# AILROAD ACCIDENT REPORT

## AZARDOUS MATERIALS RAILROAD ACCIDENT
## IN THE ALTON AND SOUTHERN GATEWAY YARD
## IN EAST ST. LOUIS, ILLINOIS

## JANUARY 22, 1972

TRANSPORTATION SAFETY BOARD

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-RAR-73-1

SS-R-18

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ADOPTED: JANUARY 31, 1973

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TECHNICAL REPORT STANDARD TITLE PAGE

| | | |
|---|---|---|
| 1. Report No.<br>NTSB-RAR-73-1 | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle<br>Railroad Accident Report - Hazardous Materials Railroad Accident in the Alton and Southern Gateway Yard in East St. Louis, Illinois, January 22, 1972. | | 5. Report Date<br>January 31, 1973<br>6. Performing Organization Code |
| 7. Author(s) | | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>National Transportation Safety Board<br>Bureau of Surface Transportation Safety<br>Washington, D. C. 20591 | | 10. Work Unit No.<br>1001<br>11. Contract or Grant No. |
| 12. Sponsoring Agency Name and Address<br>NATIONAL TRANSPORTATION SAFETY BOARD<br>Washington, D. C. 20591 | | 13. Type of Report and Period Covered<br>RAILROAD ACCIDENT REPORT<br>January 22, 1972<br>14. Sponsoring Agency Code |

15. Supplementary Notes

This report contains Railroad Safety Recommendations R-73-1 through R-73-4.

16. Abstract

At about 6:20 a.m., on January 22, 1972, an overspeed tank car loaded with liquid petroleum gas collided with a standing hopper car in the Alton & Southern Railroad Company's Gateway Yard in East St. Louis, Ill. In the overspeed impact, an overriding coupler on the empty freight car punctured the tank head. The pressurized propylene gas in the tank car leaked to the ground and vaporized. A large vapor cloud was formed, which ignited and exploded. More than 230 people were injured as a result of the explosion, and property damage was estimated at more than $7½ million.

The National Transportation Safety Board determines that the probable cause of the overspeed impact was the failure of the retarding system in the hump classification yard to decelerate effectively heavy cars with oil or grease on their wheel rims; the absence of a backup system to halt cars passing through retarders at overspeeds; and the routine acceptance at the Gateway Yard of uncontrolled overspeeds. Propylene leaked from the tank car because the tank head was too weak to resist the impact of the overriding coupler of the hopper car. Lack of specifications that define permissible impact and adequate crash resistance was a contributing factor.

| | |
|---|---|
| 17. Key Words<br>Railroad accident, classification yards, hazardous materials, tank-car puncture, liquid petroleum gas, retardation systems, tank-car design. | 18. Distribution Statement<br>Released to public; distribution unlimited. |

| | | | |
|---|---|---|---|
| 19. Security Classification (of this report)<br>UNCLASSIFIED | 20. Security Classification (of this page)<br>UNCLASSIFIED | 21. No. of Pages<br>25 | 22. Price |

NTSB Form 1765.2 (11/70)

## FOREWORD

The accident described in this report has been designated as a major accident by the National Transportation Safety Board under the criteria established in the Safety Board's regulations.

This report is based on facts obtained from an investigation conducted by the Safety Board, in cooperation with the Federal Railroad Administration. The conclusions, the determination of probable cause, and the recommendations are those of the Safety Board.

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Figure 1. Alton & Southern Gateway Yard after the explosion.

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RAILROAD ACCIDENT REPORT

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# HAZARDOUS MATERIALS RAILROAD ACCIDENT IN THE ALTON AND SOUTHERN GATEWAY YARD IN EAST ST. LOUIS, ILLINOIS JANUARY 22, 1972

## I. SYNOPSIS

At approximately 6:20 a m on January 22, 1972, a large cloud of vaporized liquid petroleum gas (LPG) exploded in the Alton and Southern Railroad Company's Gateway Yard in East St. Louis, Ill. More than 230 residents of East St. Louis and railroad employees were injured. Property damage in the railroad yard and surrounding residential and business area was estimated at $7½ million. The vapor cloud originated when the head of a tank car containing LPG (propylene) was punctured in an overspeed impact with a standing hopper car during a switching operation.

The National Transportation Safety Board determines that the probable cause of the overspeed impact was the failure of the retarding system in the hump classification yaid to decelerate effectively heavy cars with oil or grease on their wheel rims, the absence of a backup system to halt cars passing through retarders at overspeeds, and routine acceptance of uncontrolled overspeeds.

Propylene leaked from the tank car because the overriding coupler of the hopper car punctured a tank head too weak to resist the blow. Lack of specifications which define permissible impact and adequate crash resistance was a contributing cause.

Losses were increased by the rapid rate at which the vaporized propylene spread at ground level, its ignition, and the acceleration of the burning reaction in air to the extent that a violent explosion occurred

## II FACTS

### Accident Site and Method of Operation

The accident occurred in the Alton and Southern Railroad Company's (A&S) Gateway Yard in East St. Louis, Ill. (See Figure 1.) Gateway Yard is a classification and interchange point for freight cars used by 16 railroads A&S receives cars from other carriers, classifies them, and delivers them to outbound carriers.

Before the cars are humped,[1] they are checked by A&S car inspectors. Cars are then pushed from one of 13 receiving tracks to the crest of the hump by a locomotive with a yard crew. (See Figure 2.) The cars are directed to one of 42 classification tracks by a computerized switching and speed-control system.

The classification operation is controlled by a general yardmaster located in a tower on the crest of the hump. He designates the cars to be humped and the classified cars to be dispatched. The humping operation is supervised by a hump conductor and conducted by a subordinate crest

[1]Humping is the practice of pushing freight cars up a mound, uncoupling them at the crest, and allowing them to roll free on a descending grade onto classification tracks

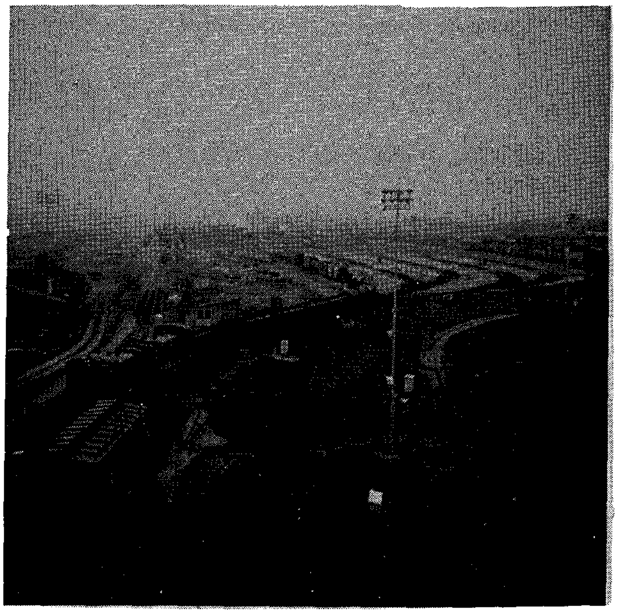


**Figure 2. Gateway Yard (picture taken from crest hump tower.)**

operator. Both are located in the tower with the general yardmaster. The crest operator uses a control console to run the hump operation and to override manually the automated switches and retarders.

The moving of classified cars and the making up of trains are directed by a bowl yardmaster located in a tower on top of the general office building. The bowl yardmaster keeps the crest operator informed of the locations of crews working in the yard so the crest operator will not route cars onto a track where a crew is working.

At the time of the accident, there were two hump engines with crews who reported to the hump conductor and two engines assigned to the general yardmaster in the classification yard. Engine movements are controlled by radio communication, fixed signals, and hand signals.

## The Accident

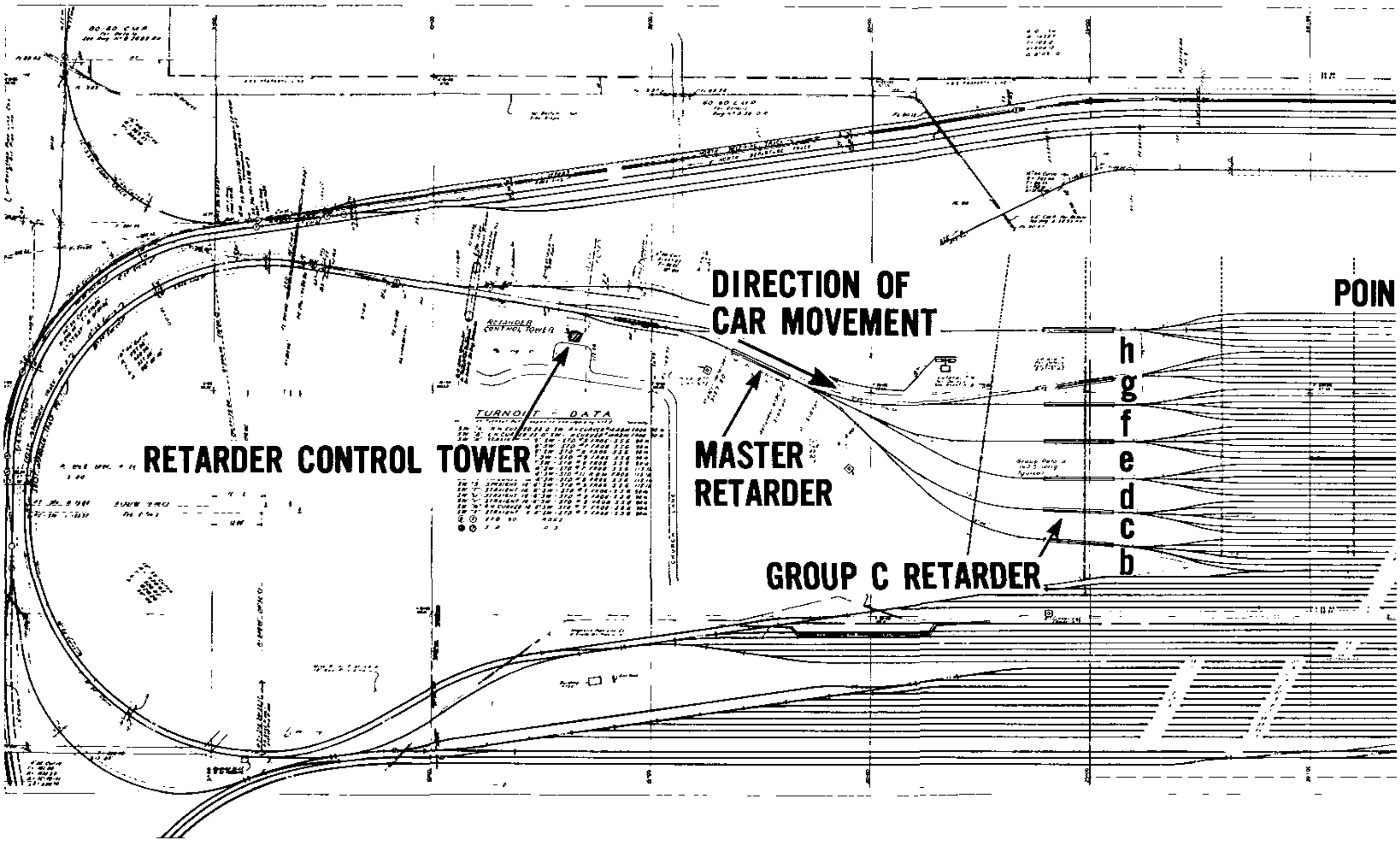
On the morning of January 22, 1972, a 44-car cut arrived on the No. 2 receiving track in the Gateway Yard. Car inspectors took no exceptions to the condition of any of the cars before they were humped.

This car inspection involved a visual check of structural components and running gear and a determination of whether brake piston travel complied with Federal requirements. Car inspectors reported the condition of cars to the computer room. At the time of this accident, A&S inspectors did not consider an accumulation of grease or other foreign substance on wheels a sufficient reason to reject a car as unsuitable for humping.

Classification of the 44-car cut began at 6:02 a.m. The first 24 cars were humped without any unusual occurrence. The 25th car, L&N 131571, an empty hopper, was humped without incident en route to track No. 15. The car, however, stopped about 1,000 feet beyond the group retarder, or about 1,300 feet short of its planned coupling point with other cars on the track. (See Figure 3.) Cars 26 through 34 were humped as programmed and routed to other classification tracks.

Cars 35, 36, and 37 (UTLX 83061, ACFX 17864, and UTLX 83048) were tank cars which contained liquid petroleum gas (LPG) consisting principally of propylene. The three cars were uncoupled from the 38th car and were humped as a unit onto track No. 15. The cars left the crest at a speed of 2.3 m.p.h. and entered the master retarder, which the crest operator had placed in full retardation position. The master retarder did not retard the cars to the programmed speed and the system overspeed alarm sounded. The crest operator responded, according to A&S instructions, by manually placing the "C" group retarder in full retardation position. The cars left the "C" group retarder at 16.5 m.p.h., about 6 to 8 m.p.h. faster than programmed. The crest operator immediately alerted the general yardmaster, the hump conductor, and the bowl yardmaster. They, in turn, alerted employees in the area of track No. 15.

Meanwhile, cars 38 and 39 were released at the hump for track No. 10. They left the master retarder at 17 m.p.h. but were controlled by the "B" group retarder. Car 40, another tank car containing LPG, was released from the hump for track No. 15. The car left the master retarder at 17 m.p.h., and the "C" group retarder released it at 17.5 m.p.h., approximately 10 m.p.h. faster than programmed.


DIRECTION OF
CAR MOVEMENT
POIN
RETARDER CONTROL TOWER
MASTER
RETARDER
GROUP C RETARDER
h
g
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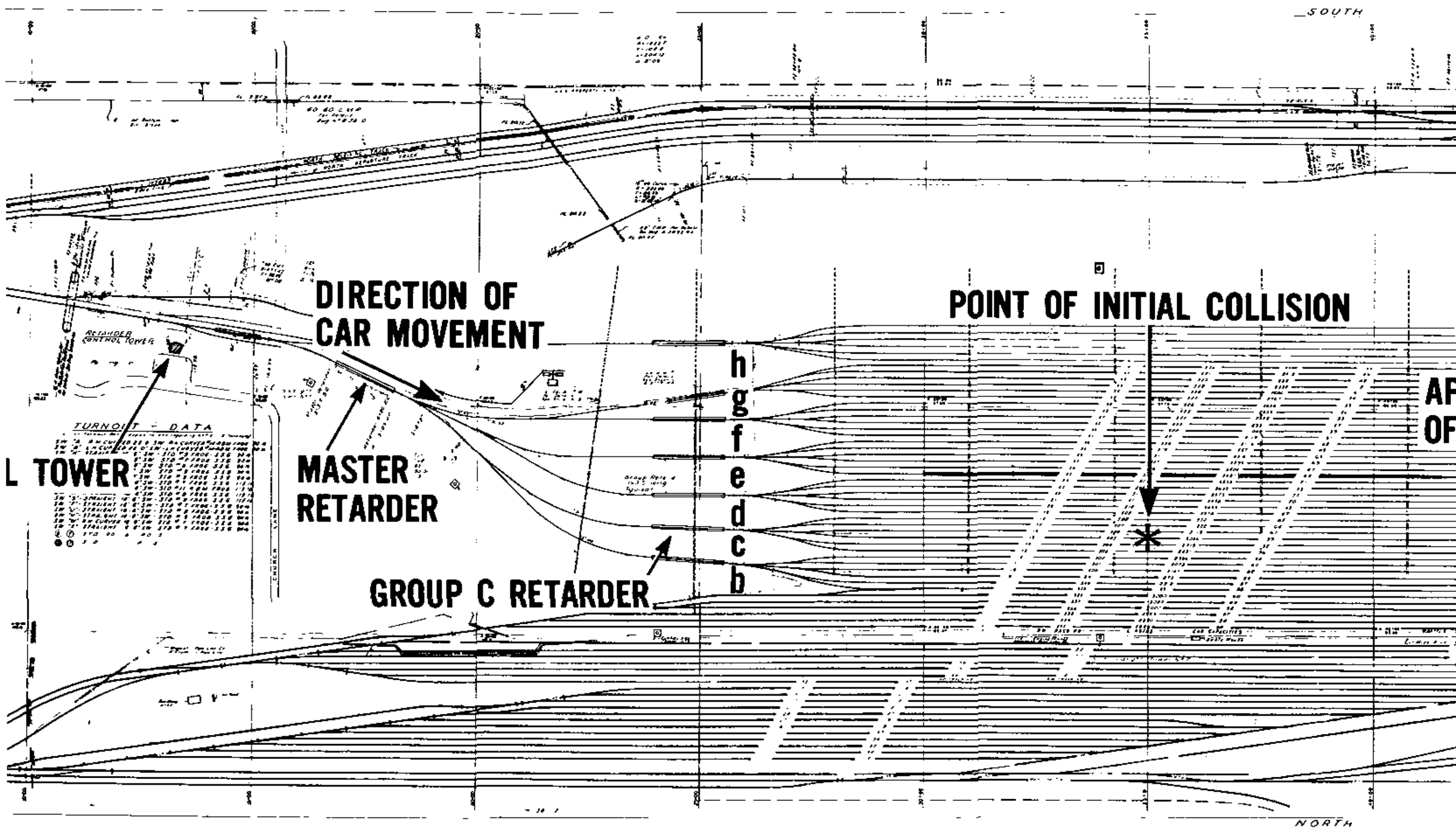
e
d
c
b
TURNOUT DATA


SOUTH
DIRECTION OF
CAR MOVEMENT
POINT OF INITIAL COLLISION
AP
OF
L TOWER
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RETARDER CONTROL TOWER
NORTH

FIN

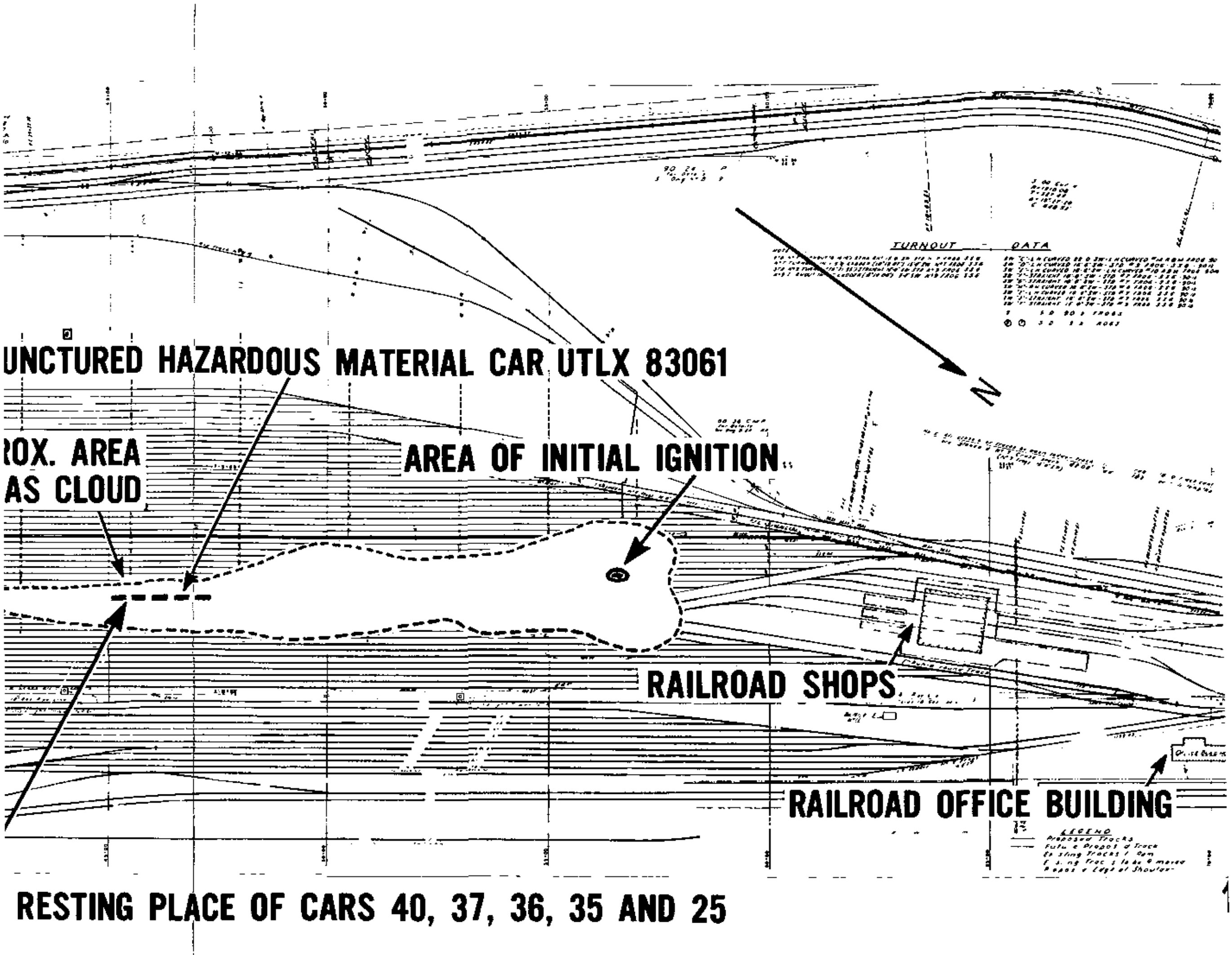



Figure 3. Plan of Alton & Southern Gateway Yard.

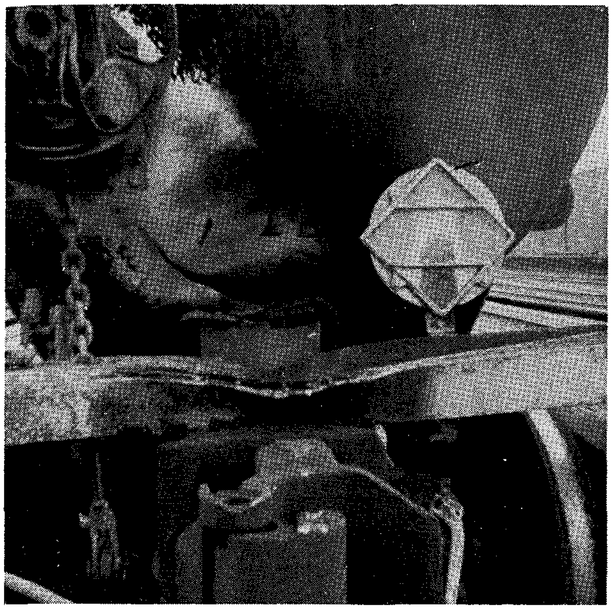


**Figure 4. Punctured head of tank car UTLX 83061.**

Cars 35, 36, and 37, still coupled together, continued onto track No. 15, where they impacted the standing L&N hopper at a speed of about 15 m.p.h. The coupler of the empty hopper overrode the coupler and end sill of the leading tank car (UTLX 83061), bent the end sill and brake wheel, and punctured the head of the tank at the edge of the reinforcing plate. (See Figure 4.) The hopper, which was slightly damaged, was set in motion by the impact. As the four cars rolled down the track together, the 40th car coupled to the last of the three tank cars at about 16 m.p.h. without damage to either car.

When the coupler punctured the head of the tank car, the liquefied contents spilled to the ground, and propylene vapor was observed as a spreading cloud at ground level. The classification-yard employees were warned of this development by the crest operator and ran away from the advancing vapor cloud. A locomotive crew on track No. 12 moved westward to escape it. The yardmaster, on the second floor of the office building at the west end of the yard, also watched this vapor cloud develop.

During this time, the last three cars of the original 44-car cut were humped and routed onto various tracks without incident. The four tank cars and the hopper continued rolling as a group down track No. 15 until they impacted with cars standing about 2,300 feet from the hump end of the track. The tear in the head of the leading tank car was enlarged to 24 x 4 inches by that impact, and the flow of escaping propylene increased.

Flames were first observed at or near an unoccupied caboose standing on track No. 19. The flames progressed westward toward track No. 25 and eastward toward track No. 15. An orange flame then spread upward, and a large vapor cloud flared with explosive force. Estimates of the time lapse between these occurrences range from 2 to 30 seconds. Almost immediately thereafter a second, more severe explosion was reported.

## Emergency Response

On January 12, 1972, A&S issued to employees a document entitled *Emergency Handling of Hazardous Materials in Railroad Cars,* in which the responsibilities of various classes of railroad employees are defined. A&S employees apparently complied with all applicable sections of this document in reponding to the explosion on the morning of January 22.

The railroad notified the East St. Louis police, fire, and civil-defense departments of the accident. Ambulances were dispatched to the scene, and representatives of the East St. Louis police and fire departments went to the main offices of the A&S. The railroad requested them to secure the area and prevent unauthorized persons from entering the yard. This was done after police and fire officials were assured that no injured employees remained in the accident area.

Radios and telephones that were not damaged by the explosion were used to coordinate the activities of railroad personnel as well as the activities of firemen, policemen, and other rescue personnel.

Fifty-three Illinois State Police personnel, 13 St. Clair County Police units, and 10 Madison

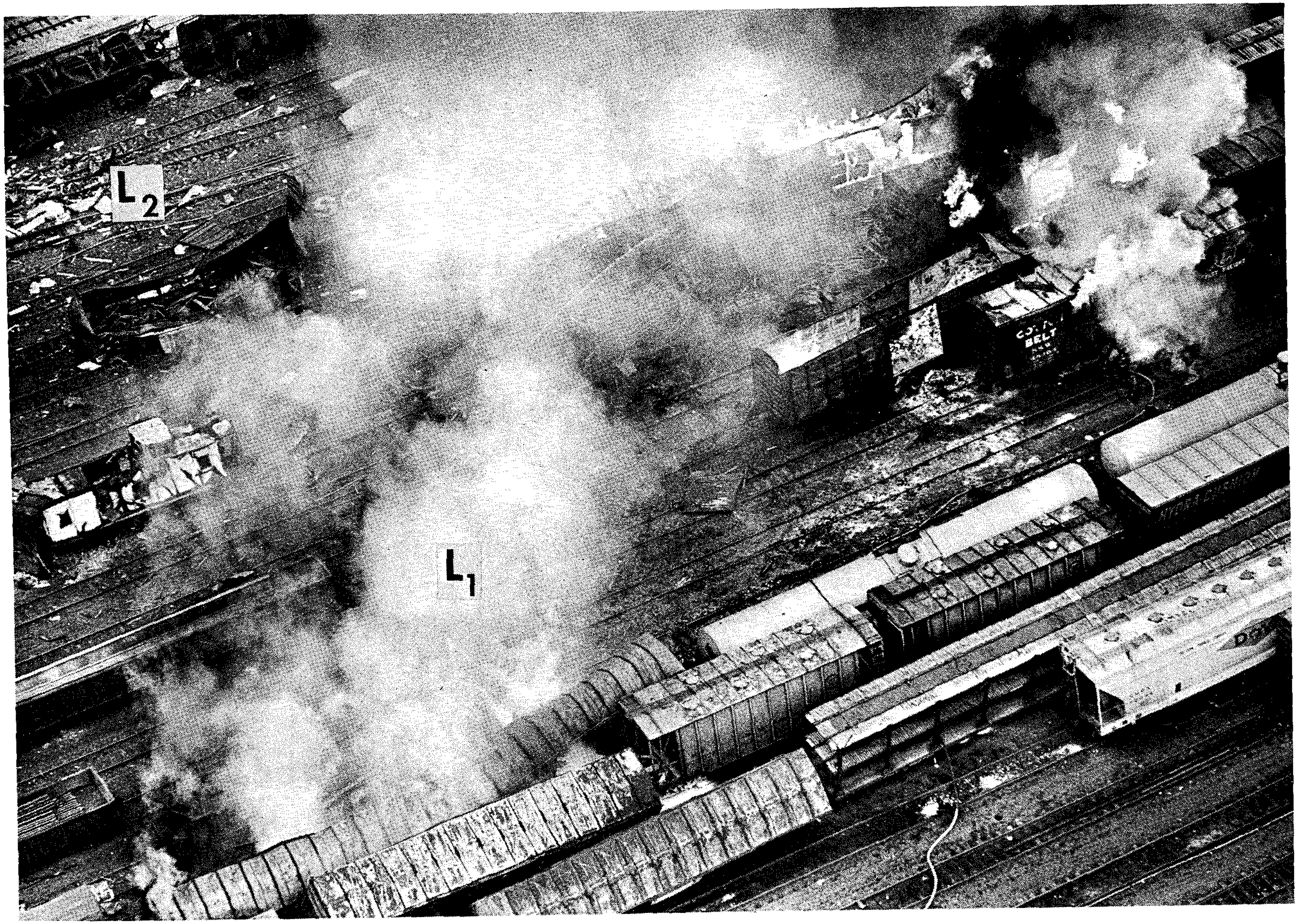



Figure 5. Aerial photo of explosion area.

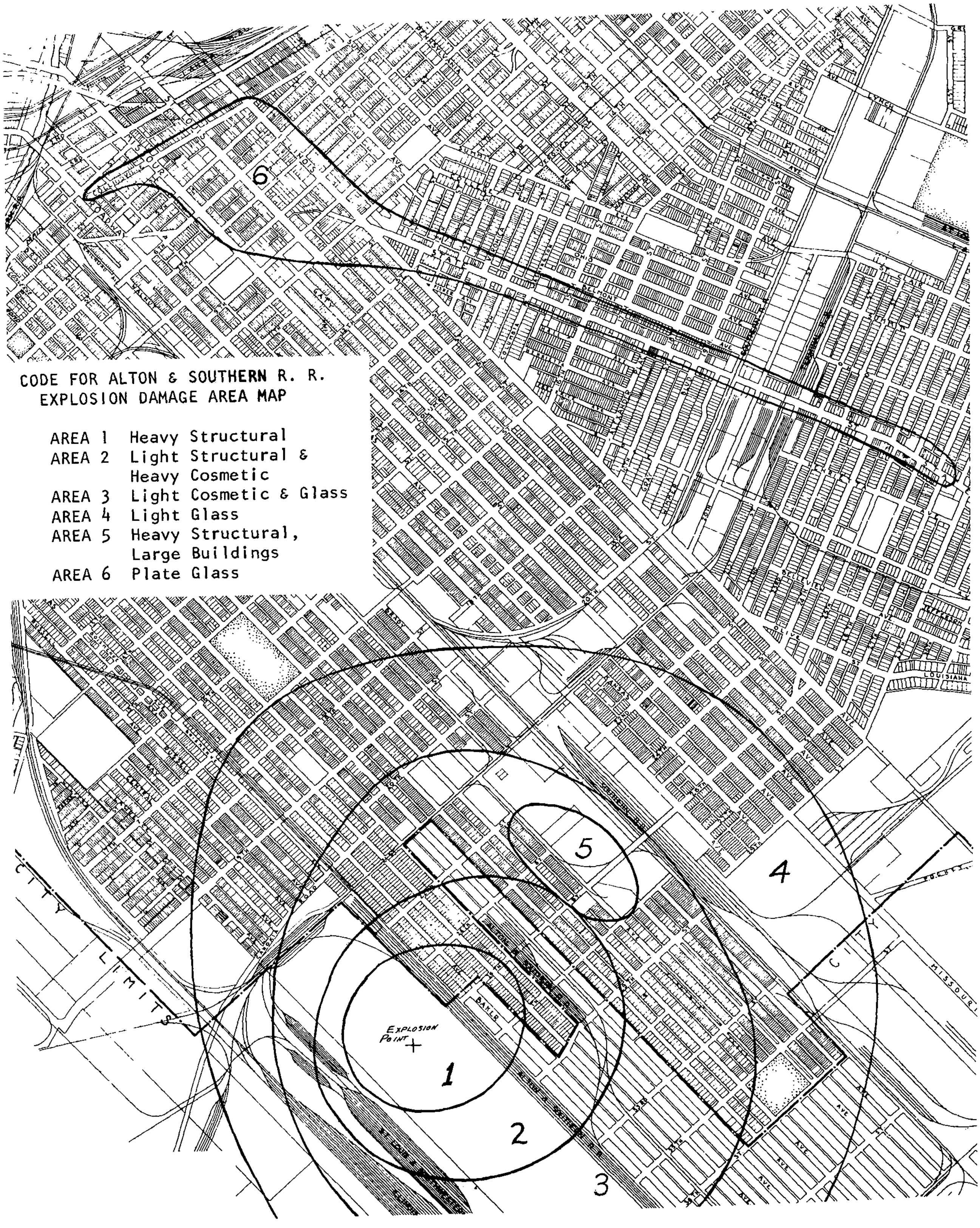



**Figure 6. Map of explosion damage.**

County Police units also went to the railroad yard to assist in rescue activities. Moɪe than 100 families vacated their homes due to structural damage from the explosion.

Employees of a neighboring Monsanto Chemical Company plant reviewed the commodity listing of cars in the yard and assisted railroad employees in identifying the threat posed by hazardous mateɪials As many cars as possible were removed from the immediate area of the explosion. Cars that remained on the rails were removed from the bowl tracks in the east and the west ends of the yard. Burning cars that were not derailed were moved to a track where it was possible to extinguish the fires

## Accident Losses

The Illinois State Police reported that 19 of the 223 people treated in hospitals for injuries were hospitalized. Of the nine railroad employees injured, three were hospitalized The railroad, however, only reported four injuries to the Department of Transportation in their Hazardous Materials Incident Report Injuries to bystanders were mostly lacerations. At least one person suffered severe eye lacerations attributable to glass broken in the explosion.

The force of the explosion damaged buildings and a number of freight cars in the area around the caboose on track No. 19. Some of the damaged freight cars and other, widely scattered cars caught fire. Car damage included both inward and outward bulges Figure 5 shows the pattern of damage in the classification yard.

Some of the tracks in the vicinity of the explosion were distorted. Heat from fires damaged some of the rails, and the force of the explosions wrapped some of the switch targets around switch stands

There was structural damage to the shop building and repair facilities. The office building and its roof tower also were damaged, and some manhole covers in the drainage system were dislodged. The carrier's estimate of property damages was as follows:

| | |
|---|---|
| Cars | $654,000 |
| Lading | 442,000 |
| Buildings | 50,000 |
| Wrecking Costs | 18,000 |
| Track | 10,000 |
| Total | $1,174,000 |

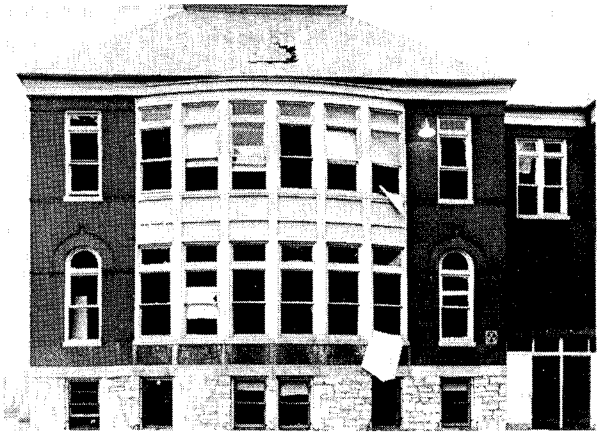
The most serious damage to noncarrier property occurred in the areas designated as 1 and 5 on the map in Figure 6. The severity of damage ranged from serious structural damage in Areas 1 and 5 to broken glass in Area 6 The Illinois State Police estimated that between 870 and 1,000 homes and buildings, including a church and a school, were damaged. City officials estimated that total damage costs, including railroad property, exceeded $7½ million. (See Figure 7.)

## Hump System

The purpose of a hump is to provide railroad cars with sufficient velocity head to roll free through switches and curves onto designated classification tracks. Cars must be accelerated enough initially to allow the time necessary to operate the switches between cars. Since the speed required for proper separation is greater than that required for cars to coast onto classification tracks, the cars, having been initially accelerated, must be retarded to prevent overspeed couplings after they go over the hump and through the switches.

The design of the hump at the Gateway Yard is consistent with recommendations of the American Railway Engineering Association and retarder manufacturers. The crest of the hump is about 24 feet above defined clearance points about 1,500 feet away. A downgrade of approximately 5.0 percent extends for about 97 feet from the crest and is followed by a 2.5-percent downgrade for about 650 feet. This second downgrade continues through the master retarder and then changes to a flat grade through the group retarders. From the exit of the group retarders onto the classification tracks, there is a 0.9-percent upgrade.

a. Interior of School.



b. Exterior of School.

Figure 7. Damage to school in the vicinity of the Gateway Yard.

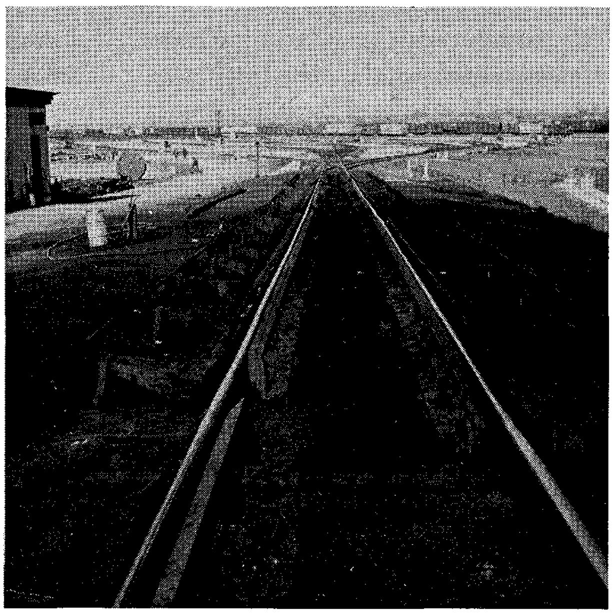


Figure 8. North master retarder on Alton & Southern hump at Gateway Yard.

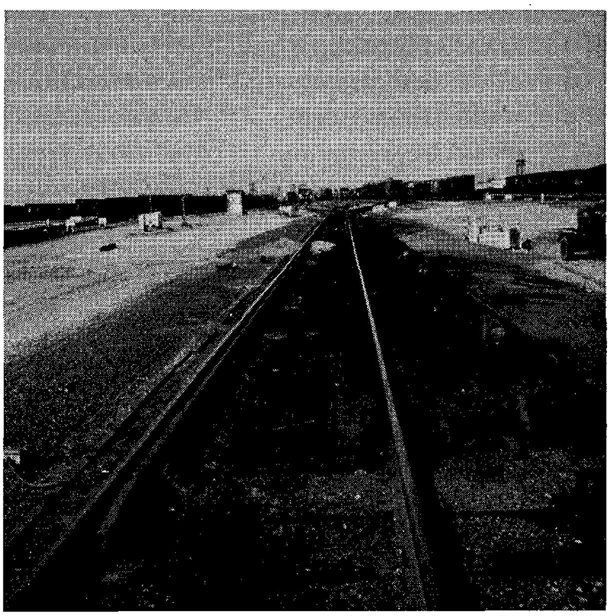


Figure 9. Typical group retarder on the Alton & Southern hump at Gateway Yard.

Retarders are stationary, mechanical brakes on tracks which grip car wheels and reduce the speed of cars as they roll down the hump. (See Figures 8 and 9.) At the Gateway Yard, the retarders on the hump are General Railway Signal Company type G retarders, which are hydraulically operated and weight responsive. They are composed of 5½-foot sections which have a hydraulic piston and lever arm at each end.

The hump has two master retarders. The north master retarder, which controls cars going onto tracks 7 through 42, consists of three 38½-foot units on the south rail and three units, 38½, 49½, and 38½feet respectively, on the north rail. This retarder is designed to stop any four-axle, 37½-ton-per-axle car with 33-inch wheels which enters at speeds up to 19 3 m.p.h. Increasing the diameter of the wheel to 36 inches decreases effective retardation by about 8 percent. Since each 38½-foot unit is capable of removing 2.695 feet of velocity head and the 49½-foot unit is capable of removing 3.465 feet of velocity head, the retarder is theoretically capable of removing 16.940 feet of velocity head. The effective reduction is however, 13.190 feet, when adjusted for the 2.5-percent downgrade through the retarder.

Each one of the seven group retarders consists of three 49½-foot units on one rail only. These retarders are designed to stop a car with a maximum weight of 150 tons which enters at a maximum speed of 17.5 m.p.h. They are not designed to stop a lighter car (e.g., 100 tons) which might roll unretarded at a higher speed from the crest of the hump.

The hump is operated automatically, semiautomatically, or manually. When in the automatic mode, the hump is controlled by a General Electric Model 4040 computer with a 16,000 all-core memory which can store information for 120 cars.

When a train is ready to be humped, information on punched cards is transmitted simultaneously to the computer, the crest operator, the hump conductor, and the general yardmaster. The data for each car include its initials and number, sequence number, whether it is loaded or empty, the assigned classification track, the number of additional cars destined for the same classification track, and other special information, such as whether the car contains hazardous materials. The punched cards also tell whether a car should or should not be humped.

As a locomotive pushes cars over the hump at about 2.3 m p.h., single-car or multiple-car cuts of up to five cars are uncoupled near the crest by a car cutter. As each car moves down the hump, sensing devices measure its weight, speed, rolling characteristics, and number of axles and transmit these data to the computer so the proper sequence can be maintained, exit speeds calculated, and switches aligned automatically for the predetermined route. The master retarder decelerates the car to programmed speed if it is going too fast.

Radar speed-control units monitor speeds in both the master and group retarders. When a car is in a group retarder the computer takes into account the speed of the car, the distance the car has to go on its destined track to couple, its weight, wind resistance (speed and direction), and track curve loss. The desired exit speed then is calculated. The radar monitors the speed of the car and transmits this information to a comparator, which responds to voltage fluctuations. The computer injects a voltage into the comparator equal to the speed it has calculated for the car. The radar, after a frequency translation to voltage, injects a voltage which represents the speed of the car into the comparator. The voltages are compared, and the speed-control equipment causes the retarder to either retard or release the car.

The hump has magnetic sensing devices which provide information for a speed readout on the control console. Overspeed alarm circuits are actuated when a car leaves a retarder at a speed 2½ m.p h greater than the speed calculated by the computer or the speed selected manually by the operator

The master and group retarders have a clamp feature which is set for maximum exit speeds in the computer program. If the speed-control equipment fails, the clamp feature is applied automatically. These clamp speeds range as follows:

Master Retarder

| | |
|---|---|
| Light loads | 15 to 17 5 m p h. |
| Medium loads | 13 to 15 0 m.p.h. |
| Heavy loads | 11 to 12.5 m.p.h. |

Group Retarder

| | |
|---|---|
| Light loads | 9.5 to 14.5 m.p.h. |
| Medium loads | 9.0 to 12.5 m.p.h. |
| Heavy loads | 8 5 to 10.5 m.p.h. |

In semiautomatic operations, the master retarder controls exit speeds by weigh-rail information only.[2] These exit speeds are 16, 14, and 12 m.p.h. for light, medium, and heavy loads, respectively. Group retarders have push-button-controlled exit speeds which range from 9 to 13 m p.h. The distance-to-go on each track is displayed in feet on the control console

Magnetic wheel sensors must count four or more axles before a sequence will advance. Both the weigh rail and the wheel sensor must give the computer information through an "AND" gate for humping to proceed in the automatic mode. If there is only one input to the "AND" gate, the master retarder locks up and stops the car.

Alarms are sounded on the operator's console to indicate certain failures or malfunctions. An IBM typer unit, located on the control console, prints out a record of these selected discrepancies and failures A monitor tape punch, located on the fifth floor of the crest tower, prints out more detailed information on an irregularity than is normally given on the typer unit. It records such information as car overspeeds and speed rates, the retarder involved, whether the console operation is manual or automatic, or whether retarders are on automatic or manual control. Such detailed information is not required by the crest operator, but it is invaluable as maintenance information.

*Rules and instructions* Humping is performed by a crew supervised by a hump conductor in the crest hump tower. The engineer who operates the hump engine and the trainmen who work with the engine, including the car cutter, get their instructions from the hump conductor. The crest operator, who directs the movement of cars, must give all directions to crewmembers through the hump conductor.

Because of carrier rules and Federal regulations, at the Gateway Yard, cars containing explosives, poison gas, or flammable poison gas are not humped. They are held on a track near the crest until the train has been humped. Then a locomotive moves them to a classification track and couples them. No car moving under its own momentum is permitted to couple with a car containing explosives At the time of the accident, however, tank cars placarded "Dangerous" (such as UTLX 83061) were humped in the same manner as other cars.[3]

When overspeeds occur, the hump conductor is supposed to stop the operation and call maintenance personnel. The entire system of hump retarders is checked every Friday and is spot checked during the week. The north master retarder needed adjusting for proper gauge (brakeshoe opening) when it was checked on Friday, January 21, 1972. Appropriate shims were added to adjust the gauge to the prescribed measurement of 5 inches between opposing brakeshoes in the retard position

At the Gateway Yard, it is not unusual for crest operators to override the automatic operation and release cars manually from retarders at speeds higher than those selected by the computer This is done when a car is not rolling as well as the computer predicted. Sometimes a preceding car stops short of its coupling position and more speed is required on the following car to move the preceding car to its proper position

---

[2] A weigh rail is a scale which weighs cars in light, medium, and heavy categories, rather than in pounds

[3] Since the accident, "Dangerous" tank cars which are rated "heavy" by the weigh rail are moved into the master retarder before they are uncoupled Lighter cars with grease on the outsides of the wheels are handled in the same manner However, cars with grease on the insides of the wheels are handled in the same manner as cars placarded "Explosives," except that cars may be humped against them

on the track. However, when the overspeed alarm sounded on the day of the accident, the overspeed was not intentional, and neither the crest operator nor the hump conductor stopped the operation, which continued until the last car of the cut was humped.

*Training and qualifications of employees* When the hump was built and automated in the early 1960's, the first group of crest operators, hump conductors, and some supervisors were trained by the equipment installers and manufacturers. Instruction books and some technical training were also provided. Since that time, employees have qualified as crest operators or hump conductors by passing an examination. They prepare for this test by studying written material which describes the hump and its operation and by observing procedures on the job

**Postaccident Test for Hump**

Immediately after the 44th car of the cut was humped, all hump facilities at the Gateway Yard were thoroughly checked. No defects or failures were found that would account for the overspeeds out of the master and "C" group retarders. There was, however, a deposit of grease on the brakeshoes of both retarders

The A&S ran two series of tests on cars with greasy wheels, at the request of the Safety Board. The first series of tests involved several tank cars which had an accumulation of grease, dust, and grit on the outside edge of the wheel rim These cars were released at varying speeds from the apex of the hump and in all instances, whether the cars were released singly or in groups, the retarders handled them normally, without overspeed exits

The second series of tests involved the following loaded cars, each of which had wheels measuring 36 inches in diameter:

| Car | Type | Gross Weight (Lbs.) |
|---|---|---|
| 1 | tank | 69,000 |
| 2 | tank | 229,000 |
| 3 | hopper | 218,000 |
| 4 | tank | 228,000 |
| 5 | —— | 270,000 |
| 6 | 3 cars | 595,000 |

Before the tests were run, there were normal amounts of greasy deposits on the brakeshoes of the master and group retarders. Adjustments were correct and all systems were functioning properly.

Both the inside and outside edges of the wheel rims of cars 1, 2, and 3 were greased with Texaco 904 grease, and the cars were released separately Technicians monitored critical readout values at check points and the following information was obtained:

| Car | Retarder | Release Speed | Speed Entering Retarder | Speed Leaving Retarder | Desired Exit Speed |
|---|---|---|---|---|---|
| 1 | MR | 2 1 m.p h. | 15 m.p h | 17 5 m.p.h. | 16 m.p.h. |
| | C | | 20 m.p.h. | 14.5 m p.h | 11 m p h |
| 2 | MR | 2.0 m.p h. | 15 m.p h. | 18 m.p.h. | 11 5 m.p.h. |
| | C | | 22 m.p.h. | 20 m p h | 9.5 m.p.h. |
| 3 | MR | 2.0 m p.h. | 16 m p h. | 18 m.p.h. | 11 m.p.h. |
| | C | | 22 m.p.h. | 18.5 m p h. | 9.5 m.p.h. |

Only Car No 1, a light-weight tank car, was within tolerance of the programmed speed.

Car 4 was released with clean wheels without removing the grease deposited on the retarder's brakeshoes by the thiee preceding cars. Results were as follows:

| | | | | |
|---|---|---|---|---|
| 4 MR | 20 m p h | 16 m p h | 15 m p h | 11 5 m.p h |
| C | | 19 m p.h | 14 m p h | 9.5 m p h |

The brakeshoes on the two retaiders were then cleaned, and car No 5 was released with clean wheels. The retarders handled the cai normally, without overspeed exits. The three-car cut was released with clean wheels, and the retardeis also handled it normally.

Several A&S employees told Safety Boaid investigators that deposits of foreign matter, such as heavy grease, on the wheels reduce oi nullify the decelerating capacity of a retarder. Certain ladings, such as coke, also leave deposits on the wheels, which pievents retarders from holding. Since the cars involved in this accident left the ietarders at overspeeds in the automatic mode, the Safety Board asked the A&S for their record of overspeeds Three such incidents are summarized below:

April 27, 1970 – A loaded 5-car cut came out of retarders overspeed and hit a car standing on track 21. The impact pushed the car into a string of cars being pulled on a laddei and derailed them. Loss of control was attributed to oil on the wheels.

Feb 14, 1970 – A two-car cut left retarders overspeed and hit a standing car on track 40. All three cars were derailed. Loss of control was attributed to oil on the wheels.

Jan 10, 1970 – A loaded tank car left the north master retarder overspeed and overtook a car going onto track 17 Both cars were damaged and derailed.

**Cars in the Collision**

The empty hopper involved in this accident weighed 40,900 pounds and was 36 feet 6 inches long. It had type E couplers, 5½ x 10-inch axles, 33-inch wheels, and a Miner, class A-22XL draft gear. The coupleis were 32 inches above the top of rail and the lateral side play at the striking castings was 2 inches.

After the accident, the car was inspected The brake valves and hoses had been burned extensively. The side bearing and the spring were missing The handbrake wheel, end handhold, sill step, and brake step were bent The coupler at the "B" end had a broken eye and the pin lifter and toggle were missing.

The loading and weight of the four tank cars involved in the accident were as follows:

| Tank Car | Gallons of LPG | Gross Weight |
|---|---|---|
| UTLX 83061 | 28,289 | 228,911 lb. |
| ACFX 17864 | 28,871 | 232,932 lb. |
| UTLX 83048 | 28,274 | 227,946 lb |
| ACFX 17859 | 28,888 | 233,105 lb. |

The shipping papers for these cars identified the lading as LPG (propylene) and indicated that the cars had been placarded "Dangerous."

The cars were loaded by the American Oil Company at Wood River, Ill , and weie shipped by American Oil to the Olin Coiporation at Doe Run, Ky. The shipper specified the following routing: "IT-EStL-AS-LN (i.e , the Illinois Terminal Railroad-East St Louis-the A&S-the Louisville & Nashville Railroad) " The Interstate Commerce Act requires that carriers comply with the shipper's routing instructions.

Each of the four tank cars was built according to DOT specification 112A400W. The cars were equipped with type E couplers, 100-ton two-axle trucks with 36-inch-diameter multiple wear wheels, and 6-1/2- by 12-inch journals. The UTLX tank cars had roller bearings and the ACFX cars had friction bearings.

UTLX 83061, the tank car whose head was punctured in this accident, was a Union Tank

Cai Company Model 50HD The tank was manufactured by the Graver Tank and Manufacturing Company, and the car was assembled by Union in December 1961. The shell and tank heads were constructed of 25/32-inch-thick steel plate. Documents certifying compliance with Association of American Railroads (AAR) requirements were filed by Union on October 9, 1962 These documents show that the design of the car had been approved by the AAR on March 9, 1962, after the car had been built The car was operated by American Oil under a lease from Union.

An examination of all four tank cars after the accident revealed that there was an accumulation of an oily or greasy substance on the wheels of the ACFX tank cars The origin of the deposit could not be determined The wheels of othei tank cars in the Gateway Yard had similar deposits of various combinations of oil, iron iust, and dirt The postaccident examination also revealed that the two ACFX tank cars were not equipped with front or rear seals and that some of the dust guards were broken

## Commodity

The commodity associated with the injury-producing events was a mixture of hydrocarbon gases consisting of approximately 93 to 94 percent propylene, 5 to 6 percent propane, and traces of methane, ethane, ethylene, and other hydrocarbons with low boiling points As loaded, the mixture had a vapor pressure of 220 p.s i and a specific gravity of 0.520 at 42°F

The mixture is classified as a flammable, compressed gas in Federal safety regulations. Propylene has properties very similar to those of propane. Its vapor pressure is slightly higher than that of propane, and the normal boiling point is about 10°F lower than that of propane. The vapor density of propylene is slightly greater than the density of air. Propylene will disperse readily in air, and its vapors form a flammable mixture with air in concentrations ranging from 2 to 11 percent.

## Federal and Industry Regulations

Federal regulations governing rail transportation of hazardous materials by common carriers in interstate commerce are specified in 49 CFR 170 through 179 Tank-car regulations address the qualification, maintenance, and use of cars by shippers and carriers. The railroad industry has adopted additional requirements foi transporting hazardous materials in tank cars, which can be found in the AAR's *Specifications for Tank Cars*

Federal regulations governing the design of tank cars are found in 49 CFR 179. Section 3 specifies piocedures for securing approval of designs, materials, and construction. This section states that the Secretary of the AAR's mechanical division will present proposals to the AAR tank car committee and other appropriate committees for review.

> "When in the opinion of the committee, such tanks or equipment therefore are in compliance with effective regulations and specifications of the Department, the application will be approved"[4]

> "When, in the opinion of the Committee, such tanks or equipment therefore are not in compliance with effective regulations and specifications of the Department, the Committee may recommend service trials to determine the merits of a change in specifications. Such service trials may be authorized by the Department under the terms of DOT Special Permits "[5]

> "Except as provided in paragraph (b) of this section, before a tank car is placed in service, the party assembling the completed car shall furnish a Certificate of Construction, Form AAR 4-2 to the owner, the Bureau of Explosives (as required by 179.5 (d)), and the Secretary, Mechanical Division, AAR, certifying

[4] 49 CFR 179 3(b)

[5] 49 CFR 179 3(c)

that the tank, equipment, and car completed comply with all the requirements of the specification."[6]

Regulations applicable to shippers of LPG are contained in 49 CFR 173. These regulations require the shipper to certify that the shipment tendered to the carrier complies with all requirements The bill of lading for UTLX 83061 had this certification

## III ANALYSIS

### Hump Design and Operation

The design of the A&S humping operation met current technological requirements of the railroad industry However, since the retarders were not able to control car speeds which were within their design limits, it appears that the design did not take into account the possibility of a lubricating substance accumulating on the car wheels or on the brakeshoes of retarders Until retarders are redesigned to handle this lubricating factor, effective speed control is unpredictable

Another critical factor in the design of the A&S hump is the inability of the group retarder to stop a heavy car which rolls free from the crest without retardation in the master retarder. No devices, such as track skates,[7] have been installed beyond the group retarders to compensate for such a failure As a result, overspeed cars can collide with any car which obstructs their routes between the group retarder and the inert retarder at the departure end of the classification track.

Some engineers and trainmen act immediately when they overhear the crest operator relaying instructions through the hump conductor, but others wait until they receive instructions from the conductor. It is extremely unlikely, however, that an engineer would wait for a conductor's instructions if he heard emergency instructions from the crest operator

In this accident, although the 35th, 36th, and 37th cars went through retarders overspeed, the hump continued to operate The 38th and 39th cars should have been the last cars released at the crest after the first overspeed

The hump crew at the Gateway Yard was aware that decreased retardation because of grease on wheels and retarder shoes is not uncommon. However, no procedures were established to inform the crest operator that a car with greasy wheels was being humped.

The training of hump employees may be too long and expensive a process for teaching proper procedures in emergencies. Perhaps formal, written instructions covering all predictable emergency situations should be drawn up, and every new hump employee should be trained and tested on his understanding of them.

### Cars in the Collision

Overriding couplers are common in overspeed impacts in humpyards Given the different weights of the tank car and the hopper, it was predictable that the coupler of the empty hopper car would override the coupler of the loaded tank car Even interlocking couplers on both cars may not have been effective in preventing the coupler of the hopper from overriding.

Overspeed impacts in railroad yards were the subject of a study made by the Draft-gear Manufacturer's Committee in 1965. A chart in that study, reproduced in Appendix A, illustrates the speed range of switch-yard impacts. Before large quantities of hazardous materials were shipped by rail, overriding couplers rarely resulted in injuries or extensive damages. However, the injuries and damages sustained in this accident suggest that these "minor accidents" are intolerable when hazardous materials are involved.

All of the evidence indicates that the design of the tank car from which the hazardous material escaped complied with all carrier and regula-

[6] 49 CFR 179 3(a)

[7] A track skate is a device which is placed on the top of the rail to stop a car gradually It can be applied manually or automatically, and can be used by a crest operator to control a car which leaves the group retarder overspeed

tory safety requirements The failure of the container indicates that either (a) the tank-car was satisfactory but the conditions encountered exceeded service expectations or (b) the conditions encountered were within expected limits, but the car was not, in fact, capable of performing satisfactorily within these limits. We do not know which factor caused the tank failure, because neither factor has been defined or documented.

The car and contents were introduced into the transportation system by the shipper, who leased the car from a tank-car manufacturer In assembling the car and offering it to the shipper, the manufacturer complied with 49 CFR 179 and with the requirements set by the AAR's Tank Car Committee However, at no single point in the assembly or introduction process were all the criteria for the tank car – including the safety criteria – assembled and documented. Furthermore, Federal regulations address different aspects of tank-car design, loading, and shipment than do the industry standards. Nowhere is the relationship of these regulations and standards to operations in trains and yards coordinated and documented Thus, a systematic analysis of unsafe conditions or interrelationships is not addressed by any single party who can be held fully accountable for safe performance.

When accidents are viewed in terms of the imposition of loads beyond the limits of any elements of the transportation system, the significance of these interrelationships becomes evident. If loadings or conditions imposed at various interfaces between elements are not defined, it cannot be determined with reasonable confidence that each element is designed to accommodate the loads or conditions likely to be encountered. Attempts to define the "transportation environment" for packages in vehicles are in progress,[8] but conditions imposed on the vehicle itself, over the full range of operations, have not been documented.

[8] An example of this type of approach can be found in a recent study of tank-head shielding sponsored by the Federal Railroad Administration The tank-shielding device suggested in that study might have prevented the rupture of tank car UTLX 83061 See FRA, *Hazardous Materials Tank Cars – Tank Head Protective "Shield" or "Bumper" Designs,* FRA-RP-72-01

Hardly any of the data collected in railroad accidents address this problem of identifying the loadings or the limits of the system components involved In order to obtain the necessary statistical basis for developing such loadings or capability limits, data recorded from accidents need to be converted to engineering values to define both the loadings imposed and the capability limits encountered. In this accident, for example, forces acting on the hopper and tank cars could be estimated and could illustrate actual in-service loadings which the equipment could not successfully accommodate.

The need for coordinating such data is suggested by the diversity and number of parties involved in the process of selecting cars to transport hazardous materials It would appear logical to assign this responsiblity to parties who introduce materials capable of threatening public safety into the transportation system and who control the mode and route of such shipments.

## Commodity-related Hazards

The extent of the injuries and damages in the area surrounding the accident site compels consideration of the hazard posed by the commodity involved

When the bottom of the tank head on UTLX 83061 was punctured, the internal pressure forced the liquefied portion of the mixture in the car into the atmosphere at a rapid rate. As this liquefied portion passed into the atmosphere, part of it vaporized and the temperature of the rest of the escaping liquid was reduced to the boiling point in air of propylene, which is approximately -55° F. While the leaking car moved toward its resting place just before the explosion, a continuous stream of escaping liquid continued to spew through the puncture at high velocity. This resulted in the vaporization and rapid dispersion of large quantities of flammable gas ahead of the damaged car and in pools of liquid along its path. Since the vapors were heavier than air, they tended to disperse and remain near the ground rather than to rise and dissipate harmlessly into the atmosphere

As the vapor spread throughout the yard, it became mixed with oxygen in the air and formed fuel-air mixtures capable of rapid chemical reaction. The gas blanketed an area of approximately 5 acres before it was halted by the reaction of the fuel vapors and the oxygen in the air.

Oxidation reactions occur at different rates, ranging from slow rusting and more rapid burning with visible flame to almost instantaneous explosions. In this accident, the mixture of air and fuel vapors became ignited, and the reaction rate accelerated from a visible burning to an explosion

At the A&S Gateway Yard, there were numerous sources of ignition capable of triggering the reaction between the fuel vapors and oxygen. Among these sources were the yard's electrical communications system, power sources in caboose MP 13361, and the internal combustion engine which powered the refrigeration system in several cars enveloped in the vapor cloud. Thermal ignition sources included the oil heater in the caboose and the exhaust system of the Fruit Growers Express engine. Physical stimuli such as the impacts of colliding cars or the friction of the overriding coupler on the tank car also were present Witnesses testified that the first fire they observed was near the caboose, but their testimony is not conclusive Both the caboose heater, which was known to have been operating, and the internal combustion engine, which may have been operating, could have been drawing propylene-enriched air into their confined chambers

The pattern of damage in the yard suggests that at least two violent reactions amounting to explosions occurred at places marked $L_1$ and $L_2$ on Figure 4. The large area affected by the explosions suggests that the rate of reaction may have approached or exceeded supersonic velocity (detonated). The phenomenon of LPG detonating in open air was identified previously by the Safety Board in its report on the Franklin County, Mo , pipeline accident in December, 1970.[9]

The scope of the damage suggests that shippers who introduce into the transportation system commodities which can explode need a better understanding of their reaction mechanisms and the resultant injury-producing events. However, the conditions which must be present for these reactions to accelerate to explosive rates in open air have not yet been identified. Undoubtedly, a large number of contributory conditions must be present, including hazardous vapor/air mixtures, a reaction stimulus, at least one confined reaction, and proper atmospheric conditions. By analyzing the events and conditions which precede such open-air explosions, the elements which must be controlled can be identified and addressed through appropriate control measures. Without such an analysis, prescription of regulatory measures to prevent a recurrence of such accidents is, at best, speculative.

## Regulations

*Classification of hazardous materials.* Damages from the burning and explosions of the hydrocarbon gas mixture are similar to damages which could occur in accidents involving materials classed as "explosives" under Federal hazardous materials regulations. Such damages demonstrate the need to consider the threat to people and properties at risk when classifying hazardous materials for transportation purposes.

Classification of the commodity involved in this accident as a "flammable compressed gas" does not adequately describe its potentially explosive character. Reclassification is needed for hazardous materials which can explode and

[9] National Transportation Safety Board, *Phillips Pipe Line Company Propane Gas Explosion, Franklin County, Missouri, December 9, 1970,* NTSB-PAR-72-1

result in the injuries and damages which characterized this accident and a similar accident in Brooklyn, New York.[10] It is no longer logical to assume that LPG will behave only as a compressed gas that will burn, because it can and has exploded in transportation accidents

The classification problem involved in this accident is fully discussed in the Safety Board's report concerning the Houston, Tex., railroad accident. (See Footnote 11.)

*Accident reporting requirements.* The discrepancy in the total number of injuries in the accident reported by the railroad versus the number reported by hospitals which treated the injured merits attention. The understatement of casualties related to transportation of hazardous materials distorts intermodal comparisons and also distorts any comparative analyses of the relative safety of various materials.

### Emergency and Rescue Operations

Although procedures established in A&S documents relating to hazardous materials accidents clearly stipulate responsibility for the postaccident phase, no criteria exist to assist the manager in determining when the area is safe for emergency personnel In this accident, the rescue of injured personnel in the immediate vicinity of the explosion was carried out promptly and the area was totally evacuated. Appropriate authorities were called in as experts to determine when the explosion area could be occupied by rescue personnel. An order was issued to clear as many cars as possible from the fire zone shortly after the explosion occurred There were several other cars loaded with potentially explosive commodities which could have detonated in secondary explosions similar to those which had such devastating effects on rescue teams in other accidents investigated by the Safety Board.[11]

Some of the railroad employees and some emergency crews from adjacent communities entered the accident area 20 minutes after the initial explosion in order to begin clearing operations. Since it would have been virtually impossible to examine closely all of the cars loaded with potentially hazardous materials in the yard in this short period of time, it can be assumed that the clearing operation began before a careful safety assessment of the area was completed The crews involved in postaccident activities thus placed themselves in jeopardy.

Civil authorities did a commendable job. Their efforts represent the extensive array of emergency services available to citizens and their actions illustrate the responsible way properly coordinated agencies can respond. Coordination was under the direction of the Mayor of East St. Louis, in cooperation with railroad and civil-defense personnel, at a control point in a nearby East St. Louis police station. Prompt, effective action by many community organizations diminished the severity of injuries and property losses

It should be noted that there undoubtedly would have been many more injuries if the accident had happened during a peak-activity period of the day, or on a day when schools and business establishments were open.

## IV. CONCLUSIONS

1. There were no violations of Federal regulations by the carrier or shipper.
2. The design of the hump at the Gateway Yard did not violate the principles recommended by the American Railway Engineering Association and by retarder manufacturers.
3. After the overspeed tank cars left the group retarder, there was no device to stop or decelerate them and to prevent them from

[10] National Transportation Safety Board, *Liquefied Oxygen Tank Explosion Followed by Fires in Brooklyn, New York, May 30, 1970,* NTSB-HAR-71-6

[11] National Transportation Safety Board, *Derailment of Toledo, Peoria, and Western Freight Train at Crescent City, Illinois, June 21, 1970,* NTSB-RAR-72-2; and *Derailment of Missouri Pacific Freight Train at Houston, Texas, October 19, 1971,* NTSB-RAR-72-6

striking a car in their path before they reached the inert retarder at the west end of the yard.

4 Lubricating substances on wheels of the tank cars reduced the effectiveness of retarders and resulted in cars leaving group retarders at unsafe speeds

5. The retardation system in the Gateway Yard failed to function properly at the time of the accident

6. The requirement at the Gateway Yard that all orders controlling movement of the hump engine be transmitted from the hump conductor to the engineer creates a lag in the procedure that may be hazardous.

7. The hump operation was not halted after the first cut of cars left the master retarder overspeed, in violation of A&S instructions.

8. Toleration of "minor accidents" in railroad humping operations increases the probability of another serious accident which may involve cars carrying hazardous materials.

9. If such "minor accidents" are tolerated in humping operations, special handling of cars containing hazardous materials is required to avoid injuries to carrier employees or bystanders, and to avoid damage to essential facilities.

10. Shippers introduce into the transportation system hazardous materials which pose a threat to public safety without coordinating and documenting design loadings or capability limits of the system elements on which their selection of packaging, vehicles, pathway, and safety controls is based.

11. There is a need to identify and document the principal loss-producing mechanisms encountered in hazardous materials transportation accidents, such as the explosion in this accident, and the conditions which initiate and sustain the injury-producing chain of events. This documentation should also identify the danger zone in which injuries occurred.

12. There is a need to reconsider the present classification scheme for hazardous materials to take more precisely into account the different types of threats to public safety posed by accidents which involve the transportation of hazardous materials.

13. Federal Railroad Administration casualty data for accidents involving hazardous materials probably are understated because of reporting difficulties.

14. Reporting requirements for fatalities, injuries, and property losses in railroad accidents involving hazardous materials need to be restated to increase the accuracy and usefulness of such data.

15. The human or mechanical limits which are exceeded in accidents should be identified and documented for use in the design stage or in modifications of new or existing systems, equipment, and facilities.

## V GENERAL CONCLUSION

In this accident, the safe movement of hazardous materials over the designated rail route depended upon the successful coordinated execution of a variety of functions. The identity and interrelationship of the required safety functions and the responsibility for their execution in rail transportation is not clear. There is no known comprehensive documentation of either the functions or their coordination. In the absence of documents which spell out the full range of functions and responsibilities for all to see, it is difficult to insure that these interdependent safety requirements will be met.

The effects of the lack of clearly defined and coordinated safety responsibilities can be observed in this accident. The railroad provided for and exercised some of the functions necessary to control overspeeds, but depended heavily on undefined performance of industry-approved couplers and on "adequate" strength of the cars it handled for the safety of its employees and facilities. The shipper depended on the car manufacturers, the carriers, and Federal regulations to insure the safety of cars carrying his products and depended on the railroads to keep operational impacts below an undefined "damage level" on the routes he selected The A&S Railroad and its hump-equipment suppliers depended on undefined cleanliness of wheels on interchanged cars in establishing the performance capabilities of their equipment. Such assumed conditions were not justified, since the crash and explosion occurred.

Similar gaps in the definitions and coordination of interrelated safety responsibilities have been observed in other hazardous materials accidents investigated by the Safety Board. Difficulties associated with establishing and documenting functional definitions and responsibilities are substantial, or the work would have been accomplished by now. Thus, the need for resolving this safety problem presents a continuing challenge to the transportation industry, its users, its suppliers, and its regulators

## VI. PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the overspeed impact was the failure of the retarding system in the hump classification yard to decelerate effectively heavy cars with oil or grease on their wheel rims, the absence of a backup system to halt cars passing through retarders at overspeeds, and routine acceptance of uncontrolled overspeeds

Propylene leaked from the tank car because the overriding coupler of the hopper car punctured a tank head too weak to resist the blow. Lack of specifications which define permissible impact and adequate crash resistance was a contributing cause

Losses were increased by the rapid rate at which the vaporized propylene spread at ground level, its ignition, and the acceleration of the burning reaction in air to the extent that a violent explosion occurred.

## VII. RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The Alton and Southern Railroad Company review the design of the hump at Gateway Yard and make those changes necessary to insure that all cars brought to the hump for classification will be handled without overspeed crashes. This review should include a systems analysis which covers grades, retarders, control for switching and maintaining programmed speed, provisions for backup, decelerating, and stopping devices, constant monitoring of overspeeds, and hump procedures in general (Recommendation No. R-73-1).
2. The Federal Railroad Administration establish a requirement that railroad carriers handle switching operations of cars containing large shipments of hazardous materials, with a danger range beyond railroad property boundaries, in the same manner as they handle switching operations of cars containing explosives. (Recommendation No. R-73-2).
3. The Federal Railroad Administration develop requirements for the collection, documentation, and technical analysis of the principal ways in which the hazardous materials present produce injuries and damages in railroad accidents. Such documentation should identify the range of distances at which injuries or damages occurred. (Recommendation No. R-73-3).
4. The Federal Railroad Administration review and, if necessary, revise its reporting requirements for accidents involving hazardous materials to obtain more accurate reporting of casualties adjacent to railroad premises. (Recommendation No. R-73-4)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

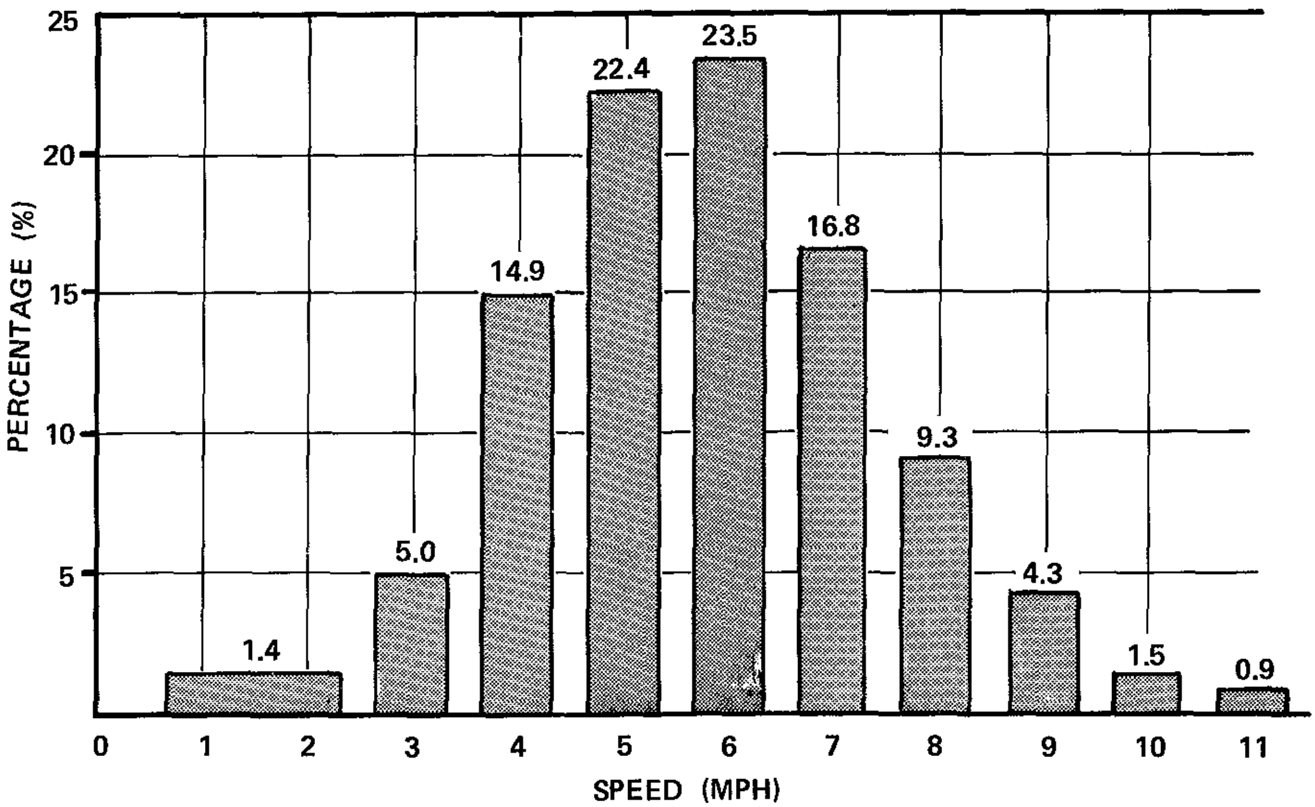
/s/ LOUIS M THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

January 31, 1973

APPENDIX A




SPEED RANGE OF SWITCHYARD IMPACTS FOR
4647 OBSERVATIONS CONDUCTED BY DRAFT GEAR
MANUFACTURERS' COMMITTEE (1965)



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