U.S. Chemical Safety and Hazard Investigation Board

Fire During Hot Work at Evergreen Packaging Paper Mill

Canton, NC | *Incident Date: September 21, 2020* | **No. 2020-07-I-NC**

Investigation Report

Published: September 24, 2021

SAFETY ISSUES:

- Hot Work Safety
- Pre-Job Planning
- Confined Space Safety
- Combustible Materials of Vessel Construction

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 change through independent investigations to protect people 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
1750 Pennsylvania Ave. NW, Suite 910
Washington, DC 20006
(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

Figures

Abbreviations

AICHE	American Institute of Chemical Engineers
AF&PA	American Forest & Paper Association
CCPS	Center for Chemical Process Safety
CFR	Code of Federal Regulations
CSB	U.S. Chemical Safety and Hazard Investigation Board
DMA	N,N-Dimethyl Aniline
ERT	Emergency Response Team
FRP	Fiber-Reinforced Plastic
IDLH	Immediately Dangerous to Life or Health
LEL/LFL	Lower Explosive Limit/Lower Flammable Limit
MEKP	Methyl Ethyl Ketone Peroxide
NFPA	National Fire Protection Association
OSHA	U.S. Occupational Safety and Health Administration
OSHNC	North Carolina Department of Labor, Occupational Safety and Health Division
PRCS	Permit-Required Confined Space
SDS	Safety Data Sheet
SIMOP	Simultaneous Operation

Executive Summary

Incident Overview

On September 21, 2020, a paper mill operated by Evergreen Packaging (Evergreen) in Canton, North Carolina, was undergoing a planned shutdown, and associated maintenance and capital project work was ongoing throughout the facility. In one of Evergreen's pulp bleaching units, two contract companies (Universal Blastco, or "Blastco," and Rimcor) were performing simultaneous maintenance work inside two connected process vessels, called an "upflow tower" and a "downflow tower."

The pulp bleaching process is corrosive by design, and the upflow and downflow towers were constructed of corrosion-resistant materials. However, due to the corrosive nature of the process, the upflow and downflow towers required periodic maintenance to their inside surfaces. The upflow tower was constructed of fiber-reinforced plastic (FRP), and Blastco's repair work in the upflow tower required the application of flammable epoxy vinyl ester resin and sheets of fiberglass to the inside walls of the vessel. However, cool ambient temperatures in the area on the night of the incident caused the resin to harden slower than the Blastco workers anticipated, resulting in the newly applied resin and fiberglass sliding down the walls of the vessel. The Blastco workers attempted several means of addressing the issue but were ultimately unsuccessful. Two Blastco workers resorted to using a portable, electric heat gun to warm the resin, enabling it to harden faster. The Blastco crew did not warn of or otherwise communicate to Evergreen or Rimcor its use of the heat gun, which was an ignition source in the presence of the flammable resin.

At approximately 5:15 a.m., a fire started inside the upflow tower when the heat gun fell into a five-gallon bucket containing flammable resin. The Blastco workers inside the upflow tower successfully escaped the fire and evacuated the vessel. However, smoke and flames quickly spread to the connected downflow tower, fatally injuring two Rimcor workers there [Brett Burgueno, Curtis Butler].

The Canton Fire Department and mutual aid from surrounding areas responded to the incident. In addition to the U.S. Chemical Safety and Hazard Investigation Board (CSB), the North Carolina Department of Labor, Occupational Safety and Health Division (OSHNC) investigated the incident.

The CSB's investigation identified the safety issues below.

Safety Issues

- **Hot Work Safety.** The electric heat gun used to warm the flammable resin could achieve temperatures in excess of the resin's flash point and auto-ignition temperatures. The electric heat gun came into direct physical contact with the flammable resin when it fell into the resin bucket. Blastco did not recognize the ignition hazard presented by the use of the heat gun, did not inform Evergreen or Rimcor of the heat gun's use, and did not take adequate action to prevent the introduction of ignition sources into a confined space containing flammable liquids. In addition, while Evergreen's internal policies defined hot work as "any activity that could serve as a source of ignition," Evergreen's contractor orientation materials limited the hot work definition to only "burning, cutting, brazing or welding." (Section 3.1).

- **Pre-Job Planning.** Cool ambient temperatures on the night of the incident caused poor performance of the resin Blastco was using to repair the inside surface of the upflow tower. Blastco workers unsuccessfully attempted several means of addressing the problem prior to resorting to warming the resin with a heat gun. Drum heaters, which might have prevented this incident by warming the resin in a drum outside the upflow tower, were not identified in pre-job planning efforts, and Blastco workers were unable to locate them on Blastco's job trailer. The work also was not performed during the day when temperatures were warmer, which may have eliminated the need to warm the resin (Section 3.2).

- **Confined Space Safety.** Evergreen, Blastco and Rimcor treated the upflow and downflow towers as separate and independent confined spaces, even though the towers were connected by a crossover pipe. Blastco failed to terminate the confined space entry when a new hazard, the heat gun, was introduced into the space. There was no coordination between the two contract crews, and no evaluation was made as to whether the simultaneous operations posed a hazard to each other. In addition, Blastco did not effectively evaluate the flammable material hazards presented by its work in the upflow tower, and Evergreen did not ensure its emergency response team was on standby outside the upflow tower while flammable materials were used inside the confined space (Section 3.3).

- **Combustible Materials of Vessel Construction.** The five-gallon bucket in which the fire initiated in the upflow tower did not contain enough fuel to sustain the size and duration that the fire achieved during the incident. Evidence shows that the upflow tower itself, constructed of combustible FRP, caught fire. This contributed to the spread of smoke and flames to the downflow tower, where the two Rimcor employees were fatally injured (Section 3.4).

Cause

The CSB determined the cause of the incident was the failure by Blastco to effectively evaluate the flammable material hazards presented by its work in the upflow tower and implement controls to prevent the introduction of ignition sources to the work area. Contributing to the incident was Blastco's failure to recognize heat guns as a form of hot work that could ignite flammable materials, gaps in Evergreen's training to contractors on forms of hot work, and poor pre-job planning that allowed Blastco's work to occur during cold temperatures which were known to make the fiber-reinforced plastic application process difficult, in addition to a lack of Blastco troubleshooting guidance for safely addressing cold-weather resin performance. Contributing to the severity of the incident were poor confined space safety practices, including Blastco's and Rimcor's lack of recognition and control of the hazards of the simultaneous operations, Evergreen's failure to ensure coordination and the integrity of pre-planning between the two contract companies, inadequate communication between Blastco and Rimcor, and the lack of immediately available emergency services during the hazardous operation involving flammable materials in a confined space. The material of construction of the upflow tower and crossover line also contributed to the severity of the incident, as it was a combustible material that enabled the fire to quickly spread.

Recommendations

Previously Issued Recommendation Reiterated in This Report

To the U.S. Occupational Safety and Health Administration (OSHA)

2008-01-I-CO-R2

Publish a "Safety and Health Information Bulletin" addressing the hazards and controls when using flammable materials in confined spaces that includes actionable guidance regarding:

a. The importance of implementing a hierarchy of controls to address hazards in a confined space that first seeks to eliminate hazards or substitute with a less hazardous material(s) or method(s). Examples include performing work outside of a confined space where reasonably practicable or substituting a flammable material with a non-flammable one.

b. The necessity of establishing a maximum permissible percentage substantially below the lower explosive limit (LEL) for safe entry and occupancy of permit required confined spaces.

c. The need to comprehensively control all potential ignition sources and continuously monitor the confined space at appropriate locations and elevations when work activities involve the use of flammable materials or where flammable atmospheres may be created.

d. The importance of treating confined spaces with the potential for flammable atmospheres above 10 percent of the LEL as a hazard immediately dangerous to life or health (IDLH) that requires rescuers to be stationed directly outside the permit space and available for immediate rescue with appropriate fire-extinguishing and rescue equipment.

e. The requirement that confined spaces such as penstocks be managed as permit-required that are so large or part of a continuous system that they cannot be fully characterized from the entry point. Such spaces need to be monitored for hazardous atmospheres both prior to entry and continuously in areas where entrants are working.

New Recommendations

To OSHA

Issue a safety information product (such as a letter of interpretation) addressing the analysis and control of hazards that are not pre-existing but which result from work activities inside permit-required confined spaces.

Require Owner/Operators to ensure the coordination of simultaneous operations involving multiple work groups, including contractors. Include in the requirement for Owner/Operators to ensure the following activities occur:

- Identification of potential simultaneous operations
- Identification of potential hazardous interactions

- Evaluation and implementation of necessary safeguards to allow for safe simultaneous operations
- Coordination, including shared communication methods, between the simultaneous operations
- Inclusion of emergency response personnel or services in the planning and coordination of the simultaneous operations

As necessary, seek the regulatory authority to promulgate this requirement.

To Evergreen Packaging

Update all documentation, training, and orientation materials provided to contractors pertaining to hot work to reflect Evergreen Packaging's internal definition of hot work. The materials should make clear that hot work encompasses any method of work that can serve as a source of ignition.

Develop and implement a formalized and comprehensive Simultaneous Operations (SIMOPs) program addressing planned work occurring close together in time and place to include policies, procedures, hazards reviews, hazards abatement, training, and shared communication methods, to protect employees and contract workers from the hazards posed by simultaneous operations at its facilities. At a minimum, the program should:

- Identify potential simultaneous operations
- Identify potential hazardous interactions
- Evaluate and implement necessary safeguards to allow for safe simultaneous operations
- Ensure coordination, including shared communication methods, between the simultaneous operations
- Include emergency response personnel or services in the planning and coordination of the simultaneous operations

Develop and implement a policy that requires the involvement of emergency response personnel in planning and coordination of activities involving the use of flammable materials in confined spaces. In the policy, require that emergency response personnel be stationed directly outside the confined space in which flammable materials are used. Ensure that the emergency response personnel are appropriately trained and equipped for confined space entry, confined space rescue and fire response.

To Universal Blastco

Update the Universal Blastco hot work policy and employee training program to specifically identify the use of heat guns as hot work. The policy and programs should make clear that hot work encompasses any method of work that can ignite a fire and not just spark- or flame-producing work methods.

Develop a formalized troubleshooting guide and/or standard operating procedure for the usage of resin and fiberglass matting in FRP operations. The procedure should direct employees on acceptable means of addressing cold-weather resin performance.

Develop a policy and standard operating procedures for the proper use of heat guns in FRP operations.

1 Factual Information

This section details the facts gathered by the U.S. Chemical Safety and Hazard Investigation Board (CSB) investigation team.

1.1 The Evergreen Packaging Paper Mill

The Evergreen Packaging (Evergreen) paper mill, in Canton, North Carolina, produces printing paper and paperboard used to make packaging materials such as cartons and disposable paper cups [1]. The mill began operations in 1908 and currently employs approximately 1,000 people [2].

1.1.1 Pulp Bleaching Process

The incident occurred in one of Evergreen's bleaching units, called the #2 Fiber line bleaching unit, which removes color from wood pulp to make white paper products. The bleaching process occurs in three reaction stages. Each stage consists of a pair of process vessels: the first, called the "upflow tower" and the second, called the "downflow tower." The two vessels are connected at the top by a large diameter pipe, called the "crossover line" (**Figure 1**).

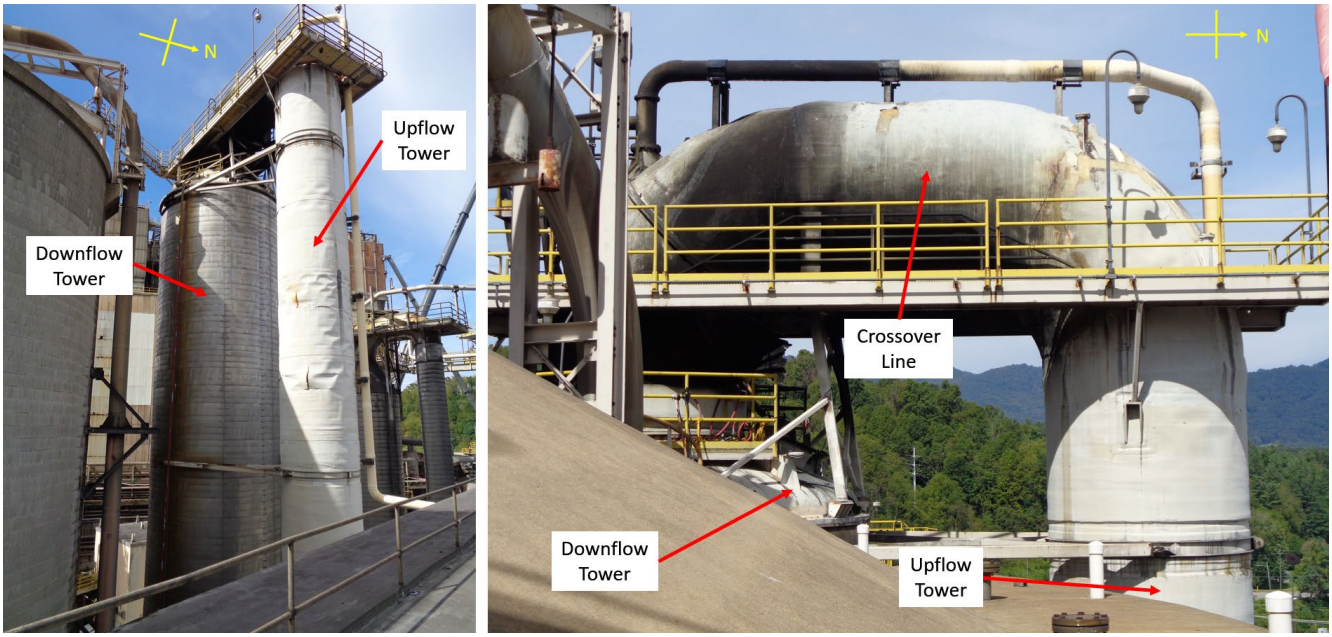


Figure 1. Typical bleach reaction stage at Evergreen. (Credit: CSB.)

Figure 2. Overhead view of the Evergreen Packaging Canton Mill. (Credit: Google. Annotated by CSB.)

The upflow and downflow towers for each reaction stage are designed such that the pulp and bleaching chemicals slowly move through the vessels to give the bleaching chemicals sufficient time to react with the pulp before moving on to the next reaction stage. As the pulp passes through each stage, more color is removed from the pulp. The pulp bleaching process is corrosive by design, and the upflow and downflow towers are constructed of corrosion-resistant materials. The upflow and downflow towers require periodic maintenance to their inside surfaces.

In this incident, a fire started in the #2 Fiber line D2 upflow tower and spread to the D2 downflow tower, which together comprise the third and final reaction stage in the bleaching process.

1.1.2 Pulp Bleaching in the United States

The CSB requested from the American Forest & Paper Association (AF&PA) information on the number of pulp and paper manufacturing facilities that operate bleaching processes. The AF&PA response stated that there are 327 pulp and paper manufacturing facilities in the United States, and of that total, 54 operate bleaching processes.

1.1.3 Upflow and Downflow Towers

The #2 Fiber line D2 upflow tower was constructed of fiber-reinforced plastic (FRP) and was approximately 96 feet tall and almost nine feet in diameter (**Figure 3**). The downflow tower was constructed of a carbon steel shell, lined internally with a urethane membrane covered with fireclay acid brick laid in vinyl ester mortar. The downflow tower was 110 feet tall and roughly 22 feet in diameter. These two towers were connected by a crossover line, which was approximately the same diameter as the upflow tower, and which was also constructed of FRP.

1.1.4 Mill Shutdown and Maintenance

On Thursday, September 17, 2020, Evergreen began a mill-wide shutdown, which Evergreen calls a "cold mill outage." During this type of shutdown, Evergreen halts all production, including all power and utilities. Cold mill outages are rare; according to Evergreen personnel, the last one was in 2011. Evergreen conducts the cold mill outages to perform maintenance work and capital projects that require a site-wide outage. In the #2 Fiber line bleaching unit, this involved, among other tasks, making repairs to both the D2 upflow and downflow towers.

1.2 Contractors

Evergreen hired two contractors to make the repairs to the D2 upflow and downflow towers during the shutdown: Universal Blastco ("Blastco") and Rimcor. Leading up to and during the incident, Blastco was working in the upflow tower, while Rimcor was working simultaneously in the downflow tower.

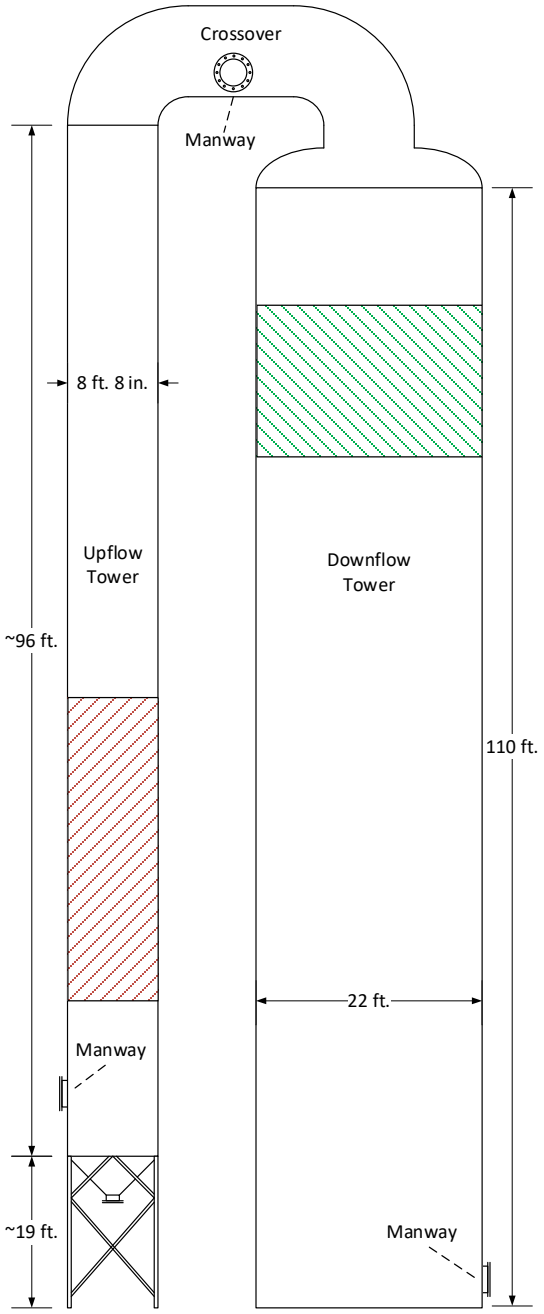


Figure 3. Diagram of the #2 Fiber Line D2 towers. (Credit: CSB.)

1.2.1 Blastco

Blastco's scope of work for the shutdown was, among other tasks, to perform FRP maintenance on four upflow towers in Evergreen's bleaching units. For the #2 Fiber line D2 upflow tower, Blastco's work scope was to repair approximately 30 feet of FRP, illustrated with red shading in **Figure 3**. This scope of work involved grinding away old material until acceptable base material was found, followed by applying alternating sheets of new fiberglass with layers of resin, until the desired thickness was reached. To accomplish this work, traditional scaffolding was built up from the ground to the entry manway of the upflow tower, which was located 23 feet above the ground. Inside the tower, additional scaffolding platforms were assembled so that workers could access the entire inside surface that was to be repaired.

1.2.2 Rimcor

Rimcor's scope of work was to re-line approximately 15 feet of the #2 Fiber line D2 downflow tower, illustrated with green shading in **Figure 3**. This work involved using pneumatic jackhammers to remove the old brick, mortar, and urethane membrane, and abrasive blasting to remove residual membrane material, until the bare steel shell was exposed. Once the steel subsurface was prepared, the next step involved applying new membrane material and lastly installing the new brick lining. To accomplish this, Rimcor used a special kind of scaffolding, called a "suspended" scaffolding, inside the downflow tower. This scaffolding consisted of a circular engineered steel scaffold with wooden decking, suspended from mounting points on the roof of the vessel via steel cables. Workers entered the tower via the manway at ground level and assembled the scaffolding platform inside the tower. Once the platform was built and suspended, six workers simultaneously used cable winches to slowly raise the platform to the desired height. Moving the platform was a slow process—it took six workers approximately four hours to raise the platform to Rimcor's work location inside the downflow tower. The platform had a barricaded hole in the middle which workers used along with a hoist to raise and lower tools, materials, and other workers, via chairlift, to and from the platform. At the time of the incident, two Rimcor workers were inside the upflow tower performing abrasive blasting operations.[a]

1.3 Fiber-Reinforced Plastic

FRP is a composite material consisting of a polymeric base material, or matrix, reinforced with a fibrous material [3]. The Evergreen #2 Fiber line D2 upflow tower was constructed of FRP consisting of fiberglass matting ("fiberglass") and epoxy vinyl ester resin ("resin"). For maintenance of the upflow tower, Blastco selected Derakane 510N resin manufactured by Ashland. According to the material's safety data sheet[b] (SDS), Derakane 510N resin has a flash point of 79°F and an auto-ignition temperature of 914°F.

The Occupational Safety and Health Administration (OSHA) and the state of North Carolina classify the resin as a Category 3 flammable liquid, defined as a liquid having a flashpoint greater than or equal to 73.4°F and less than or equal to 140°F.[c]

1.3.1 Blastco FRP Application Process

The FRP resin required preparation by Blastco workers. Workers could "activate" the resin by mixing a cobalt "promoter," or catalyst, and a curing accelerant, N,N-Dimethyl Aniline (DMA), into the raw resin drum. This "promoted" resin then required a second activation step, which involved mixing an "initiator," methyl ethyl ketone peroxide (MEKP), and DMA into the resin. Following these steps, the FRP resin was ready for use. Blastco workers could apply resin to the vessel walls using paint rollers and subsequently alternating layers of fiberglass matting and resin until the specified thickness was reached.

[a] At the time of the incident, Rimcor was using a blasting media described on its SDS as non-flammable

[b] A publicly available SDS for Derakane 510N can be found here: https://www.b2bcomposites.com/msds/dow/300944.PDF

[c] 29 CFR 1910.106(a)(19)(iii)

1.3.2 Resin Gel Time

The amounts of cobalt promoter, MEKP initiator, and DMA accelerant used can be adjusted by the user based on ambient temperature conditions and the target "gel time," which is the amount of time the user has to work with the resin as it hardens before it becomes unworkable.

A correct gel time is essential to performing a quality FRP application. If the resin hardens too quickly, the workers would not have adequate time to laminate. If the resin hardens too slowly after being applied to the vessel walls, the resin would slide down due to gravity before it hardened, preventing the fiberglass matting from adhering properly. According to the resin manufacturer, cooler temperatures lead to longer gel times, while warmer temperatures lead to shorter gel times [4].

1.4 Weather at Time of Incident

Data from the Asheville, NC, climate summary from the National Weather Service for September 21, 2020, indicate that the low temperature on the morning of the incident was 47°F at 12:11 a.m. The summary also indicates the highest observed wind speed was 12 miles per hour.

1.5 Heat Gun

The heat gun Blastco used to warm the resin was a Chicago Electric model heat gun [5]. According to the tool's manual, it had six different heat settings, each with a low and high sub-setting, for a total of 12 temperature settings. These settings ranged from a minimum of 430°F to a maximum of 1,160°F. One of the Blastco workers who used the heat gun could not recall the exact setting used leading up to the fire but told the CSB that it was set on the third or fourth setting, which corresponds with a temperature of between 650°F (the low temperature of the third setting) and 790°F (the high temperature of the fourth setting).

Figure 4. Exemplar heat gun (left). Heat gun recovered from scene (right). (Credit: Harbor Freight [6], CSB.)

The manufacturer of the heat gun, in the tool's instruction manual, includes numerous warnings [5]:

- "Do not operate … in explosive atmospheres, such as in the presence of flammable liquids, gases or dust."
- "When working with plastics, varnish, or similar materials, gases develop that are easily flammable and can lead to explosions. Be prepared for flames to develop and keep suitable fire extinguishing means at hand."
- "The Nozzle becomes very hot. Do not lay the Heat Gun on flammable surfaces when operating the Gun or immediately after turning the Gun off. Always set the Heat Gun on a flat, level surface so that the Nozzle tip is directed upwards and away from the supporting surface."
- "Do not use the Heat Gun near flammable materials."
- "Remove all flammable and heat sensitive materials from the work area."
- "Keep multiple class ABC fire extinguishers readily accessible while working and while workpiece cools."

1.6 OSHA and OSHNC

Federally, OSHA is the regulatory body responsible for worker safety. At the state level, North Carolina operates an OSHA-approved State Plan [7]. State plans are workplace safety and health programs that are created and operated by individual states or territories that choose to administer their own programs. States and territories without an OSHA-approved state plan fall under OSHA's federal jurisdiction. Thus, the North Carolina Department of Labor, Occupational Safety and Health Division (OSHNC) is the regulator responsible for performing occupational safety inspections and issuing inspection details and citations in the state. Rather than creating its own standards, North Carolina generally adopts federal OSHA standards verbatim [8]. This report references various federal OSHA standards as a result, including 29 CFR 1910.146 – Permit-Required Confined Spaces and 29 CFR 1910.106 – Flammable Liquids.

1.7 Hot Work

1.7.1 Evergreen and Blastco Hot Work Policy Requirements

Evergreen defines hot work as "any activity that could serve as a source of ignition" and lists the following as examples:

- Welding and allied processes
- Heat treating[a]

[a] Heat treating in this context refers to the practice of applying heat to metals, such as in annealing or post-weld heat treating.

- Grinding
- Hot riveting
- Propane torches
- Compressed gas torches
- Chipping hammers and wedges
- Drills or other power tools in specific areas

Blastco did not have a standalone hot work policy, and instead used a single comprehensive document titled "Safety Program" that contains sections on fire prevention and the handling of combustible and flammable liquids. Blastco's fire prevention plan did not specifically discuss hot work and contained no definition for hot work.

Blastco's fire prevention plan stated that:

> All chemical products will be handled and stored in accordance with the procedures noted on their individual SDS.
>
> Heat producing equipment will be properly maintained and operated per the manufacturer's instructions to prevent accidental ignition of combustible materials.
>
> […]
>
> Combustible liquids and trash must be segregated and kept from ignition sources.

Blastco also had a Confined Space Entry policy (discussed below in Section 1.9) that contains the following definition of hot work:

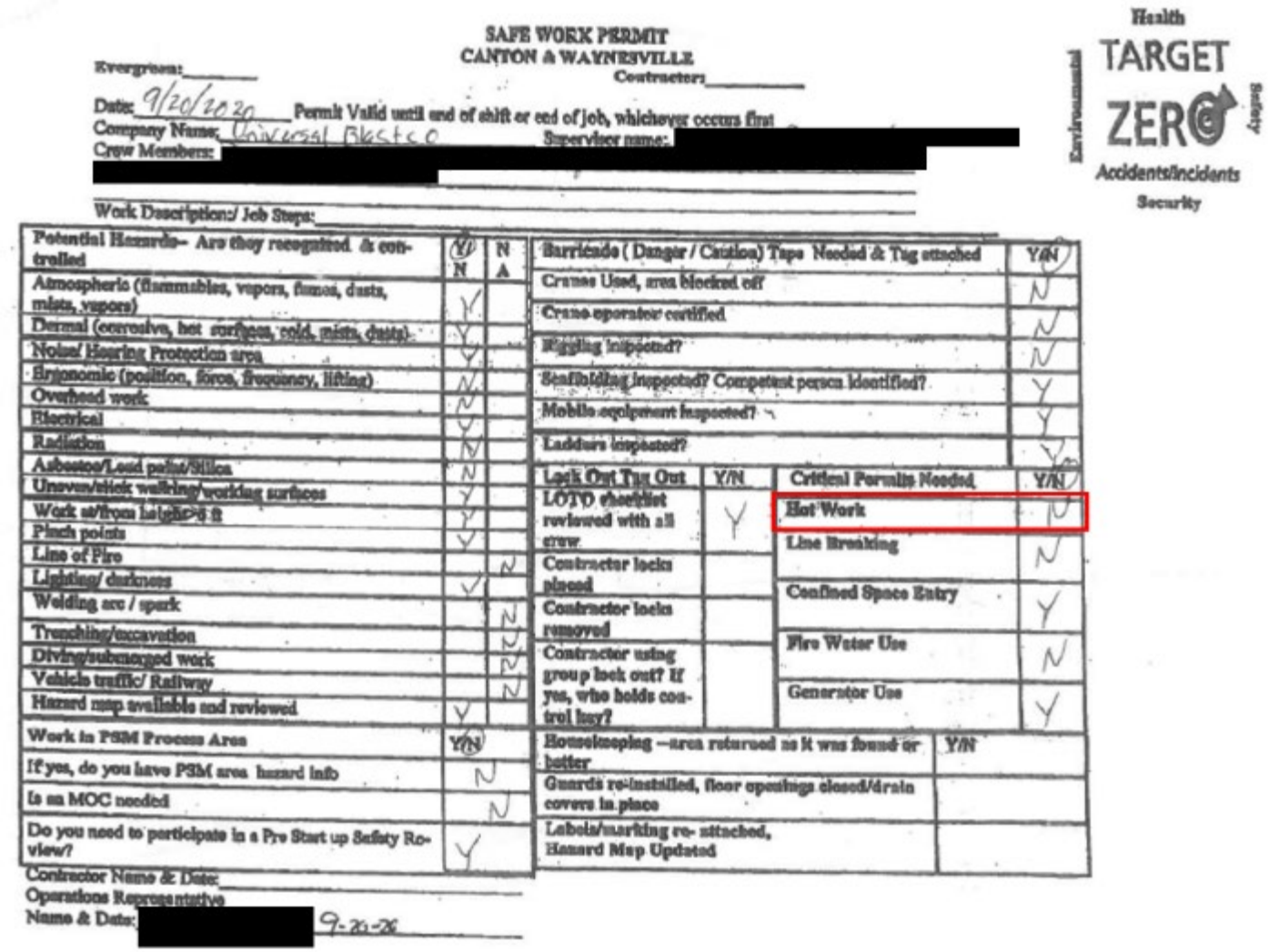
> Hot work means operations capable of providing a source of ignition (for example, riveting, welding, cutting, burning, and heating).

1.7.2 Hot Work Permitting

Blastco did not request, and Evergreen did not issue, a hot work permit on the night of the incident. Evergreen requires all contractors to obtain a "Safe Work Permit" prior to beginning any work on site. Blastco received this permit from Evergreen prior to beginning the night shift, and the permit was authorized by an Evergreen employee. The Safe Work Permit for the night shift beginning Sunday, September 20 is shown below in **Figure 5**. It indicates that no hot work was to be performed.

During the turnaround, Evergreen also required contract companies to fill out a form called a "Contractor Daily Briefing Report." This form was used to prompt discussion and notify Evergreen of any safety incidents, job delays, and other safety topics during a twice-daily in-person contractor safety meeting between contract and Evergreen representatives. Blastco and Evergreen filled out three such forms for Blastco's work at the

Evergreen facility prior to the incident. A portion of the form dated for Sunday, September 20 is shown below in **Figure 6**. It also indicates that no hot work was to be performed.



SAFE WORK PERMIT
CANTON & WAYNESVILLE

Evergreen: _____ Contractor: _____

Date: 9/20/2020 Permit Valid until end of shift or end of job, whichever occurs first

Company Name: Universal Blastco Supervisor name: [redacted]

Crew Members: [redacted]

Work Description/ Job Steps: _____

Health
TARGET ZERO
Environmental Safety
Accidents/Incidents
Security

Potential Hazards– Are they recognized & controlled	Y/N	N/A
Atmospheric (flammables, vapors, fumes, dusts, mists, vapors)	Y	
Dermal (corrosive, hot surfaces, cold, mists, dusts)	Y	
Noise/ Hearing Protection area	Y	
Ergonomic (position, force, frequency, lifting)	N	
Overhead work	N	
Electrical	Y	
Radiation	N	
Asbestos/Lead paint/Silica	N	
Uneven/slick walking/working surfaces	Y	
Work at/from height>6 ft	Y	
Pinch points	Y	
Line of Fire		N
Lighting/ darkness	Y	
Welding arc / spark		N
Trenching/excavation		N
Diving/submerged work		N
Vehicle traffic/ Railway		N
Hazard map available and reviewed	Y	
Work in PSM Process Area	Y/N	
If yes, do you have PSM area hazard info	N	
Is an MOC needed	N	
Do you need to participate in a Pre Start up Safety Review?	Y	

Barricade (Danger / Caution) Tape Needed & Tag attached	Y/N
Cranes Used, area blocked off	N
Crane operator certified	N
Rigging inspected?	N
Scaffolding inspected? Competent person identified?	Y
Mobile equipment inspected?	Y
Ladders inspected?	Y

Lock Out Tag Out	Y/N
LOTO checklist reviewed with all crew	Y
Contractor locks placed	
Contractor locks removed	
Contractor using group lock out? If yes, who holds control key?	

Critical Permits Needed	Y/N
Hot Work	N
Line Breaking	N
Confined Space Entry	Y
Fire Water Use	N
Generator Use	Y

Housekeeping –area returned as it was found or better	Y/N
Guards re-installed, floor openings closed/drain covers in place	
Labels/marking re- attached, Hazard Map Updated	

Contractor Name & Date: _____

Operations Representative Name & Date: [redacted] 9-20-20

Figure 5. Evergreen Safe Work Permit issued to Blastco. (Credit: Blastco. Annotated and redacted by CSB.)

Contractor Daily Briefing Report

At each Daily Briefing, please be prepared to answer the following items.

EHS to be updated when conditions change, or at least at the beginning of each shift.

Contractor Company: Universal Blastco # of Employees (onsite): 12 Date: 9/20/2020

Area(s) Working Today: Pulp Mill, D1 & D2 Tower Upflow

Injuries □ Yes ☒ No (if yes, be prepared to summarize) **Near miss** □ Yes ☒ No (if yes, be prepared to summarize)

Covid19 Plan ☒ Yes □ No (please be prepared to summarize, if No, explain why)

Any problems related to Covid19? (masks, sanitizer, cleaning schedules, etc)

The information to be shared should include "forward looking" information, as well as any issues encountered ***within the time since the last briefing.***

Could your work impact other trades: ☒ Yes □ No

Could other trades impact your work: □ Yes ☒ No

Could weather impact your work: ☒ Yes □ No

Summary of activities – Please briefly discuss the following as they relate to your work tasks

Please be prepared to provide a copy of your JHA for any high hazard work

- Hot work □ Yes ☒ No Permit# N/A **Please summarize Fire Prevention Plan**
- Number of Fire Watch Persons N/A
- Confined Space Entry ☒ Yes □ No Permit# _____ **Please summarize Entry Plan**
- Number of Attendants 2
- Line breaking Activities □ Yes ☒ No
- LOTO ☒ Yes □ No
- Crane lifts □ Yes ☒ No - Roads blocked □ Yes ☒ No
- New chemicals □ Yes ☒ No
- Waste Disposal (Summarize how you are handling any waste, if applicable)

*If you are conducting Hot Work or any work that could impact our fire prevention plan, please let the EHS Department know specifically what you will be doing and your fire plan.

**If you potentially could block roadways, please advise EHS Department immediately as this may impact the fire response plan.

Do you currently have any safety issues/concerns? Please be prepared to summarize for EHS Staff.

Figure 6. Blastco "Contractor Daily Briefing Report." (Credit: Evergreen. Annotated by CSB.)

1.7.3 Hot Work Hazard Recognition

After the incident, Blastco employees told the CSB that they were not performing any hot work on the morning of the incident, and that hot work permits are used when a tool produces sparks or open flames. Further, Blastco employees told the CSB that heat guns were common tools of the FRP trade and that Blastco had brought several heat guns with them for this work at Evergreen. Blastco did not produce any documentation showing any training related to the acceptable use of heat guns or their qualification as a form of hot work, and employees told the CSB they did not receive any such training by Blastco.

Key Evergreen employees told the CSB that Blastco never communicated the use of the heat gun to them at any point during the planning process or on the night of the incident.

1.7.4 Contractor Management and Hot Work

The CSB requested from Evergreen a copy of its Contractor Management Policy. In response, Evergreen submitted the following:

- The Evergreen Packaging Canton Contractor Safety Policy
- The Evergreen Packaging Canton 2020 Contractor Safety Handbook
- The Evergreen Packaging General Contractor Orientation Training

The three documents include various responsibilities and expectations Evergreen places upon its contractors regarding hot work. The 2020 Contractor Safety Handbook contained no specific definition for hot work, listing burning or welding as examples (emphasis added):

> Hot Work
>
> Before any hot work **(such as burning or welding)** is performed:
>
> - The contractor will obtain a Hot Work Permit from their Canton Mill representative prior to beginning hot work.
> - Hot Work permits must be signed at Fire Control and by area Canton Mill supervision prior to start of the job. All Hot Work Permits must be returned to Fire Control upon completion of the work.
> - No flammable or combustible material can be located within 35 feet of the work area or it must be covered with flameproof covers or shields.
> - The Fire Watch shall be responsible for maintaining constant surveillance of the hot work area during the hot work and for 30 minutes thereafter. He must be thoroughly familiar with fire equipment provided (extinguishers, hose, etc.).

- The Fire Watch or a properly qualified relief must be maintained during all breaks and lunch periods to assure continuous watch service. The Fire Watch will remain at the work location for a minimum of 30 minutes after all hot work has stopped to ensure there are no live sparks or smoldering fires.

- If there is a danger of fire traveling more than one floor, up or down, additional Fire Watches for each affected floor(s) must be assigned. When the 30-minute fire watch is completed, contractors must inform area supervision. Area supervisor will then ensure a fire watch is established for an additional 4 hours. Hot work permits must be returned to Fire Control.

- When hot work is performed **(burning or welding)** in an area where cable trays are located, cable trays will be covered by metal or flame retardant materials to prevent damage caused by falling sparks or hot metal.

- If tar pots are going to be used, a Hot Work Permit must be secured as stated in item 1 of this section. No tar pot may be located on a roof.

- Fire Water Use - Any use of the Canton Mill's fire system water must be approved by Fire Control […]. If approved, Fire Control will issue a "Fire System Water Use Permit" which is valid for only the shift in which it is issued.

Similarly, the presentation slides used in Evergreen's contractor site orientation also contained the following direction regarding hot work (emphasis added):

> Hot Work Requirements:
>
> - Prior to any **burning, cutting, brazing or welding** a hot work permit must be obtained and authorized by an [Evergreen] representative
>
> - All combustibles must be removed within a 35 feet diameter of the hot work
>
>   - This includes lower levels as well if sparks can travel to the lower levels
>
> - A charged fire hose or extinguisher must be present at all times
>
> - A fire watch must be present at all times
>
>   - Fire watch is required to remain in the area for at least 30 minutes after the hot work is completed

1.8 Cold Work Options to Decrease Gel Time

During interviews, Blastco employees described three methods to troubleshoot longer-than-desired gel times, described below: adding extra DMA, changing the application method, and using drum heating bands.

Addition of DMA

First, after the workers add MEKP into the five-gallon buckets, they could add additional DMA. Adding additional DMA decreases gel time.

Change in Application Method

Second, the workers described how they can change the method used to apply the resin and mat onto the wall by rotating their work location inside the tower so as not to place the full thickness of FRP all at once on one spot, thereby reducing the weight on the walls in any one spot at any given time. By changing their work method, the workers can achieve less movement of the new resin and fiberglass material in the event of longer than desired gel times.

Use of Heating Bands

Third, Blastco employees told the CSB that on other jobs, to address the long gel times resulting from cold temperatures, they would apply heating bands to the 55-gallon resin drum to improve the cold weather performance of the resin (**Figure 7**).

Figure 7. Drum heaters. (Credit: Grainger [18].)

Blastco performed a post-incident inventory of its two job trailers and located two drum warmers. According to Blastco, the two drum heaters were located separately, one on each trailer. According to an employee, the company had recently begun renovating and reorganizing one of the trailers but was not yet finished at the time Blastco's work at Evergreen started. The employee stated that when he went to locate the heat bands on the night of the incident, the bands were not in their normal location and he could not locate them on the trailers.

Evergreen told the CSB that another contract company it has used in the past for upflow tower maintenance used a similar method of warming the resin in the drum outside of the tower.

1.9 Confined Space Entry

1.9.1 Confined Space Requirements

OSHA regulation 29 CFR 1910.146—*Permit-Required Confined Spaces* requires employers to isolate confined spaces prior to permitting entry.[a] The D2 upflow and downflow towers were permit-required confined spaces[b] that OSHNC required Evergreen to isolate before workers could enter. Evergreen prepared the upflow and downflow towers for confined space entry in the days leading up to the shutdown by halting upstream pulp production and flushing the towers with water. Evergreen isolated the space according to its lockout/tagout procedures. Evergreen did not isolate the upflow tower from the downflow tower, but instead isolated them together as a single space from upstream and downstream processes.

For permit-required confined spaces, OSHA requires the presence of an "attendant," sometimes referred to in industry as a "hole watch," whose duties include monitoring entrants' status, maintaining contact with them, and ordering evacuation of the space when an unsafe condition is detected.[c] OSHA also includes among the various duties of the attendant the responsibility to "summon rescue and other emergency services as soon as the attendant determines that … entrants may need assistance" escaping from a confined space.

OSHA requires[d] that the confined space entry permit shall identify "[t]he…emergency services that can be summoned and the means (such as the equipment to use and the numbers to call) for summoning those services." Evergreen's confined space permit contained this information on the back face of the permit, which also contained the entry log.

OSHA also requires the designation of an "entry supervisor." The duties of the entry supervisor include knowing the hazards and consequences that may be faced during entry, verification of the means used to contact emergency services, and termination of the entry operation whenever a condition not allowed under the permit arises.[e]

During confined space entry, OSHA requires[f] employers to:

> Develop and implement procedures to coordinate entry operations when employees of more than one employer are working simultaneously as authorized entrants in a permit space, so that employees of one employer do not endanger employees of any other employer[.]

Interviews with each contracting company revealed both companies separately conducted an initial Job Safety Analysis for the vessel in which they were completing work, and each company was only minimally aware of

[a] 29 CFR 1910.146(d)(3)(iii)

[b] A permit-required confined space is defined as a confined space that meets one or more of the following criteria: 1) Contains or has the potential to contain a hazardous atmosphere; 2) Contains material that has the potential for engulfing an entrant; 3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a downward-sloping floor tapering to a smaller cross section, or; 4) Contains any other recognized serious safety or health hazard.

[c] 29 CFR 1910.146(i)

[d] 29 CFR 1910.146(f)(11)

[e] 29 CFR 1910.146(j)

[f] 29 CFR 1910.146(d)(11)

the work being done in the other vessel. Witnesses confirmed to the CSB that there was no communication between the two attendants prior to the fire, and that the two crews operated throughout the night totally independent of each other.

OSHA requires that a confined space entry be terminated whenever, among other conditions, "a condition that is not allowed under the entry permit arises in or near the permit space."[a] Blastco's confined space policy contained a similar requirement.

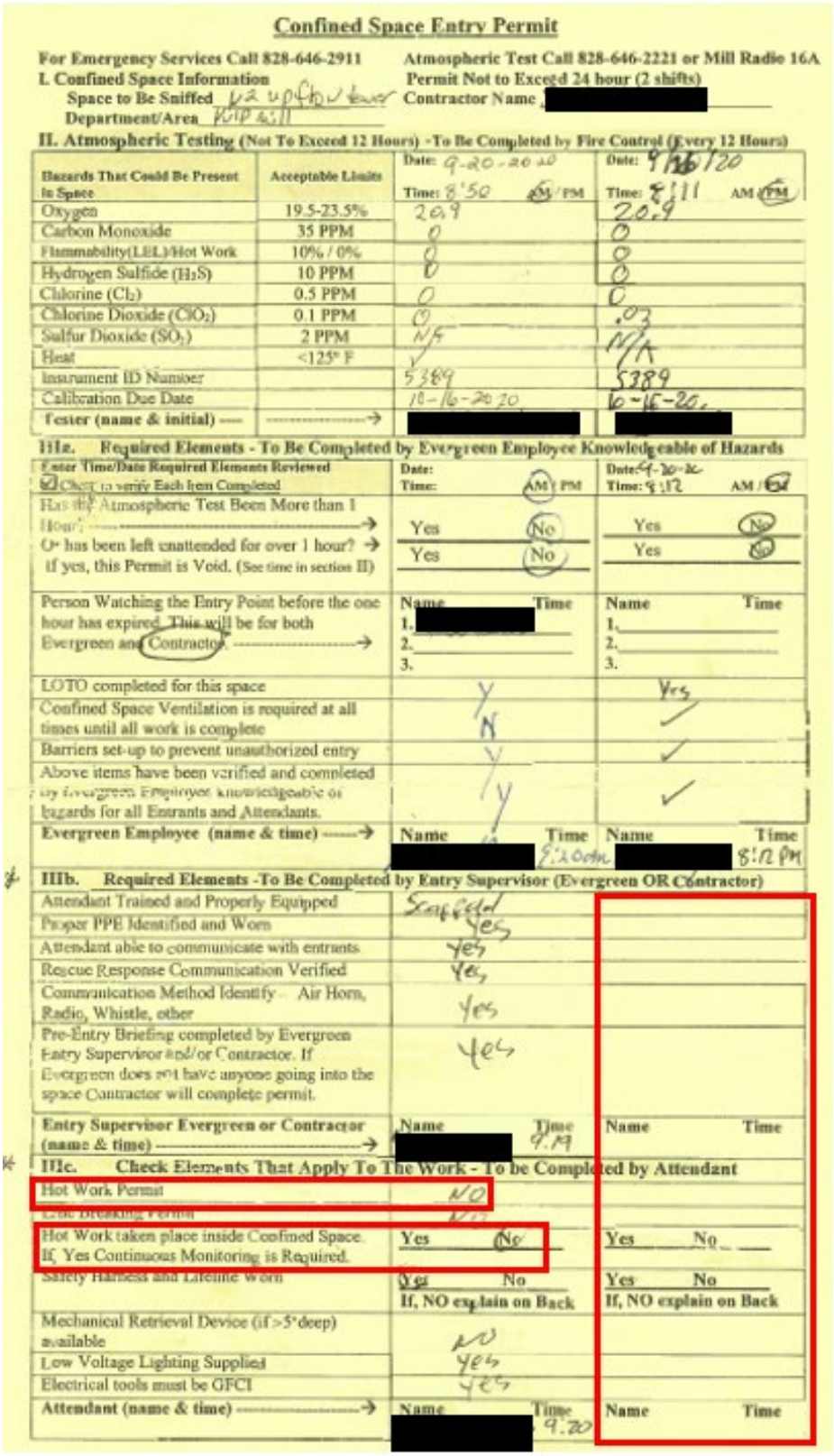
1.9.2 Confined Space Permitting

Evergreen issued confined space entry permits to both Blastco and Rimcor for their work on the night of the incident. On Blastco's confined space permit (**Figure 8**), the rightmost column was meant to authorize the night shift's work beginning on Sunday, September 20. The permit is left blank in the spaces prompting about hot work permits. Sections I, II, and IIIa were completed by Evergreen employees for the night shift. Sections IIIb and IIIc for the night shift were not completed (refer to red highlighting in **Figure 8**). These sections specify crucial information for the permitting system, including designation of the entry supervisor and attendant, and specifying whether additional permits are required. If confined space entry is being performed by a contractor, Evergreen's confined space policy requires sections IIIb and IIIc to be completed by that contractor. Blastco's own confined space entry policy also required that it specify an entry supervisor and attendant, as follows:

> Before entry begins, the entry supervisor identified on the permit must sign the entry permit to authorize entry.
>
> […]
>
> The entry permit that […] authorizes entry to a permit space must identify:
>
> […]
>
> f. Each person, by name, currently serving as an attendant;
>
> g. The individual, by name, currently serving as entry supervisor, and the signature or initials of each entry supervisor who authorizes entry […]

However, as shown below in **Figure 8**, Blastco did not designate an entry supervisor or an attendant on the permit, and never completed the permit. Blastco's and Rimcor's confined space permits for the night of the incident are shown below in **Figure 8** and **Figure 9,** respectively:

[a] 29 CFR 1910.146(e)(5)(ii)



Confined Space Entry Permit

For Emergency Services Call 828-646-2911 — **Atmospheric Test Call 828-646-2221 or Mill Radio 16A**

I. Confined Space Information — **Permit Not to Exceed 24 hour (2 shifts)**

Space to Be Sniffed: V2 upflow tower — Contractor Name: [redacted]

Department/Area: RCP & TI

II. Atmospheric Testing (Not To Exceed 12 Hours) -To Be Completed by Fire Control (Every 12 Hours)

Hazards That Could Be Present In Space	Acceptable Limits	Date: 9-20-2020 Time: 8'50 AM / PM	Date: 9/26/20 Time: 8:11 AM / PM
Oxygen	19.5-23.5%	20.9	20.9
Carbon Monoxide	35 PPM	0	0
Flammability(LEL)/Hot Work	10% / 0%	0	0
Hydrogen Sulfide (H_2S)	10 PPM	0	0
Chlorine (Cl_2)	0.5 PPM	0	0
Chlorine Dioxide (ClO_2)	0.1 PPM	0	.03
Sulfur Dioxide (SO_2)	2 PPM	N/A	N/A
Heat	<125° F	✓	
Instrument ID Number		5389	5389
Calibration Due Date		10-16-2020	10-16-20
Tester (name & initial) ——→		[redacted]	[redacted]

IIIa. Required Elements - To Be Completed by Evergreen Employee Knowledgeable of Hazards

Enter Time/Date Required Elements Reviewed ☑ Check to verify Each Item Completed	Date: Time: AM / PM	Date: 9-20-20 Time: 9:12 AM / PM
Has the Atmospheric Test Been More than 1 Hour? ——→	Yes (No)	Yes (No)
Or has been left unattended for over 1 hour? → if yes, this Permit is Void. (See time in section II)	Yes (No)	Yes (No)
Person Watching the Entry Point before the one hour has expired. This will be for both Evergreen and Contractor. ——→	Name Time 1. [redacted] 2. 3.	Name Time 1. 2. 3.
LOTO completed for this space	Y	Yes
Confined Space Ventilation is required at all times until all work is complete	N	✓
Barriers set-up to prevent unauthorized entry	Y	✓
Above items have been verified and completed by Evergreen Employee knowledgeable of hazards for all Entrants and Attendants.	Y	✓
Evergreen Employee (name & time) ——→	Name Time [redacted] 9:20am	Name Time [redacted] 8:12 PM

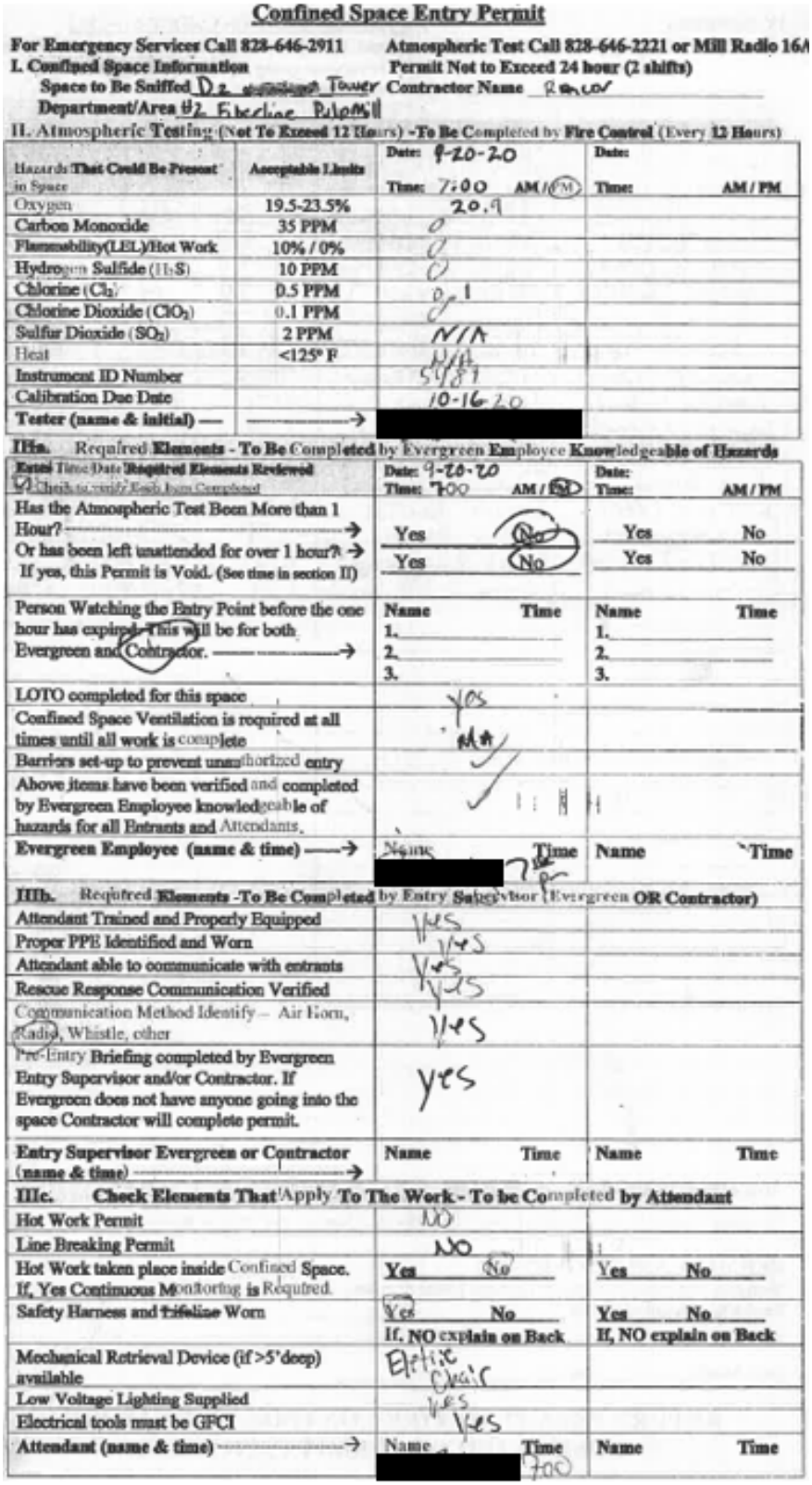
IIIb. Required Elements -To Be Completed by Entry Supervisor (Evergreen OR Contractor)

Attendant Trained and Properly Equipped	Scaffold	
Proper PPE Identified and Worn	Yes	
Attendant able to communicate with entrants	Yes	
Rescue Response Communication Verified	Yes	
Communication Method Identify – Air Horn, Radio, Whistle, other	Yes	
Pre-Entry Briefing completed by Evergreen Entry Supervisor and/or Contractor. If Evergreen does not have anyone going into the space Contractor will complete permit.	Yes	
Entry Supervisor Evergreen or Contractor (name & time) ——→	Name Time [redacted] 9:19	Name Time

IIIc. Check Elements That Apply To The Work - To be Completed by Attendant

Hot Work Permit	NO	
Line Breaking Permit	NO	
Hot Work taken place inside Confined Space. If, Yes Continuous Monitoring is Required.	Yes (No)	Yes No
Safety Harness and Lifeline Worn	Yes No If, NO explain on Back	Yes No If, NO explain on Back
Mechanical Retrieval Device (if >5' deep) available	NO	
Low Voltage Lighting Supplied	Yes	
Electrical tools must be GFCI	Yes	
Attendant (name & time) ——→	Name Time [redacted] 9:20	Name Time

Figure 8. Blastco confined space permit. (Credit: Blastco. Annotated and redacted by CSB.)



Confined Space Entry Permit

For Emergency Services Call 828-646-2911 — **Atmospheric Test Call 828-646-2221 or Mill Radio 16A**

I. Confined Space Information — **Permit Not to Exceed 24 hour (2 shifts)**

Space to Be Sniffed D2 [illegible] Tower — Contractor Name Rimcor

Department/Area #2 Fiberline Pulp Mill

II. Atmospheric Testing (Not To Exceed 12 Hours) -To Be Completed by Fire Control (Every 12 Hours)

Hazards That Could Be Present in Space	Acceptable Limits	Date: 9-20-20 Time: 7:00 AM / PM	Date: Time: AM / PM
Oxygen	19.5-23.5%	20.9	
Carbon Monoxide	35 PPM	0	
Flammability(LEL)/Hot Work	10% / 0%	0	
Hydrogen Sulfide (H_2S)	10 PPM	0	
Chlorine (Cl_2)	0.5 PPM	0.1	
Chlorine Dioxide (ClO_2)	0.1 PPM	0	
Sulfur Dioxide (SO_2)	2 PPM	N/A	
Heat	<125° F	N/A	
Instrument ID Number		5489	
Calibration Due Date		10-16-20	
Tester (name & initial) ——→		[redacted]	

IIIa. Required Elements - To Be Completed by Evergreen Employee Knowledgeable of Hazards

Enter Time Date Required Elements Reviewed Check to verify Each Item Completed	Date: 9-20-20 Time: 7:00 AM / PM	Date: Time: AM / PM
Has the Atmospheric Test Been More than 1 Hour? ——→	Yes (No)	Yes No
Or has been left unattended for over 1 hour? → If yes, this Permit is Void. (See time in section II)	Yes No	Yes No
Person Watching the Entry Point before the one hour has expired. This will be for both Evergreen and Contractor. ——→	Name Time 1. 2. 3.	Name Time 1. 2. 3.
LOTO completed for this space	YES	
Confined Space Ventilation is required at all times until all work is complete	NA	
Barriers set-up to prevent unauthorized entry	✓	
Above items have been verified and completed by Evergreen Employee knowledgeable of hazards for all Entrants and Attendants.	✓	
Evergreen Employee (name & time) ——→	Name [redacted] Time 7:00	Name Time

IIIb. Required Elements -To Be Completed by Entry Supervisor (Evergreen OR Contractor)

Attendant Trained and Properly Equipped	YES	
Proper PPE Identified and Worn	YES	
Attendant able to communicate with entrants	YES	
Rescue Response Communication Verified	YES	
Communication Method Identify – Air Horn, Radio, Whistle, other	YES	
Pre-Entry Briefing completed by Evergreen Entry Supervisor and/or Contractor. If Evergreen does not have anyone going into the space Contractor will complete permit.	YES	
Entry Supervisor Evergreen or Contractor (name & time) ——→	Name Time	Name Time

IIIc. Check Elements That Apply To The Work - To be Completed by Attendant

Hot Work Permit	NO	
Line Breaking Permit	NO	
Hot Work taken place inside Confined Space. If, Yes Continuous Monitoring is Required.	Yes (No)	Yes No
Safety Harness and Lifeline Worn	Yes No If, NO explain on Back	Yes No If, NO explain on Back
Mechanical Retrieval Device (if >5' deep) available	Electric Winch	
Low Voltage Lighting Supplied	YES	
Electrical tools must be GFCI	YES	
Attendant (name & time) ——→	Name [redacted] Time 7:00	Name Time

Figure 9. Rimcor confined space permit. (Credit: Evergreen. Annotated and redacted by CSB.)

1.9.3 Confined Space Entry Preparation

Evergreen issued separate confined space entry permits for the two crews and required an attendant for each crew. Despite not listing an attendant or entry supervisor on the confined space entry permit, Blastco did designate an attendant and entry supervisor in practice. The Blastco attendant was positioned at the upflow tower entry manway and the Rimcor attendant was stationed at the downflow tower entry manway (refer to **Figure 3**). Each company also had its own entry supervisor.

Blastco's designated means of egress from the upflow tower was to dismount the scaffolding inside the tower and exit via the manway. Rimcor had three methods of egress from the downflow tower: 1) a cable ladder from the work platform up to the upper crossover manway; 2) a cable ladder from the work platform down to the floor of the tower; and 3) the chair lift used to move workers and equipment to and from the platform.

For communication with the attendant, Blastco used cell phones. Rimcor used radios for its workers and attendant. Blastco and Rimcor did not use a common mode of communication between the two crews or attendants.

For atmospheric monitoring during the confined space entry, the Blastco attendant used a monitor at the upflow tower bottom manway. Blastco's confined space permit required the use of continuous ventilation for the duration of Blastco's work. However, a witness stated that at some point during the night shift, the ventilation fan was turned off. Another Blastco employee told the CSB that in addition to commonly required articles of PPE such as hard hats and hearing protection, the Blastco workers were wearing chemical resistant coveralls and full-face respirators.

1.10 Fire Damage to Upflow Tower

OSHA considers FRP to be combustible:

> OSHA defines noncombustible materials as those materials which are not capable of burning or igniting. Since FRP is capable of burning in the presence of a flame, OSHA considers such material to be combustible[.] [9]

In order to determine the extent of the fire-induced damage sustained during the incident inside the upflow tower, 16 one- to two-inch circular core samples were removed from the side of the vessel (**Figure 10**). Blastco was working inside the tower from roughly the heights of sample "D" to sample "I." In the figure, the apostrophe symbol (') is used to notate feet and the quotation symbol (") is used to notate inches. During post-incident examination of the upflow tower, burn damage was found on the inside surface of the vessel's insulation near the top of the vessel.[a]

Figure 10. Internal fire damage in the upflow tower. (Credit: Evergreen. Edited by CSB.)

2 Incident Description

2.1 Beginning of Night Shift

Between 7:00 p.m. and 8:00 p.m. on Sunday, September 20, 2020, the night shift crews for Blastco and Rimcor arrived and began preparing for their shift in the D2 upflow and downflow towers, respectively. Evergreen issued a Safe Work Permit and a confined space entry permit separately to both Blastco and Rimcor for their work in the towers. By about 8:20 p.m., Blastco had completed permitting and setup and entered the upflow tower.

To prepare the FRP resin for use inside the upflow tower, Blastco workers first opened a 55-gallon drum of raw resin outside of the vessel. Workers "activated" the resin by mixing a cobalt "promoter," or catalyst, and DMA into the drum. Next, workers filled five-gallon buckets with "promoted" resin from the drum. Inside the vessel, workers then performed the second activation step, which involved mixing MEKP and DMA into the buckets.

After the promoted resin was initiated, it was ready for use. Blastco workers dipped paint rollers into the buckets and rolled the resin on the wall, subsequently alternating layers of resin and fiberglass matting until the specified thickness was reached.

2.2 Lamination Difficulty and Troubleshooting

Throughout the night shift, Blastco experienced problems with the resin application. Blastco workers informed the CSB that the cold temperatures were interfering with their work and their progress was slower than expected. As discussed in Section 1.3.2, colder temperatures result in longer gel times, which ultimately resulted in Blastco's lamination patterns sliding down the walls of the vessel before the resin hardened.

Blastco workers attempted several means of addressing the resin gel time. First, after the workers added MEKP into the five-gallon buckets, they added additional DMA. Adding the additional DMA decreased the gel time.

Second, the workers changed the method they were using to apply the resin and mat onto the wall. Instead of stacking the layers to the full thickness (five or more layers) in one spot before moving onto the next spot, the workers stacked two layers of mat on one side of the vessel and then moved to the opposite side to add two more layers. They rotated and added two more layers next to the first two. With this method, there was less weight on the wall of the tower, which resulted in less movement of the new material. While these strategies helped somewhat, neither of these methods sufficiently addressed the overly long gel time, and the workers continued to struggle.

Sometime after 2:00 a.m. on September 21, 2020, one of the workers went to locate drum warming bands. The worker could not locate the warming bands in their usual location on Blastco's job trailer. Instead, one of the Blastco workers obtained a heat gun from the Blastco trailer, brought it into the tower, and began using it to warm the resin for easier application. They warmed the resin by turning on the heat gun and pointing it into the bucket of resin, stirring while they added heat.

2.3 Fire Ignition

At approximately 5:15 a.m., the two Rimcor entrants radioed their foreman outside of the tower to inform him that they had only 10 minutes of abrasive blasting remaining before they would need the scaffolding raised. This was the last contact made by the two Rimcor workers.

A Blastco employee stated that at roughly the same time, around 5:15 a.m., they had just finished warming and mixing a bucket of resin inside the upflow tower and needed to pass it to another worker inside the tower applying the resin. The worker stated that he looped the heat gun cord around the scaffolding railing, leaving it powered on. He repositioned himself, preparing to pass the bucket, turned around and saw a fire in the bucket. Another Blastco worker, who was applying the resin, stated that he turned and saw a fire in the bucket, and that the heat gun was inside the bucket. The Blastco crew did not have a fire extinguisher immediately available, and Evergreen did not require Blastco to have one available.

2.4 Response

One of the Blastco workers inside the tower removed the heat gun from the bucket and alerted the rest of the crew to the fire. The Blastco workers dismounted the scaffolding inside the upflow tower, exited the tower, and climbed down to the ground. The last Blastco employee to leave tried to smother the fire by covering the bucket with a plastic lid. The lid quickly melted, and the worker then grabbed some nearby fiberglass mat and placed it on the bucket. This did not put the fire out either. The worker told the CSB that the bucket had started melting and that flaming resin was pouring downward from the platform. The worker decided to leave the tower, as the fire had progressed too far. One worker noted that the walls of the tower, portions of which were likely still covered in partially cured resin, had caught fire.

Witnesses stated that at approximately 5:17 a.m., they saw the Blastco workers exit the upflow tower and throw a heat gun on the ground. The heat gun appeared to have been damaged by fire. One of the Blastco workers approached the Rimcor workers and alerted them to the fire. Two Rimcor employees looked up toward the upflow tower manway where Blastco had been working and could see fire inside the vessel. One Rimcor worker radioed the two Rimcor entrants inside the downflow tower to tell them to exit the tower, but received no response. The worker attempted to yell from the bottom manway and then went to the top of the D2 towers to attempt to make contact with the entrants from the upper manway. Black smoke was seen flowing out of the upper manway of the two towers and the Rimcor worker was unable to contact the two entrants. He then made his way back down.

At 5:18 a.m., the Blastco night foreman notified his Evergreen contact of the fire via cell phone. That Evergreen employee then notified the Evergreen area operations foreman of the fire via radio. Someone at Evergreen subsequently notified the Evergreen safety office of the fire via radio. At approximately 5:20 a.m., the safety office activated the Evergreen site emergency response team (ERT). At 5:22 a.m., the Evergreen employee overseeing the repairs to the D2 towers arrived at the scene and called 911. Shortly thereafter, the Evergreen night shift safety manager arrived at the scene of the incident, assumed the role of incident commander, contacted the county emergency dispatch, and requested that all county mutual aid fire resources be summoned. She believed the fire was beyond the Evergreen ERT's response capabilities.

At 5:24 a.m., a Rimcor worker called Rimcor's Evergreen contact to notify him that Rimcor had lost contact with the two workers inside the vessel.

At approximately 5:25 a.m., the Evergreen ERT began arriving on scene. The ERT was informed that two Rimcor workers had not been accounted for in headcounts and were likely still inside the downflow tower. Witnesses confirmed that the amount of smoke and the velocity with which it flowed from the manway caused the ERT to decide against entering the vessel to attempt rescue and that ERT members moved away from the manway. Within a minute of moving away from the downflow tower manway, a witness stated that the smoke flowing out of the manway transitioned into an active flame front. A few minutes after flames erupted from the manway, a witness heard a sound that he believed was the scaffolding platform falling to the floor of the vessel.

The Evergreen ERT, area fire departments, and emergency responders fought the fire for approximately two hours. At various points throughout the incident, witnesses saw flames jetting from each manway.

The two Rimcor workers who were inside the downflow tower at the time of the incident were fatally injured. The bodies of the two deceased Rimcor workers were found positioned close to one another, a few feet away from the bottom manway of the downflow tower. The scaffolding platform upon which the two Rimcor workers were working was found upside down and on top of them. The Haywood County, NC, medical examiner deemed the cause of death of the two workers to be carbon monoxide poisoning due to smoke inhalation, although multiple blunt force injuries were noted for both as contributory factors.

3 Incident Analysis

The sections below discuss the following safety issues the CSB identified in its investigation:

- Hot Work Safety
- Pre-Job Planning
- Confined Space Safety
- Combustible Materials of Vessel Construction

3.1 Hot Work Safety

Evergreen and Blastco used the following hot work definitions in their respective hot work and confined space policies:

- Evergreen's hot work policy defines hot work as an "activity that could serve as a source of ignition."
- Blastco's confined space entry policy defines hot work as an "operation capable of providing a source of ignition."

These definitions are consistent with the 2019 version of the National Fire Protection Association (NFPA) Standard 51B: *Fire Prevention in Use of Cutting and Welding Processes*, which is widely cited in industry as a good practice document. NFPA 51B defines hot work as [10, p. 5]:

> Work involving burning, welding, **or a similar operation that is capable of initiating fires** or explosions. (emphasis added)

Discussed below, the CSB identified problems with hot work hazard recognition.

3.1.1 Heat Gun as an Ignition Source

The resin used in the maintenance of the upflow tower has a flash point of 79°F and an auto-ignition temperature of 914°F. The heat gun used by the Blastco crew could achieve temperatures ranging from 430°F to 1,160°F. Witnesses stated that the fire started when the heat gun fell into a bucket of resin.

The CSB concludes that given that the heat gun could produce temperatures in excess of the resin's flash point and auto-ignition temperatures, it should have been recognized as an ignition source, and its use should have been considered hot work under Evergreen's, Blastco's, and the NFPA's definitions.

However, in the OSHA flammable liquids rule, OSHA requires[a] that (emphasis added):

[a] 29 CFR 1910.106(e)(2)(iv)(c)

> Category 1 or 2 flammable liquids, or Category 3 flammable liquids with a flashpoint below 100 °F (37.8 °C), may be used only where there are no open flames or **other sources of ignition** within the possible path of vapor travel.

As discussed in Section 1.3, the resin Blastco used to re-line the upflow tower is classified as a Category 3 flammable liquid and has a flash point below 100°F. Thus, per OSHA requirements, the use of a heat gun to warm buckets of flammable resin is a prohibited practice. The CSB concludes that the heat gun should not have been used in the confined space in the presence of the flammable resin. OSHNC issued a citation[a] to Blastco for use of the heat gun in the presence of the resin.

3.1.2 Blastco Hazard Recognition

As presented in Section 1.7.3, Blastco workers told the CSB that they were not performing any hot work leading up to the incident, and that hot work consists solely of work methods that produce sparks or open flames. The Blastco workers' narrow understanding of types of ignition sources and hot work was not in alignment with the broader definition of hot work in Blastco's own confined space policy, which defines hot work as an "operation capable of providing a source of ignition."

The CSB concludes:

- Blastco did not recognize the ignition hazard posed by the heat gun because it did not recognize its use as a form of hot work, and Blastco did not inform Evergreen or Rimcor of the heat gun's use.
- Worker understanding of ignition sources and forms of hot work is critical to ensure that permitting and effective safety precautions are implemented.
- Blastco's understanding of ignition sources and hot work could be improved by Blastco revising its policies and training methods to specifically identify the use of heat guns as hot work, and by making clear that hot work encompasses any method of work that can ignite a fire and not just spark- or flame-producing work methods.
- Blastco should update its policies and training to include the use of non flame- and spark-producing tools and work methods, such as heat guns and other ignition sources, as hot work.

The CSB recommends to Blastco to update its hot work policy and employee training program to specifically identify the use of heat guns as hot work. The policy and programs should make clear that hot work encompasses any method of work that can ignite a fire and not just spark- or flame-producing work methods.

3.1.3 Evergreen's Role in Ensuring Hot Work Safety

As the operator of the facility, Evergreen has a role in overseeing contractors and developing programs for contractor safety. As stated by the Center for Chemical Process Safety (CCPS) in its book *Guidelines for Risk Based Process Safety*, "While contractors have a responsibility to monitor the action of their employees and to

[a] Inspection Detail, Item 01001

enforce the safety performance requirements, the ultimate responsibility for ensuring the safety of its facility rests with the company [11, p. 376]."

All facilities that employ contractors should have a contractor management program that trains contractors on company and site-specific policies, hazards, and safe work practices such as confined space entry and hot work. The training conducted as part of the contractor management program must clearly communicate company safety requirements.

As discussed in Section 1.7.4, Evergreen's contractor safety handbook and site orientation program only define hot work as "burning, cutting, brazing or welding." This is not in alignment with Evergreen's own internal hot work policy, which as discussed in Section 1.7.1 defines hot work as "any activity that could serve as a source of ignition."

The CSB concludes that companies have an important role in ensuring contractor safety in addition to employee safety. The CSB also concludes that Evergreen should update all documentation, training, and orientation pertaining to hot work provided to contractors with Evergreen's internal definition for hot work.

The CSB recommends to Evergreen to update all documentation, training, and orientation materials provided to contractors pertaining to hot work to reflect Evergreen Packaging's internal definition of hot work. The materials should make clear that hot work encompasses any method of work that can serve as a source of ignition.

3.2 Pre-Job Planning

Cold ambient temperatures caused Blastco's resin to perform poorly, experiencing unacceptably long gel times. The poor performance of the resin in the cold temperatures drove Blastco to use a heat gun to reduce the resin gel time. The CSB concludes that weather was a significant factor in the occurrence of this incident.

NFPA guides companies and workers to avoid hot work—in this case, the use of the heat gun—altogether if there is a suitable alternative. NFPA 51B contains a decision tree (**Figure 11**) for hot work permitting, encouraging users to ask the question "Is there an acceptable alternative to hot work [10, p. 13]?"

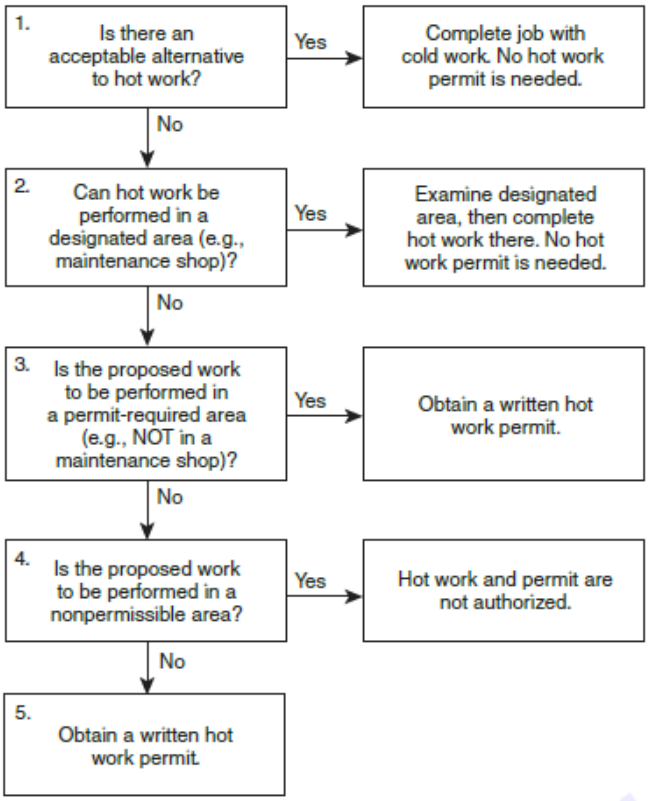


Figure 11. NFPA hot work decision tree. (Credit: NFPA [10].)

As discussed in Sections 1.8 and 2.2, Blastco workers attempted several alternatives to hot work. According to Blastco, the company had two drum heating bands available at the time of the incident. However, the two heaters were stored separately on Blastco's two job

trailers, at least one of which was undergoing renovation and reorganization. According to a Blastco worker, the reorganization was not complete at the time of the trailer's use for the job at Evergreen. The worker stated that when they searched for drum heating bands, the bands were not in their usual location, and that they could not locate the bands. The worker resorted to using a heat gun instead.

Blastco workers informed the CSB that they had successfully used drum warming bands in the past to address cold temperatures. Evergreen told the CSB that another contract company it has used in the past for upflow tower maintenance used a similar method of warming the resin in the drum outside of the tower. Thus, the CSB concludes that the drum heaters may have provided enough heat to the resin to eliminate the need for the heat gun.

In the absence of the drum warming heat bands or other methods, the CSB concludes that Blastco could have delayed lamination work to day shifts when temperatures in the area were in the mid-60s (degrees Fahrenheit). The CSB concludes that temperatures in the 60s (degrees Fahrenheit) might have produced adequate resin gel times for the Blastco workers and might have eliminated the need to warm the resin at all.

Given that Blastco could have used drum warming bands, or could have delayed the work until ambient temperatures were warmer, the CSB concludes that Blastco had acceptable alternatives to using the heat gun to warm the resin.

The CSB concludes that effective pre-job planning, such as taking into account the potential for poor performance of the resin in cold temperatures and identifying solutions to avoid or correct the problem, could have prevented this incident. The CSB also concludes that to assist with pre-job planning efforts, a Blastco troubleshooting guide or standard operating procedure addressing resin gel time could prevent a similar incident in the future. The CSB recommends that Blastco develop a formalized troubleshooting guide and/or standard operating procedure for the usage of resin and fiberglass matting in FRP operations. The procedure should direct employees on acceptable means of addressing cold-weather resin performance.

In addition, there may be FRP applications in which the use of a heat gun is appropriate. The CSB concludes that Blastco should develop a policy, procedure, or guidance document on the correct use of heat guns in FRP operations. The CSB recommends that Blastco develop a policy and standard operating procedures for the proper use of heat guns in FRP operations.

3.3 Confined Space Safety

3.3.1 Confined Space Permitting

On its confined space entry permit, shown above in **Figure 8**, Blastco did not complete required portions of the permit. For these omissions, OSHNC cited Blastco with multiple violations of the confined space standard.[a] The citations included Blastco's failure to document the hazards of the space, such as the presence of the flammable resin, Blastco's failure to designate an entry supervisor on the permit, and the entry supervisor's failure to sign the permit authorizing entry.

[a] Inspection Detail, Items 02006 and 02007

3.3.2 Entry Termination

OSHA requires that a confined space entry be terminated whenever, among other conditions, "a condition that is not allowed under the entry permit arises in or near the permit space."[a] Blastco's confined space policy contained a similar requirement.

Beyond OSHA's regulatory requirements, industry groups such as NFPA also offer guidance on confined space safety. According to NFPA, in its Standard 350 *Guide for Safe Confined Space Entry and Work* [12], hazard identification primarily occurs during the pre-planning stage of the work, but the identification and evaluation should occur throughout the work period [12, pp. 18-19]. Further, NFPA 350 gives the following guidance:

> If changes occur in the use of or configuration within a confined space or external to the confined space that affect the hazards, Contractors/Subcontractors should ensure that the entry permit is cancelled, Entrants immediately vacate the space, the confined space is re-evaluated, and new or renewed permits are issued establishing revised entry criteria, as necessary.

The Blastco crew did not terminate the entry when the new hazard presented by the heat gun was introduced into the space. The CSB concludes that Blastco should have terminated its confined space entry when the heat gun was introduced into the space, and that its failure to do so resulted from Blastco's failure to recognize the ignition hazard presented by the heat gun.

3.3.3 Emergency Communication

The CSB determined that there was a protracted chain of emergency communication from the Blastco crew to the Evergreen ERT that delayed activation of the ERT. As described above in Section 2.4, the Blastco attendant did not summon emergency services when the fire started and did not notify the Rimcor attendant of the emergency until some or all of the Blastco workers had evacuated the upflow tower. Instead, one of the Blastco crew members attempted to extinguish the fire themselves, and the crew only called for help once they determined they could not extinguish the fire. Further, instead of summoning the Evergreen fire control center or ERT directly, the Blastco foreman contacted his Evergreen contact, who contacted the operations foreman, who contacted the fire control center, who summoned the ERT.

The role of the attendant is critical for safe confined space operations. OSHA includes among the various duties[b] of the attendant the responsibility to "summon rescue and other emergency services as soon as the attendant determines that … entrants may need assistance" escaping from a confined space. OSHA requires[c] that the confined space entry permit shall identify "[t]he…emergency services that can be summoned and the means (such as the equipment to use and the numbers to call) for summoning those services." Evergreen's confined space permit contained this information on the back face of the permit. The CSB concludes:

[a] 29 CFR 1910.146(e)(5)(ii)
[b] 29 CFR 1910.146(i)
[c] 29 CFR 1910.146(f)(11)

- OSHA requires confined space entry permits to define the emergency services that can be summoned and the means to be used to summon those services.
- Evergreen followed this OSHA requirement by including on its confined space permit the contact information to directly call emergency services.
- Blastco did not properly activate emergency services when it did not directly call the Evergreen emergency phone number listed on the permit when the fire started.

3.3.4 Flammables in Confined Spaces

Another opportunity to prevent this incident was through addressing hazards and implementing controls when using flammables in a confined space. This section discusses another similar incident investigated by the CSB—a fire in a penstock at Xcel Energy in Colorado—in which flammable materials ignited in a confined space, causing a fire that led to fatal injuries to five workers. The resulting recommendations are then discussed regarding their applicability to the Evergreen incident.

Xcel Energy Incident

On October 2, 2007, a chemical fire inside a permit-required confined space at Xcel Energy's hydroelectric plant in a remote mountain location 45 miles west of Denver, Colorado, fatally injured five workers. Industrial painting contractors were in the initial stages of recoating the 1,530-foot steel portion of a 4,300-foot enclosed penstock[a] tunnel with an epoxy coating product when a flash fire occurred. Flammable solvent being used to clean the epoxy application equipment in the open penstock atmosphere ignited, likely from a static spark. The initial fire quickly grew as it ignited additional buckets of solvent and substantial amounts of combustible epoxy material, trapping and preventing five of the 11 workers from exiting the single point of egress within the penstock. The five trapped workers communicated using handheld radios with co-workers and emergency responders for approximately 45 minutes before succumbing to smoke inhalation [13, p. 10].
The flash fire occurred and spread rapidly as a result of the ignition of flammable methyl ethyl ketone vapors in the atmosphere inside the penstock. Neither RPI's (the contractor working inside the penstock) nor Xcel Energy's (the owner of the penstock) policies or permits established safe limits that prohibited entry or occupancy of a confined space with a hazardous flammable atmosphere [13, pp. 13-14], even though both companies claimed to have developed their respective policies and permits in accordance with OSHA's general industry permit-required confined space standard (29 CFR 1910.146).

As a part of its investigation,[b] the CSB reviewed OSHA regulations and policies pertaining to the use of flammable materials inside confined spaces. The CSB concluded that at the time, the standard did not prohibit entry or occupancy above a maximum permissible level of the lower flammable limit (LFL).[c]

[a] A penstock in hydroelectric service is typically an enclosed conduit such as a tunnel or pipe that delivers a flow of water to a turbine that generates electric power.

[b] The CSB's report on the Xcel Energy incident can be found here: https://www.csb.gov/file.aspx?DocumentId=5703

[c] A substance's lower flammable limit (LFL) is defined by NFPA [12, p. 10] as the "lowest volume concentration of a combustible gas or vapor that when mixed with air will ignite, causing a fire or explosion." "LFL" and "LEL" (lower explosive limit) are often used interchangeably in industry.

As a result, the CSB issued two recommendations to OSHA.[a] The first (2008-01-I-CO-R1) recommended that OSHA:

> Amend the OSHA Permit-Required Confined Spaces Rule for general industry (29 CFR 1910.146) to establish a maximum permissible percentage substantially below the lower explosive limit (LEL) for safe entry and occupancy in permit-required confined spaces.

ln April 2011, OSHA advised the CSB that the general industry permit-required confined space standard:

> […] already prohibits entry into atmospheres greater than 10% of the Lower Flammable Limit (LFL),[b] unless the flammable/explosive hazard has been controlled through inerting of the space to reduce the oxygen content below that needed to support combustion.
>
> […]
>
> The standard requires the use of isolation of the permit space […] in combination with purging, inerting, flushing, or ventilation to eliminate or control hazardous atmospheres […]. For control methods based on reducing flammable concentrations, a concentration in excess of 10% of the LFL constitutes a *prohibited condition*, as defined in [29 CFR] 1910.146(b), and requires immediate evacuation of the permit space […].
>
> The use of inerting to control flammable hazards is rare in practice, but is allowed under the standard. When this control method is chosen by the employer, a hazardous oxygen-deficient atmosphere is created and employees must be protected against this hazard […]. Other methods of safeguarding employees would be strongly preferred, but there are situations in General Industry when inerting may be the best approach to protect personnel.

Thus, per OSHA's 2011 letter to the CSB, entry into a space containing greater than 10% LFL is prohibited, unless inerting is used to reduce the space's oxygen content below the combustion threshold. As a result, the CSB closed the first OSHA recommendation as "Closed – Reconsidered/Superseded."[c]

With the second recommendation (2008-01-I-CO-R2), the CSB recommended that OSHA:

> Publish a "Safety and Health Information Bulletin" addressing the hazards and controls when using flammable materials in confined spaces that includes actionable guidance regarding:

[a] The recommendations can be read here: https://www.csb.gov/recommendations/?F_InvestigationId=3506

[b] 29 CFR 1910.146(b) defines an atmosphere containing greater than 10% LEL as a "hazardous atmosphere," and both 29 CFR 1910.146(c)(5)(ii)(D) and 1910.146(d)(3)(iv) require the elimination or control of hazardous atmospheres.

[c] This recommendation's status change summary can be found here: https://www.csb.gov/assets/recommendation/status_change_summary__osha_(xcel_r1)__c-r_s__7-5-2017.pdf

> a. The importance of implementing a hierarchy of controls to address hazards in a confined space that first seeks to eliminate hazards or substitute with a less hazardous material(s) or method(s). Examples include performing work outside of a confined space where reasonably practicable or substituting a flammable material with a non-flammable one.
>
> b. The necessity of establishing a maximum permissible percentage substantially below the lower explosive limit (LEL) for safe entry and occupancy of permit required confined spaces.
>
> c. The need to comprehensively control all potential ignition sources and continuously monitor the confined space at appropriate locations and elevations when work activities involve the use of flammable materials or where flammable atmospheres may be created.
>
> d. The importance of treating confined spaces with the potential for flammable atmospheres above 10 percent of the LEL as a hazard immediately dangerous to life or health (IDLH) that requires rescuers to be stationed directly outside the permit space and available for immediate rescue with appropriate fire-extinguishing and rescue equipment.
>
> e. The requirement that confined spaces such as penstocks be managed as permit-required that are so large or part of a continuous system that they cannot be fully characterized from the entry point. Such spaces need to be monitored for hazardous atmospheres both prior to entry and continuously in areas where entrants are working.

The status of this recommendation is listed as "Open – Acceptable Response or Alternate Response."[a] In the same 2011 letter to the CSB, OSHA addressed this second recommendation. In the letter, OSHA wrote:

> With respect to [recommendation number] 2008-01-I-CO-R2, we agree that there is a need for greater industry awareness of the critical importance of controlling hazards of the types identified in the CSB [Xcel Energy] report and recommendation, particularly those hazards that are not pre-existing, but which result from work activities inside the PRCS. Furthermore, analysis […] revealed a need for additional guidance on evaluating and controlling hazards in spaces and compartments adjoining [confined spaces]. OSHA plans to take the following steps:
>
> 1. Issue a Safety and Health Information Bulletin to address the issues in [recommendation number] 2008-01-I-CO-R2.
>
> 2. Issue an RA [Regional Administrator] letter or revised PRCS compliance directive to provide clear guidance on controlling

[a] https://www.csb.gov/recommendations/?F_InvestigationId=3506

> hazards brought into PRCSs, as well as the need to ensure that adjoining voids, spaces, and compartments are made, and maintained, safe when work is planned in a PRCS.

However, since the 2011 response letter to the CSB, OSHA has not taken action to close that recommendation.

Need for OSHA Guidance to Prevent Future Ignition of Flammable Materials Inside Confined Spaces

Had the guidance recommended in 2008-01-I-CO-R2 existed, it might have caused Evergreen and Blastco to better evaluate and control the hazards of Blastco's work in the upflow tower.

As discussed in Sections 1.7.3 and 2, Blastco workers did not recognize or control the ignition hazard presented by the heat gun when they introduced it into the upflow tower, in which flammable resin was being used for the FRP repair work. As discussed in Section 1.9.2, Blastco did not complete its confined space entry permit and left blank the sections that would have required continuous atmospheric monitoring. As discussed in Section 1.9.3, according to a Blastco worker, Blastco used continuous atmospheric monitoring, but only at the entrance to the upflow tower and not at the work location inside the vessel, where the potential for a hazardous flammable atmosphere existed. A worker communicated to the CSB that Blastco also turned off the continuous ventilation, which Evergreen required on Blastco's confined space permit. As discussed in Section 2, Blastco did not have fire extinguishing equipment immediately available, and Evergreen's ERT was not on immediate standby in the vicinity. Had the ERT been on standby in the vicinity, they may have been able to respond to the incident immediately, potentially by extinguishing the fire before it could spread to the downflow tower.

The CSB concludes:

- An evaluation of flammable material hazards, ignition source recognition and control near flammable materials in a confined space, atmospheric ventilation, atmospheric monitoring at the work location, and immediately available standby emergency personnel may have prevented this incident.
- Safety at Evergreen's facilities would improve from the development and implementation of a policy that requires the involvement of emergency response personnel in planning and coordination of activities involving the use of flammable materials in confined spaces.
- An OSHA publication is needed that includes actionable guidance on addressing hazards and implementing controls when using flammables in confined spaces.

The CSB recommends to Evergreen to develop and implement a policy that requires the involvement of emergency response personnel in planning and coordination of activities involving the use of flammable materials in confined spaces. In the policy, require that emergency response personnel be stationed directly outside the confined space in which flammable materials are used. Ensure that the emergency response personnel are appropriately trained and equipped for confined space entry, confined space rescue and fire response.

The CSB reiterates recommendation 2008-01-I-CO-R2 to OSHA to publish a "Safety and Health Information Bulletin" addressing the hazards and controls when using flammable materials in confined spaces that includes actionable guidance regarding:

a. The importance of implementing a hierarchy of controls to address hazards in a confined space that first seeks to eliminate hazards or substitute with a less hazardous material(s) or method(s). Examples include performing work outside of a confined space where reasonably practicable or substituting a flammable material with a non-flammable one.

b. The necessity of establishing a maximum permissible percentage substantially below the lower explosive limit (LEL) for safe entry and occupancy of permit required confined spaces.

c. The need to comprehensively control all potential ignition sources and continuously monitor the confined space at appropriate locations and elevations when work activities involve the use of flammable materials or where flammable atmospheres may be created.

d. The importance of treating confined spaces with the potential for flammable atmospheres above 10 percent of the LEL as a hazard immediately dangerous to life or health (IDLH) that requires rescuers to be stationed directly outside the permit space and available for immediate rescue with appropriate fire-extinguishing and rescue equipment.

e. The requirement that confined spaces such as penstocks be managed as permit-required that are so large or part of a continuous system that they cannot be fully characterized from the entry point. Such spaces need to be monitored for hazardous atmospheres both prior to entry and continuously in areas where entrants are working.

As shown above, OSHA identified a gap in guidance regarding the evaluation and control of hazards that are not pre-existing but which are introduced into confined spaces. The CSB concludes:

- Blastco did not adequately evaluate or control the hazards associated with introducing a flammable liquid into a permit-required confined space.
- Had Blastco adequately evaluated the hazards associated with the introduction of a flammable liquid into a confined space, it may have implemented controls to prevent the introduction of ignition sources into the space.
- Specific guidance is needed for companies to analyze and control hazards that are not pre-existing in confined spaces but which result from work activities in permit-required confined spaces.

Therefore, the CSB recommends to OSHA to issue a safety information product (such as a letter of interpretation) addressing the analysis and control of hazards that are not pre-existing but which result from work activities inside permit-required confined spaces.

3.3.5 Simultaneous Operations

During confined space entry, OSHA requires[a] employers to:

> Develop and implement procedures to coordinate entry operations when employees of more than one employer are working simultaneously as authorized

[a] 29 CFR 1910.146(d)(11)

> entrants in a permit space, so that employees of one employer do not endanger employees of any other employer[.]

Thus, per the OSHA permit-required confined space standard, Blastco and Rimcor should have coordinated their simultaneous entries into the D2 towers. Blastco and Rimcor were both cited by OSHNC for violating this requirement.[a,b]

Beyond the minimum requirements in the OSHA confined space standard, industry groups also offer guidance on simultaneous confined space operations. NFPA 350 places the responsibility on Owners/Operators to coordinate confined space entry operations involving multiple companies [12, pp. 50-51]:

> Owners/Operators should coordinate activities between multiple employers […] working on the same job or on other nearby jobs that could affect the confined space operations.

Per NFPA, Evergreen should have ensured coordination between the Blastco and Rimcor crews.

The American Institute of Chemical Engineers (AICHE) publishes a quarterly periodical titled *Process Safety Progress*. In the March 2017 edition, the AICHE published an article titled "Simultaneous Operation (SIMOP) Review: An Important Hazard Analysis Tool [14]." The author defines SIMOPs as:

> …situations where two or more operations or activities occur close together in time and place. They may interfere or clash with each other and increase the risks of the activities or create new risks resulting in undesired events … with adverse impacts on … process safety. SIMOPs often involve work in the same area by multiple … workers whose work may overlap and/or interact.

The author outlines a six-step process for analyzing simultaneous operations [14, pp. 64-65]:

1. Identify potential SIMOPs
2. Collect information on those activities
3. Identify interactions
4. Identify consequences
5. Identify existing safeguards
6. Identify missing risk controls

The CSB concludes:

[a] Inspection Detail, Item 02003
[b] Inspection Detail, Item 01001

- Given that the upflow and downflow towers were not isolated from each other, and were connected by the crossover line, the towers and crossover line constituted a single confined space.
- Given that the two towers constituted a single confined space, and Blastco's and Rimcor's entries were simultaneous, the two maintenance tasks constituted simultaneous operations.
- Blastco and Rimcor did not effectively coordinate simultaneous entry operations based on evidence that Blastco and Rimcor workers did not communicate with each other prior to the fire, that Blastco and Rimcor did not have a shared communication method (e.g., radios), and that Blastco and Rimcor had separate entry supervisors.
- It is essential that work groups performing operations close together in time and place can effectively communicate using a reliable, appropriate, easily accessible, shared communication method that is easily understood by all affected workers using audible and/or visual indications.
- Evergreen did not follow existing guidance available to industry in NFPA 350 that recommends that Owners/Operators should coordinate activities between multiple employers working on the same job or on other nearby jobs that could affect the confined space operations.
- A regulatory requirement for Owner/Operators to ensure the coordination of simultaneous operations involving multiple work groups, including contractors, would improve worker safety in industry.
- Evergreen did not have a SIMOPs program in place at the time of the incident to facilitate coordination between parties performing work close together in time and place.
- Had Evergreen had a SIMOPs program, it could have analyzed the necessity of performing the upflow and downflow tower maintenance simultaneously. Such analysis could have resulted in the jobs being performed separately, preventing the fatal injuries to the Rimcor employees. Alternately, had Evergreen determined it was necessary to perform the work simultaneously, Evergreen could have implemented control measures to ensure coordination between the two contract companies and Evergreen emergency response personnel, which could have prevented the ignition or spread of the fire.
- Contractor and employee safety at Evergreen's facilities would improve from the implementation of a SIMOPs program that involves a hazards review process of planned work occurring close together in time and place.

The CSB recommends that Evergreen develop and implement a formalized and comprehensive Simultaneous Operations (SIMOPs) program addressing planned work occurring close together in time and place to include policies, procedures, hazards reviews, hazards abatement, training, and shared communication methods, to protect employees and contract workers from the hazards posed by simultaneous operations at its facilities. At a minimum, the program should:

- Identify potential simultaneous operations
- Identify potential hazardous interactions
- Evaluate and implement necessary safeguards to allow for safe simultaneous operations

- Ensure coordination, including shared communication methods, between the simultaneous operations
- Include emergency response personnel or services in the planning and coordination of the simultaneous operations

The CSB recommends to OSHA to require Owner/Operators to ensure the coordination of simultaneous operations involving multiple work groups, including contractors. Include in the requirement for Owner/Operators to ensure the following activities occur:

- Identification of potential simultaneous operations
- Identification of potential hazardous interactions
- Evaluation and implementation of necessary safeguards to allow for safe simultaneous operations
- Coordination, including shared communication methods, between the simultaneous operations
- Inclusion of emergency response personnel or services in the planning and coordination of the simultaneous operations

As necessary, seek the regulatory authority to promulgate this requirement.

3.4 Combustible Materials of Vessel Construction

The upflow tower and crossover line were constructed of FRP, a combustible material. As discussed in Section 2, the fire started when a heat gun fell into a bucket of flammable vinyl ester resin. Members from Evergreen's ERT told the CSB that just minutes after they arrived on scene, flames were observed coming out of the manway at the bottom of the downflow tower. The fire in the D2 towers continued to burn for the next several hours. Physical evidence shows that the FRP upflow tower and crossover line were partly consumed by the fire.

As discussed in Section 1.10, the upflow tower was examined for structural integrity and fire damage post-incident. The examination found that all of the core samples except for the sample labeled "A" showed a significant amount of thermal degradation. Multiple samples, including "L" and "O" (refer to **Figure 10**) completely delaminated when removed from the column. This is due to the loss of the resin, which binds the layers of fiberglass together.

The CSB concludes that due to the combustible FRP construction of the upflow tower and crossover line, the bucket fire spread to the upflow tower walls and to the crossover line, resulting in the two Rimcor workers' exposure to smoke and flames.

4 Conclusions

4.1 Findings

1. Given that the heat gun could produce temperatures in excess of the resin's flash point and auto-ignition temperatures, it should have been recognized as an ignition source, and its use should have been considered hot work under Evergreen's, Blastco's, and the NFPA's definitions.
2. The heat gun should not have been used in the confined space in the presence of the flammable resin.
3. Blastco did not recognize the ignition hazard posed by the heat gun because it did not recognize its use as a form of hot work, and Blastco did not inform Evergreen or Rimcor of the heat gun's use.
4. Worker understanding of ignition sources and forms of hot work is critical to ensure that permitting and effective safety precautions are implemented.
5. Blastco's understanding of ignition sources and hot work could be improved by Blastco revising its policies and training methods to specifically identify the use of heat guns as hot work, and by making clear that hot work encompasses any method of work that can ignite a fire and not just spark- or flame-producing work methods.
6. Blastco should update its policies and training to include the use of non flame- and spark-producing tools and work methods, such as heat guns and other ignition sources, as hot work.
7. Companies have an important role in ensuring contractor safety in addition to employee safety.
8. Evergreen should update all documentation, training, and orientation pertaining to hot work provided to contractors with Evergreen's internal definition for hot work.
9. Weather was a significant factor in the occurrence of this incident.
10. Drum heaters may have provided enough heat to the resin to eliminate the need for the heat gun.
11. Blastco could have delayed lamination work to day shifts when temperatures in the area were in the mid-60s (degrees Fahrenheit).
12. Temperatures in the 60s (degrees Fahrenheit) might have produced adequate resin gel times for the Blastco workers and might have eliminated the need to warm the resin at all.
13. Blastco had acceptable alternatives to using the heat gun to warm the resin.
14. Effective pre-job planning, such as taking into account the potential for poor performance of the resin in cold temperatures and identifying solutions to avoid or correct the problem, could have prevented this incident.
15. To assist with pre-job planning efforts, a Blastco troubleshooting guide or standard operating procedure addressing resin gel time could prevent a similar incident in the future.

16. Blastco should develop a policy, procedure, or guidance document on the correct use of heat guns in FRP operations.

17. Blastco should have terminated its confined space entry when the heat gun was introduced into the space, and its failure to do so resulted from Blastco's failure to recognize the ignition hazard presented by the heat gun.

18. OSHA requires confined space entry permits to define the emergency services that can be summoned and the means to be used to summon those services.

19. Evergreen followed this OSHA requirement by including on its confined space permit the contact information to directly call emergency services.

20. Blastco did not properly activate emergency services when it did not directly call the Evergreen emergency phone number listed on the permit when the fire started.

21. An evaluation of flammable material hazards, ignition source recognition and control near flammable materials in a confined space, atmospheric ventilation, atmospheric monitoring at the work location, and immediately available standby emergency personnel may have prevented this incident.

22. Safety at Evergreen's facilities would improve from the development and implementation of a policy that requires the involvement of emergency response personnel in planning and coordination of activities involving the use of flammable materials in confined spaces.

23. An OSHA publication is needed that includes actionable guidance on addressing hazards and implementing controls when using flammables in confined spaces.

24. Blastco did not adequately evaluate or control the hazards associated with introducing a flammable liquid into a permit-required confined space.

25. Had Blastco adequately evaluated the hazards associated with the introduction of a flammable liquid into a confined space, it may have implemented controls to prevent the introduction of ignition sources into the space.

26. Specific guidance is needed for companies to analyze and control hazards that are not pre-existing in confined spaces but which result from work activities in permit-required confined spaces.

27. Given that the upflow and downflow towers were not isolated from each other, and were connected by the crossover line, the towers and crossover line constituted a single confined space.

28. Given that the two towers constituted a single confined space, and Blastco's and Rimcor's entries were simultaneous, the two maintenance tasks constituted simultaneous operations.

29. Blastco and Rimcor did not effectively coordinate simultaneous entry operations based on evidence that Blastco and Rimcor workers did not communicate with each other prior to the fire, that Blastco and Rimcor did not have a shared communication method (e.g., radios), and that Blastco and Rimcor had separate entry supervisors.

30. It is essential that work groups performing operations close together in time and place can effectively communicate using a reliable, appropriate, easily accessible, shared communication method that is easily understood by all affected workers using audible and/or visual indications.

31. Evergreen did not follow existing guidance available to industry in NFPA 350 that recommends that Owners/Operators should coordinate activities between multiple employers working on the same job or on other nearby jobs that could affect the confined space operations.

32. A regulatory requirement for Owner/Operators to ensure the coordination of simultaneous operations involving multiple work groups, including contractors, would improve worker safety in industry.

33. Evergreen did not have a SIMOPs program in place at the time of the incident to facilitate coordination between parties performing work close together in time and place.

34. Had Evergreen had a SIMOPs program, it could have analyzed the necessity of performing the upflow and downflow tower maintenance simultaneously. Such analysis could have resulted in the jobs being performed separately, preventing the fatal injuries to the Rimcor employees. Alternately, had Evergreen determined it was necessary to perform the work simultaneously, Evergreen could have implemented control measures to ensure coordination between the two contract companies and Evergreen emergency response personnel, which could have prevented the ignition or spread of the fire.

35. Contractor and employee safety at Evergreen's facilities would improve from the implementation of a SIMOPs program that involves a hazards review process of planned work occurring close together in time and place.

36. Due to the combustible FRP construction of the upflow tower and crossover line, the bucket fire spread to the upflow tower walls and to the crossover line, resulting in the two Rimcor workers' exposure to smoke and flames.

4.2 Cause

The CSB determined the cause of the incident was the failure by Blastco to effectively evaluate the flammable material hazards presented by its work in the upflow tower and implement controls to prevent the introduction of ignition sources to the work area. Contributing to the incident was Blastco's failure to recognize heat guns as a form of hot work that could ignite flammable materials, gaps in Evergreen's training to contractors on forms of hot work, and poor pre-job planning that allowed Blastco's work to occur during cold temperatures which were known to make the fiber-reinforced plastic application process difficult, in addition to a lack of Blastco troubleshooting guidance for safely addressing cold-weather resin performance. Contributing to the severity of the incident were poor confined space safety practices, including Blastco's and Rimcor's lack of recognition and control of the hazards of the simultaneous operations, Evergreen's failure to ensure coordination and the integrity of pre-planning between the two contract companies, inadequate communication between Blastco and Rimcor, and the lack of immediately available emergency services during the hazardous operation involving flammable materials in a confined space. The material of construction of the upflow tower and crossover line also contributed to the severity of the incident, as it was a combustible material that enabled the fire to quickly spread.

5 Recommendations

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

5.1 Previously Issued Recommendation Reiterated in This Report

5.1.1 OSHA

2008-01-I-CO-R2

Publish a "Safety and Health Information Bulletin" addressing the hazards and controls when using flammable materials in confined spaces that includes actionable guidance regarding:

a. The importance of implementing a hierarchy of controls to address hazards in a confined space that first seeks to eliminate hazards or substitute with a less hazardous material(s) or method(s). Examples include performing work outside of a confined space where reasonably practicable or substituting a flammable material with a non-flammable one.

b. The necessity of establishing a maximum permissible percentage substantially below the lower explosive limit (LEL) for safe entry and occupancy of permit required confined spaces.

c. The need to comprehensively control all potential ignition sources and continuously monitor the confined space at appropriate locations and elevations when work activities involve the use of flammable materials or where flammable atmospheres may be created.

d. The importance of treating confined spaces with the potential for flammable atmospheres above 10 percent of the LEL as a hazard immediately dangerous to life or health (IDLH) that requires rescuers to be stationed directly outside the permit space and available for immediate rescue with appropriate fire-extinguishing and rescue equipment.

e. The requirement that confined spaces such as penstocks be managed as permit-required that are so large or part of a continuous system that they cannot be fully characterized from the entry point. Such spaces need to be monitored for hazardous atmospheres both prior to entry and continuously in areas where entrants are working.

5.2 New Recommendations

5.2.1 OSHA

2020-07-I-NC-R1

Issue a safety information product (such as a letter of interpretation) addressing the analysis and control of hazards that are not pre-existing but which result from work activities inside permit-required confined spaces.

2020-07-I-NC-R2

Require Owner/Operators to ensure the coordination of simultaneous operations involving multiple work groups, including contractors. Include in the requirement for Owner/Operators to ensure the following activities occur:

- Identification of potential simultaneous operations
- Identification of potential hazardous interactions
- Evaluation and implementation of necessary safeguards to allow for safe simultaneous operations
- Coordination, including shared communication methods, between the simultaneous operations
- Inclusion of emergency response personnel or services in the planning and coordination of the simultaneous operations

As necessary, seek the regulatory authority to promulgate this requirement.

5.2.2 Evergreen Packaging

2020-07-I-NC-R3

Update all documentation, training, and orientation materials provided to contractors pertaining to hot work to reflect Evergreen Packaging's internal definition of hot work. The materials should make clear that hot work encompasses any method of work that can serve as a source of ignition.

2020-07-I-NC-R4

Develop and implement a formalized and comprehensive Simultaneous Operations (SIMOPs) program addressing planned work occurring close together in time and place to include policies, procedures, hazards reviews, hazards abatement, training, and shared communication methods, to protect employees and contract workers from the hazards posed by simultaneous operations at its facilities. At a minimum, the program should:

- Identify potential simultaneous operations
- Identify potential hazardous interactions
- Evaluate and implement necessary safeguards to allow for safe simultaneous operations
- Ensure coordination, including shared communication methods, between the simultaneous operations
- Include emergency response personnel or services in the planning and coordination of the simultaneous operations

2020-07-I-NC-R5

Develop and implement a policy that requires the involvement of emergency response personnel in planning and coordination of activities involving the use of flammable materials in confined spaces. In the policy, require that emergency response personnel be stationed directly outside the confined space in which flammable materials are used. Ensure that the emergency response personnel are appropriately trained and equipped for confined space entry, confined space rescue and fire response.

5.2.3 Universal Blastco

2020-07-I-NC-R6

Update the Universal Blastco hot work policy and employee training program to specifically identify the use of heat guns as hot work. The policy and programs should make clear that hot work encompasses any method of work that can ignite a fire and not just spark- or flame-producing work methods.

2020-07-I-NC-R7

Develop a formalized troubleshooting guide and/or standard operating procedure for the usage of resin and fiberglass matting in FRP operations. The procedure should direct employees on acceptable means of addressing cold-weather resin performance.

2020-07-I-NC-R8

Develop a policy and standard operating procedures for the proper use of heat guns in FRP operations.

6 Key Lessons for the Industry

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

1. The use of heat guns and other heating tools that can ignite flammable or combustible materials is a form of hot work. Hot work encompasses any task that can cause a fire and not only those tasks that produce sparks or open flames. Company hot work policies and training should identify the use of heating tools, such as heat guns, as forms of hot work, in addition to the common flame- or spark-producing hot work activities.

2. Companies and workers must terminate confined space entries when new hazards that are not authorized on the entry permit are introduced to the space.

3. Companies should ensure not only that pre-existing hazards in confined spaces are evaluated before workers enter the space, but hazards that could result from work activities in the confined space are also evaluated and controlled before workers enter the space.

4. When flammable materials are used inside confined spaces, companies should ensure that emergency response personnel are involved in planning and coordination of the activities involving the use of flammable materials in confined spaces. Companies should also ensure that emergency response personnel are stationed directly outside the confined space in which flammable materials are used. Companies should ensure that the emergency response personnel are appropriately trained and equipped for confined space entry, confined space rescue, and fire response.

5. Companies should develop and implement formalized and comprehensive Simultaneous Operations (SIMOPs) programs addressing planned work occurring close together in time and place to include policies, procedures, hazards reviews, hazards abatement, training, and shared communication methods, to protect employees and contract workers from the hazards posed by simultaneous operations at their facilities. At a minimum, the program should identify potential simultaneous operations, identify potential hazardous interactions, evaluate and implement necessary safeguards to allow for safe simultaneous operations, ensure coordination—including shared communication methods—between the simultaneous operations, and include emergency response personnel or services in the planning and coordination of the simultaneous operations

6. Vessels and piping constructed of FRP are combustible. Companies must adequately understand and control hazards when performing hazardous work inside a confined space constructed of combustible material such as FRP.

7 References

[1] Evergreen Packaging, "Paper Packaging and Services - Evergreen Packaging," [Online]. Available: https://evergreenpackaging.com/products-and-services/. [Accessed 2 October 2020].

[2] Evergreen Packaging, "Canton, North Carolina Mill," [Online]. Available: https://evergreenpackaging.com/careers/why-evergreen-packaging/canton-north-carolina-mill/. [Accessed 30 November 2020].

[3] O. W. Siebert, K. M. Brooks, L. J. Craigie, F. G. Hodge, L. T. Hutton, T. M. Laronge, J. I. Munro, D. H. Pope, S. J. Scott and J. G. Stoecker II, "Materials of Construction," in *Perry's Chemical Engineers' Handbook, 8th edition*, D. W. Green and R. H. Perry, Eds., The McGraw-Hill Companies, 2008, pp. 25-40 - 25-44.

[4] INEOS Composites, "Derakane Fabrication Guide," 2019. [Online]. Available: https://www.ineos.com/globalassets/ineos-group/businesses/ineos-composites/markets/corrosion/ineos-com-19-dera-fabrication-guide-bro-135-web-1.pdf. [Accessed 09 November 2020].

[5] Harbor Freight, "69343.pdf," [Online]. Available: https://manuals.harborfreight.com/manuals/69000-69999/69343.pdf. [Accessed 21 Jan 2021].

[6] Harbor Freight, "1500 Watt 12 Temperature Heat Gun," [Online]. Available: https://www.harborfreight.com/1500-watt-12-temperature-heat-gun-69343.html. [Accessed 5 January 2020].

[7] U.S. Occupational Safety and Health Administration (OSHA), "State Plans," U.S. Department of Labor (USDOL), [Online]. Available: https://www.osha.gov/stateplans. [Accessed 12 November 2020].

[8] North Carolina Department of Labor , "NC DOL: Which OSHA Standards Apply?," [Online]. Available: https://www.labor.nc.gov/safety-and-health/occupational-safety-and-health/which-osha-standards-apply#does-29-cfr-part-1910---general-industry-standards-apply. [Accessed 8 October 2020].

[9] U.S. Occupational Safety and Health Administration (OSHA), "The storage of flammable and/or combustible materials in fiberglass reinforced plastic," U.S. Department of Labor (USDOL), 9 September 1991. [Online]. Available: https://www.osha.gov/laws-regs/standardinterpretations/1991-09-09. [Accessed 8 March 2021].

[10] National Fire Protection Association (NFPA), Standard 51B - Fire Prevention During Welding, Cutting, and Other Hot Work, 2019 ed., National Fire Protection Association (NFPA), 2018.

[11] Center for Chemical Process Safety, Guidelines for Risk Based Process Safety, Hoboken: American Institute of Chemical Engineers and John Wiley & Sons, Inc., 2007.

[12] National Fire Protection Association (NFPA), Standard 350 - Guide for Safe Confined Space Entry and Work, 2019 ed., National Fire Protection Association (NFPA), 2018.

[13] U.S. Chemical Safety and Hazard Investigation Board (CSB), "Xcel Energy Hydroelectric Plant Penstock Fire," 25 August 2010. [Online]. Available: https://www.csb.gov/file.aspx?DocumentId=5703. [Accessed 25 August 2021].

[14] P. Baybutt, "Simultaneous Operation (SIMOP) Review: An Important Hazard Analysis Tool," *Process Safety Progress,* vol. 36, no. 1, pp. 62-66, March 2017.

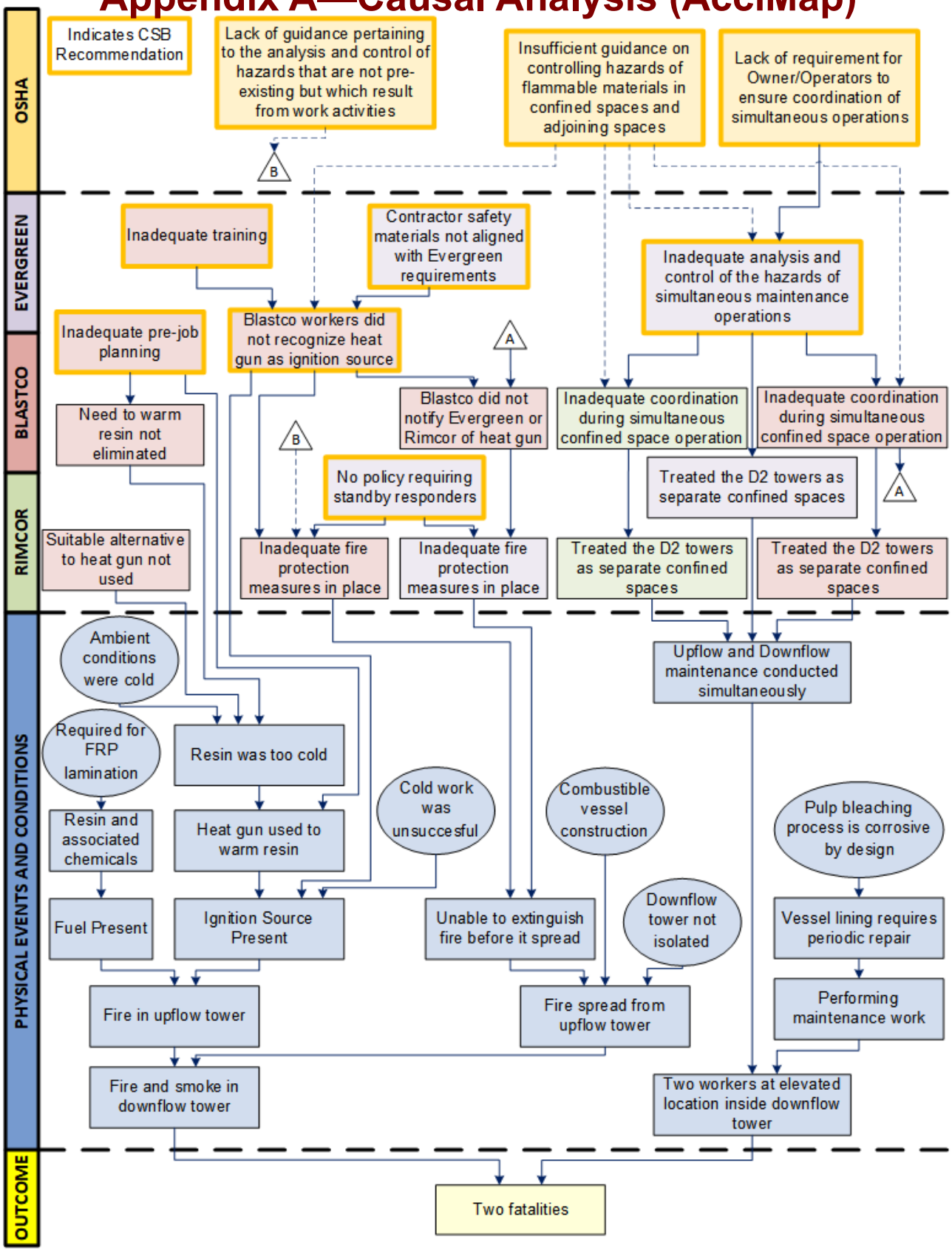
[15] U.S. Chemical Safety Board, "Board Order 22: Recommendations Program," [Online]. Available: https://www.csb.gov/assets/record/csb_board_order_022_final_20161.pdf.

[16] U.S. Chemical Safety Board (USCSB), "Board Order 40: Investigation Program," [Online]. Available: https://www.csb.gov/assets/record/board_order_040_approved_2_14_17.pdf.

[17] U.S. Occupational Safety and Health Administration (OSHA), "1910.146 - Permit-required confined spaces," U.S. Department of Labor (USDOL), [Online]. Available: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.146. [Accessed 4 January 2021].

[18] Grainger, "BRISKHEAT Drum Heater," [Online]. Available: https://www.grainger.com/product/BRISKHEAT-Drum-Heater-52RX22. [Accessed 10 December 2020].

Appendix A—Causal Analysis (AcciMap)



U.S. Chemical Safety and Hazard Investigation Board

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

Katherine A. Lemos, PhD
Chairman and CEO