Railroad Accident Investigation Report, 1979. no.9

Report No. 79-9

LOUISVILLE AND NASHVILLE RAILROAD COMPANY

CRESTVIEW, FLORIDA

APRIL 8, 1979

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION.
Office of Safety.

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The computerized Train Operations Simulator (TOS) model was used to simulate the derailed train operations. Detailed conclusions resulting from the simulations are as follows:

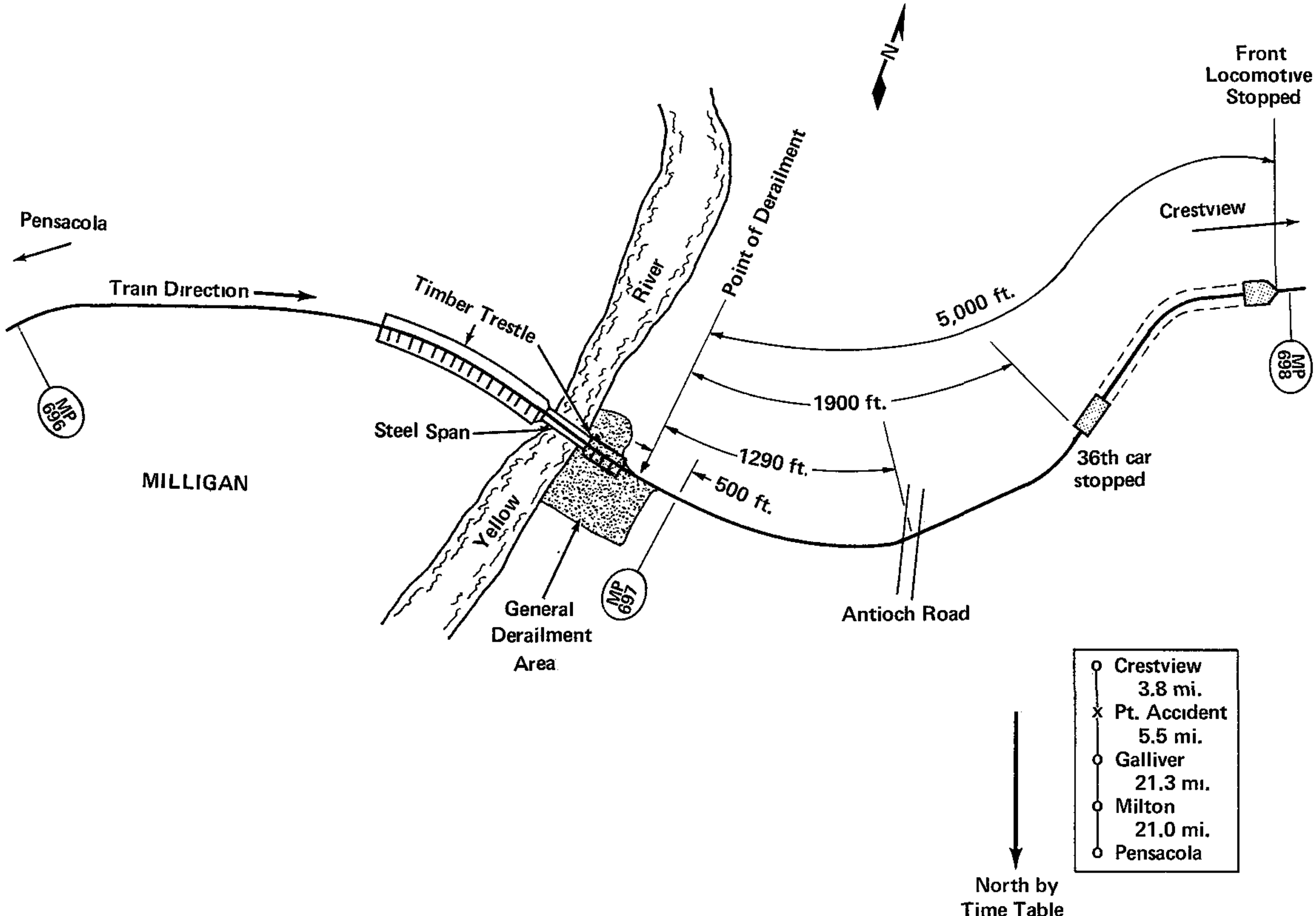
1. Based on the engineer's second interview with FRA, train speed would have increased from the stated 38 mph at MP 691.8 to 47 mph at MP 693.1 before the second reduction made at MP 692.9 would have slowed the train. As stated in the train handling section of this report, the second phase of the split service reduction and subsequent throttle reductions should have been made sooner to control train speed.

2. Using the information in the engineer's statements, it was found that after the full-service application (26 psi reduction) at MP 693.5, the simulated train stopped between MP 693 and MP 695 before reaching the point of derailment. However, in one case, the simulation showed that after reaching 47 mph, the full-service application and the intervening ascending grade would have reduced speed to 24 mph at MP 695.8.

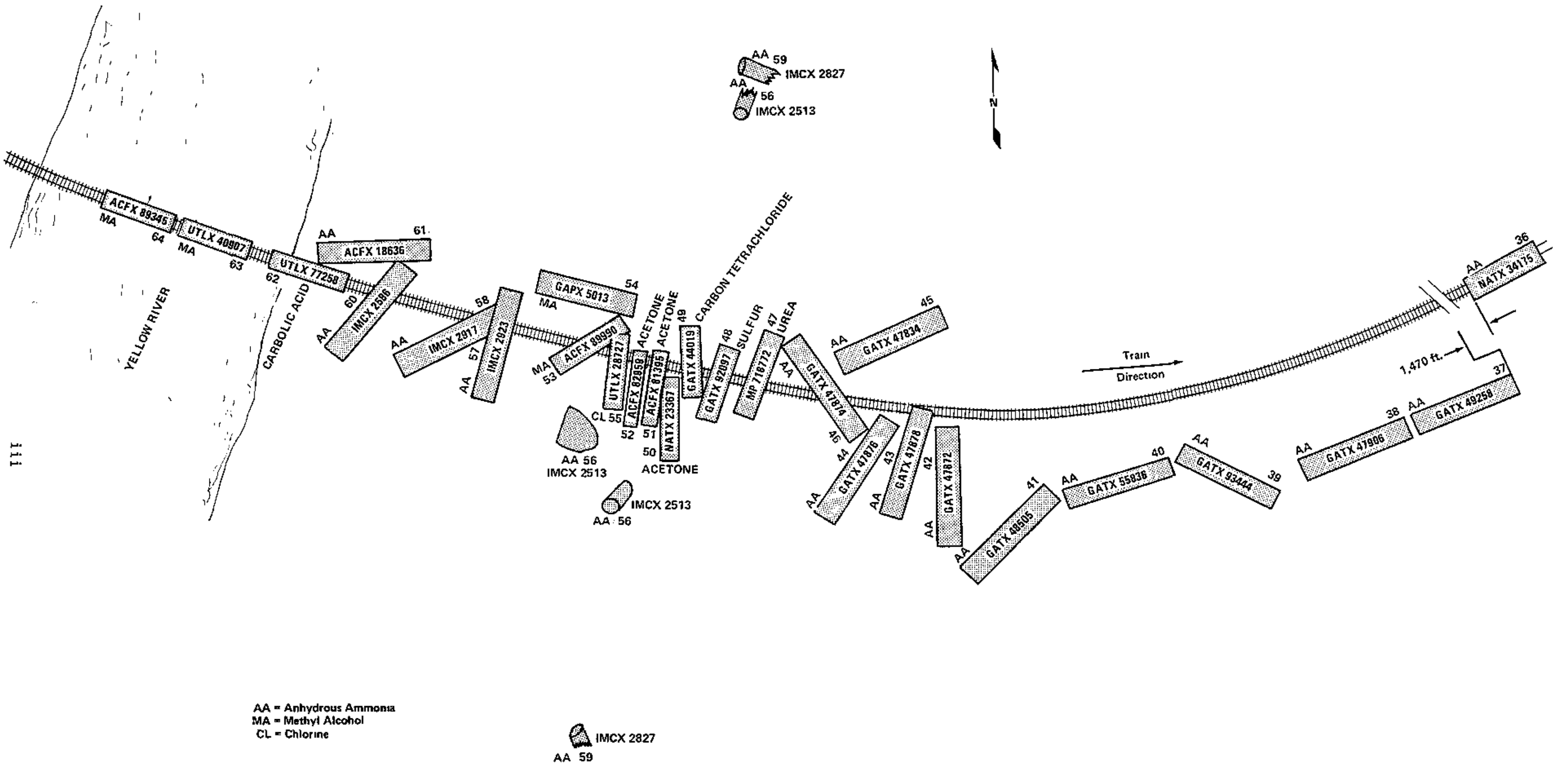
3. With a maximum brake pipe reduction of 15 psi made on the grade between MP 691.8 and MP 693.5, train speed would have been controlled before reaching the accident area, even when initial speeds of 50 mph were reached at MP 691.8.

4. Based on simulations and test rack results, it is evident that the full service brake pipe reduction at MP 693.5 was not made. However, the initial minimum reduction could have been released, and the effect of subsequent reductions diminished. To simulate this possibility, a run on the air brake test rack was made with an unintentional release occurring during the initial minimum reduction to determine what effect this would have on subsequent handling. This was simulated by using test rack brake cylinder pressures divided by 2.5 to obtain a brake pipe reduction amount, and using that amount of reduction in the TOS model. Starting at MP 691.7 at 38 mph, the simulated train reached 53 mph at MP 693.8 and was slowed to only 48 mph at MP 694.3 because the release made during the initial application resulted in lower brake cylinder pressures when the full-service was made at MP 693.4.

Appendix D, Train Operations Simulator Analysis (1)



SKETCH OF ACCIDENT AREA



PLAN VIEW OF ACCIDENT SITE

ACCIDENT REPORT

SYNOPSIS

On April 8, 1979, at approximately 8:00 a.m., twenty-eight cars of a southward Louisville and Nashville Railroad Company (L&N) freight train derailed 3.8 miles north of Crestview, Florida. The weather was overcast with light rain falling at the time of the accident.

The derailment occurred as the train entered a 4° curve and longitudinal forces built up in the area of the 36th to the 40th car. These longitudinal forces accentuated the lateral forces already present because of track curvature and speed. One of these cars derailed as a result of the high lateral forces and disturbed the track sufficiently to derail the following cars. Twenty-five of these cars were placarded tank cars containing hazardous materials. The severity of the accident was greatly magnified due to the types and amounts of hazardous materials contained in the train.

CAUSE

The probable cause of the accident was the failure of the engineer to operate the train in accordance with prevailing speed restrictions and proper train handling procedures. Contributing to the accident were: (1) the dispatching of a heavy train consisting of a variety of large-capacity tank cars with motive power inadequate to properly negotiate the ruling grade on the line; and (2) the failure of the railroad to adequately instruct its personnel in proper train handling procedures.

CASUALTIES

One local resident in the area at the time of the derailment was hospitalized for shock and ammonia inhalation. There were no injuries to train crew members.

LOCATION AND METHOD OF OPERATION

The accident occurred 3.8 miles north of Crestview, Florida on that part of the Mobile Division extending between Pensacola and Chattahoochee, Florida, a distance of 163.2 miles. In the accident area, the railroad is a single-track line over which trains operate by timetable and train orders.

Geographically, the train was moving eastward. However, timetable direction is southward, and timetable directions will be used throughout the report.

AUTHORIZED TRAIN SPEEDS

The maximum authorized speed for freight trains on the sub-division is 49 miles per hour (mph). Approaching the accident area, speed is restricted by timetable special instructions to 40 mph between Mile Post (MP) 692.6 and MP 696.5, and further restricted to 35 mph between MP 696.5 and MP 698.5. This includes the point of the accident at MP 696.9.

TRACK GEOMETRY AND STRUCTURES

From the north, beginning at MP 695, there are in succession: a tangent for 300 feet, a 2° curve to the right for 670 feet, a tangent 950 feet in length, a 2° 30' curve to the left for 1,600 feet, a tangent 1,030 feet in length, a 2° curve to the right 1,866 feet in length, a tangent 1,250 feet in length, a 3° curve to the right 1,490 feet in length, a tangent 540 feet in length, and a 4° curve to the left 100 feet to the approximate point of derailment, and an additional 1,954 feet beyond.

Beginning at Galliver, MP 691.4, the grade is about level to MP 691.8. The track descends about one percent to MP 694.3, ascends about one percent to MP 695, then descends about one percent to MP 696.3. The track is approximately level to the point of derailment at MP 696.9 and through to MP 697.3. The track ascends about one percent to MP 700.5. This grade is the ruling grade for this sub-division.

From the north, at MP 696.6, there are in succession: a 1,363-foot ballast deck timber pile trestle, a 125-foot open deck steel thru truss bridge, and a 72-foot ballast deck timber pile trestle spanning the Yellow River.

PREVIOUS TRACK AND BRIDGE INSPECTIONS

The track in the immediate vicinity of the derailment was last inspected prior to the derailment on April 6, 1979, by the carrier's inspectors and no exceptions were taken. FRA's last inspection prior to the accident was made on March 9, 1979, in connection with FRA Emergency Order No. 11. This inspection was made with FRA's hi-rail Rail Flaw and Track Geometry Vehicle (R-2). At the time of this inspection, a cross-level defect of 1 3/8-inch variation in 31 feet was found in the north spiral of the curve, just south of the bridge and near the point of derailment.

The carrier's division engineer, who was present during this inspection, placed a slow order reducing the speed from 35 mph (FRA Class 3), to 25 mph (FRA Class 2), which brought the track into compliance. Federal Track Safety Standards permit a cross-level variation of 1 1/4-inch for Class 3 track, and 1 3/4-inch for Class 2 track. The carrier corrected this cross-level defect on April 1, 1979. The slow order was lifted on April 3, 1979, by the roadmaster, and the speed was restored to 35 mph.

The bridge was inspected on March 20, 1979, by the carrier's bridge inspector. This inspector took no exception to any item on the bridge that would involve the regular operating speed of 35 mph.

FRA EMERGENCY ORDER NO. 11

The FRA issued Emergency Order No. 11 on February 7, 1979, requiring the L&N to take several steps concerning train operations and maintenance of track used for the transportation of hazardous materials. The order was issued due to numerous serious hazardous material incidents which occurred as a result of several derailments on L&N property.[1]

Included in the order was a 30 mph speed restriction on trains handling hazardous materials.

On March 1, 1979, L&N requested relief from all the terms of the order on two line segments which were said to be in compliance with FRA regulations. One of these

[1]On June 18, 1979, the Federal District Court for the District of Columbia concluded that Emergency Order No. 11 was invalid.

segments included the accident area. After numerous inspections and extensive investigation by FRA and state personnel, the FRA lifted the emergency order for this line segment on April 6, 1979.[2]

OPERATIONS PRIOR TO THE ACCIDENT

The train originated at Gentilly Yard, New Orleans, Louisiana, and departed that point at 6:08 a.m. on April 7, 1979. It arrived at Pensacola, Florida, at 2:00 a.m. on April 8th, the day of the accident. In order to reduce tonnage, 16 cars were removed from the rear of the train. One locomotive unit was removed for maintenance, and locomotive unit No. LN 4129 was added. An initial terminal air brake test was made; the brake pipe leakage was about three pounds per minute and no exceptions were noted.

The train departed Pensacola as No. 403, a second class southward freight train, at about 5:25 a.m. The train consisted of five diesel-electric locomotive units, LN 1045 (EMD GP-30), LN 1013 (EMD GP-30), SCL 515 (EMD GP-38-2), LN 510 (EMD GP-9) and LN 4129 (EMD GP-38-2), 107 loaded cars, six empty cars and a caboose. Train tonnage totalled 11,360 tons. The front locomotive unit was headed south operating with the short hood forward, and was equipped with 26L brake equipment. This train was not equipped for dynamic braking because only two of the five locomotives had this capability. The locomotive units were not equipped with speed recorders. All locomotive units had four wheel trucks. Frequent observations of the train were made after departure and no unusual conditions were observed. A hot box detector, passed at MP 677, displayed a clear indication.

The engine of the fifth locomotive unit (LN 4129) shut down several times between Pensacola and the accident area. The engine shutdown was due to the operation of the low water protective device which was being activated because the pressure cap was not properly applied to the filler opening located at the top of the engine water expansion tank. The front brakeman stated that he went back to restart the engine at MP 668. He manually depressed the low water protective device reset button while the train was ascending the grade near Milton, Florida. This enabled the train

[2] Due to a court order, the 30 mph restriction was not in effect between February 26 and April 4, 1979. On April 4, the court order was overturned which again placed the 30 mph restriction in effect.

to ascend the grade at MP 674 at a speed of 8 to 10 mph. The brakeman returned to the front unit as the train was passing the hot box detector near MP 677. Locomotive unit No. 4129 again shut down. The engineer stated that he went back to restart the engine after the train had passed Floridale, near MP 684. In the engineer's absence, the brakeman operated the train. The engineer further stated that he returned to the cab of the front locomotive unit at approximately MP 687.

As the train approached the point of the accident at 8:00 a.m., the engineer and front brakeman were in the cab of the front locomotive unit. The conductor and the flagman were in the cupola of the caboose.

DERAILMENTS IN THE CRESTVIEW AREA

On April 10, 1978, approximately three miles south of Crestview, the engineer involved in the April 8, 1979, accident was operating a northward train with five locomotive units and 137 cars (7,946 tons) at an estimated speed of 40 mph. After descending a three-mile grade to the Shoal River, and starting to ascend a three-mile grade into Crestview, the 23rd car in the train derailed in a 4° curve to the left. Subsequently, the 33rd through the 54th cars were derailed. The 23rd car derailed to the inside of the curve. The L&N Derailment Committee reported the cause as "... lateral drawbar force on curve excessive."

On May 29, 1978, about 12 miles south of Crestview, a southward train with another engineer operating a consist of five locomotive units and 112 cars (10,446 tons) was involved in a derailment. The 35th, 85th, 88th, 89th, 90th, 99th and 100th cars derailed. The L&N assigned the cause to a broken rail. The FRA had some doubt about the cause, and a dissenting report was submitted stating that the accident was due to excessive slack action forces within the train near the 35th car and the rail broke as a result of the derailment.

THE ACCIDENT

The engineer stated that at 8:00 a.m., the front end of the train was between a 4° curve to the left and a 4° curve to the right in the vicinity of MP 697.5. While the train was moving at a speed of about 30 mph, the train air brakes applied in emergency. He and the front brakeman looked back and observed a huge column of fire rising above the tree tops from a point farther back in the train. About 15 to 20 minutes later, a "tremendous" explosion occurred.

Train No. 403 stopped with the front locomotive unit a short distance north of MP 697.9. The first 35 cars remained coupled to the locomotive and did not derail. The 36th car stayed coupled to the front end of the train, and only the trailing truck derailed. All wheels on the following 26 cars were derailed. The cars stopped in various positions on or about the track structure at MP 696.6. (See Plan View of Accident Site) The leading truck of the 63rd car was derailed. The 64th car subsequently derailed when fire weakened the bridge structure. Of the derailed cars, 17 were destroyed, 10 were substantially damaged and one sustained minor damage.

Twenty-five of the derailed cars contained hazardous materials. Seventeen cars contained anhydrous ammonia, three contained acetone, three contained methyl alcohol (methanol), one contained chlorine, and one contained carbolic acid (phenol). Two cars of anhydrous ammonia ruptured and rocketed. The contents of two cars of acetone and one car of methyl alcohol completely burned. The contents of one car of acetone and one of methyl alcohol were partially lost due to fire. Six cars of anhydrous ammonia, one of chlorine, and one of carbolic acid developed leaks from various causes.

A large vapor and smoke cloud developed and blanketed the immediate area. The cloud eventually spread over an area three to five miles wide.

COST OF DAMAGES

The carrier's estimate of loss and damage to train equipment, bridge and track structure was $1,061,500. This damage does not include the costs associated with evacuation, emergency response by civil or local authorities, loss and damage to lading, clearing of track and claims settlements for injuries.

EMERGENCY MEASURES

Immediately after the derailment, the engineer contacted the train order operator at Crestview, and informed him of the situation via radio. The operator immediately telephoned the fire, police and sheriff's departments and unsuccessfully attempted to contact the County Civil Defense Office. Personnel from the various departments arrived at the scene minutes later. An assessment was made of the situation, and a decision was made to evacuate a thirty square mile area. About 4,500 people were evacuated.

Crew members of the derailed train had the train consist and waybills covering the cars in the train in their possession. The train consist contained a listing of cars by type of hazardous materials as well as general procedures to follow in case of a hazardous materials incident. This information was made available to local authorities.

Numerous Federal, state, county and surrounding community agencies participated in the operation. An airplane from the local Air Force Reserve flew over the area and provided valuable information which was used to plan emergency response operations.

FEDERAL RAILROAD ADMINISTRATION (FRA) RESPONSE TO THE DERAILMENT

On April 8, 1979, at approximately 8:50 a.m., the L&N diesel shop foreman on duty at Mobile, Alabama notified the FRA inspector headquartered in Mobile of the derailment. The FRA inspector called the L&N train dispatcher for additional information and then informed his supervisor. Personnel of the L&N immediately notified the National Response Center, who in turn promptly notified key FRA safety personnel.

The FRA inspector left Mobile enroute to the derailment site, stopping at Pensacola, Florida to gather information with regard to the train consist and operation. The inspector arrived in the accident area at approximately 2:30 p.m. Additional FRA inspectors assigned to the derailment investigation arrived from their offices in Birmingham, Alabama, Jacksonville, Florida, and Atlanta, Georgia, between 4:15 and 6:30 p.m., on the day of the accident.

POST ACCIDENT ANALYSIS

LOCOMOTIVE UNITS

Examination of the locomotive units disclosed that the fifth locomotive unit was inoperative at intervals, unless the low water protective device was manually overridden. No defective conditions were found in the remaining locomotive units which could have contributed to the accident.

The front locomotive unit's speed indicator was calibrated and found accurate at 30 mph, and 1 mph fast at 40 mph.

CARS

The 36th car, NATX 34175, and the 37th car, GATX 49258, bore rail markings on the bottom of the east truck frames. The 36th car remained upright. The north truck, although derailed, remained with the car after the derailment. Side bearing clearance measurements were within FRA limits on this car. The 37th car, equipped with type F couplers, had a knuckle broken on the "A" (south) end of the car. The break in the knuckle was new. It was determined to have occurred due to stresses of the derailment. The 38th car had an air hose removed from the "A" (north) end by L&N employees to determine if the air hose burst or was gouged in the derailment. It was subsequently determined that the hose did not burst from air pressure. The puncture evidently occurred during the derailment. The 39th car had SE-60 couplers with the "A" (north) end knuckle broken by a twisting movement during the derailment. A piece of rail about 12 feet long was driven through the body bolster of this car. The rail was originally a part of the west (high) rail located about 70 feet south of the 72-foot ballast deck trestle. The 37th through 40th cars and their trucks were damaged to a point that reconstructed measurements would not be meaningful.

The 42nd through the 62nd car involved in the derailment sustained damages to the extent that a complete inspection could not be made. Listed below are details of damages to the derailed equipment and the performance of head shields and couplers during the derailment:

36th Car NATX 34175 Tank Car DOT Spec. 112S340W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Only trailing truck derailed. Remained coupled to train and was dragged a short distance on track structure. No lading was released.
37th Car GATX 49258 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally parallel to the track structure. No lading was released.
38th Car GATX 47906 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally parallel to the track structure. No lading was released.
39th Car GATX 93444 Tank Car DOT Spec. 112S340W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally parallel to the track structure. No lading was released.
40th Car GATX 55836 Tank Car DOT Spec. 112A340W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally parallel to the track structure. No lading was released.
41st Car GATX 48505 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally parallel to the track structure. No lading was released.

42nd Car GATX 47972 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally perpendicular to the track structure. Tank was leaking around the protective housing, due to a loose packing gland at the gauging device. The jacket separated at the 3rd-4th concourse weld seam, approximately 75% around the car, apparently the result of impact with other rolling stock.
43rd Car GATX 47878 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally perpendicular to the track structure. Sustained a 3-inch puncture on the left side on the "B" end of the tank. Approximately 100 gallons of lading was released, apparently the result of impact with a truck side frame.
44th Car GATX 47876 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car turned over rolling down a fifteen foot embankment. Generally perpendicular to the track structure. Sustained a cut on the bottom side of the tank at the "A" end. The cut apparently was the result of impact with a truck side frame or other rolling stock in the train. Approximately 100 gallons of lading was released.
45th Car GATX 47834 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest on the north side of and diagonal to the track structure. Sustained 48-inch jacket cut as a result of the derailment impact. No lading was released.

46th Car GATX 47874 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest diagonal to and across track structure. Sustained jacket tearing as a result of the derailment impact. No lading was released.
47th Car MP 718772 Covered Hopper AAR Mech. Designation LO Urea, Feed Grade Not a DOT Hazardous Material	Car came to rest generally perpendicular to and across the track structure. Car was damaged and lading contaminated.
48th Car GATX 92097 Tank Car DOT Spec. 111A100 Sulfur, Crude Molten Not a DOT Hazardous Material	Car came to rest generally perpendicular to and across the track structure. Sustained a 4-inch cut on the tank head at the "A" end as a result of impact with other rolling stock. An estimated 60 tons of sulfur was released and burned.
49th Car GATX 44019 Tank Car DOT Spec. 111A100W Carbon Tetrachloride Not a DOT Hazardous Material	Car came to rest generally perpendicular to and across the track structure. Sustained a cut on the "BL" side. The top of the tank at the "A" end was crushed. Approximately one-half of the lading was released.
50th Car NATX 23367 Tank Car DOT Spec. 111A100W Acetone Flammable Liquid	Car came to rest generally perpendicular to and across the track structure. Car was crushed by force of trailing cars. Approximately three-quarters of the lading was released and burned.
51st Car ACFX 81395 Tank Car DOT Spec. 111A100W Acetone Flammable Liquid	Car came to rest generally perpendicular to and across the track structure. Car was crushed by force of trailing cars. All of the lading was released and burned.

52nd Car ACFX 82959 Tank Car DOT Spec. 111A100W Acetone Flammable Liquid	Car came to rest generally perpendicular to and across the track structure. Car was crushed by force of trailing cars. All of the lading was released and burned.
53rd Car ACFX 89990 Tank Car DOT Spec. 111A100W Methyl Alcohol (Methanol) Flammable Liquid	Car came to rest diagonal to and across track structure. Car was crushed by force of trailing cars. Approximately three-quarters of the lading was released and burned.
54th Car GATX 5013 Tank Car DOT Spec. 111A1100W Methyl Alcohol (Methanol) Flammable Liquid	Car came to rest on the north side of and parallel to the track structure. Car was crushed by force of trailing cars. Lading was completely released and burned.
55th Car UTLX 28727 Tank Car DOT Spec. 105A500W Chlorine Non-Flammable, Toxic Compressed Gas	Car came to rest generally perpendicular to and across the track structure. Sustained a puncture on the "BL" side of the car. The puncture appeared to be the result of perforation by a type E coupler. Approximately one-half of the lading was released and vaporized. The remainder was neutralized and burned during clean-up operations.
56th Car IMCX 2513 Tank Car DOT Spec. 112S400W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest south of the track structure with the protective housing in the ground. As a result of damages sustained during the derailment and the fire in the area, the car tank ruptured and tank pieces rocketed. The entire lading was released and subsequently vaporized.

57th Car IMCX 2923 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest perpendicular to and across the track structure. The tank jacket was torn severly. The tank and jacket suffered severe burns. Due to a slight leak caused by the fire, approximately 100 gallons of lading was released and vaporized.
58th Car IMCX 2917 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest perpendicular to and across the track structure. Sustained damage to the inner tank during derailment. The car was still leaking during the field investigation, preventing a thorough determination of damage.
59th Car IMCX 2827 Tank Car DOT Spec. 105A300W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Sustained damage which caused the car to break into several pieces and rocket. Visual examination of the tank failure indicated that the break was initiated by a severe impact near the center of the tank.
60th Car IMCX 2586 Tank Car DOT Spec. 112S400W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest perpendicular to and across the track structure. The coupler and draft sill were damaged on both ends of the car. Head shield partially torn off "B" end; head shield missing from "A" end. No leaks. Contents of car transferred to another car.
61st Car ACFX 18636 Tank Car DOT Spec. 112A340W Anhydrous Ammonia Non-Flammable, Toxic Compressed Gas	Car came to rest parallel to and 20 feet north of the track structure. Tank head on "B" end dented and subjected to fire. Tank head on "A" end undamaged. No loss of contents. Contents transferred to another car.

62nd Car
UTLX 77258
Tank Car
DOT Spec. 111A100W3
Carbolic Acid (Phenol)
Poison B

Bottom outlet valve sheared off when leading end of car dropped off end of bridge and the trailing end remained on the bridge. Minimum loss of contents.

63rd Car
UTLX 40907
Tank Car
DOT Spec. 111A100W-1
Methyl Alcohol (Methanol)
Flammable Liquid

Remained upright on bridge span. No damage to the car. No leakage of contents. Contents transferred to another car.

All cars were equipped as required by Federal Hazardous Materials Regulations.

No severe head dents were sustained in the area of the head shields on the cars so equipped; the head shields evidently performed as intended, though several separated from the cars during the derailment.

The compressed gas cars (DOT Specification 105 and 112) were equipped with either E shelf, F shelf, or F couplers. Only the first five cars remained reasonably in line. The remainder of the cars were at diagonal angles or perpendicular to the track structure. No cars were observed coupled together. One coupler was observed with a type F coupler head coupled to it. Some couplers remained intact on the cars. Other couplers and draft gears were torn away from the cars and were missing.

The first six derailed tank cars were equipped with shelf couplers of various manufacture. Consideration was given to the possibility that shelf interference caused a possible lifting of a car body. However, it could not be determined that this type of action occurred prior to the derailment.

The 47th car (MP 718772), a hopper car loaded with Urea, had a "Home Shop for Repairs" tag attached which noted that the car had been involved in a derailment at Dallas, Texas on January 21, 1979, during delivery to the Santa Fe Railway. The Santa Fe applied the home shop tag stating that, when empty, the car should be returned to the Missouri Pacific Railroad for examination of the roller bearings. It appears that the bearing examination was never made and that the loaded car was interchanged to the L&N with the home shop tag still applied. Examination of the car after the derailment disclosed no evidence of damage to the roller bearings or adapters. There was no evidence that this car caused or contributed to the derailment.

Other derailed cars showed no indication of defects which could have caused the derailment. Some knuckles and couplers were broken, but the appearance of the breaks indicated that they were a result of the derailment and not the cause of the accident. (Appendix A, Sketch of Mechanical Damage to Cars)

Following the accident, the 35 front end cars were taken south. Two cars were set-out at Chattahoochee, Florida. The remaining 33 cars received a brake test and inspection at Baldwin, Florida. No exceptions were noted.

The 50 rear end cars were inspected by L&N inspectors and were returned to Pensacola, Florida. The inspection and brake test, performed by FRA and Florida State inspectors at Pensacola, Florida, revealed a three pounds per minute brake pipe leakage caused by a hole in the auxiliary reservoir pipe on the 65th car in the train. No other exceptions were noted.

Of the 112 pairs of wheels involved in the accident, 108 pairs were accounted for and inspected. During the wrecking operation, four wheels were located that had loosened and moved on their axles. Evidence and tests performed at the L&N Louisville wheel shop showed that this had occurred either as a result of the initial derailment or during the wrecking operation. Four pairs of wheels involved in this accident could not be located. It was determined, however, that these wheels were not applied to cars initially involved in the derailment.

TRACK AND STRUCTURES

The track structure in the immediate vicinity of the derailment consisted of 132-pound continuous welded rail laid on an average of 22 treated hardwood crossties per 39 feet of rail length, fully tie plated, with 7 3/4" x 14" double shoulder tie plates, and spiked with two rail holding spikes per plate. The track had been timbered and surfaced in late 1976.

The rail was welded relayer rail and was laid in late 1976. It was box anchored with drive-on type rail anchors on alternating ties.

The ballast was granite stone and basic chemical slag with an average depth of 12 to 16 inches below the bottom of the ties. Shoulder ballast extended about 12 inches beyond the end of the ties.

The sub-soil beneath the track structure was of a solid sandy type. The roadbed extended about 12 feet beyond the track structure. The track in the general area of the derailment was on a 10-foot fill.

Due to a thorough track inspection in conjunction with Emergency Order No. 11, an FRA track inspection vehicle, R-2, detected a cross-level defect in the general area of the derailment on March 9, 1979. The division engineer was present when the defect was located. On that date, both an FRA and a Florida State track inspector measured a 1 3/8-inch change in cross-level in 31 feet on the north spiral of the curve at the south end of the 72-foot ballast deck timber trestle. A 25 mph slow order was immediately placed on the track by the carrier. On Sunday, April 1, 1979, the track foreman stated that his gang surfaced and lined the spiral of the curve. On April 3, 1979 the slow order was removed by the roadmaster after he inspected the location. The division engineer inspected the location on April 5, 1979, and stated that the condition had been repaired. The front end crew of the train involved in the derailment noted nothing unusual in the ride in this area, nor did the crew of the last train to pass prior to the derailment.

A witness, who stated that he saw a gang working in this track area on April 1, 1979, also stated that he noticed, on the same day, a rail that had been damaged by high-powered rifle bullets. He reported this to the track foreman at that time. After the derailment, this rail was recovered and three indentations were observed in the web of the rail. However, there were no breaks in this rail near the indentations.

Examination of the track structure in the derailment area revealed that the derailment occurred on the entering north spiral of a 4° curve to the left, 2,054 feet in length and approximately 100 feet south of a 72-foot ballast deck trestle. The designated elevation of this curve was 3 1/2-inches. The trestle and the track structure for a distance of 503 feet were destroyed. The 36th car remained coupled to the head of the train with the rear truck derailed. As this car continued around the curve after the truck derailed, the rear wheels turned the high rail over to the outside for a distance of 156 feet, causing minor damage to tie plates, rail anchors, spikes and crossties for an additional distance of 1,419 feet.

Examination of the main track north of the initial derailment point disclosed no evidence of dragging equipment or other obstruction. Cross-level measurements taken, while not under load, disclosed variations of up to 1/2-inch. Track gage varied between 56 1/8-inches and 57 1/8-inches.

The carrier recovered all except 25 feet of the west rail from the accident area. All rail recovered from the wreck site was examined. This examination revealed only stress breaks and no signs of internal defects. Marks on the rail did not indicate where the initial derailment had occurred. Although 25 feet of the west rail, which was the low or stress rail in the accident area, was never recovered, examination of the cars which passed the derailment site did not reveal any of the markings which are usually associated with the presence of a broken rail.

Post-accident examination of the bridge structure revealed that the 72-foot, pile-driven trestle was completely destroyed by the derailment and resulting fire. The thru-truss span sustained substantial damage to the southeast hip hanger, south end stringers of panel five, east bottom chord of panel five and south end floor beam. Heat damage was also sustained to various other bridge members. The 125-foot track structure on the thru-truss span of the bridge received extensive heat damage from the burning cars. About 80 percent of the ties and 70 percent of the rail were destroyed on the truss. Samples of the web of the south ends of both stringers, the bottom flange angles, and a rivet from the west stringer were tested by an independent laboratory. The results indicate that the fire did not alter the metallurgical or mechanical properties of the samples tested.

TRAIN SPEED

The establishment of speed approaching and at the accident site is dependent on statement of the engineer, statements from witnesses, and computer analysis.

1. Engineer's statement: The engineer stated that he experienced some difficulty maintaining the 40 mph timetable speed with the train brake as he descended the long grade to the accident scene. He stated that as the train entered the 4^{o} curve where the accident occurred, he was traveling 30 mph, which is within the 35 mph maximum timetable speed permitted.

2. Witnesses' statements: At least thirteen witnesses made statements estimating train speed. The witnesses nearest to the derailment site thought that the train was going faster than usual. Five witnesses located about 1/2-mile north of the derailment, at various distances from the track, estimated the speed between 25 and 40 mph.

One of the witnesses stated that the locomotive was going by her house at about 40 mph and it later started slowing to 30 mph. The observations varied depending upon what part of the train was sighted. When the 36th car was derailing, the rear end cars would have been decelerating as they passed the locations of the witnesses.

Two witnesses sighted the train two miles north of the accident point while riding in an automobile traveling in the opposite direction. They estimated the train speed at that location at 30 to 40 mph. One witness stopped at Galliver crossing, five miles north of the derailment, and estimated the speed at 40 mph.

Three other witnesses were in an automobile proceeding on U.S. 90 in the same direction as the train. This route parallels the track in some areas and crosses the track by an overhead bridge at one location. The three occupants of the automobile make this trip routinely, and are quite familiar with the area. They were in the best position of all the witnesses to judge train speed, since their automobile was moving in the same direction as the train. When retracing the course that they followed, it was found that their statements were valid with respect to where they could see the train at different locations along the highway.

These witnesses stated that the caboose passed their car as they started from a stop near Galliver (MP 691.2). They stated that, at a speed of 55 mph, they were unable to keep up with the caboose as the railroad diverged from the highway (MP 692.5). One of the witnesses stated that she saw the caboose again as they passed over the track (MP 694.5). All three occupants of the automobile saw the train stopped in the vicinity of Antioch Road (MP 697.3).

A detailed analysis of their statements was made, and is attached (Appendix B, Mathematical Analysis of Statements). The mathematical analysis takes into account the slightly different distances of road versus rail, and is based on the assumption that the witnesses' memories are correct, and that the automobile in which they were riding did average an estimated speed of 55 mph. Assuming that they accelerated to 55 mph in 15 seconds, it would have taken 1,614.3 feet to catch a caboose traveling at 40 mph. The auto starting from a stop, accelerating and traveling at 55 mph would have caught up to a caboose moving at 50.5 mph at MP 692.5, where the road diverged from the track. Had the auto continued at 55 mph for 2.5 miles on the bridge, the caboose would have been moving at 50.6 mph to cover the 2.3 track miles to the bridge. The auto continued to average 55 mph to a point just east of Antioch Road. From this point, the witnesses could have seen the forward portion of the stopped train. If the train had stopped an instant before they saw it, train speed would have had to average at least 42.6 mph from where the train would have been when the caboose was at the overhead bridge to where the train went into emergency.

3. Computer analysis: A computerized Train Operations Simulator (TOS) model, developed from a joint Federal and industry program, was used to simulate the stopping distance of the five locomotive units and the front 36 cars after the emergency application

of the brake. The five locomotive units and the front 36 cars traveled an estimated 1,700 feet to 2,000 feet. The trailing truck of the loaded 36th car was derailed during this entire movement. Analysis of this condition using the TOS indicated that a minimum speed of 45 mph was necessary for the car to travel 1,900 feet. This projection may be conservative, since the computer model cannot accommodate the drag produced by the derailed equipment which occurred prior to the emergency application as well as the drag produced by the derailed trailing truck of the 36th car. Additional results from the simulator are discussed in the TOS section of this report.

Based on the three statements of the witnesses in the car and the computer analysis, the train is estimated to have been traveling at least 40 mph at the time of derailment.

TRAIN HANDLING

L&N Train No. 403 departed Pensacola, Florida, with 5 locomotive units, 107 loaded cars, 6 empty cars, and a caboose. The carrier estimated 10,628 trailing tons. A re-calculation of train tonnage indicated an error in that estimation; at least 11,360 tons were trailing.

L&N's Mobile Division tonnage ratings show that the locomotives assigned to this train should handle 10,663 tons maximum between Milton and Deerland, the area where the ruling Crestview grade is located.

Locomotive unit LN 4129 had been restarted at Pensacola due to a low water protective device shutdown. Enroute, on a grade south of Milton, this problem again occurred several times and the device was manually overridden to enable the train to negotiate the grade at 8 to 10 mph. Since the pressure cap was not in place, the fifth locomotive unit was intermittently inoperative except when the device was manually overriden. However, there is no evidence that an attempt was made to manually depress the low water protective device reset button on the fifth locomotive unit while approaching the Crestview grade as accomplished on the Milton grade.

The rule of thumb employed by the L&N on this line is that, if the Milton grade can be negotiated at a minimum of 10 to 15 mph, the Crestview grade can be handled with the assigned motive power. It was, therefore, clear that four locomotive units would not be able to make the grade. Had the trailing tonnage been computed correctly, the L&N supervision could have realized that the assigned motive power was less than required under L&N ratings for the terrain to be negotiated.

Given the 1.43 mile-long heavy train, without dynamic braking, a predominance of roller bearing equipment, 75 loaded chemical cars with their heavy effective mass, a wet rail, and engine trouble, the engineer was faced with the difficult task of descending the curving grade to the Yellow River, and ascending the long ruling grade to Crestview. The probability of the train not negotiating the hill had been discussed by the engineer and dispatcher after it was noted at which speed the train negotiated the grade at Milton.

The FRA has not been able to determine with certainty how Train No. 403 was handled on the date in question. The engineer has given three separate statements. One statement was given to the carrier and two directly to FRA's investigators. (Appendix C, Train Handling Applications) The statements are similar in several respects, although markedly dissimilar in others.

Each of the engineer's three statements concerning manipulation of the throttle and automatic air brake equipment was subjected to a three-part analysis. This analysis included the use of the Air Brake Test Rack, the Train Operations Simulator (TOS) and an evaluation of the procedures recommended in the manual for Train Track Dynamics to Improve Freight Train Performance (TTD)[3].

AIR BRAKE TEST RACK

Simulation of Train No. 403's air brake system was made using the Westinghouse Air Brake Company's 150 car test rack at Wilmerding, Pennsylvania. The brake valve types, the known piston travel information, the auxiliary reservoir pipe leak, and the 3 pounds per minute brake pipe

[3]Government-Industry Research Program on Track Train Dynamics, Track Train Dynamics to Improve Freight Train Performance, 1973.

leakage (similar to that in the derailed train) were set up on the rack. A brake pipe length of 7,365 feet was used with braking equipment to simulate 114 cars and 5 locomotives.

Three tests were made based on three different statements from the engineer. In each of these cases, sufficient brake cylinder pressures were obtained throughout the train in the first series of applications to either stop, or to almost stop the train before enough time expired to allow it to reach the bottom of the grade. It was noted in all three tests that after the brakes were released from the first series of applications, the brake applications that would have occurred at the bottom of the hill produced less than one-half of the desired brake cylinder pressures in the train, because the system had not fully recharged from the first applications. The short duration of time before release of the second set of applications, plus the low brake cylinder pressures, would have produced a relatively small amount of braking force as the train reached the bottom of the grade. In each of these tests, had the brakes been applied as the engineer described, the train simulated on the test rack would have almost stopped prior to the point of derailment.

Additional tests were made which introduced variations into braking procedures described by the engineer. These tests indicated that a series of brake applications, with very short time periods between applications and releases, produced very little effect in slowing the train.

During one other test, which introduced a brake pipe leakage equivalent to 19 pounds per minute, the result was an unintentional release of the train brakes and significantly lower brake cylinder pressure during subsequent brake applications.

If the brake system on Train No. 403 had been operated employing the methods utilized during these additional tests, the ability of the engineer to control Train No. 403 would have been significantly reduced.

TRAIN OPERATIONS SIMULATOR

The computerized Train Operations Simulator (TOS) model was used to simulate the derailed train's operations. Several different throttle and brake application combinations, including those described by the engineer, were simulated in the TOS model. All simulations made using the applications described by the engineer resulted in the train almost coming to a stop after the first full service application. This was consistent with the findings from the air brake test rack.

Additional simulations were conducted using variations to the brake application and throttle procedures described by the engineer. These simulations produced values for maximum longitudinal forces and L over V ratios (the ratio of lateral to vertical forces on the rail) in the train by car location. Due to the variables and uncertainties involved in the accuracy of these values, and the fact that they differed a great deal, it is difficult to draw precise conclusions. However, in most runs, buff forces developed in that part of the train where the derailed cars were located as the train approached the point of derailment. These simulations also showed that this train would have made the Crestview grade if all five units had been working properly, and if sanding on the wet rail was effective. Another simulation indicated that four locomotive units would have stalled on this grade.

Detailed conclusions resulting from various simulations are contained in Appendix D, Train Operations Simulator Analysis.

TRACK TRAIN DYNAMICS (TTD) MANUAL

An analysis of the engineer's handling of the throttle and automatic air brake was conducted. This analysis focused on the actions described by the engineer in each of his statements which detailed the events during the descent of the 2.8 mile grade, the ascent of the one percent intervening grade for 0.7 of a mile, and the final descent of the 1.5 mile grade to the Yellow River accident site. Based on the comparative analysis of the engineer's reported actions and the recommended procedures contained in the TTD Manual, it appears that the engineer did not follow the recommended procedures as outlined in the manual. A detailed comparison is contained in Appendix E, Track Train Dynamics Manual Comparison.

L&N TRAIN HANDLING INSTRUCTIONS

The overall analysis of the stated train handling techniques employed by the engineer of Train No. 403, particularly the disparity between recommended procedures and the engineer's stated methods, led to a review of L&N train handling instructions for this territory.

A review of the L&N book "Special Rules Governing Train Handling, Air Brakes and Dynamic Brakes" revealed that the carrier appears to have general procedures similar to those outlined in the TTD Manual relative to controlling slack. However, the book does not contain detailed instructions on how to control train speed through use of train air brakes when operating over undulating grade territory. (Similar to the procedures contained in the TTD Manual.)

The book contains instructions on the use of the automatic air brake where trains should be braked to slow down or stop. The instructions also state that normally, slowdowns or stops should be completed with not more than a 15 psi total brake pipe reduction. However, it does not include comprehensive instructions on train handling in undulating territory and there are no instructions of the use and functions of 26L and ABD brake equipment.

The carrier has an instruction car which contains an air brake simulator. However, attendance is on a voluntary basis. Much of the instruction and evaluation of train handling is done by the road foreman, usually when riding trains.

Despite the fact that the territory between Pensacola and Chattahoochee requires particularly skillful handling of long heavy tonnage trains, due to several areas of undulating grades and numerous curves, the carrier made no sustained effort to improve the quality of its train handling instructions. In addition, this particular engineer, who had been involved in an accident in this same general area approximately one year prior to this derailment in which the L&N determined the cause to be "lateral drawbar force on curve excessive," had received no training in the period of time between the two accidents.

L&N POST ACCIDENT OPERATING INSTRUCTIONS

The wreck was cleared, the track and bridge were temporarily repaired, and train operations were resumed on April 14, 1979. At that time, L&N issued additional operating instructions on the line between Pensacola and Chattahoochee, Florida. Southward trains were restricted to a maximum of 120 cars and 8,000 tons. A speed restriction of 5 mph, later increased to 10 mph, was placed in effect in the area of the derailment until permanent bridge repairs could be made. Supervisors were assigned to ride all road trains on this sub-division for a period after the track was reopened.

FINDINGS

1. Examination of the track structure revealed no defective conditions which could have caused the derailment. The track structure in the accident area was within the limits of FRA Track Safety Standards for the maximum authorized speed.

2. Examination of the cars in the train did not reveal any defective conditions that could have contributed to the derailment.

3. Examination of the locomotive units revealed that the fifth locomotive unit was intermittently inoperative, unless the low water protective device was manually overridden. No defective conditions were found in the remaining locomotive units which could have contributed to the accident.

4. The train was dispatched without sufficient motive power to properly negotiate the ruling grade on the line.

5. The train was not handled in accordance with the engineer's statements concerning speed, throttle or air brake procedures.

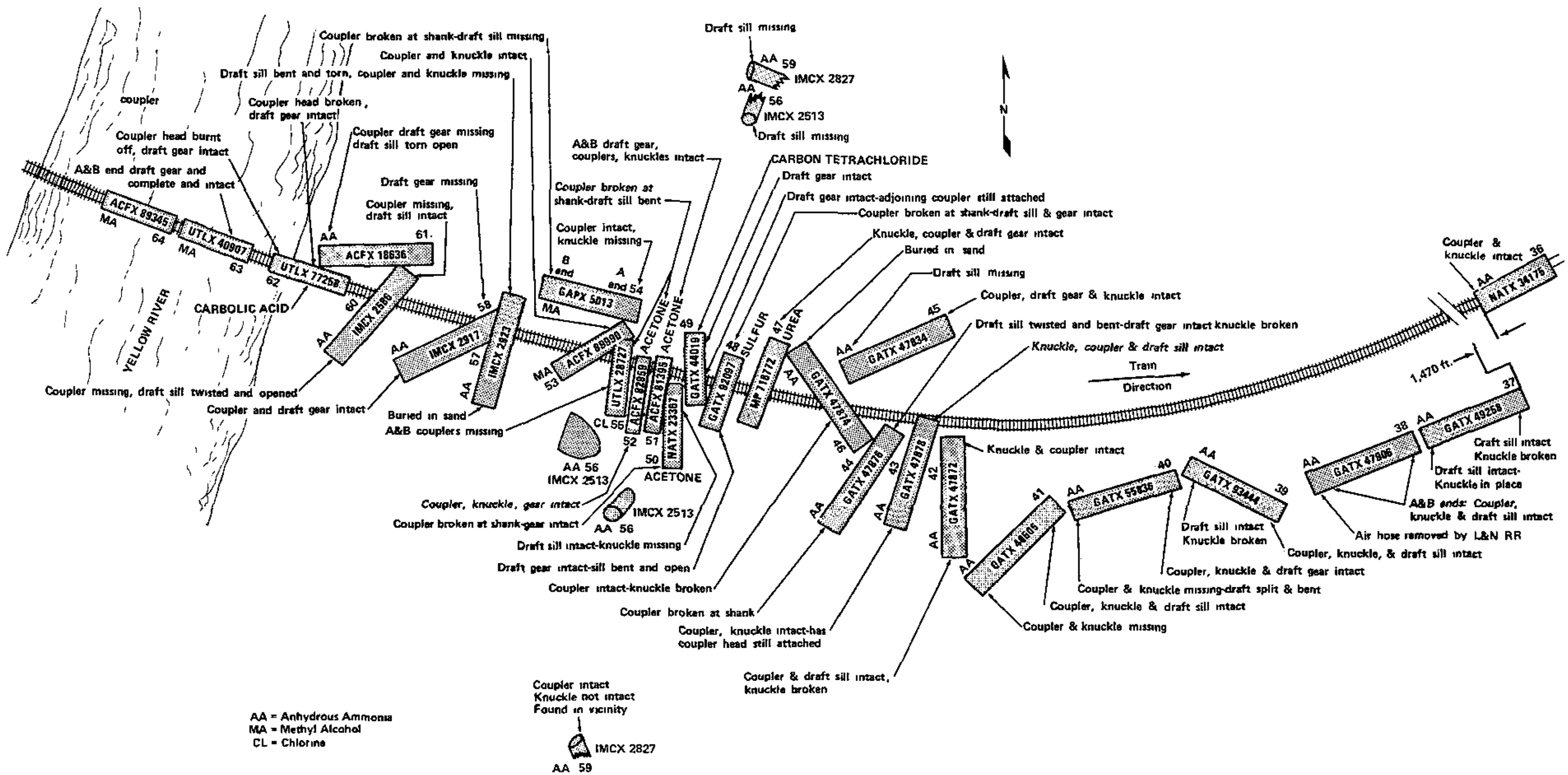
6. The estimated speed of the train approaching the point of derailment and at the point of derailment was at least 40 mph.

7. It could not be determined with certainty how the train was operated on the date of the accident. The general methods of train handling employed by the engineer could have permitted heavy slack running from the rear of the train. This would have produced excessive lateral forces causing the outside rail to be disturbed sufficiently to derail the train.

8. The carrier's training and instruction program fails to insure that engineers receive adequate instruction on all facets of train handling and air brake systems.

Dated at Washington, D. C., this 28th day of November 1979
By the Federal Railroad Administration

J. W. Walsh
Chairman
Railroad Safety Board



APPENDIX A, SKETCH OF MECHANICAL DAMAGE TO CARS

Distance from MP 691.2

Location	Rail miles	Road miles
Switch at MP 692.5	1.3	1.3
Overhead Bridge at MP 694.8	3.6	3.8
Vicinity of Antioch Road	6.1	6.4

1) Given:

Car started at MP 691.2 as caboose passed. Car accelerated to 55 mph in 15 seconds. Train was moving at 40 mph.

D = Distance (in feet) traveled by car to reach caboose.

V_1 = auto velocity in feet per second (fps)

V_2 = train velocity in fps

t = time in seconds

$V_1 = 55$ mph $= 80.7$ fps

$V_2 = 40$ mph $= 58.7$ fps

Compute t and then find D:

$$(1/2)\ V_1\ (15) + V_1\ (t-15) = V_2 t = D$$

$$1/2\ (80.7)\ 15 + 80.7(t-15) = 58.7\ t$$

$$605.25 + 80.7\ t - 1210.5 = 58.7\ t$$

$$22\ t = 605.25$$

$$t = 27.5 \text{ seconds}$$

$$D = V_2 t = 58.7 \times 27.5$$

$$D = 1614.3 \text{ feet}$$

2) Given:

V_1 = 55 mph = 80.7 fps

D_0 = 1.3 mile (distance from car's starting point to where road diverged from track)

D_0 = 6864 feet

Compute V_2:

$$V_1 (t-15) + 1/2 (15) V_1 = D_0$$

$$80.7 t - 1210.5 + 605.25 = 6864$$

$$t = 92.6 \text{ seconds}$$

$$V_2 = \frac{D_0}{t} = 74.1 \text{ fps}$$

$$V_2 = 50.5 \text{ mph}$$

3) Given:

Auto nearing caboose at MP 692.5 continued toward the overhead bridge at 55 mph where one witness sighted the caboose from the bridge.

Compute the speed of the caboose at the overhead bridge:

V_1 = 80.7 fps

D_1 = 2.5 miles (road)

D_2 = 2.3 miles (track)

Compute V_2:

$$\frac{V_2}{D_2} = t = \frac{V_1}{D_1}$$

$$\frac{V_2}{2.3} = \frac{80.7}{2.5}$$

$$V_2 = 74.2 \text{ fps} = 50.6 \text{ mph}$$

4) Given:

Auto continued to average 55 mph to a point just east of Antioch Road where the witnesses saw the stopped train. The following calculations are made under the assumption that the witnesses had sighted the train just after it came to a stop.

D_3 = 2.6 miles = 13,728 feet

V_1 = 80.7 fps

Compute t:

$$t = \frac{D_3}{V_1} = \frac{13,728}{80.7} = 170.1 \text{ seconds}$$

Compute D_4 and V_2:

When the caboose was at MP 694.8, the lead locomotive unit was at MP 694.8 + 1.43 (train length = 1.43 miles) or MP 696.23. The locomotive unit stopped at MP 697.9.

D_4 = 697.9 - 696.23

D_4 = 1.67 miles = 8817.6 feet

D_5 = distance which lead unit traveled after emergency application = 1800 feet.

t_1 = time from emergency to stop

V_2 = minimum average velocity of lead unit from 696.23 to emergency application.

$$\frac{t_1 V_2}{2} = 1800$$

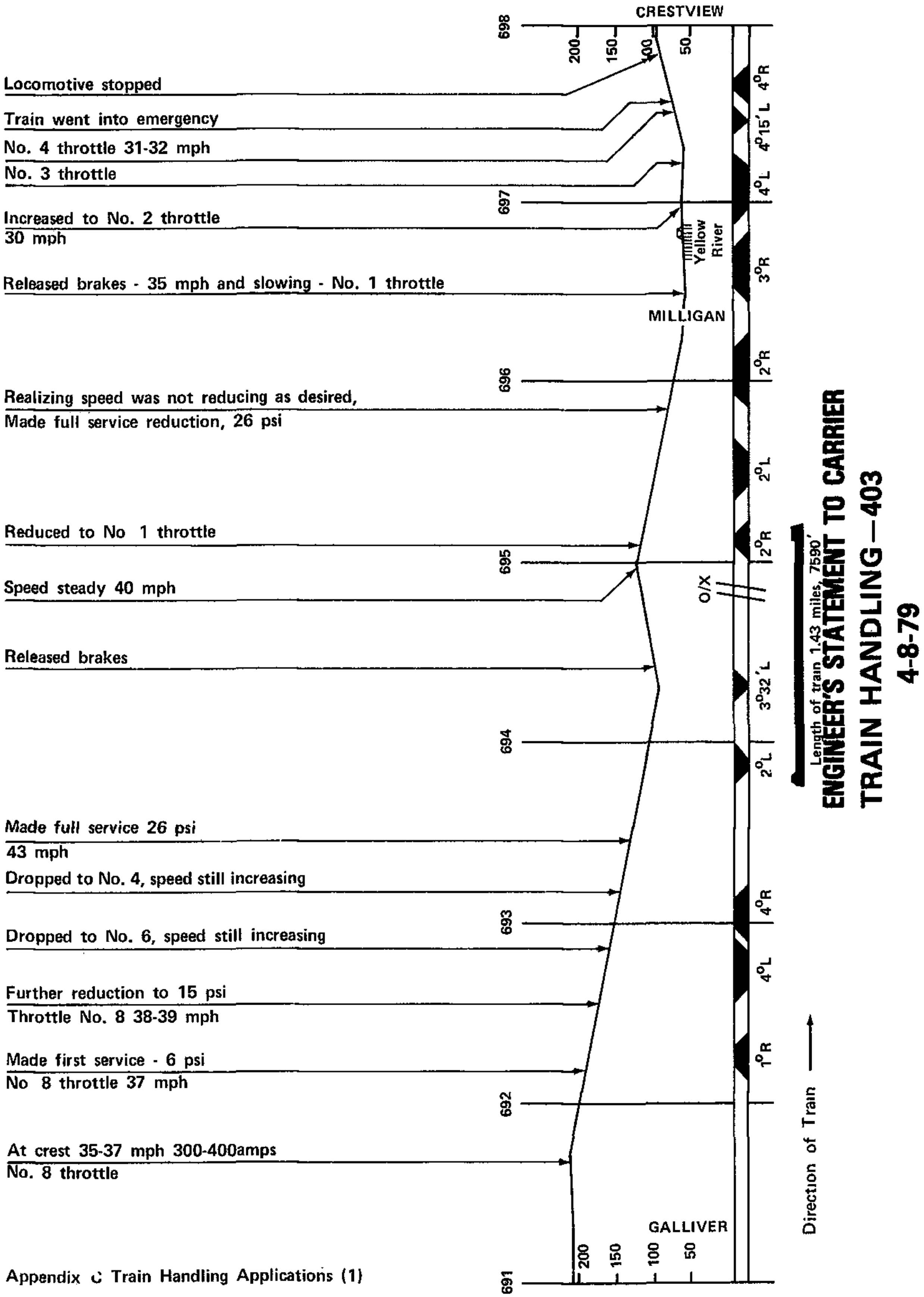
$$(170.1 - t_1)\, V_2 + 1/2\, t_1 V_2 = 8817.6$$

$$170.1\, V_2 - 1/2\, t_1 V_2 = 8817.6$$

$$170.1\, V_2 - 1800 = 8817.6$$

$$V_2 = 62.4 \text{ fps}$$

$$V_2 = 42.6 \text{ mph}$$

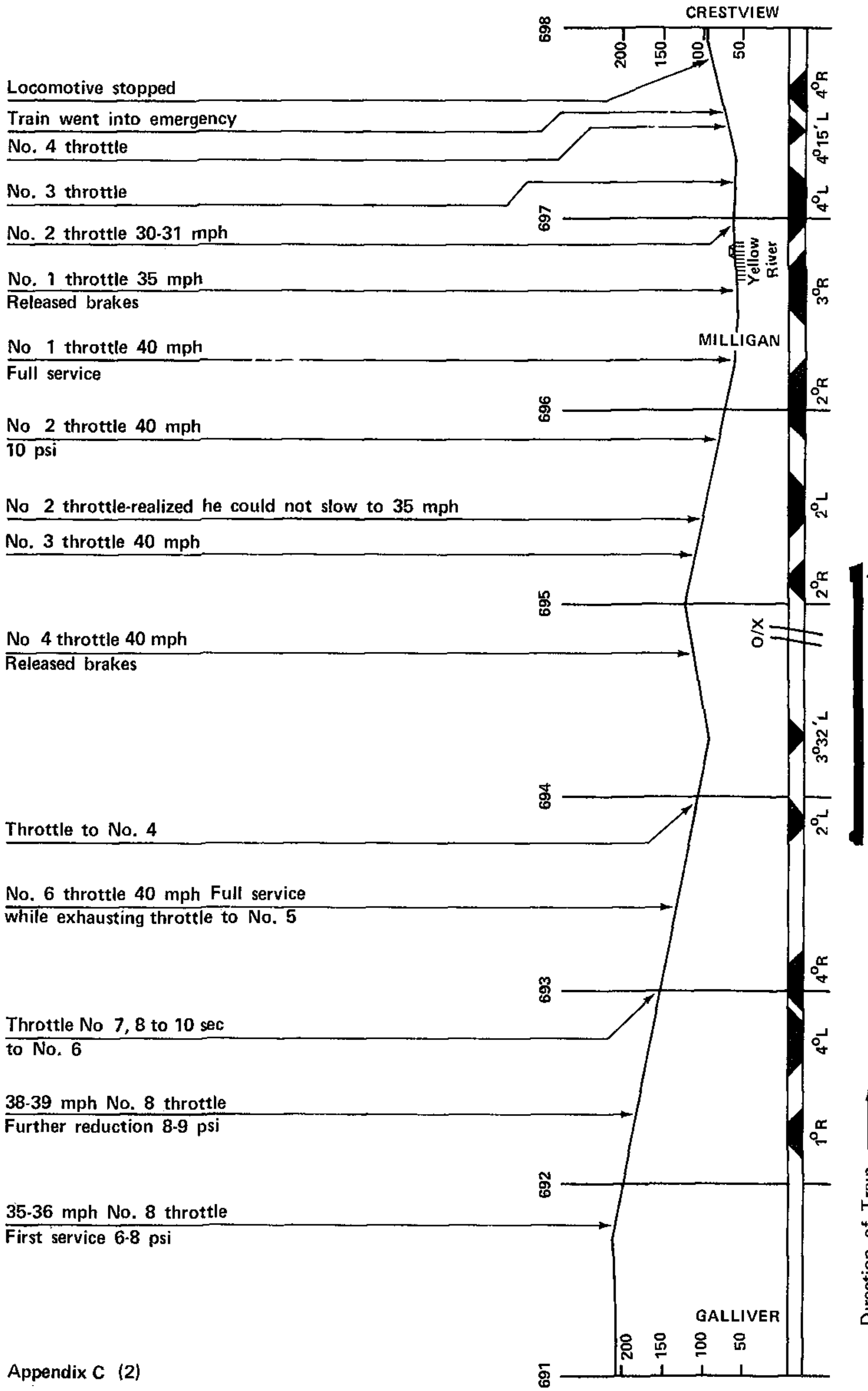


Appendix C Train Handling Applications (1)

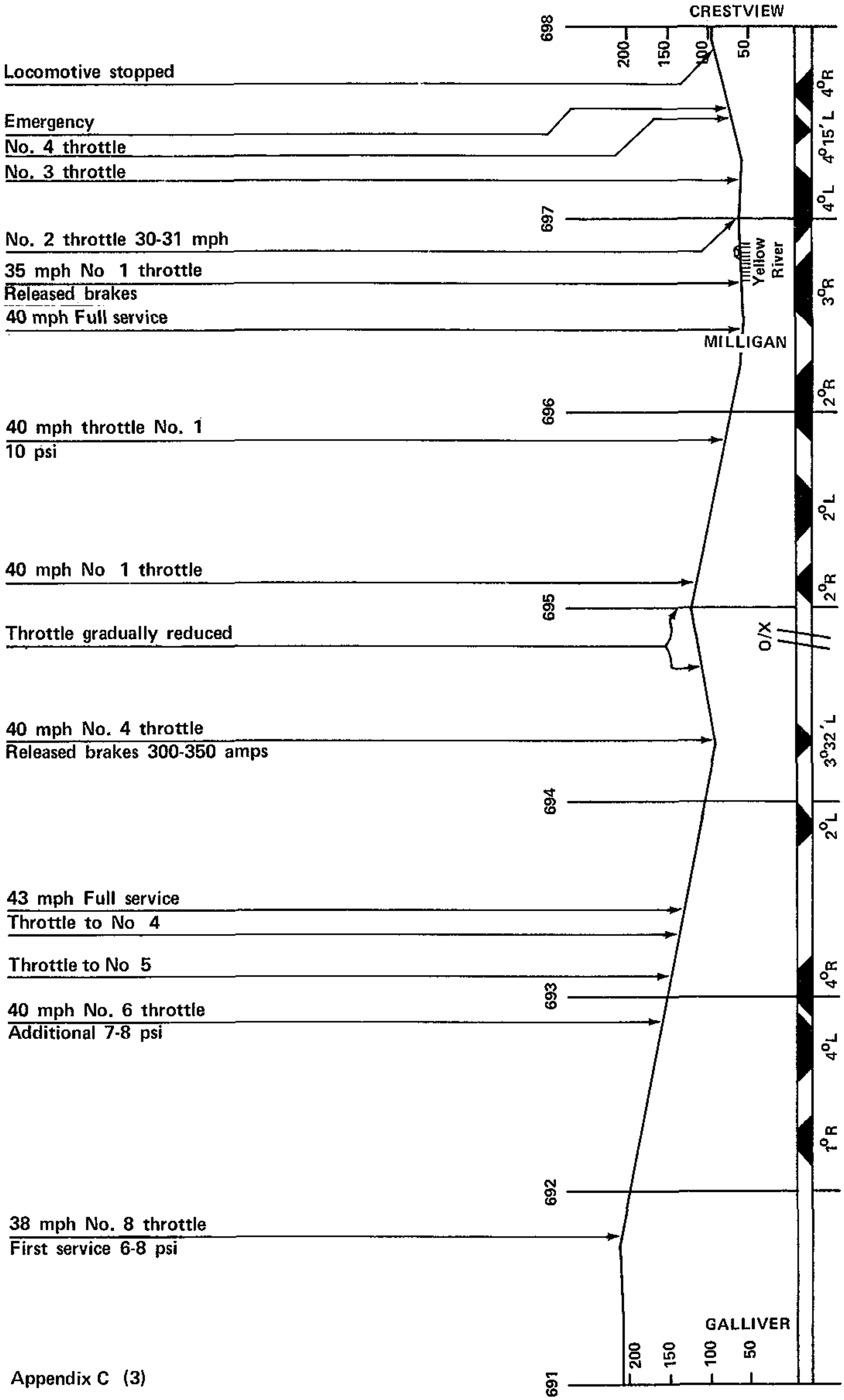
ENGINEER'S FIRST INTERVIEW STATEMENT

TRAIN HANDLING—403

4-8-79



TRAIN HANDLING—403
4-8-79
ENGINEER'S SECOND INTERVIEW STATEMENT



The computerized Train Operations Simulator (TOS) model was used to simulate the derailed train operations. Detailed conclusions resulting from the simulations are as follows:

1. Based on the engineer's second interview with FRA, train speed would have increased from the stated 38 mph at MP 691.8 to 47 mph at MP 693.1 before the second reduction made at MP 692.9 would have slowed the train. As stated in the train handling section of this report, the second phase of the split service reduction and subsequent throttle reductions should have been made sooner to control train speed.

2. Using the information in the engineer's statements, it was found that after the full-service application (26 psi reduction) at MP 693.5, the simulated train stopped between MP 693 and MP 695 before reaching the point of derailment. However, in one case, the simulation showed that after reaching 47 mph, the full-service application and the intervening ascending grade would have reduced speed to 24 mph at MP 695.8.

3. With a maximum brake pipe reduction of 15 psi made on the grade between MP 691.8 and MP 693.5, train speed would have been controlled before reaching the accident area, even when initial speeds of 50 mph were reached at MP 691.8.

4. Based on simulations and test rack results, it is evident that the full service brake pipe reduction at MP 693.5 was not made. However, the initial minimum reduction could have been released, and the effect of subsequent reductions diminished. To simulate this possibility, a run on the air brake test rack was made with an unintentional release occurring during the initial minimum reduction to determine what effect this would have on subsequent handling. This was simulated by using test rack brake cylinder pressures divided by 2.5 to obtain a brake pipe reduction amount, and using that amount of reduction in the TOS model. Starting at MP 691.7 at 38 mph, the simulated train reached 53 mph at MP 693.8 and was slowed to only 48 mph at MP 694.3 because the release made during the initial application resulted in lower brake cylinder pressures when the full-service was made at MP 693.4.

A release was simulated at MP 694.3. The ascending grade and lower throttle settings resulted in a speed reduction from 48 to 43 mph at MP 695.8. The train, again on a descending grade, began picking up speed. Since the air brake system was not fully charged, the brake applications made at MP 695.8 produced very little brake cylinder force. The full-service at MP 697.3 produced an average of only 30 psi maximum brake cylinder force. The train would have reached 49 mph at the time of derailment.

5. All simulations demonstrated that train speed would have been substantially slowed by the 0.7 mile ascending grade between MP 694.3 and MP 695. For the train to be traveling at 40 mph between MP 695 and MP 696, as the engineer stated, speeds of approximately 50 mph would have been necessary approaching the grade.

6. The brake applications which the engineer stated were made at MP 695.8 and MP 696.3, produced about one-half the brake cylinder pressures produced by a fully charged system. The simulations, using a fully charged system, showed these applications to have little effect on reducing speed. The results in the simulator using lower pressures showed that the train would have increased speed since the rear part of the train was on a descending grade.

7. The five locomotive units and the front 36 cars were located in their exact position when the derailment occurred. An emergency brake application at the 36th car was made using the distance the train ran after the derailment to determine train speed. Retardation, due to the derailing of the 37th through the 40th cars, and the additional drag of the rear truck of the 36th car which was derailed and remained with the head end of the train, was not taken into consideration. The simulation showed that if the train was traveling at 45 mph when the emergency brake was applied, with all wheels on the rail, the front end would have moved away from the point of derailment for 1,870 feet before stopping.

8. The simulations produced values for maximum longitudinal forces and L over V ratios (the ratio of lateral to vertical forces on the rail) in the train by car location. Due to the variables and uncertainties involved in the accuracy of these values, and the fact that they differed a great deal, it is difficult to draw precise conclusions. In most runs, buff forces developed in that part of the train where the derailed cars were located as the train approached the point of derailment. The buff forces were not abnormally high. However, the simulations showed that the entire train was in a buff mode for a significant distance before and up to the point of derailment.

9. A simulation was made from MP 691 at 38 mph with throttle settings and brake reductions in accordance with those recommended in train handling manuals for normal operations. Speed restrictions were observed and not more than a 15 psi total brake reduction was necessary to keep the train under normal operating control.

10. Simulations showed that this train would have made the Crestview grade if all five units had been working properly, and if sanding on the wet rail was effective. Simulation indicated that four locomotive units would have stalled.

A comparative analysis of the engineer's reported actions and the recommended procedures for train handling contained in the manual for Track Train Dynamics to Improve Freight Train Performance (TTD) is listed below:

1. At the top of the grade (MP 691.8) the engineer made a minimum 6 to 8 pounds per square inch (psi) brake pipe reduction with the throttle in No. 8 position while moving at 38 mph. No further action was taken until the train was in the vicinity of MP 692.7. At this point the throttle was gradually reduced to No. 6 position.

TTD MANUAL -

a. WHILE WORKING POWER, MAKE AN INITIAL REDUCTION OF 6 TO 8 PSI. IF THE INITIAL BRAKE PIPE REDUCTION DOES NOT PROPERLY CONTROL THE SPEED, THEN ADDITIONAL LIGHT REDUCTIONS MAY BE MADE WITH THE AUTOMATIC BRAKE VALVE.

b. KEEP THE LOCOMOTIVE BRAKE FROM APPLYING.

c. WHILE THE BRAKE PIPE SERVICE EXHAUST IS DISCHARGING FROM THE INITIAL REDUCTIONS, LEAVE THROTTLE WHERE IT IS WHILE THE REDUCTION IS BEING MADE. AS THE SPEED REDUCES, GRADUALLY REDUCE THE THROTTLE ONE NOTCH AT A TIME.

2. At MP 692.9, more than one minute and 30 seconds after the initial reduction, the engineer made an additional 7 to 8 psi brake pipe reduction with the throttle in No. 6 position while moving at 40 mph. At this time, most of the train was on the one percent descending grade.

TTD MANUAL -

a. UNDER NORMAL CONDITIONS, THE USE OF A SPLIT SERVICE REDUCTION OR GRADUATED APPLICATION IS THE DESIRABLE METHOD TO BE USED FOR APPLYING TRAIN BRAKES. THIS TYPE APPLICATION IS MADE BY A 6 to 8 PSI INITIAL REDUCTION, WAITING FOR AT LEAST 20 SECONDS FOLLOWING WHICH FURTHER REDUCTIONS MAY BE MADE AS REQUIRED TO THE POINT OF EQUALIZATION. BEARING IN MIND, HOWEVER, THAT A TOTAL REDUCTION TO EQUALIZATION, IF MADE TOO RAPIDLY, CAN RESULT IN A HEAVY UNDESIRABLE SLACK SURGE DEPENDENT ON TRAIN MAKE-UP AND GRADE.

b. THE INITIAL REDUCTION OF 6 TO 8 PSI RESULTS IN HAVING QUICK SERVICE RUN THROUGH THE TRAIN AND ASSURES A MINIMUM BRAKE CYLINDER PRESSURE ON ALL CARS OF 10 PSI. THE 20 SECONDS DELAY ALLOWS THE BRAKE SHOES TO GO AGAINST THE WHEELS, PROVIDING LIGHT RETARDING FORCE TO THE TRAIN AND SNUBBING SLACK ACTION. ADDITIONAL BRAKING EFFORT IS THEN STARTED, AFTER THE TRAIN SLACK HAS BEEN CONTROLLED, TO THE DEGREE REQUIRED TO CONTROL THE TRAIN.

3. At about MP 693.1 the throttle was reduced to No. 5 position, and at about MP 693.3 to No. 4 position.

4. At MP 693.5, while moving at 43 mph, a full service (total 26 psi) reduction was made while the entire train was moving on the one percent descending grade within an area where speed was restricted to 40 mph.

TTD MANUAL -

THE USE OF FULL SERVICE REDUCTION LEAVES NO RESERVE BRAKING POWER, SHORT OF AN EMERGENCY APPLICATION.

5. At MP 694.3 after stabilizing speed at 40 mph in No. 4 throttle, the brakes were released.

6. At various points between MP 694.6 and MP 695.1, the throttle was gradually reduced to No. 1 position.

7. At MP 695.8, train speed had not been reduced and the engineer made a 10 psi brake pipe reduction when the brake system was not charged sufficiently for this brake pipe reduction to be effective.

TTD MANUAL -

IF A SERVICE REDUCTION IS NECESSARY WHEN THE BRAKE SYSTEM IS NOT FULLY CHARGED, THE EQUALIZING RESERVOIR SHOULD BE FURTHER REDUCED BY THE AMOUNT OF THE DESIRED REDUCTION FROM ITS READING AT THE MOMENT THE SERVICE EXHAUST OPENED.

8. At MP 696.3, while moving at 40 mph, a full service (total 26 psi) reduction was made and at MP 696.6, the brakes were released at a speed of about 35 mph prior to the brake application becoming fully effective on the rear car of the train.

TTD MANUAL -

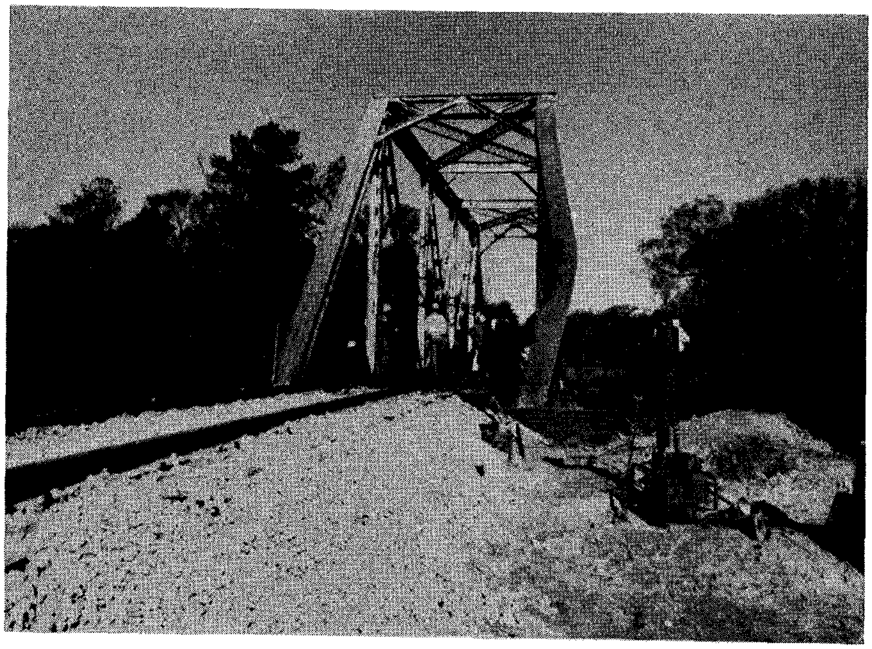
WHEN DESIRING TO MAKE RUNNING RELEASE OF TRAIN BRAKES THE RELEASE OPERATION SHOULD NOT BE STARTED UNTIL THE LAST REDUCTION OF A BRAKE APPLICATION HAS BECOME EFFECTIVE ON THE REAR CAR OF THE TRAIN.

9. At MP 697, the speed was down to 30 mph as the train entered the 4^{o} curve on which the derailment occurred. The engineer then increased to No. 2 throttle.

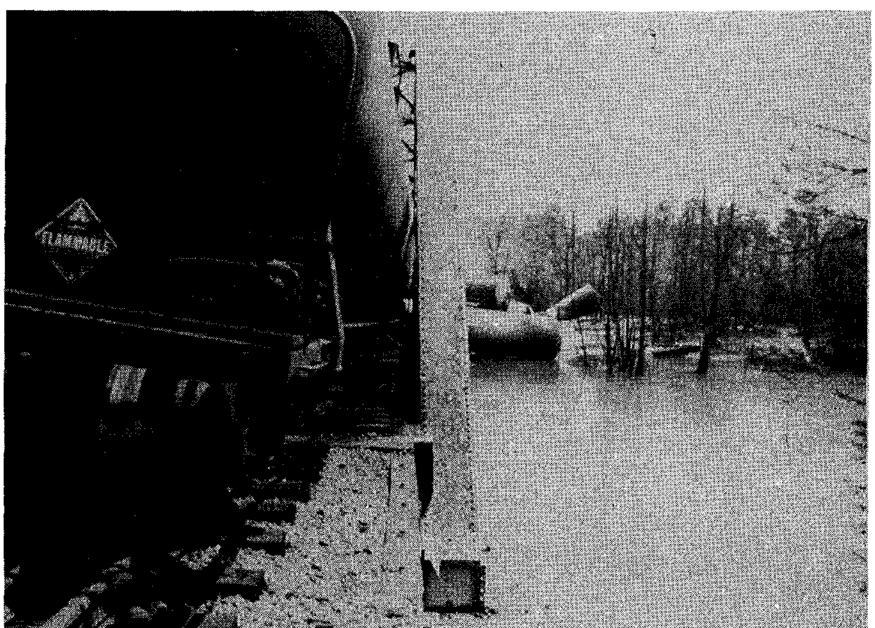
TTD MANUAL -

IF CONDITIONS PERMIT, SPEED CHANGES AS A RESULT OF THROTTLE MANIPULATION AND/OR AIR BRAKE APPLICATION SHOULD NOT BE MADE WITHIN OR NEAR THE BEGINNING OR END OF ANY CURVE IN EXCESS OF 2^{o}. THE SPEED SHOULD BE REDUCED TO AUTHORIZED SPEED BEFORE THE LOCOMOTIVE ENTERS THE RESTRICTIVE AREA. DECELERATION MAY CAUSE ONE PART OF THE TRAIN TO BE MOVING AT AS MUCH AS 10 MPH FASTER THAN ANOTHER PART, WHICH WILL IMPART EXTREME LATERAL FORCE ON A CURVE.

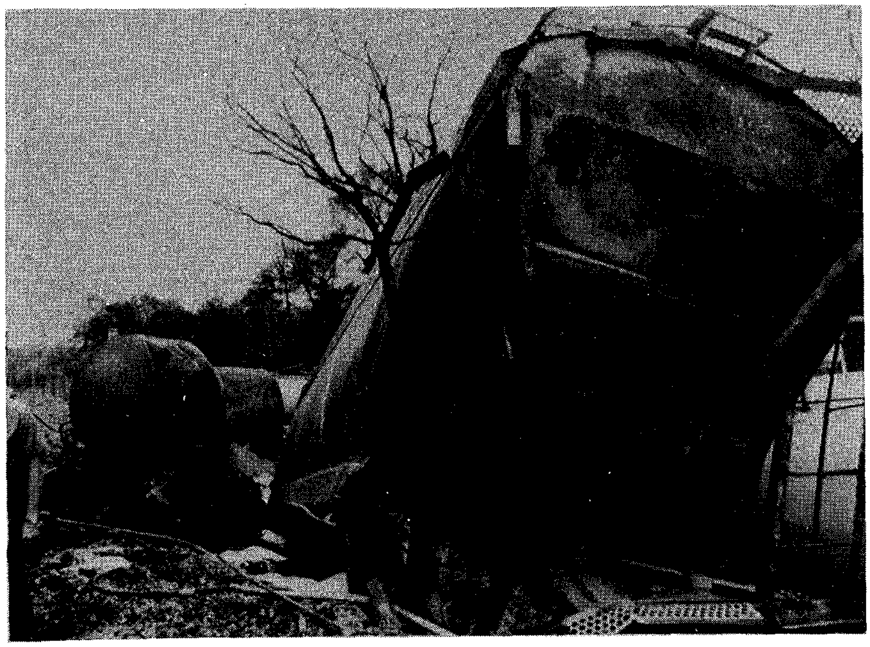
10. The throttle was gradually increased to No. 4 position, and as the locomotive was at about MP 697.5, the train brakes applied in emergency.



Damage to west portal member of Yellow River bridge.

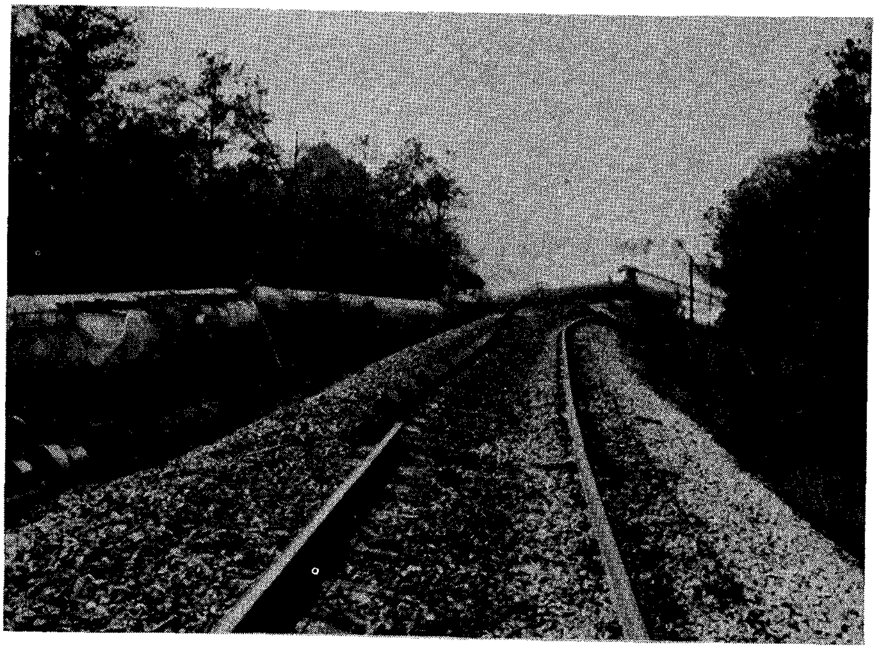


View of derailment site from east portal member of bridge

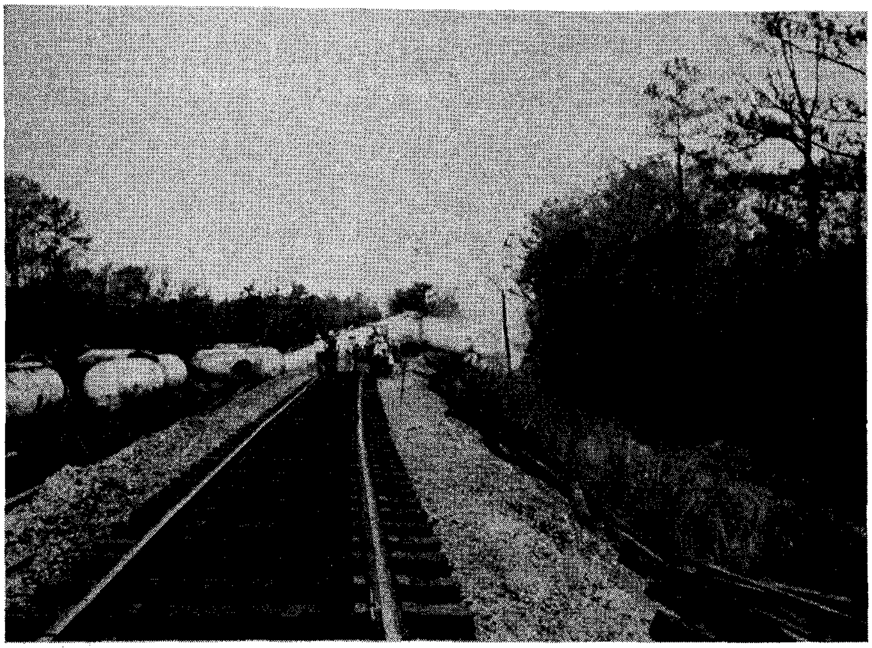


View of damaged equipment.

View of damaged tank cars.



Track structure after derailment.



Track structure being restored.

Appendix F (3)

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