].	evacuation
February 19, 2020	Clearon Corp. South Charleston, West Virginia	The incident was described as “decomposition of chlorinated dry bleach…The product goes into making tablets and puts off a gas cloud” [105].	community monitoring
January 27, 2022	OxyChem / Occidental Chemical Corporation Ingleside, Texas	Several chemicals and compounds, including chlorine, ethylene dichloride, and ethylene, were released, resulting in a fire, which led to a small explosion at a pool-treatment chemical manufacturer’s plant. [106]	shelter-in-place

*Some incidents necessitated a building evacuation, and others required an evacuation of the surrounding area(s)

Date	Incident Location	Description	Impact*
July 6, 2023	Puryear Custom Pools Fort Worth, Texas	A supply warehouse fire that stored pool chemicals, such as chlorine and acid bicard, raised some concern about the air quality. [107]	1 injured and an evacuation
June 11, 2025	Diversey Solenis Florence, Kentucky	A chemical reaction led to the off-gassing of chlorine during a routine cleaning of the manufacturing process at a company that specializes in water treatment solutions for various markets, including the pool and spa water sectors. [108]	evacuation
July 1, 2025	Baystate Pool Supplies Clayton, North Carolina	A fire involving sodium hypochlorite occurred at a pool supply store. Media reported the fire activated an overhead sprinkler system, which put water onto pallets of a common pool chemical known as "SHOCK". [109]	evacuation

*Some incidents necessitated a building evacuation, and others required an evacuation of the surrounding area(s).

Additional incidents can be found in literature published by EPA [110], National Fire Protection Research Foundation [111, pp. G-2 to G-13], and other sources.

APPENDIX C—DESCRIPTION OF SURROUNDING AREA

There are four census tracts located within approximately 1 mile of Bio-Lab Conyers (**Figure 53**). The demographic information of the population residing within these census blocks is summarized in **Table 17**.

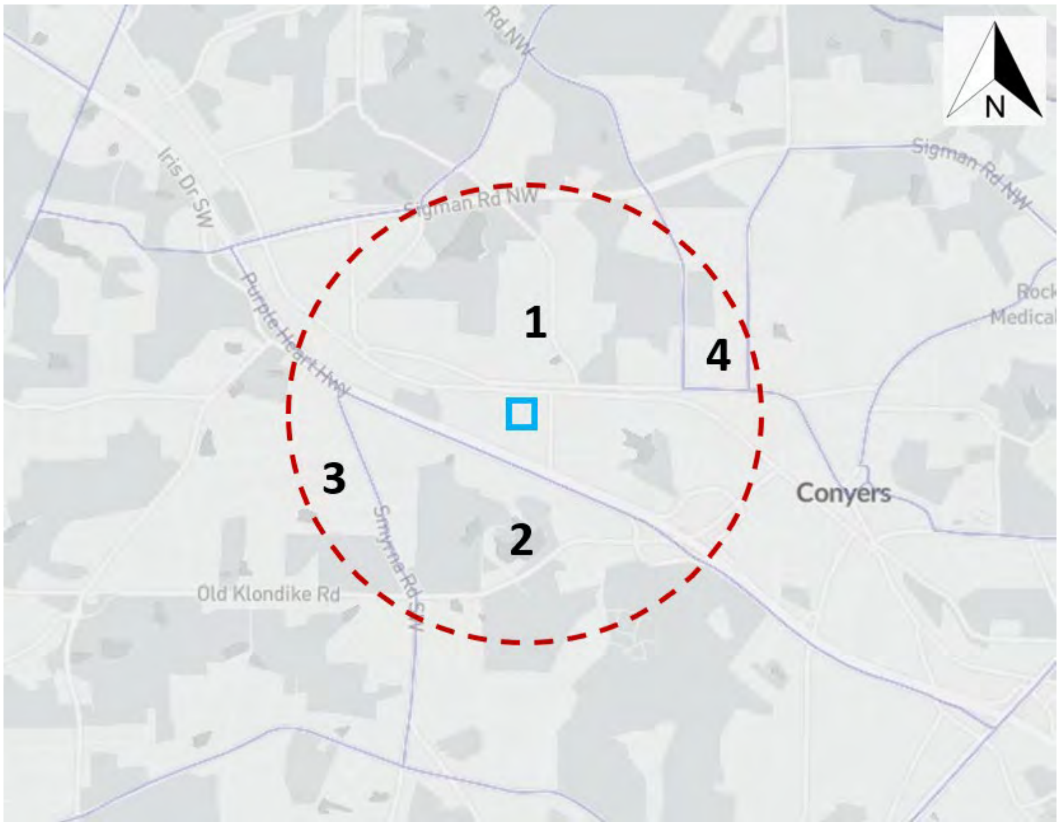


Figure 53. Census blocks within the approximately 1-mile distance from Bio-Lab Conyers. (Credit: Census Reporter, annotated by CSB).

Table 17. Tabulation of demographic data for the populations within the census blocks shown in **Figure 53**.

Tract Number	Population	Median Age	Race and Ethnicity		Per Capita Income	% Persons Below Poverty Line	Number of Housing Units	Types of Structures	
1	2,099	49.4	31%	White	$ 34,145	5.2%	1,114	68%	Single Unit
			29%	Black				28%	Multi-Unit
			0%	Native				4%	Mobile Home
			16%	Asian				0%	Boat, RV, van, etc.
			0%	Islander					
			0%	Other					
			16%	Two+					
			8%	Hispanic					
2	4,208	40.5	24%	White	$ 33,196	18.3%	1,653	78%	Single Unit
			54%	Black				22%	Multi-Unit
			0%	Native				0%	Mobile Home
			0%	Asian				0%	Boat, RV, van, etc.
			0%	Islander					
			3%	Other					
			4%	Two+					
			15%	Hispanic					
3	4,938	36.9	30%	White	$ 27,392	22.4%	2,035	91%	Single Unit
			54%	Black				9%	Multi-Unit
			0%	Native				0%	Mobile Home
			0%	Asian				0%	Boat, RV, van, etc.
			0%	Islander					
			1%	Other					
			5%	Two+					
			10%	Hispanic					
4	4,179	37.2	15%	White	$ 33,311	6.3%	1,484	68%	Single Unit
			62%	Black				32%	Multi-Unit
			0%	Native				0%	Mobile Home
			0%	Asian				0%	Boat, RV, van, etc.
			0%	Islander					
			1%	Other					
			2%	Two+					
			20%	Hispanic					

APPENDIX D—KIK'S 2021 TCCA AND WATER TESTING DATA

Following Bio-Lab's 2020 incident at its Lake Charles facility,[a] the company obtained material hazard testing through a third-party process safety consultant to characterize TCCA's incompatibility with water. The stated purpose of this "reactivity testing program" was to "identify conditions under which [TCCA] when exposed to water can produce chlorine gas and sufficient heat to cause ignition of combustible materials."[b]

During the series of small-scale material incompatibility experiments, TCCA was exposed to varying percentages of water as a "contaminant" in an insulated stainless-steel tumbler with a thermocouple probe inserted through the lid and positioned within the center of the sample.[c] The thermocouple probes were connected to a data acquisition system, which continuously logged the sample temperature throughout the 72-hour test duration. Qualitative incompatibility data were also collected during the testing runs, such as noting any observations of smoke, flame or fire, charring, vapor or fumes, and any corrosion or discoloration of testing equipment in contact with the materials tested. The time to reaction was also documented for each run, as measured "from the introduction of contaminant to start of temperature rise." Although chlorine and hydrochloric acid were identified as "expected byproducts of reaction," these were not measured during the testing. The peak temperature (left) and time to reaction results (right) from the series of six tests conducted with TCCA and rainwater at ratios ranging from 1 percent to 15 percent are presented in **Figure 54**.

[a] For more information, refer to the CSB's *Bio-Lab Lake Charles Chemical Fire and Release* final report at Bio-Lab Lake Charles Chemical Fire and Release | CSB.

[b] Client: Bio-Lab Inc., a KIK Custom Products Company

[c] Two series of test runs were performed to compare the extent of variability introduced between two types of water contaminants, one with deionized water with a pH of 7.0 and another with collected rainwater containing trace minerals with a pH of 6.7. Although slight variability was observed between results obtained from both types of water contaminants, the report was inconclusive as to the significance of this difference. The test series using deionized water was performed only at TCCA-to-water ratios ranging from 0.25 to 2.0 percent. The rainwater was used for the test series, where TCCA-to-water ratios ranged from 1.0 to 15 percent, as the rainwater more closely represented the scenarios most likely to occur outside of a controlled laboratory environment than deionized water.

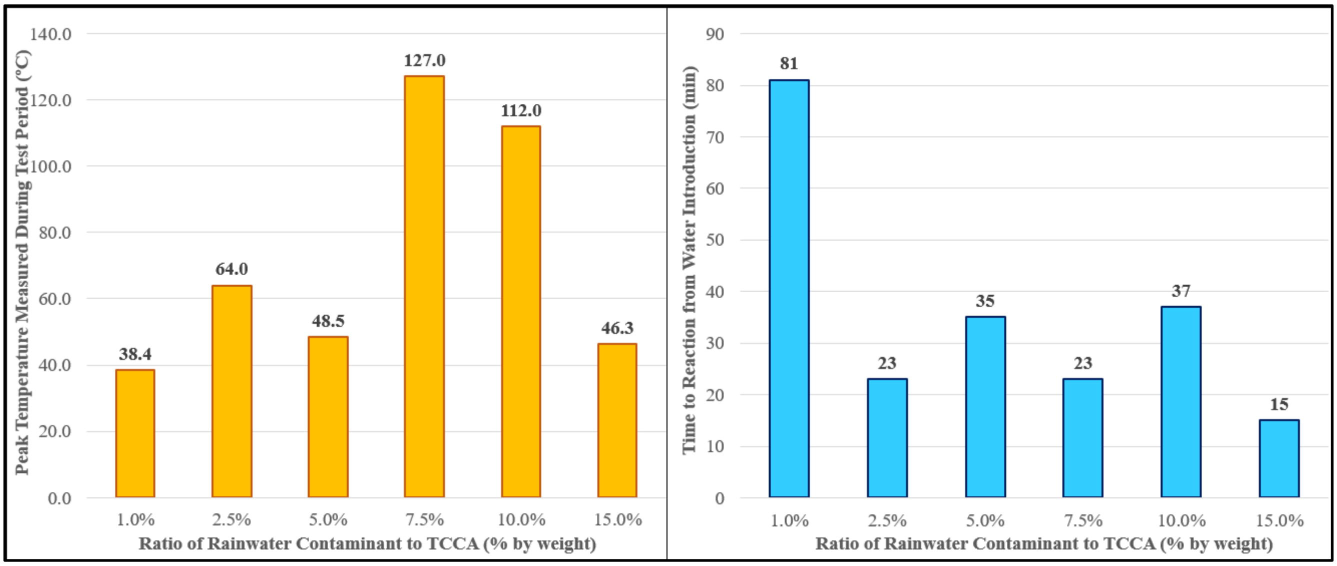


Figure 54. Summary of peak temperature (left) and time to reaction results (right) from TCCA and rainwater test series (2021). (Credit: Raw data from Bio-Lab, summary graphics developed by CSB)

Although all samples exhibited a temperature increase relative to ambient conditions (29ºC), the highest peak temperatures measured were for the tests performed at concentrations of 7.5 percent and 10 percent water. For the samples in the concentration range of 2.5 percent to 10 percent water, the time between water exposure and onset of temperature rise was approximately 30 minutes. Upon initiation of reaction, active TCCA decomposition and elevated temperatures persisted for several hours for the samples tested at water concentrations of 2.5 percent, 5 percent, 7.5 percent, and 10 percent. For example, during the test for the 7.5 percent water concentration, although the time to reaction was 23 minutes, the peak temperature was not achieved until approximately 400 minutes, declining to approximately 40ºC at 700 minutes. The 2021 testing results demonstrated that TCCA exhibits the strongest reaction concentration of approximately 7.5% to 10 percent water to total material.

APPENDIX E—2025 CSB TESTING DATA REPORTS

Due to the size of the combined reports, Appendix E is provided as a separate PDF.

ioKinetic
safeguarding chemistry™

Water Reactivity of Pool Treatment Chemicals (Organic-Stabilized Chlorine - and Bromine-Releasing Compounds)

Summary Report

Report to:
U.S. Chemical Safety and Hazard Investigation Board
470 L'Enfant Plaza SW 710 Kipling St.
Suite 604 #23278
Washington, DC, 20026

Date: June 18, 2026

This report was prepared by ioKinetic for the account of the CSB. This report represents ioKinetic's best judgment in light of information made available to us. Opinions in this report are based in part upon data and information (Sample Identification) provided by the CSB and / or the CSB's advisors and affiliates. This report relates only to the sample as received unless otherwise noted. The reader is advised that ioKinetic has not independently verified the data or the information contained therein. This report must be read in its entirety. The reader understands that no assurances can be made that all liabilities have been identified. This report does not constitute a legal opinion. The results provided are apparatus dependent and should not be used for direct scale-up. They apply to the samples as tested and are useful as a comparison tool only.

No person has been authorized by ioKinetic to provide any information or make any representation not contained in this report. Any use the reader makes of this report, or any reliance upon or decisions to be made upon this report are the responsibility of the reader. ioKinetic does not accept any responsibility for damages, if any, suffered by the reader based upon this report.

Report No.: ioK#: 25230-00 Rev. 1

ilac-MRA ANAB AT-1922

95 Stiles Road | Salem, New Hampshire 03079
www.ioKinetic.com | P: 603.893.7009 | F: 603.386.6522

APPENDIX F—2025 CSB TESTING DATA EXPANDED SUMMARY OF REACTION GAS ANALYSIS

Table 18. Full summary of constituents detected in gases generated during reaction of TCCA (94% and 100%), NaDCC, and NaDCC dihydrate with water (2025).[a]

Constituents Detected Post-Reaction in Sampled Gas	Sample Material				Characteristics of Gases Detected	
	TCCA (~94%)	TCCA (~100%)	NaDCC	NaDCC Dihydrate	Characteristics	Source
Results for Gas Analysis Conducted by GC-MS (% of total peak area for sample) [1,2]						
Acetic acid	0.6%	---	---	---	**Poison/Toxic**; **Corrosive**	[112, p. 1]
Acetone	---	---	2.5%	**10.3%**	**Flammable**	[53, p. 1]
Acetonitrile and Methyl isocyanide	---	---	---	0.5%	Acetonitrile: **Flammable** Methyl isocyanide: **Poison/Toxic**	[113, p. 1] [114, p. 15]
Carbon dioxide, and adjacent peaks[3]						
• Carbon dioxide; Dimethylamine; Methyl-hydrazine	**43.2%**	---	---	---	Carbon Dioxide: Nontoxic Methyl-hydrazine: **Poison/Toxic**, **Flammable**	[62, p. 1] [55, p. 1]
• Carbon dioxide; Dimethylamine; 2-hydroxy-Propanamide	---	**8.0%**	---	---	Dimethylamine: **Flammable**	[54, p. 1]
• Carbon dioxide; Ethanolamine; Methyl-hydrazine	---	---	**67.9%**	---	Ethanolamine: **Poison/Toxic**	[57, p. 1]
• Carbon dioxide; Methyl-hydrazine; nitrous oxide	---	---	---	**67.7%**	2-hydroxy-Propanamide: **Poison/Toxic**	[56, p. 12]
Carbon monoxide, and adjacent peaks[3]						
• Carbon monoxide; Nitrogen	**12.7%**	---	---	---	Carbon monoxide: **Poison/Toxic**, **Flammable** Ethylene: **Flammable**	[58, p. 1] [59, p. 1]
• Carbon monoxide; Nitrogen; and Ethylene	--	**20.3%**	**24.5%**	**19.5%**	Nitrogen: Nontoxic	[115, p. 1]
Chloroacetic acid; Chloroacetaldehyde, Chloromethane	---	0.6%	---	---	Chloroacetic acid: **Poison/Toxic**; **Corrosive** Chloroacetaldehyde: **Poison/Toxic** Chloromethane: **Flammable**	[116, p. 1] [117, p. 1] [118, p. 1]
Cyanogen chloride	---	---	3.2%	1.0%	**Poison/Toxic**; Corrosive	[119, p. 1]
Ethanedinitrile; β-Cyano.L-alanine	---	---	1.9%	---	Ethanedinitrile: **Poison/Toxic**, **Flammable** β-Cyano.L-alanine: No data	[120, p. 1]
Furan, 2-ethyl	0.9%	---	---	---	**Poison/Toxic**, **Flammable**	[121, p. 27]
Hydrogen chloride	**33.5%**	**56.5%**	---	---	**Poison/Toxic**; **Corrosive**	[16, p. 1]
L-Homoserine	**8.7%**	----	---	---	Skin/Eye/Respiratory Irritation	[60, p. 32]
Methylene Chloride	---	---	---	0.3%	**Poison/Toxic**	[118, p. 1]
Nitrous Oxide	---	0.5%	---	---	Nontoxic (<40-60%)	[122, p. 1]
Propane, 1,2-dichloro-2-methyl-	---	2.4%	---	---	**Flammable**, Skin/Eye/ Respiratory Irritation	[123, p. 16]
Propane, 2-chloro-2-nitro-	---	**9.0%**	---	---	**Flammable**	[61, p. 1]
Trichloromethane, and adjacent peaks[3]						
• Trichloromethane only	0.5%	---	---	0.7%	**Poison/Toxic**	[124, p. 1]

[a] Summary compiled from Reaction Gas Analysis conducted by GC-MS. *See* **Appendix E**.

Constituents Detected Post-Reaction in Sampled Gas	Sample Material				Characteristics of Gases Detected	
	TCCA (~94%)	TCCA (~100%)	NaDCC	NaDCC Dihydrate	Characteristics	Source
• Trichloromethane; Dichloronitromethane; Dichloroacetyl chloride	---	2.7%	---	---	Dichloronitromethane: No data Dichloroacetyl chloride: **Poison/Toxic**; **Corrosive**	[125] [126, p. 2]

1 Percentages represent the peak areas for the individual constituent, relative to total peak areas measured for sample.
2 Percentages >20% of total for sample are depicted as **purple (%)**, 10-20% depicted as **blue (%)**, 5-10% highlighted **orange (%)**, and <5% depicted as **greyscale (%).**
3 Indicates where multiple constituents were identified, but individual peaks areas could not be determined for each due to the presence of the multiple peaks in close proximity.

Cyanogen chloride was detected in reaction gases from both NaDCC (anhydrous and dihydrate), as is consistent with the technical literature on its decomposition, and is toxic and classified as a chemical warfare blood agent [119, p. 1].

APPENDIX G—CONSULTANT REPORT, FIRE PROTECTION REQUIREMENTS REVIEW

Due to the size of the report, Appendix G is provided as a separate PDF.

REPORT

FIRE PROTECTION SYSTEM DESIGN BASIS

Georgia Pool Chemical Warehouse

PREPARED FOR

United States Chemical Safety Board
1750 Pennsylvania Avenue NW, Suite 910
Washington, DC 20006

Project #: 1AAK00103.000
Date: March 20, 2026

PREPARED BY

Alwin Kelly, P.E.
Joe Castellano, P.E.
8830 Stanford Boulevard, Suite 200
Columbia, MD 21045, USA

akelly@jensenhughes.com

JENSEN HUGHES

jensenhughes.com

U.S. Chemical Safety and Hazard Investigation Board

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

Steve Owens
Chairperson

Sylvia E. Johnson, Ph.D.
Member