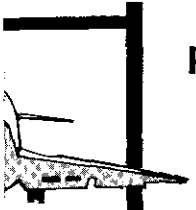
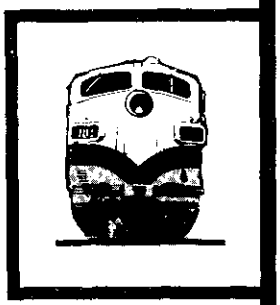
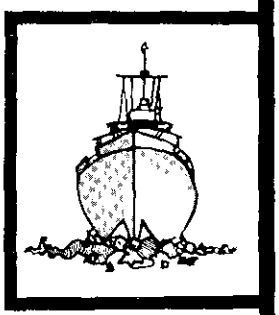
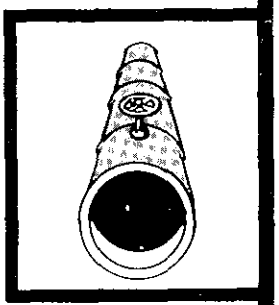
HE
1780
.A33
no.
85-10

PB85-916310









NATIONAL TRANSPORTATION SAFETY BOARD

DEPARTMENT OF TRANSPORTATION
AUG 13 1985
LIBRARY

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DENVER AND RIO GRANDE WESTERN RAILROAD COMPANY TRAIN YARD ACCIDENT INVOLVING PUNCTURED TANK CAR, NITRIC ACID AND VAPOR CLOUD, AND EVACUATION DENVER, COLORADO APRIL 3, 1983

NTSB/RAR-85/10.

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1 Report No NTSB/RAR-85/10	2.Government Accession No. PB85-916310	3.Recipient's Catalog No.
4 Title and Subtitle Railroad Accident Report--Denver and Rio Grande Western Railroad Company Train Yard Accident Involving Punctured Tank Car, Nitric Acid and Vapor Cloud, and Evacuation, Denver, Colorado, April 3, 1983.		5 Report Date May 14, 1985 6 Performing Organization Code
7 Author(s)		8.Performing Organization Report No
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10.Work Unit No. 3763-B 11.Contract or Grant No
12 Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D C. 20594		13.Type of Report and Period Covered Railroad Accident Report October 27, 1983 14.Sponsoring Agency Code

15.Supplementary Notes

16 Abstract About 4:00 a.m. mountain standard time on April 3, 1983, a Denver and Rio Grande Western Railroad Company (D&RGW) switch crew was switching 17 cars in the D&RGW's North Yard at Denver, Colorado, when a coupler broke on the 4th car, leading to an undetected separation of 150 feet between the 3rd and 4th cars. The engineer, responding to a hand lamp signal from the foreman, accelerated the locomotive, with a caboose, an empty freight car, and a loaded tank car coupled ahead. The loaded tank car impacted a fourth car at a speed of about 10-12 mph. Upon impact, the end sill of the fourth car (empty boxcar) rode over the coupler of the (loaded tank car) and punctured the tank head. Nitric acid spilled from the car and formed a vapor cloud which dispersed over the area. As a result, 9,000 persons were evacuated from the area; 34 were injured. Damage to railroad property was estimated to be about $341,000.

The National Transportation Safety Board determines that the probable cause of the accident was the complete failure of a coupler of a box car leading to an undetected separation of cars being switched and the puncturing of a tank car by the end sill of the box car when the coupled cars overtook those which had separated. Contributing to the accident was the lack of a federal regulatory inspection or an industry practice for a periodic inspection to detect defects in hidden car components. Contributing to the severity of the accident was the nature of the released product, insufficient guidelines and absence of preplanning which led to the evacuation of about 9,000 residents and injury to 34 persons.

17 Key Words Collision, yard, aluminum tank car, puncture, head shields, draft gear, coupler, hazardous material, evacuation.		18 Distribution Statement This document is available to the public through the National Technical Information Service Springfield, Virginia 22161	
19 Security Classification (of this report) UNCLASSIFIED	20 Security Classification (of this page) UNCLASSIFIED	21.No of Pages 17	22.Price

NTSB Form 1765 2 (Rev. 9/74)

CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: May 14, 1985

DENVER AND RIO GRANDE WESTERN RAILROAD COMPANY TRAIN YARD ACCIDENT INVOLVING PUNCTURED TANK CAR, NITRIC ACID VAPOR CLOUD, AND EVACUATION OF 9,000 RESIDENTS, DENVER, COLORADO, APRIL 3, 1983.

SYNOPSIS

About 4:00 a.m. mountain standard time on April 3, 1983, a Denver and Rio Grande Western Railroad Company (D&RGW) switch crew was switching 17 cars in the D&RGW's North Yard at Denver, Colorado, when a coupler broke on the fourth car, leading to an undetected separation of 150 feet between the third and fourth cars. The engineer, responding to a hand lamp signal from the foreman, accelerated the locomotive, with a caboose, an empty freight car, and a loaded tank car coupled ahead. The loaded tank car struck the fourth car at a speed of about 10-12 mph. Upon impact, the end sill of the fourth car, an empty boxcar, rode over the coupler of the loaded tank car and punctured the tank head. Nitric acid spilled from the car, formed a vapor cloud which dispersed over the area, and ignited small fires involving the crossties. As a result 34 persons were injured and 9,000 persons were evacuated from the area. Damage to railroad property was estimated to be about $341,000.

The National Transportation Safety Board determines that the probable cause of the accident was the complete failure of a coupler of a box car leading to an undetected separation of cars being switched and the puncturing of a tank car by the end sill of the box car when the coupled cars overtook those which had separated. Contributing to the accident was the lack of a federal regulatory inspection or an industry practice for a periodic inspection to detect defects in hidden car components. Contributing to the severity of the accident was the nature of the released product, insufficient guidelines, and absence of preplanning which led to the evacuation of about 9,000 residents and injury to 34 persons.

INVESTIGATION

The Accident

At 3:00 a.m., on April 3, 1983, a Denver and Rio Grande Western Railroad (D&RGW) yard crew, consisting of an engineer, an engine foreman, and two switchmen, was assigned to switch 66 cars in the railroad's North Yard at Denver, Colorado. The engine foreman assigned the two switchmen to take positions along the switching lead to operate the various switches of the tracks into which the cars were to be switched. The engine foreman took a position where he could give hand lamp signals to the engineer and also be able to uncouple the cars as the switching was performed. About 4:00 a.m., after making numerous switching moves, 16 cars and a caboose remained attached to the

yard locomotive. The engine foreman stated, "I gave the kick sign 1/ for the car going toward 23. When the car got near me, I gave the stop sign and pulled the pin. 2/ After I stepped out as the cars were drifting, I heard the pin drop. 3/ At this time I gave another kick sign." The engineer stated, "I received a kick sign and moved the throttle to run eight. The engine couldn't have moved more than 100 to 150 feet, when I felt a hard jolt and saw a large gas cloud forming about 150 feet ahead of me. When I saw that, I stopped the movement." Later inspection indicated that a tank car of nitric acid (the third car) had been overridden by an empty box car (the fourth car). Acid began leaking from the tank car; and a puffy-yellow cloud of toxic fumes formed and small fires were ignited on the crossties. The general yardmaster, who was working in the adjacent yard office tower, observed that a cloud of fumes was engulfing the area of the 48th Avenue overpass (see figure 1). The yardmaster was notified that a tank car had been punctured and checked the switch list to identify the tank car as one containing acid. Recognizing the possible hazard to occupants of automobiles that might pass through the cloud on the 48th Avenue overpass, he immediately instructed the engineer to pull the car southward 150 feet in an attempt to minimize the hazard of the fumes to the motorists. The engineer complied with the instruction and then left the locomotive and evacuated the area. When the cars were pulled southward the nitric acid that spilled out of the damaged tank car caused additional crossties to catch fire. Using the yard loudspeaker system and the intercom system, the yardmaster warned the employees in the yard to evacuate the spill area. After doing so, he reported the accident to the yard supervisor, the train dispatcher, and the Denver Police Department. He then left the area. Approximately 1 hour later, about 3,000 residents were evacuated from a 1-square-mile area. Businesses were not allowed to open at their regular time and employees were kept out of the area. Four area hospitals treated 34 patients for inhalation of fumes and skin irritation.

Emergency Response

At 4:05 a.m., the Denver police dispatcher received the notification from the D&RGW general yardmaster that a tank car containing acid had been damaged under the 48th Avenue overpass west of Broadway. The police dispatcher contacted patrol units in the area and directed them to investigate. At 4:08 a.m., the D&RGW terminal supervisor contacted the Denver Fire Department dispatcher and reported that a tank car with acid was burning. Two fire engines, a truck company, and five units were dispatched to the accident site.

At 4:12 a.m., while fire equipment was en route, the fire department thought they were responding to a highway accident on one of two bridges over the D&RGW yard. However, the D&RGW again contacted the fire department dispatcher, identified the location and the product as nitric acid, and provided from the waybill the following Association of American Railroads (AAR) computer generated Emergency Hazardous Material Guide Information to the fire dispatcher: "Use water in flooding quantities from distances as far as possible."

1/ A hand lamp signal given to indicate an accelerative movement and a quick stop to cause a car that has been uncoupled to roll free.
2/ Operated the uncoupling lever.
3/ The coupler locking mechanism reengaging.

Figure 1.--North Yard and 48th Avenue Overpass

The fire department personnel arrived at the yard at 4:12 a.m. The yardmaster provided the fire chief with both the waybill and the printout of the AAR Emergency Guide for Nitric Acid. After receiving this information, the fire chief established a command post at 48th Avenue and decided at 4:20 a.m. to attack the burning railroad ties with handlines.

At 4:23 a.m., the fire dispatcher paged the Denver Hazardous Material Squad (DHMS). As members of this squad approached the yard, they reported seeing a pale yellow to brown cloud crossing Interstate 70 (I-70). At 4:28 a.m., the Denver Hazardous Materials Coordinating Chief (HMCC) arrived on scene and ordered all fire units to shut down hose operations and withdraw to a safe distance--1,200 feet. The HMCC's main concern was that the acid pool apparently was increasing in size and that the hose attack would create large amounts of fumes which might drift into unevacuated areas if the wind shifted (see figure 2). The HMCC decided to prepare for an evacuation, to isolate and contain the spill from spreading farther into the yard, and to neutralize the spill with soda ash. 4/ The HMCC then requested activation of the city's Office of Emergency Preparedness (OEP) and requested the police to close Interstate Highways I-70 and I-25.

4/ On October 15, 1979, the Denver Fire Department had responded to a 9,000-gallon tank truck incident involving nitric acid; and had gained first-hand experience with soda ash neutralization of nitric acid.

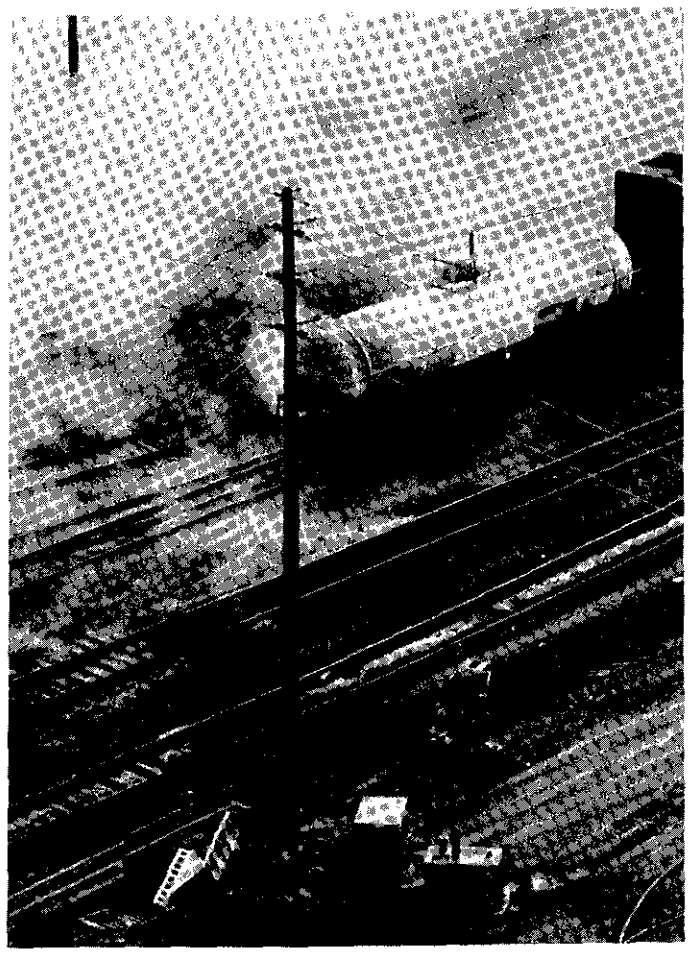


Figure 2.--Punctured Tank Car and Nitric Acid Vapor Cloud

At 4:51 a.m., 46 minutes after the accident, the Denver fire dispatcher contacted Chemtrec, which advised the Denver Fire dispatcher not to use water on the spill, but rather to neutralize the acid with soda ash.

The Department of Transportation (DOT) emergency response guidebook was not used to determine the action to take to control Nitric Acid; however, neither it, nor the AAR data which is taken from the DOT emergency response guidebook refers to the use of soda ash except in the context of dealing with small fires.

At 5:30 a.m., 58 minutes after the accident, the OEP began activating selected sirens in an area extending 1 mile by 1 mile down wind of the North Yard, and the evacuation of all persons in that area was begun.

After considerable searching, the D&RGW located a source within the Denver area having 7 hopper cars of soda ash, about 700 tons, and at 6:30 a.m., a yard locomotive was dispatched to pick up the 7 cars and bring them to the D&RGW's North Yard. A spill cleanup contractor had been contacted by the D&RGW to assist in containment and cleanup of the spill. The contractor estimated that his crews would arrive at the accident site about 11:00 a.m.

Local, State and Federal officials at the command post decided that the best course of action was to extend the evacuation zone an additional 1 mile before the neutralization effort began. By 10:30 a.m., the additional evacuation was completed and the

neutralization effort began. The hopper cars of soda ash were unloaded. Using frontend loaders, private contractors and Denver Public Works Division personnel started piling soda ash along the railroad right-of-way. Several inches of soda ash were sprayed over the nitric acid by driving a snow blower, brought to the scene from Stapleton International Airport, through the soda ash piles. The operation of neutralizing the nitric acid required 1 1/2 hours. At 12:30 p.m., the evacuation order was lifted and the residents were allowed to return to their homes. The shipper assisted in the off loading of the residual nitric acid over the next 3 days.

The D&RGW did not have in place an emergency plan for accidents or incidents in its Denver rail yards, and no prior arrangements had been made with Denver public safety organizations for them to respond.

Damage

Cars	$17,000
Lading	90,000
Cleanup of spill	168,000
Overtime and damaged equipment1/	66,000
Total	$341,000 2/

1/ Costs to the city of Denver.
2/ This estimate does not include the costs of and losses resulting from the evacuation and interruption to community life.

The tank car (GATX 27006) had the top shelf broken off of the A end (north end) coupler as a result of the overriding by the box car. The bottom half of the tank head on the A end was crushed inward and punctured. The head had separated beginning about 6 inches from the bottom of the tank; the separation was 24 inches long with an opening 4 1/2 inches wide. There were two small punctures in the tank. The end running board and coupler attachments were bent and broken (see figure 3).

The empty box car (WP 66132) was found after the accident with the truck 5 feet off center. The A end (south end) center sill, draft gear pocket, and coupler carrier iron were bent and broken from impact; the A end E-type coupler was missing and was found at the initial point of collision. The coupler had failed completely through it's shank at the coupler pin hole and the fracture surfaces indicated a preexisting fracture of about 70 percent of the cross section. Wear on both couplers of the car was within limits prescribed by Federal Railroad Administration (FRA) Safety Standards.

Car Information

Car GATX 27006 was an uninsulated aluminum fusion-welded tank car. It was 56 feet 3 inches long and had a capacity of 17,187 gallons. The car was built in December 1971 and carries a Department of Transportation (DOT) Classification, DOT-111A60ALW1. It was equipped with AAR type F shelf couplers. The car was not equipped with headshields or thermal protection.

Car WP 661322 was a 60-foot-long box car with a sliding center sill. The sliding sill underframe was capable of 20-inch travel in draft and buff. The car was built by Pacific Car and Foundry in October 1969. It was equipped with AAR type E couplers with long shanks. Repair records indicated the car was repaired by Atchison, Topeka and Santa Fe

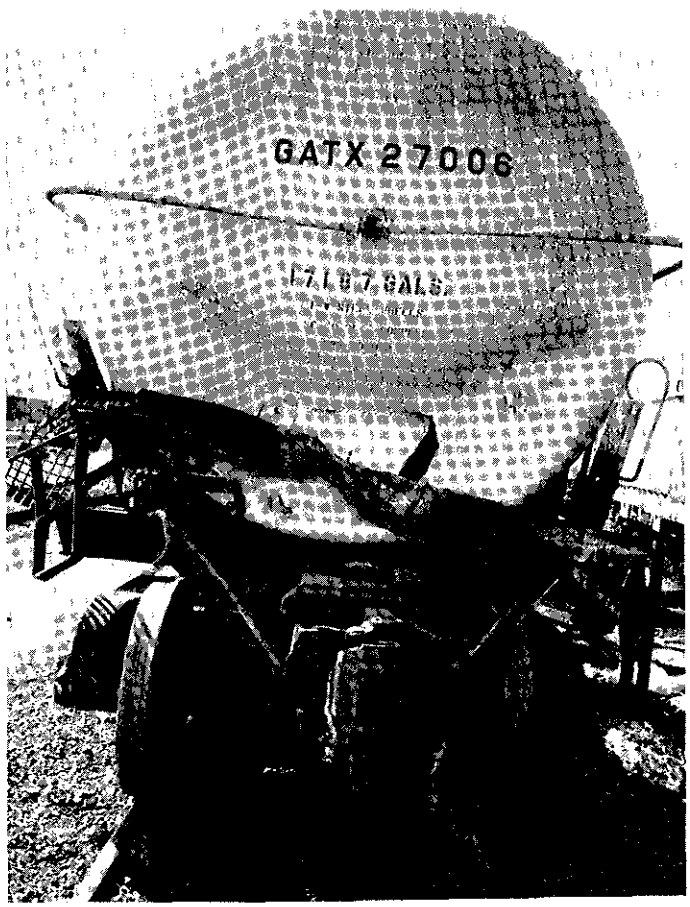


Figure 3.--Damage to A end of tank car GATX 27006.

Railway Company (ATSF) at Barstow, California, on December 7, 1982. No repairs were made to the couplers at that time. The car received the last FRA required periodic inspection on July 7, 1979. The inspection required that the couplers be inspected at that time.

In 1980, in its revision of the freight car safety standards and subsequent to the foregoing inspection, the FRA eliminated the requirement for periodic inspections of freight cars. The periodic inspection requirements had required that the inspecting party remove the coupler pin retaining plate and examine the coupler in the coupler pin hole area.

Method of Operation

Switching operations in the D&RGW's North Yard are performed by a locomotive engineer, a switchman (pin puller), a switchman (fieldman), and an engine foreman. The engine foreman supervises the crewmembers during the switching operations. A general yardmaster monitors the entire yard operation from his position in the tower. During switching operations, cars are routed by the switchman from a switch list prepared before switching begins. The D&RGW recommends as safe, coupling speeds of between 4 and 5 mph. Operational procedures are established by bulletins, notices, timetable special instructions, operating rules, and computer printed information pertaining to the type of lading carried in each car.

The general yardmaster communicated through yard loudspeakers, local and company telephones, and radio. He was in radio contact with the engineers of yard locomotives and with the switchmen through the yard speakers located in the yard. He was in direct communication with the chief dispatcher.

Yard Information

The North Yard includes 25 classification tracks, bounded by two long receiving tracks on the east. The yard is lighted at night by high tower lights. The yard is within the Denver City limits and is surrounded completely by light industrial buildings, motels, commercial and warehouse buildings, private residences, and two interstate highways. (see figure 4).

Meteorological Information

The closest surface weather observations were made at Denver, Colorado, Stapleton International Airport. On April 3, 1983, at 3:45 a.m. it was cloudy, the wind was from the southeast at 12 mph, the temperature was 35° F, and visibility was 20 miles.

Tests and Research

In April 1983, acceleration tests were conducted at the accident site for the purpose of determining the approximate speed of the overtaking cars at the time of the impact between GATX 27006 and WP 66132. The locomotive (146), caboose, and empty freight car involved in the accident were used in the tests, with the addition of a loaded tank car with about the same gross tons (113 tons) as the combined load and weight of GATX 27006 on the day of the accident. The separated cars were assumed to have been stopped.

Figure 4.--Aerial view of the North Yard and surrounding industries.

The tests were conducted as follows:

Test No. 1 - From a distance of 100 feet south of the approximate point of impact, with throttle in off-position, a signal to accelerate was given. The engineer responded by moving the throttle to No. 8 position. When the switcher began to move, recording of time was initiated and was continued until the impact point was reached. In addition to calculations based on the timing test, a radar gun was used to determine speed. Results of test No. 1 indicated a speed of 10 mph at impact.

Test No. 2 - From a distance of 100 feet south of the approximate point of impact, the throttle was moved to No. 4 position with the locomotive brake set. Upon signal, the locomotive brake was released, and the throttle moved to No. 8 position. Results of test No. 2 indicated a speed of 11 mph at impact.

Test No. 3 - Was conducted the same as test No. 1 except from a distance of 150 feet. Results of test No. 3 indicated a speed of 12 mph at impact.

Test No. 4 - Was also conducted from 150 feet and in the same manner as test No. 2. Results of this test indicated a speed of 12 mph at impact.

History of the Hazardous Material Shipment

On March 30, 1983, Hercules Incorporated, Louisiana, Missouri, consigned GATX 27006 to the local Burlington Northern agent. The shipper-certified waybill provided routing and described the product as: "Nitric Acid-Oxidizer, UN 2031 -RQ, Placard Oxidizer." The shipper's waybill routed GATX 27006 through the Burlington Northern-Denver-D&RGW to the Trojan Corporation, Gomex, Utah. The Burlington Northern in turn prepared a waybill with the following description: "1 T/C Nitric Acid 99.1% Oxidizer-Placarded Oxidizer." GATX 27006 arrived at the D&RGW's North Yard on April 3, 1983, around 1:30 a.m. The BN waybill accompanied GATX 27006 and was provided to the D&RGW yardmaster.

The hazardous material shipment in GATX 27006 consisted of about 14,500 gallons (184,400 lbs) of a 99.1 percent concentration of fuming nitric acid, classified by the DOT as an oxidizer, UN2031. 5/ Nitric acid has an Environmental Protection Agency (EPA) reportable quantity (RQ) in the event of a discharge of 1,000 pounds. 6/ As described in the AAR 1981 Emergency Guide: "This material is a colorless to pale yellow liquid with a suffocating odor. It is used to make other chemicals, as a reagent in chemical analysis for ore flotation, and for many other uses. Nitric acid is soluble in water with release of heat. It is noncombustible, but it will accelerate the burning of combustible material and can cause ignition upon contact with combustible materials. It is corrosive to some metals and tissue."

5/ A four-digit identification number in the primary international coding system for hazardous materials.

6/ Nitric acid in any concentration is considered by the EPA and DOT as an environmentally hazardous substance requiring a National Response Center notification for discharges greater than 1,000 pounds.

The National Fire Protection Association (NFPA) warns that the health hazard for nitric acid is that on short exposure it can cause serious temporary or residual injury even when prompt medical treatment is given.

The Chemical Manufacturing Association Chemical Safety Data Sheet SD-5 states that nitric acid is considered "fuming acid" at or above 85 percent concentrations and will give off gaseous oxides of nitrogen (NO, NO_2, etc.) or nitrous fumes which range in color from clear to dark brown.

DOT 1981 Emergency Response Guide book recommends a 0.7- by 0.5-mile down wind evacuation for large tank car accidents.

ANALYSIS

The Accident

Since the coupler of the empty box car had been drastically weakened by a pre-existing fracture, the continual quick accelerations and stops, necessary for the switching operation, stressed the weakened coupler and it failed completely. Because the broken coupler was still attached to the tank car coupler, it was pulled from the empty box car and the broken end fell to the track structure. This separated cut of cars apparently drifted away from the cars attached to the locomotive so that there was a separation of about 150 feet from the string of freight cars which was being pushed. Because of darkness and their location none of the crewmembers were in a position to see the separation and it went undetected.

Since the engine foreman and engineer were not aware of the separation, the next switching movement following the separation was made as though all the cars still were attached to the locomotive. Therefore, instead of all the cars moving when the engineer accelerated quickly, a rapid closing of the space that separated the cars led to a collision at a speed of about 12 mph. As a result of the impact, the empty box car, now without a coupler, overrode the tank car and struck the tank head, puncturing the tank shell with it's end sill.

Tank Car Information

Had the tank car been equipped with head shields, the end of the tank car probably would not have been punctured and the release of the material probably would not have occurred. Because the capability of the aluminum tank car to resist end puncture on impact has not been fully tested, the Research and Special Programs Administration (RSPA) in consultation with the FRA and AAR should subject the DOT 111 specification aluminum tank car to full testing and evaluation to determine what type of head shields are needed to protect the ends of aluminum tank cars. Thereafter RSPA should mandate their installation at an early date.

On April 4, 1978, after a number of major hazardous materials accidents, the Safety Board conducted a public hearing to study problems with the shipment of hazardous materials by rail as well as the safety of tank cars. After this public hearing, which led to recommendations addressed to the RSPA and the FRA and railroad industry that head shields should be installed on all 112/114A type tank cars, the railroad industry and tank car manufacturers took action and completed the installation of head shields on 112/114A type tank cars by January 1981.

On July 27, 1981, a loaded DOT 111 type tank car of ethylene oxide, classified under DOT requirements as a flammable liquid, was breached in a railyard and the escaping ethylene oxide ignited and burned for 40 hours. During this time, local authorities ordered the evacuation of an area within a 1-mile radius of the tank car because they were concerned that the tank car might explode. Several hundred workers were ordered to leave their jobs, air traffic at Newark International Airport was delayed, hotel guests were evacuated, the New Jersey marine terminal was closed, and a 4-mile section of highway leading to the Holland Tunnel was closed. As a result, on September 30, 1981, Safety Recommendation I-81-6 was issued to RSPA. The Board noted that at least four other ethylene oxide tank cars had exploded in accidents since 1964 and recommended that the DOT:

> Complete rulemaking on Docket HM-175 to require the extension of specified puncture and thermal protection levels to DOT specification tank cars and established priorities for installation based on the relative dangers posed in accidents by the commodity being transported.

The Safety Board notes that the final rule in Docket HM-175 became effective March 1, 1984. The Board is concerned that the complete spectrum of DOT specification tank cars authorized to carry materials posing risks to public safety if punctured or otherwise breached was not addressed in the rule. Additionally, the docket was not expressly kept open to accommodate further rulemaking. To underscore its concern, the Safety Board recently placed Safety Recommendation I-81-6 in a "Closed--Unacceptable Action" status. The Safety Board believes RSPA needs to consider the need for additional protective measures for all DOT specification tank cars. The Safety Board will be evaluating the performance of all cars not required to be fitted with puncture and thermal protection when they are involved in accidents.

In the North Yard accident the top and bottom shelf coupler of the tank car was not able to prevent the empty box car from overriding and striking the tank end because the coupler of the box car had fallen out at the attachment to the car when the coupler failed at the pin hole. Since the pin attachment is not visible to a car inspector during routine inspections and because there is no federal regulation or industry practice requiring periodic inspection of this portion of a coupler, it is possible that a car with a partially broken coupler at the pin hole will go undetected for a considerable length of time while the fracture progresses until a complete failure occurs, as it did in this accident. Moreover there are other car components that are not visible to an inspector during a routine inspection procedure; therefore, since the FRA has eliminated periodic inspection requirements, the AAR should, in cooperation with the railroads, incorporate in its interchange rules a requirement that hidden areas of a freight car be inspected periodically.

Emergency Response

The various guidelines given to the public safety officials were contradictory and contributed to a possibly unnecessary extension of the evacuation area. The decision by the Denver Hazardous Materials Coordinating Chief to withdraw the Fire Department, to cease the water attack, and to attempt to neutralize the spill was based on past experience. Chemtrec's instructions were consistent with this procedure. The application of water increased the size of the vapor clouds of the fires involving the

crossties. The first firefighters to arrive at the accident scene cannot be faulted for using water because the AAR information accompanying the waybill indicated that water in flooding amounts should be used. This information is the same as in the DOT Emergency Response Guidebook. This emergency response indicates that the AAR emergency instructions and DOT Emergency Response Guidebook need to be more specific indicating when and in what environment the various methods to attack a spill should be used.

About 9 a.m., on April 3, 1980, a Boston and Maine Corporation (BM) switch train consisting of a locomotive and 38 cars collided, while moving at a speed of 4 mph, with a standing cut of cars in Somerville Yard at Somerville, Massachusetts. 7/ The locomotive struck and punctured a tank car, the second car of the standing cut; the tank car contained about 130,000 gallons of phosphorus trichloride (PCl_3), a hazardous material classified by DOT as a corrosive liquid. The product spilled onto the moist ground and created a toxic cloud, necessitating the evacuation of a 1 1/2-square-mile area containing 23,000 persons. During the first 48 hours following the accident 418 persons were treated at the Somerville hospital for injuries caused by the fumes. Damage to railroad equipment was reported to be $8,100 and cleanup costs were reported to be in excess of $130,000. Phosphorus trichloride is a fuming liquid, which decomposes when diluted with water into hydrochloric and phosphoric acids. It is corrosive to metals and human tissue. Its vapors are extremely irritating and can burn moist tissue. Both the AAR and DOT emergency guides recommend for phosphorus trichloride downwind evacuation distances between 0.5 and 1.0 mile in the event of an accident.

In the Denver accident, there was similar contradictory, insufficient, and ambiguous advice contained in the emergency response guidelines used by emergency response agencies which created uncertainties about the emergency actions firemen should take and about the protective clothing to be worn.

Because the D&RGW had no emergency plan for accidents or incidents in the railyard and because it had not consulted with public Denver safety organizations, there was not a well defined procedure for notification of emergency response forces when the accident occurred. The police were notified first, and they promptly dispatched a patrol unit to check out the incident. However, the unit could take no action beyond reporting the situation. About this time D&RGW notified the Denver fire dispatcher and from this point on, the response by the Denver safety organizations was effective. The lack of coordinated planning between the railroads and municipalities is not limited to Denver, but is true in many major metropolitan areas. Because of the Denver accident and several similar prior accidents, the Safety Board, on July 26, 1983, conducted a public hearing addressing safety issues associated with the handling of hazardous materials tank cars at railyards in populated areas. In its special investigation report, 8/ the Board reviewed handling of hazardous materials in railyards and planning by railroads and communities to reduce and to deal with the impact of hazardous materials accidents on persons working and residing near railyards.

7/ Special Investigation Report--Phosphorus Trichloride Release in Boston and Maine Yard 8," (NTSB-HZM-81-1).

8/ Special Investigation Report: Railroad Yard Safety--Hazardous Materials and Emergency Preparedness. (NTSB/SIR-85/02.)

The Director of the Denver, Colorado, Office of Emergency Preparedness stated that this accident tested all of the city's capabilities to the fullest and that the incident will be the basis for planning to deal better with the next large scale incident, which he believes is inevitable. He urged that the railroads be required to submit some type of a disaster plan to the city similar to what the Environmental Protection Agency (EPA) requires of industry. Procedures he believes should be addressed are the priorities of proper notification, identification of the material involved, the names of contact persons, and the availability of resources to mitigate the incident within the area. City of Denver officials since have informed the Safety Board that their relationship with all the operators of railroads within their jurisdiction had improved 100 percent as a result of improvements in emergency preparedness procedures.

CONCLUSIONS

Findings

1. The flat switching of cars was being performed in accordance with normal industry practices.

2. No Federal regulation or industry practice requires periodic inspection of hidden car components; therefore, the empty box car, which had an undetected fracture in the pin hole area of a coupler continued in service.

3. The repeated quick accelerations and sudden stops, required in the switching operation, sufficiently stressed the weakened coupler to the point of complete failure, resulting in a separation in the string of cars.

4. Because of darkness and their positions the separation of the cars occurred at a location where no crewmembers were in position to see it. All the crewmembers were at the positions assigned by the engine foreman to accomplish the switching of the cars.

5. There was a heavy impact when the moving cars overtook and struck the separated cars. An override followed in which a tank car was breached and spilled nitric acid. The spilled acid resulted in a vapor cloud and ignited some crossties in the track.

6. No cooperative emergency plan for the Denver railyard had been developed between the D&RGW and City of Denver public safety organizations.

7. There were delays in notifying the City of Denver safety organizations because the D&RGW did not have an emergency plan.

8 Firefighters relied on the Association of American Railroad's Computer Generated Emergency Hazardous Material guide waybill instructions furnished them by the D&RGW and applied water to the spill.

9. The water used to knock down the vapors and to fight the fire spread the pool of nitric acid and enlarged the vapor cloud.

10. The Denver Hazardous Materials Coordinating Chief correctly decided to use soda ash to neutralize the nitric acid based on his past experience with the material.

11. The AAR emergency instructions and DOT Emergency Response Guidelines were not specific enough to indicate in what environments the various methods of attacking a spill should be used.

12. The tank car involved in this accident was not equipped with a head shield which may have prevented the accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the complete failure of a coupler of a box car leading to an undetected separation of cars being switched and the puncturing of a tank car by the end sill of the box car when the coupled cars overtook those which had separated. Contributing to the accident was the lack of a federal regulatory inspection or an industry practice for a periodic inspection to detect defects in hidden car components. Contributing to the severity of the accident was the nature of the released product, insufficient guidelines, and absence of preplanning which led to the evacuation of about 9,000 residents and injury to 34 persons.

RECOMMENDATIONS

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

--to the Research and Special Programs Administration:

In consultation with the Federal Railroad Administration and the Association of American Railroads conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture and mandate installation of the head shield at an early date. (Class II, Priority Action) (R-85-61)

--to the Association of American Railroads:

Seek agreement between member railroads to periodically inspect hidden car components in a manner at least equivalent to the requirements of the federal regulations which were in effect prior to the revision of the Freight Car Safety Standards in 1980 and incorporate this inspection as a rule in the car interchange requirements. (Class II, Priority Action) (R-85-62)

In consultation with the Federal Railroad Administration and the Research and Special Programs Administration conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture and incorporate installation of the head shield at an early date as a rule in the car interchange requirements. (Class II, Priority Action) (R-85-63)

--to the Federal Railroad Administration:

In consultation with the Research and Special Programs Administration and the Association of American Railroads conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture and mandate installation of the head shield at an early date. (Class II, Priority Action) (R-85-64)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ Jim Burnett
Chairman

/s/ Patricia A. Goldman
Vice Chairman

/s/ G. H. PATRICK BURSLEY
Member

May 14, 1985

APPENDIX

INVESTIGATION

The National Transportation Safety Board learned of this accident via the news media about 7:30 a.m., on Easter Sunday, April 3, 1983. An investigator-in-charge from the Safety Board's Field Office in Denver, Colorado, was dispatched to the scene immediately. He later was joined by a hazardous material investigator from Safety Board headquarters in Washington, D.C.

The Federal Railroad Administration and the Denver and Rio Grande Western Railroad Company were designated parties and joined the Safety Board in the investigation of the operations, mechanical, hazardous materials, and emergency response aspects of the accident.

* U S GOVERNMENT PRINTING OFFICE: 1985-461-136:20008