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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SPECIAL INVESTIGATION REPORT

SURVIVAL IN HAZARDOUS MATERIALS TRANSPORTATION ACCIDENTS

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16. Abstract

The National Transportation Safety Board has investigated many accidents in which persons were killed following the release of hazardous materials from vehicles involved in the accidents. For example, 16 persons died following the rupture of a liquefied petroleum gas tank-semitrailer in a 1975 highway accident near Eagle Pass, Texas. In Youngstown, Florida, eight persons died following the puncture of a rail tank car carrying chlorine during an accident in 1978. In Houston, Texas, five persons were killed and 178 persons were injured by the release of anhydrous ammonia following the crash of a tank-semitrailer in a 1976 highway accident. The Safety Board has previously reported the causes of these accidents. However, the extent of the casualties in these and other accidents following the release of hazardous materials far exceeded the initial crash losses. Improving survivability in such accidents would contribute significantly to reduced hazardous materials transportation risks.

Using the 1976 Houston accident as an example, the Safety Board investigated survival actions by the victims to determine what actions they took, why they were taken, and what effects these actions had on the victims' survival. These actions were then analyzed to determine the effectiveness of the U.S. Department of Transportation-mandated safeguards in reducing casualties in hazardous materials accidents.

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Adopted: December 6, 1979

INTRODUCTION

The National Transportation Safety Board has investigated many accidents in which persons were killed following the release of hazardous materials from vehicles involved in the accidents. For example, 16 persons died following the rupture of a liquefied petroleum gas (LPG) tank-semitrailer in a 1975 highway accident near Eagle Pass, Texas. In Youngstown, Florida, eight persons died following the puncture of a rail tank car carrying chlorine during an accident in 1978. In Houston, Texas, 5 persons were killed and 178 persons were injured by the release of anhydrous ammonia following the crash of a tank-semitrailer in a 1976 highway accident. The Safety Board has previously reported the causes of these accidents. 1/ However, the extent of the casualties in these and other accidents following the release of hazardous materials far exceeded the initial crash losses. Consequently, improving survivability in such accidents would contribute significantly to the safe transportation of hazardous materials.

Using the 1976 Houston accident as a basis, the Safety Board investigated survival actions by the victims to determine what actions they took, why the actions were taken, and what effects these actions had on the victims' survival. These actions were then analyzed to determine the effectiveness of the U.S. Department of Transportation's (DOT) mandated safeguards in reducing casualties in hazardous materials accidents.

The analysis disclosed that none of the DOT-mandated safeguards were effective in reducing casualties which occurred after the ammonia release. These findings led to a further investigation of the DOT program for the collection and use of survival action data in its hazardous materials safety program. The Safety

1/ "Highway Accident Report--Surtigas, S.A., Tank-Semitrailer Overturn, Explosion and Fire, Near Eagle Pass, Texas, April 29, 1975" (NTSB-HAR-76-4); "Railroad Accident Report—Derailment of Atlanta and Saint Andrews Bay Railway Company Freight Train, Youngstown, Florida, February 26, 1978" (NTSB-RAR-78-7); and "Highway Accident Report--Transport Company of Texas Tractor-Semitrailer (Tank) Collision with Bridge Column and Sudden Dispersal of Anhydrous Ammonia Cargo, I-610 at Southwest Freeway, Houston, Texas, May 11, 1976" (NTSB-HAR-77-1).

Board found that the primary element of that program is the Research and Special Programs Administration's (RSPA) Materials Transportation Bureau (MTB) accident/incident reporting system. The system does not collect information about survival actions following the accidental release of hazardous materials. The system focuses on the collection of information about the performance of hazardous materials packaging and on trend analyses of such data to identify needed improvement in hazardous materials packaging regulations. The Safety Board concludes that the existing data system does not permit the DOT to adequately analyze the effectiveness of the regulatory hazardous materials safeguards it has mandated.

HAZARDOUS MATERIAL RELEASE

About 11:08 a.m. on May 11, 1976, at the interchange on Interstate 610 and U.S. 59 in southwest Houston, a tractor-semitrailer (tank), carrying 7,509 gallons of anhydrous ammonia, was traveling westbound on an elevated highway ramp connecting I-610 with U.S. 59 when it penetrated a bridge rail, left the ramp, struck a support column of an overpass, and fell approximately 15 feet onto U.S. 59. (See figure 1.) When the tank struck the bridge column, a tear formed near the head weld and propagated circumferentially around the weld. When the tear was long enough, the pressure differential between the liquid in the tank and the atmosphere severed the front head. Without the front head, the liquid anhydrous ammonia in the tank shot out through the front end—an opening 86 inches in diameter--at an estimated pressure of 90 psi.

Some of the ammonia vaporized and formed a large gas cloud. (See figure 2.) As the cloud absorbed heat from the surrounding warm air, it became buoyant and began to rise from the surface into the atmosphere. As the buoyant gaseous ammonia was carried upward, the cloud was limited and directed downrange by a moist, 7-mph wind. (See figure 3.) The meteorological conditions at the crash site and the large amount of suspended ammonia maintained noxious concentrations of ammonia droplets 3,000 feet downwind for 3 to 5 minutes. (See figures 4 and 5.) Cold liquid ammonia flowed along the contours of the ground and formed in pools along the ditches bounding U.S. 59. The advancing cloud caused exposed vegetation to temporarily brown. (See figure 6.)

The liquid ammonia in the pools in the ditches boiled vigorously. 2/ After 5 minutes, the cloud size shrank from 3,000 feet to 200 feet downwind. Even though large amounts of anhydrous ammonia were still in pools along the shoulders of U.S. 59, the boiling rate subsided as the ground temperature dropped to -28° F because of the contact with the cold liquid ammonia, and the pooled anhydrous ammonia began to "self-refrigerate." 3/ Firemen sprayed water on the ammonia pools, which boiled violently when the warm water was added, until the ammonia was diluted so much that it no longer emitted fumes.

2/ Liquid anhydrous ammonia boils and vaporizes at -28° F.
3/ W.L. Ball, "A Review of Atmospheric Ammonia Research Study," Ammonia Plant Safety Manual, Vol. 12, Part 1-1970.

Figure 5. North view of accident site showing cloud at 4 minutes after the crash.
(Photo by Carroll S. Grevemberg)

VICTIMS' ACTIONS

During each stage of the cloud behavior, decisions affecting life, environment, and property were made by different groups of persons reacting to on-the-scene observation and smell and the varying ammonia concentrations. More than 500 persons were within 3,000 feet of the accident site--and thus subject to the effects of the cloud--at the time of the accident. Initially, only motorists on U.S. 59 and I-610 were affected by the dispersed ammonia. As the ammonia migrated eastward from the highway, occupants of nearby buildings were affected. Organized emergency response groups which entered the spill area within 5 minutes of release were also affected by the ammonia.

U.S. 59 Motorists

All vehicular traffic on U.S. 59 stopped after the anhydrous ammonia was released. Fifteen motorists were underneath the I-610 bridge when the ammonia escaped from the damaged tank. Five vehicles were heavily damaged either by fragment impact or collision. These damaged vehicles were completely disabled, with broken windshields and roof separations. The released ammonia immediately permeated the interiors of these vehicles. Several victims in the undamaged vehicles reported what appeared to be a "blinding snowstorm" with no "strong ammonia odor" apparent. Because of the warm ambient temperature and high humidity, nearly all cars were traveling with their windows rolled up and air conditioners turned on.

Motorists in those vehicles not disabled or entrapped by other vehicles in their path stopped either on the U.S. 59 shoulder or beside the median guardrail. Ten of the 15 motorists independently left their vehicles and attempted to flee using the median guardrail or a fixed point as a guide. In leaving their vehicles, they attempted to run at first, while holding their breath or breathing through their clothing. Many of the survivors found that once outside their vehicles, the odor was stronger than inside and that ammonia was causing eye irritation, impairment of vision, blindness, nausea, disorientation, and choking. So severe were these symptoms that the victims felt they could not return to their vehicles. Many disoriented victims attempted to outrun the cloud as it advanced downwind. Victims found that obstacles like roadside fencing impaired their ability to escape. Many received abrasions after falling and continuing to crawl along the ground.

The following cases explain in more detail how some motorists on U.S. 59 reacted to the emergency (see figure 7):

Victim A. — A 45-year-old woman was westbound on U.S. 59 alone in her car at the time of the accident. She stopped her car underneath the I-610 bridge in what she later described as a "blinding snowstorm." She then stopped her car 40 feet downwind from the crash site, as close to the median as possible. At this time, with the windows rolled up, she did not see or smell ammonia inside her car. Because she could not see ahead, she felt her pathway was blocked and left her car on the driver's side during the height of the spill. She was immediately engulfed by

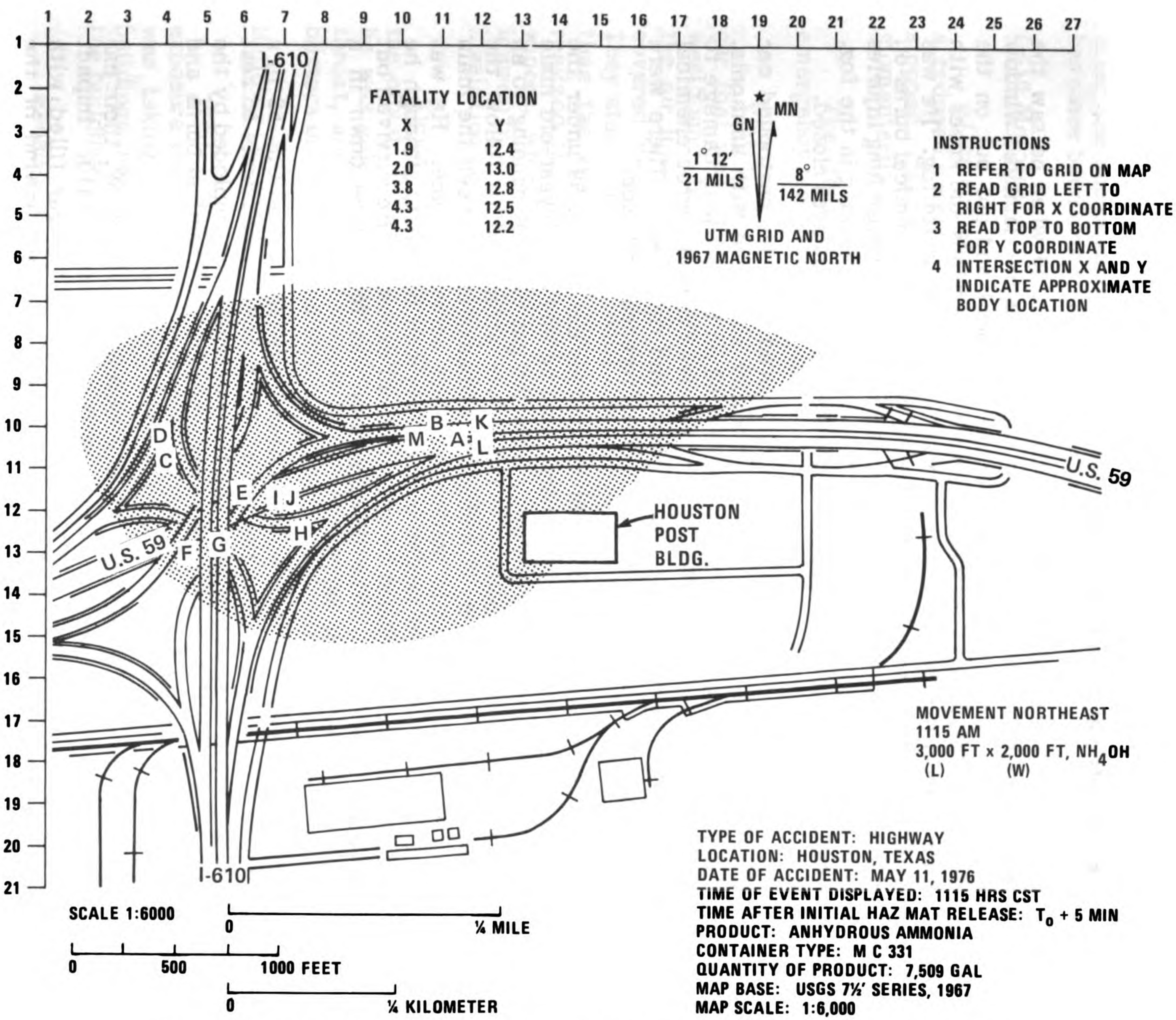

Figure 7. Location when rescued of victims discussed in case histories.

ammonia vapor as she made her way to the highway median. She walked for about 600 feet downwind along the median, while feeling with her hands along the guardrail. As she followed the guardrail, she kept her eyes open because she feared getting lost. Several times she fell or stumbled. Within 10 minutes of the crash, she was picked up by an emergency rescue unit and taken to a nearby hospital in serious condition; she remained in intensive care for several weeks. It took 4 months for the victim's condition to stabilize.

Victim B. — A 55-year-old man was westbound on U.S. 59 when he saw the crash. His car was immediately filled with toxic vapors through a damaged window on the passenger side. He drove his car into the guardrail and got out on the passenger side. He followed the guardrail by crawling on his hands and knees with his eyes shut for several hundred feet until he was clear of the white fog. He was taken to a hospital within 10 minutes of the crash. He received chemical burns on his hands and knees. In contrast to victim A, he received more intense lung injuries as he crawled in the fog during the same time that victim A was walking in the fog. His eye injuries were not so severe, apparently because he kept his eyes closed.

Victim E. — A 38-year-old man was fatally injured when his eastbound car was struck by the wreckage of the tractor-semitrailer and filled with ammonia. His car was found underneath the I-610 loop southbound on U.S. 59 with damage to the roof and windshield from debris. The victim received second-degree chemical burns on the upper right face, upper right forearm, and right hand. There were multiple brush burns on his head and lacerations of his forehead and face.

Victims F and G. — A 32-year-old man stopped his car on U.S. 59 under the I-610 bridge to avoid debris from the wreckage, and he and his 35-year-old male passenger got out. Both men tried to get away from the gas cloud by running to an open field 100 feet beyond the roadway. The driver attempted to follow the passenger. The passenger escaped by climbing the embankment between the main highway and an elevated ramp while holding his shirt across his face. He was following a procedure he had been taught in the Navy and felt that, although he was not able to see, he would at least be able to avoid exposure. He survived but had some breathing impairment. The driver's body was found face down in a watery ditch within 100 feet of the car.

Victim H. — A 30-year-old man who had been traveling west on U.S. 59 in a tractor-trailer was pronounced dead at the scene. His vehicle, which came to rest 100 yards from the crash site, was crushed and the windshield was imploded by the explosion of the tank truck. The man received lacerations and chemical burns and died from ammonia inhalation.

Victims I and J. — While traveling 50 mph eastbound on U.S. 59, their car was struck by debris from the ammonia truck as it passed under I-610. Impact from the debris severed the car's roof and the interior of the car filled with ammonia fog. The driver immediately stopped 100 to 200 feet upwind of the bridge. He and a passenger left the car and headed east on foot on U.S. 59. They were overcome by the ammonia but were rescued. Both victims were hospitalized; the driver was temporarily blinded for several days.

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Victims K and L. — A 30-year-old man and a woman passenger were westbound on U.S. 59 when they saw a large white vapor cloud 100 feet away advancing toward them. The driver quickly stopped his vehicle near the median, 500 feet from the crash site. The driver got out of the car and shouted for the passenger to follow him along the guardrail. Both victims were engulfed for 10 minutes in the ammonia fog. The passenger recovered uneventfully. Four months after the accident, doctors removed granulomas from the driver's larynx, and he has since been able to return to work.

I-610 Motorists

After the ammonia release, traffic on the I-610 bridge continued to move at a reduced speed with vehicle windows rolled up, whereas traffic on I-610 ramps stopped. Motorists on the bridge reported that the traffic slowed because fog momentarily blocked their path.

The following cases illustrate how motorists on I-610 reacted to the emergency (see figure 7):

Victims C and D. — A 28-year-old woman and her 3-year-old son were in a car that was blocked by other cars on the exit ramp of the I-610 bridge heading westbound, 15 feet above the crash site. When white fog began entering through the air intake of the air conditioning, the woman placed the child on the floor, covered his head with a blanket, and laid on top of the blanket to protect the child. They stayed in the car until the ammonia vapor cloud had dissipated. During this time the vehicle's air circulation system remained operative. Rescue personnel realized that someone was in the car when they noticed the moving windshield wipers, which the driver had turned on accidentally. The woman was severely injured by ammonia inhalation and was in intensive care for 30 days. Effects of the inhalation persisted after 1 year. The child suffered only minor injuries.

Victim M. — A man driving southound on I-610 heard the explosion and saw the cloud. By wetting a towel in his vehicle and placing it over his nose and eyes, he was able to continue driving. He reportedly received irritation of the nose, throat, and eyes. He complained of headaches that lasted for a month. He had blisters on his hands and throat, and had nosebleeds that lasted for several days.

Building Occupants

While many victims on the highway decided to leave their cars and accept exposure during the early release period, occupants in nearby buildings saw what was taking place and took other actions. Those who remained in their office buildings incurred relatively minor inhalation injuries compared to those who fled the buildings.

Because of the size of the cloud, many office buildings and residences east of the crash site were affected, including the Houston Post newspaper building where more than 400 persons were at the time. Because several occupants saw what was happening outside, the first action at the newspaper building was to shut down the air handling units to keep the ammonia out of the building. Afterward, supervisory

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During cleanup operations, firefighters wearing self-contained breathing units washed down the spill area to dilute the remaining ammonia that had collected in the ditches. A helicopter hovering over the site had little effect in reducing the ground level ammonia concentration. Firefighting units remained for 1 hour to wash down and dilute the residue on the ground.

INJURIES

The major injuries which the victims incurred were attributed to ammonia inhalation that caused impairment of the pulmonary system. Table 1 shows the injury classifications for anhydrous ammonia. Of the 178 persons hurt in this accident, 100 persons had mild injuries. They recovered quickly and were discharged from the hospital within a few hours. Seventy-two persons had moderate injuries. They were released from the hospital within 2 weeks but some had lingering effects. Six persons had serious injuries where symptoms persisted after 1 year. Five persons were killed.

In the first 24 hours, the treatment focused on administering oxygen to keep the lungs ventilated and on injecting steroids to promote dilation of the pulmonary blood vessels to aid in edemal fluid release. Immediate attention given to eye injuries consisted of constant irrigation to neutralize the caustic solution in the eyes. During the first week of recovery, the tissue in the lining of the bronchial tree of the severely injured victims was rejected. At this stage X-rays taken to determine the extent of lung damage indicated that major injury was to the upper section of the bronchial tree. During the second week of the victim's recovery, infections were treated with antibiotics. Usually, the condition of the victim stabilized during the first or second month and permanent damage as a result of infection and scarring in the bronchial tubes was identified.

INTERPRETATION OF SURVIVAL ACTIONS

In order to determine the effectiveness of the survival actions of the Houston victims and to identify ways to improve survivability, the success of the victims' actions in reducing harm from the anhydrous ammonia release and the influence of DOT-mandated safeguards in reducing the injuries must be analyzed.

Influence of Victims' Actions

The behavior of the released ammonia was complex; it involved three rapidly changing stages during its dispersion and interaction with the moisture in the air, the wind currents, the topography, and heat content of the surroundings. Both the time span of this behavior and the interaction with the environment affected the available choices of survival actions and their outcome.

During the first minutes of the emergency, several phenomena occurred as the ammonia was released to the atmosphere. More than 20 percent of the liquid ammonia turned immediately into gas—at 855 parts gas to 1 part liquid—and formed a lethal puff of cold gas 400 feet in diameter. This ammonia cooled the surrounding moist air, reduced the dewpoint of the air, and resulted in water vapor condensation or fog. Because of the affinity of anhydrous ammonia for water, some ammonia was attracted to condensed moisture in the fog, interacting to form small liquid droplets of ammonium hydroxide, which was probably the "blinding snowstorm" described by victims. This formation of ammonium hydroxide also produced heat, which warmed the surrounding air and gas mixture, contributing to the buoyancy of the gaseous ammonia and to the evaporation of the water droplets. Beyond the visible fog was an invisible olefactory region of gas vapors emitted by the fuming ammonia. This region was relatively thin, reportedly less than 50 feet beyond the visible fog, and contained strong incapacitating gas concentrations. (See figure 8.) Within 5 minutes, the puff migrated farther downwind. The boiling liquid ammonia pools continued to give out gas that formed a plume. This plume continued until the pools were diluted by the firefighters, after which only residue remained in the ditches. (See figure 9.)

Figure 10 shows the effect of the prevailing wind in dispersing the puff, plume, and residue stages downwind and the maximum downwind range affected by the fog, gaseous ammonia, aerosolized anhydrous ammonia, and ammonium hydroxide. The wind in Houston is prevalently southeasterly which would favor cloud travel and dispersion from the accident site to a heavily populated section of the inner city much of the time. Within the first minute, based on the photographs, the estimated volume of the first puff was greater than 1 million cubic feet which would correspond to a flash evaporation rate greater than 20 percent by volume. Thus, depending on their proximity to the point of release, the persons within the changing boundaries of the affected area faced different and changing dangers.

Events charting was used to organize and analyze the survival action information reported. (See appendix A.) The technique displays victims' actions and key decisions during the spill in a time-ordered sequence. By displaying, in parallel, the sequence of victims' actions during each stage of the emergency and their actual injuries, similarities and differences among these events can be identified and analyzed for their effect in minimizing injuries and in formulating recommended evasive measures and improved safeguards.

While the ammonia vapor was engulfing U.S. 59 and all evacuation paths were closed, some motorists attempted to leave their cars during the height of the puff. They took this action, even though many said they did not detect the presence of ammonia inside their cars, because they did not know the threat to their lives and how long it would last, and they were uncertain if they would be rescued in time.

Many motorists reported that the noxious vapors overcame them as soon as they got out of their cars. In leaving their vehicles, the motorists attempted to locate a reference point to guide their escape since: (1) their vision was blurred by the effect of the ammonia fumes, (2) the white fog was opaque and limited vision, and (3) physiological effects caused disorientation.

When the motorists got out of their cars, they actually decreased their chances of survival because of the high ammonia concentration around the cars. In following the median guardrails, victims were in the direct path of the vapor cloud during the height of the spill. Further, the victims were not aware that the air

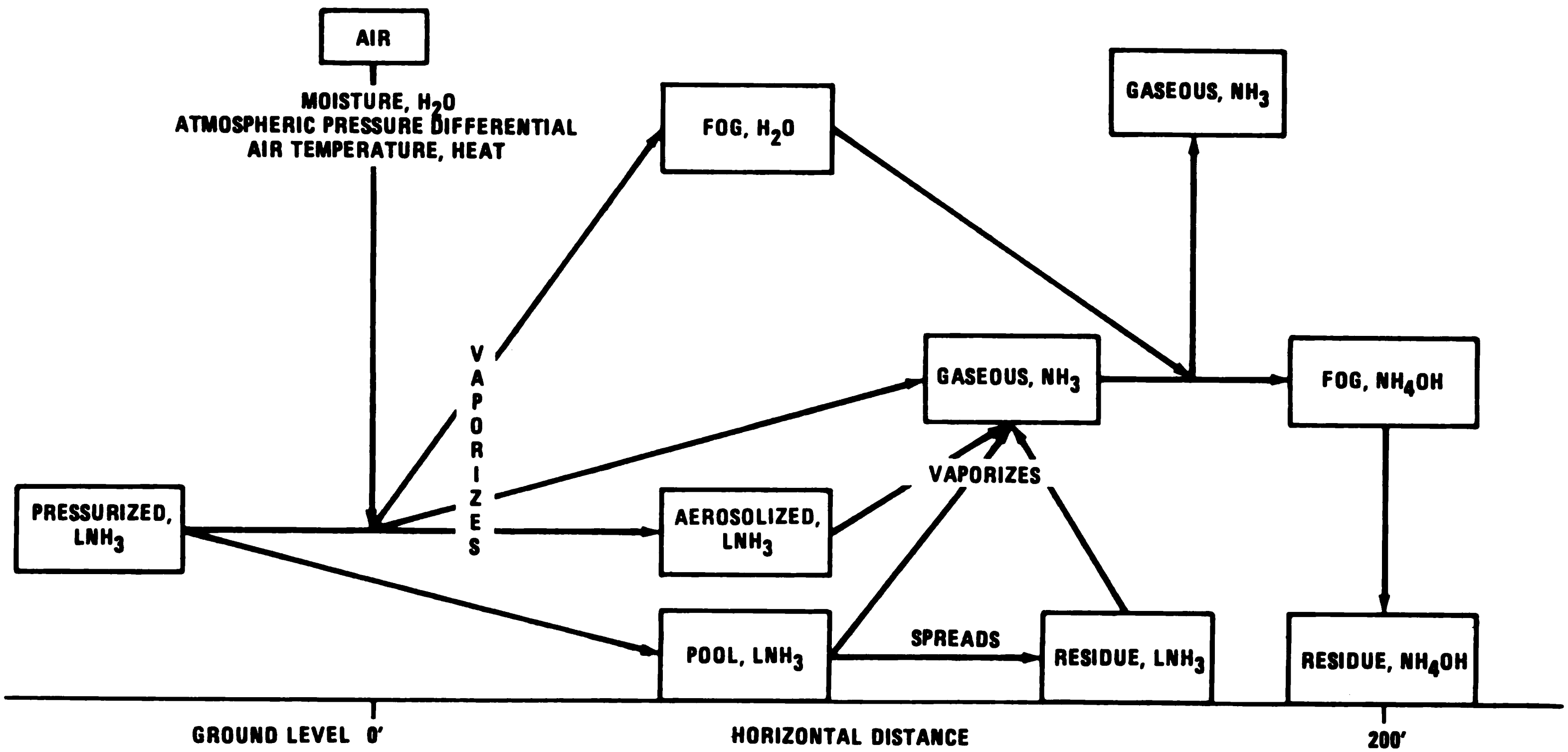

Figure 8. Formation of 1st puff between T_o (time when ammonia first released) and T_o + 1 minute.

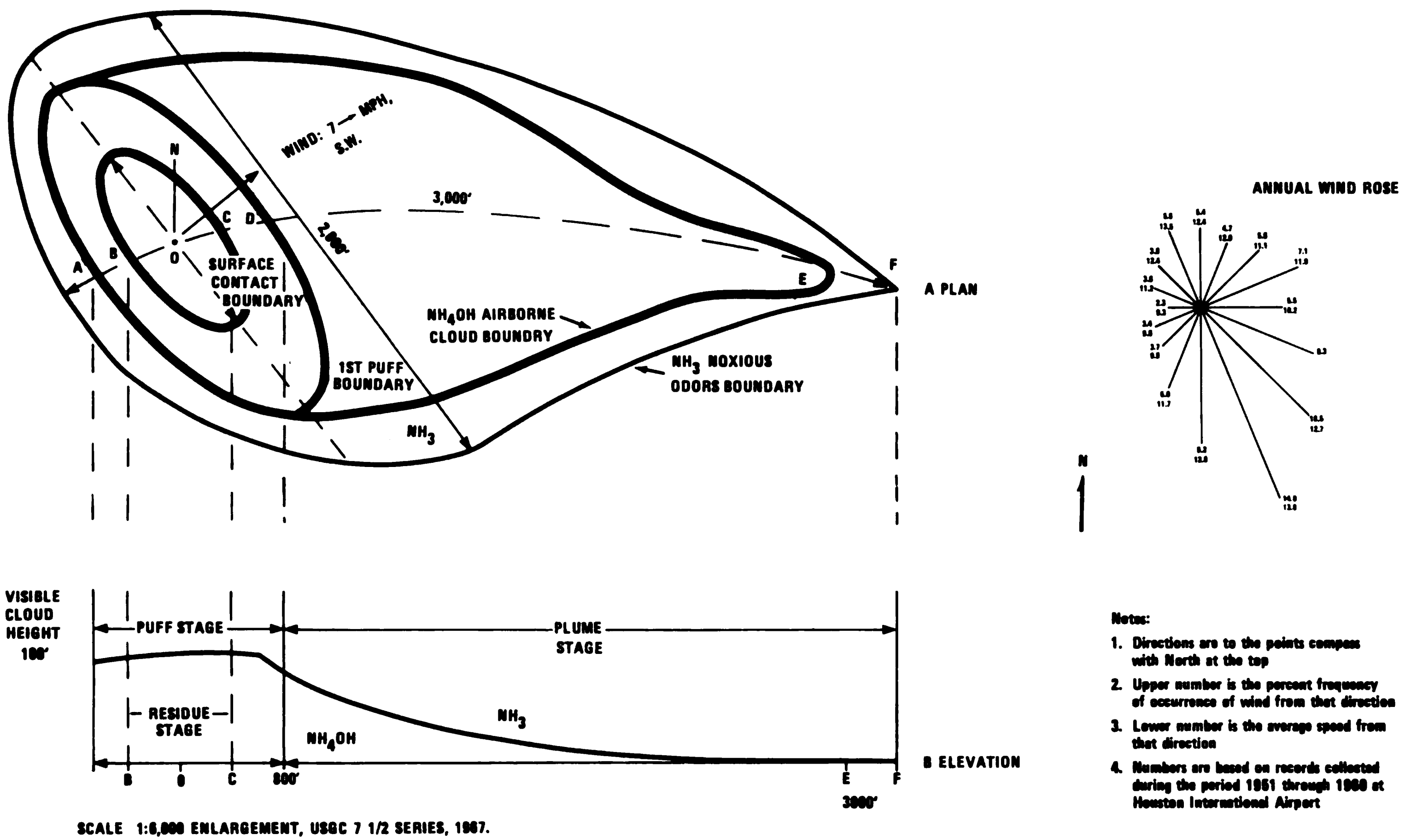

Figure 10. Approximate boundaries of ammonium hydroxide cloud migration.

flow systems inside their cars were drawing in large amounts of the contaminants outside the vehicles. With the motor shut off and the windows rolled up, occupants in the cars would have avoided the aerosolized cloud which presented the greatest threat. Finally, most of the victims did not know that effective use of personal clothing could have had an additional favorable effect on reducing their injuries.

The location of a victim's car at the time of release in the first puff affected the degree of disabling injuries. All of the fatalities and permanent major disabling injuries involved victims within 200 feet of the release point. The size and location of the primary zone remained relatively fixed throughout the emergency due to the fuming ammonia residue in the ditches. Based on the amount released and the volume of the vapor cloud, it is estimated that within 400 feet of the release point the ammonia concentration was greater than 2,000 ppm (0.2 percent) by volume for at least 2 minutes. The actual concentration of the ammonium hydroxide could not be established.

Persons in the path of the advancing cloud had more time to assess the threat and to react, and could decide to remain in their vehicles or indoors and observe the progressive stages of the cloud movement and the effects of actions being taken by other persons. Although faced with a lesser concentration of ammonia than the motorists on U.S. 59, the 400 persons in the newspaper building would have been affected if they had evacuated immediately. The chief circumstances that favorably influenced their survivability were: (1) they were under the direction of one person, (2) they could observe the developments outside, and (3) they had time in which to act.

Some potential for exposure remained until the entire area was washed down and the residue was diluted. The emergency service personnel had never previously contended with an ammonia transportation emergency, but they reacted to the emergency without outside assistance. Because emergency rescue ambulances usually do not carry self-contained or portable breathing apparatus, emergency service personnel had to wait, either for the residual ammonia vapors to disperse or for the survivors to stagger out of the dense cloud. Some emergency service personnel who eventually were able to obtain self-contained breathing equipment found that they had to remove their facepieces in order to maintain radio communications. No emergency service personnel were injured, however.

Influence of DOT Safeguards

Federal safeguards are involved in four major areas of the accident: (1) 49 CFR 178.337 prescribes specifications for MC 331 cargo tanks for anhydrous ammonia; (2) 49 CFR 172 contains hazardous materials identification and communication regulations; (3) DOT guidelines for handling hazardous materials emergencies; and (4) 49 CFR 397 restricts routes used by hazardous materials carriers. However, none of the safeguards for MC 331 cargo tanks prescribed by 49 CFR 178.337 prevented the large-scale abrupt breakage and complete release of the product within several seconds. The marking, placards, and labeling prescribed in 49 CFR 172, Communication Regulations did not help persons involved to identify the nature of the threat, to communicate what actions to take, or to help flow systems inside their cars were drawing in large amounts of the contaminants outside the vehicles. With the motor shut off and the windows rolled up, occupants in the cars would have avoided the aerosolized cloud which presented the greatest threat. Finally, most of the victims did not know that effective use of personal clothing could have had an additional favorable effect on reducing their injuries.

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Some potential for exposure remained until the entire area was washed down and the residue was diluted. The emergency service personnel had never previously contended with an ammonia transportation emergency, but they reacted to the emergency without outside assistance. Because emergency rescue ambulances usually do not carry self-contained or portable breathing apparatus, emergency service personnel had to wait, either for the residual ammonia vapors to disperse or for the survivors to stagger out of the dense cloud. Some emergency service personnel who eventually were able to obtain self-contained breathing equipment found that they had to remove their facepieces in order to maintain radio communications. No emergency service personnel were injured, however.

Influence of DOT Safeguards

Federal safeguards are involved in four major areas of the accident: (1) 49 CFR 178.337 prescribes specifications for MC 331 cargo tanks for anhydrous ammonia; (2) 49 CFR 172 contains hazardous materials identification and communication regulations; (3) DOT guidelines for handling hazardous materials emergencies; and (4) 49 CFR 397 restricts routes used by hazardous materials carriers. However, none of the safeguards for MC 331 cargo tanks prescribed by 49 CFR 178.337 prevented the large-scale abrupt breakage and complete release of the product within several seconds. The marking, placards, and labeling prescribed in 49 CFR 172, Communication Regulations did not help persons involved to identify the nature of the threat, to communicate what actions to take, or to help to control the emergency. The current DOT evacuation guidelines could increase rather than reduce injuries in some accidents. Conditions have changed since I-610 was selected and specified as a hazardous materials route. In the absence of periodic review procedures, the route's change to a higher risk area was not identified.

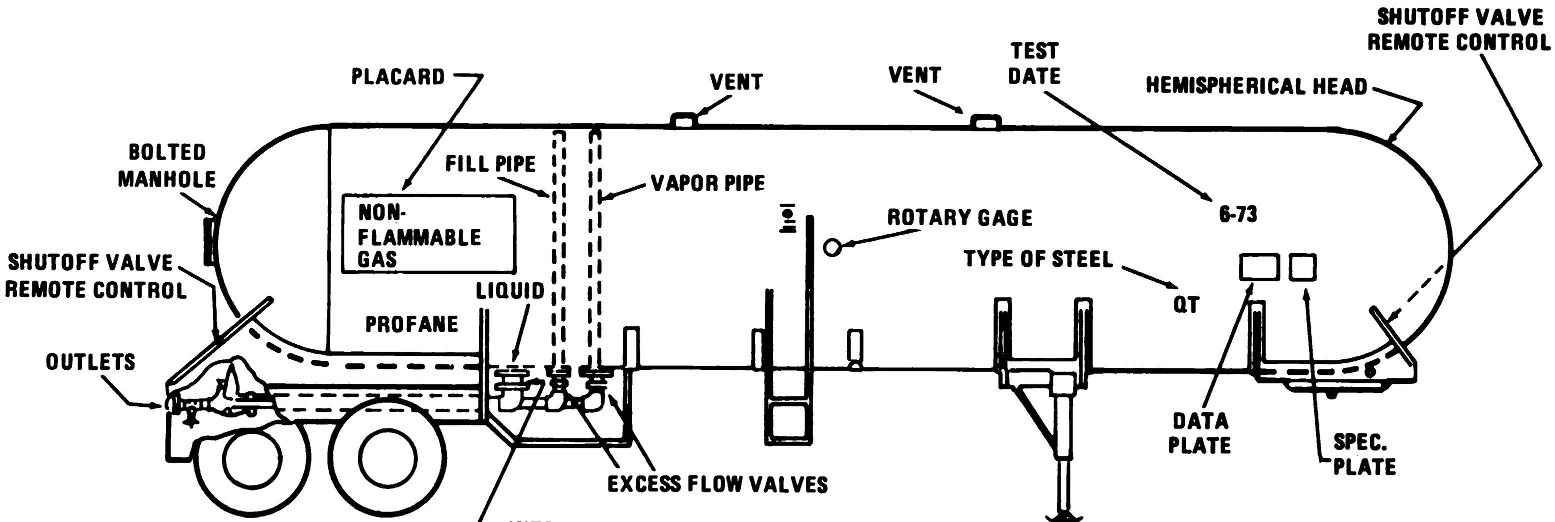
Cargo Tanks. — Title 49 CFR 178 prescribes the minimum packaging for hazardous materials in transportation. The DOT says these requirements are to contain the materials "to withstand conditions normally incident to transportation and minimize the chance of an incident". 4/ Title 49 CFR 178.337-11 prescribes emergency discharge controls for MC 331 cargo tanks, such as the one involved in the Houston accident. Emergency discharge controls, which are provided to minimize the possibility of overloading the tank from internal pressure, consisting of two pressure-relief vents, excess-flow valves, and emergency controls, are not effective in case of catastrophic damage to the tank. (See figure 11.)

In the absence of an internal lateral baffling system, the anhydrous ammonia, which was a liquid in the semitrailer tank, contributed to the driver's loss of control when the liquid surged to the outside of the tank. The combination of the shipping pressure and the deceleration impact forces forced the front end of the tank to act as a pressure relief device and fail catastrophically, propelling parts of the tank as far as 600 yards. Due to the pressurized form of the product, with its high release, evaporation, and dispersion rates, a 100-foot-high puff formed immediately and engulfed the area.

In other accidents the Safety Board has investigated, the product's shipping pressure played a role in contributing to container breakup. For example, in the accident in Eagle Pass, and in accidents in Crete, Nebraska, and Waverly, Tennessee, 5/ a critical tank crack, propagated by the product's internal pressure, resulted in bursting and complete release of the product within several seconds. Because flow rate is pressure dependent, pressurized liquefied gases discharge at higher rates than nonpressurized, self-refrigerated gases.

Hazardous Materials Identification.— Title 49 CFR 172, Hazardous Materials Communications Regulations requires the use of stenciling, placards, labeling, and shipping papers to facilitate the identification of a product so that the threats and protective measures may be assessed quickly in emergencies. At Houston, those involved first became aware of the presence of a hazardous material from the strong incapacitating fumes they described as having an "ammonia-like odor." Only after the victims were removed and the shipping papers retrieved were

4/ 7th Annual DOT Report on Hazardous Materials Control, 1976.
5/ "Railroad Accident Report—Chicago, Burlington, and Quincy Railroad Company Train 64 and Train 824 Derailment and Collision, with Tank Car Explosion, Crete, Nebraska, February 18, 1969" (NTSB-RAR-71-2); "Railroad Accident Report—Derailment of Louisville & Nashville Railroad Company's Train No. 584 and Subsequent Rupture of Tank Car Containing Liquefied Petroleum Gas, Waverly, Tennessee, February 22, 1978" (NTSB-RAR-79-1).



Source: Department of Transportation

Figure 11. Inspection guide for MC 331 cargo tank safeguards.

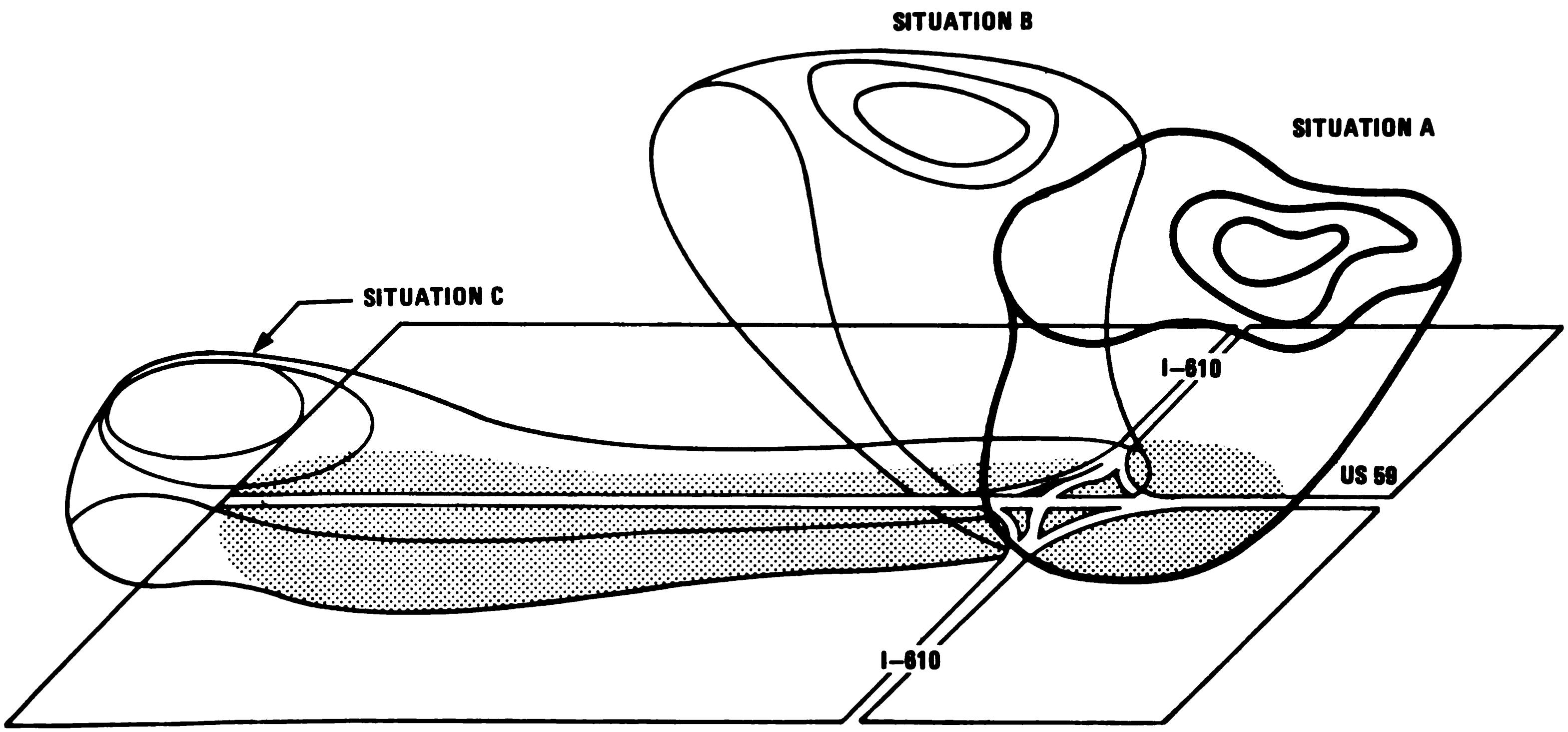
the local officials certain that ammonia was involved. One witness in the newspaper building testified that the visible cloud reached him before he could see the placards. Even if the placards could have been seen, the victims would have needed to refer to an emergency action guide to obtain any direct information on what to do. There are over 18,000 different hazardous products shipped daily, and it may be unreasonable to expect to identify products in this manner in all cases. However, delay in identifying the product can only delay survival actions, the emergency decisionmaking process, and treatment of exposed victims. For treatment purposes, knowing the specific commodity name may often be essential to survival.

Evacuation Guidelines. — DOT-recommended procedures for emergency service personnel to follow are described in a National Highway Traffic Safety Administration (NHTSA) booklet "Emergency Action Guide for Hazardous Materials" which covers general emergency handling practices during the first 30 minutes of an incident. However, the NHTSA guide is not intended to be followed during the early minutes of a rapid release involving highly volatile materials. Unfortunately, injuries are most likely to occur during this time when a pressurized compressed liquefied gas is released and when help is needed the most. The events in the Houston and Crete accidents and an accident involving ammonia in Pensacola, Florida 6/ indicate that immediately after the ammonia was released, many decisions affecting the survival of many untrained individuals had to be made rapidly based only on their observations at the scene. These accidents suggest the need to develop guidelines covering what to do in the first minutes of an emergency before help arrives.

In Houston, if some of the victims had not left their vehicles and shelters, they would have been able to avoid the lethal aerosolized chemical during the first 5 minutes. In that event, the number of serious injuries would have been significantly lower. Evacuation is not the best action in every emergency involving released gases. Specifically, untrained victims in a vehicle or building engulfed by a vapor puff do not know what personal protective measures to take, such as staying indoors or breathing through a handkerchief or other "filter." They do not know the rapid dispersive properties of certain vapors, the ability of the atmosphere to dissipate these vapors, and the ability of their own vehicles and shelters to resist the lingering effects of concentrated noxious vapors. Previous accidents have demonstrated that in some instances, a tightly closed building or vehicle affords good protection longer than the first 5 minutes after release.

In Houston, the dispersion rate of the released cargo was limited and directed by the meteorological conditions following the puff release. Figure 12 depicts the predicted dispersion of the anhydrous ammonia release in Houston under three different potential meteorological situations. Meteorological conditions at Houston at 11:15 a.m. on May 11, 1976, produced a condition

6/ "Railroad Accident Report—Louisville & Nashville Railroad Company Freight Train Derailment and Puncture of Anhydrous Ammonia Tank Cars at Pensacola, Florida, November 9, 1977" (NTSB-RAR-78-4).



8/City of Houston, Air Pollution Control, Accident Report, 1976

Figure 12. Artist's concept of the spread of ammonia under three different meteorological situations.

comparable to Situation A, the least harmful dispersion. The Safety Board found examples of "Situation C" in its investigation of the Pensacola accident where a puff traveled more than 9 miles along the surface under a light steady wind, and in its investigation of the Crete accident where a strong temperature inversion at 4° F produced a heavy ground vapor concentration forcing a house-to-house search and evacuation of 200 to 300 persons.

Routing. — Title 49 CFR 397.9, Routing requires that motor vehicles containing hazardous materials be operated over routes other than those through heavily populated areas. Additionally, 49 CFR 397.3 gives blanket approval for State and local route controls for hazardous materials motor vehicles unless these local laws and ordinances contradict DOT regulations. In order to "help carriers more easily determine the fastest and safest routes," the Federal Highway Administration publishes a pamphlet, "A Summary of Highway Facilities where Hazardous Materials are Restricted," listing 20 States and routes where transportation of hazardous materials is restricted or prohibited.

The use of designated routes for hazardous materials is a widely recognized safety measure to reduce risks. In 1970, after a series of gasoline semitrailer accidents in crowded urban areas of Houston, city officials passed Ordinance No. 70-180 to place hazardous materials vehicles on less crowded routes where the density of traffic and surrounding population was relatively low and relative vehicle speeds were similar. As a result, I-610, a 38-mile circumferential highway surrounding the city, was posted as a hazardous materials transportation route, and all vehicles transporting hazardous materials through the city were restricted to this route. In 1970, I-610 was not heavily traveled and had few office buildings nearby. By 1976, the vehicular traffic had increased to more than 70,000 vehicles daily, and high-rise commercial and residential complexes lined the entire route. Consequently, the routing safeguards designated by the city of Houston in 1970 did not prevent this accident from affecting 183 of the estimated 500 persons who were within 3,000 feet of the accident at the time of the ammonia release.

IMPROVING SURVIVABILITY

An analysis of the sequences of events that led to the injuries at Houston suggested several potential improvements in safeguards, not just against anhydrous ammonia releases but also against releases of similar types of hazardous materials.

Reaction Time

One key observation was that the victims on the highway lacked sufficient time to identify and take adequate protective actions. (Table 2 shows the typical reaction of a motorist following the accident.) On the other hand, increased time to react helped reduce the harmful effects of the ammonia release to persons inside the newspaper building. Therefore, to improve survivability, one objective of regulatory safeguards should be to increase the time available for exposed individuals to successfully react to the danger posed by the release.

TABLE 2

INTERPRETIVE SUMMARY OF VICTIMS' ACTIONS

Victim's Action	Emergency Stage	Significance for Decisionmaking
Observed semitrailer fall, or heard sound	Puff	Immediately directed attention toward crash site
Observed blinding vapor cloud	1 minute after crash	First indication that accident was "out of the ordinary"
Exited car	Between 1 and 5 minutes after crash	Threat still unidentified; odor inside
Smelled ammonia-like odor outside	5 minutes after crash	Ammonia aerosols and gas outside; threat still unclear
Experienced eye and chest pain	More than 5 minutes after crash	First indication that effects of exposure would hamper ability to react
Walked from area trying to protect eyes and seeking guardrail	More than 5 minutes after crash	True threat recognized as injury occurred; decided to flee from cloud

Both the cargo tank burst and the quantity and form of the cargo contributed to the inadequate reaction time for the motorists. In 1976, following its investigation of the accident in Eagle Pass, the Safety Board recommended that the DOT: "Initiate a research program to identify new approaches to reduce the injuries and damages caused by the dangerous behavior of pressurized, liquefied flammable gases released from breached tanks on bulk transport vehicles. (I-76-5)" The MTB has contracted for research 7/ into "new approaches for controlling pressurized flammable liquefied gas releases" from breached tanks on bulk transport vehicles.

Similar rapid bursting or releases involving bulk hazardous materials containers, and the dangers they created, have been observed in other accidents involving pressurized liquefied nonflammable gases. 8/ To a degree, problems with the transportation of nonflammable gases are similar to transportation problems with flammable gases, and because current research may be relevant to both, the Safety Board recommended in its Crestview accident report that the RSPA:

> Expand current research into "new approaches for controlling pressurized liquefied flammable gas releases" from breached tanks on bulk transport vehicles to include control of pressurized liquefied nonflammable ammonia and chlorine gas releases. (Class II, Priority Action) (I-79-12)

The burst was influenced, in part, by the quantity and form of the contents. Changing the quantity and form carried in existing equipment is probably impractical. However, the design of new equipment should consider the need to reduce product dispersal rates so that persons have adequate time to react to the accidental release of the hazardous materials carried by the equipment.

Ball 9/ has calculated the initial flash or immediate vaporization rate from liquid to vapor gas for various conditions. In the case of storage systems under a pressure of 90 psig at 75° F, which were the conditions in the Houston accident, about 20 percent of the spill would immediately flash, while only 2 percent of chilled product would immediately flash if spilled from an insulated tank operating

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7/ Contract DOT-RC-82039, September 26, 1978.

8/ "Highway Accident Report--Truck-Automobile Collision Involving Spilled Methyl Bromide on U.S. 90, near Gretna, Florida, August 8, 1971" (NTSB-HAR-72-3); "Railroad Accident Report--Chicago and Northwestern Transportation Company Freight Train Derailment and Collision, Glen Ellyn, Illinois, May 16, 1976" (NTSB-RAR-77-2); "Railroad Accident Report--Derailment of Atlanta and Saint Andrews Bay Railway Company Freight Train, Youngstown, Florida, February 26, 1978" (NTSB-RAR-78-7); "Railroad Accident Report--Louisville & Nashville Railroad Company Freight Train Derailment and Puncture of Hazardous Materials Tank Cars, Crestview, Florida, April 8, 1979" (NTSB-RAR-79-11).

9/ W.L. Ball, op. cit.

at 0.5 psi. Thus, shipping pressure and temperature were a critical factor in producing the inescapable massive ammonia cloud. Because the amount dispersed and the dispersion rate are determined by the quantity released and by evaporation rates, both of which depend on shipping pressure, reductions in either would reduce the affected area and permit improved survival.

Alternatives to Evacuation

The differences in the degree of injury among the exposed victims suggest that alternatives to evacuation of people from the area affected by a release could improve survivability. The protection offered survivors by the vehicles, buildings, clothing, and a blanket at Houston demonstrates that alternatives to simply running away from the released gas in future accidents may exist and should be identified.

The victims on U.S. 59 did not remain in their vehicles because they were unaware of the capability of their vehicles to resist most of the harmful ammonia effects. A structure or vehicle can provide partial protection from a transient puff of dangerous vapors. Understanding the behavior of such vapors would contribute greatly to the safe handling of future large releases of highly volatile materials. This is particularly true where wind shifts would require potential victims to be directed to remain in their vehicles or facilities.

Furthermore, if the structure or vehicle were tightly sealed, even further protection could be achieved. There are numerous models to predict the time required to evacuate a building and the ability of buildings to withstand outside dangerous chemical dosages. 10/ However, this knowledge is not being used routinely by the DOT in emergency guidelines to determine what evacuation options should be considered in the early stages of a spill, what to expect in terms of prevailing meteorological conditions, and the feasibility of alternatives to evacuation. 11/

We recognize that educating the public about alternatives to evacuation would be difficult. However, most large cities can quickly dispatch a helicopter equipped with a public address system. This helicopter could serve a vital role if equipped with effective communication links to emergency response experts or, alternatively, with emergency action guides, data on hazardous materials behavior, and information about the capability of vehicles and structures to protect persons. This helicopter could provide a vital communication link with those trapped in their vehicles and nearby buildings. In the Houston accident, police vehicles provided instructions for evacuation in this manner. Additionally, the ability of a helicopter to respond promptly could provide vitally needed information on cloud dispersion and effects to the ground emergency rescue personnel. This would aid in gathering data needed to control urban transportation emergencies. For example, the helicopter at Houston could have helped the ambulance chief locate the injured survivors, perhaps using map grid coordinates to guide rescuers on the ground.

10/ J.D. Wood, Contingency Plans for the Disposal of Chlorine from the Ohio River Barge Incident, March 1972, Proceedings of the Environmental Protection Administration, New Orleans (1972) Conference, p. 176.
11/ NTSB-RAR-78-4, op. cit.

Improved Routing Controls

Local routing controls should provide for periodic review and assessment to reflect changed exposure potentials due to changing urban environments. Hazardous materials accidents are infrequent in most communities, so it is extremely difficult to determine the best routes from experience. No guidelines for selecting the best routes exist, nor has survival action data that could form a basis for their selection been collected. Consequently, local officials and carriers must make decisions affecting hazardous materials routing on the basis of their limited experience and best judgments without access to safety analysis capabilities and data at the local or national levels. Without Federal guidelines or data, high-risk areas along routes are not being identified uniformly and regulatory requirements among cities will likely become increasingly inconsistent.

Because of the problem with designating routes and the changes which may occur following the adoption of a designated route, the Safety Board recommended in its Houston accident report that the Federal Highway Administration (FHWA):

> Develop guidelines for local and State agencies to use in designating and periodically reviewing routes for the transportation of hazardous materials as a means of reducing injury and damage from accidents involving hazardous materials in their jurisdictions. (Class II, Priority Action) (I-77-1)

In May 1979 the FHWA contracted for the development of routing criteria for hazardous materials.

The survival actions in the Houston accident suggest that the limited-access highways in congested urban areas may not be desirable for certain hazardous materials shipments. The high vehicle speeds, traffic density, lack of escape channels, inaccessibility to rescue personnel, and rapid buildup of vehicles in the affected area all suggest that operations on lower speed, lower density routes could reduce catastrophic risks for certain pressurized, liquefied gases and other hazardous materials where survival action timing and size of the affected area determine survivability.

In designing safety programs, the comparative effects of changes to safeguards can be evaluated for various survival action situations to identify the changes which would provide the greatest reduction in risks. As the variety of situations observed in releases begins to accumulate in a data collection system, the degree of certainty about the most effective improvements can also increase.

DOT Accident/Incident Reporting System Deficiency

The DOT maintains accident reporting systems to improve safety by identifying regulatory deficiencies and to undertake effective compliance actions. The U.S. Coast Guard, the Federal Aviation Administration, the FHWA, and the Federal Railroad Administration administer accident reporting systems for their respective modes of transport. All require carriers to report transportation accidents involving deaths or injuries or property damage exceeding certain pre-established limits. These systems focus on the vehicle, operator, roadway, weather, and operating factors. None incorporates a reporting requirement specifically related to hazardous materials or to details of packaging or storage of cargo.

The MTB maintains a central reporting system for all incidents involving the release of hazardous materials in transportation, regardless of whether they are caused by an accident. Carriers must give immediate notice of any transportation incidents in which hazardous materials are directly responsible for a fatality, an injury, or property damage exceeding $50,000, or for suspected contamination involving shipment of radioactive materials or etiologic agents. Further, carriers must submit a written hazardous materials incident report (Form DOT F 5800.1, issued October 1970). The report requires details of classification name and quantity of the hazardous material; packaging and storage conditions and the suspected cause of the product release; and information about the type of incident and the nature of the hazardous material involvement. A copy of the incident report is provided to the appropriate modal operating administration, which may conduct an investigation to determine if a violation of the hazardous materials regulations occurred. In addition, summaries, tallies, and analyses based on these incident reports are regularly provided to the operating administrations. A copy of the report submitted to the MTB following the Houston accident is shown in appendix B.

Thirty-seven of the 47 entries on form F 5800.1 involve information relating to the packaging and contents of the hazardous materials shipment. The form does not ask for any information about survival actions. In its annual hazardous materials report for 1976, the DOT reported that it planned to "improve the hazardous materials incident reporting system" in 1977 "through refinement of the reporting requirements. This improvement will enable better trend analysis and will provide a more reliable indicator of regulation effectiveness and compliance levels." Form F 5800.1 is still in use.

The Safety Board has previously expressed concern about the need for data to help improve emergency training for law enforcement and firefighting personnel. In 1976, following its special investigation of firefighter fatalities in transportation accidents, the Safety Board recommended 12/ that the DOT redesign its hazardous materials accident/incident data reporting system to generate information about emergency response actions in hazardous materials emergencies for use in training firefighters and law enforcement personnel to handle hazardous materials emergencies, and for evaluating the validity of the advice which the DOT provides to other agencies with regard to hazardous materials transportation emergencies. Contracts let in 1979 to resolve this problem do not address the accident/incident reporting forms.

In September 1978, a DOT Hazardous Materials Transportation Task Force acknowledged deficiencies in the department's hazardous materials data system. 13/ The task force concluded that the DOT hazardous materials data collection systems should be strengthened and centralized, and should become the

12/ NTSB Safety Recommendations I-76-9 through -11

13/ Department of Transportation, Report of the Task Force on Hazardous Materials, September 1978.

basis for hazardous materials program planning, regulation development, enforcement, and program evaluation. The recommendation that a centralized hazardous materials information system be established within the DOT to collect and analyze hazardous materials program information was approved on September 28, 1978. Work on that project is being performed by the RSPA's Transportation System Center. The Safety Board reviewed the work in progress and finds that survival action data has not yet been singled out for attention in this project.

Collection of Survival Data

The type of survival action data for the adequate evaluation of DOT regulatory program elements and safeguards is illustrated by the analysis of survival actions in the Houston accident. The collection of hazardous materials survival action data would be useful because it could lead to an improved understanding that can be applied to hazardous materials which behave in a comparable manner in accidents. Thus, the proper analysis of these actions can contribute to the assessment of safeguards in a broader range of general situations.

On the other hand, the failure to collect survival action data can result in misdirection of regulatory programs. The underlying safety purpose for regulation of hazardous materials transportation is the concern about the harm which can occur when hazardous materials are released unintentionally. The DOT's overwhelming concern for the performance of the packaging, as evidenced by the packaging data required on form F 5800.1, must be balanced with a concern for the effects of hazardous materials when they do escape from their containers. Without survival action data, this balance cannot be achieved.

The DOT should collect data on the degree of injuries in an accident to aid in determining the effects of the release. The DOT should consider recovery time for a victim as the primary factor in rating the degree of injury. This data would provide indicators of unreasonable risk.

Data Sources

The Safety Board's experience in acquiring the survival action data in the Houston accident indicates that by modifying its policy requiring carriers to report incidents, the DOT can acquire the needed survival action data from other sources. For example, during this special investigation, the survival data were collected by one Safety Board staff member over several months. Data were gathered from the Houston Fire Department, the City of Houston Department of Health, the Texas Air Pollution Control Board, the Houston Area Disaster Emergency Medical Service, a local hospital, local physicians, interviews with survivors, the Houston Police Department, coroner's reports, and the Houston Department of Traffic and Transportation. In previous investigations, the Safety Board has worked with other sources to acquire information about survival actions.

This experience persuades the Safety Board to conclude that a program to acquire survival action data for hazardous materials accidents is practicable and feasible. Only the designation of a method for collecting such information, and a program to marshal the efforts of the sources who can provide it, stand in the way of its implementation by the DOT.

Using Data

The interpretation of the survival action data collected in the Houston accident demonstrates how survival action data can be used after an accident for the evaluation of safeguards, without lengthy delays. The Safety Board has been encouraged by the DOT's acknowledgement that "the hazardous materials information system should be carefully designed to record the significant characteristics of the Department's programs in order to assist in the Department's planning, regulatory, and compliance efforts." 14/ In redesigning its data system, the DOT must reexamine the ways in which it analyzes the data it collects, as well as the data it collects.

The Houston accident occurred more than 3 years ago. With study efforts recently initiated, no specific regulatory changes that would overcome deficiencies in the safeguards and regulatory programs have been made. A study contract to examine tank failure behavior is in progress, but the Safety Board understands that the study is handicapped by the lack of the type of data presented in this report. The study to develop routing guidelines, also initiated recently, faces a similar problem.

Analysis of the survival actions in the Houston accident, and the potential improvements identified during that analysis, demonstrate that it is not necessary to wait for a large number of accidents to occur to develop data to evaluate safeguards. Using the methods shown in this report, these evaluations can be performed within a few months after a serious accident. By understanding the sequences of events which determine the harmful consequences in serious hazardous material releases, the delays in identifying corrective safety actions inherent in statistical trend analysis approaches could be substantially reduced, with a corresponding improvement in current levels of risks for hazardous materials transportation.

In a few instances involving packaging, the MTB has improved its regulations after investigating a single accident. 15/ A reduction in delays in bringing about demonstrated improvements of deficient survival safeguards merits high priority among the MTB's safety program efforts. Therefore, the task of collecting and using survival action data in serious accidents should be incorporated expeditiously into the project to redesign RSPA's hazardous materials information system. The DOT's coverage of perhaps 50 to 100 serious accidents with serious or fatal injuries each year would not seem to be an unreasonable task.

In addition to internal use of the data, dissemination of survival action data in serious accidents, and the dissemination of maps of the hazardous materials

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14/ DOT Task Force Report, op. cit.
15/ Docket HM99, Amendment 173-115, prohibiting certain natural gas transportation in DOT 3AX, 3AAX, and 3T cylinders.

behavior in such releases, 16/ would enable safety program managers nationwide to benefit from and act on the lessons learned in such accidents. The task is to organize the resources available so that survival action information and hazardous materials behavior information is accessible to all who manage hazardous materials safety programs. This would permit voluntary implementation of corrective measures based on such information, further reducing the delay in achieving improved safeguards and reduced transportation risks.

CONCLUSIONS

1. None of the regulatory safeguards—vehicle, roadway, placarding, or emergency action guides—were effective in reducing the injurious effects of the hazardous materials release in the Houston accident on May 11, 1976.

2. The threat to personal safety was not generally recognized by the exposed motorists until injury occurred; then the only survival action recognized was to flee the ammonia cloud.

3. The markings, placards, and labeling under 49 CFR 172, Hazardous Materials Communications Regulations did not assist those involved to identify the nature of the threat, to communicate what actions to take, or to help control the emergency.

4. The MTB's current reporting system requires the occurrence of numerous accidents in order to identify data trends that demonstrate a need for improved safeguards.

5. The MTB cannot evaluate its safeguards affecting hazardous materials transportation releases adequately or promptly because it does not have a procedure by which survival action data are collected and used.

6. The DOT hazardous materials incident reporting system requires carriers to help prepare data to support trend analysis that is directed toward packaging rather than improved survivability; both factors need to be considered.

7. The MTB needs to change its policy of relying solely on carriers to support its accident/incident reporting system; it should marshal all the available resources for collecting accident information to support its regulatory program.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board recommended that the Research and Special Programs Administration of the U.S. Department of Transportation:

16/ "Special Investigation Report—Standardized Maps for Hazardous Materials Accidents" (NTSB-HZM-79-1).

Incorporate hazardous materials incident survival action data in the new centralized hazardous materials information system which the Department of Transportation is establishing under recommendation No. 3 of the September 1978 Report of the Hazardous Materials Task Force. (Class II, Priority Action) (I-79-14)

Establish procedures to promptly utilize survival action data and to analyze the harm from an accident in evaluating the influence of regulatory safeguards upon the outcome of serious hazardous materials incidents. (Class II, Priority Action) (I-79-15)

Use survival action data collected to revise emergency guidelines, incorporating recommended actions, their purpose, and the effect they should have in reducing losses following the release of hazardous materials. (Class II, Priority Action) (I-79-16)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

December 6, 1979

APPENDIX B

Form DOT F 5800.1
Hazardous Materials
Incident Report
of Houston Accident

DEPARTMENT OF TRANSPORTATION — Form Approved OMB No. 04-R613

HAZARDOUS MATERIALS INCIDENT REPORT

INSTRUCTIONS Submit this report in duplicate to the Secretary, Hazardous Materials Regulations Board, Department of Transportation, Washington, D.C. 20590, (ATTN: Op. Div.). If space provided for any item is inadequate, complete that item under Section H, "Remarks," keying to the entry number being completed. Copies of this form, in limited quantities, may be obtained from the Secretary, Hazardous Materials Regulations Board. Additional copies in this prescribed format may be reproduced and used, if on the same size and kind of paper.

A INCIDENT

1. TYPE OF OPERATION

1 ☐ AIR 2 ☒ HIGHWAY 3 ☐ RAIL 4 ☐ WATER 5 ☐ FREIGHT FORWARDER 6 ☐ OTHER (Identify) ______

2. DATE AND TIME OF INCIDENT (Month - Day - Year)	3. LOCATION OF INCIDENT
5-11-76 11:20 a.m. ____ p.m.	HOUSTON, TX

B REPORTING CARRIER, COMPANY OR INDIVIDUAL

4. FULL NAME	5. ADDRESS (Number, Street, City, State and Zip Code)
THE TRANSPORT CO. OF TEXAS	5503 AGNES STREET CORPUS CHRISTI, TX 78408

6. TYPE OF VEHICLE OR FACILITY

C SHIPMENT INFORMATION

7. NAME AND ADDRESS OF SHIPPER (Origin address)	8. NAME AND ADDRESS OF CONSIGNEE (Destination address)
TENNACO CHEMICAL INC. PASADENA, TX	PPG P. O. BOX 4026 CORPUS CHRISTI, TX
9. SHIPPING PAPER IDENTIFICATION NO.	**10. SHIPPING PAPERS ISSUED BY**
A 63788	☐ CARRIER ☒ SHIPPER ☐ OTHER (Identify) ______

D DEATHS, INJURIES, LOSS AND DAMAGE

DUE TO HAZARDOUS MATERIALS INVOLVED		13. ESTIMATED AMOUNT OF LOSS AND/OR PROPERTY DAMAGE INCLUDING COST OF DECONTAMINATION (Round off in dollars)
11. NUMBER PERSONS INJURED: 150	12. NUMBER PERSONS KILLED: 5	$ UNKNOWN
14. ESTIMATED TOTAL QUANTITY OF HAZARDOUS MATERIALS RELEASED: 38,820 LBS.		

E HAZARDOUS MATERIALS INVOLVED

15. CLASSIFICATION (Sec. 172.4)	16. SHIPPING NAME (Sec. 172.5)	17. TRADE NAME
COMPRESSED GAS	ANHYDROUS AMMONIA	ANHYDROUS AMMONIA

F NATURE OF PACKAGING FAILURE

18. (Check all applicable boxes)

	(1) DROPPED IN HANDLING		(2) EXTERNAL PUNCTURE		(3) DAMAGE BY OTHER FREIGHT
	(4) WATER DAMAGE		(5) DAMAGE FROM OTHER LIQUID		(6) FREEZING
	(7) EXTERNAL HEAT		(8) INTERNAL PRESSURE		(9) CORROSION OR RUST
	(10) DEFECTIVE FITTINGS, VALVES, OR CLOSURES		(11) LOOSE FITTINGS, VALVES OR CLOSURES		(12) FAILURE OF INNER RECEPTACLES
	(13) BOTTOM FAILURE		(14) BODY OR SIDE FAILURE		(15) WELD FAILURE
	(16) CHIME FAILURE	X	(17) OTHER CONDITIONS (Identify) RUPTURE ON IMPACT		19. SPACE FOR DOT USE ONLY 6050911

Form DOT F 5800.1 (10-70)

APPENDIX B

G PACKAGING INFORMATION – If more than one size or type packaging is involved in loss of material show packaging information separately for each. If more space is needed, use Section H "Remarks" below keying to the item number.

	ITEM			#1	#2	#3
20	TYPE OF PACKAGING INCLUDING INNER RECEPTACLES (Steel drums, wooden box, cylinder, etc.)			STEEL T-1		
21	CAPACITY OR WEIGHT PER UNIT (55 gallons, 65 lbs., etc.)			10,500 GAL		
22	NUMBER OF PACKAGES FROM WHICH MATERIAL ESCAPED			ONE		
23	NUMBER OF PACKAGES OF SAME TYPE IN SHIPMENT			-		
24	DOT SPECIFICATION NUMBER(S) ON PACKAGES (21P, 17E, 3AA, etc., or none)			MC 331		
25	SHOW ALL OTHER DOT PACKAGING MARKINGS (Part 178)					
26	NAME, SYMBOL, OR REGISTRATION NUMBER OF PACKAGING MANUFACTURER			DAL-WORTH MFG.		
27	SHOW SERIAL NUMBER OF CYLINDERS, CARGO TANKS, TANK CARS, PORTABLE TANKS			TP-46834		
28	TYPE DOT LABEL(S) APPLIED			COMPRESSED GAS		
29	IF RECONDITIONED OR REQUALIFIED, SHOW	A	REGISTRATION NO. OR SYMBOL			
		B	DATE OF LAST TEST OF INSPECTION	1-15-75		
30	IF SHIPMENT IS UNDER DOT OR USCG SPECIAL PERMIT, ENTER PERMIT NO.					

H REMARKS—Describe essential facts of incident including but not limited to defects, damage, probable cause, stowage, action taken at the time discovered, and action taken to prevent future incidents. Include any recommendations to improve packaging, handling, or transportation of hazardous materials. Photographs and diagrams should be submitted when necessary for clarification.

TANK RUPTURED ON IMPACT WITH LOSS OF ALL PRODUCT IN SURROUNDING AREA. NO KNOWN DEFECTS. CAUSE OF ACCIDENT UNKNOWN. AWAITING FINDINGS OF NATIONAL TRANSPORTATION SAFETY BOARD INVESTIGATION.

SEE ATTACHED ARTICLE FROM HOUSTON POST DATED MAY 12, 1976.

60509111

31. NAME OF PERSON PREPARING REPORT (Type or print)	32. SIGNATURE
HOYT GABBARD	Hoyt Gabbard
33. TELEPHONE NO. (Include Area Code)	**34. DATE REPORT PREPARED**
512/882-8491	5-24-76

Reverse of Form DOT F 5800.1 (10-70)