RAILROAD ACCIDENT REPORT

SOUTHERN PACIFIC TRANSPORTATION CO.
FREIGHT TRAIN 2ND BSM 22 MUNITIONS EXPLOSION
BENSON, ARIZONA
MAY 24, 1973

NATIONAL TRANSPORTATION SAFETY BOARD

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Washington, D.C. 20594
REPORT NUMBER: NTSB-RAR-75-2

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16. Abstract

On May 24, 1973, Southern Pacific Transportation Company's freight train 2nd BSM 22, was approaching Benson, Arizona, when 1 of 12 munitions boxcars in the train's consist caught fire The boxcars were loaded with 500-lb MK 82 bombs. As the train stopped, the cargo exploded, and the explosions continued for several hours

The National Transportation Safety Board determines that the probable cause of the accident was the exposure of heat-sensitive bombs in Car 38 to a fire inside the car. The fire most likely originated from sparks off the brakeshoes which ignited the sodium nitrate impregnated floorboards.

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FOREWORD

The accident described in this report has been designated 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.

The Safety Board acknowledges the assistance and cooperation extended in this investigation by the following organizations: The Southern Pacific Transportation Company; the Missouri-Kansas-Texas Railroad Company; the Association of American Railroads; the Bureau of Explosives; Cochise County, Arizona; State of Arizona; the United States Department of Agriculture, Forest Service, Products and Engineering Research; the United States Department of Defense; the United States Navy; the Federal Bureau of Investigation; U. S. Railway Manufacturing Company; Westinghouse Air Brake Division; Pittsburgh Testing Laboratory; Southern Railway System; Boston and Maine Corporation; Kansas City Southern Railway Company; ACF Industries, Inc.; and Olin Corporation

TABLE OF CONTENTS

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FREIGHT TRAIN 2ND BSM 22 MUNITIONS EXPLOSION
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SYNOPSIS

At 4:30 p.m. on May 24, 1973, Southern Pacific Transportation Company's freight train, 2nd BSM 22, left Lordsburg, New Mexico, an en route stop from San Antonio to San Francisco. Cars 35 through 46 contained MK 82, 500-lb. bombs.

At Dragoon, Arizona, unbeknown to the crew, there was an explosion in one of the cars of bombs, part of the car was blown out, and the right-of-way was littered with car and lading fragments. About 5 miles farther on, another explosion occurred, scattering bombs and car fragments on the right-of-way. About 1 mile farther on, after the rear end crew had set the emergency brakes and detrained, a large explosion occurred as the train stopped. A series of explosions between 6:50 p.m. and 1:15 a.m. destroyed the 12 munitions cars. Other boxcars also were destroyed or damaged, and about 460 feet of roadbed were destroyed. Two trainmen were injured when they jumped from the caboose.

The National Transportation Safety Board determines that the probable cause of the accident was the exposure of heat-sensitive bombs in Car 38 to a fire inside the car. The fire most likely originated from sparks off the brakeshoes which ignited the sodium nitrate impregnated floorboards.

FACTS

The Accident

At 6:43 p.m., on May 23, 1973, Southern Pacific Transportation Company's (SP) freight train 2nd BSM was descending a 1-percent grade at Dragoon, Arizona, at about 45 mph. The train consisted of 5 locomotives, 106 cars, and a caboose. Cars 35 through 46 contained 500-lb. MK 82 bombs. At a culvert near the west switch of the Dragoon siding (MP 1052.6), 1/ an explosion occured within Missouri-Kansas-Texas Railroad Company car MKT 6259 (Car 38). Fragments of the car flooring and lining, parts of bomb pallets and strapping, pieces of tritonal (the bomb's explosive), and a piece of tubing from the

1/ Milepost indicates distance from San Francisco.

interior of one of the bombs were blown onto the track area. The explosion did not interfere with the progress of the train and occurred without the knowledge of the traincrew. The driver of a vehicle on the railroad access road adjacent to the south side of the track saw the train pass through "mustard yellow smoke." After the train passed, the witness extinguished smoking embers on the right-of-way.

As the caboose passed the west switch at the Dragoon siding, the rear brakeman noticed a crosstie smoldering and later noticed grass fires along the right-of-way. When the conductor brought this information to the attention of the engine crew, the engineer looked back, observed gray smoke, and began braking. The train was at that time traveling about 30 mph.

As Car 38 passed MP 1048.04, a second explosion occurred which blew from the car, six bombs, a portion of a seventh bomb, a side ladder, internal and external car parts, fragments from a bomb pellet, and other debris.

When the conductor saw fire and black smoke above the train, he placed the train brakes in emergency, and he and the rear brakeman jumped from the caboose.

The crew on the locomotive notice black smoke, a flash, and a huge ball of fire when the emergency brakes were applied from the caboose.

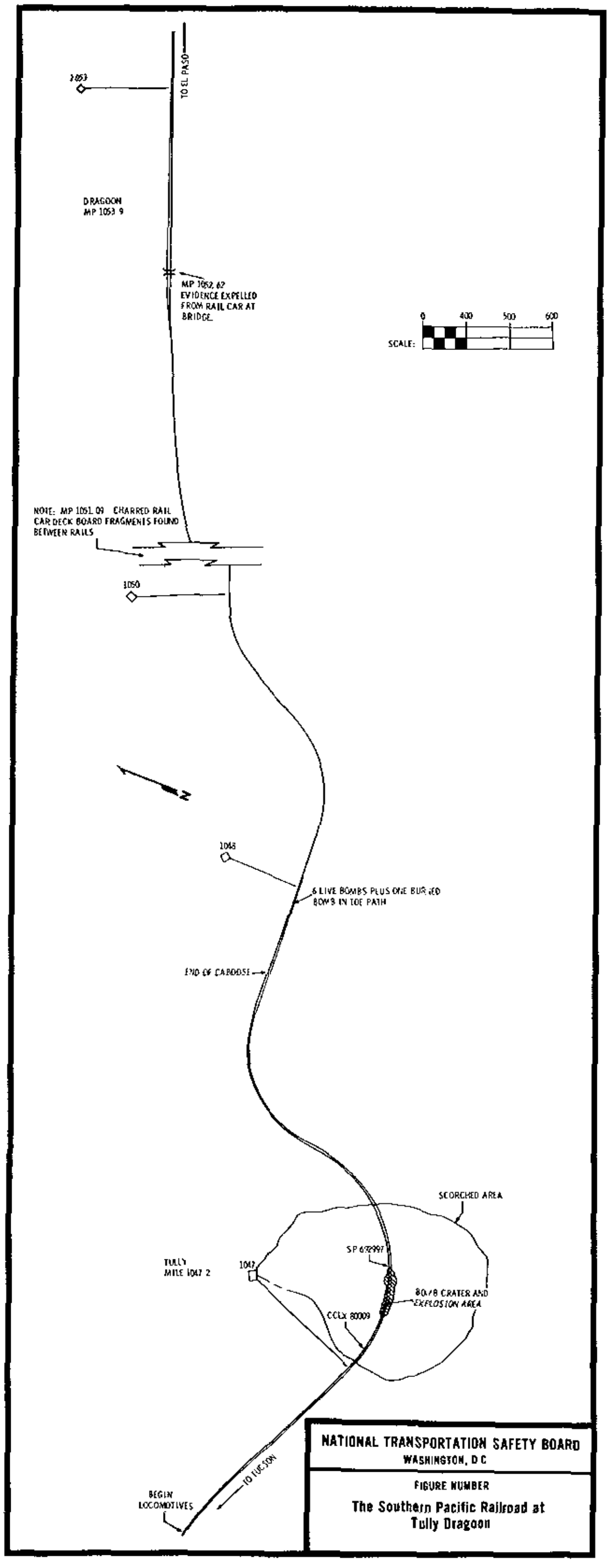
As Car 98 passed MP 1048.4, a low-order explosion of one of the bombs that had been expelled from Car 38 produced a small crater and other damage. The train then separated between Car 35, the lead munitions car, and Car 34, a covered hopper car of starch (CCLX 80009). The force of the explosion blew starch from this car and debris from other cars onto the railroad right-of-way. Explosions of varying intensity continued until 1:15 a.m. on May 25, 1973.

The cars which followed the last car of bombs, containing zinc ash, clays, fiberboard, water heaters, auto tires, and asbestos, were severely damaged, and most of their cargoes spilled onto the right-of-way. The locomotives stopped at MP 1046.7; the caboose stopped at MP 1047.8. (See Figures 1 and 2.)

The Accident Area

The accident occurred in a sparsely populated region of Arizona. The nearest residence was 5 miles away. The single track line has numerous grades which vary to a maximum of 1.4 percent descending westward as a train approaches the accident area and numerous curves.

Figure 1. Main Crater Area.


TO EL PASO
1053
DRAGOON
MP 1053 9
MP 1052.62
EVIDENCE EXPELLED
FROM RAIL CAR AT
BRIDGE
SCALE:
0
400
500
600
NOTE: MP 1051.09 CHARRED RAIL
CAR DECK BOARD FRAGMENTS FOUND
BETWEEN RAILS
1050
N
1048
6 LIVE BOMBS PLUS ONE BURIED
BOMB IN TOE PATH
END OF CABOOSE
SCORCHED AREA
TULLY
MILE 1047 2
1047
CRATER AND
EXPLOSION AREA
CCLX 80009
TO TUCSON
BEGIN
LOCOMOTIVES
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D C
FIGURE NUMBER
The Southern Pacific Railroad at
Tully Dragoon

Environmental Factors

May 24, 1973, was a clear day with visibility up to 50 miles. The temperature was 87°F, the relative humidity was 15 percent, and the wind was from the southwest at 10 mph.

Method of Operation

Trains are operated on the main track by automatic signals of a traffic control system Railroad rules require employees, where practical, to stand on the ground and inspect both sides of passing trains. If a defect is observed, employees must signal the passing train to stop. The crew of the train is also required by railroad rule to perform visual inspections of their train as often as possible.

Hotbox and dragging-equipment detectors are located along the right-of-way, which, when actuated, cause "stop" signals to be displayed. Hotbox detectors are designed to detect an overheated journal (axle bearing) by measuring the difference between ambient temperature and the journal temperature on locomotives and cars as they pass. Dragging equipment detectors are designed to detect anything dragging from the bottom of the train.

During the trip between San Antonio and El Paso, there were numerous inspections of the train by crewmembers and other employees and by dragging equipment and hotbox detectors. At El Paso, the seals of the munitions cars, cars 35 through 46, were found intact. Three new brakeshoes were installed on Car 38 at undetermined locations on the car.

At 1:40 p.m. on May 24, the train departed El Paso and arrived at Lordsburg, New Mexico, at 4:25 p.m. The train left Lordsburg at 4:30 p.m.

At 5:15 p.m. the train stopped on a siding at San Simon where the crew of a passing train reported seeing smoke near the middle of 2nd BSM 22 that appeared to be from braking. The crew of 2nd BSM 22 observed the train on both sides as it left San Simon, but saw no smoke.

Both sides of the train were inspected by a track gang at 5:50 p.m., by a traincrew at 6:05 p.m., and by still another trackcrew at 6:11 p m., after arriving at Wilcox, Arizona. The train passed a hotbox detector at MP 1069.3; no irregularities were detected.

The train passed four hotbox detectors and four dragging equipment detectors after it left Lordsburg, New Mexico. The last hotbox detector was located at MP 1069.3, 16.7 miles before the first explosion.

Between San Antonio, Texas, and the accident site, the train was observed or inspected by at least 116 operating employees and 114 maintenance-of-way employees.

The Train and Its Cargo

The cars -- Cars 35 through 46 were railroad-owned, general-purpose boxcars. Car 38 was built in 1950 by the American Car and Foundry Company for the MKT Railroad. The car was not equipped with spark shields to prevent sparks from the brakeshoes from contacting the car floor. It was equipped with friction bearings. Nineteen lining boards were replaced in its interior in 1970. (See Figure 3.)

On April 28, 1972, the car was loaded with 400 100-lb. bags of sodium nitrate in Lake Charles, Louisiana, which were shipped to Medford, Massachusetts. Twenty-one bags had broken open in transit and were left in the car at Medford. The car had not been damaged by fire when it was unloaded at Medford.

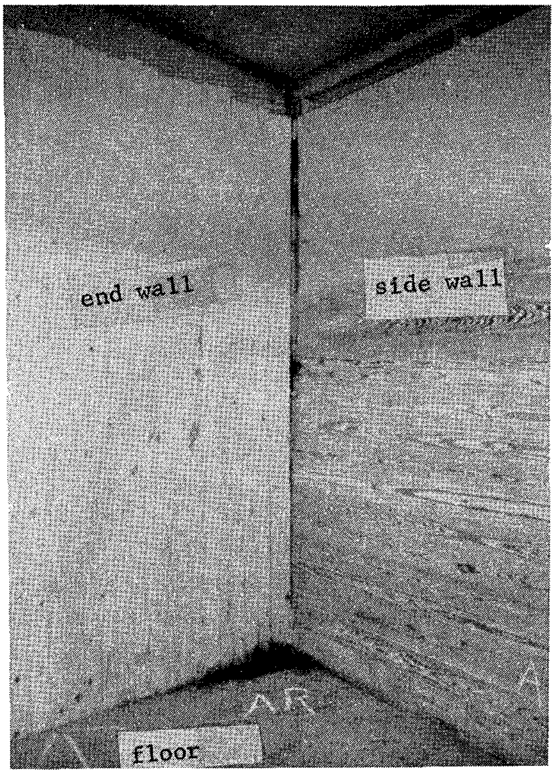
On June 10, 1972, at Ray, Texas, an inspection revealed that the car had been damaged by fire and would require $1,200 for repairs. The date and cause of the fire has not been determined. The car was in a repair yard exposed to the elements and was not repaired until April 1973, at which time the interior was upgraded to qualify the car for munitions shipments. The interior of the car was washed with water before it left MKT shops on May 5, 1973, and it was routed directly to McAlester.

Another car, MKT 5394, which was not involved in this accident, was taken out of the train at Waco, Texas, for repairs. The car and its lading of bombs were examined at El Paso after the accident. Bracing in the car had shifted and was loose at one end wall, but the pallets were intact. Some of the plastic nose plugs were missing from bombs, and an exterior examination of the car disclosed a broken floor. (See Figure 4.)

Further examination of the load after the car had been returned to McAlester showed that the blocking and bracing were damaged and loosened. Some of the banding on the pallets was loosened and others had shifted. Several of the bombs had contacted one another.

The MK 82 bombs -- The MK 82 bombs consisted of coated steel casings filled with tritonal (80 percent TNT and 20 percent aluminum powder), fuse wells and charging tubes for arming the bombs, and plastic plugs in each opening. (See Figure 5.) The tritonal was cast in place hot and allowed to partially solidify by ambient air cooling. After the tritonal solidified, its shrinkage required the addition of more tritonal to the base area. This procedure resulted in internal voids in the cast tritonal. Hot wax was poured on top of the tritonal to seal the casting.

The bombs were then cooled, assembled for shipment (unfused), and placed horizontally on a wooden pallet which held six bombs. The palletized bombs were secured with metal straps and loaded in cars.



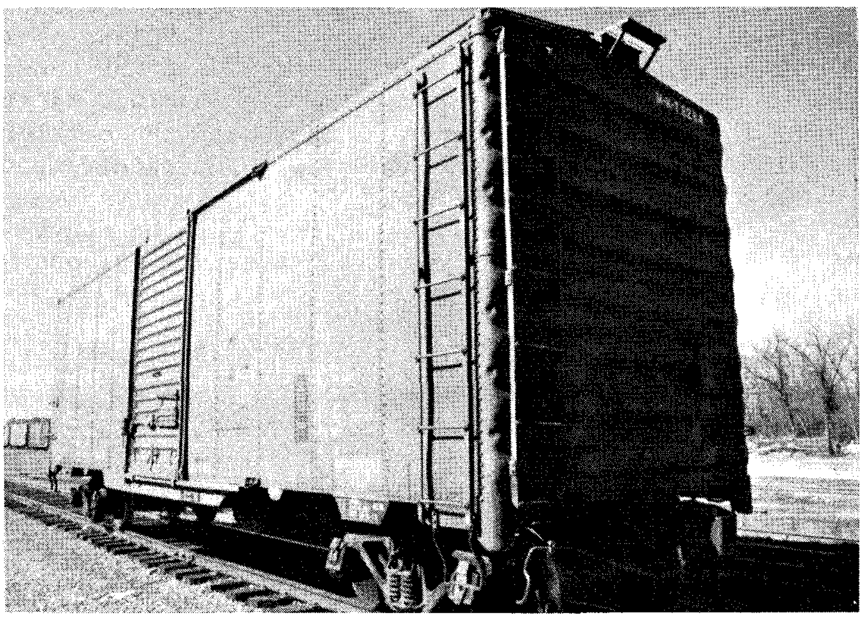


Figure 3. Interior and exterior views of a car similar in design to Car 38.

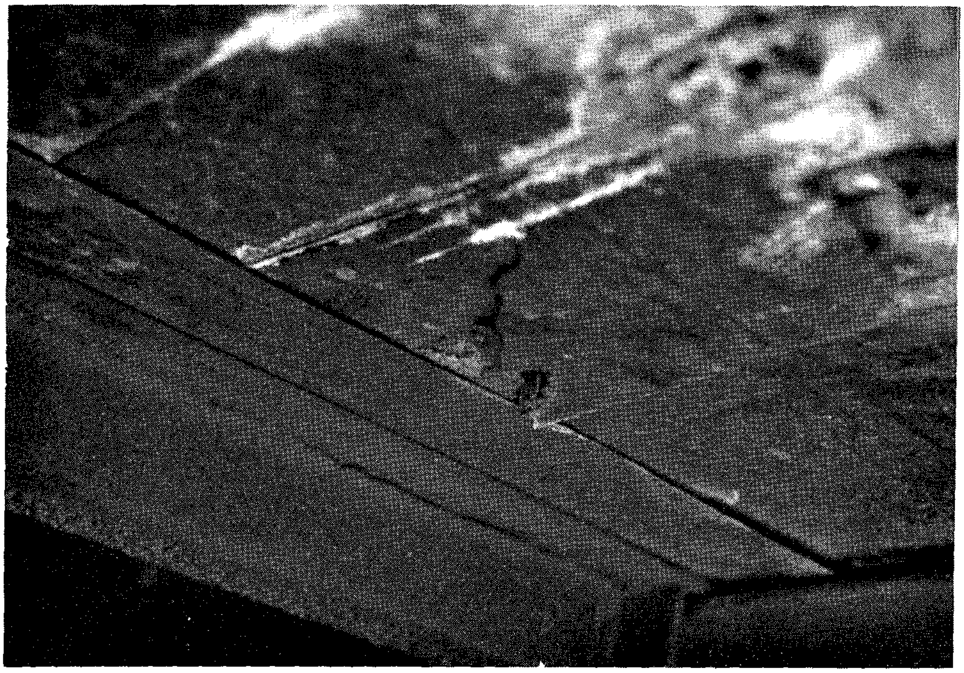


Figure 4. Broken floorboard of MKT 5394.

Certification of Cars and Lading

The boxcars were certified by MKT employees for munitions loading as required by 49 CFR 174.525. The regulation sets forth the specifications for railroad freight cars for the transportation of "Class A" explosives. It requires the carrier to certify that the car meets the specifications, the shipper to inspect the car's interior before loading and after loading to certify that the car meets the requirements, and the carrier to certify after loading that the car and load comply with the requirements.

49 CFR 174.526(h) requires that the bombs "must be stayed (blocked and braced) by the one who loads the car so as to prevent change of position by the ordinary shocks incident to transportation."

Additionally, the Navy specifies inspection and loading requirements in "Navy Procedures for Rail Car Inspection and Loading." which were approved by the Bureau of Explosives. (See Appendix B for loading diagram.)

Blank seals were placed on the door until the cars were ready for shipment. When the cars were ordered to be shipped, the blank seals were removed, and the interiors of the cars were inspected.

Shipper and railroad representatives did not enter cars to determine and certify that the bombs were loaded according to regulations. After the loading, they certified that the car met the requirements. These

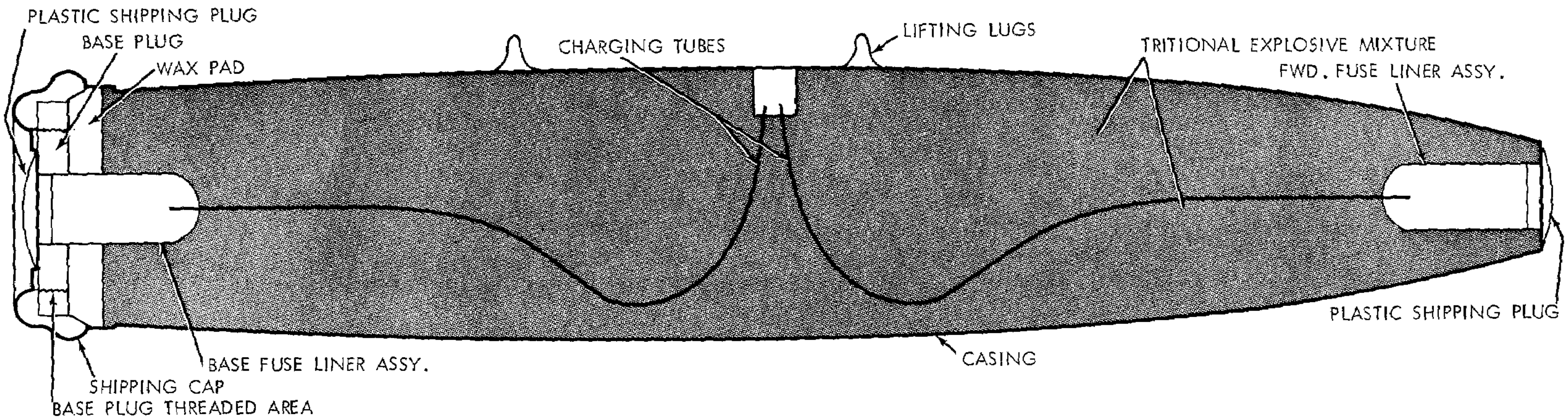


Figure 5. Diagram of MK 82 Bomb.

inspections were made from the ground. The doors were then resealed and recorded.

Damages

The major explosions produced a 115-foot by 93-foot crater, 25 feet deep, and scorched the desert for 1/4 mile in all directions. Four hundred sixty feet of track and roadbed were destroyed. The force of three of the main explosions were recorded by the Seismological Observatory in Tucson, Arizona, as 1.6, 1.4, and 1.2 on the Richter scale.

Car doors were found on both sides of the track. Twisted underframes, parts of rail car bodies, undercarriages, wheels, axles, and pieces of cars were found up to 3/4 mile from the main crater area. Cars 35 through 46 were totally destroyed.

The estimated damages amounted to $274,600 for railroad equipment, $70,000 for track, $47,000 for lading, and $70,000 for clearing the wreck. Estimated total damages were $884,600.

About 500 of the 2,600 bombs were recovered unexploded. Bombs were blown as far as 1 mile from the main crater area. Cars adjacent to the munitions cars were damaged by the blasts, and windows were shattered in a home 5 miles from the accident.

Injuries

Two crewmembers were injured when they jumped from a moving caboose.

Postaccident Activities

The locomotive crew radioed a railroad control point and notified them of the accident. An Air Force pilot, who was flying over the scene, notified military authorities of his assessment of the damage and estimated the smoke cloud to be about 3,000 feet high.

Benson Police, the Cochise County Sheriff's Department, and the Arizona Highway Patrol responded to the emergency and secured the area. The Rural Fire Department at Tucson dispatched six trucks.

Fort Huachuca Army Base sent a demolition team to the scene, and after the area was safe to enter, the team gathered debris from the bomb shipment. A large quantity of loose tritonal was recovered.

Safety Board investigators attempted to recover all available car parts. No munition car door seals were recovered No causative abnormalities were noted in the parts of the train recovered at the main site. The debris that was expelled from the car as a result of the explosion at MP 1052.6 and 1048 was recovered.

The Naval Investigative Service (NIS) and the Federal Bureau of Investigation (FBI) investigated the incident to determine if a willful act to impair or disrupt a military munitions shipment had taken place. They did not find evidence to suggest that sabotage or arson was involved.

Postaccident Car Reconstruction and Tests

Car 38 -- All identifiable car debris recovered from MP 1052.6 and MP 1048 was assembled into a partial mockup which indicated that the car involved in the first explosion was Car 38; the events which occurred at MP 1052.6 were in the right forward corner of the car; the piece of board which was found at MP 1051 was from this corner of the car; and the explosion which occurred at MP 1048 was in the same location in Car 38. (See Figure 6.)

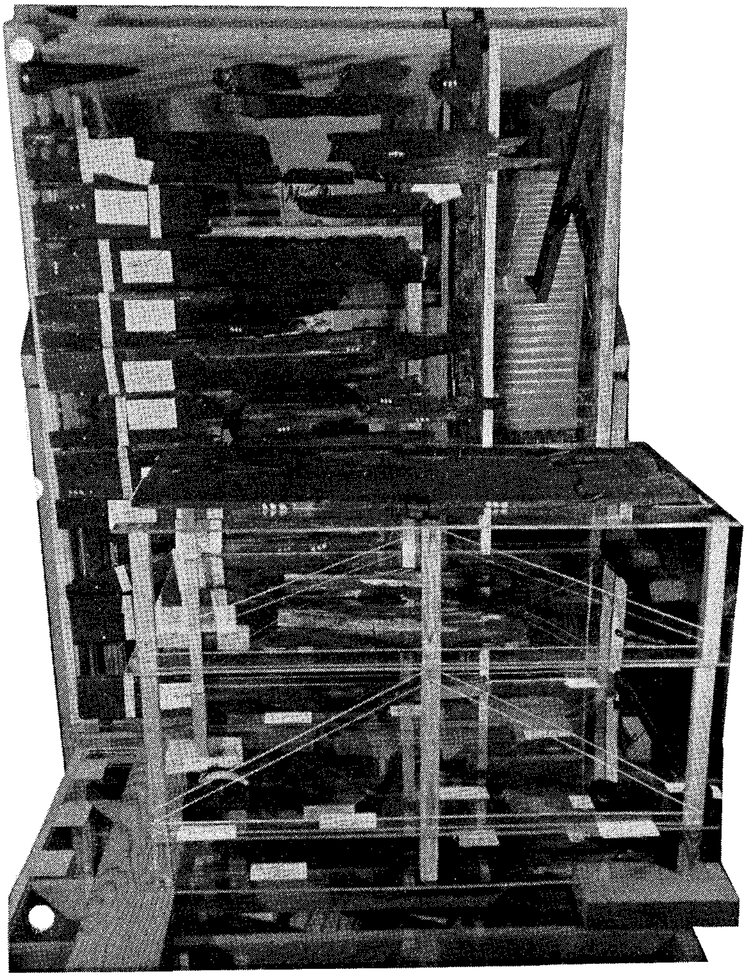


Figure 6. Interior view of reconstructed debris from the northwest corner of Car 38.

Analysis by the Forest Products Laboratory estimated, based on the depth and characteristics of the charred areas, that a piece of flooring on the inside of the car below a pallet was exposed to a fire of 1,500°F for 25 minutes. The outside of that board burned about 5 minutes. The charred areas were separated by uncharred surfaces approximately the same width as the pallet deck board.

FBI examinations indicated that boards from Car 38 contained residues of tritonal and sodium nitrate.

The Naval Research Laboratory determined that sodium nitrate was present in samples from floorboards that were blown from Car 38, at MP 1052.6. Sodium nitrate concentrations varied from 3 percent at the surface of the board to 0.10 percent 1/2 inch beneath the surface.

After the accident, explosives experts formulated tests which would help identify the sequence of events of the accident. The quality of the bombs and evidence from the scene were tested.

Bomb quality -- The Navy conducted tests to evaluate the quality of MK bombs similar to those which exploded in the accident. Deviations from expected quality were found during the tests. (See Appendix C.)

Condition of recovered evidence -- The following findings relate to the evidence recovered at MP 1052.6:

Charging Tube (See Figure 7).

- Crystals of TNT were found on the outside of the tube, especially in the collapsed portions of the tube. These crystals contained unreacted aluminum particles.

- "Hot melt" coating was found on the outside surface, some of which appeared to have been affected by heat. One small piece of charred wood was embedded in the coating.

- The collapsed portions of the tube appeared to have been heated above the melting point of the "hot melt" in several locations.

- The tube was twisted along its longitudinal axis, but retained an approximation of its original contour.

- The tube had been pulled out of its center and end connections.

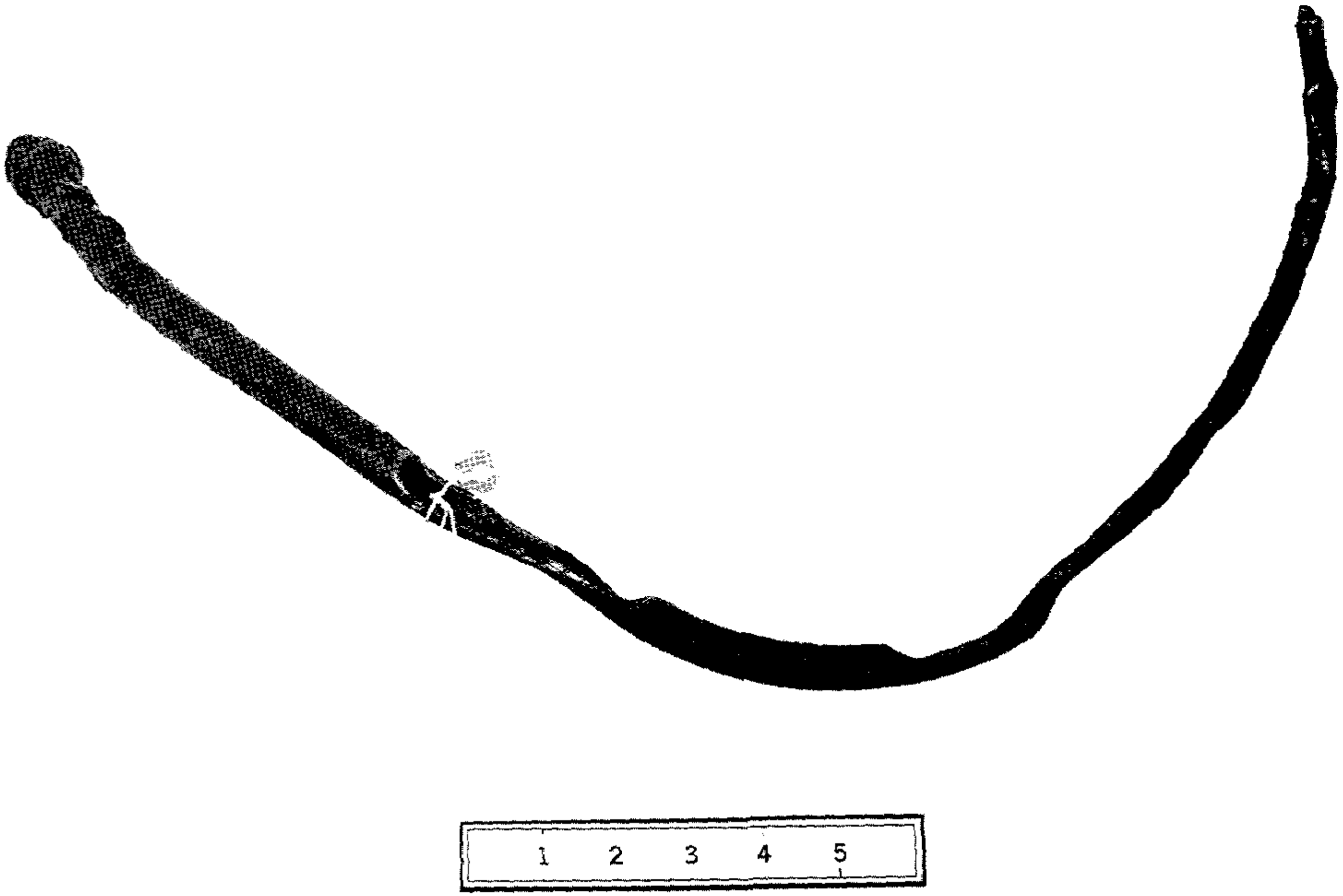


Figure 7. Charging Tube Found at MP 1052.6.

Tritonal Fragments

Sensitivity of samples was within specifications, and no contaminants were present.

The following findings relate to the evidence recovered at MP 1048: Charging Tube Fragments. (See Figure 8.)

Examination and tests disclosed that two of the fragments were similar in numerous details, and that external residues and appearances of both tubes were similar, except for the mass of "hot melt" at the straight end of the charging tube found in MP 1052.6.

Bomb behavior under "slow heating" conditions -- In an attempt to reproduce the conditions of the bomb fragments found at MP 1052.6 and MP 1048, test bombs were subjected to gradual external heat.

These tests resulted in the bursting of some of the test bombs, intensification of fire and smoke, and detonation of bombs. Resultant debris consisting of collapsed sections, hot melt, and crystal residues was similar to that found at the accident area. (See Figure 9.)

Other Energy Sources -- The Navy conducted a study to determine the energy which could be generated by relative motion between the pallets and the car floors or pallets and the sidewalls in a railroad car. An estimated maximum temperature rise of $30^{\circ}F$ could occur during the worst circumstances. However, the study concluded that in this accident situation the heat rise from that source was probably not more than 3 $1^{\circ}F$.

The Navy also conducted a study of static electricity as a source of energy which might trigger a reaction in the bombs. The maximum energy available was determined to be insufficient to initiate a reaction.

Other Information

Inspection and loading -- After the accident, Safety Board investigators observed car inspection and loading procedures. Several significant irregularities were noted. Navy civilian personnel arbitrarily added oil to the journal boxes, in excess of that required by the Association of American Railroads' recommended practices. Any excess oil in a journal box will be spilled out in transit and sprayed by the rotating wheel onto the floor, brake rigging, and anything else in its path and will readily support combustion.

Car fires -- The history of this division of the Southern Pacific railroad indicates that 237 car fires occurred during a 5-year period including 14 fires from overheated journals (hotbox), 184 fires from brakeshoe sparks, 2 fires from friction, 5 fires from spontaneous combustion (including cotton fires), 10 originating in the pre-cool fan system of refrigerated cars, and 22 from other causes.

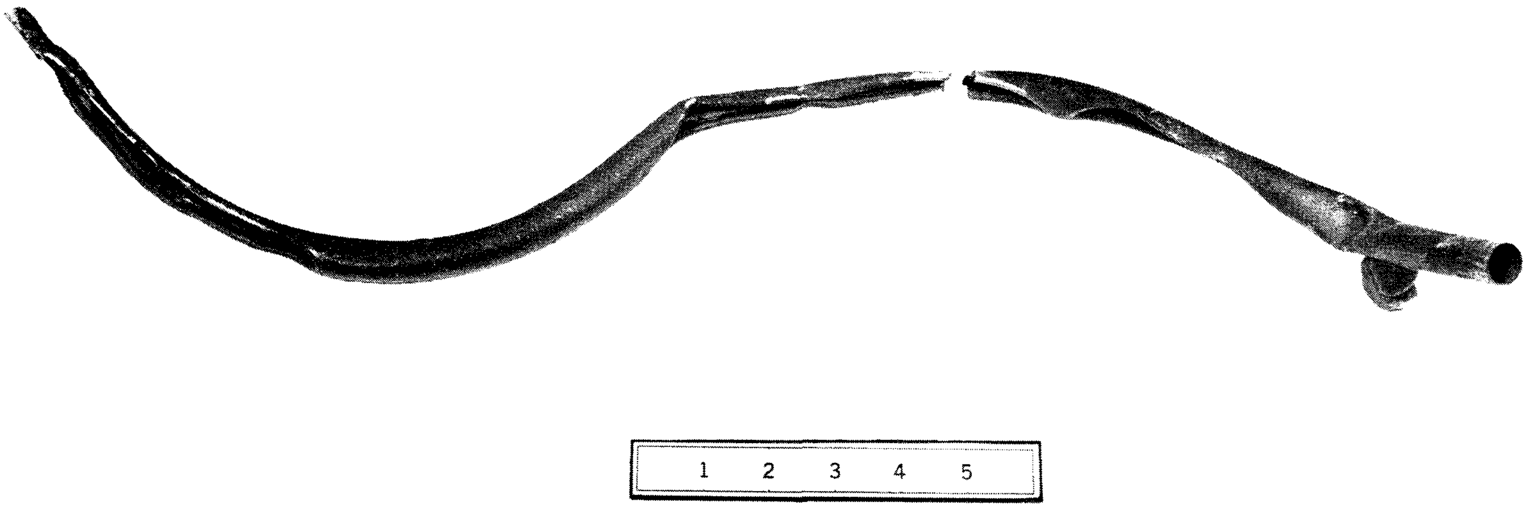


Figure 8. Charging Tubes Found at MP 1048.

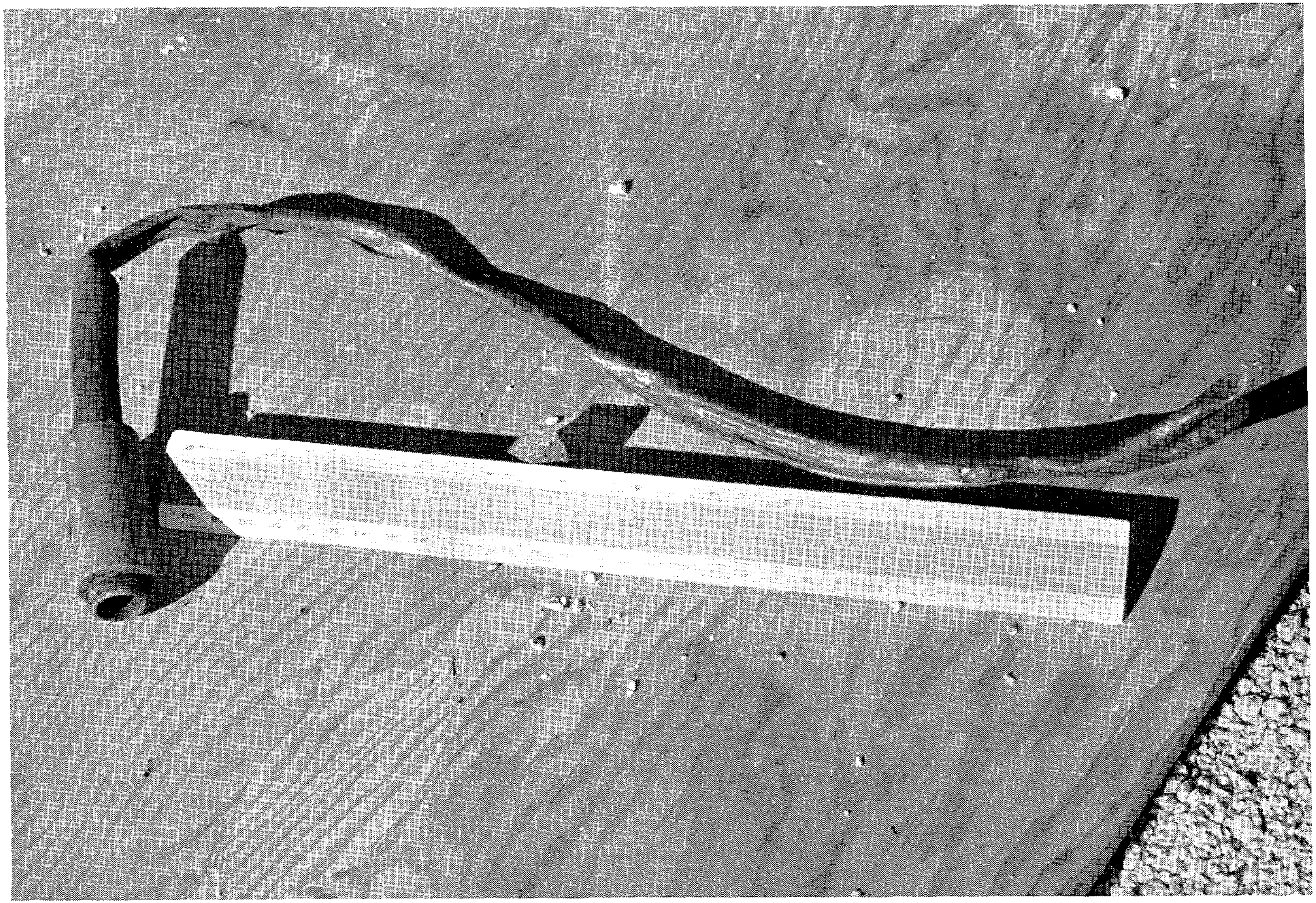


Figure 9. Debris Recovered from Externally Heated Test Bomb.

ANALYSIS

The Fire in Car 38

The evidence indicated that the wooden floor of Car 38 was on fire at least 25 minutes before the "explosion" of a bomb at MP 1052.6. In an attempt to determine what might have caused the fire, the Safety Board examined the available evidence and conducted tests to determine the probable sequence of events.

The munitions -- If the bomb which exploded at MP 1052.6 had experienced a vigorous internal chemical reaction of tritonal below the level of explosion, and if the products of the reaction had escaped through the nose or the tail section and onto the floor, the charging tube would probably have been consumed in the reaction. In addition, the wooden floorboard ejected from the car at MP 1052.6 showed a pattern of tritonal residue which contained unreacted aluminum. Therefore, the board was impinged by unreacted liquid tritonal as it was ejected from the car. Tritonal will remelt when the bomb is exposed to external heating. The large tritonal fragments recovered at MP 1052.6 indicate that the bomb casing failed in a manner which permitted these large fragments to escape through abnormal openings in the bomb casing.

The "mustard yellow" smoke observed at MP 1052.6 could only have been a quantity of vaporized TNT, or an oxide of nitrogen (NO_2) from an extensive chemical reaction inside the bomb. If the reaction capable of producing this quantity of NO_2 had occurred in the bomb before it exploded, large quantities of dense black smoke would have been visible. However, neither witness saw black smoke until the train was well past MP 1052.6.

The conditions of the charging tubes found at MP 1052.6 and those from the Navy's slow heating tests indicate that the bombs involved experienced similar heat exposures. Crushing and crumpling patterns were found on both tubes, and crystalline TNT was discovered on the exteriors of both.

An understanding of the basic chemical reaction process is helpful in considering the possible phenomena. TNT decomposes at a rate related to its temperature. As it decomposes, heat is generated. At very low temperatures the decomposition rate and heat generated are essentially undetectable; as its temperature rises, the decomposition rate and heat generated increase. Above 180°C to 185°C, the decomposition rate and heat released begin to increase rapidly. In a confined space, such as a bomb, the decomposition and heat generation can escalate quickly into self-accelerating reactions, leading to a low-order explosion. When unconfined tritonal is overheated, it burns, producing a dense black smoke.

The location of the 25-minute char on the floorboard was in the vicinity of the tail of the center, bottom bomb on the pallet in the right forward corner of Car 38 (see Figure 10), and under and slightly ahead of the nose of the bottom, center bomb on the adjacent pallet. If either of these bombs had experienced an internal chemical reaction, the hot reaction products would have had to escape from the nose or tail fuse liner area of one of the bombs to have burned the floor in this area. A flame of this type would be accompanied by dense black smoke. No such smoke was observed until the train was well beyond MP 1052.6.

The condition of the charging tube found at MP 1052.6 is significant. If an internal reaction spewed flames out of the nose or tail fuse liner over a 25-minute period, it would probably have overheated or consumed the charging tube in that bomb. The tube found at MP 1052.6 was not significantly overheated; in fact the conditions of the hot melt and the crystals indicate that the charging tube remained relatively cool during the explosion. The crystals on the tube indicated an exposure to vaporized tritonal, which would occur if the tritonal was overheated rather than reacting. The similarity between the appearance of the recovered tube and a tube recovered during the slow heating tests suggests that external overheating was more likely.

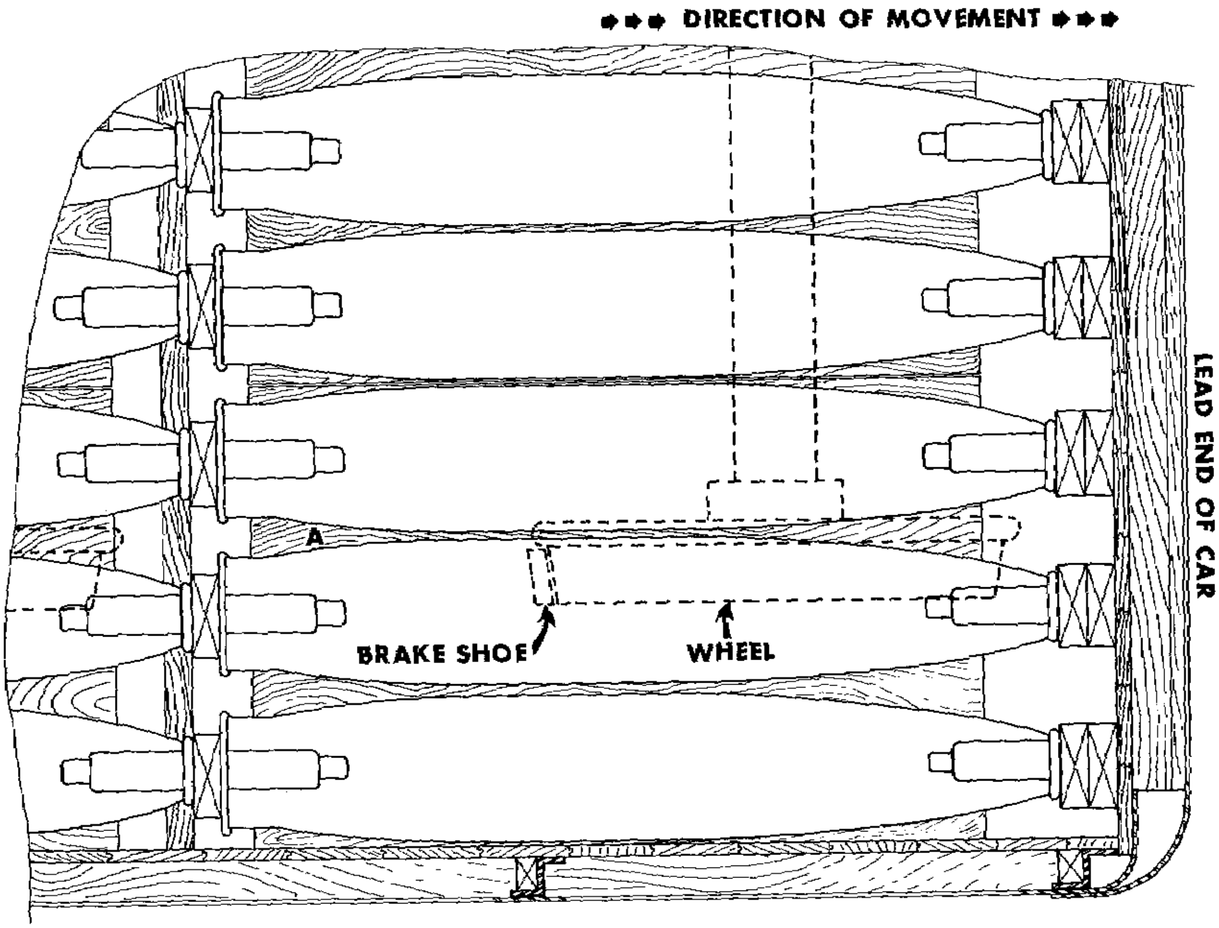
<u>The Environment Around the Bomb in Car 38.</u>

An examination of the charring on the recovered floorboards, on the pallet components, and on the other recovered fragments disclosed that the fire was most intense at floor level in the body bolster area and burned toward the end wall. In addition, the condition of the pallet parts indicates that the center bomb on the bottom row of the pallet in the right forward corner of the car split open at MP 1052.6. The Safety Board believes that the initial fire was localized between the floor and the bottom surface of the pallet in the vicinity of the center bomb. (See Figure 10.)

The debris pattern indicated that the center bomb in the bottom row of the corner pallet in Car 38 burst at MP 1052.6. It was probably exposed to the fire for the longest time. Therefore, the fire must have been most intense at, or near, the floor of the car in the area of the rear pallet chocks and the car body bolster. The location was almost directly above the leading wheel of the lead truck. The rear of the pallet was above the area where sparks from the brakeshoes could impinge the sodium-nitrate impregnated floor. While none of the floorboards recovered showed conclusive evidence of burning through from the bottom of the floor, the location of the bomb which first reacted, the location of the impingement area for brakeshoe sparks, and the location of the most extensively charred car floor and pallet all coincide.

Figure 10.

CROSS SECTION PLAN VIEW AT NORTH WEST CORNER OF CAR BOTTOM ROW OF MK 82 MOD I G.P. BOMBS ON PALLET SHOWN AS LOADED ON BOX CAR MKT 6259



NOTE:

1 MK 82 MOD I G P BOMBS LOADED ON BOX CAR MKT 6259 IN ACCORDANCE WITH WR 52/150, ALTERNATE LOADING PLAN FOR 40'6" COMMERCIAL BOX CAR

2. PALLETIZED IN ACCORDANCE WITH AF TPO 1325 294 4152 REV V

Floor Fires

Car floor fires can result from spontaneous combustion of products in the cars, a preexisting contaminant in the car, heat from a hot journal bearing, or from a brake-related difficulty. Despite this knowledge, the railroad and the shipper used boxcars to transport bombs which had no safeguards to prevent such fires. Neither the Navy, DOT, nor the carrier required that the cars be equipped with spark shields. In addition, combustible pallets, blocking, and bracing were used by the shipper and approved by the Bureau of Explosives, under delegated authority from the Department of Transportation (DOT).

The progression of events in this accident indicates that: (1) The likelihood of a fire must be reduced, (2) timely detection of a fire must be assured, and (3) the heat from the fire must be controlled before it adversely affects the cargo.

Journal bearing fires -- Burning lubricant of an overheated journal can ignite a car floor. This train passed numerous visual inspections between Lordsburg, N. Mex., and the accident site. Additionally, the train passed a hotbox detector at MP 1069.3, slightly over 16 1/2 miles before MP 1052.6. If the 25-minute charring estimate is correct, the floor fire was probably burning before the car passed this hotbox detector.

When checked, the detector functioned properly which indicates that there was no overheated journal and that detectors cannot be relied upon to detect floor fires. Further, no axles or parts were recovered at the accident site which showed indications of an overheated journal; however, all of the components from Car 38 were not recovered. In any case, a journal hot enough to ignite the floor would probably have burned off before the train arrived at the main crater area. No evidence was found along the right-of-way which indicated that a truck side was down or that a journal had failed.

Brakeshoe sparks -- Brakeshoe sparks which result from brake malfunctions or heavy braking can cause floor fires. The history of car fires on this division of the SP shows that about 77 percent of the 237 reported car fires in the past 5 years resulted from brakeshoe sparks. As recently as December 16, 1972, a car transporting MK 82, 500-lb. bombs caught fire at Hughson, California, as a result of "dragging brakes." The deduced pattern of fire in Car 38 indicates that the major effect of the fire was in the area immediately above the wheel. Therefore, the most probable source of ignition was brakeshoe sparks.

The wooden floor in Car 38 was particularly vulnerable to brakeshoe sparks because it was impregnated with sodium nitrate and oil. Once ignited, the sodium nitrate and oil would sustain the burning of the floor.

The extent of the penetration of sodium nitrate into the floorboards would have required extensive exposure of the floor to the nitrate. Some of the sodium nitrate from the April 1972 shipment may have remained in the car for almost 1 year--until the car was prepared for the loading of bombs involved in the accident. As sodium nitrate is hygroscopic, either atmospheric moisture, water used to extinguish a fire in the car, or water used to clean the car could have dissolved the nitrate and permitted it to penetrate the wood flooring. To have prevented such penetration, the car should have been properly cleaned immediately after unloading at Medford, Mass. Safety regulations 49 CFR 174.566(c) are vague as to how to and who is responsible for cleaning residues from cars, as the ICC's car cleaning requirements are not enforceable on consignees unloading cars. There is a need for safety controls applicable to the removal of contaminating residues.

Spark shields -- Since the fire was probably ignited by brakeshoe sparks, the absence of spark shield contributed to the accident. (See Appendix D.)

FRA's Emergency Order No. 3 (Appendix E) did not make the use of spark shields mandatory but required stringent surveillance when they were not used. Recently the FRA has adopted a permanent rule which requires the use of spark shields on cars used for the shipment of Class A explosives. (See Appendix F.)

Quality of MK 82 Bombs

In the course of the investigation, the Safety Board's staff found a number of deviations in the manufacturing process of the bombs involved in this accident, suggesting serious quality control problems which require correction. For example, the tritonal migration and crystals in the base plug area and crystals in the cavities were found which could cause an additional explosion. This deficiency is now known to appropriate officials of the Department of Defense. (See Appendix C.) The deviations in bomb production, however, probably had no influence on the cause or effects of this accident.

The condition of the pieces of pallet recovered at MP 1052.6 and MP 1048 indicates that the pallet was essentially intact before the explosion at MP 1052.6 and bomb fragments recovered at these locations disclosed no evidence of any internal reaction.

Inspection and Surveillance

Since the train and Car 38 were inspected numerous times along the way by many persons but the en route inspections did not detect the fire, on June 1, 1973, the Safety Board recommended that the FRA require more inspections and surveillance of car selection, loading, and transportation of munitions shipments (Recommendation R-73-24). FRA Emergency Order No. 3 partially implemented the recommendation. (See Appendix E.)

Even if the traincrew had detected the fire at MP 1052.6, the outcome of this accident probably could not have been materially changed. The bombs were transported in a closed car in which any heat produced by a fire or chemical reaction would have been confined and would have heated the lading. Means for coping with small fires before they affect heat-sensitive cargoes should be considered. Insulation systems, automatic fire-suppression systems, or thermal barriers or shields might solve this problem.

Regardless of the origin of the fire, the detection problem is critical. Crewmembers, who are required by Federal regulation to ride at least 15 car lengths from the explosives in transit, cannot be expected to detect fire or defects in those cars.

Although 49 CFR 174.525 specifies the kinds of cars for transporting Class A explosives, the regulations do not prohibit the use of a car having large amounts of combustible material in its structure, or in the blocking and bracing of the lading.

No effort has been made by the Federal Government, the shipper, the carriers, or the car manufacturer to design cars specifically for munition shipments. No fire detection or suppression system is used in cars carrying munitions.

Although the Safety Board could not conclude that the munitions cars in the accident failed to meet regulatory requirements, the inspection and loading procedures at McAlester and the conditions found in MKT 5394, which was cut out of the train at Waco, raised questions about compliance with the regulations. The broken floorboard and the failure to compensate for the bulged end of the car point to the need for improved inspection and loading procedures. The Federal Railroad Administration and the Navy have since taken steps to improve this condition. The FRA has adopted regulations which require more stringent inspection procedures and improved conditions for cars. (See Appendix F.)

The shifting of the lading in MKT 5394 resulted either from improper blocking or high-speed impacts. There was some indication that both had occurred. The maximum impact to be expected in normal rail transportation has never been defined. However, the Navy designed the blocking and bracing of munitions to withstand impacts of 8 mph. Either this standard was not met in MKT 5394, or the car was subjected to a potentially damaging impact which was not reported.

Explosions at the Main Crater Area

Based on the recordings of the seismograph and the crater patterns, there were at least three massive explosions at the main crater area, each involving several cars. Because the cars containing bombs were placed adjacent to each other in the train, several cars exploded simultaneously. Such placement is not consistent with the quantity distance separation principles practiced by the military in almost all of its procedures involving the handling of explosives. The size of the area threatened by these explosions suggests that some type of safety controls are needed to reduce the probability of simultaneous, multiple car explosion.

On June 1, 1973, the Safety Board also recommended that spacer cars be placed between cars of bombs to limit the total damage from such accidents. (See Appendix D.) Although considerably more switching would be required, the severity of the catastrophe can be reduced by separating the cars of bombs from each other. Smaller loads in cars, without use of spacers, might effectively limit the magnitude of the explosions. The Department of Defense is currently examining this issue.

The explosions occurred a few minutes before the train's planned arrival in Benson, Arizona, and shortly before it was due to arrive at Tucson. The potential for catastrophe in a densely populated area is apparent. Routing to avoid transporting bombs through populated centers, to the extent possible, should be considered as another means of limiting potential catastrophes.

Considerations for Corrective Measures

Control of multiple explosions in transportation -- Regulations now in effect are designed to reduce the likelihood of the initiation of accidents. However, they still occur. Therefore, there is a need to control the harmful effects and limit the losses in such accidents.

The DOT has authority to prescribe such "loss limiting" regulations for the movement of munitions in rail transportation. However, since the factors which contribute to the multiple explosions of munitions in adjacent cars in trains are not fully understood, methods by which this safety problem can be controlled, other than by separation, are unknown. The amount of separation required for particular loads is not known. The Department of Defense is examining the problem, and with its knowledge of the characteristics and behavior of the material it produces and utilizes, it should be in the best position to provide technical assistance to the DOT to correct this problem.

While safety controls are being developed, interim control measures, such as the use of "spacer cars" appears to be justified.

Safety of Explosives in Transportation Fires -- This is the second transportation accident 2/ investigated by the Safety Board involving

2/ Highway Accident Report, NTSB HAR-72-5, "Automobile-Truck Collision followed by Fire and Explosion of Dynamite Cargo on U.S. Highway 90 near Waco, Georgia, on June 4, 1971."

shipments of explosives capable of producing widespread injury and destruction when overheated, in which the overheating problem was not addressed in the regulations. In both accidents, the progression of the fires, when they occurred, and the absence of protection of the heat-sensitive cargoes against overheating, contributed to the increased losses. The need to resolve this safety problem continues and should be diligently pursued.

Coordinating Safety Compliance Efforts -- With respect to the transportation of hazardous materials, in general, including bombs, the responsibility for inspection and enforcement of the regulations concerning their packaging, loading and shipment is divided among several agencies. The regulatory complexity and intermodal scope of the problems involved in the transportation of hazardous materials were discussed in the Safety Board's report in connection with the Pan American Airways accident at Boston, Massachusetts. 3/ We find a demonstrated need for a coordinated compliance enforcement program at the Federal level.

CONCLUSIONS

1. The occurrence and control of car fires is a necessary consideration in the promulgation of safety requirements governing rail transportation of heat-sensitive hazardous materials shipments.

2. Neither the DOT regulations for the transportation of "Class A" explosives by rail, nor DOD requirements for loading and shipment of MK 82, 500-lb. bombs, prohibit the use of cars with wood floors.

3. Car 38 was susceptible to fire because it contained a contaminated wooden floor and because it was not equipped with spark shields to prevent sparks from striking the flooring or roller bearings which could preclude a hotbox condition.

4. Sodium nitrate impregnation and possibly excess oil sprayed from the journal boxes made the wood more sensitive to ignition and accelerated combustion after the fire ignited.

5. The accident events in this case began with a fire in Car 38. The physical evidence, suggesting the ignition of the car floor fire by brakeshoe sparks, though not conclusive, substantially outweighs the evidence of any other ignition sources.

6. There was no evidence of arson or sabotage.

7. None of the current visual or mechanical methods of surveillance of trains insures reliable detection of fires inside boxcars.

3/ Aircraft Accident Report, NTSB AAR-74-16, Pan American World Airways, Inc., Boeing 707-321C, N458PA, Boston, Massachusetts, November 3, 1973.

8. The wooden pallets, blocking, and bracing in Car 38 intensified the fire adjacent to heat-sensitive munitions.

9. Existing Federal regulations do not address the problem of detection and suppression of fires in railcars transporting munitions.

10. The explosion at MP 1052.6 was probably the bursting of the bomb casing caused by external heat, rather than the result of an internal chemical reaction.

11. The consecutive placement of the cars carrying bombs in the train increased the probability of the en masse, multiple-car explosions and increased the size of the danger zone in the accident.

12. The quality of the bombs deviated from the design specifications. Although the effects of these deviations on the safety of the bombs in transit could not be determined conclusively, the deviations probably did not initiate the fire in Car 38.

13. The requirements in 14 CFR 170 - 174 for removal of potentially hazardous residues from railroad cars after unloading were not clear as to responsibility for, or method for, proper and timely cleaning.

14. The circumstances of this accident indicate that improved coordination or integration of the compliance activities of all parties who prescribe safety requirements intended to assure safe transportation of hazardous materials could raise the overall level of safety. This warrants further study.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was the exposure of heat-sensitive bombs in Car 38 to a fire inside the car. The fire most likely originated from sparks off the brakeshoes which ignited the sodium nitrate impregnated floorboards.

RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The Secretary of Transportation reassess the regulations applicable to the packaging, loading, storing and transportation of military munitions and develop a safety compliance program to unify and coordinate Federal activities relating to the shipment of military munitions as now authorized by the Transportation Safety Act of 1974. (Recommendation R-75-8)

2. The Federal Railroad Administration in conjunction with the Secretary's program develop and require the use of a mechanism for the

timely detection of fire by crews of trains carrying Class A explosives. (Recommendation R-75-9)

3. The Secretary of Defense design, develop and use special rail cars for the transportation of military munitions which are constructed of noncombistible materials, or are otherwise resistant to ignition from sources external to the car, and reduce or eliminate the use of wooden or other combustible sheathing, blocking and bracing inside the cars. (Recommendation R-75-10)

As the result of this accident the Safety Board on June 1, 1973, made three recommendations to the Federal Railroad Administration which would require (1) the use of cars with roller bearings and either composition brakeshoes or spark shields in the transport of military munitions, (2) the placement of "spacer" cars between cars transporting munitions, and (3) increased inspection and surveillance of freight car loadings in the transportation of military explosives. (See Appendix D.)

The Federal Railroad Administration on November 19, 1974, promulgated a regulation effective July 1, 1975, establishing new requirements for selection, preparation, inspection, certification, and loading of rail cars transporting Class A explosives. (See Appendix F.)

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

February 26, 1975

APPENDIX A

CONSIST OF TRAIN SECOND BSM 22

Car Number	Load or Empty	Contents		
SP 1870—Caboose	Empty		107	1
SOU 263456	Load	Furniture	106	2
SOU 17025	Load	Paper	105	3
IC 136682	Load	Shpasc	104	4
SP 512163	Load	Vans	103	5
SOU 26724	Load	Shpasc	102	6
LINX 42491	Load	El Eqp	101	7
NW 164842	Load	El Eqp	100	8
DRGW 50245	Load	Furniture	99	9
TTBX 961864	Load	Trucks	98	10
SPFE 450459	Load	Beer	97	11
NP 96099	Load	Beer	96	12
MP 786033	Load	Beer	95	13
UPFE 454855	Load	Beer	94	14
SSW 34579	Load	Shpasc	93	15
SOU 40520	Load	Stoves	92	16
NW 285246	Load	Furniture	91	17
TTRX 962663	Load	Autos	90	18
CG 11369	Load	Walbrd	89	19
SSW 47712	Load	Claypr	88	20
SOU 30982	Load	Refgrs	87	21
FEC 92419	Load	Cndjui	86	22
CEI 3457	Load	Refgrs	85	23
SP 211433	Load	Prefab	84	24
CO 1239	Empty		83	25
CO 1188	Empty		82	26
CEI 701009	Empty		81	27
SP 224125	Load	Shpasc	80	28
SOU 508132	Load	Shpasc	79	29
SOU 45100	Load	Furniture	78	30
SOU 36741	Load	Fabric	77	31
SOU 263015	Load	Tires	76	32
SOU 308090	Load	Tires	75	33
SFRE 29225	Load	Gl fbr	74	34
SCL 20503	Load	Yarn	73	35
ACL 98127	Load	Pigirn	72	36
IC 422038	Load	Tires	71	37
UTLX 42200	Load	Chemicals	70	38
SSW 23412	Load	Fabric	69	39
UTLX 42467	Load	Chemicals	68	40
UTLX 84897	Load	Chemicals	67	41
DUPX 7424	Load	Chemicals	66	42
NW 310892	Load	Stlpip	65	43
NYC 150772	Load	Lumber	64	44
NW 161570	Load	Nuts	63	45
CNW 49	Load	Tanks	62	46
PRR 469463	Load	Concrt	61	47
NW 164145	Load	Fibers	60	48
SP 329157	Load	Alumn	59	49
ITC 7255	Load	Starch	58	50
ITC 7316	Load	Cereal	57	51
PFE 14710	Load	Bottle	56	52
PFE 456829	Load	Bottle	55	53
SP 660028	Load	Lumber	54	54
PLE 44189	Load	Stlpip	53	55
CN 556350	Load	Asbest	52	56
IC 422006	Load	Tires	51	57
NP 659997	Load	Heater	50	58
SSW 60696	Load	Fib Brd	49	59
SP 692997	Load	Clays	48	60
MKT 11614	Load	Zncash	47	61
MKT 5162	Load	Bombs	46	62
SOU 509067	Load	Bombs	45	63
NW 42242	Load	Bombs	44	64
MKT 6713	Load	Bombs	43	65
MKT 5557	Load	Bombs	42	66
MKT 6753	Load	Bombs	41	67
MKT 5569	Load	Bombs	40	68
MKT 5153	Load	Bombs	39	69
MKT 6259	Load	Bombs	38	70
MKT 6743	Load	Bombs	37	71
MKT 7071	Load	Bombs	36	72
SOU 500696	Load	Bombs	35	73
CCLX 80009	Load	Starch	34	74
UP 29589	Load	Scrap	33	75
UP 114795	Load	Lumber	32	76
ATSF 81216	Load	Fluspr	31	77
CCLX 80018	Load	Starch	30	78
NP 98164	Load	Clays	29	79
SP 652772	Load	Clays	28	80
GFCX 2392	Load	Cereal	27	81
MP 352031	Load	Tissue	26	82
PC 179879	Load	Tissue	25	83
SSW 28756	Load	Liquor	24	84
CO 24070	Load	Alumnm	23	85
EFCX 1155	Load	Tires	22	86
PLE 6170	Load	Tin plt	21	87
SP 694559	Load	Plastic	20	88
SSW 25918	Load	Aluminum	19	89
SP 691931	Load	Beer	18	90
RBCS 2542	Load	Beer	17	91
ATSF 625068	Load	Beer	16	92
TLDX 6288	Load	Corn	15	93
CS 2934	Load	Beer	14	94
UP 462112	Load	Beer	13	95
UP 462111	Load	Beer	12	96
RBCS 2601	Load	Beer	11	97
CBQ 43793	Load	Corn	10	98
NP 28878	Load	Corn	9	99
RTTX 150096	Empty		8	100
SP 337641	Empty		7	101
SP 692691	Load	Beer	6	102
RBCS 2860	Load	Beer	5	103
CBQ 17081	Load	Corn	4	104
GN 19945	Load	Corn	3	105
NP 43046	Load	Corn	2	106
SP 515237	Empty		1	107

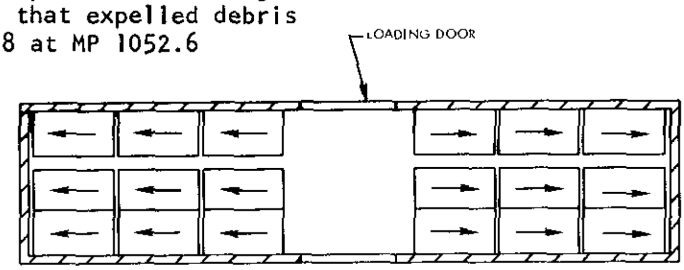
APPENDIX B

WR-52/150A

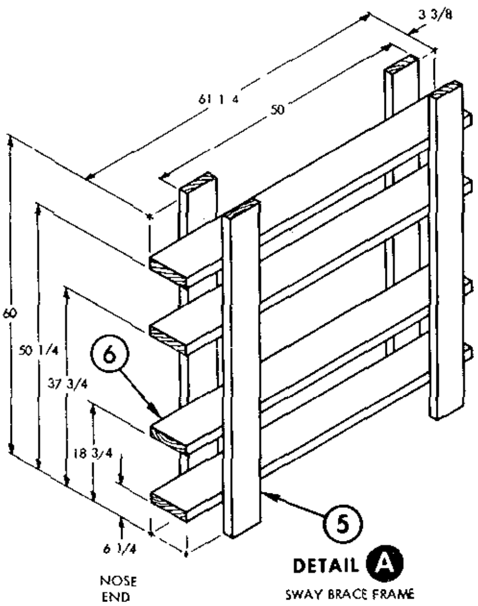
40 FT 6 IN. BOXCAR, COMMERCIAL

1 THE CARLOAD CONSISTS OF 36 UNIT LOADS WHICH MUST BE LOADED AND DUNNAGED IN ACCORDANCE WITH THIS PROCEDURAL DRAWING
2 WHEN LESS THAN CARLOAD (LCL) QUANTITIES ARE REQUIRED TO BE SHIPPED IN COMMERCIAL BOXCARS AND A PARTIAL LAYER RESULTS, THE PARTIAL LAYER OF LADING SHALL BE BRACED BY MEANS OF END BRACING AND/OR PARTIAL LAYER BRACING CONSTRUCTED IN ACCORDANCE WITH WR-52/100 SELECT THE TYPE OF BRACE TO COMPLY WITH THE WEIGHT OF THE UNITS TO BE RETAINED THE CENTER GATE HEIGHT SHOULD BE ADJUSTED AS REQUIRED QUANTITIES CAN ALSO BE ADJUSTED BY SUBSTITUTING DUMMY UNIT LOADS (SEE PAGE 42) AS REQUIRED TO COMPLY WITH LOAD LIMIT OR WEIGHT DISTRIBUTION RULES OF THE A A R
3 THE LOADS AS SHOWN ARE BASED ON CARS WHICH HAVE 6-FT WIDE DOORWAY OPENINGS AND ARE EQUIPPED WITH CONVENTIONAL SLIDING TYPE DOORS THE DEPICTED PROCEDURES AND METHODS OF BLOCKING ARE APPLICABLE TO BOXCARS EQUIPPED WITH CONVENTIONAL SLIDING TYPE DOORS OTHER THAN 6 FT WIDE PROVIDED DOORWAY PROTECTION WHEN REQUIRED IS INSTALLED IN ACCORDANCE WITH WR-52
4 THE SWAY BRACE FRAME SHOWN IN DETAIL A IS FOR BOXCARS WITH 9 -2 OR 9 -4" INSIDE WIDTH FOR BOXCARS WITH LESS THAN 9 -2 WIDTH, PIECE 6 OF DETAIL A SHOULD BE 2 x 4 MATERIAL AND FOR BOXCARS WIDER THAN 9 -4 PIECE 6 SHOULD BE 2 x 8 MATERIAL

Location of pallet containing
first bomb that expelled debris
from car 38 at MP 1052.6



LOADING PLAN



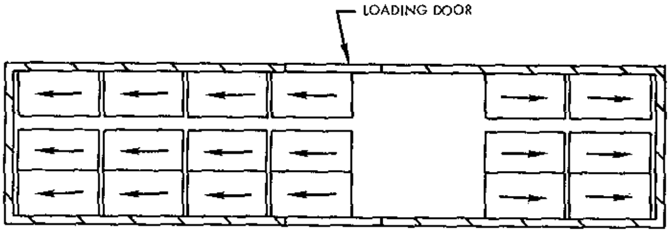
DETAIL A
SWAY BRACE FRAME
6 REQUIRED

*2 x 6 STRUTS DOUBLED AND LAMINATED WITH 10d NAILS MAY BE SUBSTITUTED IN PLACE OF 4 x 4 S

PIECE NO	DESCRIPTION	SIZE	NO PCS REQD	NAIL TO	NAILS NUMBER	NAILS SIZE
19	VERTICAL TIE BAR	2 x 4 x 66	6	15	2 PER JOINT	16d
18	HORIZONTAL TIE BAR	2 x 4 x CAR WIDTH-1	4	15	2 PER JOINT	16d
17	HOLD DOWN CLEAT	2 x 6 x 24	4	16	5	10d
16	GATE HOLD DOWN	2 x 6 x 10 FT	2	CAR WALL	5 EACH END	10d
15	STRUT	4 x 4 x WEDGE FIT*	24	11	2 PER JOINT	16d
14	SWAY BRACE STOP	2 x 6 x 30	2	11	3 PER JOINT	10d
13	CENTER GATE HORIZONTAL	2 x 4 x CAR WIDTH-1	2	11	3 PER JOINT	10d
12	CENTER GATE STRUT CLEAT	2 x 4 x CAR WIDTH-1	8	11	3 PER JOINT	10d
11	CENTER GATE VERTICAL	2 x 6 x 72	12	SEE 10	-	-
10	CENTER GATE HORIZONTAL	2 x 6 x CAR WIDTH-1	8	11	3 PER JOINT	10d
9	SWAY BRACE STOP	2 x 4 x 72	4	SEE 8	-	-
8	SEPARATOR GATE HORIZONTAL	2 x 4 x CAR WIDTH-1	8	7 9	3 PER JOINT	10d
7	SEPARATOR GATE VERTICAL	2 x 6 x 72	36	SEE 8	-	-
6	CROSS BRACE	2 x 6 x 61 1 4	24	SEE 5	-	-
5	SWAY BRACE VERTICAL	2 x 6 x 60	24	6	3 PER JOINT	16d
4	END WALL MEMBER	2 x 4 x 72	2	3	1 PER FOOT	10d
3	END WALL MEMBER	2 x 4 x 72	2	CAR WALL	1 PER FOOT	10d
2	END WALL MEMBER	2 x 6 x 72	18	1	1 PER FOOT	10d
1	END WALL MEMBER	2 x 6 x 72	18	CAR WALL	1 PER FOOT	10d

LIST OF MATERIALS AND NAILING DATA

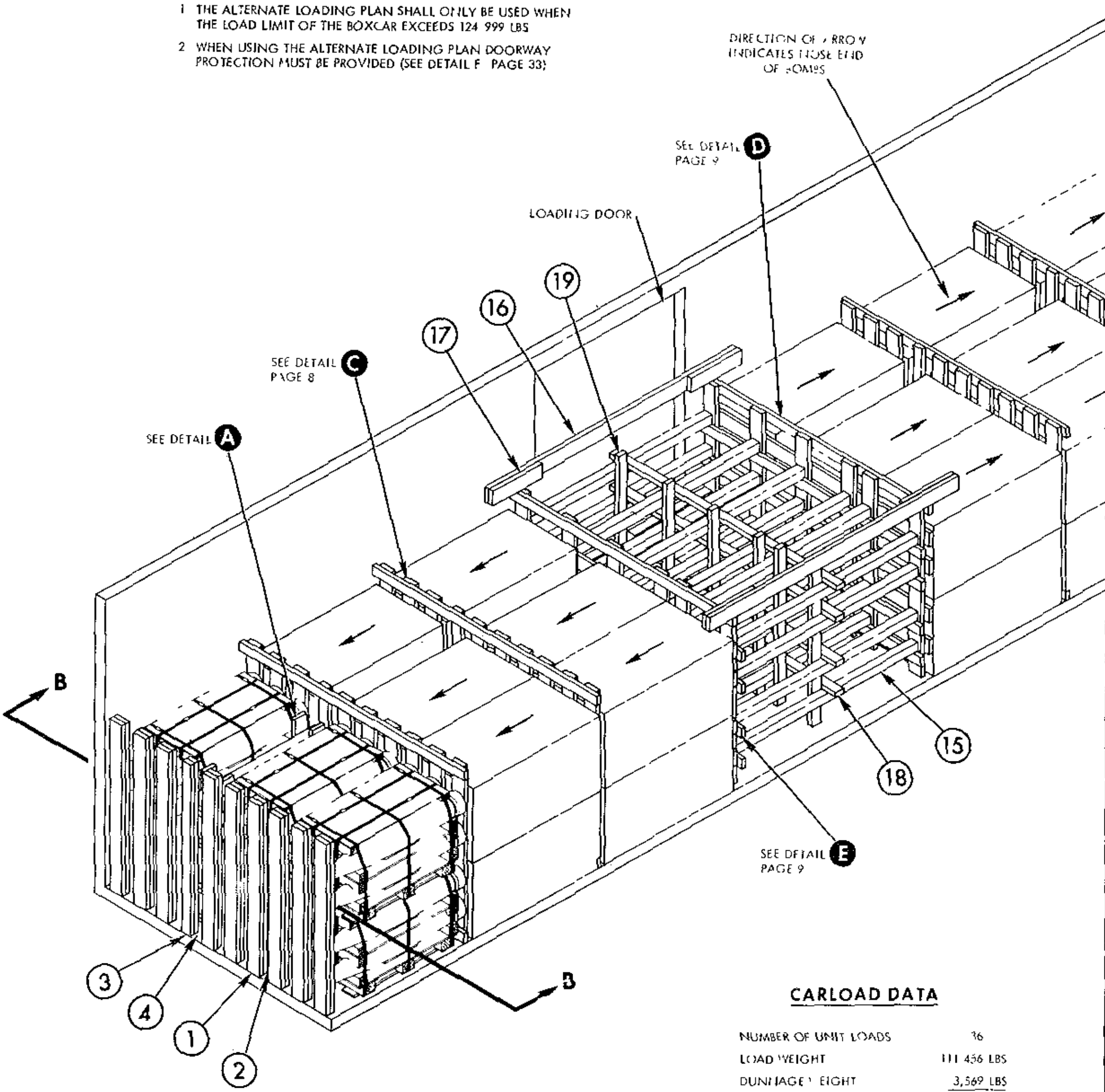
APPENDIX B
WR-52/150A



ALTERNATE LOADING PLAN

1 THE ALTERNATE LOADING PLAN SHALL ONLY BE USED WHEN THE LOAD LIMIT OF THE BOXCAR EXCEEDS 124 999 LBS

2 WHEN USING THE ALTERNATE LOADING PLAN DOORWAY PROTECTION MUST BE PROVIDED (SEE DETAIL F PAGE 33)



CARLOAD DATA

NUMBER OF UNIT LOADS	36
LOAD WEIGHT	111 456 LBS
DUNNAGE WEIGHT	3,569 LBS
CARLOAD WEIGHT	115 025 LBS

APPENDIX C

Examples of "Defect Conditions" Found in MK 82 Bombs
Reported in U. S. Naval Ammunition Depot, Hawthorne, Nevada,
"Evaluation Report on GP Bomb MK 82 - Benson Incident"
dated 14 March 1974

1. Explosive on base fuze cavity liner flange.
2. Explosive on bomb body, base threads (up to 3" around bottom 6 threads).
3. Explosive against base plug.
4. Excessive TNT/Aluminum separation.
5. Explosive migrated behind sealing compound.
6. Lumps of aluminum powder in explosive mixture.
7. 1/16" circumference piece (appeared to be explosive) in base cavity.
8. Charging tube contained approximately 1/8" piece of material which appeared to be explosive.
9. Wrench hole on shipping cap screw 2/3 full of material, appeared to be explosive.
10. Minute splashes of material on small area of bomb exterior which appeared to be explosive.
11. Approximately 1/16" piece of material under base cap, appeared to be explosive.
12. Approximately 1½" void between base plug and explosive charge.
13. Traces of material on bomb body counterbore appears to be explosive.
14. Explosive on base plug starting thread.
15. Explosive on base plug-fuze liner seat surface extending approximately 3" around circumference.
16. Explosive in fuze liner threads flush with thread major diameter and extends into last two threads approximately 2" around liner threads.
17. Material, probably anti seize compound, in base cavity liner thread undercut. Excessive amount on all base component threads and seat surface material in liquid state.

APPENDIX C

18. Material in nose liner appears to be explosive.

19. Explosive leaked through fuze cavity liner retainer-fuze cavity liner threads into base cavity liner.

20. Approximately 1" void between explosive and sealing compound.

21. ¼" diameter shrinkage cavity adjacent to charging tube and 4" long.

22. Approximately ¼" thick layer of explosive on base fuze liner-base plug seat surface, fuze liner thread and thread undercut. Covers 3 threads around 2/3 of circumference.

23. No evidence of anti-seize or "lock-tite" on bomb body or base plug threads.

24. Low concentrations of unidentified materials in chemical tests of certain samples.

25. One sample of tritonal with alkalinity of .0041% (pH of 7.68).

UNITED STATES OF AMERICA

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

APPENDIX D

ISSUED: June 1, 1973

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 1st day of June 1973

FORWARDED TO:

Honorable John W. Ingram
Administrator
Federal Railroad Administration
Washington, D. C. 20590

SAFETY RECOMMENDATION R-73-22 thru 24

The explosion of 12 carloads of bombs in the Southern Pacific Transportation Company train near Benson, Arizona, is being investigated by the National Transportation Safety Board. This accident involved the transportation of military munitions containing a mixture of trinitrotoluene and aluminum powder. This mixture or variations thereof have been involved in three explosions in rail transportation of which the Safety Board is aware, including the explosion at Benson on May 24, 1973, an explosion at Roseville, California, on April 28, 1973; and an explosion at Tobar, Nevada, on June 29, 1969.

At this time, it has not been determined what probably caused the explosion at Benson. Until our investigation can be completed and this determination made, we cannot make the final or the most efficient recommendations to prevent future accidents of this nature. However, it appears that specific actions should be taken even before our investigation is complete to reduce the possibility of the exploding of these munitions in transportation, and to reduce the effects of such explosions if they occur.

Explosions can occur when the cargo is exposed to excessive heat. One source of excessive heat in rail transportation is the overheating of friction journal bearings, and the burning of oil and pads used in lubricating friction bearings. Roller bearings are less likely to overheat then friction bearings on railroad cars. The elimination of lubricating devices and free oil in friction bearing assemblies would minimize the likelihood of open flames should the bearing assemblies overheat.

Another source of excessive heat occurs during brake applications or when brake shoes are dragging significantly. Cars equipped with standard cast iron brake shoes experience higher wheel temperatures during such braking operations than cars equipped with composition brake shoes. In addition, cast iron brake shoes produce a "sparking" phenomenon, during which hot metal occurring at the face of the brake shoes can be thrown against the car body. To minimize the temperatures attained during braking operations and to minimize the possibility of sparking, the use of composition brake shoes is desirable.

The Safety Board has no direct evidence of overheating of friction bearings, heating from brake applications or dragging shoes in this accident at this time. Nevertheless, these conditions are possibilities.

Some railroad cars are equipped with "spark shields" to prevent brake shoe sparks from striking the wooden floors. Such spark shields are installed on many box cars of the type used to transport the munitions. Their presence reduces the likelihood of car floor fires.

In addition to reducing the likelihood of overheating of such cargoes, efforts to reduce the effects of the explosions, when they occur, appear necessary. In both the Benson and Roseville explosions, the cars containing the munitions were located in consecutive order within the trains. In both instances, the explosions progressed through the adjacent cars until the munitions in all cars had exploded. At Tobar, Nevada, the chain of explosions terminated when the next car in the chain contained a nonexplosive cargo. This indicates that separation of the cars carrying explosives in trains would reduce the magnitude of the total damage by reducing the probability that explosion would spread to other cars, irrespective of the initial cause.

For transportation, munitions are heavily braced with wood dunnage inside the railroad cars. Of the 13 cars shipped in this case, one car was delayed en route, and the other 12 were destroyed at Benson. Observations of the surviving car indicated that minor shifting of some of the dunnage had occurred in transit, and that the floor was damaged. There has been one instance in recent years in marine transportation when dunnage failure preceded a low order explosion. While dunnage failure has not been determined to be a factor in the Benson accident, increased surveillance of the loading and bracing of such shipments would nevertheless appear desirable at this time. Increased surveillance of the loading and bracing of shipments of these cargoes would reduce the possibility that cargo might be shifting, with undesirable consequences, in rail shipments.

APPENDIX D

In view of the foregoing, and until its investigation of the Benson accident is concluded, the National Transportation Safety Board recommends that the Federal Railroad Administrator:

1. Issue temporary regulations requiring the use of cars with roller bearings and either composition brake shoes or spark shields for the rail transportation of military explosive munitions of the type involved in the Tobar, Roseville, and Benson explosions.

2. Require, on a temporary basis, the placement of at least one "spacer" car not containing materials regulated under 49 CFR 172-177 between cars of munitions when munitions cars are en route between origin and destination in railroad transportation service.

3. Increase inspection and surveillance of the car selection, loading and transportation of military explosives of the type involved in the Tobar, Roseville, and Benson accidents, enlisting the assistance of the Bureau of Explosives and the Department of Defense, as necessary, to assure conformance of such transportation with current regulations and best known safety requirements.

These recommendations will be released to the public on the issue date shown above. No public dissemination of the contents of this document should be made prior to that date.

By: John H. Reed
Chairman

APPENDIX E

Federal Railroad Administration

[FRA E.O. No. 8]

TRANSPORTATION OF TRITONAL BOMBS

Emergency Order Regarding Class A Explosives

As a result of investigations of recent rail accidents and incidents involving the transportation of Tritonal Bombs (Class A Explosives), the Federal Railroad Administration (FRA) has determined that the use of low-sparking brake shoes and adequate spark shields or increased inspection and surveillance of car selection and transportation of Class A explosives are essential to prevent further occurrences Although the accidents involving Class A explosive bombs which occurred on the Southern Pacific Transportation Company at Roseville, California on April 28, 1973, and at Benson, Arizona on May 24, 1973, are still under investigation, on June 1, 1973, the National Transportation Safety Board (NTSB) issued its safety recommendation R-73-24 In R-73-24 the NTSB recommended that the FRA issue temporary regulations requiring "Increased inspection and surveillance of the car selection, loading and transportation of military explosives of a type involved in Tobar, Roseville, and the Benson explosions"

In addition to the action recommended by the NTSB, the FRA believes that an effort must be made to eliminate sources of excessive heat in the rail transportation of these munitions and that increased inspection is needed of those car components which can cause such heat. One source of excessive heat is the sticking of brakes In addition, cast iron brake shoes can produce a "sparking" condition which can cause hot metal sparks to be thrown against and ignite a wooden car body Similarly, the application of high-friction composition brake shoes to a car equipped for the application of low-friction composition shoes may cause a fire in the brake shoe which can be transmitted to the wooden floor of a car body

I have thoroughly reviewed this matter and conclude that the present practice of transporting Class A explosives creates an emergency situation involving a hazard of death or injury to persons affected by the use of railroad equipment in transporting the explosives Therefore, pursuant to the authority contained in section 203 of the Federal Railroad Safety Act of 1970 (45 U S C 432), I am hereby issuing the following order:

ORDER

In addition to the requirements of Parts 170-189 of Title 49 of the Code of Federal Regulations governing the transportation of explosives, effective 12:01 a m, August 16, 1973, a railroad may transport Class A explosives only under the following conditions:

(a) Each car transporting Class A explosives must be designed for and equipped with one of the following types of brake shoes All brake shoes on the car must be of the same type and of a type for which the car is designed. All brake shoes must be in a safe and suitable condition for service, and in compliance with the wear limit set forth below according to type of brake shoe:

Type of brake shoe	*Wear limit* Brake shoe must have a uniform thickness of more than—
Low friction composition	3/8 inch
High friction composition	3/8 inch
High phosphorous	1/2 inch

(b) Except as provided in subdivision (c) of this order, each car transporting Class A explosives must be equipped with—

(1) A continuous steel sub-floor; or

(2) Metal spark shields, located on each side of the center sill, extending continuously from the center sill to the side sill, and continuously from the end sill to a point not less than one foot beyond the tread of the inside wheel of the car truck and which do not have an accumulation of oil, grease, or debris constituting a fire hazard

(c) A car which does not meet the requirements set forth in subdivision (b) of this order may be used to transport Class A explosives under the following conditions:

(1) The car transporting Class A explosives and each car coupled to that car in a train must be inspected as provided in clause (2) of this subdivision, by employees qualified to make the inspection, while the train is stopped at each of the following points:

(i) Where the train and engine crews are changed;

(ii) Immediately before traversing a 1 75 percent or more descending grade of 10 miles or more in length;

(iii) The first point practicable after traversing a 1 75 percent or more descending grade of 10 miles or more in length, but not more than two miles after descending the grade;

(iv) The first point practicable after the automatic air brakes have been in continuous application on a moving train for a period of 30 minutes or more; and

(v) The first point practicable after an emergency application of the automatic air brakes

(2) The inspection required by clause (1) of this subdivision must be conducted to determine that—

(i) The air brakes are released;

(ii) There is no evidence of fire;

(iii) There is no evidence of overheating of brake shoes, wheel rims, wheel treads, or journals; and

(iv) The car suspension system and draft gear assembly are in a safe and suitable condition for service

(3) With respect to an inspection made under clause (2) of this subdivision—

(i) If there is evidence of sticking brakes, measures must be taken to assure that air brakes and hand brakes are fully released.

(ii) If any evidence of overheating of any component of a car is discovered, or the suspension system or draft gear assembly of a car are found to be in an unsuitable condition for service, each defective car must be set out from the train, or the train may proceed at a speed of not more than 10 miles per hour to the nearest point where each defective car can be removed from the train Cars set out from the train under these conditions may not be used for the transportation of Class A explosives until they have been repaired, inspected, and certified as safe and suitable for service by a responsible mechanical officer of the railroad concerned If a car cannot be certified to be in a safe and suitable condition for service, the Class A explosives lading must be transferred to a car which meets the requirements set forth in this order before they are transported by rail

A civil penalty of not less than $250 nor more than $2500 will be assessed for each violation of this order and each day of such violation will constitute a separate offense

An opportunity for review of this order is provided in accordance with section 554 of Title 5 of the United States Code

(Sec 203, 84 Stat 972, 45 U S C 432; and § 1 49(n) of the regulations of the Office of the Secretary of Transportation, 49 CFR 1 49 (n)).

Issued in Washington, D C on August 9, 1973

JOHN W. INGRAM,
Administrator.

[FR Doc 73-16804 Filed 8-13-73;8:45 am]

APPENDIX F

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON DC 20590

41365

[Docket No HM-114; Amdt No 174-24]

PART 174—CARRIERS BY RAIL FREIGHT

Rail Cars Used To Transport Class A Explosives

This amendment prescribes standards to eliminate potential fire hazards resulting from overheated friction journal bearings, overheated and sparking brake shoes, and the presence of combustible material on the undersides of cars used to transport Class A explosives It establishes new requirements for selection, preparation, inspection, certification and loading of these railroad cars

On February 6, 1974, the Hazardous Materials Regulations Board published a notice of proposed rulemaking (NPRM), Docket No HM-114; Notice No 74-1 (39 *FR 4668*), *which proposed this amendment* The reasons for this amendment were discussed in that notice of proposed rulemaking Interested persons were invited to comment and several comments were received by the Board In addition, a public hearing was held on March 21, 1974, to provide interested persons an opportunity to present information orally to assist the Board in developing a final rule in this proceeding All written comments received and those made at the public hearing have been fully considered by the Board The interest shown and the views expressed are appreciated by the Board

The major issues raised in these comments involve bearings, brake shoes, and spark shields These issues were discussed at length in the NPRM and are also discussed separately below

Bearings One commenter strongly opposed requiring all box cars used to transport Class A explosives to be equipped with roller bearings He noted that solid bearing cars travel an average of one million miles before occurrence of an overheated journal or "hot box" and that only four percent of these result in reportable accidents This average mileage figure is expected to improve as more cars are equipped with stabilized bearings under an industry specification which requires the owning railroad to stabilize bearings whenever it disassembles a truck Because of the expected improvement in the ratio of overheated journals and freight car miles operated, the present requirement that trucks and journals be inspected before a car is loaded with Class A explosives, and the substantial investment of the railroad industry in "hot box" detectors, this commenter contended that there is no factual basis for excluding solid bearing box cars from Class A explosives service Any type of bearing can fail for any number of reasons, including poor design, bad maintenance and undetected structural flaws Since the primary cause of solid *bearing failure is inadequate servicing* and any existing service-related defects will be corrected during the required preloading inspection, he concluded that cars equipped with solid bearings should remain acceptable for the transportation of Class A explosives

One commenter stated that if the proposed roller bearing requirement were adopted it would create a serious shortage of cars available to transport Class A explosives

After carefully considering these arguments, the Board still believes that safety considerations require that all box cars used to transport Class A explosives be equipped with roller bearings after December 31, 1975 Cars transporting Class A explosives should be equipped with the safest journal bearings available because a major cause of derailments due to equipment failures is the overheating of journals In its report entitled "Journal *Failure Report*" dated October 1972, the FRA established that in the years 1968, 1969 and 1970, the failure ratio of plain bearings to roller bearings was 11 4, 8 1 and 5 8, respectively The report projected that the failure rate of plain bearings would probably level off at about three times the failure rate of roller bearings By January 1, 1976, sufficient time will have elapsed since issuance of Emergency Order No 3, by the Federal Railroad Administration (FRA) on August 9, 1973 (38 FR 22172), for car owners and railroads to locate and equip a sufficient *number of cars to transport Class A* explosives Approximately one-half of the national rail car fleet is equipped with roller bearings and all new cars placed in service are equipped with roller bearings.

Brake Shoes None of the commenters opposed the proposed elimination of cast iron brake shoes However, two commenters vigorously opposed elimination of high phosphorous brake shoes on cars used to transport Class A explosives One commenter submitted extensive test data to support its contention that with respect to the fire hazard, the high phosphorous shoe coupled with the Association of American Railroads standard spark shield, is the safest material developed for braking railroad freight cars

Both commenters also stated that the sparking of high phosphorous shoes under heavy sustained braking promptly stops when the brakes are released On the other hand, it was noted that, while high friction composition brake shoes do not spark under these conditions, they may ignite and burn freely and will continue to burn freely with an open flame after the brakes have been released

Both commenters recognized the hazards inherent in the possible *misapplication* of standard metal brake shoes instead of high phosphorous brake shoes One commenter relied upon a program for positive identification of high phosphorous brake shoes which is now underway within the railroad supply industry to resolve this problem The other commenter indicated that the high phosphorous brake shoe may soon replace the cast iron brake shoe and that this would eliminate any possibility for misapplication of metal shoes

FRA has carefully considered these *comments but still believes that the exclusive* use of high-friction composition brake shoes on cars transporting Class A explosives is necessary to assure safety Sparks resulting from the friction of a brake shoe wearing on a wheel tread provide a high potential for ignition of any exposed combustible material The high-friction composition brake shoe has a practically zero sparking effect

The risk of high friction composition shoes igniting and burning is rather remote since combustion occurs only under the most severe and sustained braking conditions Although the high phosphorous type brake shoe exhibits a dramatically reduced tendency for sparking compared to the common cast iron shoe, it is still a metallic material which can produce sparks under certain braking conditions

Spark Shields Two commenters opposed the spark shields proposed by FRA They contended that composition brake shoes alone provide sufficient protection on cars not equipped with spark shields and that high phosphorous shoes on cars equipped with the smaller AAR standard spark shields provide a sufficient degree of safety

FRA does not agree The criteria re*quiring spark shields is the flammability* of material exposed to ignition from truck effects such as overheated journals, dragging equipment, and sparks from braking Although the high-friction composition brake shoe has minimal sparking characteristics, there is no positive assurance that metal type brake shoes will not be substituted in error Although measures have been developed recently to prevent misapplication of cast iron shoes on brake heads intended for none other than high-friction composition type brake shoes, it will be years before these measures are implemented and become totally effective In the interim, and pending availability of sufficient cars with all-metal sub-flooring, the security of Class A Explosives demands the protection of the larger FRA spark shields

Several commenters suggested that the FRA require the placement of at least one spacer car not containing hazardous materials regulated under 49 CFR Parts 170–189 between cars of explosives This suggestion and a number of other suggestions which were beyond the scope of a notice of proposed rulemaking are being studied by the FRA and may be the subject of future rulemaking proceedings

Several commenters requested clarification of the term "qualified inspector" in the proposed amendment Accordingly, FRA has changed this term to "qualified person designated under § 215 - 15 "

In consideration of the foregoing, Title 49 of the Code of Federal Regulations, § 174 525 is amended by revising paragraphs (b) (1), (3), (4), (6), (11), (12), (13), and (14) and by revising paragraphs (c) (1) and (3) as follows:

§ 174.525 Loading packages of explosives in cars, selection, preparation, inspection and certification.

* * * * *

(b) Certified closed cars must be inspected inside and outside, other cars must be inspected as applicable to the type of cars and must conform to the following specifications:

(1) Closed cars of not less than 80,000 pounds capacity, with steel underframes and friction draft gear, must be used except that on narrow-gage railroad explosives may be transported in cars of less than that capacity provided the available cars of greatest capacity and strength are used for this purpose

* * * * *

(3) Must have no holes or cracks in the roof, sides, ends, or doors through which sparks may enter, or unprotected decayed spots which may hold sparks and start a fire

(4) The roof of the car must be carefully inspected from the outside for decayed spots, especially under or near the running board, and such spots must be covered or repaired to prevent their holding fire from sparks A car with a roof generally decayed, even if tight, must not be used

* * * * *

(6) The roller bearings or journal boxes, and the trucks must be carefully examined and put in such condition as to reduce to a minimum the danger of hotboxes or other failure necessitating the setting out of the car before reaching destination The lids or covers of journal boxes must be in place After December 31, 1975, the car must be equipped with roller bearings

* * * * *

(11) The car must be equipped with high-friction composition brake shoes only and brake rigging designed for this type of brake shoe Each brake shoe on the car must be at least three-eighths inch thick, and in safe and suitable condition for service

(12) The car must have either a metal sub-floor with no combustible material exposed beneath the car, or metal spark shields extending from center sill to side sills and from end sills to at least 12 inches beyond the extreme treads of the inside wheels of each truck, which are tightly fitted against the subfloor so that there is no vacant space or combustible material exposed The metal sub-floor or spark shieds may not have an accumulation of oil, grease, or other debris which could support combustion

(13) The carrier must have the car examined by a qualified person designated under § 215 15 of this title to see that it is properly prepared, and must have a "Car Certificate" signed in triplicate upon the form prescribed in paragraphs (c) (2) and (3) of this section before permitting the car to be loaded

(14) Except as provided in § 174 584 (h), a car must not be loaded with any explosives, class A, until it shall have been thoroughly inspected by a qualified person designated under § 215.15 of this title who shall certify as to its proper condition under this section and shall sign Certificate No 1 prescribed in paragraphs (c) (2) and (3) of this section

(c) * * *

(1) For all shipments loaded by the shipper, a qualified person designated under § 215 15 of this title must inspect the finished load and certify to its compliance with this part before the car shall be accepted for transportation; and Certificate No 2 as prescribed by paragraphs (c) (2) and (3) of this section shall be signed before the car is permitted to go forward When a car is loaded by the carrier, Certificate No 2 must be signed only by the representative of the carrier

* * * * *

(3) Car certificate: The following certificate, printed on strong tag board measuring 7 by 7 inches, or 6 by 8 inches, must be duly executed in triplicate by the carrier, and by the shipper if he loads the shipment; the original must be filed by the carrier at the forwarding station in a separate file; and the other two must be attached, one to each outer side of car to the fixed placard board or as otherwise provided

-------------------------------- Railroad

CAR CERTIFICATE

No 1 ------------------ Station ------, 19--

I hereby certify that I have this day personally examined Car Number -- and that the car is in condition for service and complies with the FRA Freight Car Safety Standards (49 CFR Part 215) and with the requirements for freight cars used to transport explosives prescribed by the DOT Hazardous Materials Regulations (49 CFR Part 174)

(Qualified Person
Designated Under
49 CFR 215.15)

This amendment is effective July 1, 1975 However, compliance with the regulations, as amended herein, is authorized immediately The Federal Railroad Administration will publish a separate notice revoking Emergency Order No 3 published in the August 16, 1973, issue of the FEDERAL REGISTER (38 FR 22172); this revocation will also become effective July 1, 1975

(Secs 831–835 of Title 18 United States Code; sec 9, Department of Transportation Act (49 U S C 1657); § 1 49(f) of the regulations of the Secretary of Transportation (49 CFR 1 49 (f)))

Issued in Washington, D C on November 19, 1974.

ASAPH H HALL,
Acting Administrator, FRA Board Member for the Federal Railroad Administration

[FR Doc 74-27763 Filed 11-26-74;8:45 am]