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Highway Accident/Incident Summary Reports
Largo, Maryland, September 6, 1985

(U.S.) National Transportation Safety Board
Washington, DC

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16. Abstract

This publication contains a report of a highway accident investigated by the National Transportation Safety Board. The accident location and date is Largo, Maryland, September 6, 1985.

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Largo, Maryland
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National
Transportation
Safety Board

Washington, D.C. 20594

HIGHWAY ACCIDENT/INCIDENT SUMMARY

Accident Number:	DCA-85-HZ-008
Location:	Largo, Maryland
Date:	September 6, 1985
Time:	12:40 p.m., e.d.t.
Owner/Operator:	Poist Gas Company
Property Damage:	$43,000
Injuries:	1 nonfatal (driver)
Type of Accident:	Overturn and fire involving truck-cargo tank filled with propane

The Accident

About 12:40 p.m., e.d.t., on September 6, 1985, a 1982 GMC 2-axle truck fitted with a 1973 MC-331 cargo tank overturned while traveling southbound on the Capital Beltway, I-95, near Largo, Maryland. The 2,500-gallon capacity cargo tank contained about 1,375 gallons of propane. The Poist Gas Company truck was traveling between 50 and 55 mph when, according to the driver, the steering wheel started shaking violently and "flew out of my hands." The driver stated that he took his foot off the accelerator but did not brake because he believed that one of the vehicle's tires was experiencing a blow out. The truck veered across the right paved shoulder of the highway and onto a grass shoulder. It then traveled 300 feet down the grass shoulder until the driver steered the truck back to the left to avoid hitting a tree. The truck clipped the north end of a guardrail when it reentered the paved shoulder of the highway as the driver tried to regain control of the truck. The truck then traveled 510 feet down the paved shoulder and the right travel lane of the highway before rotating clockwise about 80° and overturning on its left side. The vehicle continued to rotate another 100° as it slid 400 feet down the highway on its left side. The truck came to rest facing north (180° opposite its original direction of travel) with the top of the cargo tank parallel with and against the guardrail. At the time of the accident the roadway was dry and the weather was clear.

The Capital Beltway is an 8-lane asphalt-paved highway which encircles Washington, D.C. It has a large grass median strip dividing the four southbound lanes from the four northbound lanes in the area of the accident. Each lane is 12-feet wide, and the southbound lanes are bordered on each side with 9-foot wide shoulders. The right (outside) shoulder on the southbound side is bordered by a W-beam guardrail extending for 436 feet along the accident site. The roadway was repaved about 1 year before the accident.

A motorist traveling behind and to the left of the truck estimated its speed to be about 50 mph when he saw the left front wheel of the truck shimmy just before the accident; a few seconds later he saw the truck go off the right side of the road. He recognized that the truck was transporting propane and saw the truck catch fire immediately after sliding to a stop. He said that the fire initially started behind the cab of the truck near the propane fuel tanks, and that it later spread back to the cargo tank.

Fearing an explosion, he stopped traffic and warned motorists to keep away from the burning truck. The truckdriver, who was not wearing an available lap belt, received moderate injuries. He climbed out of the truck and helped warn motorists about the danger of an explosion.

When a Maryland State Police officer arrived on the scene a few minutes later, the truckdriver informed him that the cargo tank contained propane and warned him about the possibility of an explosion. The Prince George's County Fire Department arrived on the scene a few minutes later and observed flames impinging on the cargo tank shell. The flame impingement and the hot afternoon temperatures (96°F) resulted in high propane vapor pressures 1/ inside the cargo tank.

Little information was available to the fire department about the condition of the cargo tank after the accident and it was not possible for the fire department to judge precisely the structural integrity of the cargo tank. The fire department evaluated the possibility of a violent thermal rupture of the cargo tank and the hazards that could result from extinquishing the fire. They concluded that a greater threat to loss of life and property would result if the flow of propane from the damaged cargo tank could not be stopped after the flames were extinguished. Therefore, the fire department decided not to extinguish the fire, and they ordered an evacuation of more than 300 persons from homes within a 3,000-foot radius of the truck. Several hundred vehicles (including about eight school buses with children onboard) were temporarily stranded on the beltway near the accident site, and an estimated 108,000 vehicles that normally use the beltway during the period it was closed were diverted to other routes. Additionally, a nearby bulk mail center was closed. Propane escaping from the cargo tank burned for 13 1/2 hours. The evacuation was lifted at 2:58 the next morning, and the highway was reopened about 5 a.m.

The weather and highway conditions were not factors in the accident. The accident occurred in a section of highway where the alignment was straight with negligible grade, and the shoulders and embankments were constructed in accordance with Federal and State highway specifications. Traffic conditions were light and the weather was clear. The truckdriver was also familiar with the highway.

Vehicle Inspection and Maintenance

The truckdriver stated that he had been operating the accident truck since February 1985 and could only remember experiencing one mechanical problem with the truck during this time. He indicated there was a front end alignment problem which was corrected in the summer of 1985.

A post accident examination of the remains of the truck did not reveal any mechanical discrepancies with the brakes, suspension, and steering components. However, a close examination of the remains of the left front tire did reveal some problems with the tire.

1/ The vapor pressure of propane in transportation is dependent on temperature. At 60°F the propane vapor pressure is about 102 psig; at 110° F the vapor pressure increases to 220 psig.

The truck was equipped with Barum 10R20, tube type, steel belted radial tires on the front axle. The tires were purchased in December 1983 and had about 34,000 miles of service on them when the accident occurred. They were manufactured by Rudy-Rijen of Czechoslovakia and imported into the United States by American Jawa, Ltd., of Plainview, New York. Examination of the left front tire after the accident disclosed that it had sustained a circumferential tread separation in the shoulder area of the tire and there was evidence of fretting (rubbing or abrasive action) of adjacent wire filaments of the body chords. (See figure 1.) This abrasive action will reduce the effective wire filament diameter and overall chord strength and, if severe, can result in chord breakage or permit excessive internal cord movement and weaken the steel-to-rubber bond. A progressive loss of bond strength will eventually result in tread/belt separation.

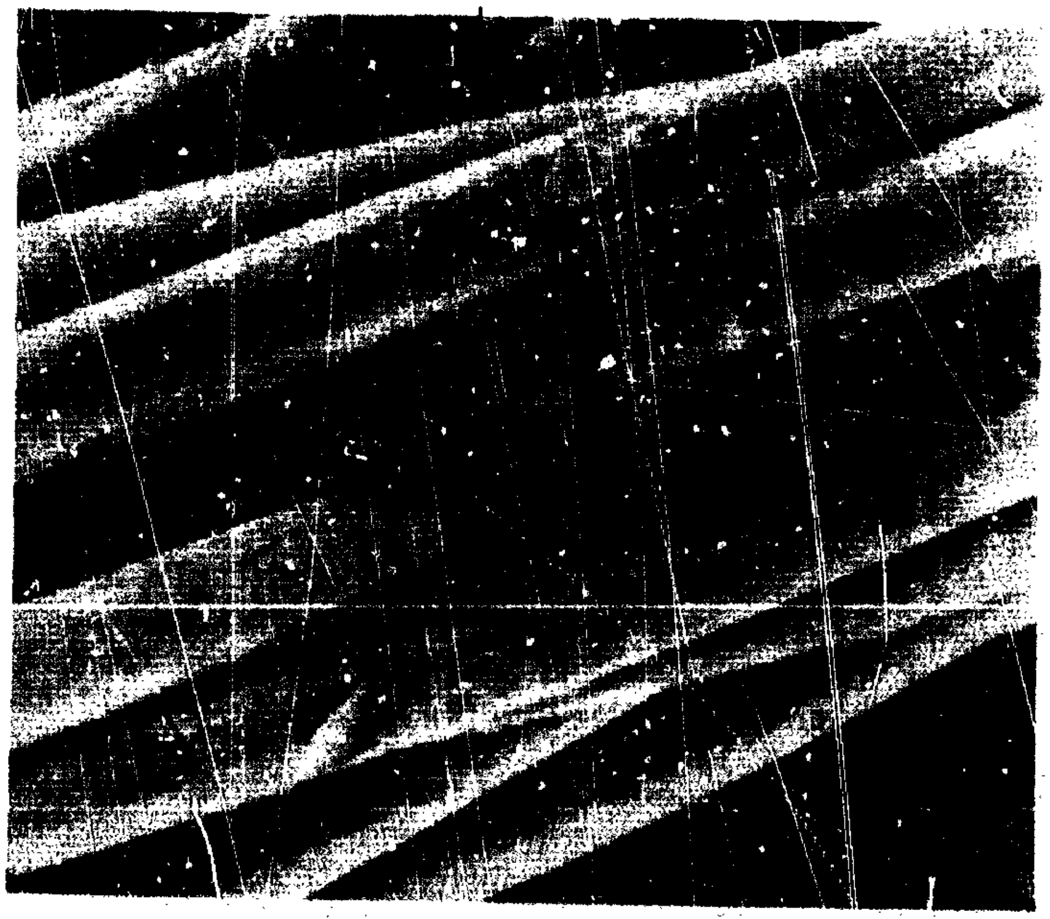
The tire probably deteriorated over an extended period of time producing warning signs, such as a rough ride, annoying vibration, or an undesired directional pull on the wheel. The truckdriver did have vibration problems with the truck and reported the condition to the owner about 2 months before the accident. On July 10, 1986, the truckdriver drove the truck to a GMC facility for repairs and service where a work order was issued noting that the truck "wanders" and that the "front end shimmies on bumps at times." The work order also indicated that a front end alignment was performed, that the two front tires were balanced as "best as possible," and that all six tires on the truck were out of round causing "hopping." No other adverse tire conditions were noted on the work order.

Continued use of the tire under these conditions probably caused a bond separation to grow to a point where partial or complete tread separation produced excessive steering wheel vibration. Postaccident examination of the vehicle revealed that tire rubber marks on the rearmost section of the front fender, most likely were caused by loose tread striking the fender after each revolution of the tire. During this time a portion of the tread section apparently separated from the tire and lodged itself near the left saddle fuel tank. Because the metallic split side rim and inner tube brass valve stem were found in their normal positions after the accident and there was no evidence of abrasions on the outside flange of the rim, the tire probably remained inflated during the accident and did not experience a blow out.

The exact cause of the tire tread separation was not determined, since most of the tires nonmetallic components were consumed by fire. Although some representatives of the tire industry in the United States 2/ indicate that unbalanced or out of round tires do not cause tread separation, the Safety Board believes that the extended use of tires under such conditions, particularly marginally constructed tires, could accelerate the failure of tires. The chord geometry used in the Barum 10R20 tire was cited by one manufacturer as being prone to wire filament fretting which can lead to a bonding separation. If this is the case, then the vibrations produced by an unbalanced or out of round tire could increase the internal stress and cyclic flexure in the tire to a point where fretting and the debonding process may be accelerated.

The Safety Board believes that it is a poor operating practice to use unbalanced or out of round tires on the steering axle of a vehicle. This is because the resulting vibrations, particularly at higher speeds, affect steering control and under certain

2/ Representatives of the tire industry indicate that normally tires which exceed out of round manufacturing tolerances will not fail because of their out of round condition. Generally, out of round tires have poor ride quality, and the tire and rim assembly have to be dynamically balanced to improve the vehicle handling characteristics.



(magnified 48 times)

(magnified 240 times)

Figure 1— Enlarged views of body cord fretting found in the truck's left front tire sidewall.

conditions can accelerate an impending problem such as a tread separation which could eventually result in a catastrophic tire failure. Although the truck involved in this accident was used predominately for local service and usually was driven at relatively low speeds where the catastrophic failure of a steering axle tire might not cause a severe control problem, the accident amply demonstrates the consequences of such a problem at high speeds. Therefore, the Safety Board believes that operators of commercial vehicles, especially those carrying hazardous materials, should not use unbalanced or out of round tires that cause vibration on the steering axles of these vehicles.

The truckdriver probably was not aware of the potential tread separation problem with the left front tire. The truckdriver thought he was experiencing a tire blow out and opted to slow the truck without applying his brakes. This response would have been appropriate had he experienced a tire blow out because it would have permitted the driver to maintain some steering control of the truck. However, in this accident the left front tire probably did not deflate during the accident sequence until it was consumed by fire. If the truckdriver had applied his brakes, he may have been able to reduce the truck's speed and corresponding tire vibration being transmitted to the steering wheel, and possibly stopped the vehicle before it overturned on its side.

Safety Board investigators asked the National Highway Traffic Safety Administration (NHTSA) for information on similar failures for this make of tire; no records of reported failures for this type of tire were found. However, a representative of Gen Corp (formerly General Tire and Rubber Co.) indicated that the cord geometry used in the manufacture of the accident tire can be subject to fretting in truck and bus tires. (See appendix A.)

Cargo Tank Maintenance and Integrity

The cargo tank, manufactured by the Petroleum Tank Company of Kenly, North Carolina in 1973, was built to a design pressure of 250 psig. Although the 2,500-gallon cargo tank had been used primarily for local delivery service, the cargo tank had been manufactured to the same U.S. Department of Transportation (DOT) construction requirements as much larger over-the-road cargo tanks. It was equipped with safety valves (manufactured by the RegO Company of Chicago, Illinois) similar to those on larger cargo tanks. The State of Maryland, where this cargo tank was being operated, like many other States, had adopted DOT's construction, testing, and repair requirements for cargo tanks used in the transportation of propane and other hazardous materials within its borders.

During the accident, the cargo tank liquid propane discharge pipe broke at a joint between the internal shut off valve and the propane delivery meter. (See figure 2.) Liquid propane in that line was released and ignited. The fire consumed flexible connectors (hoses) installed in the liquid propane return line, the propane vapor return line, and the liquid propane discharge line. Those lines were connected to three openings in the cargo tank, which was equipped with separate safety valves designed to prevent or control the unintentional flow of propane from the cargo tank. The three valves (an internal shut off valve, an excess flow check valve, and a back pressure check valve) were removed from the cargo tank after the accident for examination and laboratory testing by the Safety Board.

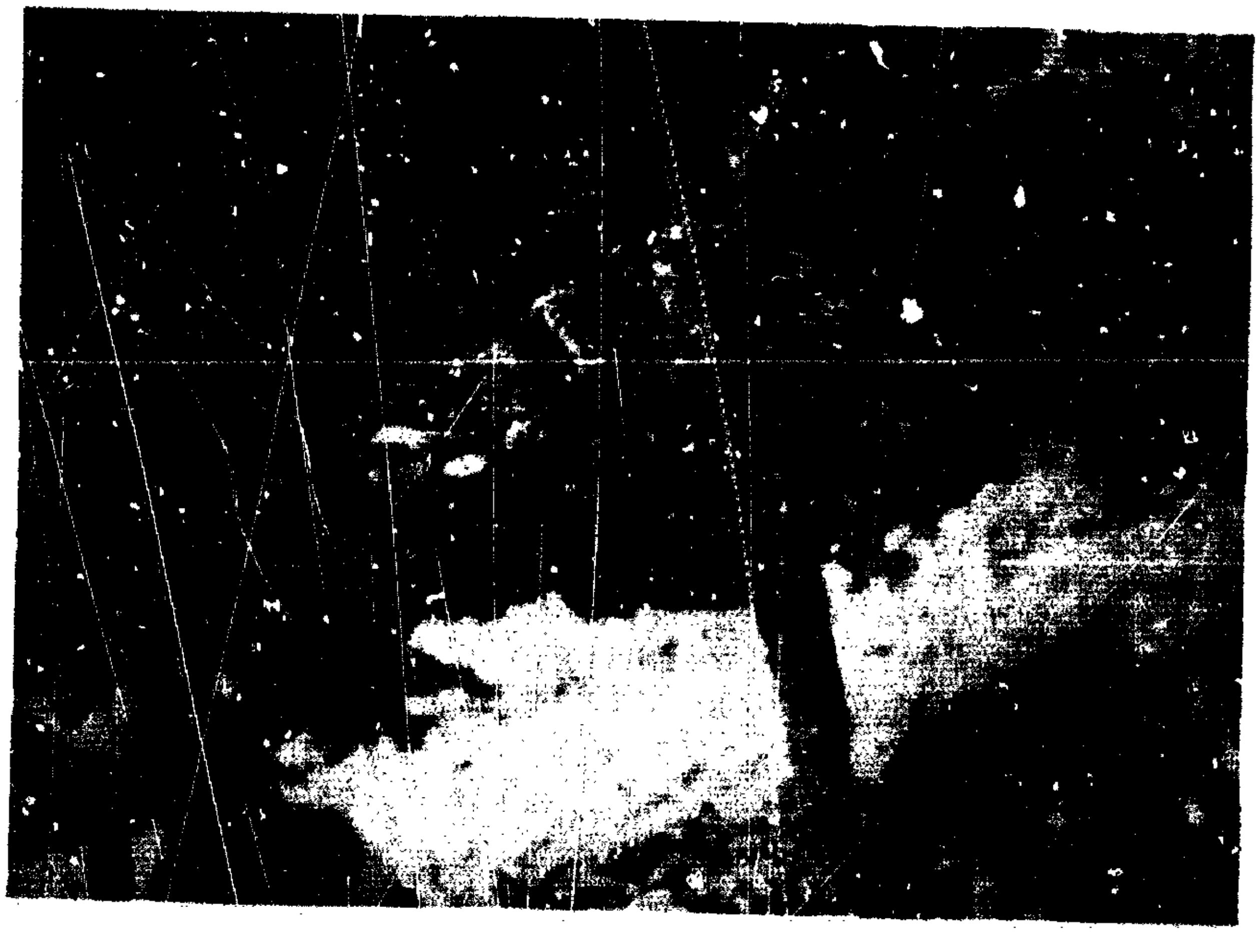


Figure 2.— The knife blade is inserted into a break in the liquid propane discharge line. The joint is located under the rear head of the cargo tank.

The internal shut off valve was installed at the liquid propane discharge opening on the bottom of the cargo tank. Examination of the 13-year-old valve after the accident disclosed that a synthetic rubber disc mounted in the piston assembly was hardened and partially disintegrated, and contained gaps up to 6/32-inch wide. (See figures 3 and 4.) The synthetic rubber disc is designed to seat against the body of the valve when the piston is in the closed position to prevent the flow of propane from the cargo tank to the discharge pipe. Tests conducted on the internal shut off valve after the accident measured a liquid propane flow rate through the valve in the closed position at 13.31 gallons per minute (GPM). In addition to the deteriorated disc, the O-shaped synthetic rubber seals (O-rings) in the valve were also hardened, one O-ring had split, and a synthetic rubber seal in the valve's packing nut assembly had deteriorated severely. (See figure 5.) While some hardening of the synthetic rubber components may have occurred as a result of heat exposure during the incident, accident photographs showed that there was no direct flame impingement on the internal shut off valve. Further, photographic evidence indicated that the valve's synthetic rubber seat disc failed to prevent the flow of propane from the cargo tank during the early phases of the incident, before the cargo tank was heated by the fire.

Figure 3.— The internal shut off valve's piston assembly is raised to the open position during disassembly of the valve. Arrow "d" points to the deteriorated synthetic rubber seat disc. In the closed position the rubber disc seats between the piston and the body of the valve, arrow "b."

The excess flow check valve was installed at the propane vapor return opening in the rear head of the cargo tank. It also allowed propane to escape from the cargo tank during the incident. However, this valve is designed to control the rate of flow of propane from the cargo tank in the event of a complete break in the vapor return line and to allow pressure equalization between the cargo tank and lines outside of the cargo tank during normal operating conditions. It is not designed to completely stop the escape of propane in the closed position.

Figure 4.— Arrows point to the deteriorated synthetic rubber seat disc in the internal shut off valve's piston assembly.

The excess flow check valve closed properly during laboratory tests conducted on the valve following the accident. However, laboratory examination of the valve disclosed no evidence indicating whether the valve was opened or closed during the incident. No obstructive foreign matter was found in the valve during its inspection after the incident, and no restriction was found in the vapor return line to indicate that the flow rate was reduced to less than a rate necessary to shut the valve. Also, it could not be determined if an angle valve, located between the excess flow valve and the vapor return line, was fully opened at the time of the accident. If the angle valve had not been fully opened, the flow rate through the excess flow valve may not have been sufficient to close it. Photographs taken during the incident indicate that a significant amount of propane flowed through the vapor return opening and that the excess flow valve may not have closed.

The back pressure check valve, which was installed at the liquid propane return opening, was also removed from the cargo tank following the accident and laboratory tested. A test of this valve indicated that it had functioned properly and that it had not allowed any significant amount of propane to flow from the cargo tank during the accident.

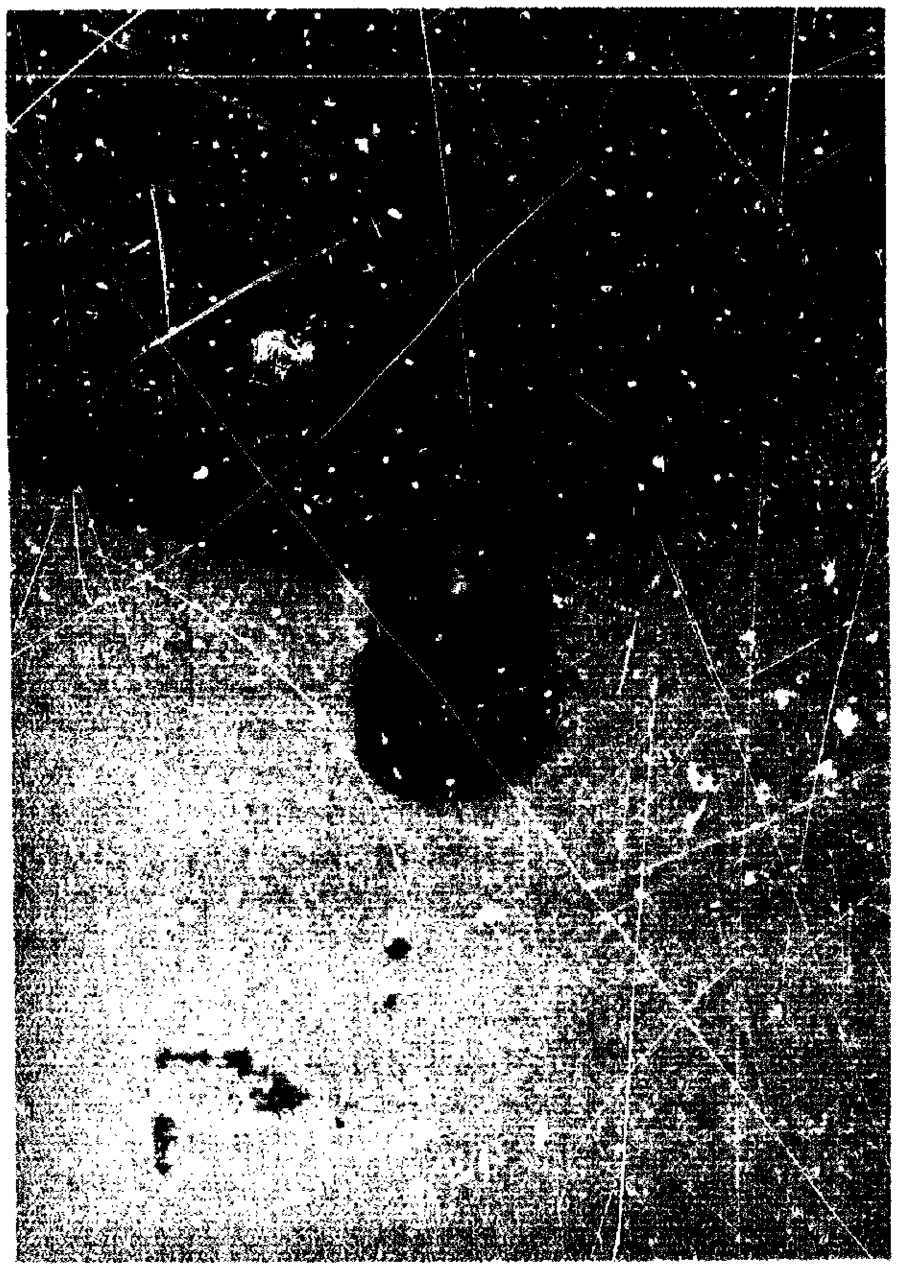


Figure 5.— An arrow points to a split in the "O" ring seal located in the internal shut off valve's packing nut and bushing assembly at the indicating stem.

The Poist Gas Company did not have records to demonstrate when the cargo tank's safety valves were last inspected or tested; however, a company official believes that the valves were tested in 1982 when the cargo tank was attached to the truck. All piping, valves, and fittings on MC-330, MC-331, and MC-338 cargo tanks must be pressure tested and proved free from leaks after installation (49 CFR 173.33(f)(5)). However, while those cargo tanks must be hydraulically or pneumatically pressure tested periodically, internal shut-off valves, excess flow check valves, and back pressure check valves are not required to be tested periodically to identify unsatisfactory valve performance. 2/ To reduce the risk of safety valve failures during accidents, carriers should frequently test the operating condition of all cargo tank safety valves.

A RegO Company safety warning bulletin on LP-Gas excess flow check valves warns that all RegO products are mechanical devices that will eventually become inoperative due to wear, contaminants, corrosion, and aging of components made of materials such as metal and rubber. The bulletin also warns that environment and conditions of use will determine the safe service life of the products, that periodic testing at least once a year is essential, and that because the valves have a long and proven record of quality and service, LP-Gas dealers may forget the hazards that can occur when valves are used beyond their safe service life. A similar safety warning bulletin should be issued for the internal shut off valves, and users of the valves should be urged to test them periodically to determine if the seals properly seat.

The National LP-Gas Association (NLPGA) has also issued several advisory safety bulletins to promote safe operating practices. NLPGA Safety Bulletin 112-71 suggests that excess flow check valves and shut off valves be checked monthly by blowing out the pressure downstream of the valves and checking for proper operation of the valves, including seat seals on shut off valves. In addition to safety advisories, the NLPGA has prepared check lists to help carriers establish safe operating procedures and attain compliance with DOT safety requirements. Further, the National Fire Protection Association's Standard for the Storage and Handling of Liquefied Petroleum Gases, 1983, NFPA 58 (an American National Standard) specifically requires all LP-Gas cargo vehicles to comply with DOT requirements. Because many carriers, States, and safety organizations rely on DOT regulations to help assure the safe transportation of hazardous materials in cargo tanks, the DOT regulations should require frequent testing of all cargo tank safety valves to determine if the valves operate properly and prohibit the use of cargo tanks equipped with improperly operating safety valves.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the circumferential tread separation of the left front tire, which caused the driver to lose steering control of the vehicle. Contributing to the accident was the continued use of unbalanced out of round tires on the steering axle of the vehicle which produced wheel vibration. Contributing to the severity of the accident was the release of propane from the cargo tank through a break in the discharge line, and the failure of safety valves on the cargo tank to prevent the continuous flow of propane from the cargo tank after the accident.

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

2/ While these safety valves are not subject to periodic retest requirements, spring loaded safety relief devices (pressure relief valves) on cargo tanks other than MC-330, MC-331, and MC-338 cargo tanks must be removed periodically and tested (49 CFR 177.824(b)).

—to the Poist Gas Company:

Establish procedures for periodically inspecting and testing all safety valves on cargo tanks, including tests to determine if seals properly seat. (Class II, Priority Action) (H-87-22)

—to the RegO Company:

Issue a safety warning bulletin for shut off valves on cargo tanks advising that the valves should be periodically tested to determine their operating condition, including tests to determine if seals properly seat. (Class II, Priority Action) (H-87-23)

—to the National LP-Gas Association:

Inform its members of the circumstances of the September 6, 1985, propane accident near Largo, Maryland. Reiterate to them, the safety procedures recommended in NLPGA Safety Bulletin 112-71 pertaining to the need for testing of excess flow and shut off valves on cargo tanks, and caution the members against using unbalanced or out of round tires on the steering axles of vehicles. (Class II, Priority Action) (H-87-24))

—to the U.S. Department of Transportation's Research and Special Programs Administration:

Require that all cargo tank safety valves be periodically tested to determine the operating condition of the valves, and prohibit the use of cargo tanks equipped with safety valves that are not determined to be operating properly. (Class II, Priority Action) (H-87-25)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

April 28, 1987

APPENDIX A

Tire construction is one steel body ply (7x4x.22+1x.15mm) with four steel belts, double helical wrapped cable beads and a nylon chafer. The first belt consists of two sections not joined across the crown centerline. The first belt wire geometry is 7x4x.175+1x.15mm. This is interpreted as seven clusters of four wire filaments each 0.175mm in diameter wrapped by one wire 0.15mm in diameter. The end count bias angle and actual belt width cannot be determined. 1/

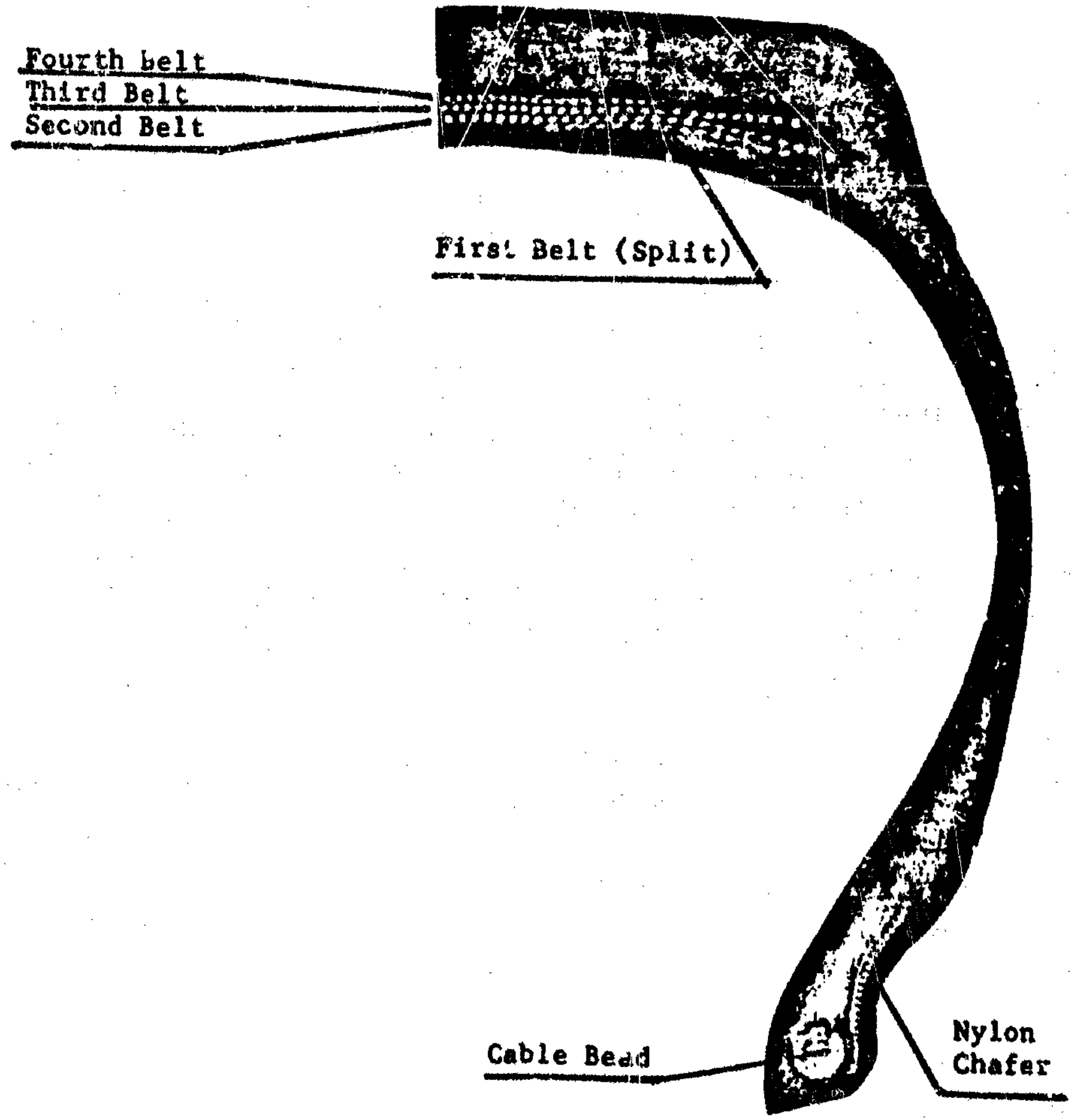
The second and third belt design is 7x4x.20+1x.15mm. The fourth belt design is 7x4x[illegible]+1x.15mm. The 7x4 with one wrap geometry is the same for all steel wire cord bu[illegible] diameter gets larger in filament size from belt one to belt four. The body ply fil[illegible]ent is still different in diameter (0.22mm) and smaller than the fourth belt filament.

The strength of the cords is in its geometry and filament diameter. The single filament wrap adds some minimal strength to the cord, but its prime function is to hold the cord geometry as a unit until the calendaring operation is complete. The calendar operation applies rubber polymer to all sides of the steel cords in a sheet form, insulating one cord from another. Some penetration of the rubber polymer is accomplished into the 7x4+1 geometry. Rubber to steel adhesion is accomplished by the bronze finish to the wire filaments during the vulcanization process.

The 7x4+1 cord geometry in a truck/bus tire can be subjected to a fatigue process termed "fretting." Fretting is literally a rubbing or abrasion action of one wire filament against an adjacent filament. This action causes a loss of effective filament diameter and thus a loss of cord strength.

Eventually the cords become broken. Fretting also means excessive internal cord movement which can cause the loss of cord-rubber adhesion. Any loss of rubber-cord adhesion is incipient separation. Continued separation growth can result in premature tire failure.

1/ Appendix A is an excerpt from a factual report prepared by Corporate Quality Assurance personnel, the General Tire Corporation, Akron, Ohio. General Tire Corporation provided assistance to the National Transportation Safety Board in the factual documentation of tire construction and laboratory documentation of postaccident evidence.

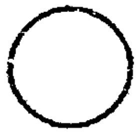


Typical 10R20F Truck/Bus Tire With One Steel Body Ply And Four Steel Belt Construction Plus A Nylon Chafer

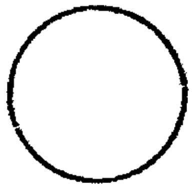
STEEL TIRE CORDS

SCALE 1/100 mm = 1/64 in.
GAUGE RANGE, mm / BREAKING STRENGTH, lb

600223, 600124 & 600125
0.037 IN.
.94-.99/316
BEAD WIRE

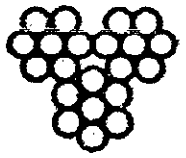


600126 & 600165
0.050 IN.
1.27-1.32/500
BEAD WIRE

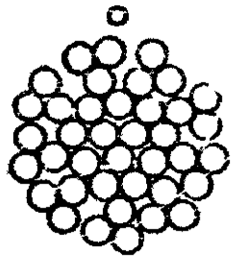


600147
0.072 IN.
1.79-1.87/1000
BEAD WIRE

600248
3x7x.175mm
1.14-1.26/236
HIGH ELONGATION

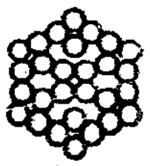


600247
3x7x.22mm
1.43-1.58/394
HIGH ELONGATION

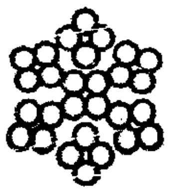


600245
3 + 9 + 9x3x.25 + 1x.15mm
2.30-2.44/1022

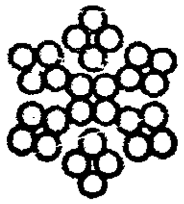
600110
5x.25mm
.64-.72/142



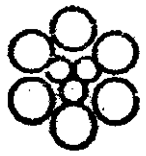
600131
7x4.175mm
1.10-1.31/383



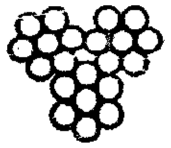
600129
7x4x.20mm
1.37-1.51/504



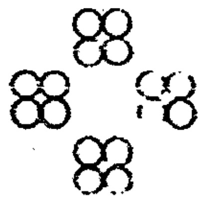
600133
7x4x.22mm
1.58-1.66/604



600162
3x.20 + 6x.35mm
1.04-1.16/360

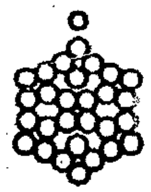


600161
3x7x.20mm
1.24-1.40/325
HIGH ELONGATION

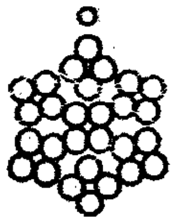


600217
4x4x.22mm
1.30-1.44/290
HIGH ELONGATION

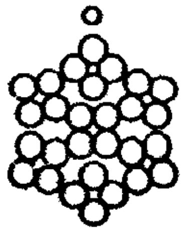
600218
4x.25mm
.56-.66/116



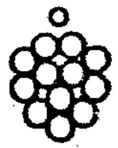
600132
7x4x.175 + 1x.15mm
1.30-1.52/383



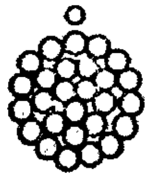
600130
7x4x.20 + 1x.15mm
1.56-1.72/504



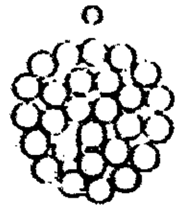
600134
7x4x.22 + 1x.15mm
1.72-1.90/604



600216
3 + 9x.22 + 1x.15mm
1.08-1.21/260



600166
3 + 9 + 15x.175 + 1x.15mm
1.25-1.39/388



600215
3 + 9 + 15x.22 + 1x.15mm
1.52-1.68/600

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APPENDIX A