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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

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Forwarded to:

Mr. W. N. Liao
Executive Vice President
Formosa Plastics Corporation, U.S.A.
Post Office Box 271
Baton Rouge, Louisiana 70821

SAFETY RECOMMENDATION(S)

R-85-65 through -67

At 3:45 a.m., on July 30, 1983, vinyl chloride monomer (VCM) 1/ under pressure escaped from a railroad tank car at the loading facility within the Formosa Plastics Corporation (Formosa) 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. 2/

During the evening of July 29, 1983, an employee (loader-1) was assigned to load VCM 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 on the tank 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. 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.

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/ For more detailed information read Railroad Accident Report--"Vinyl Chloride Monomer Release from a Railroad Tank Car and Fire, Formosa Plastics Corporation Plant, Baton Rouge, Louisiana, July 30, 1983" (NTSB/RAR-85/08).

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 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. 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/ 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.

Following the accident, investigators found that the safety valve 4/ 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.

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

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.
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.

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 12-psi pressure on the hose, it would have been impossible to reconnect the hose.

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.

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.

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.

Formosa purchased the plant in 1981 and reorganized the plant operations. At the time of the reorganization, 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.

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. 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.

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.

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.

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.
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> 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 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.

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-thejob 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.

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. 5/ 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

5/ 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).

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.

Therefore, the National Transportation Safety Board recommends that 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)
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> 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)
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> 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)

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility ". . . to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter.

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.

By: Jim Burnett
Chairman