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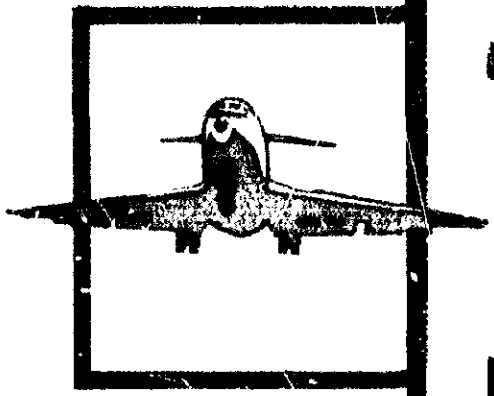

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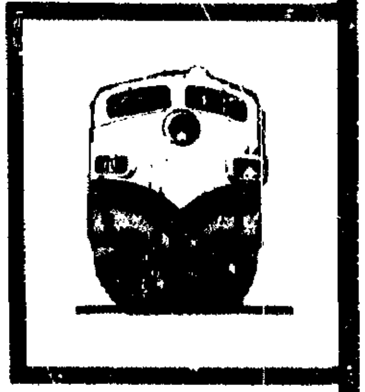

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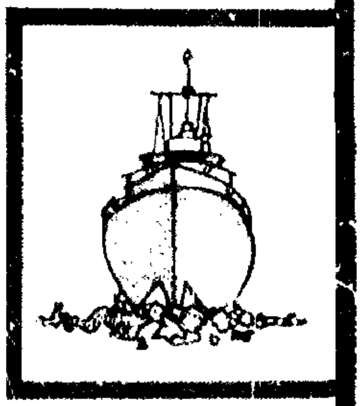
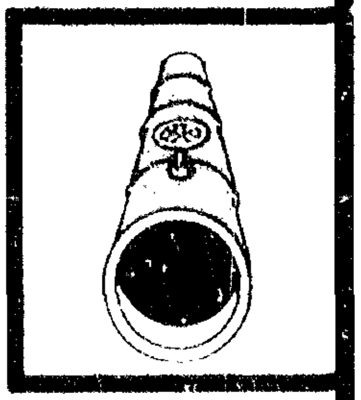
RAILROAD ACCIDENT REPORT



VINYL CHIORIDE MONOMER RELEASE FROM A RAILROAD TANK CAR AND FIRE FORMOSA PLASTICS CORPORATION PLANT BATON ROUGE, LOUISIANA JULY 30, 1983



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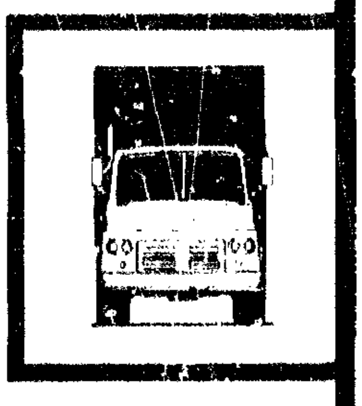

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16. Abstract At 3:45 a.m., on July 30, 1983, vinyl chloride monomer (VCM) under pressure escaped from a railroad tank car at the loading facility within the Formosa Plastics Corporation chemical manufacturing plant at Baton Rouge, Louisiana. The released VCM was ignited by an undetermined source, and a large billowing fire ensued. An adjacent tank car containing VCM was involved in the fire but did not rupture violently. Two persons were injured seriously, two tank cars were destroyed, three tank cars were damaged moderately, and the loading facility was damaged extensively. Damage was estimated to be $1 million.

The National Transportation Safety Board determines that the probable cause of the sudden release and ignition of vinyl chloride monomer from a loaded tank car was a plant employee's failure to close the tank car liquid valves and purge the pressurized vapor return and loading hoses before disconnecting them, and the presence of one or more sources of ignition at the loading rack. Contributing to the cause of the accident was the failure of the Formosa Plastics Corporation to maintain safe facilities for the loading of vinyl chloride monomer and to provide written procedures, adequate training, and supervision for its loading personnel. Also contributing to the cause of the accident were the improperly seated excess flow valves in the tank car.

17. Key Words

tank cars; loading rack; tank car fittings; tank car insulation; tank car loading fixtures, excess flow valves; ignition; vinyl chloride monomer; escape; emergency response

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: May 14, 1985

VINYL CHLORIDE MONOMER RELEASE FROM A RAILROAD TANK CAR AND FIRE FORMOSA PLASTICS CORPORATION PLANT BATON ROUGE, LOUISIANA JULY 30, 1983

SYNOPSIS

At 3:45 a.m., on July 30, 1983, vinyl chloride monomer (VCM) under pressure escaped from a railroad tank car at the loading facility within the Formosa Plastics Corporation chemical manufacturing plant at Baton Rouge, Louisiana. The released VCM was ignited by an undetermined source, and a large billowing fire ensued. An adjacent tank car containing VCM was involved in the fire but did not rupture violently. Two persons were injured seriously, two tank cars were destroyed, three tank cars were damaged moderately, and the loading facility was damaged extensively. Damage was estimated to be $1 million.

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INVESTIGATION

The Accident

During the evening of July 29, 1983, an employee (loader-1) at the Formosa Plastics Corporation (Formosa) chemical manufacturing plant at Baton Rouge, Louisiana, was assigned to load vinyl chloride monomer (VCM) 1/ into five railroad tank cars located at station Nos. 5-1, 5-2, 5-3, 6-1, and 6-2 at the plant's VCM loading rack. After loading all five tank cars, he began to secure them for shipment, a process which includes closing the VCM supply valve on the loading rack, closing the liquid valves and vapor valve 2/ on tank

1/ Classified by the U.S. Department of Transportation as a flammable compressed gas, VCM is ignited easily in either liquid or vapor form, producing hazardous combustible gases largely composed of hydrogen chloride and carbon monoxide. It also is classified as carcinogenic.

2/ As liquid is loaded into a tank car, a vapor valve allows the vapor inside the tank car to exhaust, thereby preventing pressure buildup inside the tank car and permitting a full load of liquid to be loaded.

cars, purging the liquid loading hoses of residual VCM with nitrogen, purging the vapor hoses with nitrogen, venting the hoses of nitrogen, releasing the locking cams on the quick-release coupler linking the loading hose to the liquid valve nipple, removing the hoses from the tank cars, and closing the tank car manway cover. (See figure 1.) He secured the tank car at station No. 5-2 but could not finish securing the four other tank cars because the pressure in the nitrogen supply line dropped to 90 psi because of other users. This pressure was too low to overcome the 120-psi pressure in the loaded tank cars. He said that on each of the four remaining tank cars, he closed off the vapor valve but left connected the vapor hose, which carries vapor from the tank car to the loading rack; left connected the two liquid loading hoses, which carry the liquid VCM from the loading rack to the tank car and in which was residual VCM; and left open the tank car liquid valves, which are located on the tank car where the liquid loading hoses are attached to liquid valve nipples during loading. (See figures 1 and 2.)

Loader-1 drew samples of the VCM from the loaded tank cars to take to the plant laboratory for testing. Before he left for the laboratory about 3:30 a.m., loader-1 was joined by another employee (loader-2). Loader-1 explained to loader-2 that he had not finished securing for shipment the four remaining tank cars because of low nitrogen pressure. He then left the loading area for the laboratory.

Loader-2 said that after loader-1 left, he crossed over the bridge from the loading rack onto the dome of the tank car located at station No. 6-2 (see figure 2) and stopped to look at the early morning sky. Loader-2 said that, as he did so, he was struck on the back by one of the VCM liquid loading hoses, which had come loose from its attachment to the tank car. (See figure 1.) Seeing pressurized VCM pouring from the liquid valve nipple and knowing that VCM is combustible, is carcinogenic, and freezes the skin on contact, he ran to the end of the tank car and slid down the side of the car to the ground below. He did not use the bridge from the tank dome to the loading rack to escape because the loose hose was between his position on the tank car and the bridge. The sudden outward flow of VCM was not stopped by the tank car's excess flow valve. 3/ (See figure 1.) VCM accumulated on the ground below and between the tank cars at station Nos. 6-2 and 5-2 and was ignited by an undetermined source; a large billowing fire ensued. VCM spraying from the liquid valve nipple of the tank car at station No. 6-2 was ignited and, because of the angle of the valve nipple, burning VCM sprayed like a torch onto the tank car at station No. 5-2. When the other liquid loading hose on the tank car at station No. 6-2 was burned off, burning VCM also began spraying onto the tank car at station No. 5-2 from the car's other liquid valve nipple.

Although severely burned, loader-2 crawled from the loading area. Another employee (loader-3), who was standing on a caustic soda loading rack nearby, smelled the VCM, turned toward the VCM loading rack, and was struck by a fireball. Although seriously burned, he immediately ran from the area. No one else was injured.

Firefighters began to arrive onscene within 15 minutes, and they found both tank cars engulfed in flames. The fire in the tank car at station No. 6-2 burned out by midafternoon. The tank car at station No. 5-2 burned for 120 hours throughout which water was applied to cool the adjacent tank cars loaded with VCM.

3/ A safety device designed to shut off the sudden outward flow of liquid in the event an external liquid valve is damaged or severed from the tank piping during transportation.

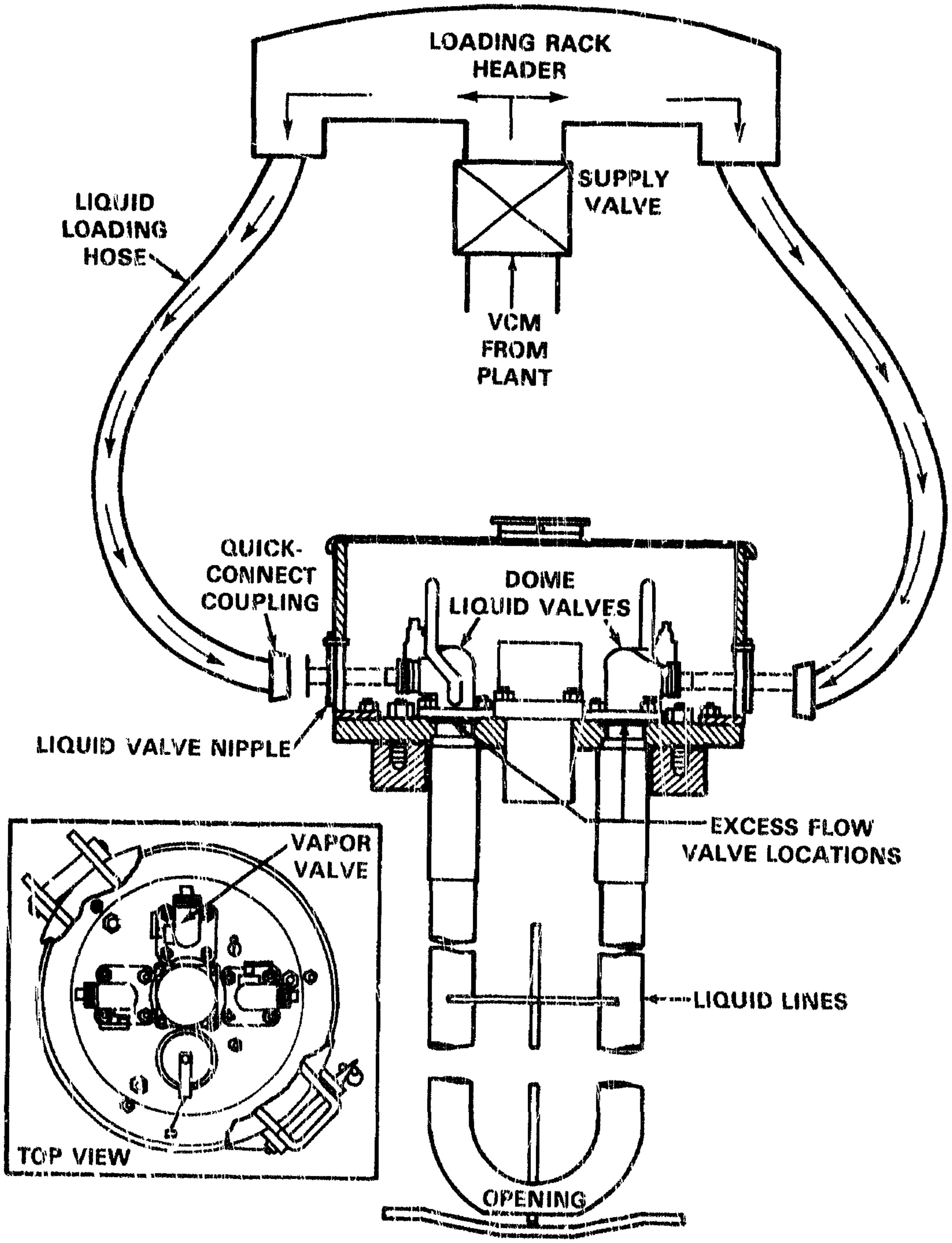

Figure 1.--Side view of tank car with liquid loading hoses attached for loading, and top view (inset) of tank car shown without manway bonnet cover.

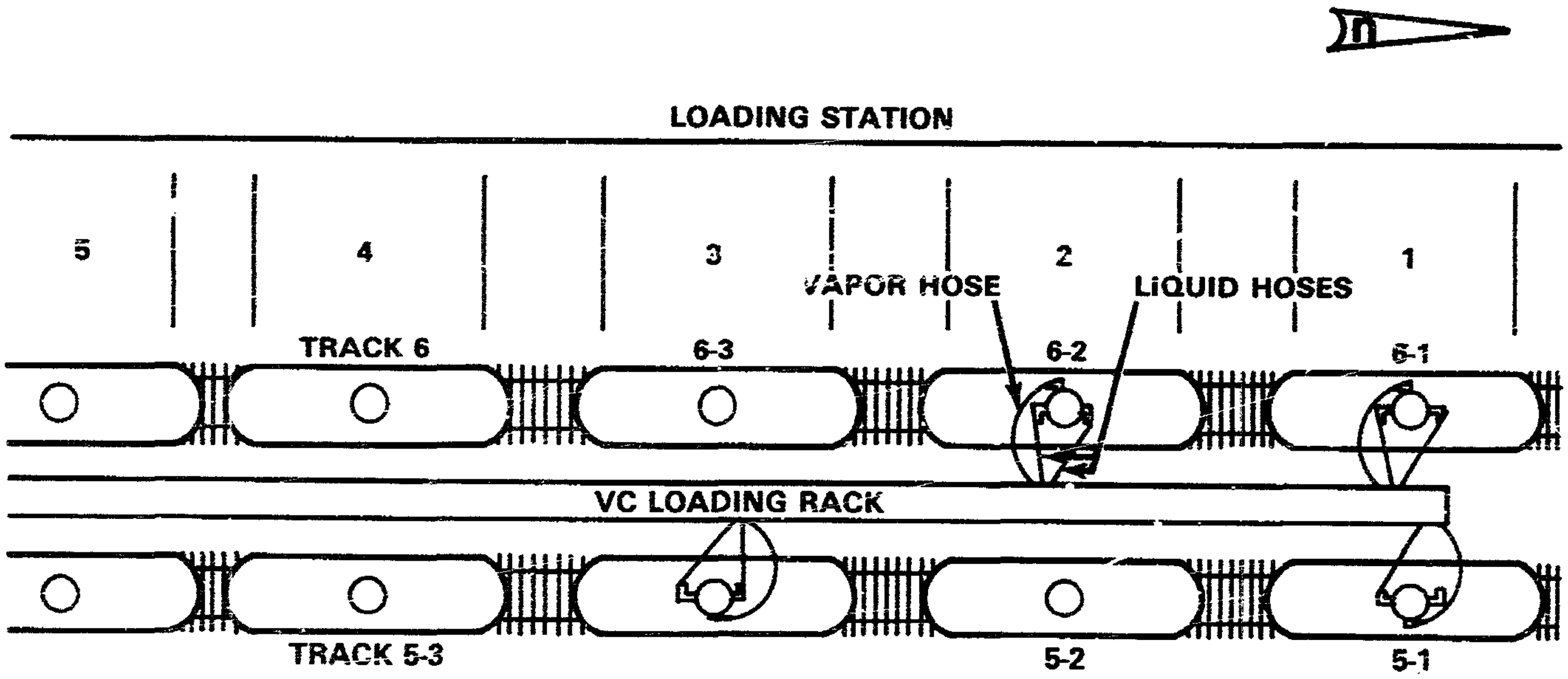

Figure 2.—Tank car locations and hose attachments when loader-1 stopped working at the loading rack.

Following the accident, investigators found that the safety valve 4/ (see figure 1) on the tank car at station No. 6-2 did not activate during the fire. Loader-1 had laid the seal used to secure the manway bonnet cover on top of the safety valve before the accident, and the seal was not blown away as it would have been if the safety valve had released. Investigators also found that the liquid loading and vapor hoses had been removed from the tank cars at station Nos. 5-1 and 6-1 and that all of the valves and manway covers on these tank cars had been closed before the accident.

Injuries to Persons

Injuries	Plant employees	Emergency response personnel	Total
Fatal	0	0	0
Nonfatal	2	0	2
Total	2	0	2

Damage

The VCM loading rack was damaged extensively between station Nos. 6-2 and 5-2. The fire destroyed the platform, crossover bridges, piping, and electrical lines.

The tank car at station No. 6-2 was destroyed. The steel outer jacket was burned and distorted by the heat of the fire, and the insulation was consumed by the fire.

The tank car at station No. 5-2 also was destroyed. The steel outer jacket was burned, and the insulation at the top of the south end of the car was consumed by the fire. The tank car walkway and handrail melted and collapsed. The wall of the tank car manway protective housing and cover on the side nearest the fire melted. The tank car shell at the top of the south end of the car bulged, causing the metal to stretch and become thinned. The metal at the bulged area split, and a hole 2 3/8 inches long and 1/2 inch wide developed. Five small holes developed in the stretched and thinned area at the side of the bulge. Built-up pressure began to release through the safety valve on the car at station No. 5-2 about 50 to 60 minutes after the fire began. This release of pressure prevented sufficient pressure from building in the tank car to cause a violent rupture of the tank shell. The bulging and thinning of the shell metal and the holes and cracks that formed in the tank also allowed release of internal pressure.

Three other tank cars in adjacent loading stations were damaged moderately by the heat of the fire.

Tank Car Information

The tank car at station No. 6-2, a U.S. Department of Transportation (DOT) specification 105A300W 5/ tank car built by the Union Tank Car Company (Union) in March 1979, was owned by Union and was leased by Formosa. It had a capacity of 24,859 gallons, a light weight of 83,000 pounds, and was designed to have a fully loaded weight of

4/ The safety valve was set to release when the internal pressure exceeded 247 psi and thereby prevent a violent rupture of the tank shell.
5/ The numbers and letters in the DOT classification refer to the following: "105" (class designation), "A" (no significance), "300" (test pressure), "W" (welded construction).

180,000 pounds. The car was insulated with 1 inch of mineral wool and 3 inches of fiberglass. The tank shell and tank heads were 9/16-inch-thick steel. The tank shell was 44 feet 2 1/2 inches long and had an outside diameter of 114 inches. A 1/8-inch-thick steel weather jacket covered the insulation and tank shell.

The tank car at station No. 5-2 was built as a DOT specification 112A340W 6/ tank car by Union in November 1968. In 1975, the car was modified to reduce the capacity of the tank from 41,777 gallons to 27,382 gallons. In March 1980, the car was fitted with head shields, Korotherm insulation, and a steel weather jacket so that it would meet the requirements of specification 112J340W 7/; the tank capacity was not changed. The tank shell was 5/8-inch-thick steel, and the tank heads were 11/16-inch-thick steel. The tank shell was 48 feet 10 inches long and had an outside diameter of 119.3 inches.

Both tank cars had two internal liquid lines through which chemicals could be loaded. The liquid lines extended into the tank from the manway entrance at the car dome. (See figure 1.) Each liquid line was fitted at the manway entrance with a 2-inch-diameter, ball-type, steel-body angle valve containing a stainless steel ball. Directly under each liquid valve was a 3-inch-diameter excess flow valve. Each tank car also contained a vapor line through which chemical vapors could be vented during loading. The vapor line extended into the tank from the manway entrance. The vapor line was fitted at the manway entrance with a 2-inch-diameter, steel-body angle valve containing a stainless steel ball. Directly under the vapor valve was a 2-inch-diameter excess flow valve. Both cars were equipped with a safety valve and were stenciled to indicate that the valve was set at 247 psi. Both tank cars also were equipped with a sampling line, a gauging device, and a thermometer well at the manway entrance.

Company, Personnel, and Training Information

The chemical manufacturing plant was built by the Allied Chemical Company and later sold to the ICI Company. During the years that Allied and ICI owned the plant, railroad tank cars were loaded by employees assigned specifically for this purpose. The loaders so assigned usually worked one of three 8-hour shifts, 5 days a week. Depending on the production schedule, there may have been a 7-day loading operation on one shift, and at other times only two shifts loading 5 days a week. Two loaders always were assigned to work together on the VCM loading rack. A supervisor also was assigned to the tank car loading rack. Other operating department employees were assigned to the duties in the tank farm, to make pipeline deliveries, and to load trucks, barges, and seagoing vessels.

ICI sold the plant to Formosa in 1981. Formosa has reorganized the plant operations and added supervision of the tank car loading operations to the duties of the supervisors at the powerhouse. Formosa has established two 12-hour shifts, from 6 a.m. to 6 p.m. and from 6 p.m. to 6 a.m. Two loaders are assigned to the 6 p.m. to 6 a.m. shift. In addition to loading tank cars at the VCM loading rack and the liquid caustic soda loading rack, the loaders may be assigned to the duties in the tank farm, to make pipeline deliveries, and to load trucks, barges, and seagoing vessels. Since Formosa reorganized, two loaders no longer are required to work together on the VCM loading rack.

6/ The numbers and letters in the DOT classification refer to the following: "112" (class designation), "A" "(no significance), "340" (test pressure), and "W" (welded construction).
7/ J indicates that the tank car is equipped with a tank car head shield and a thermal protection system enclosed in a metal jacket, as required by the phase II report on behavior of a DOT 112J340W tank car in a torch fire accident.

A loader who was not involved in this accident told Safety Board investigators that before the reorganization, the two loaders assigned to the VCM loading rack would do maintenance work on the loading equipment, such as changing loading hoses as needed, changing fittings as required, and replacing broken cam arms on the quick-release couplings when they were broken. This loader said that since only one loader has been assigned to the VCM loading rack per shift, loaders have not done any preventive maintenance work on the loading equipment and broken equipment is repaired only as it is needed in the loading operation. Formosa's Manager of Administration said that an industrial engineering study has not been made of the total workload of the loaders, but that the superintendent of the loading section had evaluated the workload and determined that it could be handled safely. The Manager of Administration serves as Formosa's chief safety officer and trains employees in the proper use of air packs, respirators, safety glasses, and hard hats.

At the time of the reorganization by Formosa, some employees who had no previous experience loading tank cars were reassigned from other duties to loading tank cars. Loader-2, who was on the tank car at station No. 6-2 at the time of the accident, had been loading tank cars for 10 months. He was trained on the job for VCM loading by observing other loaders. Loader-1 had 10 years' experience as a loader at the plant.

The Safety Board's investigation determined that the most experienced loading employees--one with 11 years and another with 10 years--had received only on-the-job training for loading VCM. These two employees had instructed the less experienced and newly assigned employees. Employees assigned to the tank car loading operations said that they had never seen a written procedure for loading VCM in railroad tank cars. After this accident, Formosa issued a procedure. (See appendix B.) The previous owners of the plant, Allied and ICI, relied almost exclusively on on-the-job training for loaders and the use of supervisors assigned specifically to the loading area.

The Chemical Safety Data Sheet SD-56 for Vinyl Chloride, issued by the Chemical Manufacturers Association (CMA) in 1972, addresses employee safety in handling VCM. (See appendix C.) The publication details information that supervisors and employees who are engaged in the loading of VCM should understand about the product and discusses the training they should receive. The publication gives an outline of a safety review that supervisors and employees of a loading facility should conduct to identify all danger points and recommends that the safety review be repeated periodically for all chemical processing operations and always following a significant change in the process. The publication states that all safety precautions to be followed should be explained in standard operating procedures.

Facility Information

The plant has facilities for loading chemicals on railroad cars, tank trucks, seagoing barges, and pipelines. Adjoining the Formosa property are an Ethyl Corporation plant to the east, a Copolymer Corporation plant to the north, the Mississippi River to the west, and an Exxon Oil refinery to the south.

The VCM railroad tank car loading rack facility is located in the center of the plant near the liquid chlorine facility. The VCM production and storage spheres are located to the north of the loading rack. High-pressure storage tanks and the liquid caustic soda railroad tank car loading rack are located to the east. An ethylene dichloride low-pressure storage tank is located to the west. All of these facilities are located within several hundred feet of the VCM loading rack and would very likely have been affected by a violent tank car rupture.

Method of Operation

The VCM loading rack is an elevated metal walkway between two railroad tracks that provides easy access to the valves located in the domes atop the tank cars. On the loading rack are (1) the VCM liquid pipes leading from the VCM low-pressure storage spheres (routed through an electrical-powered pump located in the production plant), (2) the VCM vapor recovery pipes returning to the VCM production plant, (3) the gaseous nitrogen pipes returning to the liquid nitrogen cryogenic storage tanks (through a heat exchanger), (4) the electrical conduit that supplies lighting for nighttime loading, (5) liquid and vapor hoses for loading the cars, (6) water pipes, (7) ambient air sampling lines, (8) a small personnel shelter at the middle of the rack, and (9) a stairway to the ground at each end of the rack.

A trackmobile is used to spot the empty tank cars at the loading rack with the car domes next to the loading stations. A ground wire is connected to the cars, the car wheels are chocked, and the hand brakes are applied. A loader lowers a small walkway that is hinged at the loading rack for access to the tank car domes. Upon boarding the car, the loader opens the dome protective housing cover and latches it in an open position. The loader unplugs the sample valve and takes a sample of any residual VCM from the car. If the VCM is not contaminated, the loader connects the two liquid loading hoses from the loading rack with quick-connect couplers to the two liquid valve nipples of the tank car. The loader opens the vapor valve and two liquid valves on the tank car and returns to the loading rack and opens the vapor recovery valve and the supply valve.

When all of the tank cars that are to be loaded are hooked up, the loader uses a radio to instruct the VCM plant operator in the plant control room to start the liquid VCM pump, and the VCM begins to flow into the tank car. When the gauging device indicates that the VCM in the tank car has reached a predetermined level near the level permitted by Federal regulation (49 CFR 173.314(f)(1)), the supply valve on the loading rack is closed. When all of the cars are loaded, the loader uses the radio to instruct the VCM plant operator to shut off the liquid VCM pump. Next, the loader opens the nitrogen valve, and the nitrogen pressure forces the residual VCM in the liquid loading hoses into the tank car. The loader closes the vapor valve and the liquid valve on the tank car, and the nitrogen pressure is vented from the liquid loading hoses into the environment. This action releases the pressure in the vapor hose, permitting the liquid loading hoses to be uncoupled from the car.

There are no Federal regulations governing the valves, hoses, or connectors used on a rack facility for the loading of rail cars with a hazardous material.

The chief safety officer for Formosa stated that the company safety program is administered by a safety council made up of the top plant managers. They meet each month to review problems and establish policy and procedures. The safety council chairman and the chief safety officer then meet with all of the plant supervisors to discuss the information that the safety council has considered that month. The supervisors in turn conduct safety meetings with employees throughout the plant. The chief safety officer further stated that there is a program to monitor the safety practices of employees. A designated safety manager tours the plant observing employees as they work to see that the job is being done correctly, that the proper tools are being used, and that employees use their safety gear. He stated that there were no specific safety rules established for individual jobs in the plant.

Supervisors and employees involved in this accident stated that they did not know if an emergency plan existed in the plant. They were not aware of any procedures they were to follow in the event of an emergency, or of a specific evacuation site when an accident occurs. Formosa gave Safety Board investigators a copy of an emergency plan for the plant and advised that the plan had been in effect for many years and that top managers knew of the plan.

Meteorological Information

The temperature was 65°, winds were light and variable, and the night was clear at the time of the accident.

Ignition Sources

Investigators were unable to determine the source of ignition. The CMA Chemical Safety Data Sheet SD-56 states:

> Vinyl Chloride is a gas at normal atmospheric temperature and pressure. The gas will burn very readily in proper mixtures of air or oxygen. An explosion hazard can exist when draining samples or venting to the atmosphere. Open flames, local hot spots, friction, any spark producing equipment, and static electricity are to be avoided when handling this material.
>
> * * *
>
> All electrical equipment, motors, lights, and flashlights used in an area in which vinyl chloride is stored or handled should conform to the National Electrical Code.

The conduit which carried the electrical lines along the loading rack was designed to prevent electrical sparking from reaching an explosive gaseous atmosphere and was termed "explosion proof;" however, investigators found that some conduit coverplates under the racks were missing, which exposed the wiring and negated the explosion-proof feature of the installation. The speaker assembly on the intercom system at the loading rack was neither designed nor protected to prevent electrical sparking in an explosive, gaseous atmosphere. A grounding cable at the track level was rusted through and did not provide grounding protection. The flashlights used by the loaders were not approved for use in a VCM handling area. Although the radios used by the loaders were authorized for use in hazardous locations, the batteries being used in the radios were not because they supplied an amount of current that exceeded the level of current that precludes thermal or electrical ignition of flammable gas in an explosive atmosphere. The hand tools used by the loaders were of a ferrous material and could produce sparking in contact with other metals.

The National Fire Code 1983, Volume 15, 77-24, 4-1.2 states:

> Static is generated when liquids move in contact with other materials. This occurs commonly in operations such as flowing them through pipes, and in mixing, pouring, pumping, filtering or agitating. Under certain conditions, particularly with liquid hydrocarbons, static may accumulate in the liquid. If the accumulation is sufficient, a static spark may occur. If the spark occurs in the presence of a flammable vapor-air mixture, an ignition may result. Therefore, steps should be taken to prevent the simultaneous occurrence of the two conditions.

Emergency Response

Because of the carcinogenic properties of VCM and a concern that further explosions could occur, Louisiana State Police evacuated 250 people immediately after the accident from a small community on the west bank of the Mississippi River. The State Police notified the Coast Guard, which immediately closed the adjacent area of the Mississippi River to traffic. The Federal Aviation Administration (FAA) was contacted to restrict air traffic in the accident area. The FAA initially closed the Baton Rouge Airport, since the Formosa plant was located within the airport traffic area. The restriction was modified later to cover only the immediate area over the plant site.

In addition to the Louisiana State Police, units from the Baton Rouge Fire Department, Baton Rouge City Police, and the Sheriff's office in East Baton Rouge responded to the accident site. Units from these organizations began to arrive at the accident site within 15 minutes after the fire erupted. The Baton Rouge Fire Department immediately positioned a ladder truck equipped with an unmanned water turret to direct water onto the chlorine storage tanks which were about 200 feet east of the fire. Also, the plant's stationary unmanned water towers were used to direct water onto the tank cars adjacent to the two tank cars that were on fire. The two tank cars continued to burn; the fire in the car at station No. 6-2 burned out by midafternoon, while the car at station No. 5-2 was allowed to burn at a steady but moderate rate while water was applied to control its temperature.

Formosa decided to hot-tap 8/ the bottom of the burning car at station No. 5-2 and to try to pump the remaining VCM--approximately 13,000 gallons--into an empty tank car. The hot-tap was completed at noon on August 2, 1983, approximately 80 hours after the fire began. An attempt was made to pump the VCM, but the pumps were not capable of overcoming the 45-psi pressure in the receiving tank car. Formosa decided to allow a controlled burn-off of the tank car by placing an open container in an adjacent ditch, connecting the tank car and container with pipe, and igniting the VCM as it entered the container. Preparations for the burn-off were completed at 4 a.m., on August 4, 1983, about 120 hours after the fire began. The burn-off was begun immediately and was completed in 12 hours The air near the plant was monitored during the burn-off, and there was no detectable increase in air contaminants. The emergency was declared to be ended when the two tank cars at station Nos. 6-2 and 5-2 were filled with water.

Medical and Pathological Information

Loader-2 sustained first-, second-, and third-degree burns over 61 percent of his body. Loader-3 also received serious burns to his left side, left arm, and face.

Survival Aspects

Loader-2 said that he does not know how far he had run from the tank car at the VCM loading rack when the leaking VCM was ignited and that he does not remember anything after that. After hearing the explosion and seeing the fire, loader-1 returned to the area to search for loader-2. Loader-1 found loader-2 in a locker room, put him into a truck, and transported him to the first-aid station at the main gate. Most of loader-2's clothing was burned away or fused to his body.

8/ To hot-tap a tank car, a flange and fitting are welded to the bottom of the car and a hole is drilled through the tank shell. The content then can be piped from the car.

Loader-3, who was on the liquid caustic soda loading rack when the VCM was ignited, was able to get off the loading rack, remove his burning outer clothes, and make his way to the locker room/toolhouse area. On arriving at the locker room area, loader-3 was met by two loading supervisors who transported him to the first-aid station at the main gate.

Both injured loaders were wearing work clothes of synthetic material. Synthetic material can create static electricity, and when burned these materials melt and impregnate the skin, resulting in more severe burns. Formosa does not furnish work clothes and does not advise its employees about the type of clothing that is acceptable and safe when working around combustible chemicals.

An emergency rescue unit driver at the neighboring Exxon plant saw the fire, and after notifying his plant manager drove the Exxon emergency rescue vehicle to Formosa's main gate. The injured loaders, accompanied by a supervisor, were transported to the Baton Rouge General Hospital in the Exxon vehicle.

Tests and Research

The quick-connect coupler from the end of the liquid loading hose at station No. 6-2 was examined after the accident, and investigators found that one of the two cam arms was broken and missing from the shank. This connection, with the cam lock fitting with the broken cam arm, had been made when the hoses were attached to the tank car by the previous shift sometime before 6 p.m. on July 29, 1983. Examination of the fracture area revealed that there was a series of parallel gouges made by pliers on the face of the fracture and on the sides of the shank. The face of the fracture and the gouges were covered with the same degree of oxidation/corrosion as the other areas of the coupler.

Loader-3 stated that while the loaders did not use couplers with a broken cam arm, it was possible to lock or unlock a cam with a broken end on the quick-connect coupler by using pliers. Following the accident, a channel-lock pliers was found next to the liquid valve connection on top of the tank car.

Investigators conducted hydrostatic pressure tests of new and used couplers and gaskets of the same type to determine how the quick-connect coupler may have failed. The tests were conducted with a hydraulic press, a coupler mount or stand, and a coupler adapter fitted with a pressure gauge. The couplers were subjected to internal pressures of 120, 300, and 1,500 psi. None of the couplers leaked or became disconnected during the tests. Investigators noted that regardless of the condition of the coupler, adapter, or gaskets being tested, the internal pressure caused the bottom edge of the adapter groove to push against the under edge of the cam arms, increasing the locking force. At 120 psi, the cam arm locking pressure was increased by a factor of 3 times ambient pressure. As internal pressure was increased to 1,500 psi, the adapter continued to push against the cam, leaving a crease or indentation in the cam arm. The coupler involved in this accident had no such impression or cam distortion.

The loaders reported that incidents have occurred during loading when the liquid loading hose has burst and allowed a release of VCM until they could shut off the supply valve on the loading rock, but in those cases VCM was effectively stopped from coming out of the tank car by the excess flow valves.

Other Information

Excess Flow Valves.--The excess flow valves in the tank car at station No. 6-2 did not operate to shut off the sudden outward flow of VCM when the liquid loading hose became disconnected. A postaccident inspection of the tank car liquid lines by Federal Railroad Administration (FRA) inspectors and Formosa personnel determined that the seats of the two excess flow valves located in the liquid piping line inside the tank car at station No. 6-2 were not screwed properly into their threaded housing within the valve body. This discovery led to the inspection of the excess flow valves of other tank cars at the Formosa plant to determine if this improper valve seating was an isolated case. Through February 1984, 23 of the 38 tank cars inspected either by Formosa alone or jointly by Formosa and FRA inspectors were found to have one or more improperly positioned excess flow valve seats.

Because of its concern that improperly positioned excess flow valve seats could allow minor railroad accidents to escalate into major threats to public safety, the Safety Board issued Safety Recommendations R-84-13 through -16 in March 1984 to the FRA, the Association of American Railroads (AAR), the CMA, and the American Short Line Railroad Association (ASLR) alerting them to the problem. (See Recommendations section on page 19.)

As a result of these recommendations, the AAR informed its member railroads and shippers of the accident at the Formosa plant and the findings regarding the excess flow valves. The AAR also notified certified tank car repair facilities of the excess flow valve problems, and the AAR tank car committee began an investigation into the design and installation of the tank car excess flow valves. The FRA joined with the AAR in a comprehensive inspection program to determine the condition of the seats on excess flow valves. The program called for an inspection of an additional 600 to 700 cars. To accomplish this inspection and analysis of the facts developed during the inspection, the AAR established a task force. The task force has completed its work and has made a report of its findings to the tank car committee. The AAR is expected to issue a report with a corrective action plan. Both the CMA and the ASLR notified their members of the accident and the findings regarding the excess flow valves.

Safety Oversight.--A Louisiana State Police hazardous materials unit spokesman said that a State statute authorizes the State Police to enter and inspect any facility handling hazardous materials. Because of limited manpower and their highway-oriented operation, however, the State Police inspect only vehicles on the highway or highway vehicles at loading racks and terminals. The spokesman said that the State Police recently had sent two officers to school for training in the inspection of railroad cars. The Louisiana State Fire Marshal's office advised investigators that, although the fire marshal had the jurisdiction to inspect loading facilities, the office lacked the resources, manpower, and expertise to inspect such facilities in a petrochemical plant. The fire marshal's office had no record that it had made any inspections at the Formosa plant.

The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) has regulatory authority and jurisdiction to inspect the Formosa plant facilities. 9/ OSHA had made inspections of the plant as follows:

9/ An OSHA inspector typically inspects such things as electrical lines, tools, and equipment and sometimes arrives at a facility unannounced.

October 10, 1973	General Schedule Inspection
November 27, 1973	Follow-up Inspection
February 21, 1974	Inspection Following an Accident
May 16, 1974	General Schedule Inspection
Unknown, 1975	General Schedule Inspection
December 10, 1976	General Schedule Inspection

Since 1976, OSHA has established priorities to perform general schedule inspections, and Formosa was not scheduled by OSHA for a general schedule inspection. Currently, OSHA is making unscheduled inspections only as the result of an employee complaint or a catastrophic accident.

Formosa has rebuilt the tank car loading rack between track Nos. 5 and 6. OSHA has not inspected the plant since the accident and has not examined the rebuilt rack. OSHA reviewed injury and illness reports for the Formosa plant on January 31, 1985. Because the injury/illness rate was lower than the national average, no inspection of the facilities was conducted or scheduled.

The Transportation Safety Act of 1974, Public Law 93-633, 88 Stat. 2156, Title I-Hazardous Materials, Section 102, states, "It is declared to be the policy of Congress in this title to improve the regulatory and enforcement authority of the Secretary of Transportation to protect the nation adequately against the risks to life and property which are inherent in the transportation of hazardous materials in commerce." The DOT's area of responsibility is further clarified in Section 103(6): "Transport or transportation means any movement of property by any mode, and any loading, unloading, or storage incidental thereto." The FRA has a hazardous materials inspector in New Orleans, Louisiana, 85 miles from Baton Rouge, but the railroad loading facility at the Formosa plant was last inspected by an FRA inspector in 1977 following a material handling accident.

OSHA and the FRA do not have an agreement of understanding for the safety inspections of railroad tank car loading and unloading facilities. OSHA has regulations for railroad tank car loading/unloading facilities, but the FRA does not.

The Coast Guard inspects the marine loading facility at the Formosa plant annually. The Coast Guard and OSHA have a working agreement, and both agencies have cooperated in the inspection of hazardous materials stored on docks and in the investigation of accidents and incidents on vessels involving hazardous materials.

ANALYSIS

The Accident

Loader-2 said that the VCM liquid loading hose unexpectedly came loose from its attachment to the tank car and that the VCM from the tank car was released under pressure of about 120 psi. It is not likely that the loading hose became disconnected because of a mechanical failure. The quick-connect coupler was tested at pressures of 120, 300, and 1,500 psi without inducing a separation of the coupler and hose. Because binding marks in the coupler metal, such as occurred during the test at 1,500 psi, were not found on the coupler used to attach the liquid loading hose to the tank car at station No. 6-2, the Safety Board concludes that the coupler did not come off because of pressure in excess of 1,500 psi.

Loader-1 had completed all of the steps involved in loading the tank car at station No. 6-2 except using nitrogen to purge the residual VCM from the vapor hoses and the liquid loading hoses and disconnecting the hoses. Loader-1 told loader-2 that he had not finished securing for shipment the four remaining cars, including the car at station No. 6-2, because of low nitrogen pressure. When he started to do the work, loader-2 might not have recalled what steps were left to be taken before the liquid loading hoses were disconnected because the turnover discussion may have been too vague and did not convey the necessary tasks to be completed. The company did not have a formal turnover procedure. Loader-2 said that he was on the tank car at station No. 6-2 at the time of the accident. The only reason for his being on the tank car would have been to disconnect the hoses and to secure the dome cover. If he did not remember that the loading hoses had not been purged with nitrogen and therefore released the locking cams on the quick-connect coupler, the connection would have separated immediately. With 120-psi pressure on the hose, it would have been impossible to reconnect the hose.

The oxidation/corrosion on the fractured surface of the cam arm being the same as on other areas of the coupler indicates that the missing shank was broken off before the accident. Therefore, since the hoses were connected to the tank cars on the previous shift, prior to 6 p.m. on July 29, 1983, the broken cam arm on the quick-connect coupler was not changed but was used to make the connection at least 10 hours before the accident occurred. The channel-lock pliers found on top of the tank car at station No. 6-2 next to the tank car connections suggest that loader-2 used the pliers to release the broken cam arm on the coupler and then laid them down while engaged in releasing the other cam arm by hand. The gouge marks on the broken surface of the cam arm could have been made by the pliers found on the tank car if they had been used to grip the cam arm to release it.

After the accident the tank cars at station Nos. 5-1 and 6-1 were found secured for shipment. Since loader-1 said that they were not secured when he left the loading rack, the Safety Board concludes that either loader-1 or loader-2 closed the liquid valves, and loader-2 completed securing the tank cars for shipment. The investigation did not determine if the nitrogen pressure came up to a level that allowed the hoses on those tank cars to be purged or whether the liquid loading hoses were released without purging. It is possible that the excess flow valves in the tank cars may have activated if the quick-connect couplers were removed before the liquid valves had been closed. If so, the VCM under pressure would not have sprayed from the tank car's liquid valve nipples, but the residual VCM in the liquid loading hoses would have spilled.

A cam-lock, quick-connect coupler is joined together when one half of the fitting is pushed onto the other half and held in place by the cam arm being forced closed, causing the cam section to engage only a grooved section of the other fitting. Therefore, a quick-connect coupler will disengage immediately if released under pressure. Because it cannot be reconnected easily, it should not be used on hoses and connections used to load or unload hazardous materials. However, there are no regulations that prohibit their use, and many chemical firms use them because that they are a labor-saving device. Other couplers are available that cannot be released while the connection is under pressure. The Safety Board believes that the use of quick-connect couplers should be prohibited in the transfer of hazardous materials and that the DOT should review the types of appliances used on hazardous materials loading racks and establish standards for the types of couplers that may be used. Since the accident, the Formosa plant has changed the type of rack hose couplers being used so that if the liquid loading hose is under pressure, the coupler will leak before it is fully disengaged and alert the loader so he can retighten the coupler quickly.

Excess Flow Valves

Neither of the two excess flow valves within the tank car at station No. 6-2 was screwed properly into its threaded valve housing. The excess flow valve in the tank car's internal liquid line that was attached to the loading hose that was disconnected did not operate to shut off the outward flow of VCM from the car when the loading hose was disconnected. It is possible that the loader may have been able to hold the hose for a short period of time after disconnecting the coupler and tried to force the hose back onto the connection. This action would have provided a sufficient restriction to the flow of VCM to prevent a sudden surge and, therefore, even a properly seated excess flow valve would not have activated to shut off the flow. However, with the excess flow valve improperly seated, the flow would not have been shut off regardless of the circumstances under which the hose was disconnected.

Shippers and receivers as a matter of routine rely upon the proper functioning of the excess flow valve to protect against the inadvertent outward flow of hazardous materials from tank cars during loading and unloading operations. There have been incidents of loading hoses bursting during the loading process in which the excess flow valves prevented the discharge of a large volume of material. Had the excess flow valves on the tank car in this accident been seated properly, the accident probably would not have occurred. However, excess flow valves are not installed on cars for the purpose of providing protection during the loading/unloading of hazardous materials, and shippers and receivers should not rely on the valve to provide protection to the exclusion of proper safeguards. A properly functioning excess flow valve is designed to and can prevent minor railroad accidents from escalating into major threats to public safety by the uncontrolled release of product when there is damage to or severing of external valves in the course of an accident.

Both the AAR and the FRA responded to Safety Board Recommendations R-84-13 through -15 regarding excess flow valves and have coordinated to conduct an investigation that soon should result in corrective action. The Safety Board is pleased that the FRA and AAR have taken prompt action to address the serious hazard presented by improperly installed excess flow valves.

Ignition Sources

Investigators could not determine which of the many possible sources of ignition started the fire. The unrestricted flow of VCM through the hose could have involved sufficient static electricity in the flammable vapor-air mixture to have caused ignition. A spark in the exposed wiring under the loading rack or in the speaker wiring and connections of the intercom could have caused ignition. The radios used by the loaders could have caused thermal or electrical ignition. A handtool in the area could have caused sparks while in use, or if dropped on the tank car shell, manway cover, valves, or fittings.

Because of the hazards involved in handling VCM, the need to review continually the safety of the operating equipment and facilities is critical. The presence of so many unsafe conditions which did not conform to the requirements of the National Electrical and Fire Codes indicates that Formosa management and supervisory personnel had allowed unsafe conditions to develop unchecked. A proper safety inspection by responsible management would have detected the unprotected wiring, the installation of a speaker assembly in the intercom system that was not spark-proof, and the use of flashlights and of batteries in radios that were unsafe for use in the VCM environment at the loading rack.

Training and Supervision

The CMA Chemical Safety Data Sheet SD-56 recommends intensive training of employees and supervisors involved in the handling of VCM; however, following the reorganization of the operation of the Formosa plant and a change in ownership, the only training given to employees and supervisors was on-the-job training. While this training can prepare employees to carry out their jobs effectively, it also leads to senior employees who have acquired poor work habits, despite their many years of experience, passing on these habits. Although supervisors engaged in handling VCM must be familiar with the hazardous characteristics of the product and how to handle it, the new supervisors, who had learned loading procedures only by observing the senior employees as they performed their duties, would not have recognized the poor work habits. Nor would the supervisors conduct any inspection that would disclose that the equipment at the loading rack was unsafe, because all of it was in place at the time of the reorganization when they were assigned as supervisors. Provisions should have been made for refining on-the-job training with particularized instruction on equipment and good safety practices.

Moreover, there were no written procedures at Formosa for loading VCM. The Safety Board believes that had Formosa management provided detailed operating instructions and training to those employees involved in loading VCM, loader-2 might have been more cognizant of the hazardous characteristics of VCM and might have made a more cautious inspection before proceeding to disconnect the loading hose.

Safety Oversight

The Formosa safety inspection program not only did not detect the generally unsafe working conditions that existed at the rail car loading racks but also did not result in the detection of defective loading equipment. Since safety inspections were not performed by Federal or State agencies, the fact that safety was not being addressed in an appropriate manner by Formosa went undetected.

The safety of petrochemical plant operations is only as good as each individual plant's safety program. While large-scale accidents may occur infrequently, they can cause large amounts of property damage, injuries, and social disruption. Toxic and/or flammable concentrations of chemicals can impact population exposures surrounding a petrochemical plant within minutes of the initial release. 10/ The potential for catastrophic accidents in an area such as Baton Rouge and surrounding communities with their extremely dense concentration of petrochemical plants is extremely high. If a BLEVE (a Boiling Liquid Expanding Vapor Explosion) had occurred in the accident, the explosion could have resulted in a chain-reaction of explosions throughout the Formosa plant and affected adjacent plants, escalating the accident to a catastrophe. Effective safety oversight is critical, and Federal and State agencies that have the responsibility and the authority to enforce safety standards in petrochemical plants should reevaluate their priorities in scheduling inspections and training inspectors to insure that a high level of safety is maintained at these chemical plants. The Safety Board believes that insufficient Federal and State oversight contributed to the lack of safety procedures, inadequate training of personnel, and poor maintenance of loading rack equipment at the Formosa plant.

10/ The Safety Board discussed the issue of emergency preparedness plans for fixed-site hazardous materials handling facilities in its Special Investigation Report--"Railroad Yard Safety: Hazardous Materials and Emergency Preparedness" (NTSB/SIR-85/02).

The Safety Board believes that employees and supervisors should be trained in emergency procedures. Even if Formosa's emergency plan is that most of its employees will evacuate to a designated location, this information should be a part of an emergency preparedness plan and should be made known to everyone in the plant. The emergency response cadre should be trained in depth.

Tank Car Safeguards

This accident demonstrated that the safeguards required by 49 CFR Parts 173 and 178 are effective in reducing the severity of hazardous materials accidents involving tank cars equipped with those safeguards. Even though the tank car at station No. 5-2 was exposed to severe fire torching, it did not rupture. Since pressure sufficient to open the safety valve did not build up until 50 to 60 minutes had elapsed, it is apparent that the Korotherm insulation and the steel jacket performed as intended to delay the heating, expansion, and vaporization of the VCM. Loader-2 and loader-3 had time to escape the area long before the safety valve was released, and emergency response personnel had time to act to mitigate the results of the fire.

As a result of its investigations of numerous railroad tank car accidents between 1968 and 1979, the Safety Board identified several tank car safety problems and recommended Federal action to improve tank car safety and to reduce the danger to the public from derailments of tank cars carrying hazardous materials. The Board held a public hearing in April 1978 on the derailments of tank cars carrying hazardous materials. 11/ As a result of the hearing, the Safety Board issued Safety Recommendations R-78-9 through -36 on April 24, 1978, recommending that the FRA accelerate Federal rulemaking actions to require the installation of head shields, shelf couplers, and thermal protection on tank cars carrying volatile products. The Safety Board has repeatedly urged the implementation of these recommendations because it was convinced that these safeguards would provide the protection needed.

FRA rulemaking (Docket No. HM-144) followed and required that all new and existing DOT specification 112A (114A) tank cars carrying flammable gases be equipped with a thermal protection system meeting certain performance standards for both torch and pool fires. The retrofit program was carried out from 1978 through 1980. The tank car at station No. 5-2 was retrofitted with the safeguards in 1980. This accident demonstrates that equipping tank cars with thermal protection should lead to a dramatic reduction in the number of violent ruptures not only in train derailments but also in train yard and chemical plant accidents.

A joint Railway Progress Institute (RPI) and AAR Tank Car Safety Project group conducted extensive evaluations of the tank car at station No. 5-2 after the accident. In a report issued on January 21, 1985, 12/ the group stated, "Had it not been equipped with HM-144 thermal shielding, it quite probably would have ruptured violently." The Safety Board is pleased that the extensive testing done by the RPI-AAR has corroborated the benefits of thermal problems of tank cars.

11/ Safety Effectiveness Evaluation--"Analysis of Proceedings of the National Transportation Safety Board into Derailments and Hazardous Materials, April 4-6, 1978" (NTSB-SEE-78-2).
12/ Phase II Report on Behavior of a DOT 112J340W Tank Car in a Torch Fire Accident.

CONCLUSIONS

Findings

1. The vinyl chloride monomer (VCM) liquid loading hose to the tank car at station No. 6-2 probably was disconnected by loader-2 before the loading hose was purged of VCM.

2. The excess flow valves in the tank car did not activate to stop the flow of VCM because they were not seated properly.

3. Sources of ignition of the VCM included exposed electrical wiring on the loading rack which could have caused sparks, the speaker assembly on the intercom system which was not designed or protected to prevent electrical sparks, the ferrous metal tools used on the unloading rack which could have caused sparks, and/or the portable radios used by the loaders which had batteries that were not approved for use in a flammable or explosive atmosphere which could have caused sparks.

4. Loading employees of the Formosa Plastics Corporation were not trained adequately in safety procedures related to loading operations at the rail loading racks.

5. The Formosa Plastics Corporation did not have written procedures or a safety program for supervisors and employees involved in the loading of VCM.

6. The unsafe working conditions at the VCM loading rack were not detected and corrected by the plant's safety inspection program.

7. No State of Louisiana agency had inspected the Formosa Plastics Corporation plant for compliance with State safety regulations before the accident.

8. Federal regulations concerning working conditions and the equipment in use at the VCM loading rack were not being enforced in the plant because the Federal Railroad Administration had not inspected the plant since 1977, and the Occupational Safety and Health Administration had not inspected the plant since 1976.

9. Tank car safeguards retrofitted to the tank car at station No. 5-2 prevented the tank car from rupturing violently in the fire and possibly causing a more catastrophic accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the sudden release and ignition of vinyl chloride monomer from a loaded tank car was a plant employee's failure to close the tank car liquid valves and purge the pressurized vapor return and loading hoses before disconnecting them, and the presence of one or more sources of ignition at the loading rack. Contributing to the cause of the accident was the failure of the Formosa Plastics Corporation to maintain safe facilities for the loading of vinyl chloride monomer and to provide written procedures, adequate training, and supervision for its loading personnel. Also contributing to the cause of the accident were the improperly seated excess flow valves in the tank car.

RECOMMENDATIONS

During its investigation of this accident, the National Transportation Safety Board issued the following recommendations in March 1984:

--to the Association of American Railroads:

Immediately advise member railroads, shippers, and receivers that handle hazardous materials in tank cars of the accident at Baton Rouge, Louisiana, on July 30, 1983, and of the subsequent findings regarding improperly positioned excess flow valve seats, and alert them not to rely upon tank car excess flow valves for protection against an undesired outward flow of hazardous materials from tank cars during loading, unloading, maintenance, or repair operations. (R-84-13)

Immediately issue a service bulletin to all Association of American Railroads-certified facilities emphasizing the need to verify the proper installation, maintenance, and testing of excess flow valves on tank cars. (R-84-14)

--to the Federal Railroad Administration:

Immediately initiate inspections of tank cars equipped with excess flow valves to determine the extent to which these tank cars may have improperly positioned excess flow valve seats, determine the cause of deficient conditions found, and require correction of deficiencies before inspected tank cars are returned to service. (R-84-15)

--to the Chemical Manufacturers Association:

Immediately advise its members of the hazardous materials accident at Baton Rouge, Louisiana, on July 30, 1983, and of the subsequent findings regarding improperly positioned excess flow valve seats, and alert them not to rely upon tank car excess flow valves for protection against an undesired outward flow of hazardous materials from tank cars during loading, unloading, maintenance, or repair operations. (R-84-16)

--to the American Short Line Railroad Association:

Immediately advise its members of the hazardous materials accident at Baton Rouge, Louisiana, on July 30, 1983, and of the subsequent findings regarding improperly positioned excess flow valve seats, and alert them not to rely upon tank car excess flow valves for protection against an undesired outward flow of hazardous materials from tank cars during loading, unloading, maintenance, or repair operations. (R-84-16)

As a result of its complete investigation of this accident, the National Transportation Safety Board made the following recommendations:

--to the Formosa Plastics Corporation:

Establish a training program and loading turnover procedures for supervisors and employees assigned to load hazardous materials for transportation. (Class II, Priority Action) (R-85-65)

Establish a safety inspection program to detect and correct any conditions at the plant that do not meet requirements of the National Electrical and Fire Codes and regulations of the U.S. Department of Transportation. (Class II, Priority Action) (R-85-66)

In cooperation with the city of Baton Rouge, Louisiana, establish an emergency preparedness plan and evacuation procedures for employees in the event of a leak or fire at the plant involving hazardous materials. (Class II, Priority Action) (R-85-67)

--to the Federal Railroad Administration:

Establish a program to inspect rail loading facilities at petrochemical plants on a regular schedule. (Class II, Priority Action) (R-85-68)

Develop a memorandum of understanding with the Occupational Safety and Health Administration to define the extent of each agency's responsibility for safety inspections of hazardous materials loading/unloading facilities at petrochemical plants to eliminate gaps or overlaps in responsibility. (Class II, Priority Action) (R-85-69)

--to the Research and Special Programs Administration:

Establish safety standards and inspection procedures for loading facilities at petrochemical plants. (Class II, Priority Action) (R-85-70)

--to the Occupational Safety and Health Administration:

Evaluate its ability to conduct inspections of petrochemical plant loading facilities and its method of establishing inspection priorities for general schedule inspections, and make necessary changes to provide for regular inspections. (Class II, Priority Action) (R-85-71)

Develop a memorandum of understanding with the Federal Railroad Administration to define the extent of each agency's responsibility for safety inspections of hazardous materials loading/unloading facilities at petrochemical plants to eliminate gaps or overlaps in responsibility. (Class II, Priority Action) (R-85-72)

—to the State of Louisiana:

Evaluate the ability of State agencies charged with administering safety regulations in petrochemical plants to carry out their responsibility, and make necessary changes to insure regular inspections of these facilities. (Class II, Priority Action) (R-85-73)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ G. H. PATRICK BURSLEY
Member

May 14, 1985

APPENDIXES

APPENDIX A

INVESTIGATION

1. Investigation

The National Transportation Safety Board was notified of the accident at 7 a.m., on July 30, 1983. The Safety Board immediately dispatched investigators from Washington, D.C., to the accident site.

Groups were formed to investigate the hazardous material release, mechanical factors, and survival factors. The Safety Board was assisted in its investigation by representatives of the parties: the Formosa Plastics Corporation, the Federal Railroad Administration, the U.S. Department of Labor, and the Louisiana State Police (Hazardous Materials Unit).

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APPENDIX B

FORMOSA PROCEDURE FOR LOADING VINYL CHLORIDE TANK CARS (ISSUED AFTER JULY 30, 1983)

1) Spot cars at tank car loading stations so that ramps are in proper position.

2) Double, diagonally, chock cars (4 chocks per car), and set all hand brakes. The double diagonal chocking results from reports that, while loading, some cars have jumped over a single chock and started rolling while still hooked up.

3) Set derails and car-connected 'flags' on tracks where cars are to be loaded north of south road to vinyl plant.

   Note: There is to be no switching permitted south of the south road to vinyl plant while the red loading light is on and vinyl cars are hooked up.

4) Inspect car. Open dome of car. Remove valve plugs. Use caution. If valves leaked, there could be pressure behind them. Remove gauge rod cover. Again, watch for a possible pressure build-up under the cover. Fill out pre-loading inspection sheet, and switch T/C placards for loading.

5) Check each car for ppm O_2 from vapor valve on car. Use special 2" x 1/4" reducer and valve to connect O_2 meter.

   a) The maximum allowable O_2 for loading is 1000 ppm. 100-500 ppm is ideal. If below 1000 ppm O_2 proceed to Step 6.

   b) If O_2 is greater than 1000 ppm refer to T/C purging instructions at end of this procedure write-up.

6) Open emergency shut-off load line valve. This valve should be closed when not loading vinyl Emergency trip buttons which will close this valve and shut down the vinyl pump are located:

   a) At the head of the stairs at the temporary loading station.

   b) In the vinyl control room.

   c) At the head of the north stairs at the main loading rack and between Nos. 3 and 4 loading stations on the main loading rack.

7) Turn on red flashing vinyl loading light. Switches are located at both the temporary and main loading stations.

8) Check to see if the intercom between loading rack and vinyl control room is functioning.

9) Check to be sure you have radio communication with vinyl and your foreman.

10) If nitrogen pressure is low notify your foreman and the vinyl foreman.

11) Connect grounding cables.

12) Use only non-sparking tools, flashlights, and radios. Tools should be made of beryllium or aluminum with recessed steel jaws. The flashlight is the Eveready No. 1259. For radios this means a green battery.

13) Hook up tank car to loading rack.

   a) Screw 2" nipples, with check valves, into T/C liquid valves. Check action of check valves before installing nipples.

   b) Screw 2" nipple into T/C vent valve. This nipple has a 1-1/4" connector at other end.

   c) Hook 2 - 2" loading hoses and one 1-1/4" vent hose to these nipples using the knock-on type connectors.

   Note: All piping must be wrench tight.

14) Once all cars to be loaded are hooked up and ready for loading, pressure test the two loading hoses with nitrogen.

15) Open vent valves on cars. If T/C pressure is 60-90 psig, vent it down to 50 psig to recovery system before starting to load, (if you have the time). Otherwise start venting upon loading even at pressures above 50 psig.

16) Insert Farenheit thermometer in thermo-well on T/C to get a starting temperature. Using this information check loading charts to get an idea of each car's load-out level.

   a) While loading, when gauge rod starts to move upward, check the temperature again to determine a correct load-out level.

   b) Record this information on loading sheet.

17) Have vinyl put on loading pump. Open T/C loading valves. Open 3" load line valves. Watch load line and vent pressure gauges. Start venting when the pressure reaches 60 psig.

18) Once cars have been loading for approximately 1/2 hour catch a load line sample and have it taken to the lab to analyze as soon as possible. Once they get it into the gas chromatograph it takes about 27 minutes to get a complete analysis.

   Always record time taken on all samples on the sample label.

19) If you are having trouble with the vent recovery system, ask vinyl foreman to check it out, especially the vents condenser. If working properly, lines should be sweating.

20) Once a car is loaded (when level rod reaches proper outage) close 3" load lines.

a) Check to be sure N_2 pressure is greater than T/C pressure and purge load lines to T/C using N_2 between one and two minutes each.

b) Close both T/C loading valves.

c) Bleed pressure off hoses. Check pressure gauge.

d) Disconnect load lines carefully making sure no pressure remains in hose.

e) Similarly close T/C vent valve. Purge vinyl out of vent hose by blowing with N_2 for one to two minutes to vent recovery system. Close 3" vent valve. Then vent nitrogen pressure off hose and disconnect hose carefully from T/C.

21) Once cars have been loaded, catch a sample from each car from the sample cock. If unable to catch one there, see (b) below.

a) When catching a sample:
(1) Connect bomb to car and low pressure vent system hose.
(2) Open sample cock valve to bomb.
(3) Open valve on bomb nearest sample cock.
(4) Open valve on bomb nearest low pressure vent line.
(5) Let product flow through bomb long enough to be sure a good clean sample has been obtained.
(6) Close valve on bomb nearest low pressure vent line.
(7) Close sample lock and valve on other end of bomb.
(8) Disconnect low pressure hose and vent pressure off between bomb and sample valve.
(9) Remove bomb.
(10) Take samples to the lab as soon as possible.

b) If sample line is plugged:
(1) Try blowing it clear using N_2.
(2) If it clears catch a sample following the procedure in (a) above.
(3) If line remains plugged, fill out a sample label with time, T/C No. and note that sample line is plugged and that lab should use the load line analysis. Also note that sample line is plugged on T/C loading sheet.

22) Insert all plugs and caps:

1 - Vent valve plug
2 - Loading valve plugs
1 - Thermometer well cap
1 - Level gauge rod cap
1 - Sample line plug
All wrench tight.

23) Close lid and seal car. Record seal number on loading sheet.

24) Fill out loading sheet as required. Attach it to the inspection sheet, Place them in folder for Traffic Department.

25) Loaded cars are to be weighed and set on outbound storage tracks for shipping.

a) All of the vinyl tank cars in our service require an average 261,000# gross weight minimum.

b) Some cars can go into the 262,000# range but none can go over 263,000#. 263,000# is the maximum gross weight we can ship.

NOTE:

(1) If any problems or questions arise with equipment or procedures notify your foreman.

(2) Do not permit vinyl to vent to atmosphere. Very small quantities are permitted as when disconnecting sample bombs.

(3) Someone must be on the rack at all times when cars are connected.

(4) Once loading has been suspended for any reason, unhook cars. This, of course, does not apply to brief interruptions.

(5) In the event of an electrical storm, shut loading operation down and disconnect tank cars.

(6) Follow all plant operating procedures and safety procedures. Do not cut corners

(7) Whenever one operator relieves another, for any reason, they must exchange all pertinent information, fill out a check list for transfer of responsibility and both sign it. Turn these in with other inspection forms and data sheets.

TANK CAR PURGING INSTRUCTIONS

1) If ppm O_2 is greater than 1000 but less than 10,000 ppm, purge car to vent recovery until less than 1000 ppm.

   a) Using N_2, build T/C pressure to 80-90 psig.

   b) Contact vinyl and vent car down to about 60 psig to their 100# vent system.

   c) Then have vinyl switch to their 50# vent system and vent car down to about 45 psig.

   d) (1) If O_2 was originally between 1000 ppm and 1500 ppm, retest.

      (2) If O_2 was originally higher than 1500 ppm, repeat steps (a), (b) and (c) once or twice more before rechecking.

      (3) Continue this procedure until O_2 is less than 1000 ppm. Then car can be loaded.

2) If O_2 is greater than 10,000 ppm, notify vinyl foreman that car must be purged to the flare. He must OK this.

   a) Using N_2, build T/C pressure to about 80 psig. Then vent it to the flare until the pressure drops to about 15 psig. Do not vent down too fast.

   b) Repeat Step (a) twice more and then recheck the O_2 level.

   c) If less than 1000 ppm, car is good to load. If not repeat Step (a) above until O_2 level drops below 1000 ppm.

NOTE: Never purge a car which has 10,000 ppm or more O_2 to the recovery system.

PERMISSIBLE VENTING

VCM LOADING

A) O_2 checking line: 1" pipe 14" long (vapor)
Volume = 1" x 1" x 3.14 ÷ 4 x 14" = 11 Cu. inch = 0.00636 Cu. Ft.

B) Sample bomb line 1/4" pipe 10" long (Liquid)
Volume = 1/4" x 1/4" x 3.14 ÷ 4 x 10" long x 0.00433 gal/cu. in. x 7.5 lb/gal.
= 0.0159 lb. ÷ 62.4 lb/lb.mole x 359 cu.ft./lb./mole
= 0.092 cu.ft.

C) VCM loading line 2" hose & pipe 20 ft. (vapor)
Volume under 100 psig pressure
= 2" x 2" x 3.14 ÷ 4 x 20 ft. ÷ 144 ft.^{2}/in.^{2} = 0.436 cu.ft.
2% VCM
Volume under 100 psig pressure
= 0.436 x 0.02 = 0.00872 cu.ft.
(100 + 14.7) x 0.00872 = 14.7 x Volume at Atmosphere
Volume, at atmosphere = 0.068 cu.ft.

The regulation of VCM loading or unloading line that are to be opened to the atmosphere should contain no greater than 0.13 cu.ft. of VCM at standard temperature and pressure.
So, the above numbers are all less than the regulation limit.

APPENDIX C

CHEMICAL SAFETY DATA SHEET SD-56-- PROPERTIES AND ESSENTIAL INFORMATION FOR SAFE HANDLING AND USE OF VINYL CHLORIDE

Chemical Safety Data Sheet SD-56

PROPERTIES AND ESSENTIAL INFORMATION

FOR

SAFE HANDLING AND USE

OF

VINYL CHLORIDE

Chemicals in any form can be safely stored, handled or used if the physical, chemical and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed.

REVISED 1972

MCA MANUFACTURING CHEMISTS ASSOCIATION

1825 CONNECTICUT AVENUE, N. W. WASHINGTON, D. C. 20009

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Chemical Safety Data Sheet

VINYL CHLORIDE

PREFACE

Vinyl chloride monomer is classified by the U.S. Department of Transportation as a **flammable compressed gas.** It is easily ignited, producing hazardous combustion gases largely composed of hydrogen chloride and carbon monoxide.

The primary health hazard of VCM is associated with excessive respiratory exposure. In acute overexposures the primary effect is on the central nervous system, producing intoxication and dulling of visual and auditory responses. Excessive chronic exposure may produce liver injury.

The full text of this chemical safety data sheet should be consulted for details of the hazards of vinyl chloride monomer and suggestions for their control.

FIRST AID—SEE PAGE 18

For assistance in the event of any emergency involving this chemical in transportation, call MCA's **Chemical Transportation Emergency Center.**

CHEMTREC

(800) 424-9300 * *(Use 483-7616 in District of Columbia)*

Toll-free, day or night

* Use long distance access number if required.

In CANADA, call Canadian Chemical Producers Association's TEAP (Transportation Emergency Assistance Plan)

Chemical Safety Data Sheet

Manual Sheet SD-56

VINYL CHLORIDE

1. NAMES

Chemical Names:	Vinyl Chloride Monomer Chloroethylene Chloroethene
Common Name:	Vinyl Chloride, VCM
Formula:	CH_2CHCl

2. PROPERTIES

2.1 **GRADE:** Commercial, sometimes referred to as Technical

2.2 **IMPORTANT PHYSICAL AND CHEMICAL PROPERTIES:**

Boiling Point at 1 atm.	−13.8°C. (+ 7°F.)
Color	Colorless or water white
Corrosivity	Noncorrosive at normal atmospheric temperatures when dry (moisture free). In contact with water at elevated temperatures vinyl chloride accelerates corrosion of iron or steel.
Explosive Limits (Percent by Volume in Air)	Lower 3.6%; upper, 26.4%
Flash Point (Open Cup)	− 78°C. (— 108.4°F.)
Hygroscopicity	No
Critical Pressure, psia	775
Critical Temperature	158.4°C. (317°F.)
Ignition Temperature, Autogenous	472.22°C. (882°F.)
Light Sensitivity	Uninhibited VCM is light sensitive
Melting Point at 1 atm (Freezing Point)	— 153.71°C. (— 245°F.)
Molecular Weight	62.50
Odor	Sweet smelling gas. Inhibited VCM may have faint phenolic odor.
Physical State	Gas at ordinary temperature and pressure. Liquid under pressure in cylinder or pressure vessel at room temperature.
Reactivity	Polymerizes readily in presence of air, sunlight, oxygen or heat. This behavior is due to the presence of a double bond. Otherwise vinyl chloride is quite stable.
Specific Gravity of liquid @ 4°C. (Water = 1)	0.9121
Vapor Density of gas (Air = 1)	2.15
Vapor Pressure @ 68°F	35 psig
Density, liquid, lb./cu. ft.	
at 70°F.	56.71
at 105°F.	54.38
at 115°F.	53.69
at 130°F.	52.61
Threshold Limit Value (ceiling)	500 ppm or 1300 mg/M³

3. HAZARDS

3.1 HEALTH HAZARDS (See Section 10 MEDICAL MANAGEMENT)

3.1.1 The primary hazard of vinyl chloride is associated with excessive respiratory exposure. Exposure to high levels may produce some lung irritation. Chronic overexposure may produce liver injury. When inhaled it acts primarily as an anesthetic. The odor is pleasant to most individuals and, therefore, acutely dangerous levels may be easily tolerated.

3.1.2 Warning Properties

The lowest concentration of VCM at which its odor can be detected is reported to be 260 ppm. Olfactory fatigue, however, may occur and the sense of smell cannot be relied upon as a warning for excessive low grade exposures.

3.2 FIRE AND EXPLOSION HAZARDS

3.2.1 Vinyl chloride is a gas at normal atmospheric temperature and pressure. The gas will burn very readily in proper mixtures of air or oxygen. An explosion hazard can exist when drawing samples or venting to the atmosphere. Open flames, local hot spots, friction, any spark producing equipment, and static electricity are to be avoided when handling this material.

3.2.2 Combustion Products of Vinyl Chloride Monomer

Analysis of a combustion gas sample obtained immediately above a flame of vinyl chloride monomer burning in air shows presence of hydrogen chloride (27,000 ppm), carbon dioxide (58,000 ppm), carbon monoxide (9,500 ppm) and phosgene less than 10 ppm. Only in the very near vicinity of a VCM fire would significant amounts of phosgene be present.

The main sources of danger to personnel result from the massive formation of hydrogen chloride gas and from carbon monoxide. However, the pungent odor of hydrogen chloride acts as a warning to clear the area or to obtain the necessary breathing apparatus before attempting any fire control measures. See MCA Chemical Safety Data Sheet, SD-39, Hydrochloric Acid (Aqueous) and Hydrogen Chloride (Anhydrous).

3.3 STABILITY HAZARDS

Vinyl chloride is shipped and used in both the inhibited and uninhibited state. In the uninhibited state, high purity must be maintained since contaminants may catalyze polymerization or cause decomposition of the VCM, liberating hydrogen chloride. Prior to shipment, uninhibited VCM should be tested for stability under shipping and storage conditions. Cleanliness of shipping containers is of prime importance when shipping uninhibited VCM.

Vinyl chloride may polymerize as a result of exposure to air, oxygen or sunlight at ambient or higher temperatures.

Vinyl chloride does not form peroxides by autoxidation as readily as many other monomers.

In the absence of an initiator, VCM is chemically quite stable. Commercial VCM, uninhibited, is stored and shipped in steel containers under conditions which avoid exposure to air and sunlight. For large volume, long term storage, refrigeration is sometimes employed to maintain the temperature at about 20° C., maximum, to minimize the formation of haze, a condition caused by a small degree of polymerization.

4. ENGINEERING CONTROL OF HAZARDS

4.1 BUILDING DESIGN

Equipment and vessels containing VCM should preferably be isolated from other facilities by walls and floors of fire resistive construction.

Standard fire walls are recommended for the isolation of larger equipment and storage tanks, while partitions of plaster on expanded metal lath may be used to isolate smaller equipment from other combustible materials.

Not less than two means of exit should be provided from each separate room or building in which VCM is stored, handled or used. No portions of such a room or building should be farther than 75 feet from the nearest exit. Additional exits should be provided depending upon the number of persons in the building. (See NFPA Standard #101 Life Safety Code.)

All exit doors should open out in the direction of travel and should be provided with panic hardware. Fire doors should open out in the direction of travel and be of an approved type.

Operations where large quantities of VCM are used should preferably be housed in one story buildings.

Explosion vents may be used to reduce destructive damage to buildings, ducts, mixers, blenders, driers and similar equipment in which flammable vapors are liable to concentrate.

Explosion venting windows, roof and wall panels, skylights, light windows, diaphragms, etc., may be used to minimize building damage due to explosion pressures.

Since the required area of explosion vents depends upon such factors as the intensity of an explosion, vapor temperature, type of structure, the type of vent closure, etc., the determination of vent ratios should be made by experienced engineers and safety and fire protection specialists. Consideration may be given to explosion suppression systems. (Reference: NFPA Fire Codes, Vol. 9—#68).

The question of adequate spacing of chemical storage buildings from other buildings and processing equipment should be considered.

A fire resistive stairwell with self-closing fire doors may be specified for hazardous operations on upper floors.

The need for segregating floor drains from sanitary or process sewer systems should be considered.

4.2 EQUIPMENT DESIGN

4.2.1 Processes should be designed so that operating personnel will not be exposed to direct contact with vinyl chloride or its vapor. The technical problems of designing equipment, providing adequate ventilation, and formulating operational procedures which promise maximum security and economy, can be handled best by engineers or other competent personnel. The manufacturers of vinyl chloride, and of the equipment in which it is to be used, are always prepared to help with these problems.

4.2.2 In the handling of vinyl chloride or operation of any type of vinyl chloride system, all valves, pipe lines, vents, safety devices, etc., should be so located that they can be readily inspected and repaired. They should always be in proper order and condition before the operation is started. All handling and storage equipment should be located away from any source of sparks, flames, heated surfaces and all sources of ignition which might cause fires or explosions. All charging and discharging pipes should enter through, or extend to, the bottom of all containers to minimize vaporization of the liquid. Use of excess flow valves and valves with fusible links should be considered on storage tanks and other large vessels in case of fires or leaks near these vessels.

4.2.3 It is essential for safety that equipment be used and maintained as recommended by the manufacturer and that a periodic test schedule of the equipment, including safety devices, should be followed. All vent lines should extend outdoors to an area free of any source of ignition for discharge. Vents and vent lines should have flash arresters.

4.2.4 Material of copper or copper-bearing alloy should not be used in contact with vinyl chloride due to the possible presence of acetylene and the formation of explosive acetylides.

4.3 VENTILATION

4.3.1 Ventilation should be adequate to maintain exposures below the ceiling value of 500 ppm recommended by the U.S. Department of Labor.

4.3.2 If the workroom or operating area is separate from vinyl chloride storage or processing equipment, general ventilation is usually adequate. For emergencies, however, the area may be provided with mechanical exhaust ventilation to maintain concentrations below 500 ppm. Mechanical ventilators should be of the nonsparking or explosion-proof type and should have motors conforming to the National Electrical Code (Class I, Division I).

4.3.3 In the processing or storage area, if outside location is impracticable, special emergency equipment for ventilation is necessary under abnormal conditions, such as leaks or spills.

4.3.4 The most important consideration in ventilation is to ensure an adequate air flow away from the work area.

4.3.5 All ventilating systems should be inspected periodically and maintained in a safe and efficient working condition.

4.3.6 Under abnormal conditions, such as when leaks or spills occur, all available ventilation should be used.

4.4 AIR ANALYSIS

4.4.1 Analysis of the air for vinyl chloride in the work area will give a measure of the effectiveness of engineering control of the vapors. It may be performed to detect leakage of vapors from equipment and also to ascertain the order of magnitude of the health and fire hazard existing in work areas.

4.4.2 It should be kept firmly in mind that the use of the following instruments and test procedures for the detection of VCM in the air requires specially trained personnel.

4.4.3 Vinyl chloride vapor concentrations in air near or within the explosive range are most easily determined by the use of a standard combustible gas indicator. The concentration of vapor may be read directly on the meter which is usually graduated in percent of the lower flammable limit. The above should not be used for the detection of health hazards.

4.4.4 A specially calibrated indicator is commercially available for vinyl chloride monomer determinations within the toxic range. Ampules which change color on exposure to VCM vapors are also commercially available and may also be employed for the detection of low level concentrations.

4.5 ELECTRICAL EQUIPMENT

All electrical equipment, motors, lights, and flashlights used in an area in which vinyl chloride is stored or handled should conform to the National Electrical Code.

5. EMPLOYEE SAFETY

5.1 EMPLOYEE EDUCATION AND TRAINING

5.1.1 Before undertaking any training of the employees who are engaged in handling or processing vinyl chloride the supervisor should be thoroughly familiar with the contents of this data sheet. MCA Case Histories describe accidents and injuries that have occurred while handling or processing vinyl chloride monomer. Safety specialists and suppliers may also be consulted.

5.1.2 After becoming thoroughly familiar with the hazardous characteristics of vinyl chloride monomer, the supervisor should review each procedure where the material is to be used and preferably with the assistance of the workers directly involved. During the review all danger points should be identified and the precautionary measures determined. The review should not only be concerned with the dangers of contact or exposure to vinyl chloride monomer, but also those which may be involved in handling containers, operating equipment and other aspects of the work. Procedures for all forseeable emergencies should be established including the location and operation of safety showers, fire extinguishers, alarms, etc. and the need for personal protective equipment.

5.1.3 During the safety review of the operations it may become apparent that some danger points can be eliminated. Possibly additional ventilation, machine guarding or modifying the method of handling the material or containers can avoid potential hazards. Process changes, however, should never be made without the approval of those who have developed the process and other knowledgeable persons. In chemical processing even a slight deviation might have disastrous results.

5.1.4 All significant hazards which cannot be satisfactorily guarded by rearrangement or other modification should be explained together with the precautions to be followed in the standard operating procedures. Preferably these safety precautions should be an integral part of the operating instructions. For example, if eye protection is required while taking a sample the standard operating procedure might read, "Wear goggles and take sample from Still No. 000." This type of instruction is preferable to explaining to the worker the need to take a sample and in another part of standard operating procedure having a notation to the effect that he is to wear eye protection when sampling.

5.1.5 If there are extremely critical steps in the process where, for example, over charge or under charge may cause uncontrollable reaction, considerations should be given to making these supervisory check points. In such instances the standard operating procedure should specify that the employee must notify his supervisor before proceeding further or as in this example, prior to charging the material to the reactor. It then becomes the supervisor's responsibility to verify that the employee has followed the proper procedure before undertaking the critical step.

5.1.6 The safety review described should be repeated periodically for all chemical processing operations and always following a significant change in the process.

5.2 PERSONAL PROTECTIVE EQUIPMENT

5.2.1 Availability and Use

Personal protective equipment is not an adequate substitute for good, safe working conditions, adequate ventilation, and intelligent conduct on the part of employees working with VCM. It is, however, in some instances the only practical means of protecting the worker, particularly in emergency situations. One should appreciate that personal protective equipment protects only the worker wearing it, and other unprotected workers in the area may be exposed to danger.

The effectiveness of personal protective equipment requires the training of workers in its proper use and care. The following personal protective equipment should be used when indicated:

5.2.2 Eye Protection

Chemical Safety Goggles

Cup-type plastic or rubber framed goggles, equipped with the approved impact resistant glass or plastic lenses, should be worn whenever there is danger of the material coming in contact with the eyes. Goggles should be carefully fitted.

5.2.3 Spectacle-Type Safety Goggles

Metal or plastic rim safety spectacles with side shields may be used where continuous eye protection is desirable, as in laboratories. Spectacles, however, should not be used where complete eye protection is needed such as when handling bulk quantities, when there is danger of splashing, or when the material is under pressure.

5.2.4 Face Shields

Plastic shields (full length, 8" minimum) with forehead protection may be worn in addition to chemical safety goggles where complete face protection is desirable. Chemical safety goggles should always be worn as added protection where there is danger of material striking the eyes from underneath or around the sides of the face shield.

5.2.5 Respiratory Protection

5.2.5.1 Severe exposure to VCM may occur in tanks during equipment cleaning and repairs, when decontaminating areas following spills, or in case of failure of piping or equipment. Employees who may be subject to such exposures should be provided with proper respiratory protection. Available types are described below:

NOTE: Respiratory protective equipment must be carefully maintained, inspected, cleaned and sterilized at regular intervals and always before and after use by another person.

(a) *Self-contained Breathing Apparatus* which permits the wearer to carry a supply of air compressed in the cylinder allows considerable mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air carried. *Compressed oxygen must not be used where there is danger of contact with flammable liquids, vapors, or sources of ignition, especially in confined spaces such as tanks or pits because of the increased fire hazard an oxygen rich atmosphere presents.*

(b) *Positive Pressure Hose Masks* which are supplied by blowers requiring no internal lubrication may be used. The wearer must be able to use the same route for exit as for entrance and must take precautions to keep the hose line free of entanglement. The air blower must be placed in an area free of contaminants.

(c) *Air-line Masks*, supplied with clean compressed air, are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. These masks are usually supplied with air piped to the area from a compressor. It is extremely important that the air supply is taken from a safe source, and that it is not contaminated by oil decomposition from inadequate cooling at the compressor. The safer method is to use a separate compressor of the type not requiring internal lubrication. Pressure reducing and relief valves, as well as suitable traps and filters, must be installed at all mask stations. An alternate arrangement frequently used is high pressure breathing air from standard (200 cu. ft.) cylinders, with a demand type valve and face piece. This arrangement may also be used with 50-100 lb. clean piped plant air, and, as an additional precaution with the demand mask, a small cylinder of compressed air may be worn for use as an emergency escape from the area. Consult a reliable safety equipment dealer for details on the proper use of U.S. Bureau of Mines approved equipment.

(d) *Industrial Canister-Type Gas Masks*, equipped with full face pieces and approved by the U.S. Bureau of Mines, fitted with the proper canister for absorbing vapor, will afford protection against concentrations not exceeding 2 percent by volume when used in accordance with manufacturer's instructions. The oxygen content of the air must not be less than 16 percent by volume. The masks should be used for relatively short exposure periods only. They are not recommended for use in an emergency since, at that time, the actual vapor concentrations is unknown and an oxygen deficiency may exist. The wearer must be warned to leave the contaminated area immediately on detecting the odor of a chemical vapor. This may indicate that the mask is not functioning properly, that the vapor concentration is too high, that the canister is exhausted or that the mask is not properly fitted. Because of the limitations outlined, use of canister masks should be restricted.

NOTE: Where other gas having little or no odor may be encountered in addition to VCM the mask should be equipped with an "all purpose canister" and a "timing device" as approved by the U.S. Bureau of Mines.

(e) *Chemical Cartridge Respirators* may be used to avoid inhaling disagreeable but relatively harmless concentrations of VCM vapor. These respirators, however, are not recommended for protection where toxic concentrations may be encountered or where there may be oxygen deficiency.

CAUTION: Filter-type respirators do not offer protection against gases or O_2 deficiency and are unsuitable for use when working with VCM.

5.2.6 Head Protection

"Hard" hats should be worn where there is danger from falling objects.

"Bump caps" are satisfactory in areas where there is little or no hazard from falling objects. They will give protection from liquid leaks and splashes.

5.2.7 Foot Protection

Leather or synthetic rubber safety shoes with built-in steel toe caps are recommended where there is danger of heavy objects falling on a workman's foot. Liquid vinyl chloride penetrates leather, and shoes wet with vinyl chloride should be (a) *discarded* if the monomer is phenol inhibited, and (b) removed and not worn until thoroughly dry when handling uninhibited monomer.

5.2.8 **Body, Skin and Hand Protection**

5.2.8.1 Any work gloves, clothing or wearing apparel which becomes contaminated with VCM should be removed immediately, and the body should be thoroughly washed. All contaminated work gloves, clothing or wearing apparel should be thoroughly washed, and dried before reuse.

5.2.8.2 When cleaning, inspecting, or repairing tanks, safety equipment such as safety belts, rescue harness, lifeline, clothing and respiratory protective equipment should be worn as required by the specific nature of the work and the hazards involved.

5.2.8.3 Frequent inspections and necessary repairs should be made to all personal protective equipment so that it is always ready to give proper protection to the wearer.

5.2.8.4 Facilities for personal cleanliness should be provided.

6. FIRE FIGHTING

6.1 When vinyl chloride burns, the hazardous gases generated are mostly hydrogen chloride and carbon monoxide (See 3.2.2).

6.2 **Emergency Measures** (See 7.5.2)

6.3 Fire involving large quantities of spilled liquid are difficult to extinguish since vinyl chloride is not miscible with water and is lighter than water (will float on top of water). Most small fires can be extinguished with carbon dioxide or dry chemical agents if properly applied. Adequate fire extinguishing equipment of carbon dioxide or dry chemical type, fixed and portable, should be provided. Water fog or spray is also satisfactory for cooling. Diking and/or draining should be provided for confining and disposing of the liquid in case of tank rupture or spills. Precautions should be taken to guard against VCM entering the general sewer system.

6.4 No one should be permitted to enter a fire area until it has been checked and approved for safe entry unless equipped with proper protective clothing and self-contained respirator.

7. SHIPPING, LABELING, HANDLING AND STORAGE

7.1 **SHIPPING**

7.1.1 **DOT Classification and Regulations**

Vinyl chloride monomer is classified by the U.S. Department of Transportation as a *flammable compressed gas*. When shipped by rail, water or highway, it must be packaged in authorized containers and shippers must comply with all DOT Regulations regarding packaging, loading, handling, labeling, marking and placarding.

7.1.2 **Usual Shipping Container— Type and Size**

Cylinders—4B150, 4BA225, 4BW225, 3A150, 3AA150, DOT-25 and 3E-1800. Cylinders with brazed seams are not permitted. Maximum permitted filling density—84%

Cargo Tanks—MC330 and 331. Maximum permitted filling density—84%

Tank Cars—DOT 106 500 X Maximum filling density—84%

DOT 105 200 W Maximum filling density—87%

DOT 112A 340W Maximum filling density—86%

7.2 **LABELING**

7.2.1 **DOT Requirements**

7.2.1.1 Each container of vinyl chloride, including tank cars shall carry an identifying label.

7.2.1.2 The proper shipping name 'Vinyl Chloride, as shown in the commodity list (para. 172.5) must be used and shown on the outside shipping containers per para 172.1(a) and 173.401(a).

7.2.1.3 Unless exempt, each individual container must bear the RED LABEL for FLAMMABLE GASES as described in para. 173.408(a)(1).

7.2.1.4 DOT 177.823(b) requires that tank motor vehicles transporting VCM shall be marked on both sides and at the front and rear, with letters at least 4" high, with the words "FLAMMABLE GAS" or "FLAMMABLE COMPRESSED GAS."

In addition, the name "VINYL CHLORIDE" must be displayed in letters at least 2" high. The words "FLAMMABLE GAS" must be displayed on other motor vehicles transporting 1000 lbs or more gross weight per para. 177.823(a).

7.2.1.5 Each railroad car must bear the "DANGEROUS" placard per para 174.541(a)(1) and (3).

7.2.1.6 Para 173.402(a)(13) specifies that an "EMPTY" label must be applied to containers which have been emptied and on which the old label has not been removed, obliterated, or destroyed. It must be so placed on the container as to completely cover the old label.

7.2.1.7 Para. 174.562(b) specifies that a "DANGEROUS—EMPTY" placard shall replace or cover the "Dangerous" placard on the railroad tank car which has been emptied.

7.2.2 **Precautionary Labeling**

7.2.2.1 The Manufacturing Chemists Association recommends that all containers of VCM should bear a label as shown. The text is designed for the product as shipped for industrial use. It should be

VINYL CHLORIDE

DANGER! EXTREMELY FLAMMABLE LIQUID AND GAS UNDER PRESSURE

HARMFUL IF INHALED

MAY POLYMERIZE VIOLENTLY UNDER FIRE CONDITIONS OR LOSS OR REMOVAL OF INHIBITOR

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor.
Avoid contact with skin.
Keep cylinder out of sun and away from heat.
Container should be grounded when being emptied.
Never drop cylinder.

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.

In case of:

Fire — Use water spray, dry chemical, or CO_2.

Spill or Leak — For small spills, evacuate area and permit to evaporate. For large spills or leaks, evacuate area. Dike or flush to ground and let evaporate. Do not flush to sewer because of explosion hazard.

MCA Chemical Safety Data Sheet SD-56 available.

used in addition to or in combination with any specific wording required by law. Since individual statutes, regulations, or ordinances may require that particular information be included in a label, that certain information be displayed in a particular manner, or that a specific label be affixed to a container, the use of this label text will not necessarily insure compliance with such laws. Such laws include the Federal Hazardous Substances Labeling Act; Federal Insecticide, Fungicide and Rodenticide Act; and similar state and municipal legislation.

7.3 CYLINDERS

7.3.1 Magnets or slings should never be used to unload cylinders. When transporting by crane or derrick a suitable platform, cradle or boot should be used.

7.3.2 Care should be exercised not to drop cylinders or otherwise handle them roughly.

7.3.3 Cylinders may be moved by tilting and rolling them on their bottom edge. Dragging and sliding them should be avoided.

7.3.4 When cylinders are transported by hand truck, they should be held securely in position by means of a locking clamp, chain or other suitable holding device.

7.3.5 Cylinders should never be used as rollers for moving any object or material.

7.3.6 Valve protection caps should always be kept in place except when the VCM containers are connected to piping, apparatus or equipment. As soon as a cylinder is disconnected the protective cap should be replaced.

7.3.7 Avoid disturbing the fusible plug. The safety device should be tagged in order to differentiate it from the discharge connection.

7.3.8 The area where the cylinder is connected should have adequate ventilation to prevent the build up of concentrations in the event of a leak.

7.3.9 Cylinders should be provided with pressure regulators as recommended by the supplier.

7.3.10 A water bath heated to a maximum of 50°C. (122°F.) may be used to empty cylinders by means of the vapor pressure of the vinyl chloride.

7.3.11 Check valves must be installed in feed lines from the cylinder to prevent the reactants from entering the cylinder.

7.3.12 When the cylinder is empty, the valve should be securely closed. Air must not be allowed to enter the container.

7.3.13 Cylinders must not be filled except by or with the consent of the owner, and then only in accordance with DOT Regulations.

7.3.14 Return of Cylinders

The cylinder valve protection cap or outlet cap must be securely replaced. The lower portion of the DOT shipping tag, if attached to the cylinder, must be removed. In other cases, applicable to DOT Regulations, compliance is essential. Bill of lading should give the cylinder identification number (which appears on the shoulder of cylinder) for each cylinder shipped, show name of consignee and indicate that the cylinders are empty.

Full or partly emptied cylinders should not be returned without permission of the supplier. Such cylinders must be shipped as full cylinders and correspondingly labeled and tagged. All empty cylinders should be returned promptly.

7.4 TANK CARS

7.4.1 Because of the flammable and toxic properties of VCM the unloading of tank cars is a hazardous operation. The supplier should be contacted for instructions and the instructions closely followed.

7.4.2 DOT Regulations, Para. 174.560 to 174.563 inclusive, contain instructions which must be observed.

7.4.3 Cars should be unloaded only on private sidings.

7.4.4 Shipper's instructions should always be followed and all caution markings on both sides of tank and dome should be read and observed.

7.4.5 No heat should be applied to the tank car. An inert gas line or compressed vinyl chloride gas line should be attached to vent connection of the tank car to provide a pressure for transfer of the liquid vinyl chloride from tank. Transfer may also be by pumping.

7.4.6 Cylinder nitrogen (inert gas) is often used as the pressuring medium in the event vinyl chloride gas is not available. Larger installations may have a suction line connected from the storage tank to a compressor which discharges compressed vinyl chloride gas to vent connection on tank car. The pressure on the car should never exceed the service pressure at which the safety valve is set to operate.

7.4.7 Return of Tank Cars

As soon as a tank car is completely unloaded, all valves must be made tight, the unloading connections must be removed and all closures made tight. Air must not be permitted to enter the vessel. The inert gas used for the unloading procedures should be left in the vessel at a pressure not to exceed the service pressure for which the car was designed, but sufficient to prevent forming a vacuum in cold climates.

7.4.8 The DOT DANGEROUS placards on sides and ends of tank cars must be removed, or reversed (if in metal placard holders) by the party discharging the tank car. The empty car must be offered to the receiving carrier either without placards, or preferably with four (4) DANGEROUS—EMPTY placards.

7.5 TRANSPORTATION EMERGENCIES

7.5.1 Assistance Available

7.5.1.1 CHEMTREC (CHEMical TRansportation Emergency Center)

This center, located in Washington, D. C. at the offices of the Manufacturing Chemists Association, is manned 24 hours per day, seven days a week, and provides, by telephone, immediate response/action information for police, fire-fighters and others concerned with the control of chemical transportation emergency situations. For assistance, dial

*(800) 424-9300 in the 48 contiguous States of the USA

483-7616 in District of Columbia

*(200) 483-7616 in Alaska

In Canada, call Canadian Chemical Producers Association's TEAP (Transportation Emergency Assistance Plan).

* Use long distance prefix if needed.

7.5.1.2 *Company Mutual Aid*

A number of vinyl chloride manufacturing companies voluntarily participate in a mutual-aid organization under which, in the event of a transportation accident, the closest company VCM plant will dispatch a qualified adviser to the scene of the accident if requested to do so by the shipper of the commodity.

7.5.2 Emergency Control

7.5.2.1 *Personnel Attending Accident Scene*

Shippers' representatives do not take charge of emergency operations. They are present as advisers only.

7.5.2.2 *Recommended Emergency Kit*

The following are considered essential:

a. Explosion meter
b. Self-contained air supply
c. Wood plugs and wood mallet
d. Data sheet and pencil
e. Camera and film
f. Flashlight (Bureau of Mines approved)
g. Rubber gloves
h. Slicker suit
i. Rubber overshoes
j. Safety lines (braided stainless, plastic covered) and harness
k. Goggles
l. Safety hat
m. O-rings
n. Strap wrench
o. 10" adjustable wrench
p. Screwdriver
q. Ground continuity meter
r. Large first aid kit and collapsible water container, approx. 50 gals. The water container should be filled at the emergency site and be available for eye wash or treatment of chemical skin contacts.

7.5.2.3 *Recommended Procedures*

Leaks of Vinyl Chloride

I. CONTROLLABLE LEAKS

a. Small holes: Drive wooden plugs.
b. Larger holes: Neoprene patch, bonded or chained to tank. Special rigs should be left to the judgment of the man at the scene.
c. Jagged holes are difficult to close
d. Potassium bicarbonate will extinguish a vinyl chloride fire but reignition often occurs. Use it around valves if it appears that a leak can be subsequently controlled.

II. UNCONTROLLABLE LEAKS—NO FIRE

a. Isolate area.
b. Remove sources of ignition.
c. Control spread of vapors by water spray.

III. UNCONTROLLABLE LEAKS—FIRE

a. Evacuate and isolate area.
b. Keep adjacent cars cool, if possible, with water spray.
c. Keep unofficial personnel away.
d. Treat a non-burning tank car in vicinity of fire as if it is about to rupture.

e. If vinyl chloride gets to a sewer, evacuate area and flush sewers with fire hoses.

7.5.2.4 ***Spilled Vinyl Chloride***

Spilled vinyl chloride should not be deliberately ignited.

7.5.2.5 ***Recovery or Removal of Vinyl Chloride***

Depending upon circumstances and extent of car damage, VCM may be recoverable, but recovery should *not* be the determining factor in controlling the situation.

a. If car condition permits, transfer contents to empty tank car using nitrogen pressure.

b. If car is ruptured, attempt to use pump with flooded suction.

c. If pumping is impractical, use water or oil to float out remainder of VCM.

d. Fill empty tank with water or nitrogen.

e. If a vinyl-ice mixture forms, keep a water stream to the tank until it dissipates.

f. Handling of vinyl chloride in a damaged car can be influenced by weather conditions. At low temperatures, since vaporization is reduced, patch tank, if possible, so that it can be moved.

7.5.3 **Marine Emergencies**

7.5.3.1 U.S. Coast Guard regulations require that a cargo information card for vinyl chloride be carried aboard the tank barge mounted near a warning sign and in such a position as to be easily read by a man standing on the deck of the barge. The cargo information card shall also be carried on the bridge or in the pilot house of the towing vessel. Copies are available from the Manufacturing Chemists Association.

7.5.3.2 ***Special Safety Equipment***

In addition to normal safety equipment provided at the dock, the following special items should be available:

a. Self-contained breathing equipment (at least two with two spare bottles).

b. Explosimeters.

c. Ground continuity meter.

d. Water with an appropriate number of nozzles.

e. Dry chemical fire extinguisher.

f. MCA Chemical Safety Data Sheet SD-56 and Cargo Information Card CIC-80.

7.5.3.3 ***Recommended Emergency Procedures***

7.5.3.3.1 *Leaks of Vinyl Chloride*

I. GENERAL—ACTIVATE ALARM

II. CONTROLLABLE LEAKS—NO FIRES

a. Isolate leak from source.

b. Eliminate ignition source.

c. Control spread of vapors by water fog.

d. Attempt to repair leak using adequat. safety protection procedures.

III. UNCONTROLLABLE LEAKS OR RUPTURES—NO FIRES

a. Isolate area.

b. Remove all sources of ignition.

c. Use water spray to prevent accumulation of liquid and to dissipate vapor cloud. It is not recommended that the ship's fire water supply be hooked into the city water supply.)

IV. UNCONTROLLABLE LEAKS—FIRE

a. Isolate area.

b. Evacuate area except for emergency personnel.

c. Use water fog on fire and fumes (do not extinguish fire unless leak can be controlled).

d. Use copious amounts of water to keep adjacent areas cool.

e. Treat adjacent tanks as if about to rupture.

f. Make provisions to minimize the mixing of air with VCM vapor in confined spaces and the burning tanks or line (water, N_2 or inert gases).

7.5.3.3.2 *Spilled Vinyl Chloride*

Spilled VCM should not be deliberately ignited.

7.5.3.3.3 *Recovery or Removal of Vinyl Chloride*

Depending upon circumstances and the extent of the tank damage VCM may be recoverable but provisions must be made to keep air out of the tank

a. If tank condition permits, transfer contents to an empty tank or back to shore.

b. If tank cannot be patched and it does not have a deep well pump or the deep well pump cannot be used, sparge heated nitrogen into the bottom of the tank to vaporize the VCM.

c. Fill empty tank with water or inert gas.

7.6 STORAGE

7.6.1 VCM should always be handled with full recognition of its flammability. Precautions should be taken both to keep the material enclosed and to eliminate sources of ignition.

7.6.2 Corrosion

VCM is noncorrosive at normal atmospheric temperatures when dry (moisture free). In contact with water at elevated temperatures VCM accelerates corrosion of iron or steel.

7.6.3 Volatility

VCM is very volatile and is a gas at normal atmospheric conditions. Containers used for handling VCM at ambient temperature are usually under pressure.

7.6.4 Temperature Requirements

Uninhibited VCM may be stored either under refrigeration or at normal atmospheric temperature in the absence of air or sunlight. Regular checks should be made for the presence of polymers.

7.6.5 Conditions of Storage

7.6.5.1 *Type of Construction*

All piping (including instruments leads), storage tanks, relief devices and equipment employed to handle VCM should be of steel and designed to have a working pressure of at least 100-150 psi with a safety factor conforming to the A.S.M.E. code for unfired pressure vessels or any code applying to locale of planned storage. Shut-off valves and control valves should be of steel or a suitable alloy not bearing copper, designed for working pressures of 150 psi or over. All-welded construction is preferred to riveted construction. It is recommended wherever possible that all liquid inlet lines enter the bottom or extend to the bottom of the vessel. This aids in guarding against the accumulation of static electricity. All equipment should be properly grounded and bonded with resistance to ground never exceeding 25 ohms. Electrical lighting, wiring and equipment should conform to NEC. An efficient water spray system should be installed or made available. Adequate diking and/or draining should be provided under tank area to confine and dispose of the liquid in case of vessel rupture. Cylinders used to store VCM must meet DOT Specifications.

7.6.5.2 *Isolation*

Storage areas should be selected in accordance with local codes or authorities having jurisdiction. For highly volatile and flammable material, storage should be located outside of buildings. Cylinders containing VCM should be stored always in a vertical position, outside of buildings, and in an isolated and well ventilated area. It is preferable to store cylinders in the open, but provision should be made to shield them from the direct rays of the sun and prevent accumulation of dirt, snow, water, or ice on valves or safety devices.

7.6.5.3 *Compatible and Dangerously Reactive Materials*

Tanks in VCM service should be used only for the storage of VCM. Before VCM is placed in a tank, the vessel should be purged with a dry inert gas until free of oxygen. VCM is generally noncorrosive at normal atmospheric temperatures when dry (moisture free). However, mild to appreciable corrosion has been noted when wet, even at ordinary temperature. This may be due to the presence of impurities. In contact with water at elevated temperatures VCM accelerates corrosion of iron or steel. Acetylene as an impurity in VCM may form an explosive compound (acetylide) when exposed to copper or possibly copper alloys.

7.7 REPACKAGING

7.7.1 Only clean, DOT Specification cylinders should be used.

7.7.2 Adequate ventilation should be provided and all sources of ignition removed from transfer area.

7.7.3 Proper personal protective equipment should be used. Transferring VCM from cylinders by the use of an uncontrolled heating method is not recommended. Temperatures of over 50°C. (122°F.) should not be applied to any part of a cylinder containing compressed gas. Excessive heating weakens the structural characteristics of the metal and may seriously damage the cylinder. Low melting safety devices may reach the fusing point by the application of excessive heat to a cylinder. Never apply direct flame to a cylinder. A definite fire hazard is created. For recommended practice to transfer contents of a cylinder see 7.3.

8. TANK AND EQUIPMENT CLEANING AND REPAIRS

(See MCA Safety Guide SG-10 "Entering Tanks and Other Enclosed Spaces")

8.1 JOB EVALUATION AND PREPLANNING

8.1.1 Because vinyl chloride monomer has physical and chemical properties which generate hazards of a toxic and flammable nature, tank and equipment cleaning and repairs should be conducted in such a manner as to eliminate or minimize the hazards. (See 10.1.1 Health Hazards—Note concerning Acroosteolysis.)

8.1.2 Equipment and tank cleaning and repair should be under the direction of thoroughly trained personnel who are fully familiar with all of the hazards and the safeguards necessary for the safe performance of the work. All precautions pertaining to education, protective equipment, and health and fire hazards should be reviewed and understood.

8.1.3 The hazardous nature of tank inspection, cleaning, and repair requires that the foreman and crew be selected, trained, and drilled carefully. They should be fully familiar with the hazards and the safeguards necessary for the safe performance of the work. The preparation of a stepwise work procedure for the entire job, recognizing all possible hazards as they might occur, developing safe procedures and designating suitable protective equipment, has been found to be particularly effective in maintaining work safety.

8.1.4 A written work permit must be prepared before tank preparation and entry. It must describe work procedures to be used, hazards which may be encountered and procedures and equipment to be used to nullify these hazards. It must be prepared, reviewed and signed by the supervisor to whom the tank is assigned after they have satisfied themselves that tank entry and repair work can be done safely.

8.2 TANK OR EQUIPMENT CLEANING

8.2.1 Tanks and equipment, pumps, lines and valves should normally be drained and thoroughly cleaned before being repaired. Workmen should never be allowed to attempt to repair equipment while it is in operation and the lines in service unless special precautions are used such as "Hot Tap" work.

8.2.2 Smoking, use of open flames, and the presence of unauthorized personnel should be prohibited.

8.2.3 All lines, which may contain hazardous substances, entering or leaving the tank should be blanked. After draining, the tank should be flushed with water to remove any remaining VCM liquid. The tank should then be steamed to remove residual VCM. Water and steam lines and nozzles should be grounded to minimize hazards of static electricity. The tank should then be cooled by filling with water and draining. Finally, the tank should be purged with fresh air and then tested for VCM by an approved method. It should also be tested for oxygen sufficiency. The controls for all agitators, pumps and other electrical equipment connected to the tank should be padlocked by the worker entering the tank.

8.3 ENTERING TANK

8.3.1 No one should enter a tank or confined space until a work permit has been signed by an authorized person indicating that the vessel has been properly prepared, tested and found to be safe.

8.3.2 No workman should enter a tank or vessel that does not have a manhole opening large enough to admit a person wearing a safety harness, lifeline and emergency respiratory equipment.

8.3.3 Forced air ventilation is recommended during the entire time men are cleaning, repairing or inspecting the tank. Ventilation can be accomplished by exhausting or removing vapors from the bottom of the tank either through a bottom opening or through a large flexible duct. Blowers should be sparkproof and should not be allowed to overheat and thus provide a source of ignition. All men who enter the tank should wear a safety harness and lifeline.

8.3.4 When a tank car or storage tank is being cleaned or repaired one man on the outside of the tank should keep the men in the tank under observation. This man should not leave his post or enter the tank without first obtaining a substitute. Another man should be available nearby to aid in rescue if any of the men in the tank are overcome.

8.3.5 Suitable respiratory protective equipment, together with rescue harness and lifeline, should always be located outside the tank for rescue purposes.

8.3.6 During the course of the work, frequent air samples should be taken to see that the concentrations are within safe range.

8.3.7 If repair work is interrupted, the tank atmoshere should be tested and a new work permit issued before work is resumed.

8.4 EMERGENCY RESCUE

8.4.1 A rescuer should not enter a confined space without wearing approved respiratory protective equipment, a safety harness and an attached lifeline. Another employee should be immediately available to man the lifeline and to assist in the rescue if needed. The rescuer should be in view of the outside attendant at all times or in voice communication with him.

8.5 EXTERIOR REPAIR WORK

All outside welding, burning or spark-producing work on tanks or equipment which have contained VCM should be done after the container has been thoroughly cleaned of VCM vapors. Purging should be tested by a competent person to see if it is free of VCM. It is not recommended that air be used to purge a vessel.

If the repair work is interrupted, the tank atmosphere should be checked thoroughly and a new work permit issued before resumption of work.

9. WASTE DISPOSAL (See 7.5)

9.1 All Federal, State, and Local regulations regarding health and pollution should be observed. Disposal of waste material, however, depends to a great extent upon surroundings, weather conditions and the emergency making disposal necessary.

9.2 When it becomes necessary to dispose of VCM as such, it is preferable to do so as a vapor, venting to an area free of any source of ignition.

9.3 When a waste disposal problem arises as a result of a major spill or equipment rupture, only properly protected and qualified personnel should remain in the area.

9.4 Waste mixtures containing VCM should not be allowed to enter drain or sewers as serious explosions in such systems may result.

10. MEDICAL MANAGEMENT

10.1 HEALTH HAZARDS

10.1.1 Vinyl chloride monomer does not present a serious industrial health hazard provided workers are adequately supervised and observe the proper means of handling it. Under the Occupational Safety and Health Act, the U.S. Department of Labor has set a 500 ppm Ceiling Value on permitted employee exposures. Based upon animal and human observations, this level provides considerable margin of safety for industrial exposures.

NOTE: A syndrome termed occupational acro-osteolysis, characterized primarily by Raynaud's phenomenon and osteolytic changes in certain bones, particularly the distal phalanges of the hands, has been noted among certain workers in vinyl chloride polymerization operations. The specific cause of this disease, and particularly any role played by vinyl chloride, is unknown.

Recent research studies reported from Italy indicate that repeated, long-term high level exposures of rats to vinyl chloride monomer vapor can result in the development of malignant tumors. However, many years of industrial experience with human exposures to concentrations frequently far above current standards have not demonstrated any carcinogenicity to humans.

10.1.2 Acute Toxicity

Levels on the order of 6,000 ppm for five minutes exposure are required to produce minimal symptoms resembling mild alcohol intoxication in humans. Levels approximately 16,000 ppm for the same length of time will produce varying degrees of intoxication, with light-headedness, some nausea, and a dulling of visual and auditory responses in most humans.

10.1.3 Chronic Toxicity

The liver is the principal target resulting from excessive chronic exposure. The currently recommended ceiling level (OSHA) of 500 ppm is well below a level producing any signs or symptoms of toxicity.

10.2 PREVENTIVE MEASURES

10.2.1 All operations in which vinyl chloride is used should be regularly evaluated and atmospheric concentrations kept, at all times, below 500 ppm. Sophisticated air sampling techniques are required. This includes gas chromatography. Processes must be closed or ventilated sufficiently to achieve a concentration control low enough so that respiratory protection devices are needed only on an emergency basis.

10.2.2 Personal Hygiene

Vinyl chloride should be kept off the skin and out of contact with the eyes. If accidental contact to the skin occurs, immediate washing with soap and water is necessary; if to the eyes, immediate irrigation for a minimum of 15 minutes with water is required. The pesence of skin and eye washing equipment in the areas where vinyl chloride is used is necessary.

Washing supplies and equipment should be maintained and always immediately available.

10.2.3 Physical Examinations

Preplacement examinations should be made on all workers having potential exposure to vinyl chloride, with particular emphasis placed upon liver and kidney functions.

10.3 SUGGESTIONS TO PHYSICIANS

Treatment for vinyl chloride intoxication is symptomatic; no special procedures are required. It should be recognized that the principal target of chronic exposures is the liver, with secondary effects, particularly in acute exposures, to the kidney. In acute overexposures the primary effect is on the central nervous system.

NOTE TO PHYSICIAN: Avoid use of epinephrine or related drugs in treating acute overexposure cases since vinyl chloride may sensitize the heart to the arrhythmic action of these drugs.

10.3.1 Oxygen Administration

Oxygen has been found useful in the treatment of inhalation exposures of many chemicals, especially those capable of causing either immediate or delayed harmful effects in the lungs.

In most exposures, administration of 100% oxygen at atmospheric pressures has been found to be adequate. This is best accomplished by use of a face mask having a reservoir bag of the non-rebreathing type. Inhalation of 100% oxygen should not exceed one hour of continuous treatment. After each hour, therapy may be interrupted. It may be reinstituted as the clinical condition indicates.

Some believe that superior results are obtained when exposures to lung irritants are treated with oxygen under an exhalation pressure not exceeding 4 cm. water. Masks providing for such exhalation pressures are obtainable. A single treatment may suffice for minor exposures to irritants. It is believed by some observers that oxygen under pressure is useful as an aid in the prevention of pulmonary edema after breathing irritants.

In the event of an exposure causing symptoms or in case of a history of severe exposure, the patient may be treated with oxygen under 4 cm. exhalation pressure for one-half hour periods out of every hour. Treatment may be continued in this way until symptoms subside or other clinical indications for interruption appear.

CAUTION: It may not be advisable to administer oxygen under positive pressure in the presence of impending or existing cardiovascular failure. The use of adrenalin is not recommended because some chlorinated hydrocarbons can increase the risk of ventricular fibrillation after adrenalin therapy.

11. FIRST AID

11.1 GENERAL PRINCIPLES

First aid should be started at once in case of acute intoxication with vinyl chloride. Immediately remove the affected individual to fresh air. Refer all injured individuals to a physician and give a detailed account of the incident.

11.2 CONTACT WITH SKIN AND MUCOUS MEMBRANES

Vinyl chloride, in concentrated form, is a skin irritant. All contaminated clothing should be removed at once; and this clothing, including shoes, if there is any evidence of contamination, should not be worn again until thoroughly dry. All affected skin areas should be thoroughly washed with warm water and soap. The individual should be referred to a physician.

11.3 CONTACT WITH EYES

If vinyl chloride has entered the eyes, prompt washing with copious quantities of water for at least 15 minutes should be instituted immediately. It is advisable to irrigate the eyes gently with water at room temperature in order to minimize additional pain and discomfort. Prompt medical attention should be obtained.

11.4 INHALATION

Promptly remove the affected individual from exposure, to fresh air. If breathing has ceased effective artificial respiration should be started immediately. If oxygen inhalation equipment is available oxygen should be administered, provided a person authorized for such administration by a physician is available. The patient should be comfortably warm but not hot. Stimulants will rarely be necessary where adequate oxygenation is maintained. Any such drugs for shock treatment should be given only by the attending physician. *Never attempt to give anything by mouth to an unconscious patient.*

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