



NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT



SURTIGAS, S. A.,
TANK-SEMITRAILER OVERTURN,
EXPLOSION, AND FIRE



NEAR EAGLE PASS, TEXAS
APRIL 29, 1975



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TABLE OF CONTENTS

	Page
SYNOPSIS	1
INVESTIGATION.	2
The Accident	2
Injuries to Persons	3
Vehicle Information	5
Driver Information	7
Survival Aspects	7
Other Information.	9
ANALYSIS	10
The Accident	10
Fixed Roadside Objects	11
Risks in LPG Transportation	13
CONCLUSIONS	14
Findings.	14
Probable Cause.	15
RECOMMENDATIONS	15
APPENDIX -- Investigation.	17

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SYNOPSIS

At 4:20 p.m. on April 29, 1975, a Surtigas, S.A., tractor-tank-semitrailer, westbound on U.S. Route 277 near Eagle Pass, Texas, swerved to avoid an automobile ahead which was slowing for a turn. The tank-semitrailer separated from the tractor, struck a concrete headwall, and ruptured; vaporized LPG was released. The ensuing fire and explosion destroyed a building and 51 vehicles. The 51 persons who were in the area were burned and 16 persons, including the truckdriver, were killed.

The National Transportation Safety Board determines that the probable cause of this accident was the evasive action taken by the truckdriver to avoid a slowing vehicle in his path of travel. The cause of the fatalities and injuries to persons in the vicinity was the explosive force and fire, from which they had no time to escape. The rapid development of the explosive force and fire was caused by the gross rupture of the tank.

INVESTIGATION

The Accident

At 4:20 p.m. on April 29, 1975, a Surtigas, S.A., tractor-tank-semitrailer (truck) was westbound on U.S. Route 277 transporting 8,748 gallons of liquid propane gas (LPG) from Big Wells, Texas, to Piedras Negras, Mexico. According to witnesses, as the truck approached Eagle Pass, Texas, at an estimated speed of 50 to 55 mph, its driver braked and swerved sharply to his left to avoid a white automobile ahead which had suddenly slowed to turn off of the road. As the truck crossed into the eastbound lane, the truckdriver steered to the right to return to the westbound lane and to avoid three eastbound automobiles. The right turn was so severe that the tractor and semitrailer began to overturn to the left. In an effort to resist the overturn, the driver steered to the left; however, the semitrailer continued to overturn. One hundred and eight feet east of an irrigation canal, the semitrailer separated from the tractor, overturned, slid across the road and the shoulder of the east lane, and struck an unprotected concrete headwall of the irrigation canal.

After the trailer had separated, the tractor remained upright and rolled into the west lane; the driver remained in the cab. The tractor stopped or was stopping near the semitrailer when the tank struck a headwall and ruptured. The tank separated into two parts and pressurized LPG was released through the opening. Several witnesses described a noise which resembled that of a violent wind storm, followed immediately by an explosion. Simultaneously, fire covered the area, and a second explosion was heard. The explosive forces separated the tractor cab from its chassis and blew it to the north; the driver remained in the cab. The chassis was snagged by a tank appurtenance and was propelled 136 feet west onto the shoulder of the eastbound lane.

After the tank broke into two pieces, the large forward section of the tank was propelled into the air, where it struck an elevated sign; traveled 1,029 feet and struck the ground; bounced into the air and traveled 278 feet; struck and demolished a mobile home; bounced back into the air and traveled 347 feet over a second mobile home, which burst into flames and was destroyed; struck a third mobile home and came to rest 1,654 feet from its point of departure. The fire in the second mobile home was attributed to the failure of an LPG tank in the mobile home.

The aft section of the tank split into three parts. The three parts rocketed through the air with the semitrailer suspension, traveled an average of 800 feet to the east and to the northwest, and fell to the ground.

Six occupants in two of the eastbound cars were overtaken by the fire and burned badly after they fled their vehicles. The used-car facility and

50 vehicles parked in front of the facility were destroyed by the explosion and the fire. Forty-four persons, both inside and outside the building, were knocked down and burned.

U.S. Route 277 was a two-lane, 40-foot-wide concrete roadway with a well-worn asphalt surface. (See Figure 1.) The eastbound and westbound lanes were divided by a double yellow centerline, which was also worn. The road crossed an irrigation canal at the accident site. Four hundred and thirty-one feet east of the irrigation canal, the roadway was intersected by U.S. Route 57. Near its intersection with Route 57, Route 277 widened and its lanes were separated by a raised concrete divider. There were 30-foot gravel and clay shoulders on each side of the roadway. The posted speed limit was 50 mph. The westbound truck approached the site on an average 1.70-percent downgrade. On the day of the accident, the visibility was 5 miles and the temperature was 80 degrees. Witnesses described traffic as light but steady.

A used-car facility was located 200 feet east of the intersection with Route 57, north of the roadway and east of the irrigation canal. North of this facility was a large fenced lot which contained wrecked and disassembled vehicles. South of the roadway and west of the canal to the Eagle Pass city limits were four businesses widely separated by open fields. Inside the city limits, south of the roadway, was a trailer park. The 50 vehicles parked on the shoulder of the westbound traffic lane denied a clear escape area for westbound traffic. The evasive maneuvers of the truck took place in the vicinity of this congestion.

The irrigation canal which ran north and south under the roadway had concrete headwalls 28 feet to the north and 29 feet to the south of the roadway's edge. The concrete headwalls were 17.5 feet long, 12 inches thick, and 23 inches high, and constructed of reinforced concrete. They were not protected by a barrier.

Injuries to Persons

<u>Injuries</u>	<u>Driver</u>	<u>Passengers</u>	<u>Other</u>
Fatal	1	0	15
Nonfatal	0	0	35
None	0	0	

Vehicle Information

The vehicle was a tractor-semitrailer (MC-330 tank) combination owned by Surtigas, S.A., a private foreign carrier located in Sabinas, Mexico. The weight of the vehicle was as follows:

	<u>lbs</u>
Tractor	14,000
Trailer	19,353
Cargo	<u>40,095</u>
Total	73,448

The Tractor -- The tractor was a three-axle, 197 $\frac{1}{2}$ International Harvester, cab-behind-engine, equipped with a Cummins NHC250 diesel engine, a 10-speed Fuller transmission, a Hendrickson bogie, and a Fontaine sliding fifth wheel (serial No. 437472Y030149). The Fontaine fifth-wheel assembly consisted of the fifth wheel, the slide plate, and the frame mounting plate.

The fifth wheel was found attached to the trailer king pin. The vertical flange of the fifth-wheel plate, adjacent to the fifth-wheel cross-shaft, was bent outward. (See Figure 2.) The slide plate was found 50 feet south of the tractor. The transverse tube through which the fifth-wheel cross-shaft normally is positioned was bent upward and was disconnected from its right-side attachment. The metal failed in the weld. The fore-and-aft positioning plunger was flush with the bottom of the slide plate. (See Figure 3.)

The mounting plate was attached to the tractor frame's slide rails and was twisted slightly in conformance with the frame distortion. The rearmost fifth-wheel positioning slot showed evidence of wear at the rear edge of the slot. Neither the left or right slide channels were distorted.

The cab and other sheet metal components had been blown off the tractor during the initial explosion. The transmission shift tower was missing. The transmission shift rails were found in "neutral." The left-side fuel tank was attached to the left-side rail. The right-side fuel tank was found 38 feet west of the tractor frame. The tractor frame was bent downward. The left-side rail's upper flange and top web section were torn. The steering gear functioned normally. The rear bogie axle top-mounted torque arm had failed in back of its crossmember attachment.

The brake linings measured about 1/2 inch at each wheel. This was the only brake adjustment that could be examined, and it was within acceptable limits. The other brake systems had been so badly distorted that their adjustments could not be evaluated. Postcrash inspection of the tandem axles did not reveal any defects that may have contributed to the loss of control and the vehicle's upset.

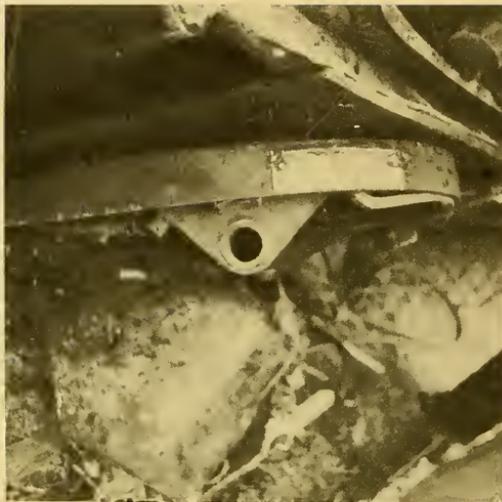


Figure 2. Fountaine fifth wheel still attached to front section of tank after the accident.



Figure 3. Fifth-wheel slide plate as it was found 50 feet north of the tractor chassis.

Tank-semitrailer -- The tank-semitrailer was a 1965 MC-330 Tatsa tank manufactured by the Lubbock Manufacturing Company. It had a 10,000-gallon water capacity with a design pressure of 250 psi at 150°F. The shell was manufactured in accordance with 49 CFR 178.336 from U.S. Steel T-1 (ASME Code Case No. 1204-11). The tank was 35 feet 8 inches long and had an 86-inch inside diameter and a thickness of 0.376 inch (min). The tank heads had a thickness of 0.250 inch.

Each of the sections of the tank shell had scratch marks on the left side. The tank's right-rear side, left side, and a section of the rear head each contained impact marks. Impact also was evident on the forward 22.8 feet of the tank.

The open end of the forward section of the tank was deformed into an ellipse. (See Figure 4.) The edges of the failure area had a mechanically deformed, gouged, and stretched dent. The dent was located on the right side of the tank, 26 inches from the top longitudinal centerline and 22 feet 9 inches rearward of the front head-to-shell weld. At the point of impact, the shell material was gouged from an original thickness of 0.387 inches to 0.279 inches. The internal tank pressure of 87 psig combined with the impact load to cause a shear-type failure around the tank circumference. The pressure, acting upon the tank material at the point of initiation of the crack, produced the extensive spread of the initial crack and permitted the violent rupture and separation of major parts of the tank.

The Safety Board analyzed a sample of the metal from the suspected impact area, and found no evidence of a preexisting crack. The analysis showed that the fracture appeared to be caused by an overload separation.

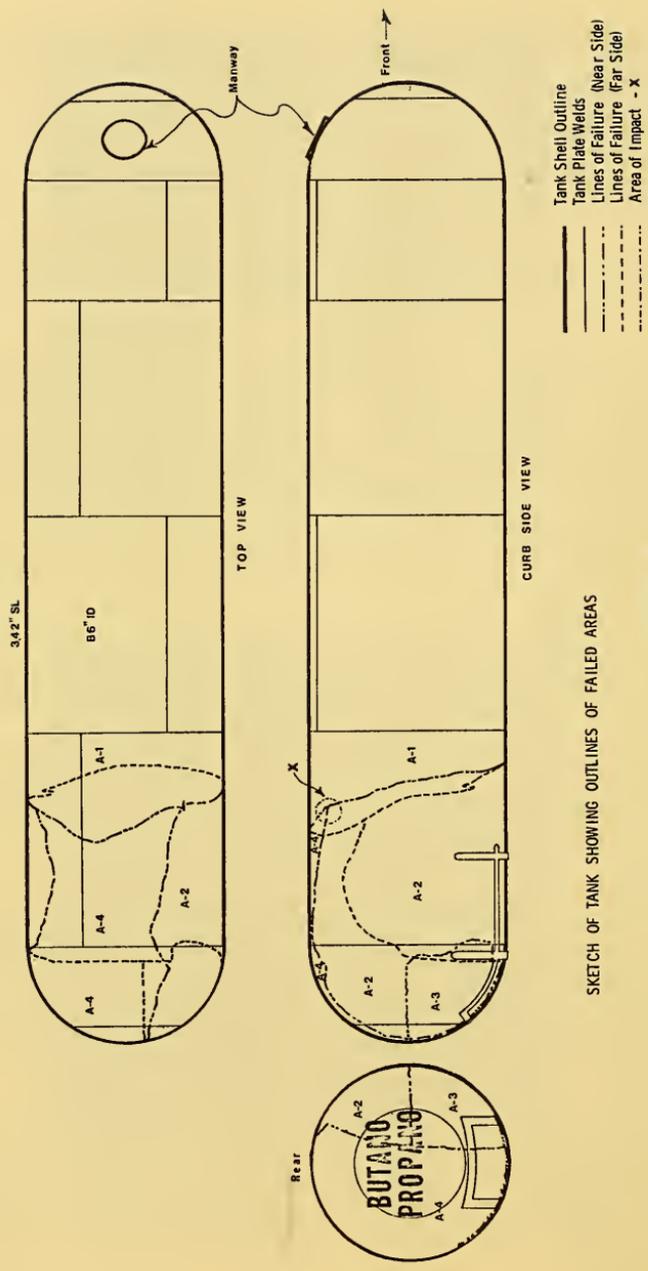
The Cargo -- The truck was transporting 8,748 gallons of LPG (4,374 gallons of butane and 4,374 gallons of propane). During transportation, the gases were maintained in a liquid state under pressure. The vapor pressure of this cargo was about 87 psig at 80°F ambient temperature.

Driver Information

The 35-year-old truckdriver was a resident of Colonial, Piedras Negras, Mexico, and had been hired by Surtigas, S.A., as a relief driver 3 months before the accident. He did not have the medical certificate required by the Federal Motor Carrier Safety Regulations; however, it was reported that he had a valid Mexican driver's license. The Safety Board could not determine the driver's experience or his driving record.

Survival Aspects

Emergency medical assistance at the accident scene was rendered by personnel from the Maverick County Hospital, Eagle Pass, Texas, and local rescue units. Thirteen persons were treated and released, and 12 were hospitalized. Three persons, including the truckdriver, were pronounced dead at the hospital. The truckdriver died as a result of a crushed skull.



SKETCH OF TANK SHOWING OUTLINES OF FAILED AREAS

Figure 4.

Six helicopters provided by the 507th Medical Company, Fort Sam Houston, Texas, transported 22 seriously burned persons to burn treatment centers in San Antonio. The first persons arrived in San Antonio at 9 p.m., and the last arrived at 1:30 a.m. on April 30, 1975.

Other Information

LPG Operator -- Surtigas transports flammable gas in cargo tank vehicles within a 150-mile-radius of its facility; the area includes Eagle Pass. Surtigas operates on both sides of the United States-Mexican border. The carrier had not been served with a copy of the Federal Motor Carrier Safety Regulations (FMCSR) nor had it been subject to any compliance inspections; however, while in the U.S., the carrier and the driver were subject to FMCSR's. The company vehicle maintenance and driver records were not available for examination. Neither the vehicle, the driver, nor the company were in compliance with all applicable FMCSR's.

Applicable Regulations and Guidelines -- The FHWA Highway Safety Program Standard No. 12, "Highway Design, Construction, and Maintenance," states:

"Every State shall have a program...(which) shall provide as a minimum that...(J) There are highway design and construction features whenever possible for accident prevention and survivability including at least the following:

1. Roadside clear obstacles, with clear distance being determined on the basis of traffic volumes, prevailing speeds, and the nature of development along the street or highway...
3. Protection devices that afford maximum protection to the occupants of vehicles wherever fixed object cannot reasonably be removed or designed to yield."

The manual for Standard No. 12 expands the Standard by stating:

"Whenever practical it is desirable that a driver control recovery area clear of obstructions for a distance of 30 feet or more from the edge of the traveled way, be provided in rural areas."

In its guidelines for the design and location of culverts, the American Association of State Highway and Transportation Officials (AASHTO) states that "If headwalls and endwalls are required, they should be designed not to protrude above the ground line." 1/

1/ Standard Specifications for Highway Bridges, AASHTO, 1973, Section 1.1.5, Culvert Location and Length.

AASHTO further recommends that "culvert headwalls...should be placed an adequate distance from the main lanes of travel or shielded from errant vehicles." 2/

The Federal Highway Administration (FHWA) recommends that "Headwalls or culvert ends should be constructed flush with the adjacent embankment to avoid a projecting fixed object." 3/ FHWA also recommends that if fixed objects cannot be removed, they should be protected by devices such as guardrails.

At the time of this accident, the Department of Transportation (DOT) had not prescribed requirements for registration of carriers of hazardous materials. However, the provisions to require the company to register now exist in Public Law 93-633, Title I - Hazardous Materials, dated January 3, 1975. Section 106(b) states that each person who transports or causes to be transported or shipped in commerce hazardous materials... "may be required to submit to the Secretary a registration statement not more often than once every 2 years. The registration statement shall include the person's name, principal place of business, a complete list of hazardous materials handled, and an averment that such person is in compliance with all applicable criteria established by the Act."

ANALYSIS

The Accident

After the accident, witnesses were questioned concerning the accident. Five occupants of three eastbound cars stated that they saw the truck coming toward them; that it was following a white automobile; that the white automobile suddenly slowed down to turn into the used car facility; that the truck swerved around the car and then back into its own lane of traffic and then turned over. The witnesses do not recall seeing a turn signal from the automobile. The other occupants, farther from the truck, did not mention the white automobile, but did see the truck swerve first to the left, then to the right, and then turn over.

Despite extensive investigation by the Safety Board and the Texas Department of Public Safety, the white automobile could not be located after the accident.

The truckdriver had no alternative but to swerve to the left. The right shoulder, which would have served as a recovery area, was occupied by vehicles. FHWA Highway Safety Program Standard 12 recommends that high-speed roads have a clear recovery area of 30 feet on each side of

2/ Highway Design and Operational Practices Related to Highway Safety, Second Edition, 1974, AASHTO.

3/ Handbook of Highway Safety Design and Operating Practices, FHWA, Section E2, Culvert and Bridge Structure.

the road and that fixed objects which cannot be removed be protected by barriers. At this site, the raised portion of the culvert's headwall should have been protected and the 50 parked automobiles should have been prohibited.

If the Texas Highway Department or the Maverick County Highway officials do not see fit to modify the headwall and prohibit the presence of the parked vehicles in the recovery area, they should reduce the speed limit to one considered safe under such conditions. If the truck had been traveling at 30 to 40 mph, its evasive maneuver may not have been necessary or would not have resulted in its upset.

As the truckdriver turned the tractor to the right to return to the westbound lane, he also was braking, which reduced his speed slightly. The high center of gravity was acted upon by the centrifugal forces from the right turn, and the tank-semitrailer began to overturn. As the trailer continued to upset to the left, the tractor frame was twisted and the fifth-wheel mounting plate was deflected. The distortion was of sufficient magnitude that the fore-and-aft position plunger in the slide plate pulled out of the tractor's mounting-plate slot. As the trailer continued to turn over, it also was sliding toward the rear of the tractor. At some point, the air hose from the tractor-trailer brake either broke or became disconnected and the trailer brakes came on automatically. With the left-side trailer wheels still in contact with the road surface, there was sufficient braking to pull the unrestrained trailer from the tractor. The front of the trailer dropped to the southerly edge of the roadway -- 108 feet from the canal.

When the trailer separated from the tractor, the upsetting forces on the tractor were removed. The tractor dropped onto its right wheels, continued westward, and stopped opposite the headwall of the irrigation canal. The trailer rolled onto its left side and slid toward the concrete headwall and struck it. (See Figure 5.)

At impact, the tank shell was gouged severely and was forced into an elliptical shape. Impact forces also caused the tank to rotate counterclockwise about 40 to 50 degrees and to rebound to the south edge of the eastbound lane. The tank shell began to crack where it struck the headwall. The internal tank pressure of 87 psig combined with the impact load to cause a shear-type failure around the circumference of the tank.

Fixed Roadside Objects

If highway design and construction standards and AASHTO recommended practices had been followed in the construction or remodeling of the concrete headwall, it would have been flush with the ground and the tank would not have ruptured. If remodeling of the headwall was not possible, it should have been protected by a barrier. Even though the truck might have penetrated the barrier, the barrier might have at least absorbed

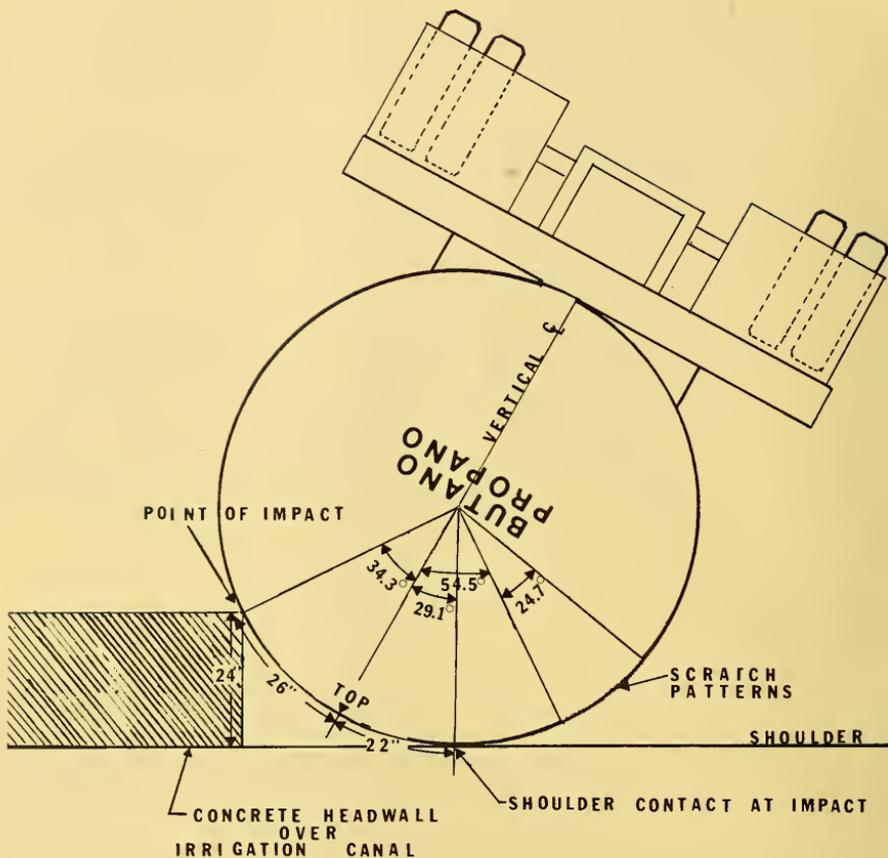


FIGURE 5. CALCULATED ATTITUDE OF TANK-SEMITRAILER AT IMPACT WITH CONCRETE HEADWALL

enough energy or redirected the tank to prevent the rupture of the tank shell. The FHWA and AASHTO should encourage the States to consider such hazards in the development of their spot improvement programs.

Risks in LPG Transportation

The pressurized LPG and the large quantity of the hazardous material being transported contributed to the severity of this accident. The pressure of the compressed LPG provided a portion of the energy needed to produce the abrupt, massive breakup of the cargo tank after it was ruptured. That pressure also contributed to the rocketing of the tank parts after they separated and to the rapid dispersion of vaporized LPG from the shattered tank. When the tank integrity was lost, much of the pressurized liquid changed into a gaseous form and was propelled away from the tank by the expanding gas.

The injuries and property damage which followed the breakup of the container could have been reduced in several ways. The size of the area endangered by the vapors and subsequent fires can be reduced if the quantity of LPG in the container which breaks apart is reduced. For example, had the LPG shipment been packaged in smaller containers, such as cylinders, it is unlikely that any fatal injuries would have occurred. The size of the affected area can also be reduced by limiting the rate at which the cargo tank breaks apart or the rate at which the contents are released and dispersed. For example, if LPG were transported in a self-refrigerated form and at ambient pressures, the rate of tank breakup would be reduced and the rate of material vaporization and dispersion would be reduced. These modifications could provide victims additional time to react to the threat of dispersing LPG.

However, technical methods of modifying the form and quantity of LPG transported have not been explored fully, possibly because the problem of modifying the behavior of liquefied, pressurized flammable gases has not been defined precisely in engineering terms.

Until a feasible method can be found to give potential victims more time for survival, a reduction in the risks will depend on improvements in the following area:

Compliance with safety regulations -- There is no evidence to indicate that lack of compliance with safety regulations was causative in this accident. However, the accident revealed that compliance with safety regulations by the carrier was not assured because the carrier was not known to the Bureau of Motor Carrier Safety nor was he served with a copy of the Federal Motor Carrier Safety Regulations. The small Federal enforcement staff responsible for assuring compliance with the safety regulations was not aware of the Surtigas operations. After the accident, the compliance staff made roadchecks at border crossing points to identify other LPG carriers and to assure that they were aware of the regulatory requirements with which they had to comply.

The Safety Board believes that these carriers would be identified more effectively if registration statements were required, for safety purposes only. All persons who transport bulk LPG in interstate commerce could be identified from their registration statements for compliance purposes. Compliance inspectors, using statistical sampling methods, could make more inspections and, thus, could improve the potential effectiveness of their program. The safety record achieved by such transporters would be available to determine future risk levels, to evaluate the need for amendment to the regulations, and to evaluate the carriers' performances. The possibility of losing their safety registrations would act as a strong incentive for compliance with safety regulations.

CONCLUSIONS

Findings

1. At a speed of 50 to 55 mph, the truck could not decelerate in time and was forced to swerve to the left to avoid the slowing automobile ahead.
2. Had the posted speed limit been reduced and had the truck been traveling at a lesser speed, the evasive maneuver may not have been necessary, or if taken, may not have been so severe as to overturn the truck.
3. The vehicles parked on the shoulder of the road in front of the used-car facility reduced the area in which the truckdriver could recover and left the truckdriver only one opportunity for evasive action. Their presence effectively eliminated the 30-foot roadside recovery area recommended by FHWA Highway Safety Program Standard 12, "Highway Design, Construction, and Maintenance."
4. A protective barrier could not have prevented the tank from striking the concrete headwall, but it could have absorbed sufficient energy or redirected the tank so as to prevent the tank from rupturing.
5. The concrete headwall should have been constructed in conformance with FHWA recommended practice and the AASHTO standard specification; if it had been flush with the ground, the severity of this accident would have been reduced.
6. There were no identifiable preimpact defects in the tractor, the tank-semitrailer, or the tank that could have contributed to the accident.
7. Persons in the used-car facility and in automobiles had no time to escape from the explosions and fire.
8. Technical methods to reduce the casualties caused by the behavior of pressurized, liquefied LPG released from broken bulk containers in accidents need to be explored and have not been.

The continuing possibility of catastrophic accidents during transportation of LPG in bulk requires that safety measures be developed to reduce the harmful effects of the sudden release of large quantities of pressurized, liquefied LPG.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the evasive action taken by the truckdriver to avoid a slowing vehicle in his path of travel. The cause of the fatalities and injuries to persons in the vicinity was the explosive force and fire, from which they had no time to escape. The rapid development of the explosive force and fire was caused by the gross rupture of the tank.

RECOMMENDATIONS

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

"Promulgate a regulation to require the criteria established in the Handbook of Highway Design for Operating Practices (E2 Culverts and Bridge Structures) be mandatory for all modified and new designs.

"Compile and evaluate accident data related to unprotected, raised concrete headwalls and sidewalls which, because of their location, are roadside fixed objects, to determine whether added emphasis for their modification or protection is warranted."

-- to the Texas State Department of Highways and Public Transportation:

"Conduct an engineering survey on U.S. Route 277 between the intersection with U.S. Route 57 and the city limits of Eagle Pass to determine if a prohibition of parking on the shoulder of this high-speed highway or a reduction in the speed limit, or both, would reduce the traffic conflicts in this area; then, take appropriate actions in accordance with the findings of the survey."

-- 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."

"Establish a regulation to require the safety registration statements authorized by Section 106(b) of the Hazardous Materials Act of persons transportation bulk shipments of pressurized, liquefied petroleum gases in a form and quantity capable of causing widespread injury and property damage in transportation accidents."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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May 5, 1976

APPENDIX

Investigation

This report is based on an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974. The Texas Department of Public Safety, the Bureau of Motor Carrier Safety (FHWA), and the Railroad Commission of Texas participated in the investigation.

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