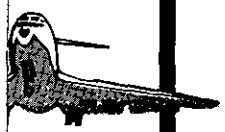

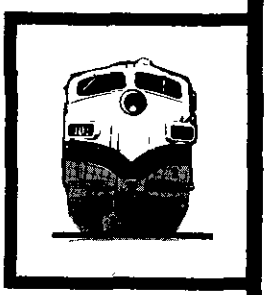

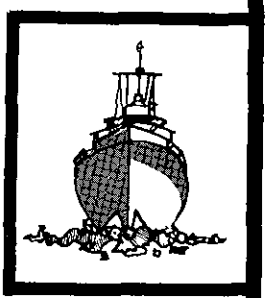

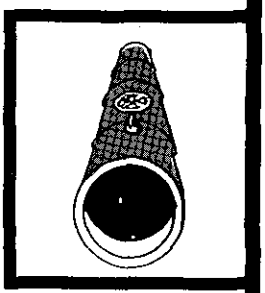

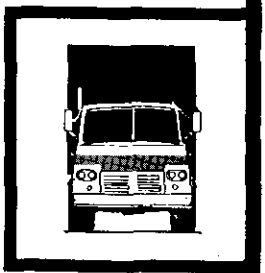

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF TANK CARS WITH SUBSEQUENT FIRE AND EXPLOSION ON CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD COMPANY

NEAR DES MOINES, IOWA

SEPTEMBER 1, 1975

REPORT NUMBER: NTSB-RAR-76-8

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes

16. Abstract

At 4:00 p.m. on September 1, 1975, 17 cars of a Chicago, Rock Island and Pacific Railroad train, No. 81A31, derailed at the frog of a facing point switch on the main line near Des Moines, Iowa. The train was descending a 1-percent grade on a 1-degree curve. Eleven of the derailed cars contained liquefied petroleum gas (LPG). Fire and explosions ensued; the LPG was consumed and three persons were injured.

The National Transportation Safety Board could not determine the cause of the initial derailment. The cause of the injuries and damages was the derailment of cars at or near the frog of the turnout and the subsequent tankhead punctures by disengaged couplers of the derailed tank cars.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: June 30, 1976

DERAILMENT OF TANK CARS WITH SUBSEQUENT FIRE AND EXPLOSION ON CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD COMPANY, NEAR DES MOINES, IOWA SEPTEMBER 1, 1975

SYNOPSIS

At 4:00 p.m. on September 1, 1975, 17 cars of a Chicago, Rock Island and Pacific Railroad train, No. 81A31, derailed at the frog of a facing point switch on the main line near Des Moines, Iowa. The train was descending a 1-percent grade on a 1-degree curve. Eleven of the derailed cars contained liquefied petroleum gas (LPG). Fire and explosions ensued; the LPG was consumed and three persons were injured.

The National Transportation Safety Board could not determine the cause of the initial derailment. The cause of the injuries and damages was the derailment of cars at or near the frog of the turnout and the subsequent tankhead punctures by disengaged couplers of the derailed tank cars.

FACTS

The Accident

On September 1, 1975, at 10:30 a.m., a Chicago, Rock Island and Pacific Railway Company (Rock Island) freight train, No. 81A31, departed Manly, Iowa, bound for Des Moines, Iowa. The train stopped en route at Mason City and at Iowa Falls. When it departed Iowa Falls, it consisted of 2 diesel locomotives, 43 loaded cars, 18 empty cars, and a caboose. Cars 24 through 34 were tank cars which contained liquefied petroleum gas (LPG). The train was inspected routinely en route and no discrepancies were noted.

The train ascended the ruling grade on Subdivision 12 of the railroad and was descending a 1-percent grade. As the train accelerated to 25 mph in a 1-degree curve, the engineer made a 6-pound brake pipe reduction while the locomotive units were operating at maximum capacity.

About 4:00 p.m., as either the rear truck of car 26 or the lead truck of car 27 traversed the frog of a left-hand turnout, the car derailed toward the east. The engineer noted a "tugging and jerking" in the locomotive. A trainman on the lead locomotive unit looked back and saw dense

vapors as the coupler of car 28 penetrated the trailing end of car 29. The head brakeman and other witnesses saw fire almost immediately after the initial derailment. An additional tankhead was punctured. The first of several explosions occurred about 9 minutes after the initial derailment. Parts of three tanks rocketed; three exploded and formed flat sheets and others continued to burn. The conductor radioed the Rock Island dispatcher at Des Moines of the derailment and fire.

Postaccident Activities

Local rescue units responded immediately. Firemen arrived at the scene after the first explosion and began to set up equipment and connect hoses to a water supply. At this time, the firemen did not know what was burning. A second explosion occurred as the firemen approached the tank cars but before they were within range of the explosion. As a result of this explosion, they decided not to fight the fire. After the firemen had retreated, another tank car exploded and cast fragements into a nearby storage facility of LPG. Firemen from surrounding fire departments arrived to assist the local firefighters. One of these departments attempted to fight the fires, but was ordered out of the area.

About 15 minutes after the train derailed, the Iowa State Fire Marshall observed the area from a helicopter and ordered that it be evacuated. Pedestrians and bystanders were removed from the area, businesses and homes were evacuated, and traffic over Interstate 80 was rerouted. The area was declared safe for reentry on September 5 -- 4 days after the accident.

An estimated 300,000 gallons of LPG were consumed in the fire and the explosions. Monetary loss was estimated at $834,000.

Accident Site

The first cars derailed at milepost (M.P.) 77.9 at a No. 10 frog of a left-hand turnout. The major fire and explosions occurred just beyond the highway bridge which carried Interstate Highways 80 and 35 over the railroad. (See Figure 1.) At M.P. 78.6, southbound trains begin to descend 2 miles of a 1-percent grade; the 2 miles extend through the 5,900-foot, 1-degree curve on which the cars derailed.

The track structure consisted of chats ballast applied in 1952 and crushed stone recently applied to correct the surface. Treated, fully-plated crossties with four track spikes per crosstie were renewed in 1970 at the rate of 1,000 crossties per mile. The 112-pound rail, which was rolled and laid in 1937, was jointed with 4-hole, 24-inch angle bars and 1-inch-diameter track bolts, and was box-anchored with 8 rail anchors per rail. A 30-mph speed restriction in the accident area had been in effect since 1974 because of ballast and surface conditions. The track was rated as FRA Class 3.

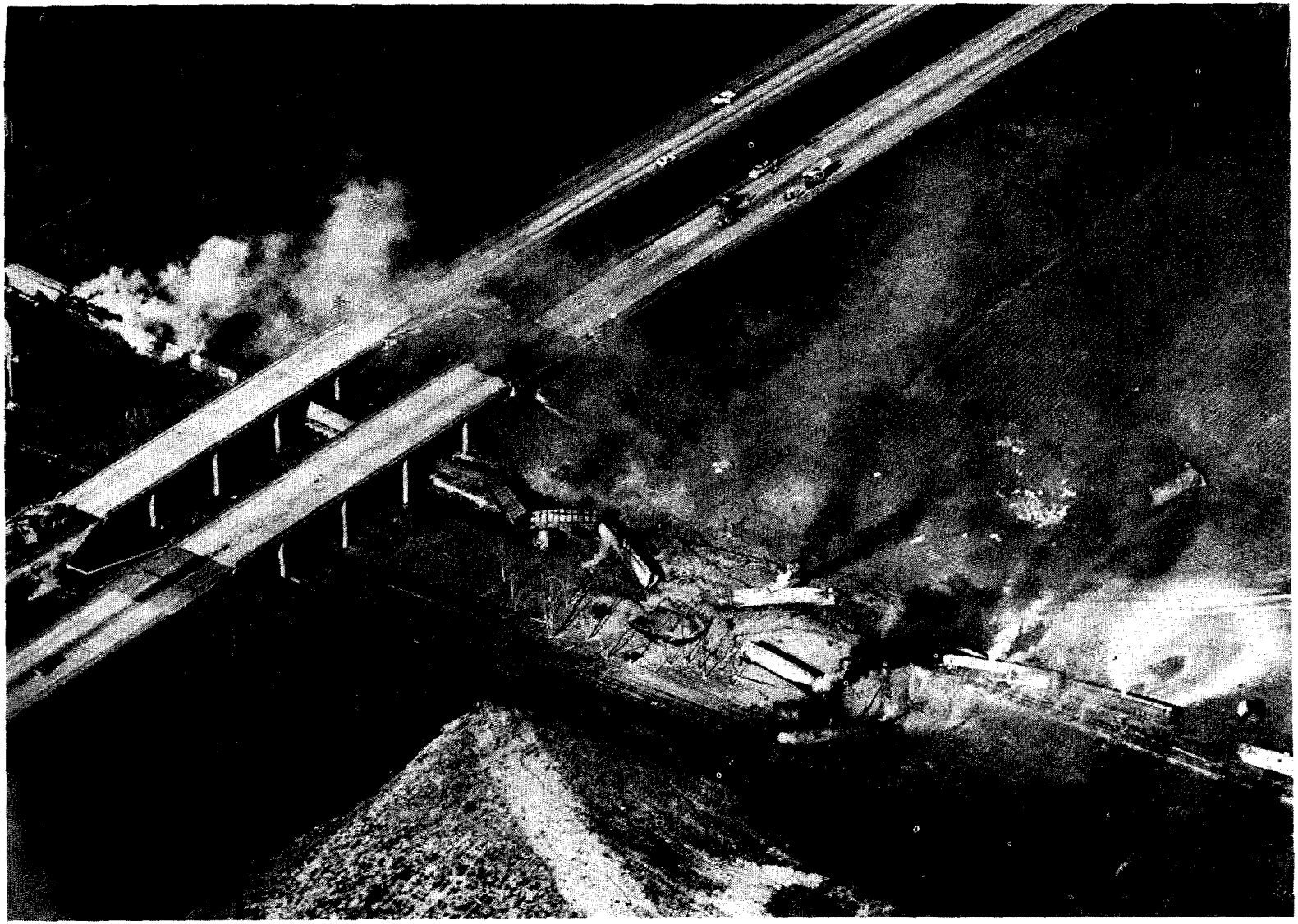


Figure 1. Aerial view of accident site.

During the week preceeding the derailment, a track supervisor and two track foremen inspected this portion of track. During the preceding year, an FRA inspector, a general roadmaster, and a division engineer inspected the track. No uncorrected discrepancies were reported.

During the 30 days before the accident, the track was ballasted, surfaced, and lined with a Plasser tamper-liner. 1/ The maintenance was supervised by a foreman.

Trains on this line are operated by train orders, timetable, and indications of an automatic block signal system. The maximum authorized speed where the cars derailed was 30 mph.

The Train and Crew

The locomotive and caboose were equipped with operative radios. Cars 24 through 36 were 30,000-gallon DOT 112A340W and 114A340W tank cars which contained LPG. They were placarded in compliance with DOT regulations.

The crew was experienced and was qualified under current carrier's rules. They complied with the requirements of the Federal hours-of-service regulations.

Postaccident Examinations

The switch was relatively undamaged except where the cars derailed. The main-line guardrail was found 126 ft south of its proper location, with its receiving end battered by wheels. There were wheel marks on the rail's web, south of the heel of the switch points. These were produced by the last few cars that derailed. The frog was found south of its original location. The main-line toe of the frog had a 1 1/16-inch-wide, 3/4-inch-long, 5/8-inch-deep mark, probably made by a wheel flange. A mark was also found on the north end of the frog's toe filler block. A flange mark was found on the insert of the frog at the bottom of the flangeway. The mark on the filler block was caused by a wheel set found in the vicinity of the guardrail, 127 feet south of its original location. Wheel marks on the turnout ties and rails beyond the frog indicate that some of the wheels of the first derailed cars went east on the siding.

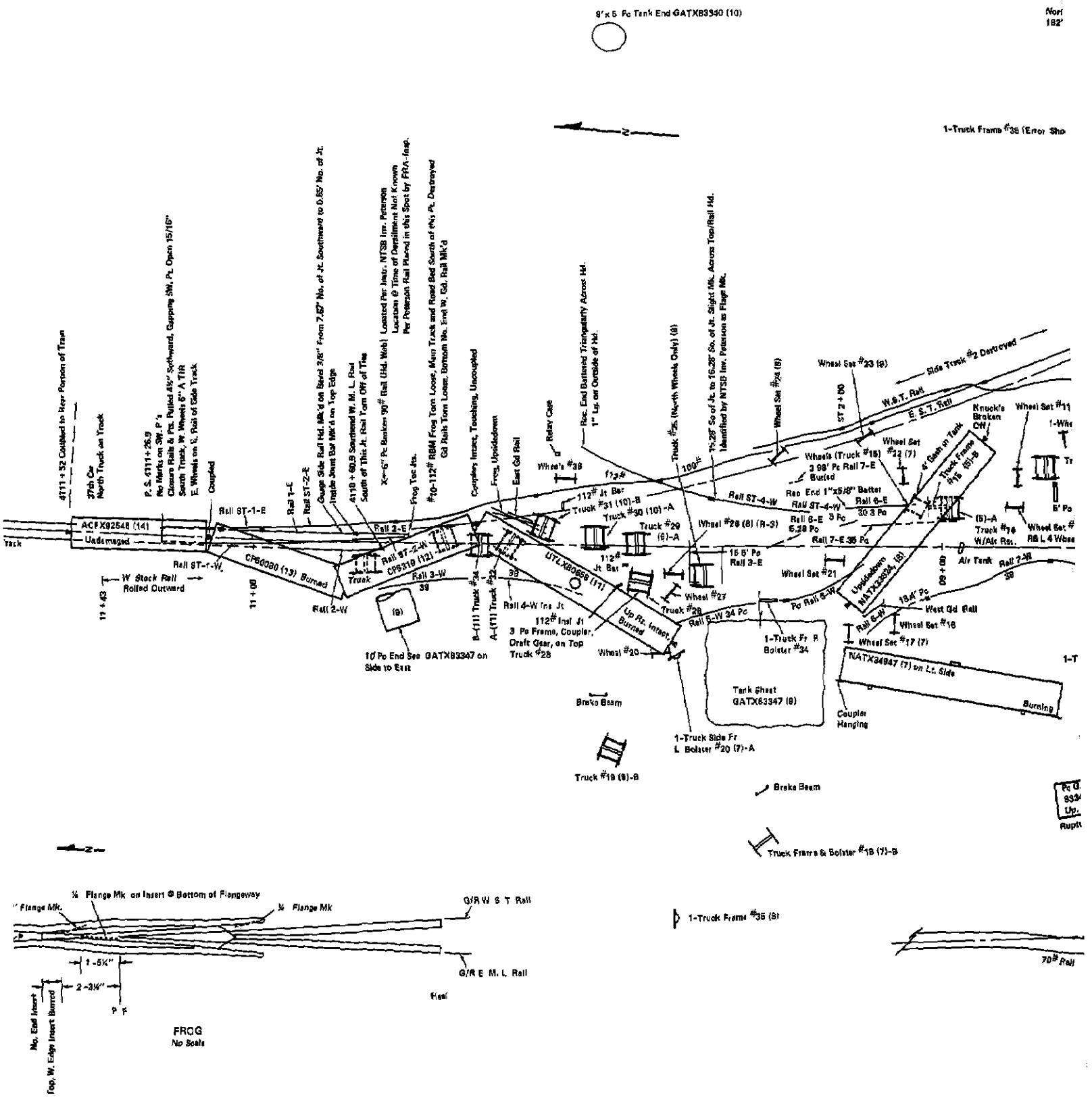
The examination of the rails did not indicate any defects which would have caused the train to derail. The breaks in the rails were caused by the derailment. There was no evidence of track movement which could have caused the derailment.

In many instances wheel marks were traced to the wheels; however, nothing conclusive could be assigned to them. In some instances, wheel sets could not be related to the cars from which they came. (See Figure 2.)

1/ A tamper-liner is a mechanized device which tamps down the stone ballast under the crosstie.

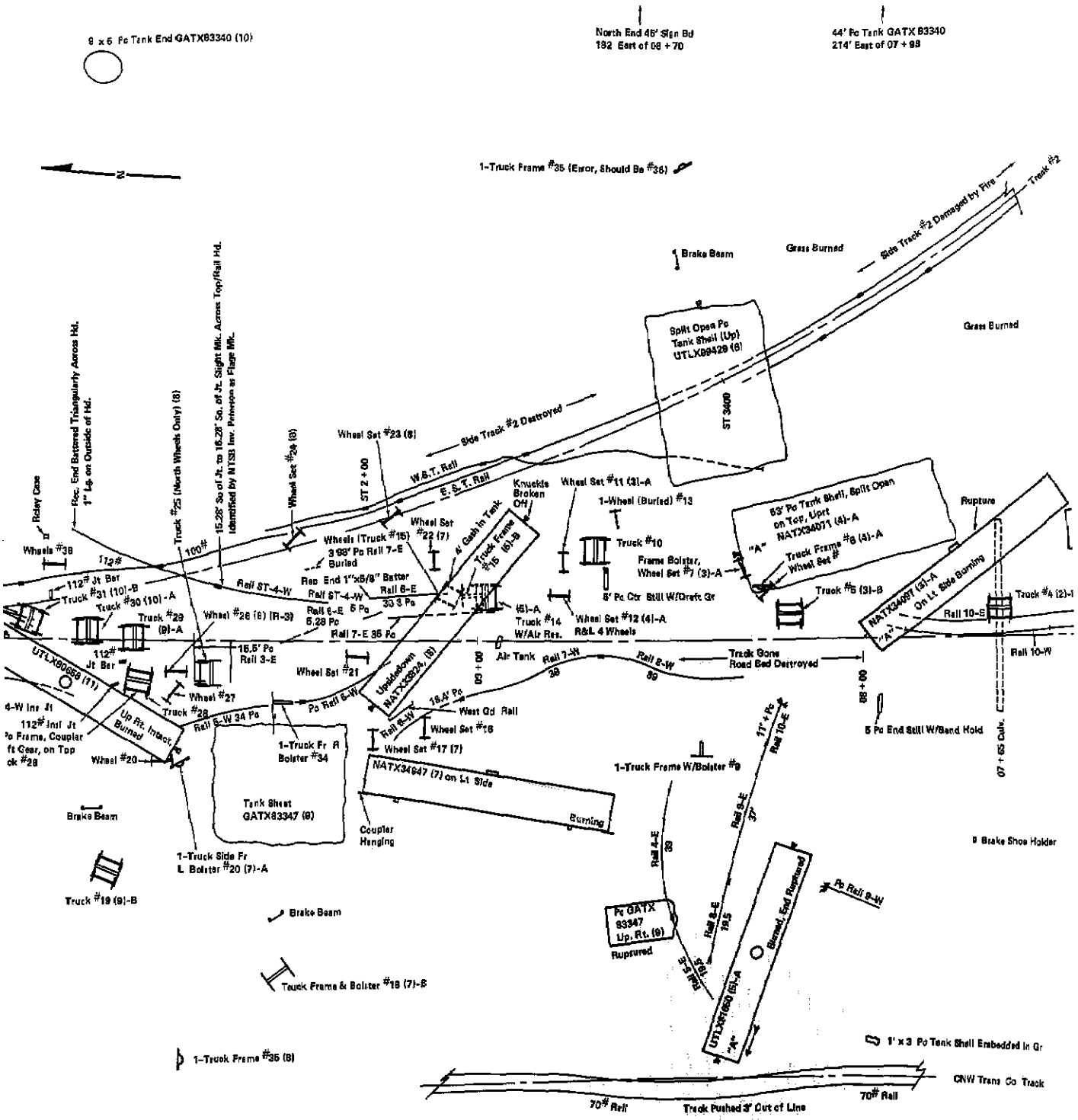
PLAN OF ACCIDENT AREA AND LOCATIO

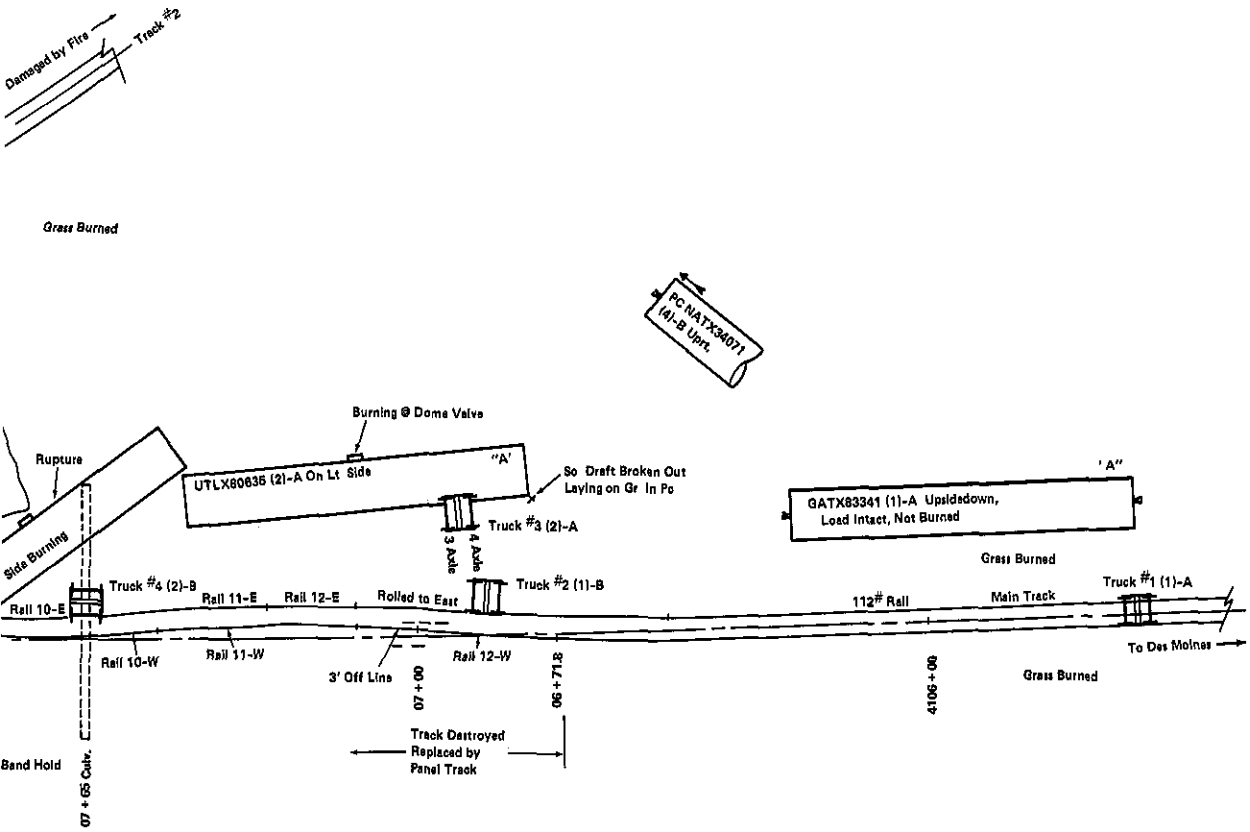
Figure 2



PLAN OF ACCIDENT AREA AND LOCATION OF CAR COMPONENTS

Figure 2





POSITION IN TRAIN NORTH OF 23rd CAR	POSITION IN TRAIN	CAR NUMBER
(1)	24th Car	GATX83341
(2)	25th Car	UTLX80635
(3)	26th Car	NATX34097
(4)	27th Car	NATX34071
(5)	28th Car	UTLX81650
(6)	29th Car	UTLX99429
(7)	30th Car	NATX34947
(8)	31st Car	NATX33824
(9)	32nd Car	GATX83347
(10)	33rd Car	GATX83340
(11)	34th Car	UTLX80658
(12)	35th Car	CP53187
(13)	36th Car	CP50080
(14)	37th Car	ACFX92545

Orig Direction of Cars Reversed by Explosion Shown By ⟶

Brake Shoe Holder

4' Pc Frame & Draft Gear Housing In Ground

nk Shell Embedded In Gr

CNW Trans Co Track

The running gear of the first three cars to derail showed no evidence of mechanical deficiencies. These three cars lost their trucks and appeared to have slid while overturned on their sides. The trailing truck and bolster of the third car were dragged on the track structure before the car overturned. The fourth derailed car exploded and was found in two parts. The lead end of the car consisted of about 1/4 of the car. The head was not punctured. The remainder of the tank shell was flattened by the explosion.

Coupler horns and strikers on the first four cars showed no evidence of heavy compressive forces. None of the cars were equipped with shelf couplers or tankhead shields.

The fifth car had a tankhead puncture and a brittle fracture, which produced a large hole near the center top of the trailing end. The puncture was caused when the lead coupler of the sixth car struck the tankhead. The entire fifth car rocketed several hundred feet.

ANALYSIS

The Initial Derailment

Because much of the physical evidence was destroyed by succeeding derailing cars and by the fire and explosions, it was impossible to determine which car derailed first and the exact point at which the initial derailment occurred. However, the final arrangement of cars and wheel sets supports certain hypotheses.

The final position of car 26 and the location at which its rear wheels came to rest indicate that its rear truck may have followed the side track to the left from the frog. The positions of the following car and of its lead truck indicate that the car may have taken the same route. The manner in which the right rail of the side track and left rail of the main track were bent during the derailment shows that one or more of the wheels followed a path with those two rails between the wheels. (See Figure 3.)

In order to follow such a route, the left rear wheels of car 26 or the left lead wheels of car 27 would have to follow the flangeway of the frog to the left. This could occur if the guardrail gauge is less than standard or greater than standard; the guardrail could have become ineffective if it was moved by continued impact of wheels on the flare of the receiving end or if the filler block on the receiving end was struck by something. It also could occur if train dynamics lift a wheel upward and to the left at the frog point; however, because of the heavy weight of the tank cars, it is unlikely that a wheel was lifted.

Unusual compressive forces, resulting from unequal braking in light and heavy cars, could have contributed to the excursion of wheels to the left of the frog point. The heavy wheel marks on the toe filler block of

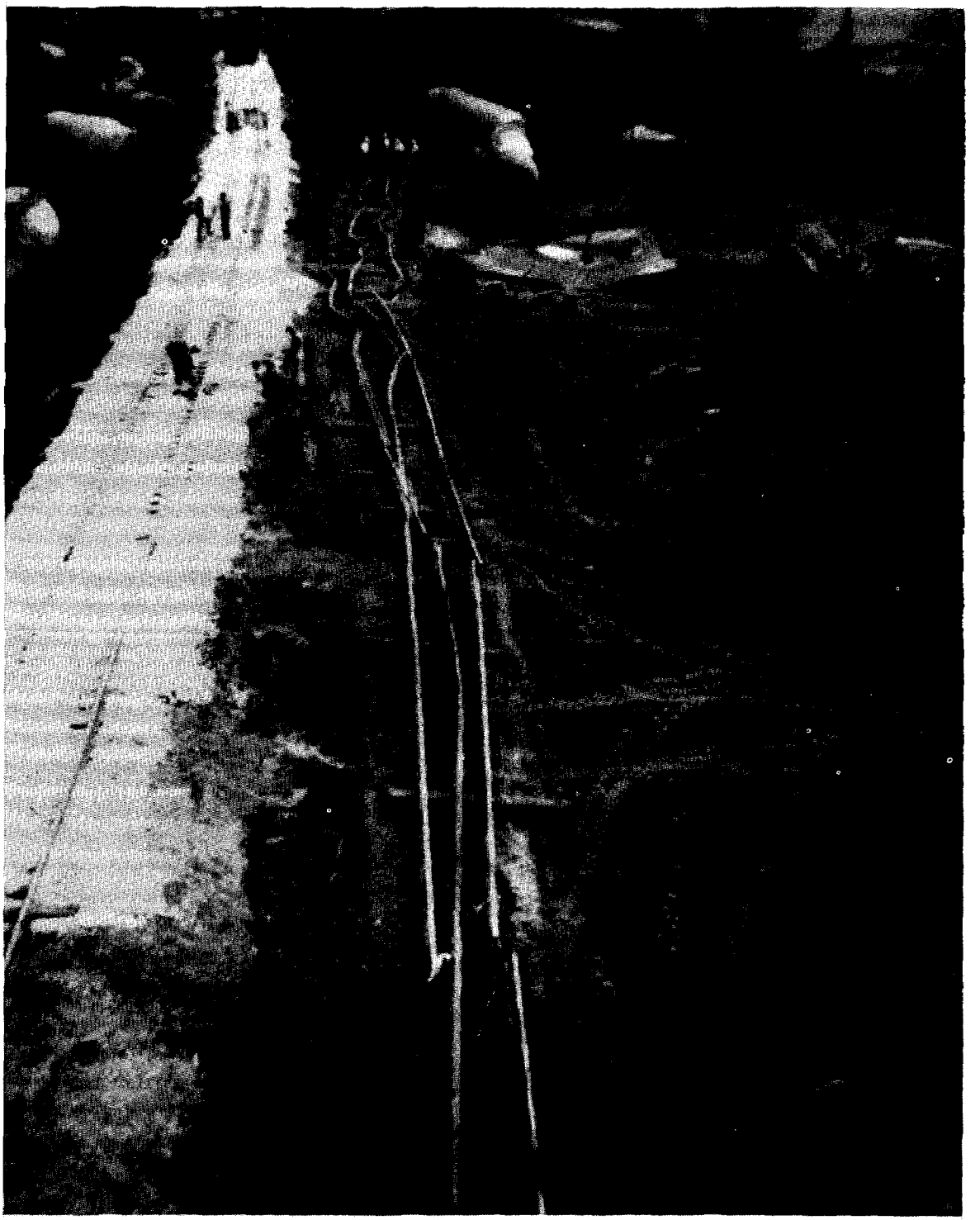


Figure 3. Reconstructed track structure.

the frog and the receiving end of the guardrail were made by derailed wheels which followed the initially derailed cars. Since there were no marks of derailed wheels on crossties or rails which led to the marked filler block or the guardrail, the marks must have resulted from wheels which left the track because of a severe compressive force that caused the wheels to jump the track and subsequently strike the frog and guardrail. The bunching action behind a car or cars which had derailed at the frog could have initiated these events.

Reaction of LPG Tank Cars

The lead coupler of the sixth tank car punctured the rear head of the fifth tank car. The coupler struck an area that would have been protected if the car had been equipped with tankhead shields. Since the forces could not be computed and since data is not available regarding the resistance of the headshield to coupler impact of that description, it could not be determined whether the puncture would have been prevented by the presence of a tankhead shield alone. The same conclusion must be drawn regarding the other tankhead punctures.

If top and bottom shelf couplers had been present, they might have resisted the vertical forces which disengaged the couplers during derailment. Even if top and bottom shelf couplers had failed to resist the vertical forces, the striking forces of the couplers against the tanks would have been diminished.

If both head shields and top and bottom shelf couplers had been present, the tankhead punctures might have been prevented.

The Federal Railroad Administration (FRA) has issued a research grant to Washington University School of Engineering and Applied Science to evaluate the effectiveness of E-type top and bottom shelf couplers in the accident environment. Washington University will issue a report to FRA which will include their assessment of the effectiveness of E shelf couplers in this accident.

Fire Control and Suppression

The Safety Board has investigated similar hazardous materials accidents in which the firemen were injured seriously. The firemen who responded to this accident used the same attack methods as the firemen in the previous accidents; the only reason that these firemen were not injured was the timing of the second explosion, which occurred before the firemen were within range and which caused them to retreat.

The firemen began to attack the fire without considering which methods would be safest and most effective, given the hazardous materials cargo. With the conventional firefighting methods which they planned to use, they could not have prevented the explosions. Despite the explosions and the

nature of the cargo, one firefighting unit persisted in its attempt to extinguish the fire; this illustrates that they were not aware of the dangers of hazardous materials fires.

Officials kept everyone out of the area for 4 days, primarily because they were concerned about the danger from LPG fireballs and rocketing tank parts if the burning tank cars continued to explode. The firemen did not eliminate this danger sooner because there is no agreement as to the safest and most effective method to fight LPG fires at that stage. Also, if fire is extinguished, flammable gas could spread and explode. The use of explosive charges or projectiles to enlarge openings in burning tank cars, so that the fire will burn out more rapidly, is controversial. Until these conflicting opinions about the best methods are reconciled, firemen cannot be expected to act safely and decisively to minimize the duration of such fires.

Although the best methods to fight hazardous materials fires need to be studied further, safety knowledge has been acquired from previous accidents. The National Transportation Safety Board, the National Fire Protection Association, the Department of Transportation, and the railroads have attempted to disseminate such information to firemen. (See Appendix.) However, this accident illustrates that such information is not being disseminated effectively.

CONCLUSIONS

1. The train derailed at or near the frog of the turnout.

2. The reason that the cars derailed could not be determined.

3. There were no apparent mechanical difficulties with the train that could have caused it to derail; the reconstructed track structure demonstrated that a broken rail probably did not occur, although speed restrictions were in effect.

4. The lead coupler of the sixth tankcar punctured the rear head of the fifth tankcar; this allowed the LPG to escape, and fire and explosions ensued.

5. There are not sufficient data to determine whether head shields and top and bottom shelf couplers would have prevented the puncture of the tank heads.

6. The firefighters did not analyze what actions would have been safest and most effective before they prepared to fight the blaze.

7. The tank cars were allowed to burn for over 4 days because there was no agreement as to the best method to fight fires which involve hazardous meterials.

8. Effective channels need to be established for communication of the safety lessons learned in hazardous materials transportation accidents to all firemen who might be confronted with such emergencies in the future.

PROBABLE CAUSE

The National Transportation Safety Board could not determine the cause of the initial derailment. The cause of the injuries and damages was the derailment of cars at or near the frog of the turnout and the subsequent tankhead punctures by disengaged couplers of the derailed tank cars.

RECOMMENDATIONS

As a result of the investigation of this accident, the National Transportation Safety Board believes that it is necessary to reiterate a recommendation to the Federal Railroad Administration:

"Determine the capabilities of top and bottom shelf couplers, head shields, and a combination of both, and issue regulations to require that DOT-112A and 114A tank cars be equipped with the best practical combination. (R-75-19)"

In addition, the Safety Board submitted the following recommendations to the Department of Commerce:

"Develop firefighting procedures which assure safety and minimize the duration of fire danger in accidents involving LPG and other compressed flammable gases in tank cars. (I-76-7) (Class II, Priority Followup)

"Establish communication with all fire services and disseminate to them specific procedures for the safe handling of railroad transportation emergencies which involve hazardous materials. (I-76-8) (Class II, Priority Followup)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

June 30, 1976

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX

ISSUED: December 27, 1971

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 13th day of December 1971.

FORWARDED TO:

State Fire Marshals

SAFETY RECOMMENDATION R-71-38

The National Transportation Safety Board issues the following information and warning as an advisory, pending the completion of the investigation and further analysis of the facts and circumstances of the derailment of Missouri Pacific Railroad Company Freight Train No. 94 at Houston, Texas, on October 19, 1971.

This freight train derailed at Houston, Texas. As the result, 16 cars piled up in the general derailment area. Included were six tank carloads of vinyl chloride, three of fuel oil, one each of acetone, butadiene, and formaldehyde. Vinyl chloride, which escaped from a damaged 48,000-gallon tank car, ignited immediately following the initial derailment.

The Houston Fire Department responded to the scene within a few minutes after the derailment occurred and took steps to control the fire with water. Forty-five minutes after the initial derailment, a second car, containing vinyl chloride, ruptured violently. This abrupt explosion and the subsequent fire resulted in fatal injury to one fireman and burns or injuries to approximately 37 other firemen, reporters, photographers, and spectators. Large sections of a tank car were found approximately 400 feet from the derailment site after the explosion.

The circumstances of this accident are markedly similar to those of the accident that occurred at Crescent City, Illinois, on June 21, 1970. At Crescent City, a 15-car derailment resulted in the initial release of propane from one of the nine cars containing this commodity. Fire ensued immediately thereafter, and fire departments responded to the seene and attempted to fight the fire. Subsequent explosions occurred during a period ranging from approximately 1 to 4 1/2 hours after the initial derailment. Large portions of the involved tank cars "rocketed" up to 1,700 feet from the accident site. Sixty-six firemen, reporters, and photographers were injured as the result of the subsequent explosions. A photograph of the explosion is shown in Appendix No. 2.

APPENDIX

The Safety Board has investigated other railroad accidents involving hazardous material where tank cars have exploded and rocketed. A synopsis of the pertinent details of these accidents is included as Appendix No. 1.

Generally, those accidents that have resulted in casualties to emergency service personnel or onlookers have had two distinguishing characteristics, namely:

1. Several tank cars lay adjacent to one another in the wreckage.

2. Fire ensued, enveloped one or more tank cars, impinging upon other relatively undamaged tank cars containing hazardous materials.

These accidents demonstrate that whenever a railroad accident involving several adjacent tank cars occurs, the presence of fire substantially increases the probability of additional flareups or explosions. The reduction in property damage achieved by fire suppression methods used in past accidents, has been generally insufficient compared to the risk assumed of injury and death when acting with inadequate or improper information as to the contents of tank cars.

The risks, however, should be studied as closely as possible in the particular circumstances present, before initiating fire suppression efforts to save the product or other property. Necessary information for this decision-making process should include the rapid identification of all commodities involved, the determination of the firefighting methods by which the risks associated with these commodities can be controlled, and whether the resources needed to cope effectively with the situation are available.

In the absence of the information necessary for an evaluation of the risks of explosion or rocketing in a fire involving several tank cars, a prudent course of action may be the complete evacuation of the area within a radius of 2,000 feet. Exposure of emergency personnel to abrupt flareups or explosions can be kept to the absolute minimum by this method when no other persons or minimal property are at risk. Under no circumstances should spectators be allowed in the potential danger radius of 2,000 feet. However, it is not possible to give all-inclusive advice concerning the degree of risk which should be taken to fight the fire in such accidents because there are so many variables involved. For example, there may be tank car fires in the vicinity of hospitals, schools, or other occupied premises which cannot be evacuated quickly.

Research work to correct the problem of exploding and rocketing tank cars has been underway in the Department of Transportation and the railroad industry since shortly after the accident at Laurel, Mississippi, on January 25, 1969. The problem is potentially reducible by technical changes which are under study.

APPENDIX

Because the Safety Board believes the need for additional knowledge for the control of tank car fires is crucial, we held a public hearing in Houston, Texas to gather facts concerning the derailment, fire, and explosion of Missouri Pacific Train No. 94 that occurred October 19, 1971.

Therefore this information and advisory warning is issued as an alert to the potential hazards of tank car derailments.

Reed, Chairman, Laurel, McAdams, Thayer, and Burgess Members, concurred in the above recommendation.

By: John H. Reed
Chairman

Enclosures

APPENDIX NO. 1

SYNOPSIS OF RAILROAD TANK CAR HAZARDOUS MATERIAL ACCIDENTS INVESTIGATED
by
The NATIONAL TRANSPORTATION SAFETY BOARD

Date of Accident	Location	Number of Cars in General Derailment	Number of Tank Cars Derailed	Time Between Initial Derailment and Subsequent Explosions	Contents of Tank Cars	No. of Fatalities	No. of Injuries	Types of Casualties	Distances Portions of Tank Cars "Rocketed"
Jan. 1, 1968	Dunreith, Indiana	14	6	45 Minutes	Acetone, cyanohydrin, methyl methacrylate vinyl chloride, ethylene oxide	0	5	Firemen and police	700 feet
Jan. 25, 1969	Laurel, Mississippi	15	15	Immediate	Liquefied petroleum gas	3	32	Residents	1,600 feet
Feb. 18, 1969	Crete, Nebraska	31	3	Immediate*	Anhydrous ammonia	9	53	Residents and transients	200 feet
Sept. 11, 1969	Glendora, Mississippi	15	10	5½ hours and 16 hours	Vinyl chloride and fuel additive	0	1	Power company serviceman	850 feet
June 21, 1970	Crescent City, Illinois	15	9	1 hour to 4½ hours	Propane	0	66	Firemen, reporters, photographers	1,700 feet
Oct. 19, 1971	Houston, Texas	16	12	45 Minutes	Vinyl chloride, fuel oil, acetone, butadiene, formaldehyde	1	37	Firemen, reporters, photographers, spectators	400 feet

*No fire. Brittle fracture of tank car in crash allowed instantaneous release of entire cargo of ammonia, producing poisoning. However, similar hazard in fire exists.

APPENDIX

APPENDIX No. 2

Explosion that occurred at Crescent City, Illinois, approximately 1 hour after initial derailment of tank cars containing propane.