RAILROAD ACCIDENT REPORT

PENNSYLVANIA RAILROAD
TRAIN PR-11A, EXTRA 2210 WEST AND TRAIN SW-6, EXTRA 2217 EAST
DERAILMENT AND COLLISION
DUNREITH, INDIANA
JANUARY 1, 1968

ADOPTED: DECEMBER 18, 1968

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D. C.
20591

FOREWORD

This report of facts and circumstances and determination of probable cause by the National Transportation Safety Board, is based on facts developed in investigation conducted by the Federal Railroad Administration, and is supplemented by information obtained from a representative of the Office of Hazardous Materials, Department of Transportation; from observations at the scene of the accident the 2 days following the accident by a Member of the Safety Board and a representative of the Board's Railroad Safety Division, and additional information developed from inquiries, of State and local sources. In developing its recommendations, the Safety Board has considered the suggestions of the Federal Railroad Administration made in forwarding the investigatory data, the observations of the representative from the Office of Hazardous Materials, and data obtained from various other sources. The recommendations made herein, however, are recommendations of the Safety Board.

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SYNOPSIS

About 9:30 p.m., January 1, 1968, Pennsylvania westbound freight train PR-11A, consisting of 98 cars and a five-unit diesel-electric locomotive, was passing Dunreith, Indiana, at 42 miles per hour when the trailing wheels of the 88th car, an empty tank car, AESX 850, derailed at a broken rail near the eastern edge of the town. At the same time, eastbound freight train SW-6, consisting of a five-unit diesel-electric locomotive and 106 cars, was moving eastward at 32 miles per hour on the adjacent track.

The derailed car in train PR-11A continued westward until it became disengaged from its trailing truck when it struck the crossing boards at a grade crossing about 723 feet west of the point of original derailment. One or more cars collided with cars of hazardous materials moving in the opposite direction in SW-6's train, causing a general derailment and puncturing several tank cars of flammable material. A large scale fire ensued, followed about 45 minutes later by a violent explosion of a tank car of ethylene oxide. Immediately after the derailment and outbreak of fire, the entire population of Dunreith was evacuated without injury.

The fire and explosion destroyed a cannery and several residences and businesses in the vicinity. There were no injuries in the derailment but three firemen and two policemen were slightly injured by the fire and explosion. Firefighters were hampered in their

activities by a lack of information as to the nature of the hazardous materials and their lack of expert knowledge of the materials involved and necessary equipment to cope with the large fire.

One car of acetone cyanohydrin, a powerful poison, which was punctured and set afire was the source of cyanides which contaminated an adjacent stream, causing, the loss of several farm animals. About two million gallons of cyanide-contaminated water have been recovered from the water table by special wells and treated before discharging to the nearby stream since the accident. Traces of cyanides are still evident in the water table at the time of this report; however, the drinking water in the area was not contaminated. The remaining contamination continues to be monitored regularly by the Indiana State Board of Health and is considered under control by the Board of Health.

The probable cause of the initial derailment in train PR-11A was the broken rail within the compromise joint where two different sizes of rail were joined.

A contributing causal factor was the inadequate track maintenance which left the joint unsupported and allowed the development of the break in the rail. This initial derailment and the design of the lift-off type of center-pin connection between the truck and body of AESX car 850 which allowed the truck to separate from the car under impacts of a simple derailment, led to the secondary collision and general derailment.

The collision and general derailment led to the intense fire, explosion, and contamination of water by the poisonous chemical. Contributing causal factors were, (a) the large volume of flammable and poison liquids in tank cars which were located next to one another in the train and flowed rapidly out of the tanks after the tanks were mechanically punctured; (b) the shortage of information and lack of firefighting equipment necessary to extinguish promptly the fire around the ethylene oxide tank; (c) the destruction of the heat insulation of the tank; and (d) the failure of pressure relief valves to vent sufficiently to prevent the very rapid buildup of pressure consequent to uncontrolled heating of the ethylene oxide.

I. FACTS AND CIRCUMSTANCES

A. Location and Method of Operation

The accident occurred at Dunreith, Indiana, which is about 40 miles east of Indianapolis. It is located on that part of the Buckeye Division of the Pennsylvania Railroad's Western Region between Columbus, Ohio, and Thorne, Indiana, (Indianapolis). The railroad at this point is a double-track line running east and west. Approaching the point of initial derailment from the east, there are 1,500 feet of 0.33 percent descending grade changing to a 0.08 percent ascending grade about 400 feet east of the point of derailment. The track is straight in this area. The westward track is designated No. 2 Main Track; the eastward track, No. 1 Main Track. A single-track line of the Norfolk and Western Railway Company crosses the Pennsylvania tracks at grade on the eastern edge of the town, 296 feet west of Dunreith interlocking station.

At the accident site, U. S. Route 40, a four-lane highway, is 40 feet north of the Pennsylvania tracks and generally parallel to them. Water Street crosses the main tracks at grade about 981 feet west of the interlocking station. A side track serving the canning plant and anhydrous ammonia storage tank has a trailing-point switch in No. 1. Track, 1,481 feet west of the interlocking station.

Dunreith Interlocking, consisting of two mainline crossovers, extends from 223 feet west of the interlocking station to a point 209 feet east of the interlocking station. A home signal, governing westbound movement on No. 2 Track, is located 391 feet east of the interlocking station, and the home signal governing eastbound movements on No. 1 Track is located 855 feet west of the interlocking station. Dunreith Interlocking Station was not manned on the day of the accident because of company instructions closing this station on January 1, 1968.

The initial derailment of PR-11A occurred 258 feet west of the block station and the general derailment and resulting wreck occurred 1,611 feet west of the interlocking station.

In this area, Pennsylvania trains operate on a two-track system with the current of traffic by indications of an automatic-block signal system, supplemented by a cab-signal system. Trains PR-11A and SW-6 were operating as extras. Both trains were equipped with train radio by which the train and engine crews could communicate with each other, with other trains, and with land stations within range. The maximum authorized speed for freight trains through Dunreith is 50 miles per hour.

B. Description of the Accident

1. Description of Trains Involved

Pennsylvania train PR-11A, operating as Extra 2210, west, was a westbound freight train which left Columbus, Ohio, on January 1, 1968, at 5:22 p.m. The locomotive consisted of diesel-electric units 2210, 6328, 2442, 6113, and 6075 coupled in multiple-unit control. In addition to the locomotive, train PR-11A consisted of 62 loaded cars and 36 empty cars, including the caboose, making a gross tonnage of about 4,000 tons.

The locomotive was equipped with a speed-recording device which recorded the locomotive's speed on tape.

At the time of the accident, the engineer of PR-11A was operating the locomotive from the customary seat on the right-hand side of the locomotive. The fireman and the head brakeman were in the cab of the locomotive with the engineer, and another brakeman was in the cab of the fifth locomotive unit. The conductor and flagman were in their normal positions in the caboose.

Train SW-6, operating as Extra 2217 East, occupying the adjacent track, was an eastbound freight train which left Pine (Indianapolis), 4.5 miles west of Thorne, at 8:31 p.m., January 1, 1968, and passed Thorne at 8:45 p.m. The locomotive consisted of diesel-electric units 2217, 2339, 2423, 2656, 2628 coupled in multiple-unit control. The five-unit locomotive was pulling a train of 90 loaded cars and 16 empty cars, including the caboose, with a gross tonnage of approximately 5,900 tons. Located in the train as the 23rd through the 27th cars were the following cars of hazardous materials:[1/]

Location In Train	Car Identification	Capacity Gallons	Content
23rd car	RTCX 26706	20,922	Acetone Cyanohydrin
24th "	NATX 21758	20,900	Acetone Cyanohydrin
25th "	UTLX 23787	20,510	Methyl Methachrylate
26th "	GATX 83568	20,500	Ethylene Oxide
27th "	GATX 30751	33,500	Vinyl Chloride

1/ See Appendix 2 for description of hazardous materials.

The locomotive was equipped with a speed-recording device and radios as described for train PR-11A.

The engineer was operating the locomotive from the right seat in the lead unit and the fireman was on the left seat; the head brakeman was in the second unit; the extra brakeman was in the fifth unit, and the conductor and flagman were in the caboose.

The rest and hours of service of all members of both train and engine crews were within the requirements of the Hours of Service Law. The required brake tests had been made on both trains before the accident and the brakes had functioned properly when used en route

2. <u>Events Leading Up to Initial Derailment</u>

After leaving Columbus at 5:22 p.m., westbound train PR-11A passed Newman, 29 miles east of Dunreith at 8:54 p.m. Approaching Dunreith, the train was running at 42 miles per hour. Approach signal No. 1459, east of Dunreith Interlocking Station, and the eastward home signal, 391 feet east of the interlocking station, displayed clear aspects. This allowed the train to proceed at the maximum authorized speed of 50 miles per hour. The engineer had encountered nothing unusual since taking over the train.

Eastbound train SW-6, after leaving Pine at 8:31 p.m., passed Thorne, 32 miles west of Dunreith, at 8:45 p.m. Approach signal 151.4, 2.75 miles west of Dunreith Interlocking Station, and the eastward home signal, 855 feet west of the interlocking station, displayed clear aspects as SW-6 approached them. This authorized SW-6 to run at maximum authorized speed of

50 miles per hour, but the train was traveling only 32 miles per hour because of tonnage and motive power. The engineer had noticed nothing abnormal about the train's operation in its run from Pine.

Approaching Dunreith about 9 30 p.m., the engineer of PR-11A saw the headlights of SW-6's locomotive approaching and contacted its engineer by radio to exchange identifications. As the trains were passing and SW-6's locomotive was approaching the Water Street grade crossing, the engineer and fireman noticed sparks and fire coming from beneath one or more cars of PR-11A's train. The engineer of SW-6 warned the engineer of PR-11A on the radio to stop his train. At the same time, the crewmembers of SW-6 heard track ballast striking the locomotive. However, an emergency application of the train brakes occurred before the engineer could react to SW-6's message. He immediately notified the engineer of SW-6 that the train brakes were in emergency and immediately was informed in return that the brakes of SW-6's train were also in emergency.

The crew of the last train to pass Dunreith on No. 2 track, 9 hours before PR-11A, stated that they noticed no abnormal condition in the Dunreith area. Neither the engineer, fireman, nor the head brakeman of PR-11A noticed any abnormal track condition or operation approaching or passing Dunreith. Their first indication of trouble was when SW-6's engineer warned them on the radio about sparks and fire coming from beneath their train.

3. Initial Derailment and Events Leading up to General Derailment

The 88th car in PR-11A's train was an empty tank car, AESX 850. The trailing wheels of the rear truck of AESX car 850 derailed to the north at a broken rail in a compromise joint. The joint was in the north rail 258 feet west of the Dunreith Block Station and 38 feet east of the N&W crossing. This compromise joint was at the west end of a length of 131-pound RE rail where it was joined to a length of 130-pound PS rail, which was east of the 130-pound PS crossing frog.1/

The receiving end (east end) of the 130-pound rail was found broken into several pieces after the accident. The first piece to break out of the rail end completely, apparently did so while Train PR-11A was passing over it. Two recovered pieces of the broken rail and the receiving end of the piece remaining in track west of the joint were heavily battered by the passage of a number of wheels over them. 2/ The wheels of all of the cars in train PR-11A which were east of the compromise joint when the rail broke, passed over the break, but only the trailing wheels of the rear truck of AESX car 850 derailed at this point.

The first mark of derailment was a wheel flange mark on a crosstie between the rails, 19 feet and 9 inches west of the point where the north rail had broken. This mark was 12 inches north of the south rail. There were additional marks on track appliances between

1/ See Appendix 3.
2/ See Appendix 4.

this point and the N&W Railway crossing where the derailed wheels mounted the rail-bound crossing which was directly in their path. The flange mark of the north wheel traversed the crossing at the juncture where the running rail is bound to the easer rail. (The easer rail is a strengthening member of the crossing which is bolted to the running rail.) West of the rail crossing, beyond the point of derailment, there were intermittent flange marks indicating that the wheels had continued westward to the grade crossings at Water Street in a derailed state. Thus the derailed wheels and AESX car 850 bounced over two heavy rails directly across their path.

4. Sequence of Events in the General Derailment and Resulting Fire and Explosion

After passing the N&W crossing, the derailed wheels of the empty tank car next struck the planking adjacent to the north side of each rail at the Water Street grade crossing. At this point, the trailing truck became separated from the tank car soon after striking the crossing planks, which bounced the car upward.

These trucks are designed to be easily removed from the car merely by lifting the body of the car in a manner similar to the lifting which occurs in a bounce. A body center plate on the bottom of the body bolster rests in the truck center plate on the truck bolster, and location in the horizontal plane is maintained by a center pin 1-3/4 inches in diameter which enters a hole in the body center plate.[1/] The body must lift only about 6 inches before the pin emerges from the hole with the result that, except for the pin which fastens the brake rod, the truck is free to separate from the car.

1/ See Appendix 6.

When the trailing truck became detached, AESX car 850 separated from the following car with a resultant emergency application of the train brakes. The tank car was equipped with conventional brakes and couplers. The following car, TTX 151184, was equipped with a standard interlocking coupler; however, this did not prevent the tank-car coupler from coming out of the top of the following coupler, which allowed complete disengagement. The derailed truck, after striking the grade-crossing planks, moved away from the track.

The detached trailing truck moved away from both tracks and stopped 150 feet west of the grade crossing, about 6 to 8 feet north of Track No. 2. AESX car 850, without its rear truck, remained coupled to the front portion of train PR-11A and was dragged about 1,900 feet until the front portion stopped.

At the time the rear truck of AESX car 850 became detached from the car, train SW-6 was passing in the opposite direction on Track No. 1. At this point, there was approximately 3 to 4 feet clearance between cars of the passing trains.

Damage evidence indicates that TTX car 151184, which was directly behind the empty tank car, was derailed at the leading end, and this car was the first car to strike train SW-6. This collision was followed by the general derailment and separation of train SW-6 which in turn resulted in an emergency application of the train brakes of SW-6.

TTX car 151184, in train PR-11A, initially impacted NAHX car 51995 and PRR car 32895 in train SW-6. NAHX car 51995 (non-hazardous) was derailed by the initial impact but remained coupled and was dragged to a stop. Car PRR 32895 was directly ahead of five successive tank cars of hazardous materials, all of which were derailed.

The major concentration of wreckage was located approximately 600 feet west of the Water Street grade crossing and adjacent to a cannery. The wreckage scene is shown by sketch at Appendix 7. The railroad track at this point was laid in a cut, bordered on the south by a retaining wall about 8 feet high. Fourteen cars of both trains were derailed here, including the five tank cars carrying hazardous materials in train SW-6. Three trailer-carrying cars in train PR-11A obstructed U. S. Route 40 running adjacent to the track at this point. The remaining six cars came to a stop in various positions on the railroad right-of-way. One gondola car, PRR 619964, not a part of either train and standing on a siding near the cannery, also was derailed.1/

The 37th through the 42nd cars in train SW-6 derailed west of the general derailment. Slack action resulting from the colliding cars and emergency brake application probably caused these cars to derail. Three of these cars obstructed the opposing No. 2 Track at this point.

1/ See Appendix 7, 8, 9.

Immediately after the emergency brake application in train SW-6, the area around the cannery was engulfed in a sheet of flames.

At 9:35 p.m., members of the locomotive crew on train SW-6 requested that firefighting equipment be sent to Dunreith. This request was made via the train radio on the locomotive and received by the railroad operators at Newman and Thorne. On receipt of the train radio report from the crew on train SW-6, officials of the railroad requested assistance from the Sheriff's Office in Henry County and the Indiana State Patrol, and these organizations arranged for dispatch of several local fire companies and ambulances to Dunreith. The first patrolman arrived at the scene a few minutes later. Firefighting equipment and police personnel from neighboring communities arrived shortly after the State Patrol.

When the caboose of train PR-11A came to a stop, a crewmember went to the nearest railroad wayside telephone but found that the lines were damaged. Within a few minutes after the accident, this crewmember proceeded to U. S. Route 40 in an effort to stop traffic. He informed the State Patrolman that there were tank cars in the center of the fire which represented a grave danger. Members of the locomotive and train crews moved the front part of train PR-11A, which was obstructing a road crossing, to permit firefighting equipment to reach the scene of the accident.

It was not known at this time what cars were involved in the fire or what materials were burning. To identify the cars, the number of the last car still on the track (20th car of SW-6) was obtained and transmitted to railroad personnel at Thorne via the train radio. At this time, it was learned that hazardous materials cars were in the train near the wreckage. A member of the locomotive crew on train SW-6 then went back toward the town to warn people to stay away from the train and fire because of the danger from hazardous materials in the train.

At 9:45 p.m., railroad officials also requested assistance from the chemical warfare unit at Fort Benjamin Harrison in Indianapolis. Emergency wreck trains were immediately dispatched by the railroad officials to the scene from Indianapolis, Richmond, and Logansport, Indiana; also from Columbus, Ohio.

Between midnight and 8·00 a.m., January 2, personnel of the railroad, in conjunction with the Sheriff's Office of Wayne County, requested gas masks and airborne equipment to combat the fire. No gas masks were available from these installations, and the airborne equipment was either inadequate or lacked the necessary chemicals to use on the fire. An Indiana State Police supplementary report revealed that about 50 self-contained gas masks could have been secured from fire departments in the surrounding counties, but their presence was not known.

After checking with other military installations in the midwest, it was learned that the only airborne equipment capable of handling the fire at Dunreith was being used to fight forest fires and was on the West Coast.

The fire started at the 27th car, GATX 30751, containing vinyl chloride (uninhibited), which came to rest in an upright position almost parallel to the right-of-way. (See Appendix 7.) Approximately 15 percent of the leading head of the tank shell was torn away in the collision. Its contents of vinyl chloride spilled at a rapid rate and ignited almost instantaneously. A derailment produces multiple spark sources which were available to initiate combustion. The ensuing fire then spread to the acetone cyanohydrin and the methyl methacrylate materials escaping through the punctures in the tanks of RTCX car 26706 and UTLX car 23787, respectively.

The 23rd car, RTCX 26706, containing about 19,200 gallons of acetone cyanohydrin, a material which is both flammable and poisonous, came to rest on its side against the retaining wall. The tank was punctured by an unidentified object at the top of the leading head, and at the bottom by a length of rail. The acetone cyanohydrin was discharged on the ground within a very short time. Part of the acetone cyanohydrin burned and part of it seeped into the ground. Through an underground drain line, part of the acetone cyanohydrin found its way into a nearby creek, thence to the Big Blue

River.[1/] A full description of the results of poisoning and counter-pollution measures taken appears later in the report.

The 25th car, UTLX 23787, containing flammable methyl methacrylate monomer, came to rest on its side almost parallel to the right-of-way, with the dome pointing to the north. The sheet metal of the insulating jacket on the tank was torn. The liquid leaked out through a puncture about 6 inches in diameter. It is not known what made this puncture, but its appearance indicated that it was probably gouged by another car during the derailment.

The 24th car, NATX 21758, containing acetone cyanohydrin, came to rest in an upright position at about a 90° angle to the railroad right-of-way. The tank was not punctured but received heavy damage. The lower side of the tank was buried in the dirt. There was a slight loss of the material. During the fire, vapors were burning around the dome of the tank, indicating that the pressure had increased sufficiently to open the safety valves, but that the pressure had later decreased, and the valves again closed.

The 26th car, GATX 83568, containing ethylene oxide, came to rest in an upright position diagonally between Tracks 1 and 2. The jacketing material was partly torn away by the impact and exposed the shell to the heat. The shell did not show signs of being mechanically punctured by the impact. The car was engulfed in flames shortly after the general derailment. Burning vapors from the dome indicated that the pressure relief valves were operating. The flame

1/ See Appendix 10

was described as being of a bright blue color. About 45 minutes after the initial fire, the volume and pitch of the sound from the pressure relief valve increased. This was taken as a warning by those who heard it. Verbal warnings by police and railroad employees prompted firefighters and bystanders to withdraw hurriedly from the immediate area. As they were running from the scene, the ethylene oxide exploded with violent force. The fire mass which followed immediately, took the shape of a fan opened to slightly less than 180°, with the tips of the fan appearing to witnesses to extend over the greater part of Dunreith on both sides of the railroad tracks. It quickly formed into a near-perfect sphere with narrower proportions, and subsequently mushroomed vertically into the atmosphere. The fire was described as being blue-white by eye witnesses near the scene and as orange-yellow by eye witnesses at a distance.

The dome of the exploded tank car, weighing about 1,600 pounds, was propelled a distance of about 720 feet into the residential area. The dome gouged a hole 2 feet deep in the frozen ground, ricocheted off the corner of a house, and came to rest about 60 feet away. The concussion caused by the explosion of GATX car 83568 damaged residential and business structures in Dunreith and surrounding areas, and knocked firefighters, policemen, and bystanders to the ground. One firefighter was knocked from the cab of a fire engine. The back of a police officer's jacket was burned away; however, the officer escaped with minor injuries to his forehead.

Examination of the torn metal failed to show any evidence of a local hot spot which could have allowed the tank to explode at pressure less than its ultimate pressure resistance. This examination was made by a representative from the Office of Hazardous Materials, Department of Transportation, and a Safety Inspector from the Bureau of Railroad Safety, Federal Railroad Administration.

5. Evacuation and Efforts to Control Fire

The explosion spread the flames to the area north of U. S. Route 40. All residents were evacuated with assistance of personnel from fire and police departments and other community organizations. This was followed by a blockade of the town. By 3:15 a.m. on January 2, 1968, fire had destroyed the canning factory and four migrant workers' homes on the south side of the track and three residences on the north side. The hazard was increased by minor chemical explosions, toxic fumes, and poisonous byproducts from burning chemicals. Many cans of tomatoes in the burning cannery exploded from the heat.

According to a Dunreith fire offical, the fire was of such intensity when the Dunreith Fire Department arrived that it was impossible to approach the scene closely enough to initiate firefighting procedures.

Efforts to control the fire were further complicated and delayed because it was not known what materials were burning and what methods should be used to fight the fire. The cardboard "Dangerous" placards on the five cars of hazardous materials involved in the accident were immediately destroyed. Only one of the five cars bore legible painted markings after the fire.

Two tank cars of anhydrous ammonia on the side track, a 12,000-gallon storage tank, and 15 small mobile tanks nearby were impinged by fire. None of these tanks ruptured; however, there was evidence that the pressure relief valves on some of the mobile tanks operated.

The possibility of additional explosions and toxic gases prevented the firefighting units from combating the fire that had spread to two residences on the north side of U. S. Route 40. The possibility of toxic vapors being carried to neighboring communities also prompted warnings to the residents in communities northwest of Dunreith.

Following the explosion of the tank car of ethylene oxide, consultation between the State Patrol, personnel of the local fire departments, and railroad personnel led to a decision to let the fire burn until it was definitely determined how it could be combated in a safe manner. This decision was based on information concerning methods of fighting chemical fires supplied by personnel of one of the fire departments, as well as the limitations of the available fire-fighting equipment.

The accident was not reported immediately by the Pennsylvania Railroad to the Bureau of Railroad Safety, Federal Railroad Administration, but the Bureau received information of its occurrence about 12:30 a.m., January 2, 1968, through one of the wire services. (When no serious injuries or fatalities are involved, the railroad is not required to report an accident to any Federal agency by telegraph or telephone.)

Upon receiving this information, a representative of the Bureau of Railroad Safety contacted the Pennsylvania Railroad to learn the nature of the accident and was informed that several cars of hazardous materials were involved. The Bureau of Railroad Safety immediately notified its regional supervisor, and three inspectors were assigned to investigate the accident. The Bureau also notified the Office of Hazardous Materials of the Department of Transportation, which sent a representative who arrived at the accident scene about 4:15 p.m., on January 2, 1968.

A member of the National Transportation Safety Board, accompanied by the Chief of its Railroad Safety Division, also arrived at the accident scene during the afternoon on January 2, 1968.

An inspector of the Bureau of Explosives of the Association of American Railroads at Columbus, Ohio, was notified of the accident by the Pennsylvania Railroad at 10:30 p.m., January 1, 1968. He was informed that the derailment involved dangerous articles and that one tank car had exploded and a fire was burning. The inspector arrived at the scene about 9:00 a.m., on January 2, 1968, about 10 hours after the report. The Bureau of Explosives did not make available to the Safety Board a report covering its activities in connection with this accident.

A short time after the accident the Indiana State Patrol contacted the State Health Commission. Within a few hours, representatives of the Indiana State Board of Health and the Indiana Stream

Pollution Control Board were at the accident scene. There it was found that early inspection of the wreckage was not possible due to fire, explosions, smoke, and fumes.

At 3:15 a.m., January 2, 1968, railroad officials notified the shipper of the vinyl chloride and ethylene oxide about the derailment and erroneously advised them that their cars were not directly involved in the general derailment and fire. The shipper of the acetone cyanohydrin and methyl methacrylate was notified about the accident at 4:00 a.m., c.s.t., January 2, 1968, by the railroad.

About 4:30 a.m., January 2, 1968, the Indiana State Patrol alerted the police organization at Wright-Patterson Air Force Base in Dayton, Ohio, and indicated the need for foam equipment to control the chemical fire resulting from the accident. Two foam units, accompanied by the Base Fire Chief and an assistant fire chief, were sent to the accident scene and arrived at Dunreith about 8 a.m., January 2, 1968. Personnel from Fort Benjamin Harrison at Indianapolis arrived at the accident scene about 8:15 a.m., January 2, 1968.

After consultation among the Indiana State Patrol, railroad representatives, and local fire officials, it was decided that no attempt would be made to extinguish the fire until representatives of the shippers of the hazardous materials involved were consulted concerning the reaction that might result from using water and foam. Wright-Patterson personnel also advised against the employment of railroad personnel downwind from the burning chemicals.

Clearing of the wreckage was begun by the railroad by 5:15 a.m., January 2, 1968. By 10:55 a.m., two of the railroad cars directly involved in the main wreckage were removed clear of the railroad tracks. One was the flatcar that had obstructed U. S. Route 40, but close to the burning tank cars and somewhat downwind from the burning chemicals and wreckage. This action was dangerous to the workers because of the hazard of possible additional explosions and toxic fumes.

The wreckage was burning when the chemical experts representing the shippers arrived at 10:30 a.m., January 2, 1968. Fire departments were containing the conflagration and railroad wreck crews were working where they could.

At the request of the State Police, the chemical experts immediately surveyed the site from an upwind position. At this time, one car was burning at the relief valve on the dome and another was burning around the bottom of the tank shell, but it was not known whether acetone cyanohydrin, methyl methacrylate, or vinyl chloride was burning. Ethylene oxide had been ruled out by deduction, based on the behavior of the fire and explosion. All personnel were kept out of the area until it had been determined that the vinyl chloride had probably vaporized and did not present a fire or explosion hazard. Wrecking operations were discontinued during this inspection and the wrecking machinery withdrawn from near the accident site. A decision was made by the chemical technicians then to permit firemen to extinguish the flames around the tank cars. The tank cars were then cooled with water from the fire hoses, and a closer inspection was made of the wreck area by the chemical experts.

6. Post-Fire Events

A post-fire examination, made on the afternoon of January 2, 1968, indicated acetone cyanohydrin in NATX car 21758 had, for the most part, remained intact. The handling of the loaded car in cleanup operations became a major problem. The lower side of the tank was buried in the dirt and its structural condition was unknown; therefore, it was decided to transfer the contents to tank trucks provided by the shipper. Pumping through the dome of the tank was started on the morning of January 3. The transfer operation, a dangerous task under the most favorable conditions, was hampered by railroad wreck crews working in proximity to this car containing hazardous material. A Safety Board observer noted several instances when the crew performing the transfer ran rapidly from the scene because of unexpected incidents related to the simultaneous clearing operations.

Wrecking operations were resumed by the railroad at about 3:50 p.m. on January 2, 1968. The clearing operations in the main wrecking area were again discontinued on January 3, 1968, as a precaution to all personnel in the area during the time the acetone cyanohydrin in NATX car 21758 was being transferred to tank trucks.

By 10:25 p.m., January 2, 1968, 11 of the derailed cars, including one of the tank cars, had been placed clear of the railroad tracks. The remaining derailed cars were removed from the tracks by 6:00 p.m., January 3, 1968.

Residents of Dunreith were permitted to return to their homes starting about 6:30 p.m., January 3, 1968.

In early afternoon on January 4, 1968, U. S. Route 40 was opened and the blockade lifted on Dunreith.

Tests for cyanide and cyanide fumes were made by the Indiana State Board of Health sometime during January 2 or January 3, in and around the accident site. There is no evidence, however, that tests were made at anytime for the presence of other toxic fumes in the atmosphere and toxic chemicals in the ground that could have been injurious to workmen and others working in and around the wreckage.

Contamination of the water in nearby Buck Creek was suspected about 10:15 a.m. on January 2, 1968, when dead farm animals were sighted in and along the creek about three-fourths of a mile from the accident scene. Later in the afternoon of January 2, when it was possible to examine the tank cars and the ground area, it was found that acetone cyanohydrin from RTCX car 26706 had found its way into Buck Creek through an underground tile drain. The acetone cyanohydrin which was released and was not consumed by fire resulted in two major hazards which were: (a) stream pollution and (b) ground water pollution.

(a) Stream Pollution[1/]

The Indiana State Board of Health and the Stream Pollution Control Board initiated emergency procedures on January 2, 1968, to determine the nature and extent of the stream pollution. The phenolphthalein test

1/ See Appendix 10

was used to determine how far the cyanide contamination extended in the streams below Dunreith.

Samples were collected from Buck Creek at various points along the nine-mile stretch from Dunreith to Knightstown. The Big Blue River at Knightstown was monitored for the presence of cyanide every 30 minutes throughout the night of January 2, and the early morning of January 3. Analysis of samples revealed a maximum concentration of 405 mg/l (milligrams per liter) in Buck Creek and 20 mg/l in the Big Blue River.

Tests made for acetone in the water from Buck Creek found it to be substantially in the same ratio to cyanide as present in the original mixture. Samples from the Blue River, further downstream, showed that the acetone was decomposing.

The cyanide slug was approximately 8 hours long when it passed Carthage, Indiana, with a maximum cyanide content of 15.6 mg/l.

The analyses made by the State agencies showed that the cyanide was being reduced by decomposition and by dilution as it flowed downstream, but not at a rate sufficient to reduce the concentration below the recommended maximum before the waters reached the city of Seymour. As the water polluted by the cyanide was a supply source for this city, representatives of the Indiana State Board of Health decided upon treatment of the cyanide in the river.

(b) <u>Ground Water Pollution</u>

Some of the acetone cyanohydrin was recovered under the supervision of the shipper and the Indiana Board of Health. Three trenches were dug down to the clay stratum about 33 to 44 inches below the surface at the accident scene, and the chemical that had accumulated in the trench was pumped into tanks and hauled to the shipper's plant for disposal. Approximately 1,200 gallons of the chemical were recovered in this manner. Trenching was also done along the right-of-way east and west of the area to define the extent of the contamination and locate the 10-inch drain tile that carried the chemical to Buck Creek. Because of the closeness of certain private water wells to the sewers, the home owners near the sewerline were advised not to use the water for drinking or cooking purposes. Weekly sampling and analysis of the wells were initiated.

During January 5 and 6, 1968, 6,200 pounds of calcuim hypochlorite were added gradually to the waters of the Big Blue River at State Road 44, west of Shelbyville, This treatment effectively reduced the cyanide concentration. By the time the residual cyanide in the slug reached Seymour, the maximum cyanide content was .015 mg/l, which is below the U. S. Public Health Service recommended maximum of .020 mg/l.

The maximum concentration of cyanide at various sampling points was as follows:

City	Cyanide Concentration	Approx. Distance from Accident
Carthage	15.600 mg/l	15 miles
Morristown	7.800 mg/l	20 miles
Noah	3.100 mg/l	30 miles
Shelbyville	1.800 mg/l	35 miles

City	Cyanide Concentration	Approx. Distance from Accident
State Road 44*	1.000 mg/l	40 miles
Edinburg	.100 mg/l	50 miles
Columbus	.040 mg/l	60 miles
Azalia	.019 mg/l	70 miles
Seymour	.015 mg/l	80 miles

* All samples from State Road 44 to Seymour were taken after treatment with calcium hypochlorite.

The raw river water and finished water at the water treatment plant in Seymour were monitored each hour while the cyanide was passing.

Following the initial emergency procedures, arrangements were made to have the Pennsylvania Railroad make a ground water exploration study. Consultants employed by the railroad recommended that exploratory wells be installed. The railroad subsequently arranged for 13 exploratory wells to be drilled at locations surrounding the area.

With the installation of the test wells, additional trenching was done at the accident scene and adjacent to the sewerline that carried the acetone cyanohydrin to Buck Creek to determine if the area of contamination had migrated. This work showed that the chemical had not migrated laterally, but had contaminated the soil near the surface in an area approximately 125 feet by 50 feet and down 3 feet to a clay stratum. An analysis showed that a considerable portion of the chemical penetrated the clay along the footing of the retaining wall on the south side of the railroad right-of-way and migrated through a sand and gravel stratum to the aquifer at the 22- to 29-foot depth.

After completion of the exploratory wells, samples of the ground water were taken three times a week and analyses made for cyanide on a weekly basis. The results showed that the contaminated ground water had not migrated beyond the immediate area of the accident.

On March 12, 1968, the railroad had an 8-inch recovery well drilled about 50 feet south of the spill area and tanks and chlorination equipment installed for treatment of the contaminated ground water. Starting on March 15, contaminated ground water was pumped into two 10,000-gallon tanks and treated with caustic soda and gaseous chlorine. The treated water, after being stored for a period of time, was released to Buck Creek. Periodic checks showed the water did not cause contamination.

Melting snow in March and heavy rains in early April raised the ground water level about 2 feet. Additional cyanide was flushed into the water table, and the contaminated ground water moved southwestward. With this development, the railroad was asked to install additional exploratory wells, a second recovery well, additional treatment tanks, and chlorination equipment. The railroad was asked to complete sealing along the footing of the retaining wall at the accident scene and the enclosure of the contaminated surface area with a bentonite barrier.

By April 20, 1968, the railroad had installed three additional treatment tanks, four additional exploratory wells, a second recovery well, and had started the bentonite sealing work. By April 22, a total of 728,450 gallons of contaminated ground water had been adequately treated. Results of the tests showed that a cone of depression in the water table had been created which extended beyond the contaminated area, and all ground water was flowing toward the recovery wells, thus preventing contamination of the ground water in adjacent areas. As of the latter part of May 1968, a total of 1,835,650 gallons of ground water had been adequately treated and discharged to Buck Creek. This treatment was to continue until the cyanide concentration in the ground water was lowered to a safe level.

It is estimated that about 1,200 gallons of acetone cyanohydrin was recovered by trenching and pumping at the spill area. Another 1,200 gallons is estimated to have escaped into streams via the 10-inch drain tile. Treatment of ground water from recovery wells indicated that at least another 1,500 gallons had seeped into the ground around the spill area. The hazards created by the pollution of ground water and receiving streams by the acetone cyanohydrin were reduced by the fact that the fire had consumed about 75 percent of the 19,200 gallons of the acetone cyanohydrin.

7. Casualties and Damges

There were no deaths and only minor injuries to three firemen and two policemen as a result of the explosion of the ethylene oxide.

Dunreith's major industry, the tomato cannery, and seven residences, including four migrant workers' cottages, were completely destroyed by the fire and explosion, and 87 other residences and businesses were damaged, totaling about $500,000 in property damage. All families were restricted from returning to their homes and businesses for 2 days, and travel on U. S. Route 40 was restricted for almost 3 days.

The Pennsylvania Railroad's preliminary estimate of damage to its own property and related costs due to the wreck was $500,000.

Cost of the total manpower could not be estimated. The total numbers of people involved during the emergency, exluding the railroad's and shipper's employees included 60 State patrolmen, three local police departments, 29 fire departments, three civil defense units, three Red Cross chapters, two ambulance services, one Salvation Army unit, and one first aid department. A number of State employees and contract personnel were involved in the evaluation of the poison situation and decontamination of the ground and river water.

C. Track

1. Description of Track

Approaching Dunreith Interlocking from the east, the rail in No. 2 Track is 132-pound, laid new in 1947. This runs to the vicinity of the westward home signal where it connects to 131-pound rail, which in turn connects to 140-pound rail. The 140-pound rail runs through the west switch of the crossover. In the north rail, it is joined to 131-pound rail which, in turn, is joined to the piece of 130-pound rail which broke. The 130-pound rail which broke was 25 feet 10 inches long and joined to the northeast leg of the N&W crossing by an insulated joint. West of the N&W track, the 130-pound crossing is joined to succeeding rails by insulated joints and compromise joints in a manner similar to the track east of the crossing. Beyond the compromise joints, the track westward is of 131-pound construction.

The track structure consists generally of rail connected with six-hole joint bars, fully bolted, laid on double-shoulder tie plates. The rail and tie plates are fastened to standard 7"x9" crossties, spaced 24 ties per 39-foot rail, by four rail-holding and four additional track spikes. There are generally six rail anchors applied for the normal direction of traffic and two for the reverse direction. The ballast is slag.

The crossing at grade with the single-track N&W line is of 130-pound bolted-rail construction. The condition of the crossing was good.

The line and surface of No. 2 Track approaching the point of derailment were irregular. There was an abrupt low spot in the surface of the south rail of about 1¼ inches at the trailing-point switch of the crossover (35 feet east of the point of derailment), as noted by the Bureau of Railroad Safety. Two consecutive crossties under the compromise joint, at which the 130-pound rail broke, had settled to the point that they were not supporting the compromise joint. This settlement was estimated by personnel of the Bureau of Railroad Safety as being about 1 inch. After the derailment, this settlement was compensated for, and support of the new joint was provided by the installation of new wooden shims on this and several other adjacent ties. There were additional visually noticeable low spots in both rails east of the point of derailment which would have tended to cause the passing freight cars to rock and oscillate vertically.

The maximum variation of cross level of opposite rails on tangent track allowed by the Pennsylvania Railroad's Form C.E. 78 for this location is three-quarters of an inch in less than 31 feet. Measurements made by Pennsylvania Railroad engineering personnel indicate that there were a number of variations in cross level which exceeded this specification in the area east of the N&W crossing. Measurements of the gage made at the same time indicated variations from 56-1/4 to 56-7/8 inches, in an inconsistent pattern. The gage to be maintained in this area was specified to be 56-1/4 inches by the Pennsylvania Railroad's Form C.E. 78.

The last general work performed by the Pennsylvania Railroad in the area on No. 2 track was completed during the last week of November 1967. This work consisted of a Railway Maintenance Corporation Spot Tamper tamping low joints and correcting cross level through Dunreith Interlocking.

The assigned Track Patrol Foreman inspected this track on foot, on December 29, 1967, 3 days before the derailment, but no report of unsafe conditions or improper maintenance was made.

In the area of the initial derailment, the ballast was fouled with frozen mud and dirt. This fouling was judged by an NTSB observer at the site to be sufficient to restrict the drainage.

The compromise joint was a four-hole joint, made to fit 130-pound rail on one end and 131-pound rail on the other end. The compromise joint bars were 27 inches long. Since the bolts had been replaced, it is not known how many bolts were in this joint before the derailment. The compromise joint in the opposite rail, and of similar design and size, had only three bolts when inspected the day after the accident. The Pennsylvania Railroad's Form C. E. 78 specifies that rails "of different sections must be brought to an even surface and gage at joints" by "compromise joints of approved designs." The use of both four-hole and six-hole joints is authorized, however, no statement is made as to the advantages of using one or the other.

The rail that broke was 130-pound, PS section, manufactured by the Illinois Steel Mills in 1929. This piece of rail was 25 feet 10 inches long and was re-laid in this location in 1944 as second-hand rail. A chemical analysis of samples from the broken rail, made by the Chief Chemist, Penn Central Transportation Company,1/ indicated a chemical composition within the limits recommended by the American Railway Engineering Association.

Examination of fragments of the rail indicated that the rail broke progressively into several pieces.2/ The final break in the head was 18 inches from the receiving end, and at the base, was 23 inches from the end. From the batter marks on the recovered pieces, it is determined that a 5-inch piece broke out of the receiving end of the

1/ The Pennsylvania Railroad was merged with the New York Central to form the Penn Central Transportation in February 1968.

2/ See Appendix 4.

rail head first. The surfaces exposed by this break showed a crack of long standing, originating at the end bolt hole and progressing upward about one-quarter of an inch into the head of the rail. Marks on the 5-inch piece of rail and at the top of a crack in the outside joint bar indicate that the broken piece bounced around under the impact of the wheels of the cars and became lodged momentarily across the joint bars. The outer joint bar had a hairline crack opposite the rail ends. Continued impact from the passing wheels progressively broke out the other pieces.

2. Track Inspection by Electronic Test Cars

The induction-ultrasonic type rail flaw detector car is normally used by the Pennsylvania Railroad to check for flaws, in end-to-end testing of rails in track. The combined induction-ultrasonic equipment now on these cars is capable of detecting all of the usual types of rail defects; however, it will not detect flaws in crossings or switches. While this equipment is capable of detecting bolt-hole cracks in the joint area, it is not completely reliable at joints.

On February 10, 1967, 11 months before the accident, the rails in No. 2 Track, including the rail that broke, were tested by an induction-ultrasonic flaw detector car, Sperry Car No. 131. No defective rails were found in the vicinity of the accident.

In addition, an "Audigage" ultrasonic flaw detector, which is especially useful at rail ends in joints, was used by the Pennsylvania Railroad to inspect rail ends as specified in "Specifications for Construction and Maintenance of Track, Form C.E. 78."

Rule 501(b)(4) from Form C.E. 78 reads as follows:

"Inspection of rail ends for web defects shall be made at regular intervals, using the audigage flaw detector as prescribed in Letter of General Practice No. 316-C."

This specification and the equipment's capability are directed toward rail ends in general, but "Letter of General Practice No. 316-C" does not require inspection of rail ends at normal joints or compromise joints unless the joint occurs in conjunction with other specified track locations. The rail which broke was not checked with the "Audigage" flaw detector because these specifications did not require it.

II. APPLICABLE LAWS, REGULATIONS, OPERATING RULES AND STANDARDS

A. Train Operation

The operation of trains PR-11A and SW-6 was in compliance with all applicable laws, regulations, and carrier operating rules.

B. Track Inspection and Maintenance

The Pennsylvania Railroad's "Specifications for Construction and Maintenance of Track Form C.E. 78½" contains the standards which guide the maintenance personnel in their work. Standards applicable in this case are listed below:

501.(a) Joint bars shall be applied with their full number of bolts, nuts, and springwashers in accordance with standard plans and specifications.

711.(b) When stone ballast becomes so filled with cinders, dirt, and other substances that the drainage is impaired and it does not properly perform its functions it must be cleaned.

803. Provided the gage is uniform, correction need not be made until the excess from the maintained is 3/16 inch on tangent main track. Any variation causing tight gage is prohibited.

903. Track must be laid and maintained to correct surface and line, to the established elevations, and in order to provide a smooth ride should be maintained in accordance with the following table:

	Speed in miles per hour			
	Up to 20	21 to 50	51 to 70	Over 70
The change in cross level on curves, spirals or of appropriate rails in tangents in 31 feet, max.	1¼"	1"	3/4	1/2"

923(b). During freezing thawing weather

* * * * * * *

(2) Irregularities of surface due to frost, that cannot be corrected by the customary procedure may be temporarily corrected by the use of shims.

The Preface of C. E. 78 indicates that the Pennsylvania Railroad promulgates these rules as guides to economical standards of track maintenance. According to the Preface of C. E. 78, these guides "must be interpreted in the light of experience, and the requirements of service, deviating from them only where experience has indicated that such deviation is permissible, without endangering the safe operation of trains.

The American Railway Engineering Association publishes a "Manual of Recommended Practice"; however, it does not contain specifications for level of track inspection and maintenance. The manual defines recommended practice as follows:

> RECOMMENDED PRACTICE - A material, device, design, plan, specification, principle or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view of promoting efficiency and economy in the location, construction, operation or maintenance of railways. It is not intended to imply that other practices may not be equally acceptable.

Under the above definition of a recommended practice, the AREA has published "General Requirements of a Rail Joint, 1961," which describes requirements relating to both original design and condition when in use. These requirements appear as Appendix 11.

There are no Federal or State regulations which specify the required level of track maintenance.

C. Hazardous Materials

United States Code, title 18, section 834, directs the Federal Railroad Administration to formulate regulations "binding upon all carriers" for the safe transportation of explosives and other dangerous articles by rail within the United States.

Regulations promulgated pursuant to this authority covering transportation of explosives and other dangerous articles by rail freight carriers (Title 49, Code of Federal Regulaties, Part 174) provide in section 174.506(a) as follows:

> (a) For the protection of the public against fire, explosion, or other, or further hazards with respect to shipment of explosives or other dangerous articles offered for transportation or in transit by any carrier by railroad, such carrier shall make immediate report to the Bureau of Explosives, 63 Vesey Street, New York, 7, New York, for handling any of the following emergency matters coming to their attention:
>
> * * * * * * *
>
> (2) Railroad wrecks or accidents involving damage to containers of explosives or other dangerous

articles to such a degree as to necessitate repacking of the articles.

The Bureau of Explosives is an agency of the Association of American Railroads.

So far as the Board has been able to determine from records, the hazardous materials involved in this accident were in tank cars meeting applicable tank car specifications, properly placarded and labeled, and properly located in Train SW-6. All shipping orders and waybills were properly made out and endorsed. A notice of placarded tank cars was prepared and distributed to crewmembers of Train SW-6. Federal regulations require notice to the crew only of cars containing explosives, 49 CFR 174.589(f). However, the Pennsylvania Railroad regulation is broader and includes all loaded placarded tank cars.

D. Accident Reporting

The reporting and investigation of the accident are covered by the Accident Reports Act. (45 U.S.C. 38 et seq.) Since there were no serious injuries nor fatalities, the carrier was not required to submit a telegraphic report to the Federal Railroad Administration. The cost of damaged track and equipment exceeded $750; therefore, the carrier was required to submit a report within 30 days after the end of the month in which it occurred. Under this system, first news of this accident came to the Bureau of Railroad Safety and the Safety Board from sources other than the railroad.

III. ANALYSIS OF CAUSAL FACTORS

General Derailment

The presence of an eastbound train, SW-6, on the adjacent track at the time that a derailment occurred in a westbound train, PR-11A, set the stage for the general derailment. When the derailed car in PR-11A, AESX 850, lost its trailing truck and became uncoupled from the following cars, the possibilities of additional derailments and subsequent collisions between the cars of the two trains were increased. At this location, there was only about 3 or 4 feet of clearance between the cars of the opposing trains. This factor, and the absence of a means of notifying the engineer of train PR-11A immediately of the initial derailment and the failure of the derailed cars to remain in line, created the conditions for the general derailment and collision.

Secondary Derailment of Cars in PR-11A

The only warning that a derailment had occurred in PR-11A's train came to the engineer by radio from the engineer of the eastbound train, SW-6, but it was too late to be effective. The car was held on the derailed truck only by gravity and a center pin in the center castings. Thus, the action of AESX car 850 bouncing over the rails of the N&W track, its continued bouncing over the crossties, and finally, striking planking at the street grade crossing, completely separated the truck from the car. The interlocking coupler on the following car, in combination with the standard coupler of the derailed car, did not prevent the separation between the two cars, and the general derailment followed.

Initial Derailment

The broken rail where the initial derailment occurred was not the result of one condition or circumstance but involved a combination of settlement of the supporting ties and a joint design which allowed flexure and movement of the rails under these conditions. The flexure and movement allowed contact between the bolt and the edge of bolt hole to occur. The break originated with the bolt-hole crack in the web of the rail. While rail-end testing on a large scale was not commenced until 1961, it has been known for much longer that a bolt-hole crack is a progressive fracture that is normally the result of unusual stresses along the edge of the hole from the bolt itself. These stresses may be caused by swinging joints, improper drilling, excessively worn joint bars, or abnormal rail-end impacts from rolling stock.[1/]

The conventional compromise joint was an approved four-hole joint, but it would not resist deflection after the crossties settled under the joint. After the bolt-hole crack developed, flexure in the joint caused the crack to progress to the extent that the first piece broke out. The use of an approved six-hole joint would have resisted flexure more than the four-hole joint after the settlement of the ties occurred. After the derailment, when the broken rail was replaced, a six-hole compromise joint was applied.

The crossties did not support the joint because the dirty ballast and lack of maintenance had allowed them to settle under the

1/ Rail Defect Manual, Compiled by Sperry Rail Service, Automation Industries, Inc.

wheel impacts at the joint. Properly cleaned and tamped ballast under the ties would have reduced the deflection at the joints. After the derailment, this settlement was compensated for by inserting wooden shims in the space between the tieplates and crossties. This is an approved maintenance practice which temporarily reduced the deflection in the joint until the ties could be tamped.

The rail-flaw detection program did not indicate the presence of the bolt-hole crack before it broke out. Either the bolt-hole crack was the type not detectable by the induction-ultrasonic rail-flaw detector car, or it developed after the last inspection was made on February 10, 1967. The Pennsylvania Railroad's recommended program for use of the "Audigage" flaw detector, which was designed to detect this type of defect, did not require that this joint be tested; however, it did require that other joints nearby be tested.

The detection of the bolt-hole crack before it broke out could have resulted in the replacement of the piece of 130-pound rail.

If the rail had been replaced during the time that the spot-tamping operation was going on in the last week of November 1967, the cost would not have exceeded $50. Thus, a modest expenditure in needed maintenance could have prevented an accident whose cost to the Penn Central will exceed $1 million. This type of defect in maintenance is the type referred to in the Safety Board's letter of recommendation to Federal Railroad Administrator Lang dated April 3, 1968, calling for the reversal of the worsening trend in train accidents. Derailments caused by defects in or improper maintenance of way and structures increased from 577 in 1961 to 1,800 in 1967, an increase of 210 percent. This accident underlines the serious nature of the derailment problem in terms of potential public disaster.

A visual inspection by the assigned Track Patrol Foreman on foot, on December 29, 1967, three days before the accident, did not reveal the unsafe conditions.

The quality of the documentation and rules which controlled the design and maintenance standards of joint and track, including crossties and ballast, is of considerable significance in this case. The rules of the Pennsylvania Railroad in Form C.E. 78, as quoted on Pages 33 and 34, appear to be firm in their language, but in the Preface it is stated that they are only guides and must be "interpreted in the light of experience." This "interpretation" makes the guides subject to judgment of those who employ them, and tends to make them difficult to enforce. In addition, the language of Form C.E. 78 does not provide an objective measure of the condition of low crossties or swinging joints involved at the joint where the rail broke; nor does it state under what conditions joints must be shimmed. Under the words of the Form C.E. 78, Rule 923 and 923(b), these low ties at the failed joint might not have required any correction, since there was no requirement that the track be loaded when the measurements were made, and the track might have met all the Rule 903 measurements when unloaded.

The second document which, if followed, might have controlled the design or condition of the joint was the AREA "Manual of Recommended Practice." This entire document becomes non-governing by the definition of their term "recommended practice" with its escape clause in the preface, "It is not intended to imply that other practices may not be equally acceptable."

Furthermore, the detailed requirement for deflection of a rail joint (Appendix 11) does not govern. Requirement No. 2, on resistance to deflection, carries another escape phrase, "as nearly as practicable." Under this phrase, the recommendation would not have prevented selection of a four-hole joint instead of a six-hole joint, even if it were definitely known that this six-hole joint had better resistance to deflection.

Based on observations of the marks on the 5-inch piece of rail which broke out first, undoubtedly the broken rail caused the trailing wheels to derail at this point. The irregular surface of the track preceding the point of derailment definitely tended to introduce a car-roll and wheel-lift action to the cars, which could have contributed to the derailment of the wheels at the time they struck the broken piece of rail.

Fire and Explosion

The mechanical puncturing of the tank cars containing hazardous materials created a rapid discharge of flammable liquids. The derailment and collisions of freight cars under such conditions create numerous sparks which could have been the source of ignition.

The mechanical damage to the jacket of the ethylene oxide tank car exposed the tank shell to the flames and heat of the intense fire. The heat, under these conditions, increased the internal pressure in the tank, causing the safety valve to operate, however, this was not sufficient to prevent the explosion. It is not known what kind of explosion occurred in the tank car of ethylene oxide; however, if heated to 1,058° F. in the absence of oxygen, ethylene oxide vapor will decompose with detonating violence. This presents a problem because safety valves capable of adequately venting a tank of ethylene oxide whose tank shell is exposed to fire for an extended time would require much greater valve-opening area than would be practicable to supply.

Ethylene oxide does not need an external supply of oxygen for combustion. The development of hot spots in the tank can cause local conditions in the liquid which would cause an explosion. It is conjectural as to the type of explosion which occurred in this case. An inspection of the edges of the ruptured tank did not indicate that increased pressure blew out a heat-softened portion of plate. Based on the properties of ethylene oxide, fire on the exposed part of the tank shell could have generated enough heat locally to initiate an explosion. There was also the possibility of polymerization with violent evolution of heat. In either case, the explosion resulted when the tank's shell was directly exposed to flames for about 45 minutes. There is at least one other case on record where a tank car of ethylene oxide exploded after being exposed to fire for about 45 minutes.[1/]

1/ ICC Railroad Accident Investigation Report No. 4036, December 13, 1964.

Severity of Fire and Explosion

The five carloads of flammable materials in one block in the freight train provided the large volume of fuel for the intense fire and explosion. Had these cars been separated by cars of a non-hazardous nature, the amount of hazardous materials in the general derailment would have been much less and the tank car of ethylene oxide might not have been involved in the fire at all.

The intensity of the fire would have been much less, and more subject to control if the rapid discharge of the flammable liquids had been retarded. It is technically possible, chemically and physically, to prevent rapid spillage of liquids from punctured vessels, but it is not known whether it is economically feasible to apply it to all products. Control of the discharge of the flammable liquids could have had two possible beneficial effects. The explosion of the ethylene oxide could have been prevented by keeping the flames away from the exposed cargo tanks and allowing the safety valve to vent it until the pressure was safe. The volume of acetone cyanohydrin, which discharged more rapidly than it burned, possibly would have been controlled and would not have contaminated the ground water. A gradual discharge of acetone cyanohydrin would have been more subject to control both physically and chemically.

There was a combination of reasons why effective firefighting techniques were not applied. Information as to the types of materials and means of combating them was not readily available.

Although the waybills described the materials in accordance with regulations, they were not immediately available to the local firefighters. To fight fire of this nature effectively requires information as to the nature of the material that is burning, a knowledge of effective firefighting techniques, and the equipment and ability to apply those techniques.

While the local fire departments did an excellent job under the circumstances, they did not possess the expertise nor the equipment to combat this fire effectively. There is an apparent need for additional equipment and training of local fire departments in how to handle hazardous materials under such circumstances. It is impractical to expect a local volunteer fire department to be proficient in handling all hazardous materials that are being shipped today. Additional highly trained aid was requested and received from Wright-Patterson Air Force Base and from Fort Benjamin Harrison. Although these forces had the equipment and expertise, the lack of information prevented their rendering immediate effective service. This again pointed up the necessity for a procedure to assure the immediate availability of the necessary information to those in authority so that proper techniques can be applied.

The availability of a source of information relative to the proper action in such a case would have made the position of the local emergency forces more tenable. The Coast Guard has a program in the Houston area which makes available information concerning hazardous materials on a 24-hour basis. This same data is available in the Coast Guard's Hazardous Materials Division in Washington, D. C.; however, a national, intermodal, 24-hour data center is not in operation.

Contamination of Water

The use of copious amounts of water in combating the fire contributed to the development of cyanides. Large volumes of water percolated into the water table and some found its way into an underground drain system. Through the underground sewer, water drained into the surface streams poisoning some animals which drank it.

The failure to recognize the potential danger in the situation resulted from a lack of information. Although the waybills contained the information required by regulations, they were not readily available and did not contain instructions for emergency procedures. Information sheets with complete description of the material and emergency procedures could be located on both cabooses and locomotives of all trains for use in handling hazardous materials under emergency conditions. Organizations responsible for emergency procedures in all communities through which trains operate could be advised as to where this information is located and how to use it.

Post-Fire Management

There was no central authority to direct the emergency operations. None of the experts in hazardous materials assumed the responsibility of controlling the emergency operations involving the effects of the hazardous materials. The lack of a central control of emergency operations resulted in a conflict between the railroad wreck-clearing operation and the transfer of the acetone cyanohydrin from the tank which was not punctured. The bottom discharge valves of the tank were buried in the dirt and their condition, and that of the under part of the tank, were unknown. There was constant danger that movement of the tank would result in a leak and cause a new fire. Because of the unknown condition of those parts of the tank which were buried in the dirt, this tank should have been emptied before undertaking any clearing operations that might disturb it. The danger of the movement of the cars causing a leak that would spill out more acetone cyanohydrin would have been avoided had this been done. Fortunately, the transfer operation was completed without mishap.

The potential danger in the lack of a central control of operations in such a catastrophe is great. There is no indication that any toxicity tests were contemplated or made to determine the contamination level before allowing personnel in the area where the chemicals had spilled and burned. There was a possibility that highly dangerous toxic materials were produced as byproducts of the decomposition of the hazardous materials which burned. The brisk wind probably dispersed the fumes rapidly, preventing damage to the workmen. The railroad superintendent supervised the clearing operation. His primary aim was to clear the wreckage and rebuild at least one track as quickly as possible so that train operation could resume over this line. He apparently accomplished this well, but the successful outcome was in spite of the lack of coordination between efforts.

In a catastrophe of this type, there is immediate need of accurate information adequately describing the hazardous materials. Placards and markings on cars are often destroyed and, if intact, personnel in rescue work cannot get close enough to read the required data. Local authorities do not know where on a train to find the documents which describe the materials. Railroads do not have standard rules requiring waybills to be carried at a specified location. Although there is a standard waybill form where specified information relative to hazardous materials should be posted, there is inadequate information for emergency purposes. Federal regulations require that a notice be given to train and engine crews of cars containing explosives. This regulation could be expanded to include all cars containing hazardous materials and to include a data sheet describing the material and emergency procedures. Furnishing train and engine crews with these sheets would insure their being available on both the caboose and locomotive and, therefore, available at both ends of a train when needed. Furthermore, this expansion of regulations would not work an economic burden on the railroad but would increase the safety for their freight and bystanders. The compliance with the recommended practice for managing hazardous materials in emergencies (Bureau of Explosives Pamphlet No. 22) depends largely upon the inclination of the carrier and the aggressiveness and expertise of the local representative of the Bureau of Explosives.

IV. CONCLUSIONS AND STATEMENT OF PROBABLE CAUSE

The Board concludes that:

1. Trains PR-11A and SW-6 were being operated in compliance with all applicable rules and regulations.

2. A broken rail in a compromise joint in the north rail, 258 feet west of Dunreith Interlocking Station, caused the initial derailment of the trailing truck of AESX car 850, an empty tank car in westbound train PR-11A.

3. The break in the rail was a progressive fracture originating at a bolt-hole.

4. After the settlement of the crossties, the four-hole compromise joint did not resist vertical deflection sufficiently to prevent the development of the fracture in the rail. The "General Requirements of a Rail Joint," as found in the Manual of Recommended Practice of the American Railway Engineering Association and the Pennsylvania Railroad's "Specifications for Construction and Maintenance of Track," are intended to serve as guides for the economic maintenance of track. However, they are vague and non-specific as to the required performance of the joint in relation to the other factors of track condition. This precludes any judgment by the Board as to whether the four-hole compromise joint was adequate for the required performance in relation to the deteriorated condition of the track support. The Federal Government does not have regulatory authority over track conditions.

5. An unknown factor in the compromise joint, combined with defects in track maintenance, led to the development of the bolt-hole crack and broken rail.

6. Electronic equipment for the detection of hidden flaws and defects in rail ends was used by the Pennsylvania Railroad but its use was not required on the joint where the broken rail occurred. The bolt-hole crack progressed undetected to the extent that a 5-inch piece of rail broke out.

7. Visual track inspections that were made did not identify the track defects that required attention.

8. Although rules of the Pennsylvania Railroad and recommendations of the American Railway Engineering Association apply to track maintenance and rail joint features of this case, these documents were ineffective as part of the railroad's system of risk management because of indefinite language and relief clauses which made such rules unenforceable by the railroad. Thus, no written regulation governing the features of track condition critical to this accident was constructively in effect.

9. The separation of the truck from AESX car 850 led to the break in train PR-11A and the subsequent general derailment. If there had been some positive means of keeping the truck and car properly attached, possibly the train would have remained coupled and probably would have been brought to a halt without disastrous results after the derailment was reported by radio

from Train SW-6. The radios were ineffective in preventing the wreck because of the rapid development of the derailment situation after the initial derailment.

10. The derailment of train SW-6 was caused by a side collision with derailed cars in train PR-11A.

11. The secondary derailment in train SW-6 was the result of slack action.

12. The intense fire, explosion, and contamination of water resulted from the large volume of flammable and poisonous liquids which flowed rapidly out of the tanks after they were mechanically punctured in the collision and resulting derailment.

13. The safety valve on the tank car of ethylene oxide operated for about 45 minutes but did not prevent the explosion.

14. The scope of the fire and explosion and the technical complexity of the hazardous materials involved were beyond the normal capabilities of local fire departments. Specialized information, equipment, and experience were required to combat safely the fire and were not readily available.

15. Firefighting personnel from military installations which were called in to assist could not effectively fight the fire because of lack of knowledge of the nature of the materials burning. The train consists, waybills, and notices to the crews did not furnish sufficient information to permit adequate handling of the hazardous materials in this wreck. The "Dangerous" placards and "Red Labels" were ineffective after the derailment because they were destroyed by fire.

16. The use of large amounts of water contributed to the decomposition of the acetone cyanohydrin which drained cyanides into the ground water system. The ground water system drained into streams, resulting in the poisoning of farm animals, before the Indiana Board of Health could initiate preventive and corrective measures.

17. No toxicity tests were performed before allowing personnel to work in the area contaminated by spilled and burned chemicals.

18. The railroad clearing operation and the transfer of acetone cyanohydrin to tank trucks were not well coordinated by the railroad or the Bureau of Explosives, resulting in unnecessary hazard to the workmen and community.

19. Federal regulations for the safe transportation of dangerous articles by rail were complied with, however, this did not serve to prevent the fire, explosion, and contamination of water.

20. Title 49 CFR 174.506, which attempts to assign the handling of emergency matters related to the transportation of hazardous materials by rail for the protection of the public to the Bureau of Explosives of the Association of American Railroads, does not require that any report be made by the Bureau of Explosives concerning its handling of the emergencies. Although the Safety Board requested such a report of its action from the Bureau of Explosives in this case, no report was provided.

21. The reporting of this accident to the Bureau of Explosives for handling of the emergency, as required for the protection of the public by 49 CFR 174.506, did not produce immediate attendance at the scene by any representative of the Bureau of Explosives until about 10 hours after the Bureau of Explosives representative was notified. The Federal regulation was intended to produce protection of the public by assigning the handling of the emergency to the Bureau of Explosives but the regulation proved ineffective in this respect.

22. The Pennsylvania Railroad complied with the requirements of the Accident Reports Act. Because there were neither serious nor fatal injuries involved in the accident, regulations did not require a report to the Federal Railroad Administration until 30 days after the end of the month in which the accident occurred (January). In this case, only a monthly report was required and it was not due until 60 days after the occurrence.

PROBABLE CAUSE

The probable cause of the initial derailment in train PR-11A was the broken rail within the compromise joint where two different sizes of rail were joined.

A contributing causal factor was the inadequate track maintenance which left the joint unsupported and allowed the development of the break in the rail. This initial derailment and the design of the lift-off type of center-pin connection between the truck and body of AESX car 850, which allowed the truck to separate from the car under impacts of a simple derailment, led to the secondary collision and general derailment.

The collision and general derailment led to the intense fire, explosion, and contamination of water by the poisonous chemical. Contributing causal factors were, (a) the large volume of flammable and poison liquids in tank cars, which were located next to one another in the train, and flowed rapidly out of the tanks after the tanks were mechanically punctured; (b) the shortage of information and lack of firefighting equipment necessary to extinguish promptly the fire around the ethylene oxide tank, (c) the destruction of the heat insulation of the tank; and (d) the failure of pressure relief valves to vent sufficiently to prevent the very rapid buildup of pressure consequent to uncontrolled heating of the ethylene oxide.

V. RECOMMENDATIONS

1. The Safety Board recommends that the Penn Central Transportation Company and the American Railway Engineering Association revise their track inspection and maintenance standards or recommended practices for track construction and maintenance so that they provide objective measures of conditions and definite criteria for correction. Decisions as to adequacy of track conditions should not be solely dependent upon variable judgment or interpretation of individuals, but should be made according to objective measurements required by written enforceable rules.

2. The Board recommends that the American Railway Engineering Association and the Association of American Railroads initiate a research program to improve the present rail-joint design. The improved joint should be as strong and dependable as the rails to which applied and also prevent the development of rail defects and failures which now commonly occur in the joint area.[1/]

3. The Board recommends that the Penn Central Transportation Company and the railroad industry in general employ to a greater degree the available rail-flaw detector equipment. It is further recommended that complete use be made of the available technical knowledge to insure the development of more dependable means of detecting rail defects within the joint areas with a greater degree of accuracy.

1/ The Sperry Railer, Statistical Issue 1967, Sperry Rail Service, Automation Industries, Inc.

4. The Board recommends that the Federal Railroad Administration include in its current study of an improved coupler design, the problem of keeping cars coupled and in line with the track and with each other after a derailment occurs. In order to attain an integrated organization of track and rolling stock features that would limit the after effects which can now follow a simple derailment, the Federal Railroad Administration should also study other related technical approaches to control interference with traffic on adjacent tracks and wayside structures during derailments, such as means of limiting the lateral excursion of wheels, and the separation of trucks from the cars.

5. The Board recommends that the Department of Transportation, through its Assistant Secretary for Research and Technology, and the Federal Railroad Administration, in cooperation with the Association of American Railroads, study the problem of proper management of hazardous materials in train accidents and take appropriate action. This study should include the matter of whether it is feasible to provide vehicles that will resist mechanical puncturing, the problem of controlling the flow of flammable and poisonous liquids out of punctures in tank cars, and whether it is feasible and preferable to separate cars of hazardous materials with cars of inert materials. The problem of adequate capacity of safety valves should also be reviewed.

6. The Board recommends that the Federal Railroad Administration review and correct the applicable regulations to provide markings at multiple locations which can survive a fire and which can be identified from a distance during fire and smoke (such as a large silhouette or see-through). Such markings should be legible to inform constructive actions by persons looking for them in cases of leakage, threat of fire, or during a fire. The problem of insufficient data relative to hazardous materials on the manifests and notices to the crew should be reviewed and appropriate action taken to establish a system that will provide those requiring it with the necessary information to initiate corrective action in emergency situations.

7. The Board recommends that the Federal Railroad Administration review 49 CFR 174.506, which intended to protect the public against fire or explosion resulting from railroad accidents by the assignment of the handling of the emergency to the Bureau of Explosives of the Association of American Railroads. This regulation appears to place responsibility for public safety in the hands of a private organization representing only one of the interests involved, and which may not be able to handle expeditiously emergencies which may develop. The Board is aware that the practice of delegating responsibility for hazardous materials regulations to private agencies is under study by the Department of Transportation.

8. The Board recommends that the Department of Transportation study means of improving the training methods available to local fire departments so that they can upgrade their skills in their handling of emergencies created by the increasing transportation of hazardous materials. The problems of controlling such accidents are especially troublesome because of the daily introduction into commerce of numerous new kinds of hazardous materials. The Board believes that local emergency organizations cannot be expected to be conversant with necessary procedures to handle situations involving the many possible emergencies involving the transportation of hazardous materials unless some form of assistance in training is provided such as a model type training course.

9. The Board recommends that the Federal Railroad Administration amend its requirements for the reporting by railroads of accidents to include the immediate reporting of any accident involving cars containing hazardous materials which constitutes a current or potential hazard to the carrier, the passengers, its personnel, or the local environment.

10. The Board recommends that the Secretary of Transportation undertake a study of the feasibility of establishing a National Hazardous Materials Advisory Data Center. It is envisioned that such a national data center, through the use of computer-stored data would be able to furnish emergency information on flammable, explosive, highly reactive, and poisonous substances,

and locally available sources of expertise and specialized emergency equipment on a 24-hour-a-day basis. The Board is of the opinion that such data center is now necessary to aid Federal, State, and local authorities faced with the varied and complex problems involved in combating actual or potential disasters involving hazardous materials.

There are working programs throughout the country which could be used as pilot models for such a center. Some of these are the Coast Guard's programs in their Hazardous Materials Division in Washington, D. C., and in the various districts and the "poison control centers" in the various States.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOSEPH J. O'CONNELL, Jr.
Chairman

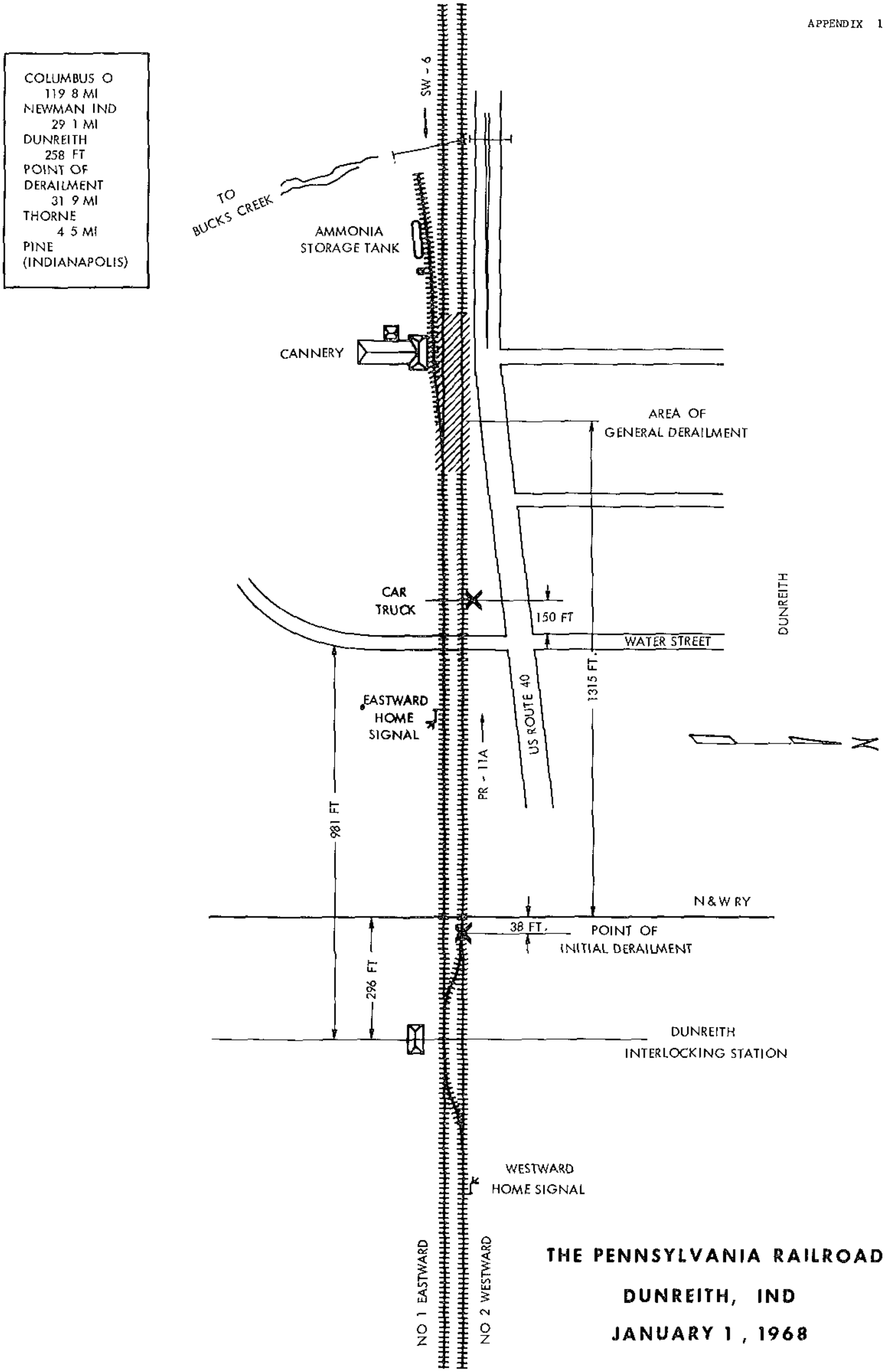
/s/ OSCAR M. LAUREL
Member

/s/ JOHN H. REED
Member

/s/ LOUIS M. THAYER
Member

/s/ FRANCIS H. McADAMS
Member

Adopted: December 18, 1968



THE PENNSYLVANIA RAILROAD

DUNREITH, IND

JANUARY 1, 1968

DESCRIPTION OF HAZARDOUS MATERIALS

Acetone Cyanohydrin

Description: Colorless Liquid

Specific Gravity: 0.93

Boiling Point 248° F. (Decomposes)

Solubility in Water: Complete

Fire and Explosion Hazard

General. Gives off highly toxic hydrogen cyanide vapors when heated to decomposition.

Flash Point: 210° F.

Flammable Limits: 2.25-11

Autoignition Temperature: 1,270° F.

Extinguishing Media CO_2, alcohol foam, water fog

Special Fire Procedures: DO NOT USE SODA-ACID EXTINGUISHER. Respiratory protection required. Wear special protective clothing.

Health Hazard Data

Highly toxic by ingestion or inhalation, moderately toxic by skin absorption. It is a slight irritant; will injure eyes unless treated promptly. Symptoms are headache, dizziness, nausea, blueness of lips and fingernails.

Reactivity Data

Stability Decomposes to form cyanide gas. Must be kept slightly acidified.

Compatibility: Dilution with water causes decomposition with formation of hydrogen cyanide.

Spill or Leak Procedure

Avoid contact with liquid. Evacuate personnel not equipped with respiratory protection. Do not flush spill where humans or animals may contact. If a spill occurs into navigable water, notify State water pollution or public health agency without delay.

Ethylene Oxide

Description   Colorless gas at ordinary temperature. Has etherlike odor.

Specific Gravity: 0.88

Boiling Point: 51° F.

Solubility in Water: Complete

Fire and Explosion Data

General: Flammable. Does not need oxygen for combustion. If local "hot spots" develop, the liquid in the tank may explode.

Flash Point: below 0° F.

Flammable Limits: 2-100

Autoignition Temperature: 804° F.

Extinguishing Media: CO_2, dry chemical, water fog.

Special Fire Procedures: It is important to keep the temperature of the tank low; use large amounts of water. Do not extinguish fire unless necessary to effect an immediate shutoff of flow. Approach only after considering explosion danger. Keep personnel behind cover if practicable. If the water supply is inadequate or the tank shows signs of overheating, evacuate the area.

Health Hazard Data

Irritating to eyes and respiratory system. The liquid can cause burns to skin and eyes. The effects may be delayed. Symptoms are burning sensations of eyes, nose, and throat, dizziness and headache.

Reactivity Data

Stability: Will oxidize with explosive violence when exposed to certain impurities. Will polymerize violently if allowed to reach temperatures above 90°F.

Compatibility: Do not use copper, silver, or their alloys. It is necessary for the tank to be absolutely clean of iron rust prior to loading.

Spill or Leak Procedure

Secure ignition sources. Avoid contact with liquid. Flush with large quantities of water. Notify local fire department. If a major spill occurs into navigable water, notify State water pollution or public health agency.

Methyl Methacrylate

Description: Colorless Liquid

Specific Gravity: 0.90

Boiling Point: 213.8° F.

Solubility in Water: Slight

Fire and Explosion Data

General Vapor is heavier than air and may travel a considerable distance to a source of ignition and flashback
Usually contains an inhibitor to prevent self-polymerization.
At elevated temperatures, polymerization may take place, if in containers, with possibility of violent rupture.

Flash Point: 50° F.

Flammable Limits: Not established

Autoignition Temperature. Not established

Extinguishing Media: Foam, CO_2, dry chemical

Special Fire Procedures: Wear goggles and self-contained breathing apparatus.

Health Hazard Data

Slight irritant to eyes, skin, and respiratory tract.

Reactivity Data

Polymerizes readily by light, heat and catalysts. Forms explosive mixtures with air.

Vinyl Chloride

Description: Colorless, sweet-smelling gas at ordinary temperatures.

Specific Gravity: 0.91

Boiling Point: 7° F.

Solubility in Water: Slight

Fire and Explosion Hazard

General: Unless the flow of gas can be stopped, putting out a vinyl chloride fire will permit accumulation of an explosive vapor concentration, with increased danger of a re-flash.

Flash Point: -108° F.

Flammable Limits: 4-22

Autoignition Temperature: 882° F.

Extinguishing Media: Stop flow of gas, CO_2, dry chemical, water fog.

Special Fire Procedures Cool tank with water spray. Heat decomposes vinyl chloride to form highly toxic phosgene gas. Heat also can cause it to polymerize with explosive force. Provide respiratory protection.

Health Hazard Data:

Vapor is anesthetic. Contact with liquid can cause frostbite. Symptoms include dizziness and drowsiness; frostbitten areas will look white. Odor threshold is not considered adequate warning to prevent exposure to possibly dangerous concentrations.

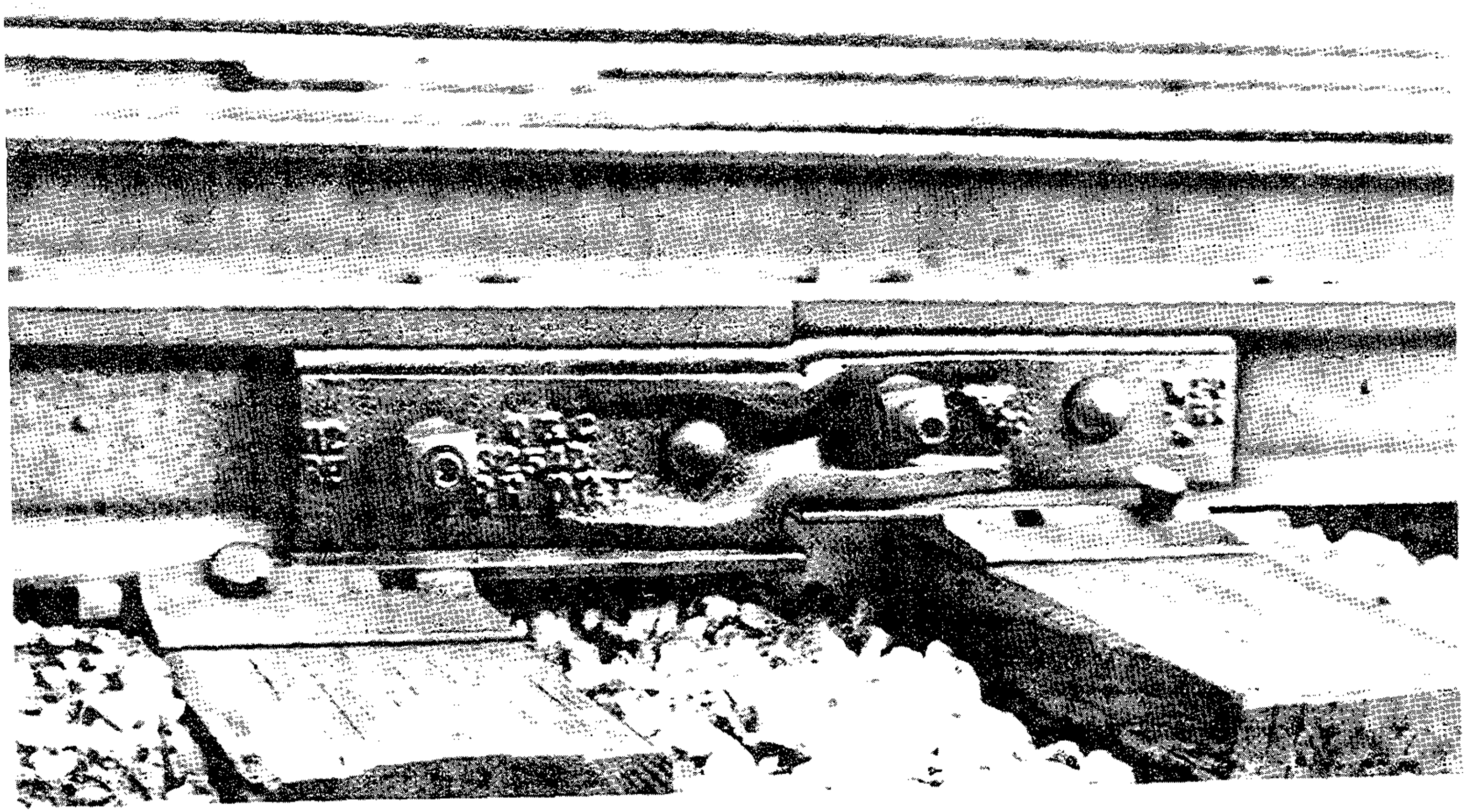
Reactivity Data:

Stability: Polymerizes in presence of air, sunlight, or heat.

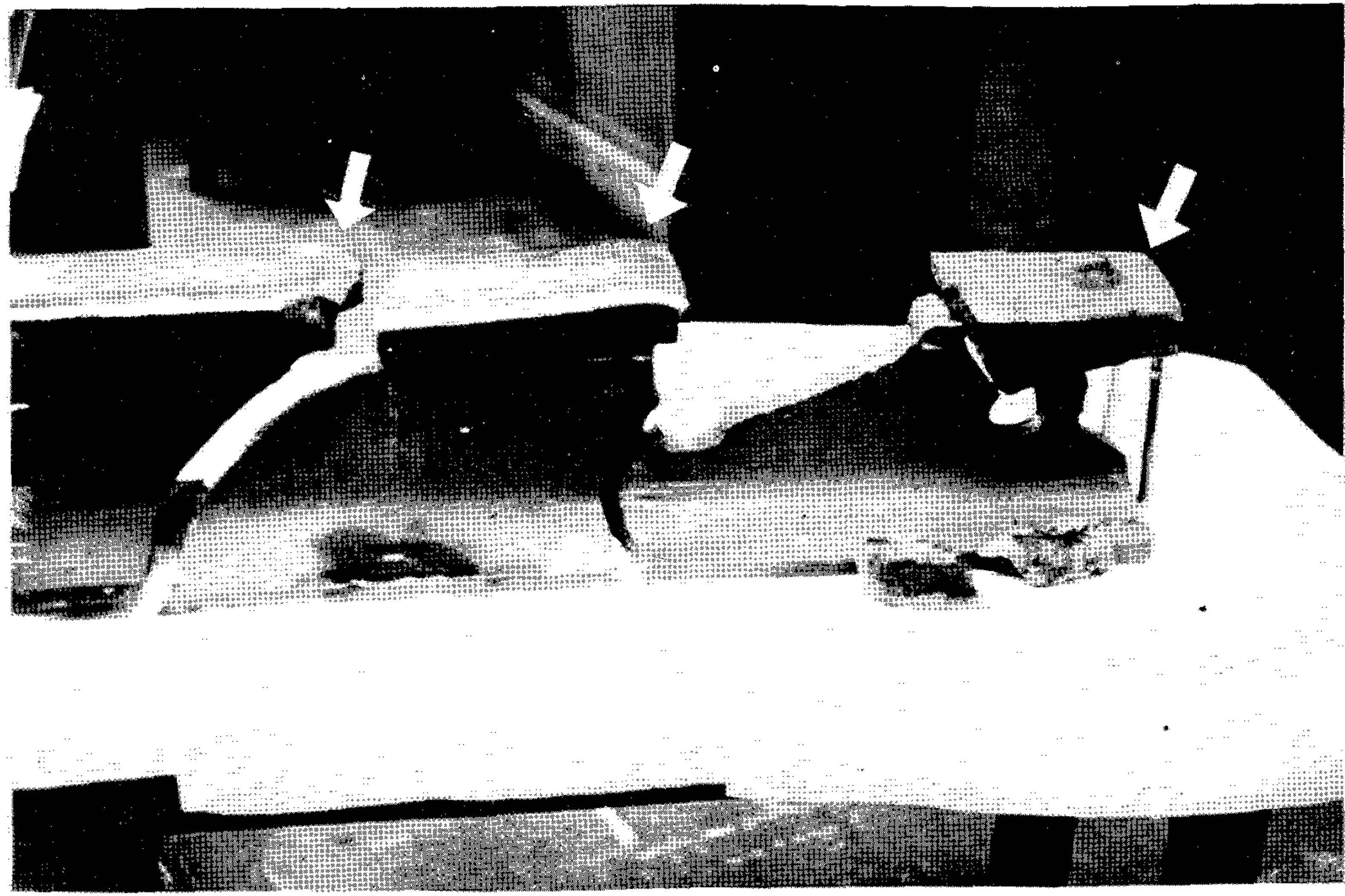
Compatibility: Contact with copper, aluminum or other acetylide-forming metals may form explosive compounds. Steel is satisfactory.

Spill or Leak Procedure:

Avoid contact with liquid. Secure ignition sources. If a major spill occurs into navigable water, notify local fire department.

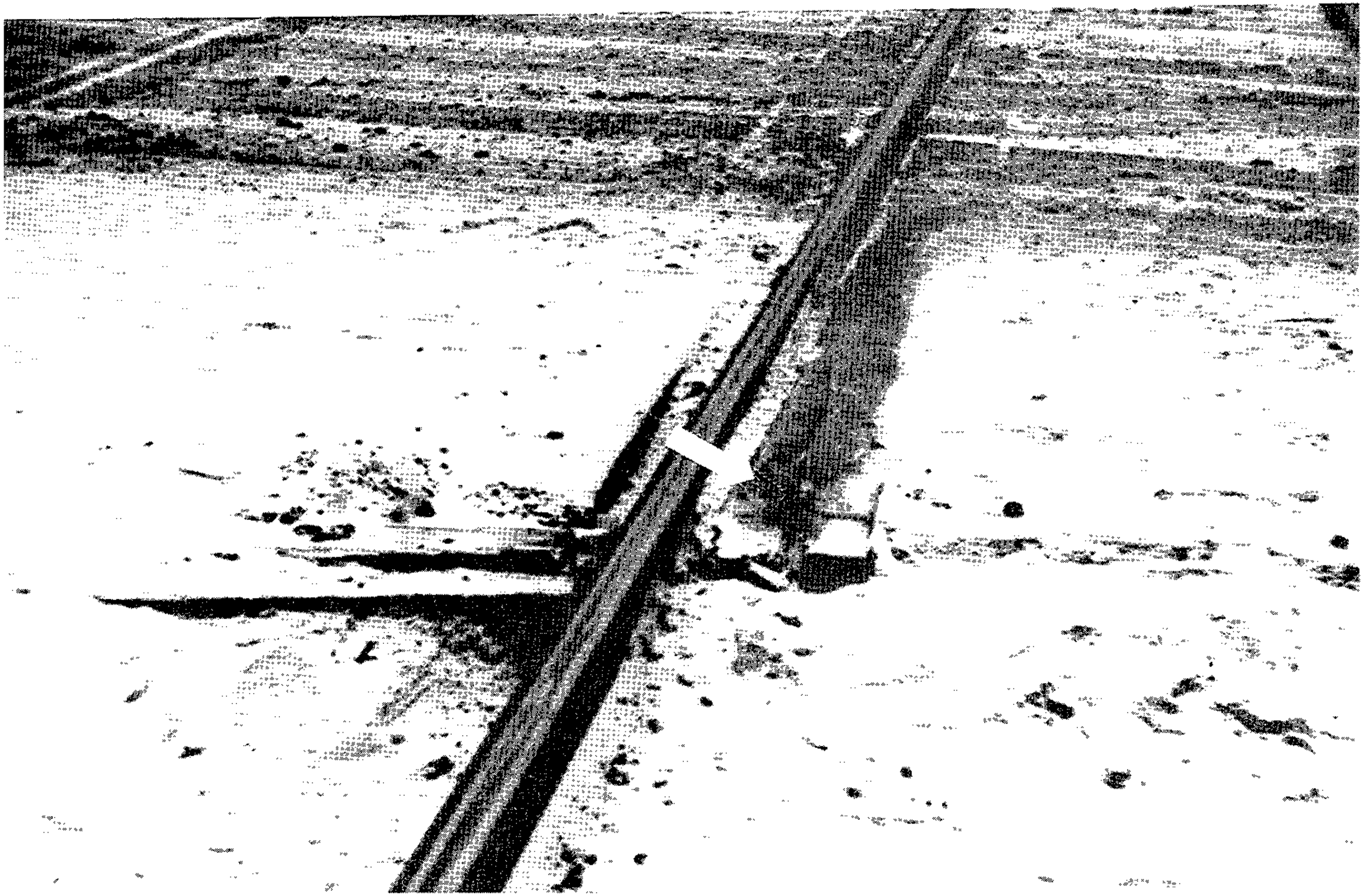


A TYPICAL AND PROPERLY INSTALLED COMPROMISE
RAIL JOINT - FOUR BOLT HOLE
THIS IS NOT THE COMPROMISE JOINT
INVOLVED IN THE ACCIDENT



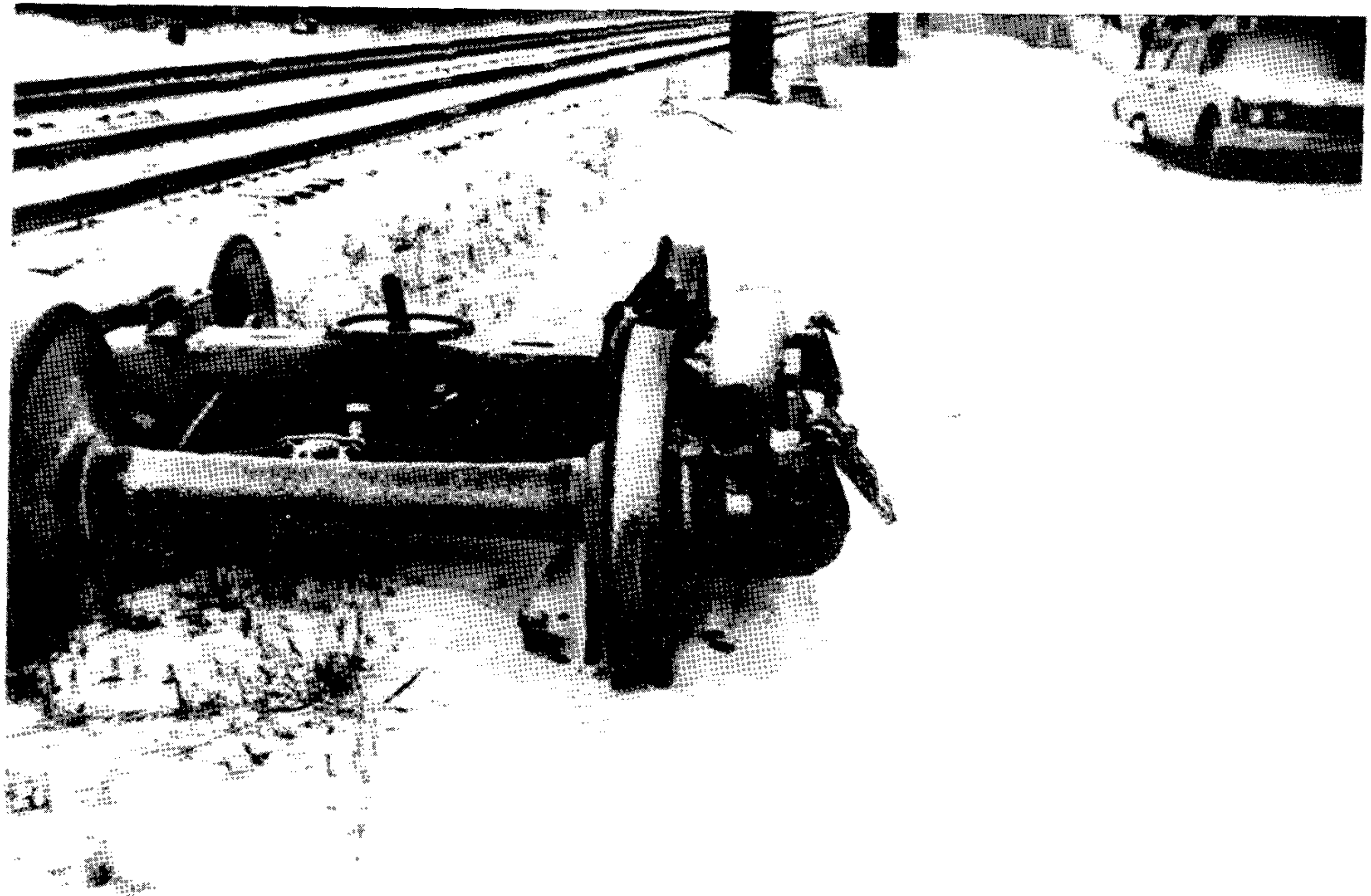
BROKEN RAIL THAT DERAILED
AESX CAR 856

ARROWS POINT TO BATTERING EFFECT ON
BROKEN PIECES BY CARS IN TRAIN PR-1[illegible]A

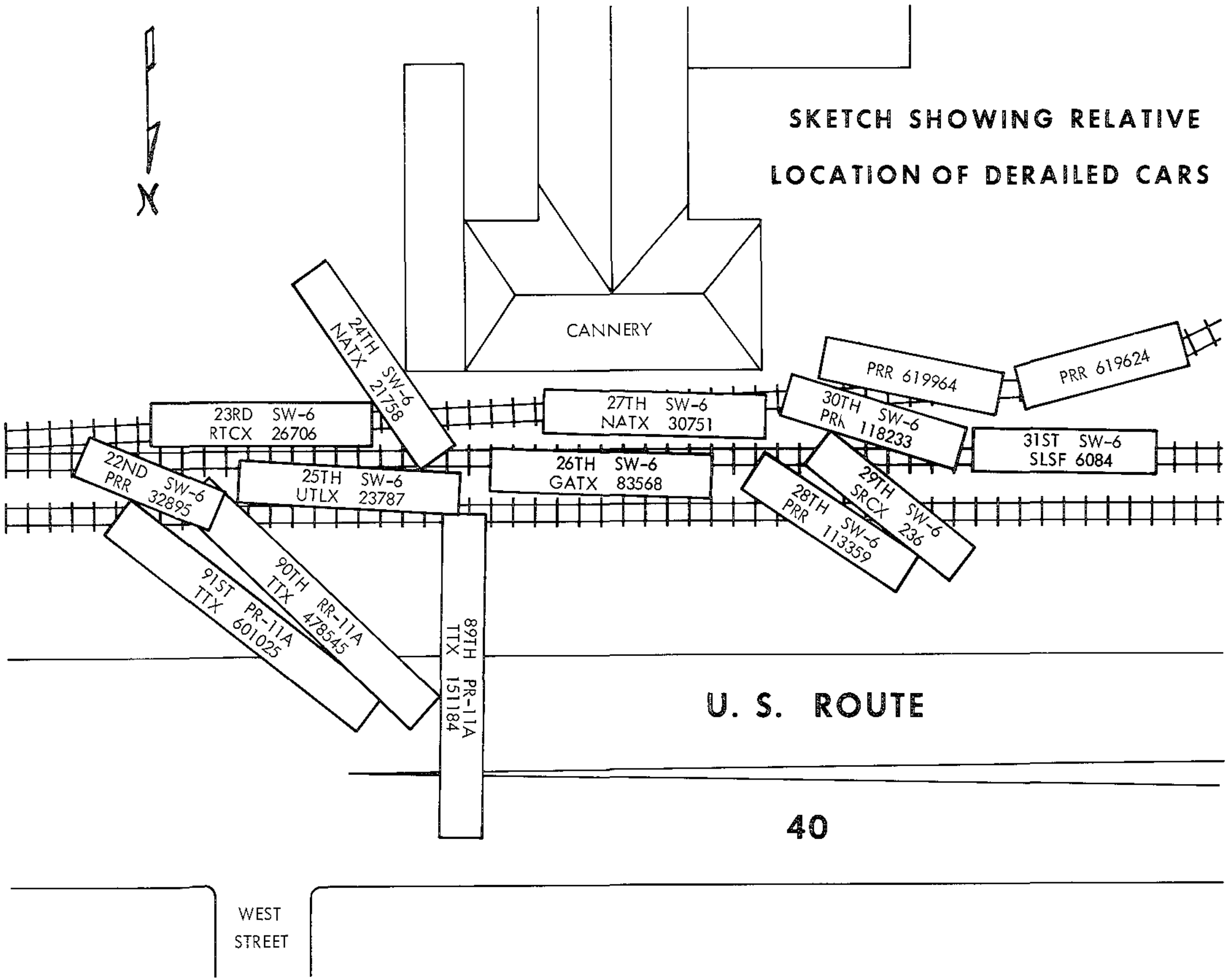


WATER STREET GRADE CROSSING
SOUTH RAIL IN TRACK NO 2
ARROW POINTS TO SPLIT IN PLANKING WHERE
STRUCK BY DERAILED WHEEL OF AESX CAR 550

APPENDIX 5

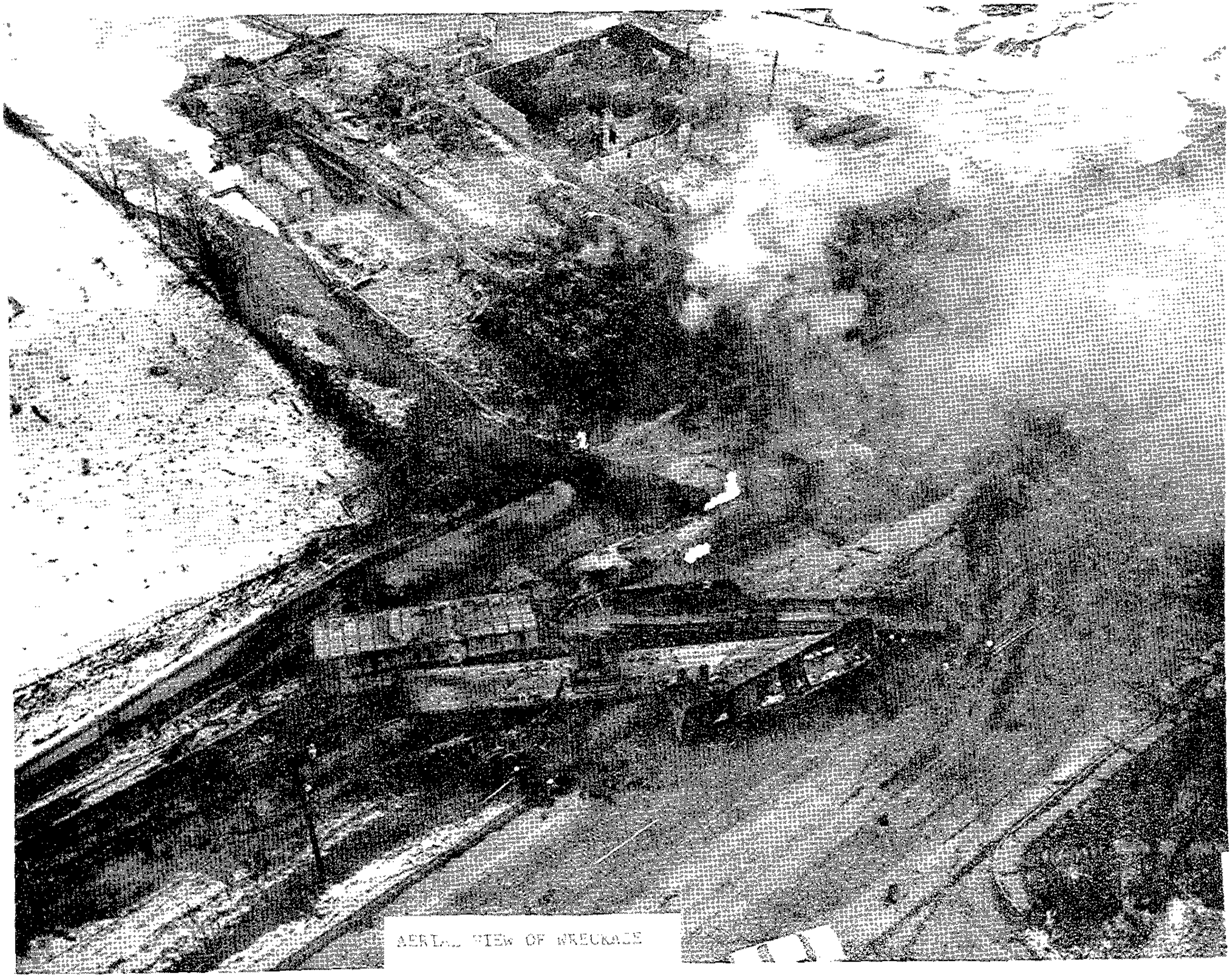


TRAILING TRUCK OF GESX CAR 850


SKETCH SHOWING RELATIVE
LOCATION OF DERAILED CARS
N
CANNERY
24TH SW-6
NATX 21758
23RD SW-6
RTCX 26706
22ND SW-6
PRR 32895
25TH SW-6
UTLX 23787
27TH SW-6
NATX 30751
26TH SW-6
GATX 83568
PRR 619964
PRR 619624
30TH SW-6
PRR 118233
31ST SW-6
SLSF 6084
29TH SW-6
SRCX 236
28TH SW-6
PRR 113359
91ST PR-11A
TTX 601025
90TH RR-11A
TTX 478545
89TH PR-11A
TTX 151184
U. S. ROUTE
40
WEST
STREET

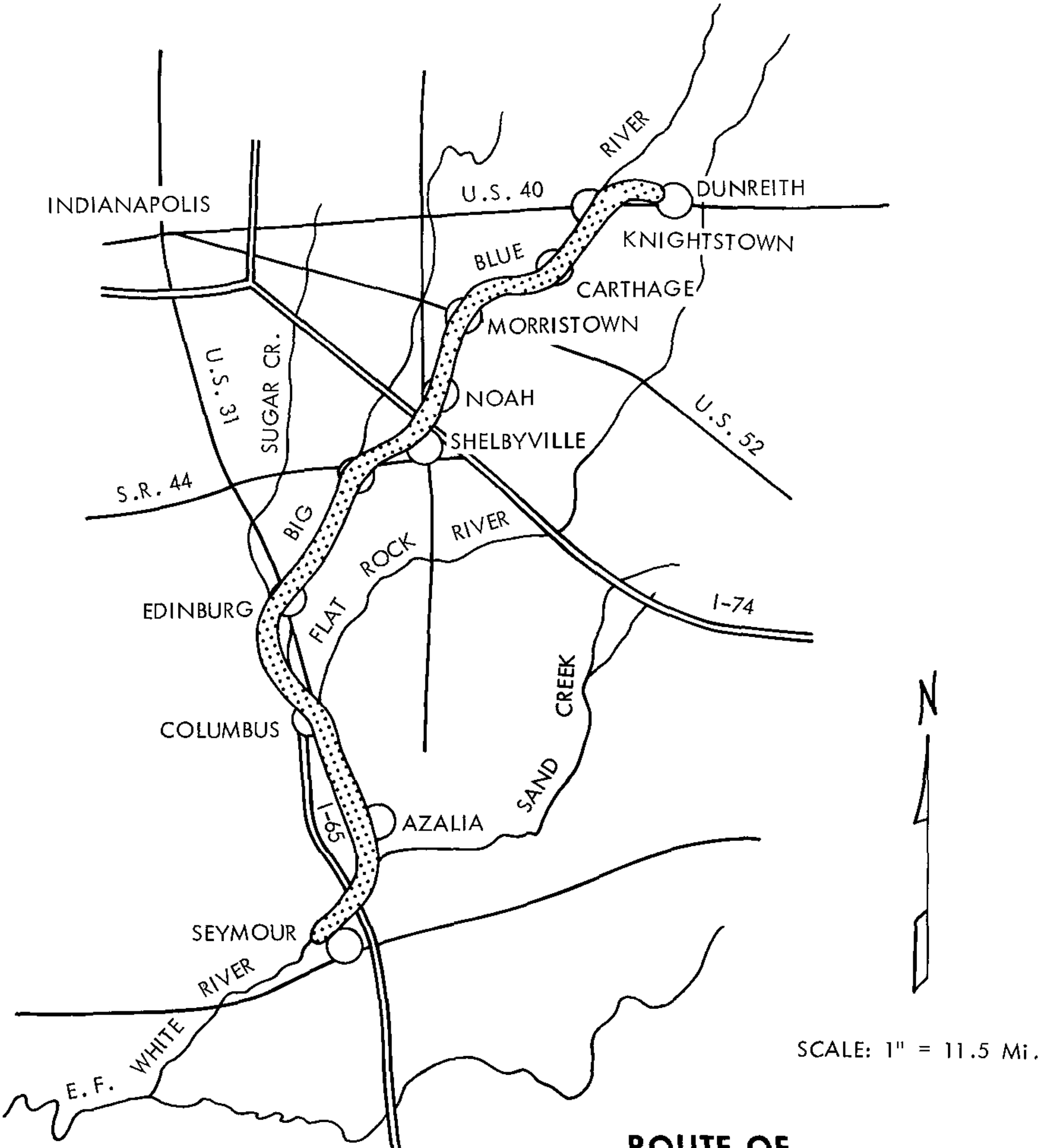
APPENDIX 8

AERIAL VIEW OF DUNREITH, IND.,
LOOKING WEST



AERIAL VIEW OF WRECKAGE

APPENDIX 6



ROUTE OF CONTAMINATED WATER FROM DUNREITH

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Engineering Division, AAR

* * * * * *

GENERAL REQUIREMENTS OF A RAIL JOINT

1961

(Reapproved with revisions 1961)

A rail joint should fulfill the following general requirements:

1. It should so connect the rails that they will act as a continuous girder with uniform surface and alinement.

2. Its resistance to deflection should approach, as nearly as practicable, that of the rail to which it is to be applied.

3. It should prevent vertical or lateral movement of the ends of the rails relative to each other, and unless otherwise specified, it should permit longitudinal movement necessary for expansion and contraction.

4. It should be as simple and of as few parts as possible to be effective.

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[1]References, Vol. 28, 1927, pp. 1009, 1354; Vol. 31, 1930, pp 1458, 1770, Vol. 49, 1948, pp. 375, 614; Vol. 54, 1953, pp. 1178 1413; Vol. 57, 1956, pp. 786, 1088; Vol. 62, 1961, pp. 590, 952.

[2]References, Vol. 7, 1906, pp 655, 657, Vol. 16, 1915, pp. 729, 1145; Vol. 38, 1937, pp. 216, 635; Vol. 50, 1949, pp. 484, 795, Vol. 54, 1953, pp. 1178, 1413, Vol. 62, 1961, pp. 590, 952.