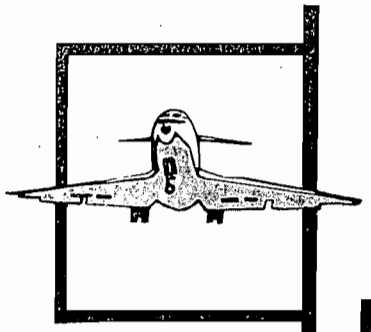

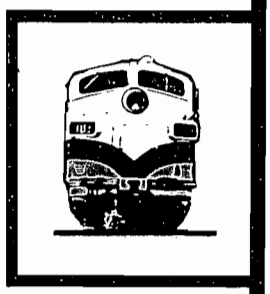

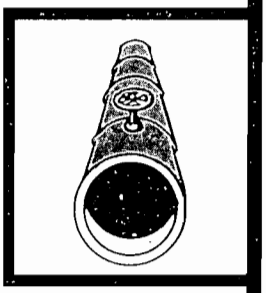

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

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

REPORT NUMBER: NTSB-HAR-77-1

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes

16. Abstract

About 11:08 a.m., on May 11, 1976, a Transport Company of Texas tractor-semitrailer (tank) transporting 7,509 gallons of anhydrous ammonia struck and then penetrated a bridge rail on a ramp connecting I-610 with the Southwest Freeway (U.S. 59) in Houston, Texas. The tractor and trailer left the ramp, struck a support column of an adjacent overpass, and fell onto the Southwest Freeway, approximately 15 feet below. The anhydrous ammonia was released from the damaged tank semitrailer.

Six persons died as a result of the accident, 78 persons were hospitalized, and approximately 100 other persons were treated for injuries.

The National Transportation Safety Board determines that the probable cause of this accident was the excessive speed of the vehicle combined with the lateral surge of liquid in the partially loaded tank truck, which caused it to overturn. The cause of 5 of the 6 fatalities and all of the 178 injuries was the inhalation of anhydrous ammonia. Contributing to the severity of the accident was the failure of the bridge rail to contain or redirect the vehicle.

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CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

Adopted: April 14, 1977

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

SYNOPSIS

About 11:08 a.m., on May 11, 1976, a Transport Company of Texas tractor-semitrailer (tank) transporting 7,509 gallons of anhydrous ammonia struck and penetrated a bridge rail on a ramp connecting I-610 with the Southwest Freeway (U.S. 59) in Houston, Texas. The tractor and trailer left the ramp, struck a support column of an overpass, and fell onto the Southwest Freeway, approximately 15 feet below. The anhydrous ammonia was released from the damaged tank semitrailer.

Six persons died as a result of the accident, 78 persons were hospitalized, and approximately 100 other persons were treated for injuries.

The National Transportation Safety Board determines that the probable cause of this accident was the excessive speed of the vehicle combined with the lateral surge of liquid in the partially loaded tank truck, which caused it to overturn. The cause of 5 of the 6 fatalities and all of the 178 injuries was the inhalation of anhydrous ammonia. Contributing to the severity of the accident was the failure of the bridge rail to contain or redirect the vehicle.

INVESTIGATION

The Accident

About 10:45 a.m., on May 11, 1976, a Transport Company of Texas tractor-semitrailer (tank) loaded with 7,509 gallons of anhydrous ammonia left TENNECO Chemicals, Inc., of Pasadena, Texas, for Corpus Christi, Texas via Interstate-610 1/ (I-610) and the Southwest Freeway (U.S. 59) in Houston.

The driver of an automobile stated that the truck followed her through heavy traffic north on I-610. At one point, she observed that her speedometer registered 59 mph while the truck kept pace several car lengths behind. She stated that in order to move over to the right lane as she approached the interchange of I-610 and the Southwest Freeway, she accelerated up to 70 mph to move ahead of other traffic. As she neared the elevated interchange she exited from I-610 and proceeded to the right down the connector ramp to the eastbound Southwest Freeway. The truck also exited from I-610 and proceeded to the left, down the connector ramp to the westbound Southwest Freeway. As the two vehicles parted, the automobile driver estimated her speed down the ramp to be about 40 to 45 mph and that of the truck to be about 55 to 60 mph.

Shortly after entering the curved ramp, the tractor-semitrailer entered onto a bridge. (See figure 1.) The truck and the trailer began to roll to the right, its wheels struck the curb, and the combination vehicle began to leave the ramp. The upsetting tank crushed and penetrated the bridge rail, and the vehicle fell onto the Southwest Freeway, approximately 15 feet below. As it fell, the tank struck a support column of an overpass that crossed over the ramp on which the truck was traveling.

During the accident, the tractor separated from the trailer and the front end of the tank separated from the main body of the tank. This permitted a sudden and rapid release of the anhydrous ammonia, which was under a pressure of about 92.9 pounds per square inch (at 60° F).

Injuries to Persons

Injuries	Drivers	Passengers	Others
Fatal	4	2	0
Nonfatal	20	12	146
None	0	0	

Except for the truckdriver, all persons were injured when exposed to the ammonia which was released from the tank during the accident. About 500 persons were within 1/4 mile of the release point at the time. The ammonia fumes penetrated automobiles and buildings, and when their occupants

1/ Interstate 610 is a 38-mile circumferential highway surrounding the city of Houston and is designated as a hazardous materials transportation route.

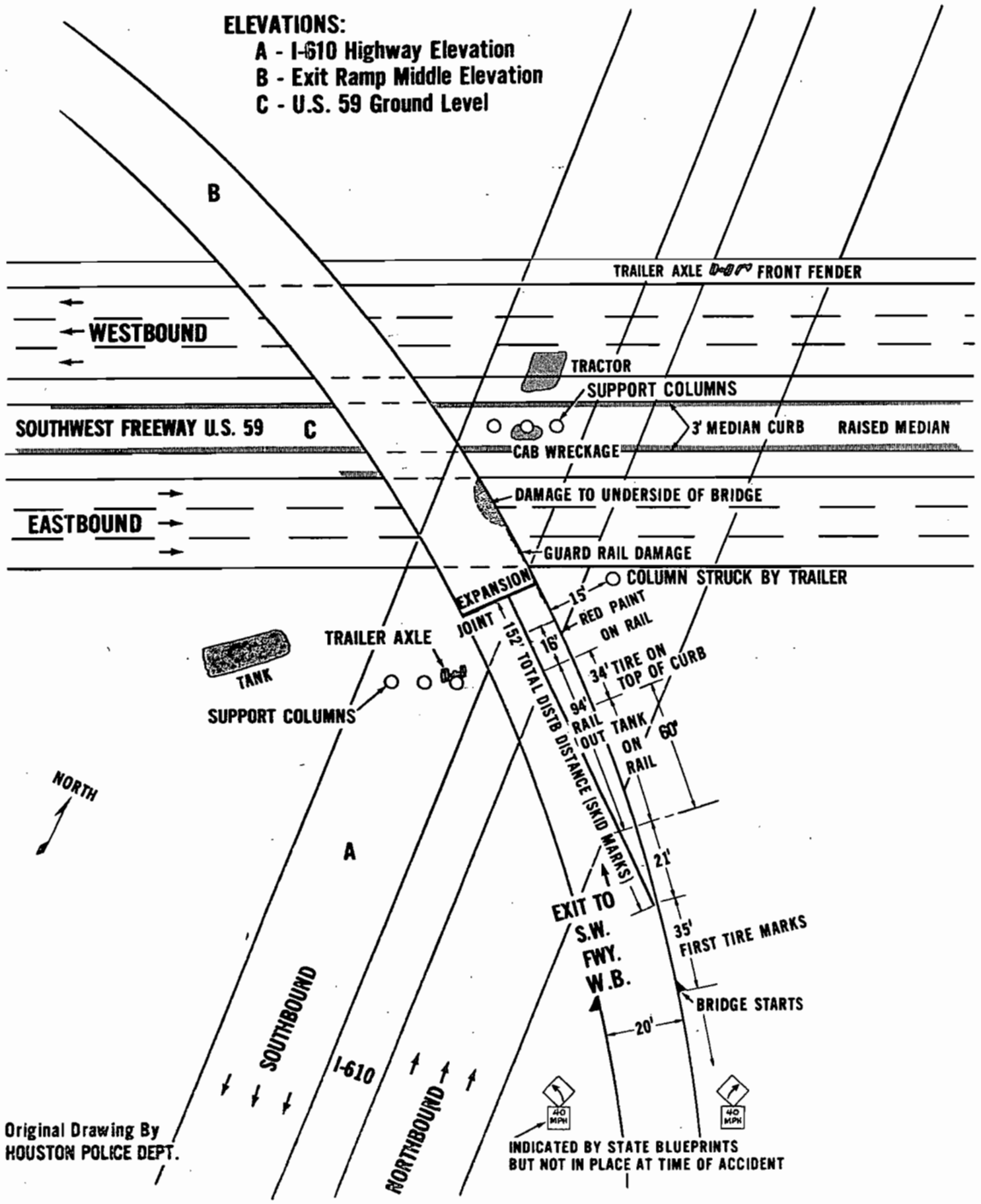


Figure 1. Plan view of accident site.

left to escape the fumes during the early minutes of release, many were exposed to higher dosages. Seventy-eight of the 178 victims, who were within 1,000 feet of the estimated release point, were hospitalized and treated for symptoms of ammonia inhalation; 2/ 100 persons were treated for less severe injuries.

Damage to Vehicles

The rapid expansion and vaporization of the escaping liquefied gas had the effect of an explosion which extensively damaged the tractor-semitrailer (tank). This damage was in addition to that caused by the truck overturning on the bridge ramp and striking the road below. (See appendix A.)

Twelve automobiles near the accident site were damaged by flying debris; four of the vehicles sustained heavy damage. A tractor-convoy trailer (automobile carrier) and the eight automobiles it was transporting were also damaged. Ten automobiles, stopped near the accident site, were not damaged.

Other Damage

Approximately 94 feet of bridge rail on the right side of the bridge ramp was damaged and had to be replaced. The rail was crushed from a point 56 feet north of the end of the bridge to the point where the trailer penetrated it. The bridge deck was broken and a support column for an overpass was sheared at its base. (See figure 2.) Guard-rails on the Southwest Freeway underneath the bridge ramp were also damaged.

Driver Information

The 28-year-old truckdriver had been employed by the Transport Company of Texas since December 18, 1975. He had driven commercial vehicles since 1969. He was certified as medically qualified to drive in interstate and intrastate commerce as required by Federal Motor Carrier Safety Regulations. The truckdriver's log was not found. According to the Texas Department of Public Safety, his traffic record showed convictions for two violations: May 27, 1975, Corpus Christi, no turn signal lamps as required and June 6, 1975, Corpus Christi, speeding. The driver's personnel file showed two single-vehicle accidents while driving a tractor-semitrailer vehicle.

2/ The Department of Transportation classifies anhydrous ammonia as a nonflammable compressed gas. Exposure to liquid or high concentration of vapor can cause severe burns. Excessive inhalation may cause severe damage to the lungs or even suffocation.

Figure 2. Damaged support column. Letter "A" indicates tank scrapes and tire marks.

The truckdriver had not driven the truck for 3 days before the accident. On May 11, 1976, he left the terminal in Corpus Christi between 5 and 5:30 a.m. and arrived at the TENNECO plant in Pasadena, approximately 235 miles away, at 9:36 a.m.

The driver had made at least 10 trips with liquid loads to Houston and was aware that I-610 was a designated hazardous materials route. At the time of the accident, the driver had driven approximately 23.4 miles from the TENNECO plant.

Vehicle Information

The tractor-semitrailer (tank) was owned by the Transport Company of Texas. The units were connected by a sliding fifth wheel. The loaded gross combination weight was 75,980 pounds.

The tractor was a 3-axle, 1974 International Harvester, Model F-4370. It was equipped with a diesel engine, a conventional cab behind the engine, air-mechanical brakes, a 10-speed Fuller Roadranger transmission, and a Holland Hitch fifth wheel. The normal road speed of the vehicle in 9th gear at governed speed (2,100 rpm) was 46.9 mph. The maximum governed speed (2,400 rpm) was 53.6 mph. The odometer showed 114,545 miles and the pyrometer needle was jammed at impact between 1,335° and 1,350° F.

The semitrailer was a MC 331, 2-axle, 10,500-gallon cargo tank, manufactured in 1969 by the Dal-Worth Tank Company. At the time of the accident, the tank was 71.8 percent full. (See figure 3.)

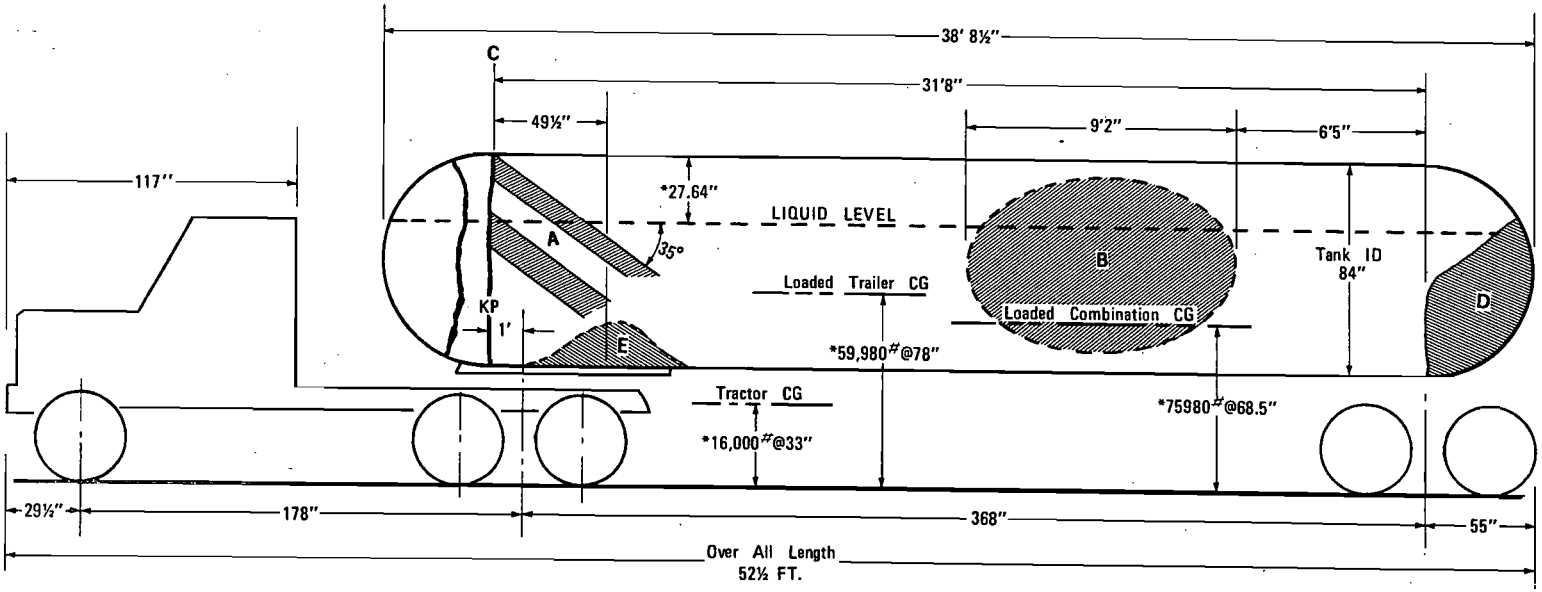
Roadway Information

Many jurisdictions restrict the transportation of hazardous materials over particular routes where hazards would be created for bridge structures or tunnels in the event of spillage or explosion. In 1970, the city of Houston designated I-610 as a hazardous materials route and restricted all vehicles transporting hazardous materials through the city to this route.

Interstate 610 is a north-south, elevated highway where it intersects the Southwest Freeway (U.S. 59) within the city limits of Houston. I-610 is the highest of three roadways which cross over the Southwest Freeway at the interchange; the Southwest Freeway is at ground level. The connector ramp from which the truck fell crosses the freeway at an elevation of 15 feet. Another ramp crosses over this connector ramp.

The main section of the roadway of I-610 northbound at a point .5 mile south from the accident site consists of five 12-foot lanes of Portland cement concrete pavement.

The exit for the Southwest Freeway is approximately .2 mile south of the accident site. It consists of two lanes which allow traffic to exit right from I-610. One of the two lanes then curves left onto the connector ramp. The ramp consists of a compound curve formed by 3 interconnected curves of 3°, 6°, and 12°. The accident occurred on the 12° curve. The pavement's superelevation at a point .1 mile south of the accident site slopes downward to the left 2 percent. The superelevation then slopes downward uniformly to 8 percent at a point .06 mile south of the accident site. The pavement is 18 feet wide approaching the bridge ramp with a 4-foot, paved shoulder to the left and a 6-inch-high curb on



Notes

A - Scrape marks on right (or curb) side
B - Indentation on left (or road) side
C - Two front head parts
D - Approximate hole size at rear head
E - Transverse inward dent across bottom
* CALCULATED FIGURES

Figure 3. Physical dimensions of tractor-semitrailer. Letters indicate damage to semitrailer explained in appendix A.

the right. Approaching the bridge on the left is a steel guardrail which is set back approximately 6 to 8 feet from the left edge of the pavement. Approaching the bridge on the right is approximately 160 feet of steel guardrail, which is set back from 1 to 10 feet from the face of the curb. The bridge width is 20 feet from curb to curb.

The bridge rail was a single steel pipe mounted above and behind a 12-inch-wide curb. (See appendix B). The rail was secured to the curb by four 1-inch-diameter steel anchor bolts. The rail is 3 feet high and the face of the rail is set back 9 inches from the face of the curb.

The posted speed limit is 55 mph for the main section of I-610. Signs indicating an upcoming Southwest Freeway exit are located at several points along the 2 1/2 miles before the exit. Adjacent to the overhead exit sign was the last advisory speed limit sign (40 mph) that the driver could have observed. (See figure 4.) This sign was about 800 feet from the connector ramps. The last overhead sign the driver could have observed indicates the south and north connector ramps to the freeway. An advisory speed limit sign (40 mph) was in place on the connector ramp to the right. An advisory speed limit sign was not in place on the connector ramp to the left at the time of the accident according to testimony taken at the Safety Board's public hearing. (See figure 5.)

The ramp on which the accident occurred was opened in 1963 and currently has an average daily traffic volume of 21,000 vehicles. During peak hours, 5 percent of the traffic volume is trucks. Eighteen accidents--12 rear end, 4 fixed object, 1 sideswipe, and 1 involving the bridge rail--have occurred on the ramp in the past 2 1/2 years.

Meteorological Information

It was a bright, sunny day with temperatures in the low 80's and a 7 mph wind.

The released ammonia vaporized and the wind gradually decreased the vapor concentration at ground level and moved it downwind about 2,000 feet until its effects were minimal. Witnesses reported the white ammonia vapor cloud initially reached a height of 100 feet before being carried by a 7 mph wind for a distance of approximately one-half mile. Within 3 minutes of release, the maximum width of the vapor cloud over the ground was 1,000 feet, diminishing in size one-half mile downwind. After 5 minutes most of the liquefied ammonia had boiled off and the vapor cloud was competely dispersed.

Medical and Pathological Information

The driver of the truck sustained fatal injuries (broken neck and broken back) in the accident. No evidence of alcohol, drugs, or barbiturates was found. The other five victims died from ammonia inhalation.

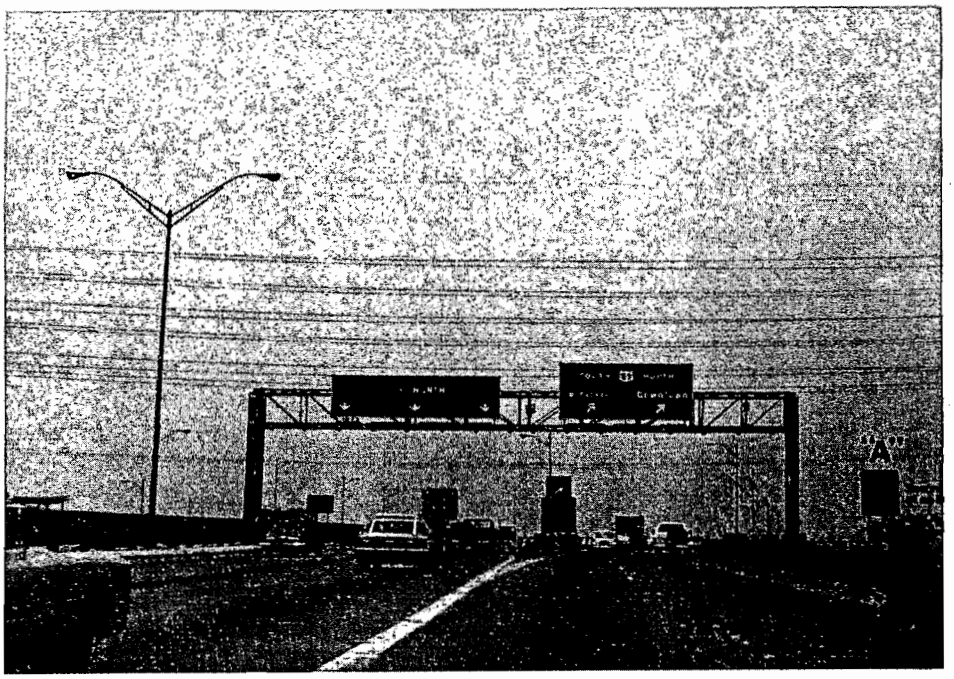


Figure 4. Next-to-last overhead sign before connector ramp. Letter "A" indicates speed limit sign located 800 feet from connector ramp.

Figure 5. Overhead signs at entrance to connector ramps and 40 mph advisory signs on ramps. Sign indicated by letter "A" was not in place at the time of the accident. Sign indicated by letter "B" was in place.

Survival Aspects

Emergency personnel responded promptly. The first ambulance was on the scene within 5 minutes and found traffic moving with no backup. This unit reported to the dispatcher that ammonia was involved and that many persons were on the highway. The dispatcher alerted hospital emergency rooms. The first unit triaged 7 persons. By 11:40 a.m., 14 ambulances and 4 pieces of fire equipment had responded. Firemen effectively used fog spray to dissipate ammonia on the ground and to wash down automobiles that contained ammonia fumes.

The injuries indicate the effects of an accumulated dosage over a period of 2 to 5 minutes. Because all fatalities were within 200 feet of the estimated release point, it is estimated that within this distance the ammonia concentration was greater than 6,500 parts per million (ppm) for at least 2 minutes. Concentrations from 5,000 to 10,000 ppm are rapidly fatal for short exposures.

Other Information

Two tire marks began 35 feet from the south end of the bridge approximately 8 feet from the curb and extended northwest down the exit ramp. (See figure 2.) One of the marks, which was about 81 feet long, diverged to the right and proceeded onto and over the right-side curb about 116 feet from the south end of the bridge. The second tire mark ran parallel to the curvature of the ramp for 152 feet and then ended in a sharp curve to the left, 37 feet beyond where the first tire mark passed over the right side curb. (See figure 3.) The damage to the bridge rail continued for an additional 34 feet beyond the tire marks.

Red marks and scraps were found on the concrete curb beginning approximately 50 feet beyond where the tire marks appeared on top of the curb. Red marks were also found on the bridge rail.

ANALYSIS

The Accident

Tire marks indicated that as the tractor-semitrailer entered the ramp's curve, the semitrailer off-tracked to the right (or outboard) of the tractor. (See figure 6.) The crushed bridge rail indicates that the tractor and semitrailer rolled to the right. (See figure 7.) As the tractor-semitrailer proceeded forward while rolling to the right, the tractor jackknifed to the left, i.e., the front moved to the left and the rear moved to the right. The tractor continued to roll as the trailer began to fall from the ramp. The tractor separated from the semitrailer at some point before the tractor struck the ground.

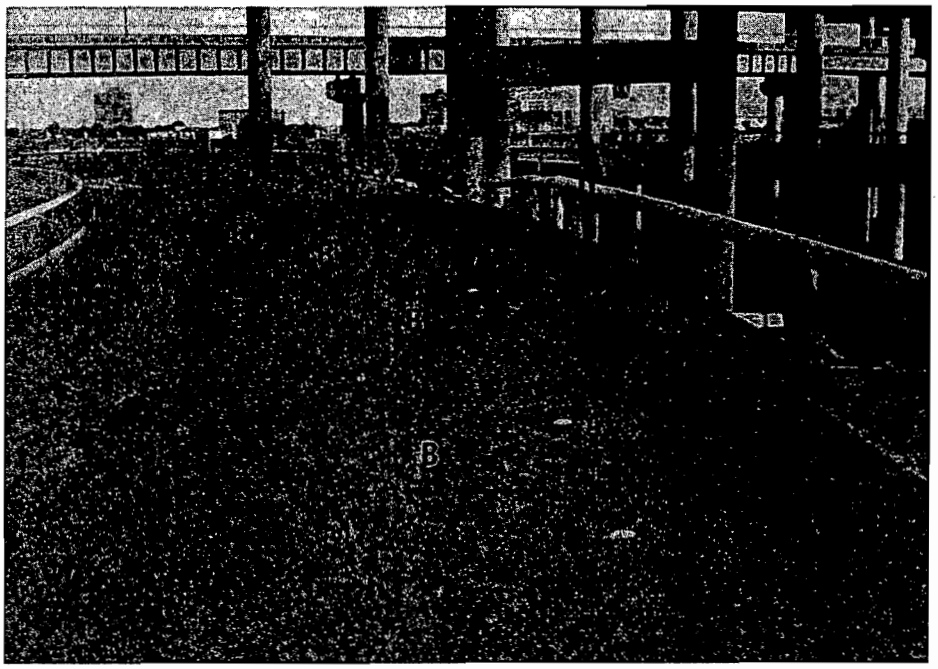


Figure 6. Connector ramp. Letters indicate conditions pertinent to investigation: (A) trailer tire mark (B) tractor tire mark curves to left (C) right side trailer tire marks on face of curb (D) red paint and scrap marks on bridge rail face (E) trailer tire marks.

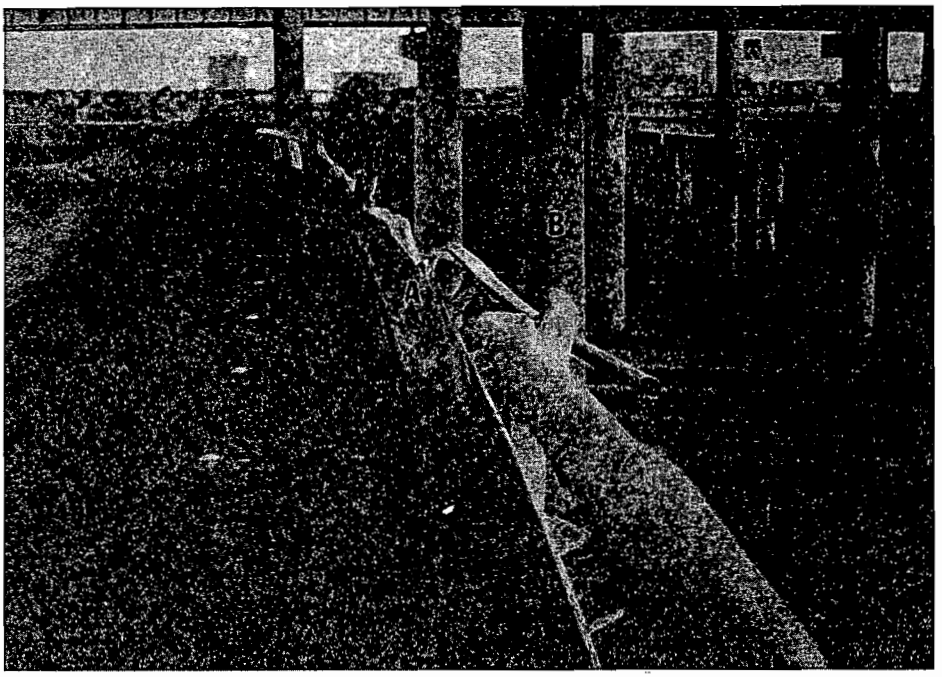


Figure 7. Connector ramp. Letters indicate conditions pertinent to investigation: (A) trailer tire marks on top of curb (B) column struck by trailer (C) damage to bridge deck.

The tractor landed on the roadway below rear end first. This is confirmed by the severe rear frame and axle damage and the rearward displacement of the engine and transmission. Scratches on the hood and roof sheet metal of the tractor and marks on the curb and bridge rail suggest that the tractor was probably upside-down while still on the ramp.

The trailer rotated 180° clockwise about its longitudinal axis before striking the bridge support column. This is confirmed not only by the dimensional relationship of the elliptical dent on the left side of the trailer and the mark on the support column, but also by the left side tire and rim damage of the trailer axles. (See figure 2.) The rear cargo tank baffle was deflected rearward when the cargo shifted to the rear as the trailer initially left the ramp rear end first. The left side of the tank was scraped as the front of the tank was dragged along the outboard surface of the ramp with the rear of the trailer dangling from the ramp. The tank shell failure was probably initiated at a point on the shell-to-head weld where scrapes had reduced the thickness of the tank shell.

The front head separated from the shell and the escaping gas propelled the tractor cab into and around the column and onto the median of the roadway below. The tank head flew upward to the north and struck the underside of the ramp from which the vehicle fell. After the front head separated, the forward and center transverse baffles were blown out of the tank. The remainder of the tank was propelled rear end first into a second ramp support column. This impact caused the rear head damage. The tank, now open at both ends, rotated end-over-end until its underside struck a third support column. Following this final impact the tank continued on until it landed in a drainage ditch.

Speed of the Truck on the Ramp

The fact that the transmission was found in ninth gear strongly suggests that the truck's speed on the ramp was between 46.9 and 53.6 mph, depending on engine rpm. Since the pyrometer needle was found in the red range, which suggests that the engine was loaded and working hard, the probable speed was near 53.6 mph.

It is reasonable to assume that the driver was familiar with the ramp since it was the primary connector between I-610 and the Southwest Freeway (U.S. 59), which was the route to his home base in Corpus Christi, Texas. Why he entered the curve at an excessive speed is not known.

The possibility that the truckdriver did not see that the ramp was curved is unlikely. The ramp was adequately delineated and its physical curvature was defined by roadway structures such as guardrails and bridge rails. Given these visual cues and the fact that a driver's eye

position while seated in a tractor cab is above that of an automobile driver's, he should have had no difficulty in determining the direction and curvature of the roadway ahead, even if automobiles had been in front of the truck.

Lateral Liquid Surge

Assuming that the truck was entering the curve at 53.6 mph, the calculated centrifugal force on the vehicle was 29,458 pounds. The loaded vehicle's center of gravity (CG) height was calculated to be 68.5 inches above the road. (See figure 3.) At this CG height the lateral force necessary to overturn the vehicle at 53.6 mph is 49,918 pounds. Therefore, the truck should not have overturned at a speed of only 53.6 mph. At a CG height of 68.5 inches and with a solid, non-fluid cargo, this vehicle should have been able to negotiate the 493-foot-radius curve 3/ at a speed up to 69.6 mph without overturning. The fact that the vehicle did overturn and that the cargo was a liquid that was loaded to only 71.8 percent of the tank's capacity suggests that transverse loadings resulting from lateral liquid surge contributed significantly to the overturn of the vehicle.

This theory is further supported by the trailer's tandem tires which followed a path (off tracked) to the right of the tractor tires. (See figure 6.) A semitrailer normally follows a path to the left of the tractor wheels when negotiating a curve to the left, unless it is subject to high lateral loadings.

Bridge Barrier System

The truck was rolling over when its tires struck the curb. While rolling over, and considering the alignment of the semitrailer and its misalignment with the tractor, it is unlikely that any current bridge barrier system would have significantly changed the collision's dynamics.

The bridge rail at the site was of an outdated design. Like most bridge rails in use in Texas and other States, it was designed to prevent only penetration by automobiles.

The Texas Highway Department has tested the concrete "safety shape" or "New Jersey shape" median barrier with a tractor-semitrailer with outstanding results. A bridge rail of the "safety shape" design has been adopted by Texas as an optional rail for use on its highways. In spite of the results of its tests, the Texas Highway Department is constructing, on I-610 interchanges, new bridge barrier systems that cannot be expected to redirect schoolbuses or heavier vehicles.

For several years, the Federal Highway Administration (FHWA) has been researching traffic barrier systems that will contain heavy vehicles.

3/ Calculation based on a chord taken at the outside curb.

The research is expected to determine an adequate system for vehicles under 40,000 pounds in gross weight. The problem of redirecting or containing vehicles of over 40,000 pounds will need further research.

Bridge barrier systems that will accommodate both automobiles and heavier vehicles such as school, intercity, commuter buses, and trucks need upgrading on most routes. Placement of the types of barriers that will redirect or contain heavier trucks will most likely require careful analysis because of the cost and, perhaps, the adverse effects they could have on smaller vehicles in collisions. Urban routes, where penetration of a barrier by a truck that is transporting hazardous materials could be disastrous, and interchanges where a large percentage of urban accidents occur, 4/ probably would be the best locations.

As a result of investigations of two accidents, 5/ the Safety Board recommended to the FHWA in 1974 that mandatory performance standards be required for all bridge barrier designs and that the standards be developed for all classes of vehicles. However, the FHWA has not adopted performance standards for barrier systems designed for automobiles on the Nation's highways. The FHWA policy is to adopt the standards of the American Association of State Highway and Transportation Officials (AASHTO). The Safety Board believes that these standards are inadequate because of their lack of performance requirements.

The FHWA Office of Research does require that all research for the development of new barrier designs be based on performance requirements. However, the FHWA does not require that the new performance-tested designs be used on the Nation's roadways. The FHWA recently granted a research contract for the crash-testing of several bridge rails recently designed by States based on the AASHTO standard. These tests should reveal whether or not the selected systems will perform adequately.

Hazardous Materials Transportation

Six persons were killed and 178 persons were injured in this accident. Although this was a tragic event, the consequences of this type of accident in a more congested area could have proved catastrophic. For example, had this accident happened in downtown Houston adjacent to office buildings, highrise apartments, or in a congested residential area, the number of fatalities and injuries could have been greatly increased. Therefore, designating a route for hazardous materials was an excellent action by the city of Houston and should be considered by other local governments.

4/ "Traffic Control and Roadway Elements--Their Relationship to Highway Safety," Highway Users Federation for Safety and Mobility, 1970, revised.

5/ "Greyhound Bus Collision With Concrete Overpass Support Column on I-880, San Juan Overpass, Sacramento, California, November 3, 1973" (NTSB-HAR-74-"Automobile Crash Off The Silliman Evans Bridge, I-24/65, Nashville, Tennessee, July 27, 1973" (NTSB-HAR-74-2)

Innovations in transportation of pressurized liquefied products could result in a reduction of accident severity. As a result of its investigation of another tank-semitrailer accident near Eagle Pass, Texas, on April 29, 1975 6/ the Safety Board recommended that the Secretary of Transportation "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." The Department of Transportation now intends to contract for such a study, depending upon the availability of funds, sometime during FY 1977. Ammonia will be included in the study.

CONCLUSIONS

Findings

1. The tractor-semitrailer (tank) was traveling at or near 53.6 mph as it approached the exit ramp to the Southwest Freeway (U.S. 59).

2. If the vehicle had been transporting a solid load of equal weight and with the same CG height, it could have negotiated the curve at a speed of 69.6 mph without overturning.

3. Because the vehicle turned over at a speed not greater than 53.6 mph, other lateral loading must have combined with the centrifugal force at that speed. This additional loading was caused by a lateral surge of liquid cargo in the partially loaded tank.

4. Barrier systems on routes designated for hazardous materials are not capable of redirecting vehicles that transport hazardous materials.

5. Traffic barrier systems for various classes of vehicles were not designed in accordance with performance standards to provide more predictable results to the occupants of an impacting vehicle.

6. The Texas Highway Department is installing bridge barrier systems on the Interstate system in Houston that will probably be less effective in redirecting heavy vehicles than could be provided by the concrete "safety shape" barrier.

7. The losses in this accident would have been greater if the accident had occurred in the city of Houston on other than the designated hazardous materials route.

8. Once barrier performance standards are established for various classes of vehicles, criteria were not developed for selecting the proper barrier system for each location.

6/ "Surtigas, S.A., Tank-Semitrailer Overturn, Explosion, and Fire, Near Eagle Pass, Texas, April 29, 1975" (NTSB-HAR-76-4.)

9. Innovations in the transportation of pressurized liquefied products are needed to reduce injury.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the excessive speed of the vehicle combined with the lateral surge of liquid in the partially loaded tank truck, which caused it to overturn. The cause of 5 of the 6 fatalities and all of the 178 injuries was the inhalation of anhydrous ammonia. Contributing to the severity of the accident was the failure of the bridge rail to contain or redirect the vehicle.

RECOMMENDATIONS

As a result of its investigation of this accident the National Transportation Safety Board submitted the following recommendations to the Federal Highway Administration:

"Expedite past recommendations of the Safety Board regarding the adoption of standards for bridge barrier systems that require new installations to comply with performance standards." (Class II, Priority Followup) (H-77-4)

"In consultation with State and local governments, establish highway design criteria for the selection, location, and placement of traffic barrier systems that will redirect and prevent penetration when struck by heavy vehicles. The criteria for preventing vehicle penetration should consider the human exposure to injury and the effects of hazardous cargo that could result from barrier penetration." (Class II, Priority Followup) (H-77-5)

"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 Followup) (I-77-1)

As a result of its investigation of this accident the National Transportation Safety Board reiterates the following recommendations made after previous investigations:

-- to the Federal Highway Administration:

"The Bureau of Motor Carrier Safety (Federal Highway Administration) in cooperation with affected industries, as represented by the Tank Truck Technical Council, conduct an investigation designed to resolve the overturn stability problems created by liquid surging

of partially loaded tank-truck combinations. The ultimate objective of such a research program should be the promulgation of Federal regulations to limit the effects of surge to a specific degree. Such regulations might be based on acceptable liquid cargo outage and/or dampening requirements, consistent with safe tank-truck operations." (H-72-45) 7/

-- to the U.S. Department of Transportation:

"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) 8/

7/ "Tank-Truck Combination Overturn Onto Volkswagen Microbus Followed By Fire, U.S. Route 611, Moscow, Pennsylvania, September 5, 1971" (NTSB-HAR-72-6)

8/ "Surtigas, S.A., Tank-Semitrailer Overturn, Explosion, and Fire, Near Eagle Pass, Texas, April 29, 1975" (NTSB-HAR-76-4)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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April 14, 1977

APPENDIX A

DAMAGE TO TRACTOR AND TRAILER

The tractor -- The tractor wreckage included the chassis frame, axles, drive-line components, fuel tanks, engine radiator, and fifth wheel slide plate. The tractor cab and related components had been separated from the chassis during the accident dynamics, and were a mass of twisted sheet metal. The rear cab sheet metal showed evidence of being forced forward. The engine drive shaft components and the transmission components had been displaced rearward with respect to the tractor frame.

The range box on the rear of the transmission was missing. The top part of the shift tower was missing. The transmission was found in 9th gear.

The most severe accident loadings appeared at the rear of the tractor frame. The rear axle housings and beam type suspension were distorted forward. The rear of both frame siderails were distorted towards the right (curb side) and forward. All frame distortion occurred rearward of the bottom fifth wheel slide plate. There was minor left side frame buckling forward of the fifth wheel slide plate. The radiator was in its normal vertical position with no evidence of significant impact on either it or the front bumper.

The trailer -- The front head of the tank had separated (see figure 3) (C) from the shell. A large dent appeared across the bottom surface of the tank in the area where the upper coupler had been attached (E). An elliptical indentation appeared on the left (road) side of the tank near the rear (B). The upper 1/3 of the rear head was still attached to the shell (D). The lower section of the rear head which had separated was available for inspection. On the right (or curb) side two significant scratch patterns (A) appeared at the forward head to shell joint. The dents and scratch patterns and their dimensional relationships are shown in Figure 3.

The tank originally was equipped with three equally spaced transverse baffles. The rear baffle was still in the tank, however, it had been deflected rearward. Approximately a third of the baffle to shell attachments had failed from a rearward acting load. The other two baffles were missing from the front and middle of the tank. Their baffle to shell attachments had failed from a forward acting load.

The trailer tandem subframe was still attached to the rear of the tank. Portions of the subframe of the tank shell were turned and deformed towards the left (or roadside).

Both front and rear trailer axles had separated from the tank. The road side tires and rims of both axles were badly damaged. Miscellaneous torque arm, spring bracket, and other suspension parts had failed. There was nothing to suggest that a preimpact trailer suspension failure had occurred.

APPENDIX B

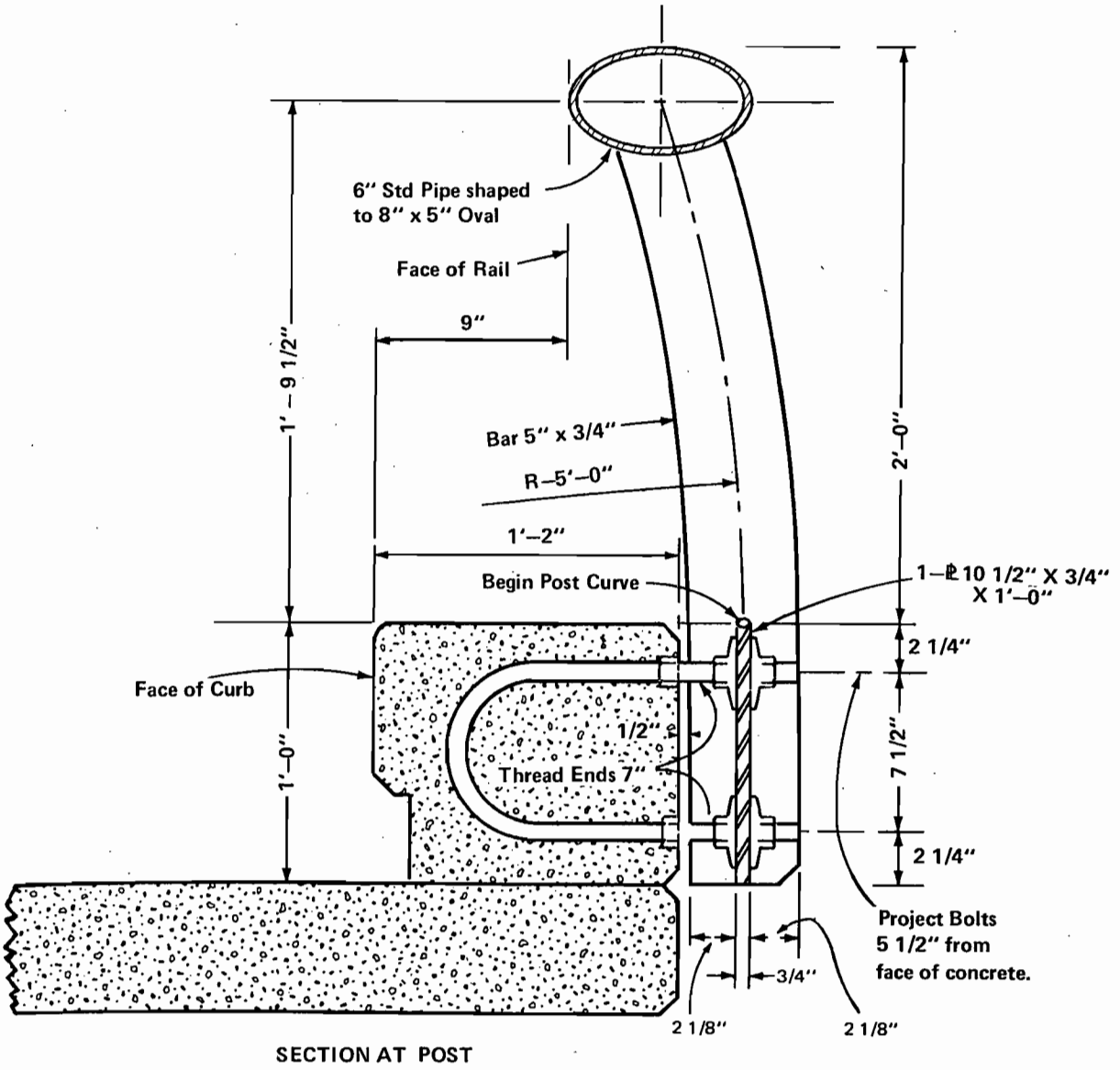

Diagram of bridge rail on connector ramp.