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EPA CHEMICAL ACCIDENT INVESTIGATION REPORT

Powell Duffryn Terminals, Inc.
Savannah, Georgia

REPORT

Chemical Emergency Preparedness and Prevention Office

The EPA Accident Investigation Program

EPA has a responsibility under section 112(r) of the Clean Air Act Amendments of 1990 for the prevention and mitigation of accidental releases. One of the fundamental ways to prevent accidents is to understand why accidents occur and to apply the lessons learned to prevent future incidents. Consequently, EPA has a responsibility to investigate and understand why certain chemical accidents have occurred. A key objective of the EPA chemical accident investigation program is to determine and report to the public the facts, conditions, circumstances, and causes or probable causes of chemical accidents that resulted, or could have resulted, in a fatality, serious injury, substantial property damage, or serious off-site impact, including a large scale evacuation of the general public. The ultimate goal of the accident investigation is to determine the root causes in order to reduce the likelihood of recurrence, minimize the consequences associated with accidental releases, and to make chemical production, processing, handling, and storage safer. This report is a result of an EPA investigation to describe the accident, determine root causes and contributing factors, and identify findings and recommendations.

In the EPA accident investigation report preparation process, companies mentioned in the report are provided a draft of only the factual portions (no findings, conclusions or recommendations) for their review for confidential business information. Federal agencies are required by provisions of the Freedom of Information Act (FOIA), the Trade Secrets Act, and Executive Order 12600 to protect confidential business information from public disclosure. As part of this clearance process, companies often will provide additional factual information that EPA considers and evaluates for possible inclusion in the final report.

Chemical accident investigations by EPA Headquarters are conducted by the Chemical Accident Investigation Team (CAIT) located in the Chemical Emergency Preparedness and Prevention Office (CEPPO) at 401 M Street SW, Washington, DC 20460, 202-260-8600. More information about CEPPO and the CAIT may be found at the CEPPO Homepage on the Internet at “www.epa.gov/swercepp/”.

U.S. Chemical Safety and Hazard Investigation Board (CSB)

In 1990, the U.S. Chemical Safety and Hazard Investigation Board (CSB) was created as an independent board in the amendments to the Clean Air Act. Modeled after the National Transportation Safety Board (NTSB), the CSB was directed by Congress to conduct investigations and report on findings regarding the causes of any accidental chemical releases resulting in a fatality, serious injury, or substantial property damages. In October 1997, Congress authorized initial funding for the CSB. The CSB started its operations in January 1998 and has begun several chemical accident investigations. More information about CSB may be found at the CSB homepage on the Internet at “www.chemsafety.gov”.

For those joint investigations begun by EPA and OSHA and prior to the initial funding of the CSB, the agencies have committed to completing their ongoing investigations and issuing public reports. Under their existing authorities, both EPA and OSHA will continue to have roles and responsibilities in responding to and investigating chemical accidents. The CSB, EPA, and OSHA (as well as other agencies) are developing approaches for coordinating efforts to support accident prevention programs and to minimize potential duplication of activities.

Basis of Decision to Investigate and for Involvement of EPA

An explosion and fire took place at the Powell Duffryn Terminals, Inc., Savannah, Georgia, on April 10, 1995, resulting in extensive public evacuations and significant plant damage. The accident involved flammable and toxic substances.[1, 2, 3] EPA and OSHA undertook investigations of this accident because of the serious consequences and the opportunity for lessons learned to prevent similar accidents from occurring. The EPA and OSHA coordinated their investigations and shared their findings. However, OSHA did not take part in writing the report.

EXECUTIVE SUMMARY

On April 10, 1995, at approximately 11:30 p.m., explosions and fire occurred at Powell Duffryn Terminals, Inc. (PDTI), a commercial bulk liquid chemical storage and transfer facility, in Savannah, Georgia. Flames and thick black smoke from the fire forced the residents of the adjacent townhome development to immediately evacuate. The company's office building on-site was engulfed and destroyed in the fire. It took fire fighters almost three days to finally put out the fire. The fire centered around a concrete walled enclosure area containing six large storage tanks. During the fire, part of the enclosure wall was breached releasing contaminated fire water. The runoff from the fire contaminated an adjacent marsh on the Savannah River resulting in a fish kill.

After the fire, chemicals leaking from the storage tanks in the enclosure area reacted and produced toxic hydrogen sulfide gas. The hydrogen sulfide gas release forced residents within one-half mile of the facility to evacuate. As many as 2,000 people were involved in the evacuation. An elementary school nearby was also forced to close. Approximately 300 people went to hospital emergency rooms complaining of symptoms attributed to hydrogen sulfide exposure. For many nearby residents, the evacuation lasted more than 30 days because of the continued evolution of hydrogen sulfide gas from the PDTI site. After the incident, extensive cleanup of the site and neighboring area was required.

PDTI is fully enclosed by a security fence with locked gates. On April 10, 1995, the last employee left the site for the day at 5:50 p.m.. The gates were locked, and no employees were on-site until after the explosions and fire had occurred.

On the day of the fire, contractor employees had been installing a sealed foam chamber on the storage tanks containing crude sulfate turpentine (CST), a flammable liquid. This closed the CST tanks to the atmosphere and directed CST vapor to the vapor control (VC) system. The VC system was designed to control fume and odor from the CST by capturing the CST vapor using activated carbon in two fifty-gallon drums connected to the CST tanks using PVC piping. According to PDTI modification plans, each CST storage tank was supposed to be equipped with a flame arrester at its connection to the PVC piping. These flame arresters had been delivered but had not yet been installed. In addition, a fixed-piping foam fire protection system was not completed at the time of the fire.

The explosions and fire at PDTI involved CST which the facility began to store on January 17, 1995. Prior to 1995, the facility was permitted only for storing non-flammable liquids. The facility had not completed modifications to accommodate the storage of flammables when the fire occurred. The CST was stored in three storage tanks (two 237,000 and one 422, 000 gallon capacity) in a walled enclosure that contained a total of six tanks. The three CST storage tanks were connected by the partially completed VC system used to remove CST vapor from any venting that may occur. In the same enclosure were three other storage tanks (one 340,000 and two 323,000 gallon respectively) containing sodium hydrosulfide solution (pH 10.4 to 11.5); Briquest, an acidic cleaning solution (pH of 1); and Antiblaze 80, a fire retardant chemical. These tanks and associated pipes were damaged by the explosions and fire and leaked their contents into the six-tank enclosure area. Reaction of the sodium hydrosulfide with acids present in the enclosure area produced hydrogen sulfide, a toxic, foul-smelling gas.

The CAIT identified the following as root causes and contributing factors in the accident:

- <u>The design for the VC system was inadequate.</u> There is a history of fires in drums containing activated carbon where the VC system design permitted the backflow of outside air through the drums. Organic sulfur compounds in CST can produce heat when they are adsorbed by the activated carbon. Enough heat may be produced in the drums to raise the temperature above the autoignition temperature of CST. Since there is a limited amount of oxygen in the drums, a fire usually does not occur. However, if outside air is permitted to be drawn through the drums containing activated carbon, as when CST is withdrawn from the storage tank or when ambient temperature drops causing the vapor in the storage tanks to contract, air can provide oxygen needed for combustion and the CST vapor in the drums may ignite triggering a fire. (The solution for preventing the backflow of outside air into the drums is to install a one-way valve between the drums and the storage tanks that would permit air to enter the storage tanks without going through the carbon drums.)

- <u>The storage tanks were not equipped with flame arresters.</u> The PVC piping provided a conduit for the fire to travel from the carbon drums to the CST storage tanks. Flame arresters were included in the design of the VC system. However, CST storage began before the modifications were completed. At the time of the fire, the flame arresters were on-site but had not been installed.

- <u>The foam fire suppression system was not completed on the tanks containing CST.</u> Foam fire suppression system was included as part of changes to be made for storing flammables. CST storage had begun before modifications were completed. Fire fighters were not able to use the foam pumper connection outside the enclosure area. Fire fighters used water to fight the fire until a connection to the foam pumper could be rigged within the enclosure area. An operational foam fire suppression system could have reduced the amount of time required to suppress the fire and reduce the amount of heat damage to the adjacent storage tanks and limited the amount of runoff from fire water which contaminated sensitive wetland area along the Savannah River.

- <u>The concrete containment wall was breached as a result of heat from the fire.</u> The enclosure area had been used to store nonflammables. No modifications were made to the secondary containment before commencing storage of flammables.

- <u>Incompatible chemicals were stored in the same walled enclosure area.</u> Sodium hydrosulfide solution was stored in the same enclosure area as acidic cleaning solution resulting in production of toxic hydrogen sulfide vapor when the tanks leaked. The toxic hydrogen sulfide release caused injuries, forced extended evacuations, and hampered response and cleanup.

Based on the root causes and contributing factors of this accident described above, the CAIT provides the following recommendations to prevent accidents like this one from occurring in the future at this and other facilities:

- Facilities designing or adding on environmental control, fire safety, or hazard control systems, must ensure that these systems do not adversely impact the processes or equipment where they are to be added and that they are properly designed and installed. Designs should be reviewed by competent professionals or recognized experts. The hazards associated with the new systems and the impact of the new system on the existing systems should be thoroughly assessed. There are many formal hazard evaluation techniques available (such as HAZOP or What If) that can facilitate this assessment.

- Facilities using activated carbon systems, in conjunction with vendors or recognized experts, should conduct tests to determine the potential for formation of hot spots, runaway reactions, or other consequences associated with adsorption of vapors on activated carbon and ensure that the hazards associated with the heat of adsorption are identified, well understood, and addressed through safeguards, procedures, or other controls. An evaluation of the potential for, and the consequences associated with, air being drawn into a carbon adsorption system (for example, associated with normal tank breathing) must also be addressed as necessary through safeguards or other controls.

- Facilities storing flammable and combustible materials must evaluate and ensure that the storage tanks and venting systems are protected from potential fire or explosion propagation back into the tank from external fire or ignition sources.

- Facilities must ensure that equipment for use in handling hazardous substances is equipped with the proper safety devices, and in compliance with national, state, and local fire and hazardous material safety codes and standards before hazardous materials are handled in such equipment. The safeguards, safety devices, or emergency systems designed to prevent or protect the equipment must be in place and fully operational as intended prior to startup of the equipment.

- Facilities should examine process and storage areas and equipment to ensure that potentially incompatible substances are kept separated. Leaks or spills of incompatible substances from equipment should not go into the same containment or other areas as a result of fire or other incident.

In addition to the root causes and contributing factors of this accident described above, the CAIT makes the following recommendations based on potential problem areas found during the investigation.

- Facilities should evaluate the need for bonding and grounding to prevent the buildup and discharge of static electrical charges that could provide an ignition source. If used, ensure that bonding and grounding devices are properly designed, installed, maintained, inspected, and tested.

- Facilities must ensure that electrical devices and equipment in areas where flammable or explosive materials are handled are properly designed, installed, maintained, tested, inspected and operated, and meet codes and standards to prevent potential ignition sources.

Table of Contents

Appendices

List of Exhibits

1.0 BACKGROUND

1.1 Facility Information

Powell Duffryn Terminals, Inc., (PDTI) of Savannah, GA, is a subsidiary of the Powell Duffryn Company of the United Kingdom. PDTI is a commercial bulk liquid chemical storage and transfer facility (i.e., a tank farm), primarily for chemicals used in the pulp and paper industry. The company provides chemical storage as a "third party," serving chemical suppliers and purchasers of the suppliers' chemicals. PDTI has facilities for shipping and receiving by truck, rail, and water.[4, 5]

PDTI is located about two miles from the middle of downtown Savannah, just northeast of the city limits of Savannah. The site covers about six acres and is situated along the banks of the Savannah River, which is to the north of the site.[6]

Oaktree Townhomes, a residential development, borders the PDTI property on the south; the two properties share a common property line. The PDTI property is bordered on the west by Wahlstrom Road, on the north by a CSX Railroad track, and on the east by marshlands. The property is surrounded by a chain link fence with concertina wire on top. Numerous commercial industrial facilities also operate in the general area. In addition, the Eli Whitney Elementary School is located in the area.[6, 7]

1.2 Physical Layout

The fire and explosion centered around six storage tanks surrounded by a five-foot concrete wall. These are the only storage tanks on-site enclosed by a containment wall. The six steel storage tanks in the enclosure area have capacities ranging from approximately 240,000 to 420,000 gallons. Exhibit 1 is a map of the area of PDTI showing the site of the explosion and fire in relation to the Savannah River, Oaktree Townhomes, and Whitney Elementary School. (The tanks and walled enclosure area are indicated in the exhibit as six small circles enclosed in a rectangle.)[8]

The six-tank enclosure area is about 100 by 200 feet (20,000 square feet in area). A diagram of the enclosure area along with the approximate capacity and contents of each tank is presented in Exhibit 2. The enclosure area is located slightly north of the midpoint of Powell Duffryn's southern property line. Five other tanks, much larger than the tanks in the enclosure, are located to the north and east of the enclosure.[8, 9] (These other tanks are also shown in Exhibit 1.)

Exhibit 1
Powell Duffryn Terminal Site

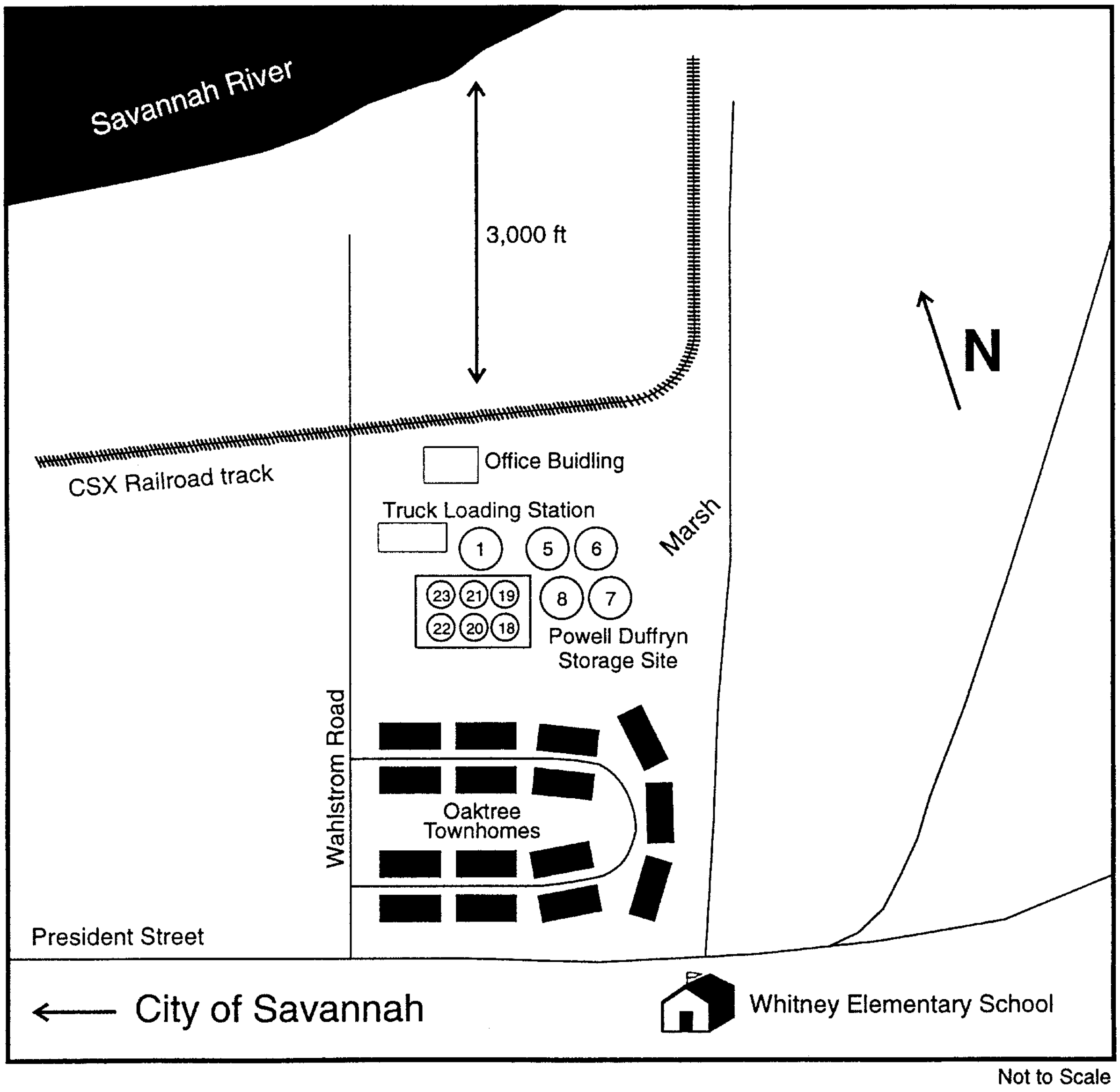
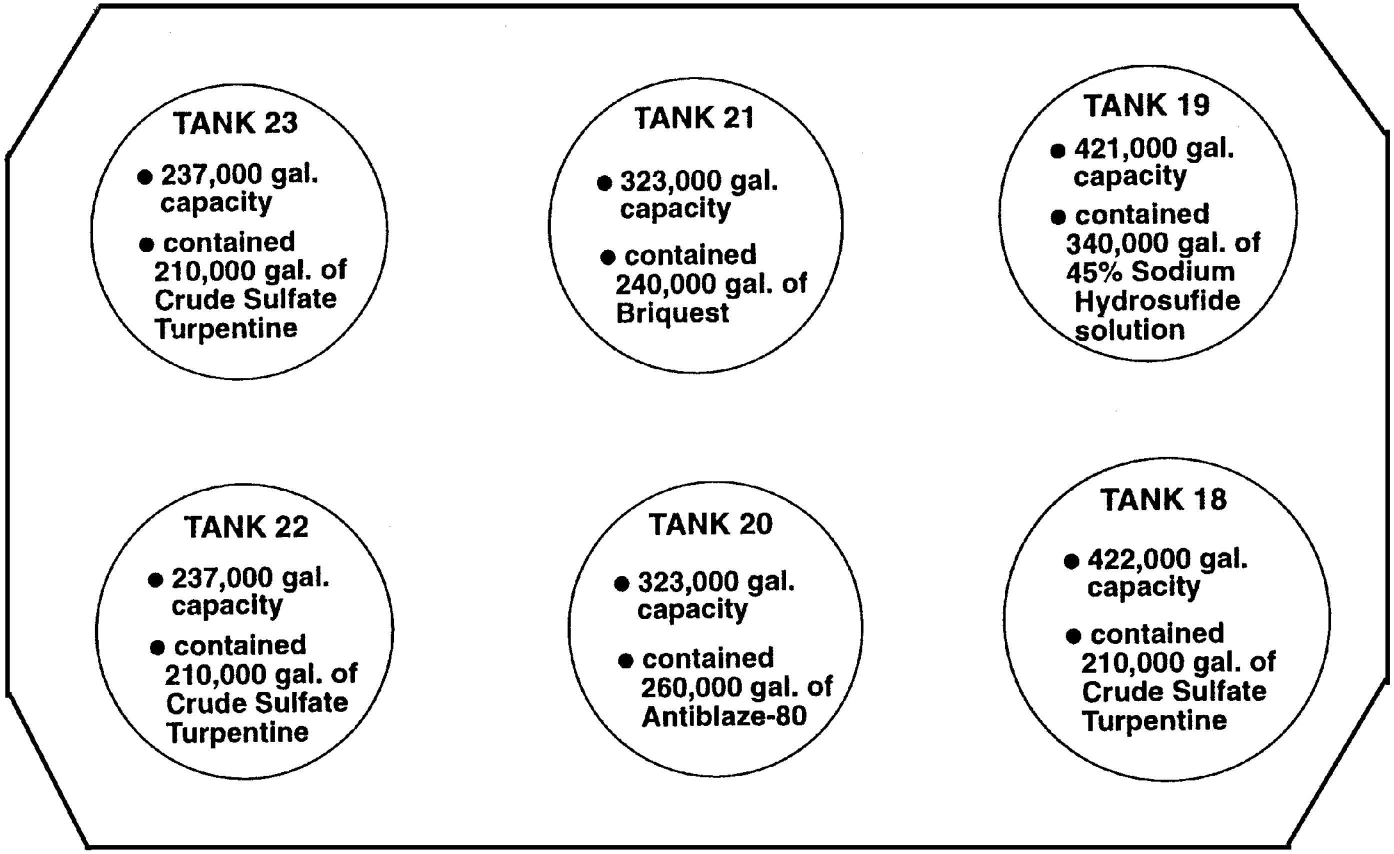


Exhibit 2
Six-Tank Enclosure, Site of Fire
(100 x 200 feet, surrounded by 5-foot Concrete Berm)



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The six tanks in the enclosure were constructed in their present location in April 1992.[4] They were constructed in accordance with API-650 standards of the American Petroleum Institute. Each of the six tanks in the enclosure was built with a weak-seam roof. The walls are welded on both the inside and the outside, but, as a safety factor, the roof is welded only on one side, the outside, and is designed to break if over pressurization occurs. In the event of a fire, these tanks are designed to contain the product and to collapse inward as the product burns off and the interior product level drops. The tanks were constructed with one-quarter to one-half inch carbon steel walls.[7]

1.3 Chemical Information

The chemicals being stored at PDTI inside the enclosure area where the fire occurred are shown in the table below. The quantities of the chemicals and the tank capacities shown in the table are approximate.

Chemical [7, 8, 10]	**Location**[7, 8, 10]	**Quantity** [7, 10] **(gallons)**	**Tank Capacity**[12] **(gallons)**	**Hazardous Properties**
Crude sulfate turpentine (CST)	Tanks 18, 22, & 23	Tank 18: 210,000 Tank 22: 210,000 Tank 23: 210,000	Tank 18: 422,000 Tank 22: 237,000 Tank 23: 237,000	Flammable, volatile[13]
Sodium hydrosulfide (NaSH), 45 percent solution in water	Tank 19	340,000	421,000	Alkaline, corrosive (pH of 10.4 to 11.5)[14, 15]
Briquest, a cleaning agent (1-hydroxyethane-1,1-diphosphonic acid)	Tank 21	270,000	323,000	Acidic, corrosive (pH of 1)[16]
Antiblaze 80, a fire retardant (tris(1-chloro-2-propyl)phosphate)	Tank 20	260,000	323,000	Relatively non-hazardous[17]

Crude sulfate turpentine (CST), the substance involved in the fire and explosion, is an impure form of turpentine produced as a byproduct of the "kraft" pulping process, also known as the sulfate process. CST is classified as a Class IC flammable liquid; this class includes liquids with flash points at or above 73° F (22.8° C) and below 100° F (37.8° C). The flash point of CST may vary somewhat with composition. It is reported by various sources as 75° - 100° F (24° -

38° C) or 90° - 115° F (32° - 46° C). The boiling point of CST is 310° - 340° F (154° - 171° C). Its lower explosive limit (LEL) is 0.8 percent by volume. Turpentine (the primary component of CST) has an autoignition temperature of 488° F (253° C). CST contains volatile sulfur contaminants (e.g., sulfides and mercaptans); it is a dermal, eye, and pulmonary irritant; and has a strong odor. [13, 18]

Sodium hydrosulfide solution, stored in the same enclosure, is strongly alkaline (pH of 10.4 to 11.5) and corrosive. When sodium hydrosulfide is exposed to heat or mixed with an acid (e.g., Briquest), hydrogen sulfide, a toxic gas, can be produced. During the fire hydrogen sulfide was probably produced as a result of the heat from the fire. Since hydrogen sulfide is combustible, hydrogen sulfide produced from heating was probably consumed in the fire. After the fire, the reaction between the sodium hydrosulfide solution and acids in the enclosure area is most likely the source of the hydrogen sulfide released at the PDTI site. As shown in Exhibit 2, Tank 19, containing sodium hydrosulfide, and Tank 21, containing Briquest, were located next to each other in the enclosure.[15]

Briquest is a strong acid (with pH of 1) and, as an acid, it is corrosive. Phosphine (a toxic gas) potentially can be produced if Briquest is heated to temperatures above 200° C (390° F). There is no evidence that phosphine was generated at the PDTI site. Phosphine is combustible; had it been produced, it could have been quickly consumed in the fire.[16]

Antiblaze 80 is nonflammable and relatively nontoxic and non-reactive. There is no evidence that any leakage of Antiblaze 80 contributed to the consequences of the fire.[17]

Appendix B contains Material Safety Data Sheets (MSDS) for the substances stored in the six-tank enclosure.

1.4 Process Information and Status Before Accident

The Chatham County Department of Inspections and the Savannah Fire Department have responsibilities for the review and approval or disapproval of operations, construction, structural modifications, fire protection systems, and electrical systems at facilities in the Savannah area, including PDTI. The Georgia State Fire Marshal's Office and the Georgia Department of Natural Resources, Environmental Protection Division, also have various regulatory and permitting authorities. [11,19]

In 1994, PDTI requested approval for storage of CST on-site from the Fire Inspector for the Chatham County Department of Inspections.[20, 21] The Chatham County Department of Inspections, with technical assistance from the Savannah Fire Department, evaluated the impact and required changes in equipment and procedures. The Chatham County Department of Inspections and the Savannah Fire Department shared this information with PDTI as PDTI was designing its activated carbon drum VC system.[22]

In December 1994, the Chatham County Department of Inspections informed PDTI in writing that there would be no problems with the storage of CST at PDTI if the following stipulations were met:[22]

(1) A fixed foam piping system must be provided;
(2) This system must be installed according to NFPA 11, *Standard for Low-Expansion Foam*, and NFPA 30, *Flammable and Combustible Liquids Code*, and others, if applicable;
(3) The pumper connection for this system must be outside the enclosure area;
(4) A foam induction system must be built into the piping, and enough of the recommended foam for this product (i.e., CST) to furnish the recommended applications for the minimum time must be on site and available to the Fire Department; and
(5) The piping connections must be compatible with the Fire Department's.

On December 22, 1994, PDTI wrote to the Savannah Fire Department that all requirements would be met and that CST would be stored for about six weeks until the fixed piping foam fire protection system could be completed.[23] On January 17, 1995, PDTI began to store CST in Tank 22; by February or March, CST was stored in three tanks.[4] The fire and explosions occurred on April 10, 1995, about 16 weeks after the date which PDTI indicated it would finish its safety system as required by the Savannah Fire Department.

On January 27, 1995, PDTI submitted to the Georgia Department of Natural Resources, Environmental Protection Division, a notification and application for storage and transfer of turpentine. The notification indicated that PDTI would connect the storage tanks together with piping and route the vapor through drums of activated carbon to control odor.[24]

The vapor control (VC) system and fixed piping foam fire protection system, designed by a PDTI employee, are described below.[4, 5, 25, 26]

Vapor Control (VC) System for Reducing Vapor Emission and Odor

Prior to the accident, contract personnel were in the process of installing a VC system. (See Exhibits 3 and 4) This system was designed to prevent CST vapor from escaping into the environment as a result of volumetric expansion due to increasing ambient temperatures or during tank filling. PDTI installed this system in response to repeated complaints from neighboring residents of strong odor arising from the facility.

The system consisted of two metal drums (50-gallon size) containing activated carbon used for absorbing CST vapor, polyvinyl chloride (PVC) piping connecting the drums to the three flame arresters, and three pressure release vents located on the storage tanks.[25] It was intended that vapor from the tanks would travel through the flame arresters to the PVC piping that was mounted to existing cat walks and enter two drums of activated carbon located at ground level just outside of the enclosure area. Each tank was supposed to be equipped with a

Exhibit 3. Vapor Control System

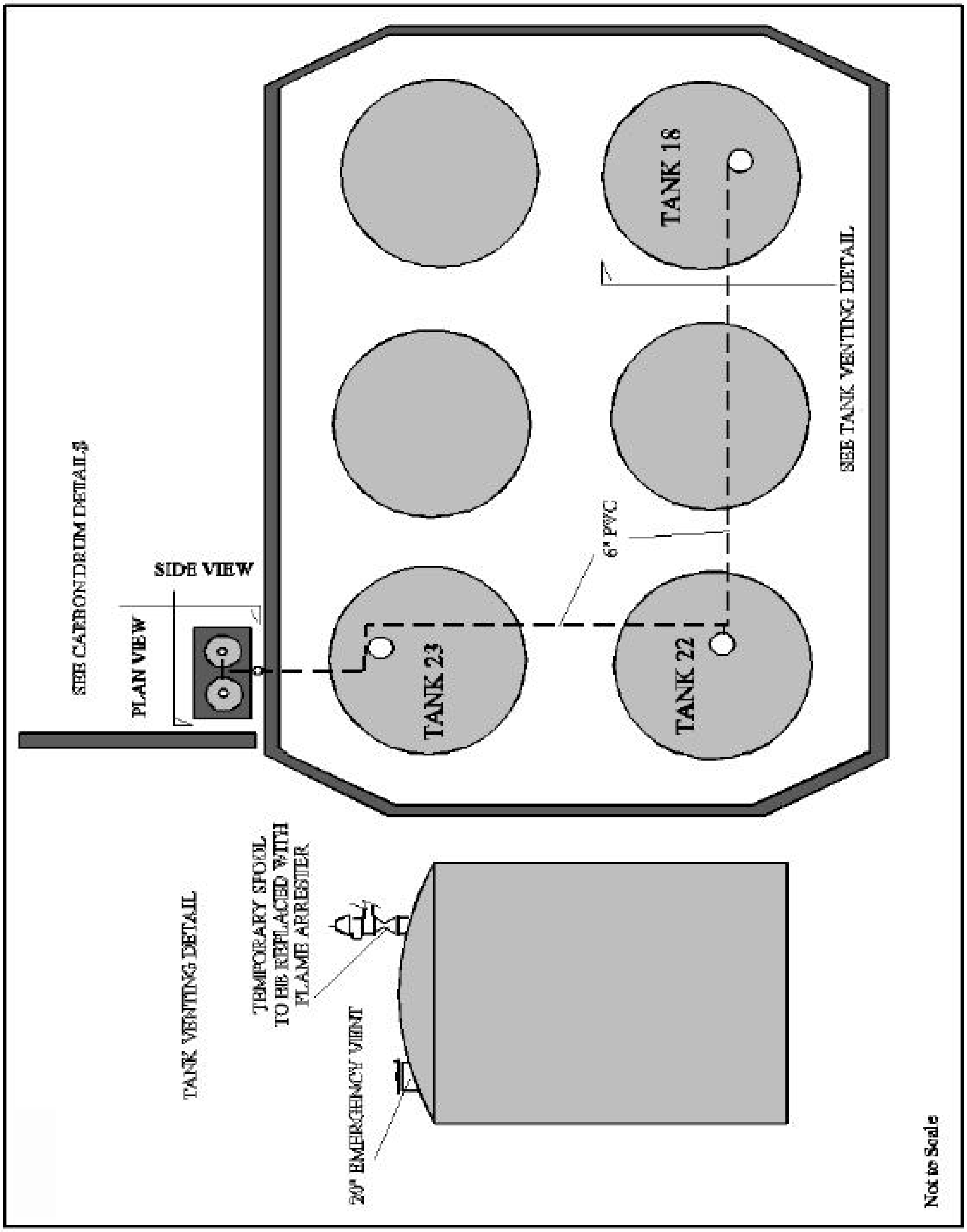
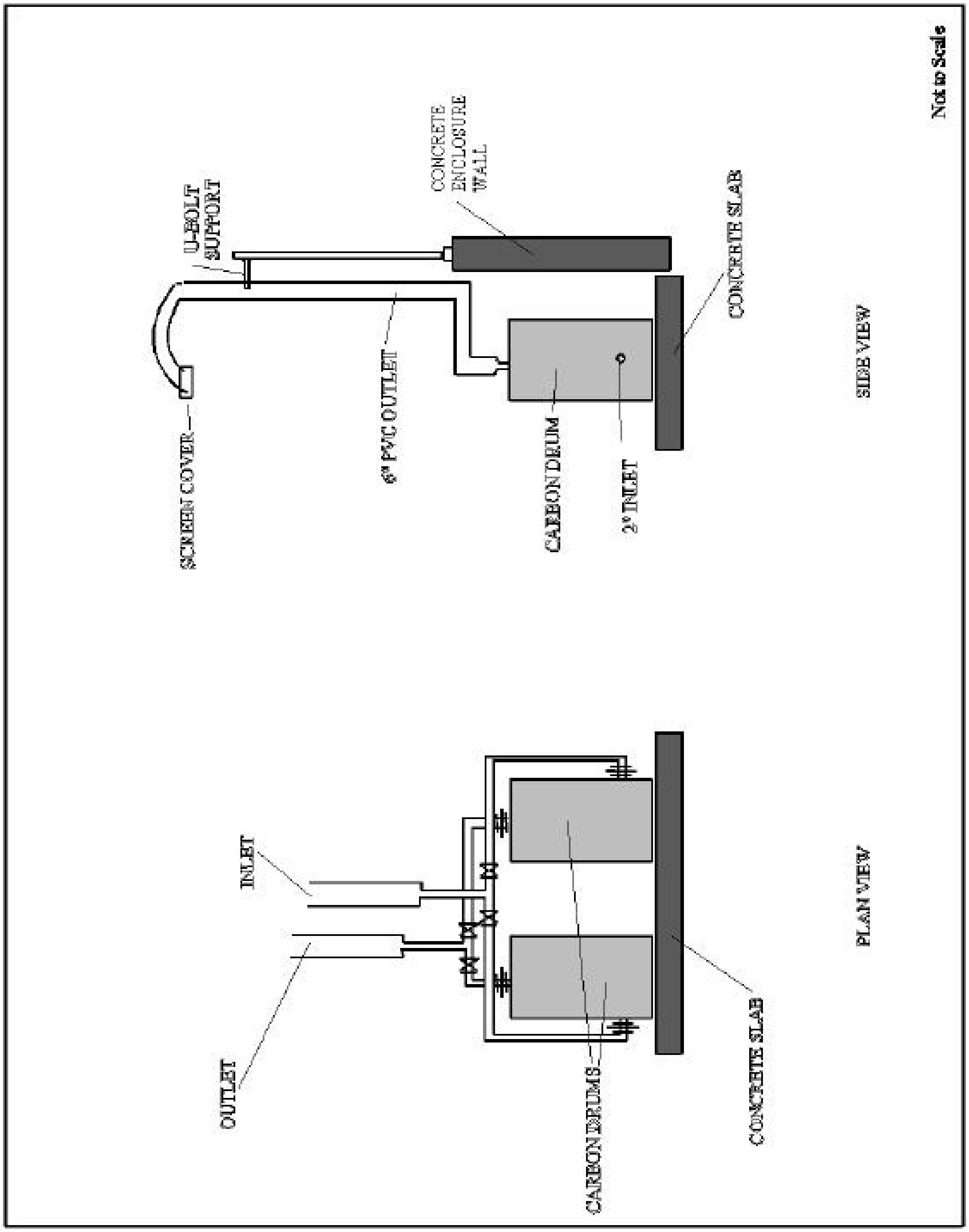


Exhibit 4. Carbon Drums



flame arrester at its connection to the PVC pipe; however, at the time of the accident, the flame arresters were not installed. The VC system was in place, with the exception of the flame arresters, for more than a month before the accident. Piping "spools" (small fixed sections) were installed in place of the flame arresters. (However, the system was not completely closed to the atmosphere until the last foamer was installed and sealed at 2 p.m. on the afternoon of the accident - see below.)

Fixed Piping Foam Fire Protection System

On the day of the accident, contractors were installing a fixed piping foam fire protection system on the tanks storing CST. (See Exhibit 5) This system consisted of carbon steel piping separately connected to a foamer unit at the top of each CST tank. The foamers were bolted over an opening on the side wall of each tank where the side wall meets the roof. The pipes were supported by brackets anchored to the concrete wall of the enclosure and joined together at a header approximately 50 feet from Tank 23. At the header, valves were to be provided for connecting fire department hoses.[26] The system was intended to enable the fire department to apply foam, from outside of the enclosure, directly into the CST tanks, in the event of a fire. At about 2 p.m., on the day of the accident, the last foamer was installed and sealed closing the system to the atmosphere.[4, 41] However, at the time of the fire, the foam system was not fully installed. The connection to enable the fire department to apply foam from outside the enclosure was not completed.

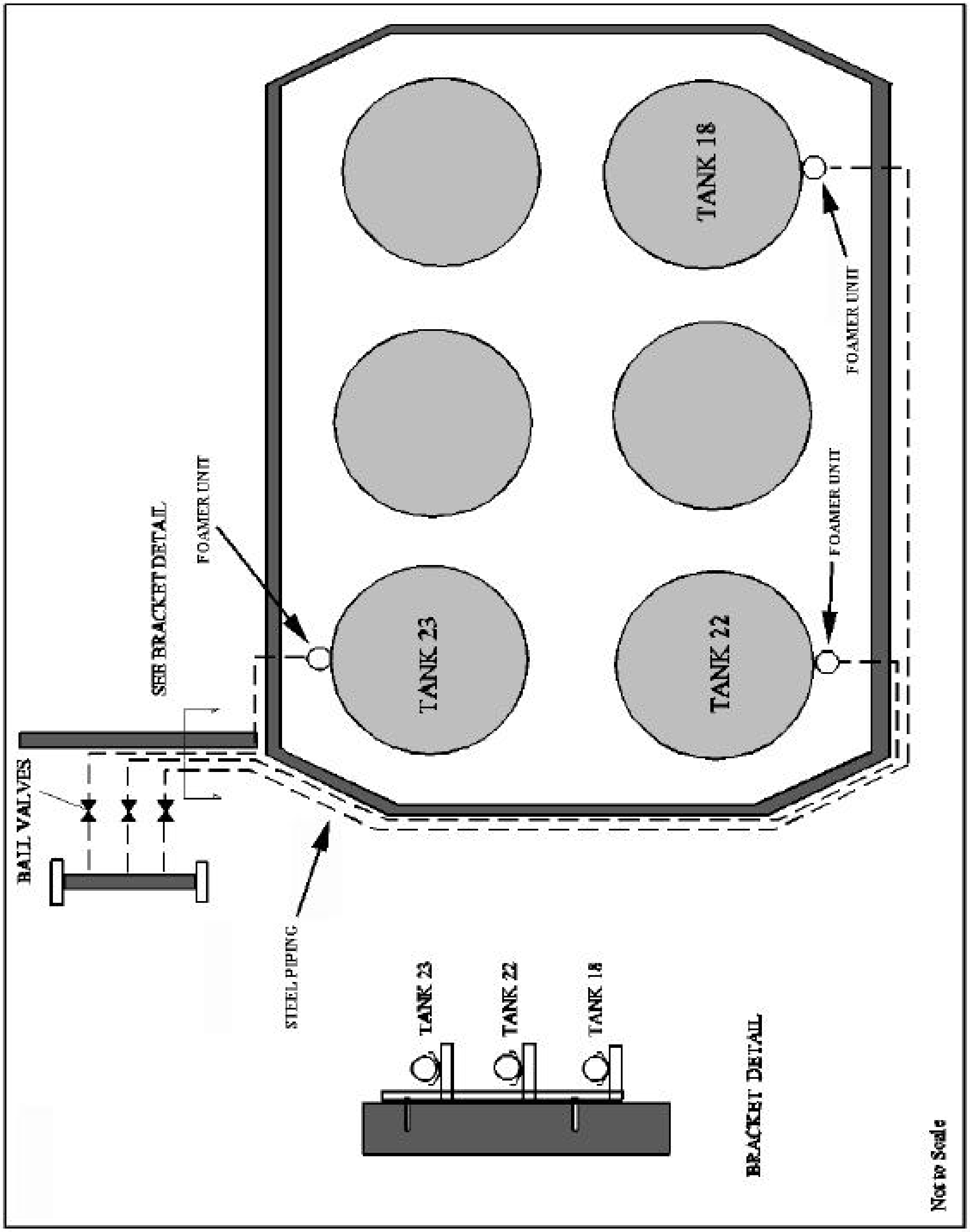
2.0 DESCRIPTION OF THE ACCIDENT

On the night of April 10, 1995, no employees were present at the PDTI site.[4] At about 11:30 p.m., fire broke out in the enclosure area where CST was stored. Several witnesses observed a flash of flame on the side of one of the tanks (identified as Tank 23, which contained CST), followed by an explosion and fireball. Other explosions and fireballs followed as the other tanks containing CST (Tanks 18 and 22) exploded and burned.[3, 4, 7, 8, 10]

Because of the intensity of the fire, firefighters had difficulty entering the area to extinguish the blaze. Black smoke was sent billowing into the air, raising fears that toxic chemicals might reach downtown Savannah.[3, 27, 28] Exhibits 6 and 7 are photographs of the fire and the firefighting efforts in progress.

Eventually, firefighters were able enter the enclosure area and connect the foam system to apply foam to the tanks. The fire appeared to be extinguished several times only to reignite because the CST tanks had become extremely hot as a result of the fire. Water was used to cool the CST tanks to prevent re-ignition and protect the adjacent tanks within the enclosure area. However, due to concerns over contamination of marshland and the Savannah River from the overflow of fire water, the use of cooling water had to be limited until the Coast Guard constructed a berm to prevent contaminated water from reaching the river. The Savannah

Exhibit 5. Fixed Piping Foam Fire Protection System



River in relation to the fire in the six-tank enclosure area can be seen in the photograph in Exhibit 8. The fire burned on and off for approximately three days before being extinguished late on April 12, 1995.[3, 30, 31,32] The three tanks containing CST (18, 22, and 23) were destroyed, and the other three tanks in the six-tank enclosure were damaged. The company's office building, located about 100 yards north of the enclosure, was also destroyed in the fire. Some of the large tanks to the north and east of the enclosure area suffered some degree of radiant heat and smoke damage, but none of them leaked as a result of the damage.[7] Some of these large tanks are shown in Exhibit 9.

The explosion and fire damaged the storage tanks and associated piping in the enclosure area and caused the leak of sodium hydrosulfide solution (pH of 10.4 to 11.5) and Briquest (pH of 1). Their reaction produced hydrogen sulfide, a toxic, foul-smelling gas whose release required extended evacuation and slowed the cleanup efforts.[3, 7, 30, 31]

The intense fire forced the nearby residents of the Oaktree Townhomes complex to immediately evacuate. The fire was sufficiently intense to cause damage to some trees and buildings in the Oaktree complex. The location of the Oaktree Townhomes in relation to the fire can be seen in the photograph in Exhibit 6.[3, 7, 30, 31]

At the start of cleanup operations, after the fire was extinguished, all residents within one-half mile of the facility were evacuated as a precautionary measure because of the generation of toxic hydrogen sulfide gas. Overall, nearly 2,000 people were involved in the evacuation. Most of the evacuees were allowed to return after a few days, but the evacuation lasted more than 30 days for residents closest to the site of the fire. A local school, Whitney Elementary, was temporarily closed during the cleanup.[30, 31, 32, 33, 34, 35]

Eleven people were treated at local hospitals during the fire Monday night.[37] Most of these people were treated for respiratory problems; one person also reported “burning eyes,” and one was treated for anxiety. About 60 people sought treatment during the cleanup operations, but no one was hospitalized.[5, 7, 8] A fish kill in the Savannah River, at Savannah, Georgia, as a result of a spill of CST was reported to Georgia Environmental Protection Division (EPD) at 7:51 am, April 11, 1975.[36]

Follow-up by the Agency for Toxic Substances and Disease Registry (ATSDR) with three area hospitals found that 171 residents reported to hospital emergency rooms from the time the incident began on April 10 up to April 18, 1995. The hospitals reported no admissions related to the incident as of April 18.[38] As of April 25, 1995, ATSDR estimated the number of persons reporting to local area hospitals emergency rooms as 337, with no admissions or follow-up treatment required.[39]

The damaged tanks and firefighting effort left approximately 12 million gallons of contaminated water covering an area of about 25 to 40 acres of marsh. The photograph in Exhibit 9 shows the area after the fire was extinguished. A large pool of water that overflowed from the enclosure area can be seen. The contaminated water was determined to be hazardous

Exhibit 6

Area of Fire and Firefighting Efforts [29]

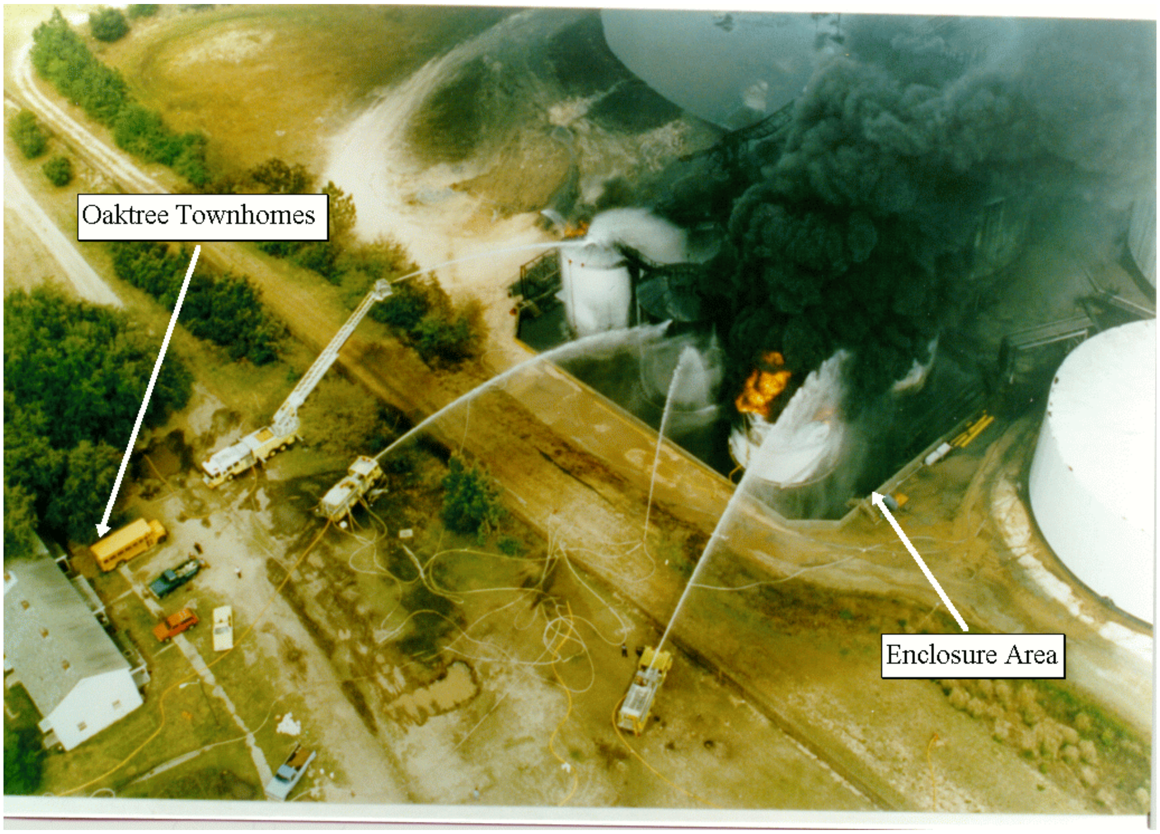


Exhibit 7

Area of Fire and Oaktree Townhomes [29]

Exhibit 8

Area of Fire and Savannah River [29]

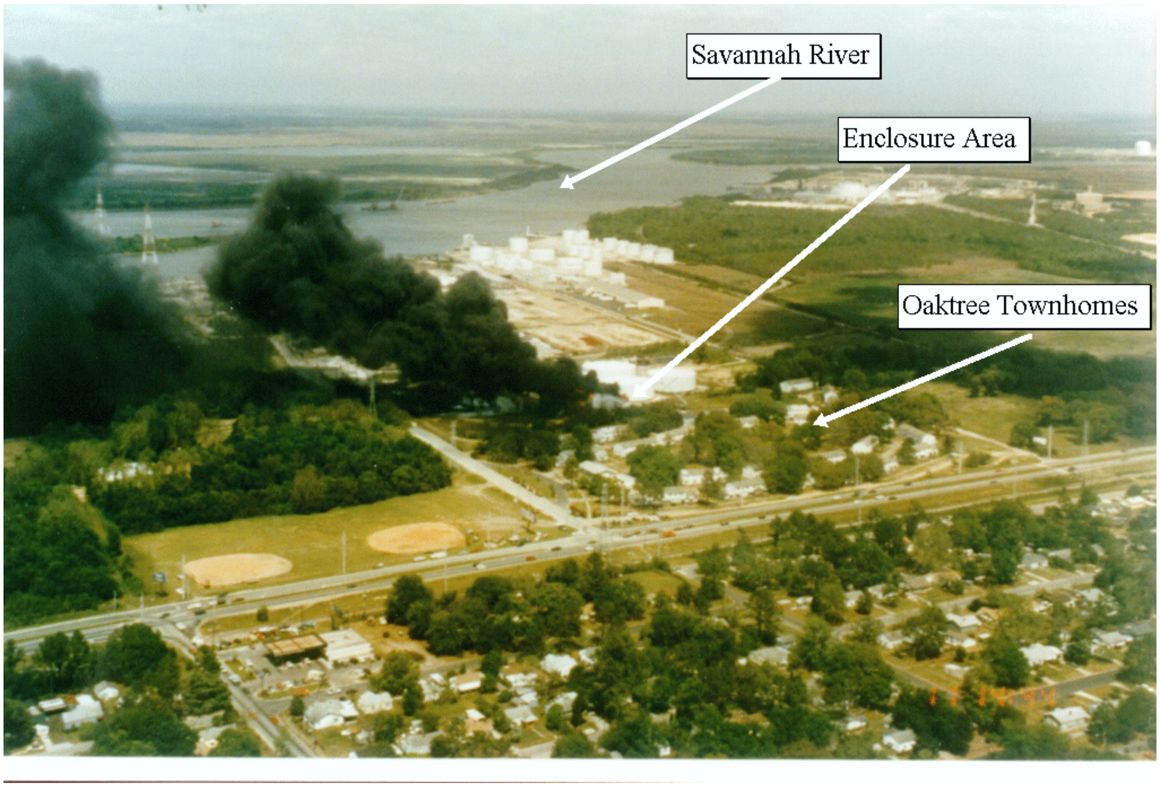


Exhibit 9

Burned-out Tanks and Pool of Contaminated Water [29]

because of the high pH and the presence of reactive sulfides that produced hydrogen sulfide. Hydrogen sulfide is toxic, with an Immediately Dangerous to Life and Health (IDLH) level of 100 parts per million (ppm). (IDLH levels are developed for worker protection by the National Institute for Occupational Safety and Health (NIOSH).) Hydrogen sulfide is also flammable, with a flammability range between 4.0 and 44.0 percent. An extensive cleanup of the area was required.[9]

3.0 ANALYSIS AND SIGNIFICANT FACTS

3.1 Analysis

After the accident, CAIT investigators toured the site and examined the storage tanks and piping and interviewed employees and contractors to determine the process and operations involving the storage tanks and sequence of event leading to the explosion and fire. CAIT investigators also received information from other federal, state, and local agencies which had investigated the fire and interviewed witnesses. Since PDTI's office on site was destroyed in the fire, CAIT investigators examined records related to the application of permits and correspondences with regulating agencies by PDTI to determine the conditions that existed prior to the fire. Extensive research was also carried out on the properties of crude sulfate turpentine and activated carbon used for removal of CST vapor.

The CAIT used the information collected to develop and Event an Causal Factors Chart. The Event and Causal Factors Chart combined with factual information collected in addition to professional and engineering judgement were used to determine the causes of this accident.

Significant facts considered by CAIT in its analysis of the causes of the accident are discussed in Section 3.2 below. Possible scenarios are discussed in Section 4.0.

3.2 Significant Facts

EPA considered the following facts to be particularly significant in determining the causes of the PDTI accident:

- In the six-tank enclosure area, Tank 19 had been used to stored sodium hydrosulfide solution since July 1992. Tank 20 had been used to store Briquest since January 1993.[4]

- Sodium hydrosulfide is incompatible with Briquest. They react to form, among other things, hydrogen sulfide gas.[40]

- On December 5, 1994, PDTI requested approval to store CST on-site from the Chatham County Department of Inspections. On December 8, 1994, the Chatham County Department of Inspections and the Savannah Fire Department stipulated that certain safety requirements be met for CST storage; however, they did not ensure that PDTI met these requirements.[20, 21, 22]

- PDTI began storing CST on-site before completing the modifications required by the Chatham County. On January 17, 1995, PDTI began storing CST in the six-tank enclosure area in Tank 22. By end of March, PDTI was storing CST in Tanks 18 and 23 as well. At the time of accident on April 10, 1995, PDTI had been storing CST without completing the required modifications for about three months.[4]

- On January 27, 1995, PDTI submitted to the Georgia Environmental Protection Division a notification of and an application for the storage and transfer of turpentine (CST) in existing storage tanks and loading lines. This notification indicated that odor would be controlled by piping the storage tanks together and routing the vapor through drums containing activated carbon.[24]

- On February 21, 1995, PDTI's contractor started installation of the VC system. The installation of the VC system was not completed at the time of the fire.[41]

- At the time of the fire, the VC system was being installed on the storage tanks containing CST. Although the design called for flame arresters, they had not been installed when the explosion and fire occurred, and pipe spools were temporarily installed in their place.[41]

- The VC system was designed by a PDTI employee and was not reviewed by a qualified engineer or recognized expert.[4, 5]

- PDTI based the design of the VC system on an existing system in use for the storage tank containing sodium hydrosulfide solution (Tank 19).[4, 5]

- The design of the VC system did not have a bypass valve that would prevent outside air from being drawn through the drums containing activated carbon.[25]

- Product literature from Calgon, the manufacturer of the activated carbon, highlighted the hazards of exotherms caused by adsorption of organic sulfur compounds on carbon and recommended installation of flame arresters and back-flow preventer (a bypass valve), and pre-wetting and re-wetting of the activated carbon.[50]

- PDTI management stated that their standard procedure was to pre-wet and re-wet periodically the activated carbon in the drums in the VC system.[5]

- The design of the VC system did not provide for electrical grounding.[25, 42]

- Bureau of Alcohol, Tobacco, and Firearms (ATF) investigators discovered the remains of an extension cord plugged in on the back side of Tank 5. This cord ran around the north side of Tank 5 to an area between Tanks 1 (the caustic soda tank), 5, and 8.[7] (See Exhibit 1 for the positions of these tanks.)

- Parts of another extension cord were observed lying between Tank 1 (the caustic soda tank) and the six-tank enclosure wall. This cord ran around the enclosure wall to the area of the stairs on the enclosure wall.[7, 42] (See Exhibit 1.)

- At the truck loading and unloading station, ATF discovered an explosion-proof electrical box that had the cover taken off and a device similar to a CB radio installed inside the box.[7] (See Exhibit 1 for the location of the truck loading and unloading station.)

- An additional electrical outlet not on the electrical schematic for the plant was found by ATF near the electrical panel the workers were using.[7, 42]

- The facility had been broken into and vandalized on two occasions -- two months prior to the fire and two weeks prior to the fire.[4]

- On March 3, 1995, PDTI's contractor began installing the foam fire protection system. The installation of the foam fire protection system had not been completed, and the system was not operational at the time of the fire.[41, 44]

- On April 7, 1995, the flame arresters for the VC system had arrived on-site and were uncrated, but they had not been installed on April 10, the day of the accident.[45]

- On the day of the accident, April 10, 1995, the third and final sealed foam chamber was installed on the CST tanks. This closed the CST tanks to the atmosphere and directed vapor to the VC system.[46]

- PDTI's Terminal Manager stated that after 2:30 p.m. on April 10, 1995, 6,200 gallons of CST was off-loaded from a tanker truck using in-house pumps.[4, 42, 43, 46]

- At 5:50 p.m. on April 10, 1995, the last PDTI employee left the site for the day.[7] The gates were locked, and no employees were there until after the fires and explosions had occurred. The facility is fully enclosed by a security fence with locked gates. There are no other provisions for site security.[4, 7, 47]

- The weather conditions at the time of the accident, as reported by the National Weather Service - Savannah were: temperature 69 degrees Fahrenheit; winds, 110 degrees (S-SE) at seven miles per hour; relative humidity 92 percent; pressure 32.09 and rising. There were scattered clouds up to 4,300 feet and thin scattered clouds up to 30,000 feet. There were no thunder storms reported in the area.[7]

- Records show that there was no lightning activity on the day of the accident within a 20-mile radius of the PDTI facility.[48]

- A resident of Oaktree Townhouses reported that on the evening of April 10, 1995, he saw what he described as a bright ball glowing red and orange near the base of Tank 23. As he tried to focus his eyes on the object, Tank 23 blew up. Other witnesses corroborated this account.[7, 49]

4.0 CAUSES OF THE ACCIDENT

An Event and Causal Factors Diagram for the PDTI accident is presented in Exhibit 10. This diagram presents the sequence of events and causal factors that may have contributed to the occurrence of each of the events. Possible scenarios for immediate cause of the accident, and contributing factors are discussed below. They are included in the Events and Causal Factors Diagram.

4.1 Most Likely Scenario

Ignition of CST Vapor within the Drums Containing Activated Carbon

On the day of the accident, the final sealed foam chamber was installed on the CST tanks. It had the effect of closing the CST storage tanks to the atmosphere and making the path through the VC system as the only opening to the outside. Also, on the day of the accident, after the foam chamber was installed, 6,200 gallons of CST was off-loaded into the tanks. The displaced vapor inside the storage tanks was forced through the activated carbon drums where the CST vapor is removed by adsorption.

Product literature from Calgon, the manufacturer of the activated carbon, highlighted the hazards of exotherms (high temperatures) caused by adsorption of organic sulfur compounds, present in CST, onto activated carbon. Heat generated from the adsorption of CST vapor on the activated carbon can raise the temperature in the drums above the autoignition temperature of the CST vapor.

Although the temperature of the activated carbon may have become hot when CST vapor was vented from the storage tanks to the carbon drums, the low level of oxygen present in the drums probably averted a fire. However, the VC system did not have a bypass for preventing outside air from being drawn into the drums when cool outside temperatures caused vapor in the storage tanks to contract. The introduction of air provided the needed oxygen to trigger a fire.

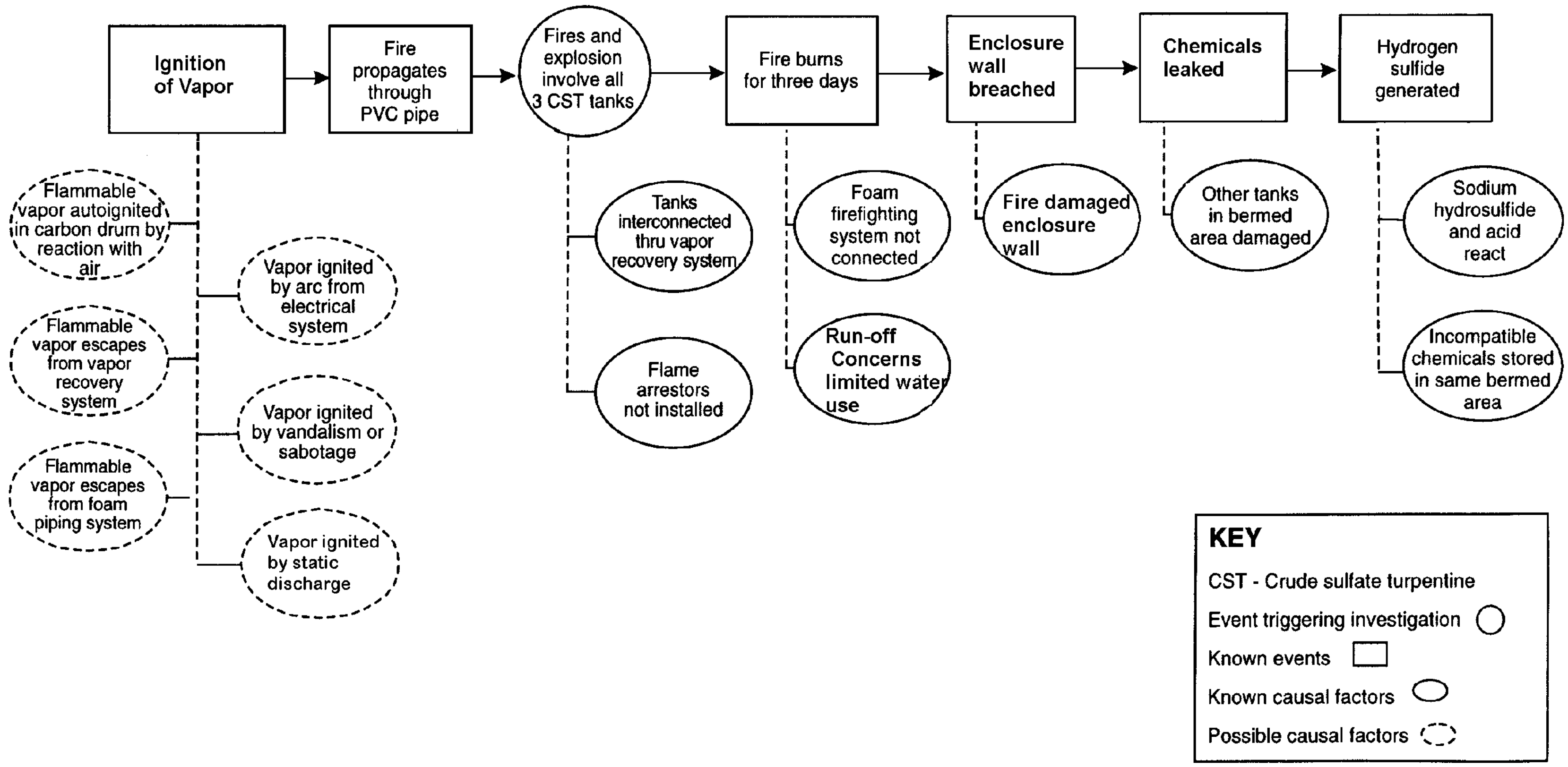
An article written by SCM Corporation personnel (see Appendix C) describes a history of fires in the drums containing activated carbon where the VC system design permitted outside air to be drawn into the drums. The article specifically mentions that typically the fires have occurred late at night following a hot sunny day, as did the PDTI accident, when the nighttime cooling of the storage tanks cause vapor to contract and draw outside air into the drums containing activated carbon. The article recommends installing a vacuum breaker (a bypass) between the storage tanks and the drums that would allow air to enter without being drawn through the activated carbon bed.[51]

Exhibit 10

Powell Duffryn Terminals, Inc. - Savannah, GA
4/10/95 Explosion and Fire
Event and Causal Factors Diagram

Prior to accident:

- CST stored for three months.
- Vapor recovery system, including drums of activated carbon, in place for one month.
- Fixed foam fire protection system partially installed on day of accident.
- Seals installed on foamers on day of accident.



The eyewitness' accounts of the accident are consistent with this scenario.

Calgon Carbon Corporation, the manufacture of the activated carbon, recommended a procedure of wetting the carbon in the drums with water and of re-wetting it periodically thereafter. The evaporation of the water in the drums would prevent the activated carbon from becoming too hot. PDTI reportedly followed this procedure during initial installation. The VC system had been in place for over a month before the accident. However, it was not functioning as designed during this time, since part of the system was open to the atmosphere. During this time, the carbon in the drums could have dried out, even if it had been wetted initially. It is not known if the carbon was rewetted at anytime after initial installation.

Other possible scenarios for initiation of this fire were considered and are described below.

4.2 Other Possible Scenarios

Ignition of CST Vapor in the Ambient Air

This scenario involves possible external ignition sources which ignited CST vapor that may have leaked out from the storage tanks. The fire then flashed back and ignited the CST in the storage tanks. There are several possible sources from which CST vapor may have leaked.

The CST vapor might have escaped from the VC system through the drums containing activated carbon. Any residual CST vapor not adsorbed by the activated carbon would be released to the atmosphere where it could be ignited if an ignition source were present.

The CST vapor might also have leaked from the pressure release vents. The pressure release vents are designed to release excess pressure in the storage tanks. If these vents were faulty, were improperly installed, or if there was too much backpressure from the VC system, the vapor could have leaked out. The fire then could have flashed back through the vents.

Another possible source of CST vapor is the foam fire protection system. If the foam fire protection system under construction were inadequately sealed, broken, or cracked, flammable CST vapor could have escaped from this system, reached a source of ignition, and flashed back to the tanks.

Finally, a breach in any of the CST storage tanks could result in release of CST vapor.

The CST vapor, being 4.8 times denser than air, may not have diffused quickly in air. It may possibly collect within the enclosure area.[13] The lower flammability limit of the CST vapor, 0.8 percent, would enable it to ignite at relatively low concentrations. [13]

Supporting these scenarios is the fact that there were several possible ignition sources. One might be arcing from electrical systems at the facility. Some of the electrical equipment at the facility was not explosion-proof. Investigators found a conventional extension cord plugged in near the six-tank enclosure and parts of what is believed to be an extension cord near an electrical outlet. They also found an explosion-proof electrical box with the cover taken off (thus nullifying its safety feature) at the truck loading and unloading station. (See Exhibit 1.) Such equipment could have provided a source of ignition for the CST vapor. Other potential ignition sources include any flame as a result of vandalism or sabotage. (ATF investigated the scene and reported that the fire was not the result of vandalism or sabotage.)

These scenarios are much more apt to take place during filling of the storage tanks or during the day when vapor may be displaced as a result of thermal expansion. The timing of the accident make these less likely scenarios.

Ignition of Vapor by Static Charge Buildup on Carbon Drum

The VC system was designed without electrical grounding for the drums containing activated carbon. The metal drums were connected to the storage tanks by non-conducting PVC pipes. This permitted possible development of differences in electric potential between the drums containing activated carbon and the CST storage tanks. A spark in the PVC pipe resulting from static discharge could possibly ignite the CST vapor and trigger a vapor explosion and fire. However, the weather conditions at the time of the fire, low wind speed and high humidity, make this an unlikely possibility.

Ignition of Vapor by Lightning

Lightning was examined as a possible ignition source. However, no lightning was detected in the area of the PDTI site at the time of the incident or for a number of hours before and after the incident.

4.3 Factors that Contributed to the Consequences

Although there is a history of fires in the drums containing activated carbon, vast majority of these fires have been of minor consequences. The conditions that existed at PDTI contributed to the serious consequences.

- The CST storage tanks did not have flame arresters. Flame arresters are devices permeable to gas flow but impermeable to any flame it may encounter by quenching the flame and cool the products to prevent reignition of hot gases exiting the arrester. They are used to prevent a flame propagating into a system from outside or other parts of the system. The fire spread to the CST storage tanks through the PVC piping system that connected all three tanks to the carbon drums.

- The pumper connection located outside the enclosure area for the fixed foam fire protection system, as required by Chatham County Department of Inspections, had not been completed at the time of the fire. The foam system was only activated after the fire department was able to reach the foam pumper connection within the enclosure area. Since the storage tanks had gotten extremely hot during the initial fire, the CST in the storage tanks reignited several times after being doused with foam. The fire burned on and off for three days before it was completely put out, causing extensive damage to other tanks and associated piping located in the same enclosure area as the CST. The other tanks and piping leaked chemicals, leading to the generation of toxic hydrogen sulfide.

- The concrete wall of the enclosure area failed during the fire, resulting in the release of contaminated water from the firefighting efforts. This contributed to damage to the environment and slowed the fire fighting effort.

- Incompatible chemicals were stored next to one another resulting in release of toxic hydrogen sulfide gas. Hydrogen sulfide gas was produced when sodium hydrosulfide solution was heated during the fire (most of the hydrogen sulfide release during the fire would likely have been consumed in the fire since it is combustible) and later leaked from its storage tank and associated piping into the enclosure area and reacted with the acid present. The hydrogen sulfide release caused injuries, forced extended evacuations, and hampered response and cleanup. Storage of incompatible chemicals in the same enclosure area created the potential for the release of a hazardous gas in the event of a fire or damage to the tanks. Proper storage of these chemicals in separate locations would have prevented the hydrogen sulfide release. Without the release of hydrogen sulfide, the evacuations would have involved a smaller area and for shorter duration, and cleanup of the site would have been quicker and easier.

4.4 Root Causes and Contributing Factors

The CAIT concludes that the most likely cause of the incident at the PDTI facility was ignition of CST vapors in the carbon adsorption drums due to the inadvertent addition of atmospheric air. The fire then traveled back to the storage tanks through the vent piping, igniting the contents triggering explosions and fire.

Below are the root causes and contributing factors associated with this incident. Root causes are the underlying prime reasons, such as failure of particular management systems, that allow faulty design, inadequate training, or deficiencies in maintenance to exist. These, in turn, lead to unsafe acts or conditions which can result in an accident. Contributing factors are reasons that, by themselves, do not lead to the conditions that ultimately caused the event; however, these factors facilitate the occurrence of the event or increase its severity. The root causes and contributing factors of this event have broad application to a variety of situations and should be considered lessons for industries that conduct similar operations.

The CAIT uses a variety of analytical techniques to determine the root causes and contributing factors of accidents, and to generate recommendations to prevent a recurrence. The techniques used in this case included Events and Causal Factors charting, engineering and operations management experience and professional judgement. A number of factors involving equipment, facility layout, and procedures may have contributed to this incident, as discussed below. Based upon the facts and circumstances described above, the CAIT identified the following root causes and contributing factors in this incident:

- The design for the VC system was inadequate. There is a history of fires in drums containing activated carbon where the VC system design permitted the backflow of outside air through the drums. Organic sulfur compounds in CST can produce heat when they are adsorbed by the activated carbon. Enough heat may be produced in the drums to raise the temperature above the autoignition temperature of CST. Since there is a limited amount of oxygen in the drums, a fire usually does not occur. However, if outside air is permitted to be drawn through the drums containing activated carbon, as when CST is withdrawn from the storage tank or when ambient temperature drops causing the vapor in the storage tanks to contract, air can provide oxygen needed for combustion and the CST vapor in the drums may ignite triggering a fire. (The solution for preventing the backflow of outside air into the drums is to install a one-way valve between the drums and the storage tanks that would permit air to enter the storage tanks without going through the carbon drums.)

- The storage tanks were not equipped with flame arresters. The PVC piping provided a conduit for the fire to travel from the carbon drums to the CST storage tanks. Flame arresters were included in the design of the VC system. However, CST storage began before the modifications were completed. At the time of the fire, the flame arresters were on-site but had not been installed.

- The foam fire suppression system was not completed on the tanks containing CST. Foam fire suppression system was included as part of changes to be made for storing flammables. CST storage had begun before modifications were completed. Fire fighters were not able to use the foam pumper connection outside the enclosure area. Fire fighters used water to fight the fire until a connection to the foam pumper could be rigged within the enclosure area. An operational foam fire suppression system could have reduced the amount of time required to suppress the fire and reduce the amount of heat damage to the adjacent storage tanks and limited the amount of runoff from fire water which contaminated sensitive wetland area along the Savannah River.

- The concrete containment wall was breached as a result of heat from the fire. The enclosure area had been used to store nonflammables. No modifications were made to the secondary containment before commencing storage of flammables.

- Incompatible chemicals were stored in the same walled enclosure area. Sodium hydrosulfide solution was stored in the same enclosure area as acidic cleaning solution resulting in production of toxic hydrogen sulfide vapor when the tanks leaked. The toxic hydrogen sulfide release caused injuries, forced extended evacuations, and hampered response and cleanup.

5.0 RECOMMENDATIONS

Based on the root causes and contributing factors of this accident described above, the CAIT provides the following recommendations to prevent accidents like this one from occurring in the future at this and other facilities:

- Facilities designing or adding on environmental control, fire safety, or hazard control systems, must ensure that these systems do not adversely impact the processes or equipment where they are to be added and that they are properly designed and installed. Designs should be reviewed by competent professionals or recognized experts. The hazards associated with the new systems and the impact of the new system on the existing systems should be thoroughly assessed. There are many formal hazard evaluation techniques available (such as HAZOP or What If) that can facilitate this assessment.

- Facilities using activated carbon systems, in conjunction with vendors or recognized experts, should conduct tests to determine the potential for formation of hot spots, runaway reactions, or other consequences associated with adsorption of vapors on activated carbon and ensure that the hazards associated with the heat of adsorption are identified, well understood, and addressed through safeguards, procedures, or other controls. An evaluation of the potential for, and the consequences associated with, air being drawn into a carbon adsorption system (for example, associated with normal tank breathing) must also be addressed as necessary through safeguards or other controls.

- Facilities storing flammable and combustible materials must evaluate and ensure that the vessel and its venting system are protected from potential fire or explosion propagation back into the tank from external fire or ignition sources.

- Facilities must ensure that equipment for use in handling hazardous substances is equipped with the proper safety devices, and in compliance with national, state, and local fire and hazardous material safety codes and standards before hazardous materials are handled in such equipment. The safeguards, safety devices, or emergency systems designed to prevent or protect the equipment must be in place and fully operational as intended prior to startup of the equipment.

- Facilities should examine process and storage areas and equipment to ensure that potentially incompatible substances are kept separated. Leaks or spills of incompatible substances from equipment should not go into the same containment or other areas as a result of fire or other incident.

In addition to the root causes and contributing factors of this accident described above, the CAIT makes the following recommendations based on potential problem areas found during the investigation.

- Facilities should evaluate the need for bonding and grounding to prevent the buildup and discharge of static electrical charges that could provide an ignition source. If used, ensure that bonding and grounding devices are properly designed, installed, maintained, inspected, and tested.

- Facilities must ensure that electrical devices and equipment in areas where flammable or explosive materials are handled are properly designed, installed, maintained, tested, inspected and operated, and meet codes and standards to prevent potential ignition sources.

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Appendix A

Personnel Participating in Accident Investigation and Report Development

EPA personnel who participated in the accident investigation and development of the accident report include:

David Speights	EPA Headquarters
Craig Matthiessen	EPA Headquarters
Henry T. Hudson, Environmental Engineer	EPA Region IV
David Chung, Chemical Engineer	EPA Headquarters
Charlie Cartwright, Chemical Engineer	EPA Region IV
Eric Simmons, Environmental Engineer	8(a) Technical Assistance Team, Resource Applications, Inc., Burke, VA

OSHA personnel involved in the investigation include:

John Vos, Safety Specialist	OSHA Savannah Area Office
James White, Industrial Hygienist	OSHA Savannah Area Office

Appendix B

Material Safety Data Sheets for Chemicals Stored in Six-Tank Enclosure

This appendix contains Material Safety Data Sheets (MSDS) for the chemicals stored in the six-tank enclosure area that was the site of the initial explosion and fire at PDTI. MSDS are included for:

- Crude sulfate turpentine;
- Briquest;
- Sodium hydrosulfide solution; and
- Antiblaze 80.

Rayonier

MATERIAL SAFETY DATA SHEET

CRUDE SULFATE TURPENTINE

Page: 1
Date Prepared: November 2, 1994
MSDS No.: 0004

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1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Identifier:	Crude sulfate turpentine
Product Description:	Mixture of terpenes and other volatile degradation products obtained during the kraft pulping process.
Synonyms:	Sulfate turpentine, wood turpentine, turpentine
Chemical Family:	Terpenes
Chemical Formula:	Mixture; primarily $C_{10}H_{16}$ isomers

MANUFACTURER:

Rayonier Inc.
Specialty Pulp Products
Jesup Mill
4470 Savannah Highway
Jesup, GA 31545
(912) 427-5000

EMERGENCY TELEPHONE NUMBERS

Health and Transportation	(912) 427-5560
CHEMTREC*	(800) 424-9300

*Transportation Emergencies only

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2. COMPOSITION/INFORMATION ON INGREDIENTS

	wt. %	CAS Registry No.
Crude Sulfate Turpentine	100	8006-64-2
Alpha pinene	60-62	80-56-8
Beta pinene	19-21	127-91-3
Limonene	7-9	138-86-3
Beta phellandrene	6-8	555-10-2
Pine oil	2-3	8002-09-3

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:	Crude sulfate turpentine (CST) is a flammable liquid; it is toxic (LD_{50} for humans is estimated to be between 1,100 and 2,400 mg/kg) and is a dermal, eye and pulmonary irritant. Acute renal injury may follow exposure to turpentine either by the dermal, oral, or inhalation routes, but there appears to be no evidence of kidney damage in nonfatal cases. A very dangerous fire hazard when exposed to heat or flame.

POTENTIAL HEALTH EFFECTS:

INHALATION:	Inhalation can be irritating to mucous membranes, produce headache, dizziness, pulmonary edema, bronchitis, rapid heart beat, cyanosis, and may resultin acute renal injury.
EYE CONTACT:	Vapors are irritating. Liquid turpentine causes immediate severe pain and eyelid spasm.
SKIN CONTACT:	Direct skin contact causes irritation. May result in acute renal injury.
INGESTION:	Ingestion can cause burning of the mouth and throat, nausea and abdominal pain. May result in acute renal injury. Initially causes CNS stimulation. This may be followed by CNS depression leading to progressive stupor and coma.
CHRONIC:	Chronic exposure may cause kidney and liver damage. May produce dermatitis and allergenic sensitization.
EXPOSURE LIMITS:	ACGIH TLV - 100 ppm (Turpentine) OSHA PEL - 100 ppm (Turpentine) OSHA TWA - 100 ppm (Turpentine)

4. FIRST AID MEASURES

INHALATION:	Remove patient to fresh air. If breathing is difficult, give oxygen. Refer to physician if patient shows any ill effects or if irritation persists.
EYE CONTACT:	Flush thoroughly with large quantities of warm water. Hold eyelids apart to ensure thorough irrigation. Refer to physician.
SKIN CONTACT:	Wash exposed skin with mild soap and water. Remove contaminated clothing. Refer to physician if irritation persists.
INGESTION:	Poisonous (mean lethal dose for adults is 4-6 oz.). Do not induce vomiting. Get medical help promptly. Stomach pumping and lavage may be required.

5. FIRE FIGHTING MEASURES

PHYSICAL PROPERTIES	Flash point: 90 - 115°F (CC) (32 - 46° C) Flammable limits: LEL - 0.8% UEL - unk.
GENERAL HAZARD:	Turpentine is a flammable liquid. Avoid heat, sparks and open flames. A very dangerous fire hazard when exposed to heat or flame. Moderate explosion hazard in the form of vapor when exposed to flame.
FIRE FIGHTING INSTRUCTIONS:	Extinguish with foam, CO_2 or dry chemical. If water must be used, use as a spray only. Water can be used to cool fire-exposed surroundings.
FIRE FIGHTING EQUIPMENT:	Use firefighters protective clothing (bunker gear) with SCBA.
HAZARDOUS COMBUSTION PRODUCTS:	Emits acrid smoke and fumes when heated to decomposition. Forms heavy black smoke and soot when burning. Carbon dioxide and carbon monoxide are among combustion products.

6. ACCIDENTAL RELEASE MEASURES

LAND SPILL:	Evacuate the area. Eliminate ignition sources. Vapor is heavy and may travel to ignition sources. An explosion hazard exists if vapor enters a confined area such as a sewer. Provide explosion-proof ventilation to remove vapors from spill area. Protect personnel from breathing vapors or contact with liquid. Air-line respirator or self contained breathing apparatus may be required. Contain spill and pick up with absorbent material and put in a labeled, closed metal container.
WATER SPILL:	Notify appropriate authorities if spill enters waterways or municipal sewers. Material is a listed marine pollutant under 49 CFR 172.101, Appendix B.

7. HANDLING AND STORAGE

Store in cool, dry, well-ventilated location away from sources of heat and ignition. Storage drums should be air-tight. Store away from oxidizing agents. No smoking.

No open flames or ignition sources in handling or storage areas. Use explosion-proof electrical equipment. Surfaces covered with crude sulfate turpentine may be slippery.

CST vapor is highly corrosive to mild steel.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Use chemical goggles or full face shield with safety glasses.

Use Viton/neoprene, Viton, chloroprene or PVA gloves and apron (to protect against splashing).

Maintain eyewash facilities and safety showers in handling areas.

Provide adequate general ventilation to meet PEL requirements.

Avoid inhalation of mist and vapor. Avoid contact with skin and eyes. No smoking in storage or use areas. Take special care when opening pumps and pipe lines.

9. PHYSICAL AND CHEMICAL PROPERTIES

Vapor Pressure:	5 mm (Hg, 77°F, 25° C)
Vapor density:	4.8 (air = 1)
Specific Gravity:	0.86
Boiling Point:	310 - 340°F (154 - 171° C)
pH:	Not applicable
Odor:	Pungent, offensive, sulfurous
Appearance:	Pale yellow liquid

10. STABILITY AND REACTIVITY

GENERAL:	CST is flammable. Spontaneous heating is possible. Avoid impregnating combustibles with CST.
INCOMPATIBLE MATERIALS AND CONDITIONS TO AVOID:	Avoid contact with strong oxidizing agents such as chlorine dioxide and chlorine. Avoid sparks and open flames. Mild steel is susceptible to severe vapor-phase corrosion by some components of CST.
HAZARDOUS DECOMPOSITION:	Emits acrid smoke and fumes when heated.

11. TOXICOLOGICAL INFORMATION

CARCINOGENICITY:	No reports of carcinogenicity were found.
MUTAGENICITY:	Several of the CST constituents were not found to be mutagenic in the Ames test.
TERATOGENICITY:	Possible teratogenic effect exists for pregnant women.
TOXICITY:	LD_{50} for humans is estimated at 1,100 - 2,400 mg/kg.
SENSITIZER:	The major constituents are non-sensitizing. Chronic exposure may produce allergenic sensitization.
IRRITANT:	CST is a skin, eye and mucous membrane irritant.

12. ECOLOGICAL INFORMATION

No data available.

13. DISPOSAL CONSIDERATIONS

Material meets the Federal definition of an ignitable hazardous waste. Disposal should be only in accordance with applicable regulations.

14. TRANSPORT INFORMATION

Shipments of this product are regulated by the Department of Transportation (DOT). The proper shipping name is Turpentine. The correct bill of lading description is:

Turpentine, (Crude Sulfate Turpentine),
3, UN 1299 , PG III" Placard - Flammable

Special provisions B1 and T1 should be noted according to 40 CFR 172.101. Therefore, bulk packing according to 40 CFR 173.241 applies.

Emergency Response Guidebook No. 27

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15. REGULATORY INFORMATION

TSCA (Toxic Substance Control Act):	This product is listed on the TSCA inventory.
RCRA:	Discarded material would be a hazardous waste under 40 CFR 261.21.
CERCLA (Comprehensive Emergency Response Compensation, and Liability Act):	Reportable under 40 CFR 302.4(b) for releases greater than 100 pounds [40 CFR 302.5(b)]
DOT Hazmat:	Regulated under 49 CFR 172.101. Listed as marine pollutant under 49 CFR 172.101, Appendix B
OSHA:	Turpentine is a 29 CFR 1910 Subpart Z compound. TWA 100 ppm (560 mg/m^3).
SARA TITLE III (Super-fund Amendments and Re-authorization Act):	311/312 Hazard Categories: Immediate health, delayed health, fire 313 Reportable Ingredients: None
OTHER	We recommend you contact local authorities to determine if there may be other local reporting requirements.

CALIFORNIA PROPOSITION 65:	This product is derived as a co-product of cellulose production from trees. As a consequence, some chemical compounds listed by the State of California under Proposition 65 may naturally be present. Rayonier does not know of any universal analytical scheme that enables us to analyze this product for the absence or presence of all chemical compounds listed by the State of California. No testing has been done for Proposition 65 listed chemical compounds.

16. OTHER INFORMATION

For more information about this product, please call Rayonier Inc., Jesup Mill, Jesup, GA at (912) 427-5000 or the Savannah office at (912) 651-8056.

THE INFORMATION RELATES TO THIS SPECIFIC MATERIAL. IT MAY NOT BE VALID FOR THIS MATERIAL IF USED IN COMBINATION WITH ANY OTHER MATERIALS OR IN ANY PROCESS. IT IS THE USERS' RESPONSIBILITY TO SATISFY THEMSELVES AS TO THE SUITABILITY AND COMPLETENESS OF THIS INFORMATION FOR THEIR OWN PARTICULAR USE.

ALBRIGHT & WILSON AMERICAS INC. MATERIAL SAFETY DATA SHEET

ALBRIGHT & WILSON AMERICAS INC.
ENVIRONMENTAL SERVICES

P. O. BOX 26229
RICHMOND, VA. 23260-6229 (USA)

*********************** PRODUCT IDENTIFICATION ***********************

BRIQUEST ADPA 60AW

SUPPLIER: ALBRIGHT & WILSON INC.	HEALTH EMERGENCY TELEPHONE: (803)554-1229
CHEMICAL NAMES AND SYNONYMS: 1-HYDROXYETHANE-1,1-DIPHOSPHONIC ACID	TRANSPORT EMERGENCY TELEPHONE: (800)424-9300(CHEMTREC)
USE OR DESCRIPTION: CLEANING AGENT	OTHER DESIGNATION: 71K

************** TYPICAL CHEMICAL AND PHYSICAL PROPERTIES *************

APPEARANCE: CLEAR-PALE YELLOW LIQUID	VISCOSITY: AT 100 F, SUS NE	AT 20 C, CS 64
ODOR: ODORLESS	VISCOSITY: AT 210 F, SUS NE	AT 100 C, CS NE
RELATIVE DENSITY: 15/4 C 1.46	SOLUBILITY IN WATER: MISCIBLE	PH: 1
MELTING POINT: F(C) NA	POUR POINT: F(C) NE	
BOILING POINT: F(C) > 212F	FLASH POINT: F(C) (METHOD) NOT FLAMMABLE	
VAPOR PRESSURE:MM HG 20C < 17 MM HG @ 68F		

NA=NOT APPLICABLE NE=NOT ESTABLISHED D=DECOMPOSES

**************************** INGREDIENTS *****************************

		PEL		TLV(TWA)	
	WT PCT (APPROX)	MG/M3	PPM	MG/M3	PPM
HAZARDOUS INGREDIENTS:					
1-HYDROXYETHANE-1,1-DIPHOSPHONIC ACID (2809-21-4)	60	NE	NE	NE	NE

NOTE: TLVS SHOWN FOR GUIDANCE ONLY. FOLLOW APPLICABLE REGULATIONS.

****************** FIRE AND EXPLOSION HAZARD DATA ******************

FLASH POINT: F(C) (METHOD)	FLAMMABLE LIMITS: LEL	UEL
NA	NA	NA

EXTINGUISHING MEDIA:

GOVERNED BY OTHER MATERIALS PRESENT

SPECIAL FIRE FIGHTING PROCEDURES:

AS IN ANY FIRE SITUATION, THE USE OF SELF-CONTAINED BREATHING APPARATUS IS RECOMMENDED.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

PRODUCT CAN FORM FLAMMABLE PHOSPHINE GAS WHEN HEATED ABOVE 200C.

**************** EMERGENCY AND FIRST AID PROCEDURES ****************

EYE CONTACT:

FLUSH THOROUGHLY WITH WATER FOR AT LEAST 15 MINUTES. GET IMMEDIATE MEDICAL ASSISTANCE. IF MEDICAL ASSISTANCE IS NOT IMMEDIATELY AVAILABLE, FLUSH FOR AN ADDITIONAL 15 MINUTES WITH WATER.

SKIN CONTACT:

IF WIDESPREAD CONTACT, IMMEDIATELY REMOVE CONTAMINATED CLOTHING UNDER SAFETY SHOWER AND WASH EXPOSED AREA WITH SOAP AND LARGE AMOUNTS OF WATER. GET MEDICAL ASSISTANCE. FOR LESSER CONTACT, WASH CONTACT AREAS WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND LAUNDER BEFORE REUSE.

INHALATION:

REMOVE FROM FURTHER EXPOSURE. IF UNCONSCIOUSNESS OCCURS, CALL A PHYSICIAN. IF BREATHING HAS STOPPED, USE MOUTH-TO-MOUTH RESUSCITATION.

INGESTION:

DO NOT INDUCE VOMITING. GIVE LARGE QUANTITIES OF MILK OR WATER. GET MEDICAL ASSISTANCE AND CALL A PHYSICIAN. DO NOT GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

*************************** REACTIVITY DATA ***************************

STABILITY: (THERMAL, LIGHT, ETC.)	CONDITIONS TO AVOID:
STABLE	TEMPERATURES GREATER THAN 200C

INCOMPATIBILITY: (MATERIALS TO AVOID)

STRONG OXIDIZING AGENTS AND SUBSTANCES WHICH REACT WITH ACIDS.

HAZARDOUS DECOMPOSITION PRODUCTS:

PHOSPHINE

HAZARDOUS POLYMERIZATION:	CONDITIONS TO AVOID:
WILL NOT OCCUR	NE

************************ SPILL OR LEAK PROCEDURE ************************

ENVIRONMENTAL IMPACT:

REPORT SPILLS AS REQUIRED TO APPROPRIATE AUTHORITIES. REGULATIONS REQUIRE IMMEDIATE REPORTING OF SPILLS THAT COULD REACH ANY WATERWAY, INCLUDING INTERMITTENT DRY CREEKS. REPORT SPILL TO NATIONAL RESPONSE CENTER TOLL FREE NUMBER 800-424-8802. IN CASE OF ACCIDENT OR ROAD SPILL, NOTIFY CHEMTREC (800) 424-9300.

PROCEDURES IF MATERIAL IS RELEASED OR SPILLED:

ABSORB ON FIRE RETARDANT TREATED SAWDUST, DIATOMACEOUS EARTH, ETC. SCRAPE UP AND REMOVE. DISPOSE OF AT AN APPROPRIATE WASTE DISPOSAL FACILITY IN ACCORDANCE WITH CURRENT APPLICABLE LAWS AND REGULATIONS, AND PRODUCT CHARACTERISTICS AT TIME OF DISPOSAL.

WASTE MANAGEMENT:

DISPOSE OF WASTE BY SUPERVISED INCINERATION IN COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS. DISPOSE OF WASTE AT AN APPROPRIATE WASTE DISPOSAL FACILITY IN ACCORDANCE WITH CURRENT APPLICABLE LAWS AND REGULATIONS, AND PRODUCT CHARACTERISTICS AT TIME OF DISPOSAL.

******************* SPECIAL PROTECTION INFORMATION *******************

EYE PROTECTION:

CHEMICAL TYPE GOGGLES WITH FACE SHIELD SHOULD BE WORN.

SKIN PROTECTION:

IMPERVIOUS GLOVES SHOULD BE WORN. PROTECTIVE CLOTHING SUCH AS UNIFORMS, OVERALLS, AND LAB COATS SHOULD BE WORN. WHEN HANDLING LARGE QUANTITIES, IMPERVIOUS SUITS AND BOOTS MUST BE WORN.

RESPIRATORY PROTECTION:

NO SPECIAL REQUIREMENTS UNDER ORDINARY CONDITIONS OF USE AND WITH ADEQUATE VENTILATION. APPROVED RESPIRATORY PROTECTIVE EQUIPMENT MUST BE USED WHEN VAPOR OR MIST CONCENTRATIONS EXCEED APPLICABLE STANDARDS.

VENTILATION:

NO SPECIAL REQUIREMENTS UNDER ORDINARY CONDITIONS OF USE AND WITH ADEQUATE VENTATION. AVOID USING IN CONFINED SPACES.

OTHER:

PRIMARY ROUTE OF ENTRY - SKIN CONTACT.

************************* SPECIAL PRECAUTIONS *************************

HANDLING:

PRODUCT IS A CORROSIVE MATERIAL WHICH CAN CAUSE EYE AND SKIN BURNS. AVOID ALL PERSONAL CONTACT.

STORAGE:

STORE PRODUCT IN SEALED CONTAINERS IN A COOL DRY PLACE.

STORED MATERIALS MUST BE LABELED AS: BRIQUEST ADPA 60AW.

************************ HEALTH HAZARD DATA ***************************

ACUTE HEALTH HAZARDS:

STRONG IRRITANT; MAY CAUSE SKIN, EYE OR MUCOUS MEMBRANE BURNING.

CARCINOGENICITY:
LISTED: NTP? NO IARC MONOGRAPHS? NO OSHA REGULATED? NO

SIGNS AND SYMPTOMS OF EXPOSURE:

IRRITATION OF EYE, SKIN OR MUCOUS MEMBRANE.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:

MAY AGGRAVATE ANEMIA.

SUBACUTE AND MUTAGENICITY (SUMMARY)

NONE KNOWN.

CHRONIC OR SPECIALIZED (SUMMARY)

POSSIBLE SKELETAL EFFECTS; MAY DECREASE THE AFFINITY OF HEMOGLOBIN FOR OXYGEN.

TARGET ORGAN EFFECTS

SKIN, EYE, RESPIRATORY TRACT(IRRITATION);
TOXIC TO BONE AND BLOOD.

OTHER DATA

FETAL ANOMALIES HAVE BEEN REPORTED IN MICE.

************************ WARNING STATEMENTS ***************************

CALIFORNIA:

"WARNING: THIS PRODUCT MAY CONTAIN A CHEMICAL KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, OR BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM".

ALL PHOSPHORUS COMPOUNDS MAY BE REASONABLY EXPECTED TO CONTAIN ARSENIC AND POSSIBLY CADMIUM AND/OR LEAD IN CONCENTRATIONS RANGING FROM A FEW PARTS PER BILLION TO A FEW PARTS PER MILLION.

HAZARD WARNING: THERE IS A POSSIBILITY BICYCLIC PHOSPHATES OR PHOSPHITES CAN BE PRODUCED AS A RESULT OF THE THERMAL DECOMPOSITION OF THIS PRODUCT IN COMBINATION WITH TRIMETHYLOL PROPANE, TRIMETHYLOL PROPANE DERIVED PRODUCTS OR THEIR CORRESPONDING TRIMETHYLOL ALKANE HOMOLOGS. BICYCLIC PHOSPHATES AND PHOSPHITES ARE A CLASS OF MATERIALS WITH ACUTE NEUROTOXIC PROPERTIES WHICH PRODUCE CHARACTERISTIC CONVULSIVE SEIZURES IN TEST ANIMALS. THEREFORE, THIS PRODUCT SHOULD NOT BE USED IN CONJUNCTION WITH TRIMETHYLOL PROPANE OR TRIMETHYLOL PROPANE DERIVED PRODUCTS.

JUPITER
CHEMICALS, INC.
P.O. BOX 789 WESTLAKE, LA 70669

MATERIAL SAFETY DATA SHEET

MSDS NUMBER ▶ 080-6J

ECTION I NAME

PRODUCT	▶ Sodium Hydrosulfide Solution
CHEMICAL/ SYNONYMS	▶ NaSH
CHEMICAL FAMILY	▶ Inorganic Salt Solution
C.A.S. NUMBER	▶ 16721-80-5

24 HOUR EMERGENCY ASSISTANCE

JUPITER 800-877-1737
CHEMTREC 800-424-9300

HAZARD RATING

LEAST 0 ▶ SLIGHT 1 ▶ MODERATE 2 ▶ HIGH 3 ▶ EXTREME 4

HEALTH	3
FIRE	0
REACTIVITY	1

SECTION II INGREDIENTS

COMPOSITION	%	TOXICITY DATA
	(typical)	
Sodium Hydrosulfide	20 - 45	ipr-rat LD_{50}: 30 mg/Kg
Water	55 - 80	ipr-mus LD_{50}: 20 mg/Kg
		* NIOSH RTECS (1983 Supplement)

SECTION III HEALTH INFORMATION

Solutions of sodium hydrosulfide are strongly alkaline (pH 10.4-11.5) and should be handled with all of the precautions which are generally used for handling strong alkalies. The solutions are highly corrosive to the eyes or any human tissue. Liquid contact causes marked eye irritation and could result in severe corneal injury. Liquid contact with the skin causes irritation and corrosion of the skin. Ingestion causes severe burning and corrosion in all portions of the gastrointestinal tract. Avoid the inhalation of fumes. Be particularly careful of fumes near open tank truck domes or open covers on storage vessels.

14/21 mg/m3

When heated or on coming into contact with acids or acidic materials, highly toxic hydrogen sulfide gas may be evolved in large quantities. Exposure to this gas causes headache, dizziness, nausea and vomiting. Continued exposure can lead to loss of consciousness and death.

Not listed as a carcinogen by NTP, IARC or OSHA.

Proper personal protection (See Section IX) is required in the handling of this product.

SECTION IV OCCUPATIONAL EXPOSURE LIMITS

Not established for this product. ACGIH and OSHA limits for hydrogen sulfide are TWA 10 ppm and STEL 15 ppm. The OSHA acceptable ceiling for hydogen sulfide is 20 ppm.

SECTION V EMERGENCY AND FIRST AID PROCEDURES

Inhalation: Remove victim from contaminated area. Wear protective respiratory equipment. If breathing is labored, administer oxygen. If breathing has ceased, clear airway and start mouth to mouth resuscitation. If heart has stopped beating, external heart massage should be applied. Obtain immediate medical attention.

Eye Contact: Immediately flush with large quantities of water for 15 minutes. Hold eyelids apart during irrigation to insure thorough flushing of the entire area of the eye and lids with water. Obtain immediate medical attention.

Skin Contact: Immediately flush with large quantities of water for 15 minutes. Remove contaminated clothing under shower. Obtain medical attention if irritation persists.

Ingestion: Do not induce vomiting. If victim is conscious, immediately give large quantities of water. If vomiting does occur, repeat fluid administration. Obtain immediate medical attention.

SECTION VI PHYSICAL DATA

BOILING POINT (°F)	▶ 253 - 269	MELTING POINT (°F)	▶ 62.6	VAPOR PRESSURE (mmHg)	▶ Not determined
SPECIFIC GRAVITY (H_2O=1)	▶ 1.152 - 1.303	% VOLATILE BY VOLUME	▶ 55 - 80 (water)	VAPOR DENSITY (AIR = 1)	▶ Not determined
SOLUBILITY IN WATER	▶ Complete	EVAPORATION RATE (BUTYL ACETATE = 1)	▶ Not determined	Freeze Pt: 20% = 0°F, 45% = 56°F pH: 10.4 - 11.5	

APPEARANCE AND ODOR

Yellow to red solutions with a strong hydrogen sulfide odor.

SECTION VII FIRE AND EXPLOSION HAZARDS

FLASH POINT AND METHOD USED	FLAMMABLE LIMITS / % VOLUME IN AIR	LOWER	UPPER
Not applicable	Hydrogen Sulfide ▶	4.3	46.0

EXTINGUISHING MEDIA

As appropriate for materials involved in the fire.

SPECIAL FIRE FIGHTING PROCEDURES AND PRECAUTIONS

Sodium hydrosulfide solutions are non-flammable. However, if these solutions are exposed to heat or acids, the hydrogen sulfide gas which is released will form explosive mixtures with air (see above). Personnel fighting a fire in any area where sodium hydrosulfide solution is stored should be equipped with NIOSH approved self-contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Storage vessels in the area of a fire should be thoroughly cooled by water spray or foam. If hydrogen sulfide venting from a vessel in a fire area is burning, it should be permitted to continue to burn until source of ignition has been extinguished

SECTION VIII REACTIVITY

STABILITY ▶ ☐ UNSTABLE ☒ STABLE

HAZARDOUS POLYMERIZATION ▶ ☐ MAY OCCUR ☒ WILL NOT OCCUR

CONDITIONS AND MATERIALS TO AVOID

Avoid any exposure to significant heat or any contact with acids or acidic materials (evolution of hydrogen sulfide). Avoid the storage of combustibles near containers or storage vessels of sodium hydrosulfide solutions.

Sodium hydrosulfide solutions are not compatible with copper, zinc, aluminum and their alloys. See also Section XI.

HAZARDOUS DECOMPOSITION PRODUCTS

In fire conditions, hydrogen sulfide gas will evolve. Combustion of this gas will produce sulfur dioxide.

SECTION IX EMPLOYEE PROTECTION

RESPIRATORY PROTECTION

Good ventilation must be provided. Feed the product below the surface of water to minimize the formation of product vapors. NIOSH approved self-contained breathing apparatus should be readily available in case of a spill or other emergency.

PROTECTIVE CLOTHING

Neoprene apron, gloves and protective boots. Safety goggles or preferably a full face shield is required. Do not wear contact lenses.

ADDITIONAL PROTECTIVE MEASURES

Contaminated clothing should be removed immediatly and launderd prior to reuse. Contaminated leather shoes cannot be cleaned and should be discarded.

SECTION X ENVIRONMENTAL PROTECTION

SPILL OR LEAK PROCEDURES

Use all proper protective equipment.

Absorb small spills with sand, earth, sweeping compound or other inert absorbant. Treat spill with dilute hydrogen peroxide to oxidize sulfides to sulfates. Place contaminated material in approved container for disposal.

Large spills should be diked to prevent entry into sewers or drains. Recover as much of the solution as possible. Carefully treat remaining material with dilute hydrogen peroxide to oxidize sulfides to sulfates. CAUTION, there will be an evolution of heat and some release of hydrogen sulfide. Neutralize remaining material, if necessary and place contaminated material in approved containers for disposal.

WASTE DISPOSAL

Dispose of contaminated material in an approved chemical waste landfill in accordance with all governmental regulations.

ENVIRONMENTAL HAZARDS

Avoid discharge of significant quantities of the product to surface waterways because of potential aquatic toxicity.

MATERIAL SAFETY DATA SHEET

MSDS NUMBER 080-6J

SECTION XI SPECIAL PRECAUTIONS

Transfer Operations:

Before transfer, carefully inspect all points using seals, gaskets or packings, as well as any hoses to be used, to be certain that they are in place and in good condition. Replace any defective units before transfer. Operators must wear protective equipment.

SECTION XII TRANSPORTATION REQUIRMENTS

DEPARTMENT OF TRANSPORTATION CLASSIFICATION	☐ FLAMMABLE LIQUID	☐ COMBUSTIBLE LIQUID	☐ OXIDIZING MATERIAL	☐ NON-FLAMMABLE GAS
	☐ FLAMMABLE SOLID	☐ POISON, CLASS A	☒ CORROSIVE MATERIAL	☐ NOT HAZARDOUS BY D.O.T. REGULATIONS
	☐ FLAMMABLE GAS	☐ POISON, CLASS B	☐ IRRITATING MATERIAL	☐ OTHER - Specify below

D.O.T. PROPER SHIPPING NAME

Corrosive liquids, poisonous, n.o.s., 8, UN2922, PG II (sodium hydrosulfide solution)

HER REQUIREMENTS

Corrosive placards are required on containers greater than 450 L (119 gal)
Corrosive and poison labels required on smaller containers.

SECTION XIII OTHER REGULATORY CONTROLS

Reportable Quantity (RQ) is 5,000 lbs (100% basis).

All chemicals contained in this product are listed on the Toxic Substance Control Act (TSCA) Inventory.

JUPITER CHEMICALS, INC.
P.O. Box 789
Westlake, LA 70669

James E. Oviatt

James E. Oviatt
Environmental Engineer

FORM # 6012 B

DATE PREPARED
6 - 1 - 1994

ALBRIGHT & WILSON AMERICAS INC. MATERIAL SAFETY DATA SHEET

ALBRIGHT & WILSON AMERICAS INC.
ENVIRONMENTAL SERVICES
P. O. BOX 26229
RICHMOND, VA. 23260-6229 (USA)

********************** PRODUCT IDENTIFICATION **********************

ANTIBLAZE 80

SUPPLIER:
ALBRIGHT & WILSON INC.
CHEMICAL NAMES AND SYNONYMS:
TRIS(1-CHLORO-2-PROPYL) PHOSPHATE
USE OR DESCRIPTION:
FIRE RETARDANT

HEALTH EMERGENCY TELEPHONE:
(803)554-1229
TRANSPORT EMERGENCY TELEPHONE:
(800)424-9300(CHEMTREC)
OTHER DESIGNATION:
947

************* TYPICAL CHEMICAL AND PHYSICAL PROPERTIES *************

APPEARANCE: CLEAR LIQUID	VISCOSITY: AT 100 F, SUS 111.9	AT 40 C, CS 23.3
ODOR: SLIGHT	VISCOSITY: AT 210 F, SUS 39.1	AT 100 C, CS 3.9
RELATIVE DENSITY: 15/4 C 1.29	SOLUBILITY IN WATER: SLIGHT	PH: NE
MELTING POINT: F(C) NE	POUR POINT: F(C) -40(-40)	
BOILING POINT: F(C) 662(350)	FLASH POINT: F(C) (METHOD) 337 F (SETAFLASH CC)	
VAPOR PRESSURE:MM HG 20C < .1		

NA=NOT APPLICABLE NE=NOT ESTABLISHED D=DECOMPOSES

**************************** INGREDIENTS ****************************

	WT PCT (APPROX)	PEL MG/M3	PEL PPM	TLV(TWA) MG/M3	TLV(TWA) PPM
HAZARDOUS INGREDIENTS:					
NONE KNOWN	NA	NA	NA	NA	NA

NOTE: TLVS SHOWN FOR GUIDANCE ONLY. FOLLOW APPLICABLE REGULATIONS.

INFORMATION GIVEN HEREIN IS OFFERED IN GOOD FAITH AS ACCURATE, BUT WITHOUT GUARANTEE. CONDITIONS OF USE AND SUITABILITY OF THE PRODUCT FOR PARTICULAR USES ARE BEYOND OUR CONTROL; ALL RISKS OF USE OF THE PRODUCT ARE THEREFORE ASSUMED BY THE USER AND WE EXPRESSLY DISCLAIM ALL WARRANTIES OF EVERY KIND AND NATURE, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE IN RESPECT TO THE USE OR SUITABILITY OF THE PRODUCT. NOTHING IS INTENDED AS A RECOMMENDATION FOR USES WHICH INFRINGE VALID PATENTS OR AS EXTENDING LICENSE UNDER VALID PATENTS. APPROPRIATE WARNINGS AND SAFE HANDLING PROCEDURES SHOULD BE PROVIDED TO HANDLERS AND USERS.

****************** FIRE AND EXPLOSION HAZARD DATA ******************

FLASH POINT: F(C) (METHOD)	FLAMMABLE LIMITS: LEL	UEL
337 F (SETAFLASH CC)	NE	NE

EXTINGUISHING MEDIA:
CARBON DIOXIDE, FOAM, DRY CHEMICAL AND WATER FOG.

SPECIAL FIRE FIGHTING PROCEDURES:
FIREFIGHTERS MUST USE SELF-CONTAINED BREATHING APPARATUS.
COOL STORAGE DRUMS WITH WATER SPRAY.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
NONE KNOWN

**************** EMERGENCY AND FIRST AID PROCEDURES ****************

EYE CONTACT:
FLUSH WITH WATER.

SKIN CONTACT:
WASH CONTACT AREAS WITH SOAP AND WATER.

INHALATION:
NOT EXPECTED TO BE A PROBLEM.

INGESTION:
IF SWALLOWED, IMMEDIATELY GIVE 1 TO 2 GLASSES OF WATER AND CALL A PHYSICIAN, HOSPITAL EMERGENCY ROOM OR POISON CONTROL CENTER FOR ASSISTANCE. DO NOT INDUCE VOMITING OR GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

*************************** REACTIVITY DATA **************************

STABILITY: (THERMAL, LIGHT, ETC.)	CONDITIONS TO AVOID:
STABLE	HEAT, STRONG OXIDATION, AND WATER

INCOMPATIBILITY: (MATERIALS TO AVOID)
HEAT,ACIDS, BASES.

HAZARDOUS DECOMPOSITION PRODUCTS:
PHOSPHORUS OXIDES. CARBON MONOXIDE. HCL.

HAZARDOUS POLYMERIZATION:	CONDITIONS TO AVOID:
WILL NOT OCCUR	NE

************************ SPILL OR LEAK PROCEDURE ************************

ENVIRONMENTAL IMPACT:

REPORT SPILLS AS REQUIRED TO APPROPRIATE AUTHORITIES. REGUALTIONS REQUIRE IMMEDIATE REPORTING OF SPILLS THAT COULD REACH ANY WATERWAY, INCLUDING INTERMITTENT DRY CREEKS. REPORT SPILL TO NATIONAL RESPONSE CENTER TOLL FREE NUMBER 800-424-8802. IN CASE OF ACCIDENT OR ROAD SPILL NOTIFY CHEMTREC (800) 424-9300.

PROCEDURES IF MATERIAL IS RELEASED OR SPILLED:

ABSORB ON FIRE RETARDANT TREATED SAWDUST, DIATOMACEOUS EARTH, ETC. SCRAPE UP AND REMOVE. DISPOSE OF AT AN APPROPRIATE WASTE DISPOSAL FACILITY IN ACCORDANCE WITH CURRENT APPLICABLE LAWS AND REGULATIONS, AND PRODUCT CHARACTERISTICS AT TIME OF DISPOSAL.

WASTE MANAGEMENT:

DISPOSE OF WASTE BY SUPERVISED INCINERATION IN COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS. DISPOSE OF WASTE AT AN APPROPRIATE WASTE DISPOSAL FACILITY IN ACCORDANCE WITH CURRENT APPLICABLE LAWS AND REGULATIONS, AND PRODUCT CHARACTERISTICS AT TIME OF DISPOSAL.

******************* SPECIAL PROTECTION INFORMATION *******************

EYE PROTECTION:

NO SPECIAL EQUIPMENT REQUIRED.

SKIN PROTECTION:

NO SPECIAL EQUIPMENT REQUIRED. HOWEVER, GOOD PERSONAL HYGIENE PRACTICES SHOULD ALWAYS BE FOLLOWED.

RESPIRATORY PROTECTION:

NO SPECIAL REQUIREMENTS UNDER ORDINARY CONDITIONS OF USE AND WITH ADEQUATE VENTILATION.

VENTILATION:

NO SPECIAL REQUIREMENTS UNDER ORDINARY CONDITIONS OF USE AND WITH ADEQUATE VENTILATION.

OTHER: PRIMARY ROUTE OF ENTRY- SKIN CONTACT

************************* SPECIAL PRECAUTIONS *************************

HANDLING: NO SPECIAL PRECAUTIONS REQUIRED.

STORAGE: NO SPECIAL REQUIREMENTS. AVOID EXPOSURE TO TEMPERATURES ABOVE 220F.

STORED MATERIALS MUST BE LABELED AS: ANTIBLAZE 80.

THIS PRODUCT IS CLASSIFIED AS NOT RESTRICTED BY DOT.

********************** HEALTH HAZARD DATA **************************

ACUTE HEALTH HAZARDS

POSSIBLE MILD IRRITATION OF THE EYES AND SKIN.

CARCINOGENICITY
LISTED: NTP NO IARC MONOGRAPHS NO OSHA REGULATED NO

SIGNS AND SYMPTOMS OF EXPOSURE:

POSSIBLE MILD IRRITATION OF THE EYE SKIN.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:

NONE KNOWN

SUBACUTE AND MUTAGENICITY (SUMMARY)

AMES TEST: NEGATIVE

CHRONIC OR SPECIALIZED (SUMMARY)

NONE KNOWN

TARGET ORGAN EFFECTS

POSSIBLY SKIN AND EYES.

OTHER DATA

NONE KNOWN

************************* WARNING STATEMENTS ****************************

CALIFORNIA:
"WARNING: THIS PRODUCT MAY CONTAIN A CHEMICAL KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, OR BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM".

ALL PHOSPHORUS COMPOUNDS MAY BE REASONABLY EXPECTED TO CONTAIN ARSENIC AND POSSIBLY CADMIUM AND/OR LEAD IN CONCENTRATIONS RANGING FROM A FEW PARTS PER BILLION TO A FEW PARTS PER MILLION.

HAZARD WARNING: THERE IS A POSSIBILITY BICYCLIC PHOSPHATES OR PHOSPHITES CAN BE PRODUCED AS A RESULT OF THE THERMAL DECOMPOSITION OF THIS PRODUCT IN COMBINATION WITH TRIMETHYLOL PROPANE, TRIMETHYLOL PROPANE DERIVED PRODUCTS OR THEIR CORRESPONDING TRIMETHYLOL ALKANE HOMOLOGS. BICYCLIC PHOSPHATES AND PHOSPHITES ARE A CLASS OF MATERIALS WITH ACUTE NEUROTOXIC PROPERTIES WHICH PRODUCE CHARACTERISTIC CONVULSIVE SEIZURES IN TEST ANIMALS. THEREFORE, THIS PRODUCT SHOULD NOT BE USED IN CONJUNCTION WITH TRIMETHYLOL PROPANE OR TRIMETHYLOL PROPANE DERIVED PRODUCTS.

Appendix C

Article on Carbon Drum Systems Applicable to Crude Sulfate Turpentine

This appendix presents an article, "Control of Malodorous Compounds by Carbon Adsorption," that describes systems of the type used at the PDTI facility which include drums of activated carbon. The article discusses fires that have occurred in such systems in the past and their causes.

Appendix D

Chemical Safety Alert -- Fire Hazard from Carbon AdsorptionDeodorizing Systems

United States
Environmental Protection
Agency

Office of Solid Waste
and Emergency Response
(5104)

EPA 550-F-97-002e
May 1997

FIRE HAZARD FROM CARBON ADSORPTION DEODORIZING SYSTEMS

The Environmental Protection Agency (EPA) is issuing this *Alert* as part of its ongoing effort to protect human health and the environment by preventing chemical accidents. Under CERCLA, section 104(e) and Clean Air Act (CAA), EPA has authority to conduct chemical accident investigations. Additionally, in January 1995, the Administration asked the Occupational Safety and Health Administration (OSHA) and EPA to jointly undertake investigations to determine the root cause(s) of chemical accidents and to issue public reports containing recommendations to prevent similar accidents. EPA has created a chemical accident investigation team to work jointly with OSHA in these efforts. Prior to the release of a full report, EPA intends to publish *Alerts* as promptly as possible to increase awareness of possible hazards. *Alerts* may also be issued when EPA becomes aware of a significant hazard. It is important that facilities, SERCs, LEPCs, emergency responders and others review this information and take appropriate steps to minimize risk.

Chemical Safety

Alert

p71022-e

PROBLEM

Activated carbon systems used to adsorb vapors for control of offensive odors may pose a fire hazard when used for certain types of substances, if proper procedures are not followed. In particular, crude sulfate turpentine, commonly produced in the pulp and paper industry, can pose a fire hazard if the adsorption system is not properly designed and proper procedures are not implemented. Facilities should take precautions to avoid or mitigate these fire hazards.

ACCIDENTS

In a 1995 accident at a chemical terminal facility, a fire and explosion occurred involving three tanks of crude sulfate turpentine. The tanks were connected to drums of activated carbon for deodorizing. The fire and explosion damaged other storage tanks, resulting in the release of toxic gases and forcing a large-scale evacuation of area residents.

Fires have occurred in the past in activated carbon systems used for deodorizing crude sulfate turpentine. In general, such fires have not had effects as serious as those reported in the 1995 fire. Serious effects would not be expected if fires are confined to the activated carbon containers and do not spread to tanks containing flammable or combustible substances.

HAZARD AWARENESS

Activated carbon is widely used to adsorb vapors to prevent their release to the air. For certain classes of chemicals, reaction or adsorption on the carbon surface is accompanied by release of a large amount of heat that may cause hot spots in the carbon bed. Such chemicals include organic sulfur compounds (e.g., mercaptans), which may be found as impurities in crude sulfate turpentine and other materials. Other classes of chemicals that may cause large thermal releases are ketones, aldehydes, and some organic acids. Adsorption of high vapor concentrations of organic compounds also can create hot spots. If flammable vapors are present, the heat released by adsorption or reaction on the surface of the carbon may create a fire hazard (e.g., a fire may start if the temperature reaches the autoignition temperature of the vapor and oxygen is present to support ignition).

The fire hazards of carbon adsorption deodorizing systems may increase at night. At certain times (typically during the day), high temperatures may lead to the expansion of vapor in the system, and vapor is likely to exit to the atmosphere. When temperatures drop (typically at night), a slight vacuum may be created, causing air to be drawn into the system. If the carbon surface is very hot, because of the heat generated by adsorption, air drawn in over the carbon may provide the oxygen to start a fire.

HAZARD REDUCTION

Facilities should be aware of the potential fire hazards of activated carbon systems for absorbing flammable vapors and take steps to minimize these hazards. Actions that may help to prevent fires include:

- Follow the manufacturer's instructions for design and operation of activated carbon adsorption systems.
- Ensure that a qualified engineer or technician supervises the design, construction, and operation of the carbon adsorption system.
- Evaluate the composition of the vapors that will contact the carbon and heed the manufacturer's warnings about potential hazardous interactions with the carbon. If the vapor may contain organic sulfur compounds (e.g., vapor from crude sulfate turpentine), ketones, aldehydes, or organic acids, or if the vapor contains high concentrations of organic compounds, consider the potential for development of hot spots on the carbon.
- Test the action of the vapors on carbon for potential heat release before putting the carbon adsorption system into service, if possible reactions are not known.
- If test results or known reactions with carbon indicate the potential for fires in the activated carbon system, design the system so that air does not enter the system over the carbon bed (e.g., install vacuum breakers on the storage tanks).
- If the potential exists for fires in the activated carbon system, be sure the carbon containers are separated from containers of flammable or combustible substances and can be easily and rapidly removed in case the container becomes hot or catches fire.
- If high concentrations of organic compounds may cause development of high temperatures, take steps to control the heating. Such steps may include diluting inlet air, time weighting the inlet concentration to allow heat to dissipate, and prewetting the carbon.
- Visually inspect activated carbon adsorption systems frequently for hot spots and fires.
- Before using an activated carbon adsorption system, ensure that safety systems are in place for fire prevention and mitigation, including flame arrestors to prevent the spread of fire from the carbon containers to the flammable chemical containers.
- Ensure that flammable and combustible chemicals connected to activated carbon adsorption systems are handled in accordance with applicable regulations, codes, and standards.

INFORMATION RESOURCES

Some references that may contain information about the fire hazards of activated carbon adsorption systems and methods of minimizing them are listed below. Regulations applicable to such systems, and codes and standards that may be relevant, are also listed.

For more information consult the following:

General References

Information on carbon adsorption systems for crude sulfate turpentine can be found in W.A. Harrell, J.O. Sewall, and T.J. Walsh, “Control of Malodorous Compounds by Carbon Adsorption,” American Institute of Chemical Engineers, *Loss Prevention*, Volume 12, 1979, pp 124-127.

Manufacturers of activated carbon can provide product literature with information on properties, safe handling, and use.

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Statutes and Regulations

Section 112(r) of the Clean Air Act focuses on prevention of chemical accidents. It imposes on facilities with regulated substances or other extremely hazardous substances a general duty to prevent and mitigate accidental releases. Accident prevention activities include identifying hazards and operating a safe facility.

EPA's Risk Management Program (RMP) Rule [40 CFR 68] is intended to prevent and mitigate accidental releases of listed toxic and flammable substances. Requirements under the RMP rule include development of a hazard assessment, a prevention program, and an emergency response program.

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Processes containing flammable gases and liquids may be covered under the Occupational Safety and Health Administration's (OSHA) Process Safety Management Standard, which establishes procedures intended to protect employees by preventing or minimizing the consequences of chemical accidents involving highly hazardous chemicals [29 CFR 1910.119].

OSHA also has a Standard for Flammable and Combustible Liquids [29 CFR 1910.106].

Occupational Safety and Health Administration
Phone: (202) 219-8151 - Public Information
Web site: http://www.osha.gov

◆

The Department of Transportation (DOT) regulates transportation of activated carbon and other flammable and combustible substances under its Hazardous Materials Regulations. Activated carbon and many combustible and flammable substances are listed individually, and several categories of flammable and combustible substances are included, in DOT's Hazardous Materials Table [49 CFR 172.102].

Department of Transportation
Phone: (202) 366-5580 - Public Information
Web site: http://www.dot.gov

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Codes and Standards

The National Fire Protection Association (NFPA) has a code for flammable and combustible liquids that may be adopted into law at the state or local level. NFPA 30 — Flammable and Combustible Liquids Code, 1996.

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
Phone: (617) 770-3000
Customer Service: 1 (800) 344-3555
Web site: http://www.nfpa.org

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FOR MORE INFORMATION...

CONTACT THE EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW HOTLINE

(800) 424-9346 OR (703) 412-9810
TDD (800) 553-7672

MONDAY-FRIDAY, 9 AM TO 6 PM, EASTERN TIME

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VISIT THE CEPPO HOME PAGE ON THE WORLD WIDE WEB AT:

http://www.epa.gov/swercepp/

NOTICE

The statements in this document are intended solely as guidance. This document does not substitute for EPA's or other agency regulations, nor is it a regulation itself. Site-specific application of the guidance may vary depending on process activities, and may not apply to a given situation. EPA may revoke, modify, or suspend this guidance in the future, as appropriate.