

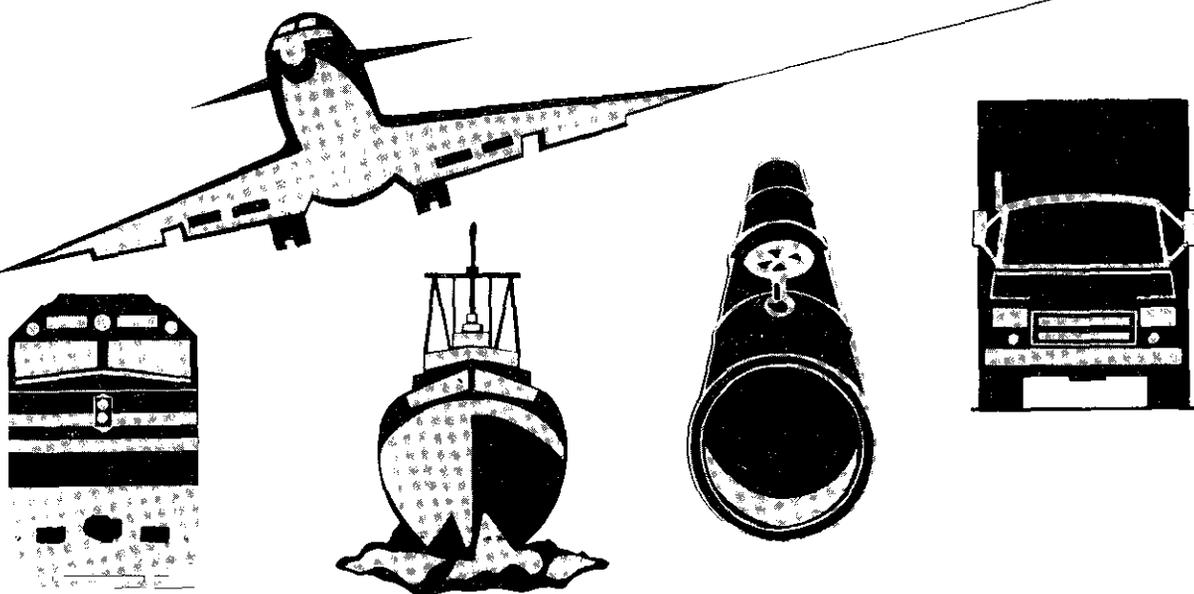
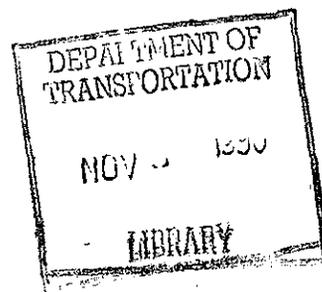
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NATIONAL TRANSPORTATION SAFETY BOARD

RAILROAD ACCIDENT REPORT

COLLISION AND DERAILMENT
OF MONTANA RAIL LINK FREIGHT TRAIN
WITH LOCOMOTIVE UNITS
AND HAZARDOUS MATERIALS RELEASE
HELENA, MONTANA
FEBRUARY 2, 1989



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16. Abstract This report explains the collision and derailment of a freight train and the resulting release of hazardous materials at Helena, Montana on February 2, 1989 The safety issues discussed in the report include testing, operation, and maintenance of train airbrake systems in extreme cold weather, oversight of employee preparedness for extreme cold weather, the use and efficacy of end-of-train devices, interpretation and instructions of the operating and airbrake rules and the training and application of those rules and instructions , tank car performance and protection, and documentation of hazardous materials shipments Recommendations addressing these issues were made to the Montana Rail Link Railroad, Burlington Northern Railroad Company, U S Department of Transportation, Federal Railroad Administration, Research and Special Programs Administration, the city of Helena, the State of Montana, Lewis and Clark County, and the Association of American Railroads					
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EXECUTIVE SUMMARY

About 4:30 a.m. mountain standard time on February 2, 1989, freight cars from Montana Rail Link Inc. (MRL) westbound train 1-121-28 (train 121) rolled eastward down a mountain grade and struck a stopped helper locomotive consist, Helper 1, in Helena, Montana. The locomotive consist of train 121 included three helper units (Helper 2) and three road units positioned at the head end of a 49-car train. The crewmembers of train 121 had uncoupled the locomotive units from the train to rearrange the locomotive consist while stopped on a mountain grade. In the collision and derailment, 15 cars from train 121 derailed, including 3 tank cars containing hydrogen peroxide, isopropyl alcohol, and acetone. Hazardous material released in the accident later resulted in a fire and explosions. About 3,500 residents of Helena were evacuated. Two crewmembers of Helper 1 were only slightly injured. The estimated damage (including clean-up and lading) as a result of this accident exceeded \$6 million.

The major safety issues in the accident include:

- o testing, operation, and maintenance of train airbrake systems in extreme cold weather;
- o oversight of employee preparedness for extreme cold weather by MRL;
- o the use and efficacy of end-of-train devices;
- o interpretation and instructions of the operating and airbrake rules and the training and application of those rules and instructions by MRL;
- o tank car performance and protection;
- o documentation of hazardous materials shipments.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the crew of train 1-121-28 to properly secure their train by placing the train brakes in emergency and applying hand brakes when it was left standing unattended on a mountain grade. Contributing to the accident was the decision of the engineer of Helper 2 to rearrange the locomotive consist and leave the train unattended on the mountain grade, and the effects of the extreme cold weather on the airbrake system of the train and the crewmembers. Also contributing was the failure of the operating management of the Montana Rail Link to adequately assess the qualifications and training of employees placed in train service. Contributing to the severity of the accident was the release and ignition of hazardous materials.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

COLLISION AND DERAILMENT OF MONTANA RAIL LINK FREIGHT TRAIN
WITH LOCOMOTIVE UNITS, AND HAZARDOUS MATERIALS RELEASE
AT HELENA, MONTANA, FEBRUARY 2, 1989

INVESTIGATION

Preaccident Train Movement

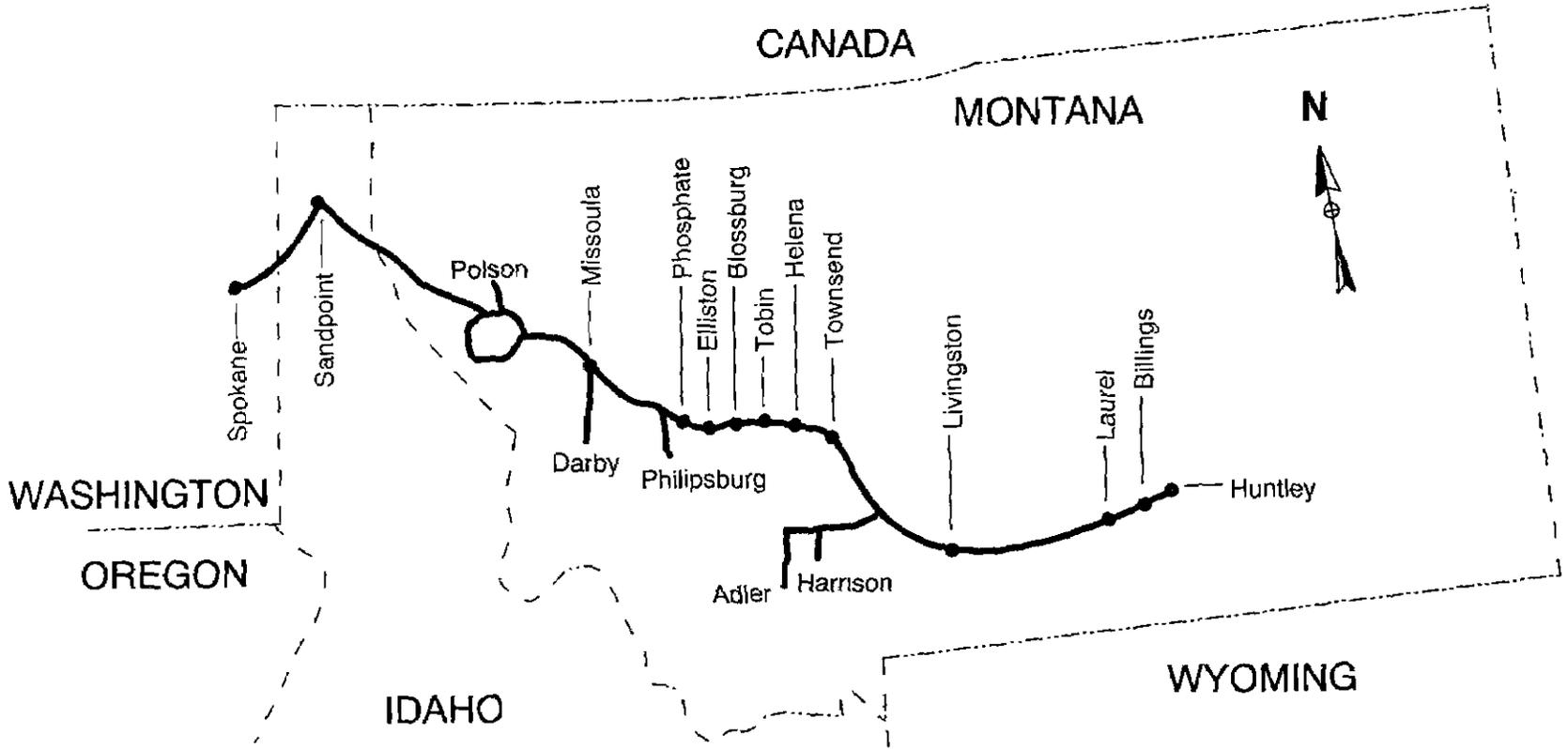
Train 1-121-28 (train 121) was received in interchange¹ by the Montana Rail Inc. (MRL) in Laurel, Montana, on the night of January 31, 1989, at 2325² from the Burlington Northern Railroad Company (BN). When BN train 121 arrived in Laurel, it was a caboosless train consisting of 3 BN locomotives and 92 freight cars. Train 121 was to be operated by an MRL crew from MRL's terminal at Laurel, Montana, to Spokane, Washington, about 628 miles, where it would be interchanged with BN. (See figure 1.)

The outbound crew was called to report for duty at 0630, on February 1, 1989, at Laurel. Twenty-eight cars of train 121 were set out for other destinations. An initial terminal airbrake test conducted on the remaining 64 cars resulted in the removal of a block of 16 cars; the MRL train activity/delay report dated February 1, 1989, showed the airbrake test failure at Laurel was "due to cold." (See appendix C.) Car SBD 121466 was added to train 121, making a 49-car consist; however, the train consist furnished to the outbound crew only showed 48 cars. A second initial terminal airbrake test followed by a roll-by³ inspection was performed by local mechanical personnel; no defects were noted. The engineer from the outbound crew informed Safety Board investigators that the brake pipe (train

¹A location where cars are transferred from one railroad to another at a common junction point.

²All times are Mountain Standard Time (MST) based on the 24-hour clock.

³During a roll-by inspection, railroad employees observe the departure of a train to note such defects as dragging equipment, excessive air leaks, brakes that have not released, inoperable end-of-train devices (see Mechanical Information) during operations, and anything that would affect the safe movement of the train. These observations are then communicated to the train crew.



Source: Montana Rail Link

Figure 1.--Schematic of Montana Rail Link System.

line,⁴ leakage was 4 psi/min⁵ with a feed valve⁶ setting of 80 psi on the locomotive, when train 121 departed Laurel.

Train 121 was a caboosless train, with an end-of-train (EOT) device,⁷ which departed Laurel at 0840 with 49 cars and 3 BN locomotives en route to Helena, about 224.5 miles to the west. (See figure 1.) The temperature at that time was about -17⁰ F. The crew of train 121 had to be relieved at 1800 at Townsend, about 29 miles east of Helena, when it was determined they would not be able to reach Helena within the Hours of Service limit.⁸ The crew stated that they did not have any problems with the airbrake operations, but that they had experienced several delays en route related to the cold weather and other trains. When train 121 arrived at Laurel, the temperature was about -12⁰ F. The crew stated that a good operating time for the trip from Laurel to Helena would have been about 5 1/2 hours.

A relief crew arrived at Townsend at 2330 to operate the train to Helena. They departed 2355 with no change in the train or locomotive consist. According to the statements of the relief engineer, the EOT receiver on locomotive BN 8061 indicated that the train line pressure on the rear of the train was 56 psi. He released the brakes and departed when the EOT indicated the train line pressure had been restored to 65 psi. Each of the BN locomotive units on train 121 were equipped with an air flow indicator (AFI).⁹ The relief engineer stated "... when I released the air, it went to 14; and by the time that we were able to pull out of Townsend, the air flow indicator had started down. The lowest it got on the scale...was 12." The relief engineer told Safety Board investigators that during the trip the EOT receiver indicated fluctuations of "...two-pound variance either way from the

⁴Train line describes the continuous line of brake pipe extending from the locomotives to the last car in a train, with all cars and air hoses coupled. The term is often used to refer to the brake pipe on a single car.

⁵49 CFR Part 232 and MRL's Air Brake, Mechanical and Train Handling rules stipulate that brake pipe leakage must not exceed 5 psi/min during the initial terminal airbrake tests.

⁶A valve that reduces main reservoir pressure to a determined amount for delivery to the equalizing reservoir and train line.

⁷A device that provided a red marker light at the rear of the train. Additionally, by radio telemetry, the EOT provides the engineer a digital readout of the train line air pressure at the end of the train, and of any changes in air pressure

⁸Railroad operating employees involved in train service must comply with the Federal requirements for the Hours of Service limitations. No covered employee may be required or permitted to work in excess of 12 consecutive hours.

⁹A dial type gauge with numbers related to an index for the rate of air flow into the train line. (See appendix G.)

70 psi..." that he had not used the airbrakes between Townsend and Helena, and that stops were made using dynamic braking (braking using locomotive power) and engine brakes. En route to Helena, train 121 again experienced numerous delays related to the cold weather and arrived in Helena at 0310, February 2, 1989.

The relief engineer stated that he had taken "exception" to the train line pressure between Townsend and Helena, and that he had notified the yard office in Helena. He said he also notified the engineer of Helper 2 (a three-unit locomotive) that was scheduled to assist train 121 westward from Helena up the 2.2 percent ascending mountain grade over the continental divide. He further stated that he gave the helper engineer the tonnage, length of train, and "...the fact that the air flow indicator was at 14." Upon arrival at Helena, the inbound (relief) crew detrained and went to obtain their track warrants for their next trip. The outbound road crew for train 121 was called to report for duty at 0130, February 2, 1989, at Helena Yard, to operate train 121 between Helena and Missoula, Montana. The crew consisted of an engineer, an assistant engineer, and a utility operating employee (UOE).¹⁰ The Helper 2 crew consisted of an engineer and a UOE. The helper engineer stated that the heater in the lead helper locomotive unit, MRL 208, was operative, but that the heaters in the trailing two units were not; he did not check to see if the heaters were working when he went to the roundhouse to get the locomotives because he had already been told by the assistant trainmaster on duty that they were not working.

Helper 2 was positioned forward of the road locomotive of train 121; the train line and electrical connections were made and the feed valve was reset from 80 psi to 90 psi for mountain grade operations in accordance with MRL operating practices. The helper engineer would have control of the operation of the train since his locomotives were positioned on the head end. While the Helper 2 locomotives were being positioned, the road engineer reviewed the consist (see appendix D) to check the position of a car. He checked the train and found that the car, ACDX 816007, shown on the consist as containing a hazardous substance (CHEMLS DAN), was listed as the fifth car on his consist, but that it was actually the sixth car in the train. (The car actually contained ORM-E material¹¹ and was indicated as such on the waybill; however, the engineer later stated that he could not find the waybill for this car after they departed Helena.) The first car, SBD 121466, was not shown on the consist. Satisfied that the car was in the proper

¹⁰An MRL utility operating employee performs the work commonly assigned to a brakeman, assists the engineer and assistant engineer in their duties, and other duties as assigned.

¹¹ORM-E - Other Regulated Material class E, i.e. hazardous wastes or hazardous substances listed in 49 CFR 173.500 that are environmentally harmful.

position,¹² he returned to the lead road unit, BN 8061. Once the EOT telemetry device showed that a minimum gradient of 15 psi was established with 75 psi at the rear of the train, the road engineer relayed that information to the Helper 2 engineer by radio. (This information had to be relayed to the helper engineer because the lead Helper 2 unit, MRL 208, was not equipped with an EOT receiving device.) The required airbrake test, a set and release as indicated by the reduction in train line air pressure at the rear of the train and the restoration of train line air pressure on the EOT transmitting device, was successfully performed. Train 121 departed Helena about 0320 as a caboosless train consisting of three MRL locomotives as Helper 2 on the head end, followed by three BN locomotives as road units, 36 loads and 13 empties. When train 121 departed Helena, the recorded local temperature was about -27⁰ F with a wind chill of about -70⁰ F.

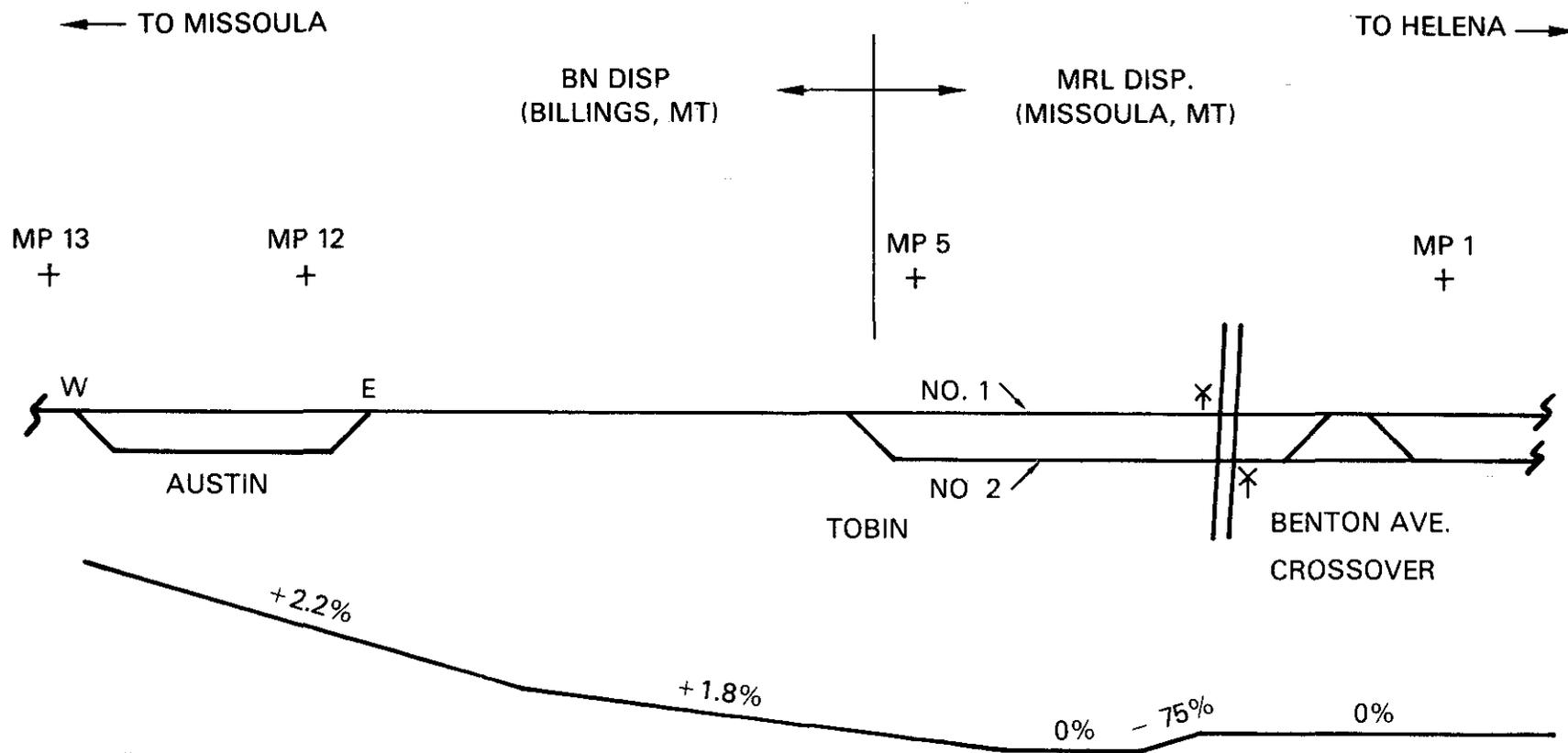
Departing Helena, train 121 crossed over from main track No. 1 to main track No. 2 at the Benton Avenue crossover. (See figure 2.) The road engineer used the footage counter request button on the EOT device so that he could let the helper engineer know when the train was through the crossover. At Birdseye, about mile post (MP) 7, the helper engineer informed the road engineer that he had "lost a unit," and asked the road engineer if he had a 150-amp fuse. Between Tobin and Birdseye the lead unit of Helper 2 (MRL 208) lost power, and the heater did not operate. According to statements of the helper UOE, the windows began to fog up and the headlight began to dim. While continuing to move, the helper crew attempted to locate the trouble and tried to restart the unit.

Train 121 approached Austin about 0358 (Austin is a siding about 13 miles west of Helena on Burlington Northern trackage);¹³ the helper engineer stated that he had an approach indication at East Austin and could see the signal at West Austin display a stop indication. The BN dispatcher called the road engineer of train 121 at that time informing him that "you've got permission to hand operate the west switch in Austin by Rule 315¹⁴ and line yourself main track to main track." The road engineer acknowledged and

¹²A provision in the MRL timetable no. 2 for the placement and switching restrictions of placarded cars, specified that placarded tank cars, must not be nearer than the sixth car from the engine, occupied caboos, or passenger car. Cars placarded ORM-E material have no restrictions.

¹³The trackage located between Helena Jct on main track No. 1, Tobin on main track No. 2 and the east switch at Phosphate is owned and operated by the Burlington Northern. Montana Rail Link operates between these points by trackage rights.

¹⁴Rule 315 of the General Code of Operating Rules provides for the hand operation of dual control switches



SOURCE: MONTANA RAIL LINK
(NOT TO SCALE)

Figure 2.--Schematic of Benton Avenue to Austin.

was further instructed to operate at restricted speed.¹⁵ The BN dispatcher testified at the Safety Board's public hearing (see appendix A) that because of the cold weather the centralized traffic control (CTC) signal system at West Austin was not operating and that he had no indication on the switch position. When a signal becomes inoperative, it may display either a red or dark (no light) signal, and train crews are to observe the appropriate signal rules. When the dispatcher came on duty at 2330 on February 1, 1989, the entire CTC was inoperative from Tobin to Garrison, and a BN signal technician was installing heaters in the trackside signal relay shelters to restore CTC on the territory. However, the BN dispatcher testified that by 0358 "the only CTC trouble I was having was right at West Austin." (See figure 2.)

During the radio communication between the road engineer of train 121 and the BN dispatcher at about 0358, another MRL helper engineer (train 120) reported train problems to the BN dispatcher.¹⁶ The engineer of Helper 2 of train 121 radioed the BN dispatcher about 0400 advising that he had "...dead batteries and our other two [helper units] engines are pointed east and no cab heater. So we're going to have to do something [switching] here at Austin...I'm not going to leave out of here without...any cab heaters..." About 0402, the MRL dispatcher contacted the Helper 2 engineer and discussed the trouble about locomotive MRL 208 of train 121. He then instructed him to continue with train 121 after the helper units had been switched with the road units and then relieve the crew of train 120 and bring that train back into Helena.

Train 121 was still moving when the road engineer overheard the conversation between the Helper 2 engineer and both dispatchers. He went up to the lead unit of Helper 2 to talk to the helper engineer. The helper engineer stated that they had a quick discussion during which the road engineer, who did not want to switch the helper units around with the road units, said, "I'll run the train the rest of the way, and you can go back and ride in a warm unit." The helper engineer refused the offer stating "...no, we should do something about it...It's the principle of the thing...If anybody will operate this locomotive...I would do it myself." The helper engineer later stated that he made the decision to switch the locomotive units around and that he did not think that the road engineer had any objection. The road engineer testified that he did not agree with the decision. He stated "...[It's] my opinion that the engineer on the lead locomotive is in control of the train, but the engineer of the road power is

¹⁵Restricted speed on the BN is a speed that will permit stopping within one half the range of vision; short of train, engine, railroad car, stop signal, derail or switch not properly lined, looking out for broken rail, not exceeding 20 mph.

¹⁶Train 120 was an eastbound MRL train between Elliston and Blossburg with helper units also designated as "Helper 2". Train 120 experienced a train separation "...broke in two..." and was requesting a relief crew because the crew could not continue without exceeding the Hours of Service provisions.

supposed to be in charge." He also stated that "...I didn't have what it takes to argue with him [helper engineer]."

The helper engineer stated that he brought train 121 to a stop about a "...car length east of the west absolute [signal] at Austin..." by gradually reducing his throttle position and allowing the speed to come down accordingly. He stated he made a minimum service reduction of 5-7 psi, increased to a full service application, shut the throttle off and then applied the independent locomotive brakes. The road engineer observed the brake application and did not leave the lead helper unit cab compartment until after the brake valve had ceased to exhaust.

The road engineer returned to the lead road locomotive unit, BN 8061, to explain to his assistant engineer and his UOE that they were going to switch the helper power around and reposition the road power to the head end of the train. He stated that when he returned from the lead helper locomotive, after having observed the automatic brake application by the helper engineer, he saw that the EOT receiving device was still displaying 75 psi for the train line pressure at the rear of the train. He further stated that he "...didn't know if it [EOT] had quit transmitting or if the calibration device could have froze up...[he] wasn't sure." He also stated that while train 121 was being operated up the mountain, the train line pressure on the EOT receiving device displayed 75 psi without any fluctuations, and he took no exception to its operation during the trip.

The Accident

Train 121.--The BN train graph recorded that train 121 passed the control point at the East Austin switch between 0356 and 0358. (See appendix E.) The assistant engineer stated that train 121 arrived at Austin at 0400. When train 121 came to a stop at West Austin, the helper engineer proceeded to drain the cooling system on the disabled unit (MRL 208) while the helper UOE proceeded to the West Austin switch. Upon receiving a lantern signal from the assistant engineer of the road locomotive that both angle cocks on the train line between the helper locomotive and the road locomotive had been closed and the electrical connections disconnected, the helper engineer moved the helper locomotive away from the road locomotive toward the West Austin switch and then backed into the siding to wait for the road locomotive. After the helper and road locomotives were separated, the road UOE went back to uncouple the road locomotive from the train. The road engineer stated that just before separating from the helper locomotive he observed that the air gauge read about 68 psi and quickly dropped to about 50 psi in "...about a minute-and-a-half to two minutes." (See appendix F.)

The road UOE stated that he stepped between the rear locomotive unit and the west (first) car and "...cut off both angle cocks..."¹⁷ The road UOE then gave the road engineer a hand signal to back up to provide slack to pull the uncoupling lever. He then uncoupled the locomotive from the train and

¹⁷closed the angle cock on the train line on both the last locomotive unit and the first car of the train.

signaled the road engineer to pull ahead about 15 feet. He stated that he left the angle cock on the west car about halfway open. He also stated that "...I was trying to keep from [putting the train into emergency]...The guys I have been working with pretty much do it that way...I figured if you get a continuous application of the airbrakes, which is completely deplete the air pressure in the train line, it's about the same as dumping it [putting the train into emergency] ...guys do that to keep from getting stuck triple [control] valves." The road UOE stated that the stuck valves usually occur near the rear of the train and since "...I was wearing cowboy boots, I didn't really want to walk that train in that weather in my cowboy boots...." The road UOE did not set any hand brakes explaining that "...it's not a practice ...you would have had to set probably more than half the brakes...from the rear end...would have took a lot longer than it would just to go over the top of the hill...." When asked if the train had been in emergency would it be necessary to set hand brakes, he replied that "...I don't think it makes any difference...by the rules you are supposed to set hand brakes...."

Concerning the procedure for partially opening an angle cock, the road locomotive assistant engineer stated that "...under normal situations ...what they generally want you to do, as far as the rules, is to go ahead and dynamite the train [leave train in emergency]...but what we have been experiencing lately is the triple valves have been setting up...with the cold the way it's been, the less time you are out in the cold, the better off you are...." He also stated that when you are "...leaving a train unattended for just a few minutes like that, either technique works...."

The road locomotive proceeded to the West Austin switch and began backing into the siding where it would be recoupled to Helper 2. The road engineer testified that "...at some point right in there I got a radio break...."¹⁸ He had asked the helper engineer to turn on his unit's rear headlight before he got off the locomotive; "...I couldn't see anything...it wasn't good visibility...so I ran to the other unit [east most helper unit] and put the headlight on bright and then I could tell it [the train] was gone...."

The helper engineer was on the ground with the other crewmembers to help make the connections between the road and helper locomotives when the road engineer ran by them. The helper engineer stated that when the road engineer returned he told them he could not see the train and that he thought it was gone. The crewmembers then hurriedly attempted to complete the connections between the locomotives.

¹⁸The EOT telemetry receiving device will cease its display, give a six beep audible alert and display a continuously flashing 'RAD BRK' (radio break) 5 minutes after the EOT transmitting device ceases to transmit a signal; after a further 5 minutes without a signal the receiving device will display a solid 'RAD BRK'.

The helper engineer asked both UOE's if they had dumped the air on the train. According to the helper engineer, the road UOE stated "...yes...I exhausted it by opening the angle cock on the portion of the train left standing..." (When the train line air is rapidly exhausted or "dumped," by leaving the angle cock fully open on the portion of the train left standing, it will cause an emergency application of the train brakes.)

The road UOE went to the westernmost unit, BN 8061, to move that locomotive consist out on to the main track. The assistant engineer was at the West Austin switch and, when the road engineer signaled that the locomotive consist was west of the switch, the road UOE in BN 8061 began moving the locomotives eastward. The road engineer and the assistant engineer got on the easternmost unit, MRL 202. The helper engineer and his UOE had already reboarded MRL 208 and later moved to the heated cab of BM 7163.

The road engineer was at the controls of the locomotive consist from the eastward unit MRL 202, as they began eastward down the mountain towards Helena in pursuit of their train. They proceeded through the absolute signal at East Austin (which was displaying a stop indication) without receiving authority from the BN dispatcher. Neither the BN dispatcher nor the MRL dispatcher had given authority for train 121 to move eastward out of Austin, and neither was aware that the locomotive of train 121 had started moving eastward. The road engineer stated that under normal operating conditions he would be required to request authority for the reverse move, but he considered this an emergency situation. During the pursuit down the mountain, the road engineer had to make an emergency application twice to control the train's speed because the independent brake (locomotive brake) was not slowing him down. He stated, "...I was applying some engine (independent) brakes because I was gaining some speed and I didn't want to hit too hard if the train was around the curve..." About one-half to three-quarters of a mile east of East Austin the road engineer instructed the assistant engineer to "...get on the radio and say emergency and tell Helena a train is coming down the hill..."¹⁹ They continued down the mountain toward Helena at speeds ranging from 35 to 45 miles per hour (mph).

Helper 1.--Helper 1 had been called at 0330 at Helena to assist train 195 westward over the mountain to Blossburg. Helper 1 proceeded westward on main track No.1 towards the west crossover at Benton Avenue (see figure 2), crossed over to main track No. 2 to clear the signal at 04:21:31,²⁰ and prepared to move east toward the yard office and train 195. The MRL dispatcher could not get an indication that the switch was lined for main

¹⁹The transcript of the MRL's West Dispatcher's Radio recorded the emergency report from train 121 at 0429

²⁰The time recorded on the MRL computerized train log for Helper 1 occupying the North and South Main at Helena West (Benton Avenue) crossovers

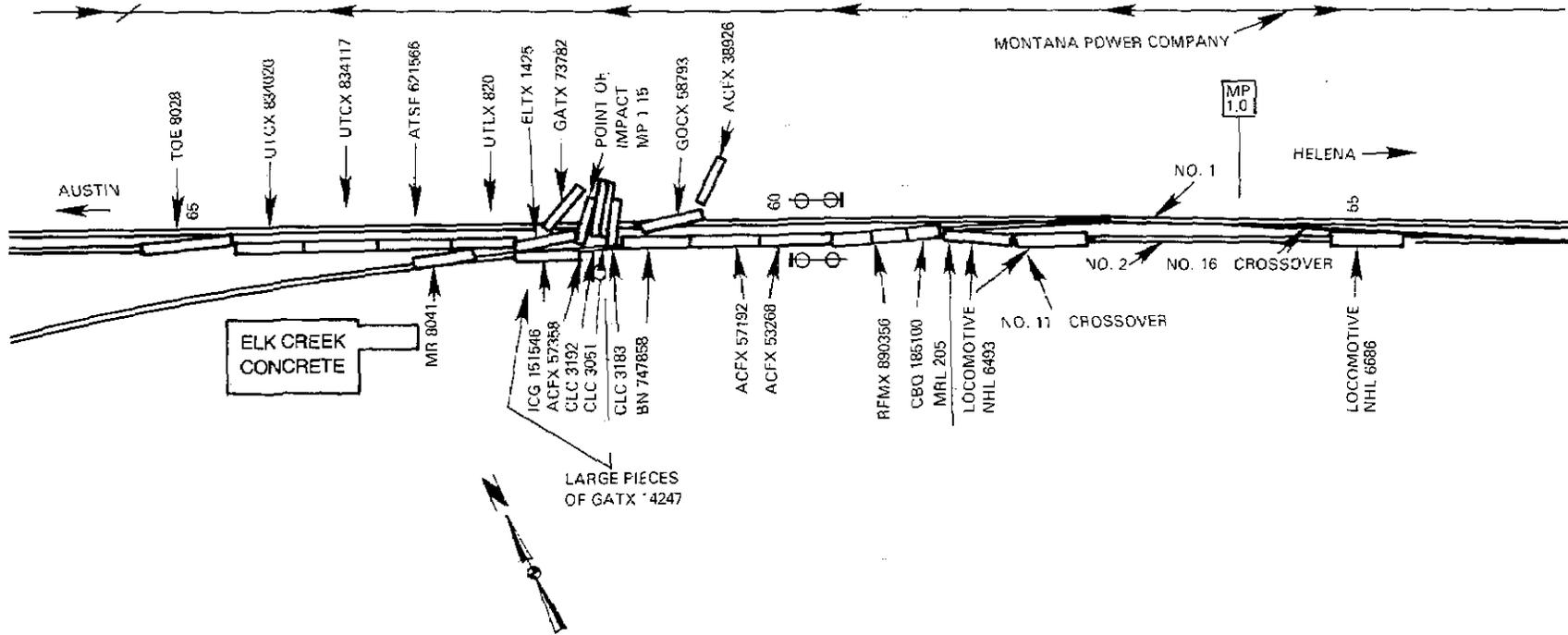
track No. 2 and told Helper 1 to manually line the switch. The Helper 1 UOE got off the locomotive at the crossover to line the switch. The engineer moved from the west unit, MRL 205, to the east unit, NHL 6686, because he wanted to observe since the UOE was fairly new and they had only worked together a couple of times.

Collision.--The engineer of Helper 1 overheard the emergency radio communication between train 121 and the MRL dispatcher about a runaway at Austin, but stated he didn't give it much thought because "...that was quite a ways away...." He started to release the independent brake to move eastward, "...when the train hit us...." The Helper 1 UOE, who was on the ground, radioed the MRL dispatcher at 04:30:46 and reported that "...we've just had a train hit us...We have some serious damage..." The engineer described the collision as "...it hit pretty hard...I think it was at least 25 miles an hour...." At the time, the MRL dispatcher did not know if the crew of train 121 had lost all or part of their train. He advised the Helper 1 UOE to be alert for more cars. Of the 49 cars of train 121 that collided with the standing Helper 1, 21 cars, of which 15 derailed, were involved.²¹ Only the west locomotive, MRL 205, of Helper 1 was derailed. The east locomotive, NHL 6686, was separated from the Helper 1 consist in the collision and came to rest about 400 feet east of the general derailment area. (See figure 3.)

The Helper 1 engineer stated that although he was dazed, he did not see any smoke or fire immediately after the collision. He walked back to the west unit, MRL 205, to retrieve his and the UOE's personal belongings. After the engineer joined the UOE, they informed the yard office of the accident and were instructed that someone would come to meet them. The two men walked west towards Benton Avenue along the north side of the tracks and past the wreckage. The engineer stated that he saw two tank cars that were upright and positioned parallel to the track and a third tank car at an angle to the tracks. According to the engineer, material was venting from a single location at or near the top of the third tank car in the form of a whitish gray cloud. He did not notice any odors or irritating vapors as he passed the cars. The UOE stated that he observed bluish-black smoke coming from the middle of a tank car and smelled a foul odor similar to "rotten eggs;" he indicated that the tank car was upright. Neither the engineer nor the UOE saw flames from the tank car as they walked past the wreckage.

An assistant trainmaster and yard clerk arrived at the accident site about 0440 and parked their pick-up truck at the Benton Avenue grade crossing. The yard clerk stated he saw an "orange glow" behind a fog "...boiling out of the wreckage...." He later described the glow as coming from behind a tank car positioned at an angle to the tracks. The assistant

²¹The MRL computerized train log shows a recorded time of 04:30:15 for an unauthorized train movement into the track circuit beyond the west crossover east of Benton Avenue crossover



ACCIDENT SITE BENTON AVE. CROSSOVER
 (NOT TO SCALE)

SOURCE: MONTANA RAIL LINK

Figure 3.--Derailment Sketch.

trainmaster saw vapors that he described as "...steam..." and also noted the "orange glow". Both men walked along the south side of the track by the wreckage and noticed a clear liquid flowing in a trackside ditch westward towards Benton Avenue. They did not detect any odors from the liquid and decided to return to the pick-up truck.

The engineer and UOE from Helper 1 crossed over the non-derailed portion of train 121 at Benton Avenue and went to the pick-up truck to meet the assistant trainmaster and yard clerk. In doing this, both stepped in the liquid that was flowing in the trackside ditch, but did not detect an identifiable odor. When they reached the pick-up truck, both crewmembers noticed 2-foot high dark orange red flames near the top middle of the tank car that was about 90 degrees to the track. The north end of the car was higher than the south end, due to a covered hopper being underneath the tank car.

Explosions.--According to the UOE of Helper 1, the first explosion occurred about 3 to 4 seconds after he had noticed the flames and had mentioned it to the others. A second explosion then followed within 1 to 2 seconds of the first. The engineer of Helper 1 stated that the electricity went off immediately after the explosions. According to Montana Power Company records, a power outage was recorded at 0448.

During the first explosion, the railroad employees observed a yellow-orange ball of flame originating from the same location as the orange glow and flames that had been previously observed. Flames were estimated to be 100 feet in the air. The employees described the sound of the first explosion as not being very loud and similar to a "...furnace catching on...." The yard clerk stated that "...it seemed like there was something being lifted up as a whole piece...." They described the second explosion as a blue-white flash of light and a very loud noise. The yard clerk indicated that the second explosion occurred in the middle of the object lifted by the first explosion, and that he could see debris being propelled to the south of the track. Later the yard clerk described the object as the top of a tank car. Following the second explosion, the yard clerk observed an orange glow and a fog. The crew from Helper 1 and the railroad personnel from the pick-up truck observed the explosions from about 200 to 300 feet away. After the first explosion, they took cover and observed the second explosion while debris was falling around them. The crew of train 121 was still traveling down the mountain and saw the explosion when they were approaching Joslin Street, about 1 mile away.

The road engineer of train 121 was the first to detrain and walk to the west end of the runaway train. He observed that "...the angle cock appeared to be closed on the westernmost car [SBD 121466]..." and that it "...indicated to me that the train line air had been bottled²²...." He then opened the angle cock and left it in the open position. He stated that no air was exhausted from the valve when he opened the valve. Later, the road

²²Maintaining air pressure in the train line of a train after locomotive is cut off.

UOE and the assistant engineer joined the road engineer while the helper engineer and his UOE remained on the locomotive consist. The road engineer sent the assistant engineer back to the locomotives to retrieve the waybills while he and the road UOE began walking eastward alongside the train towards Benton Avenue. When the assistant engineer returned with the waybills and consist, the road engineer arranged the waybills so that those for the hazardous materials cars were on top. The road engineer then gave this information to the MRL trainmaster who had just arrived at Benton Avenue. The road engineer did not discuss the missing waybill with the trainmaster. The trainmaster was concerned only about the waybills of cars involved in the derailment.

Emergency Response

MRL Notification to City of Helena.--The Helena yard office is located about 1.3 miles east of the Benton Avenue highway grade crossing. On the morning of the accident, an assistant trainmaster and two yard clerks were on duty. About 0431 the Helper 1 UOE notified the Helena yard office and the yard office clerk contacted the Helena Police Department (HPD) dispatcher²³ to report the accident at Benton Avenue and that there were no injuries. The clerk did not request an ambulance or assistance, indicating that the railroad would call back if there was anything else to report. At this time, police, fire, or medical units were not dispatched.

At 0438, the Helper 1 crew radioed the MRL dispatcher in Missoula that "...it looked like they [train 121] probably lost about 20-25 cars...." About 0441, the road engineer of train 121 radioed the dispatcher that "...we got the dangerous cars in there too...." The Helena yard clerk, who overheard this communication, contacted the Helper 1 UOE telling him that there were dangerous cars involved.

The power outage following the explosions resulted in the loss of radio communications at the yard office. The yard office attempted to contact the HPD dispatcher by telephone to advise them to contact the MRL dispatcher for train consist and commodity information. Due to the heavy influx of telephone calls to the HPD as a result of the explosions, the yard office was unable to immediately reach the HPD dispatcher. The assistant trainmaster and a yard clerk then drove to the police station to talk directly with the HPD dispatcher; however, because the personnel on duty were too busy to meet with them, they could not pass the information to the dispatcher.

About 0507, a yard office clerk contacted the MRL dispatcher from a mobile radio/telephone requesting hazardous material information for the rear cars of train 121. After receiving information for hydrogen peroxide and isopropyl alcohol and making hand written notes, the yard clerk contacted the HPD dispatcher about 0512 and requested that someone come to the yard office to pick up the information. Shortly afterwards, a police officer arrived and picked up the clerk's hand written notes. Meanwhile, the HPD

²³The HPD dispatcher is a central dispatcher for both the police and fire departments.

dispatcher had contacted the MRL dispatcher about 0514 and was told "...there were two cars of hydrogen peroxide, one car of isopropyl alcohol, and one car of ORM-E liquid...only four cars that show dangerous on this train...." The HPD dispatcher asked for and received additional information on the ORM-E material, including the Standard Transportation Commodity Code Number²⁴ which the HPD dispatcher believed was the United Nations/North American Identification Number²⁵ and told the MRL dispatcher that "...(the HPD dispatcher) already had received that number...."

Firefighting Efforts.--About 0513, about 43 minutes following the accident, four HFD units were dispatched to the Benton Avenue crossing. Four units, two engines, and two light trucks arrived about 0519. The HFD Assistant Fire Chief surveyed the derailment site and decided to pull back all equipment until additional information was available.

The yard clerk stated that about 0530 he returned to the accident site and repeated the information concerning the hazardous materials and evacuation instructions for a half-mile radius to emergency response personnel. The trainmaster stated that he gave a copy of the hydrogen peroxide waybill to a fireman at the scene. The trainmaster then proceeded to the HFD command post (see Command Posts) located at Benton Avenue and Euclid Street, south of the accident scene. He stated that he reviewed the consist and waybills with the HFD Assistant Fire Chief, and that when the Acting Fire Chief arrived, they called the MRL dispatcher to verify the commodities involved. According to the Hazardous Materials Emergency Response Plan,²⁶ the Acting Fire Chief was designated the Incident Commander following his arrival about 0520. The trainmaster stated that he read the emergency instructions on the hydrogen peroxide waybill "...In case of derailment and fire - evacuate within a half mile radius...", and suggested that the Acting Fire Chief evacuate the area. About 0600, the Incident Commander ordered the placement of an unmanned 3-inch deluge cannon with a direct stream on the south side of the tracks to cool the exposed tank cars. (See appendix K.)

Shipper Notification.--The City of Helena reported that their dispatcher had been given instructions at 0513 by a fireman to contact

²⁴The Association of American Railroads' seven digit number which refers to a particular commodity

²⁵A four digit number for each hazardous material regulated by the USDOT and listed in Title 49 of the Code of Federal Regulations.

²⁶ Lewis and Clark County, Helena, Helena East-Hazardous Materials Emergency Response Plan (HMER), completed October, 1988.

CHEMTREC;²⁷ however, CHEMTREC's records do not indicate that the dispatcher contacted them.

About 0557, the Montana Disaster and Emergency Services Division (DES) notified CHEMTREC of the derailment and reported that four tank cars were involved, one containing isopropyl alcohol (UTLX 820), two containing hydrogen peroxide (GATX 14247 and GATX 73782), and one containing ORM-E liquid (ACDX 816007). DES advised CHEMTREC that there was a fire and product leakage, but could not identify which product was leaking. CHEMTREC was able to provide product information about hydrogen peroxide solutions exceeding 52 percent (the solution was actually 70 percent) and about isopropyl alcohol. Since DES had identified the carrier as MRL and indicated that it was former BN property, CHEMTREC advised DES that it would contact BN for shipping information and then contact the shippers. At 0623, CHEMTREC contacted the BN operations center. A BN official stated that his office had been notified of the incident about 0610. The BN official provided CHEMTREC with the car numbers, commodity, shipper and consignee for all five of the tank cars (including ACDX 816007 which was not involved in the derailment) on the train and the two covered hoppers containing polyvinyl chloride plastic pellets (ACFX 57192 and ACFX 53268).

CHEMTREC notified the hydrogen peroxide shipper, Interlox America (Interlox), and the isopropyl alcohol shipper, Exxon Chemical America (Exxon), about 0702 and 0726, respectively, of the details of the accident. CHEMTREC also notified the other shippers by 0802. When CHEMTREC contacted Interlox again about 0916 of an unconfirmed report of a ruptured hydrogen peroxide tank car, Interlox advised that an emergency response team was leaving by charter jet for Helena. About 0926, MRL contacted Exxon and requested on site assistance in handling the tank car (UTLX 820) containing isopropyl alcohol. MRL contacted CHEMTREC about 1119 and 2136 to request product information about the plastic pellets in car ELTX 1425 and the ORM-E product in box car ATSF 621566.

Command Posts.--The Assistant Fire Chief moved the initial command post (a HPD vehicle) from the accident scene to the intersection of Benton Avenue and Peosta Street and established this location as the forward command post. Shortly thereafter, the HPD and the Lewis and Clark County sheriff's department established a command post at the intersection of Benton Avenue and Euclid Avenue (U.S. Highway 12) in a shopping center parking lot. Later, the Lewis and Clark County Search and Rescue mobile command post (with multiple radio frequency capabilities) was ordered by the sheriff's department to respond to the accident and set up adjacent to the HPD command post. The HPD command post maintained perimeter security and requested other appropriate agencies as needed. Approximately 92 law enforcement personnel with 58 units were involved. A total of 10 firefighting units manned by 20

²⁷CHEMTREC - the Chemical Transportation Emergency Center provides information and assistance to those involved in or responding to chemical or hazardous materials emergencies. Established in 1971, it is a public service of the Chemical Manufacturers Association.

firefighters were actively engaged in the fire suppression activities from February 2 until the fire was extinguished about 1000 on February 3.

The Montana DES established the state emergency operations center (SEOC) at the National Guard Armory to provide staff and communications support and coordinate the State resources. The Montana Department of Health and Environmental Sciences provided technical support; the Montana Highway Patrol provided communications and security; the Montana National Guard provided three fire fighting vehicles, shelter and management support for evacuees; the Governor's office provided a Public Information Officer; and the Radio Amateur Communication Emergency System (RACES) provided a communications link between the State and County emergency operation centers.

The city and county established an Emergency Operations Center (EOC) at the Lewis and Clark County Law Enforcement Center. The EOC was staffed by about 30 people and served mainly as an information gathering point and source for the public via the media and as headquarters for personnel not involved in the response.

On February 3, 1989, a post-accident critique held by the Disaster and Emergency Services Coordinator, identified the following problems: the inability to utilize the radio repeater on Mount Helena for communications because of the power outage; delays in activating the Emergency Broadcast System (EBS) (no one was manning the facility) and in contacting the local radio station (KMTX) because of disrupted telephone communications; and delays in obtaining information from the various command posts on the nature of the accident and the chemicals involved.

Evacuation.--On February 2, 1989, the mayor of Helena declared a local disaster and emergency for the city affirming the incident commander's decision for an evacuation and requested state assistance. The incident commander ordered an immediate evacuation to begin about 0530 and had established boundaries by 0600. (See figure 4.) The initial evacuation involved a 16-square-block area which was more than a 1/2 mile radius from the derailment site. About 1900, the evacuation area was reduced to a 12 by 13 block area. By 1000 on February 4, 1989, the evacuation was ended. The evacuation involved approximately 3,500 people. About 350 were evacuated to the National Guard Armory while the rest elected to go to homes of friends and relatives.

Medical Response.--Following the explosion, emergency medical technicians (EMT) were dispatched from St. Peter's Hospital when a police radio transmission was overheard that "They [police] believed the explosion was at the airport." En route to the airport, the EMT personnel overheard on their radio that the explosion was at Benton Avenue. They arrived at Carroll College near a dormitory (Guadalupe Hall) along Benton Avenue and observed extensive property damage, and students evacuating the building. The EMTs advised the hospital to initiate the Multiple Casualties Incident

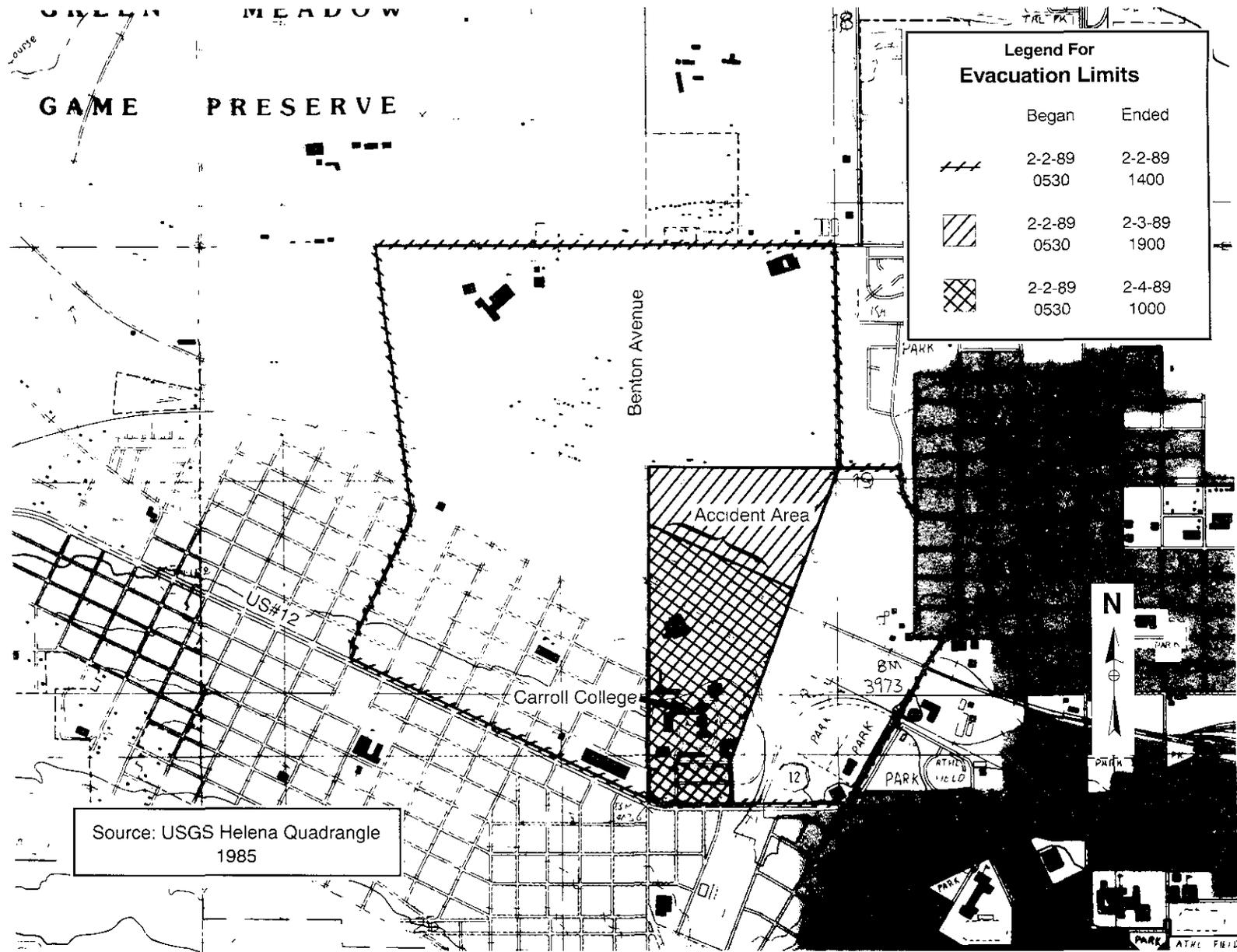


Figure 4.--Evacuation Limits.

Plan.²⁸ They were directed by the hospital dispatcher to evacuate the college because of the extremely low temperatures. With the assistance of 12 volunteer students, the EMTs along with other arriving EMTs began to coordinate the evacuation of the dormitories temporarily to another college building until arrangements were made to transport the students to another location. St. Peter's Hospital staff requested product information from MRL and DES and was advised that hydrogen peroxide was involved.

Injuries

<u>Injuries</u>	<u>Train 121</u>	<u>Helper 1</u>	<u>Total</u>
Fatal	0	0	0
Serious	0	0	0
Minor	0	2	2
None	<u>5</u>	<u>0</u>	<u>0</u>
Total	5	2	7

Four emergency response personnel and three resident/students reported receiving minor injuries such as smoke inhalation and lacerations.

Damages

The 49 cars of train 121 collided with the standing Helper 1; however, only 21 cars, of which 15 derailed, were involved in the general area of the derailment. Fourteen of the 21 cars received extensive damage and were considered not repairable. Damages to the tank cars were as follows: (1) GATX 14247 disintegrated in the explosion with tank car fragments and debris scattered to the north and south; (2) GATX 73782 had overturned with the top of the tank car facing north, but remained in line with the track; (3) ACFX 57358 burned in the wreckage and about 1/3 of the car was missing; (4) ELTX 1425 was penetrated at the A-end by UTLX 820 and about 1/4 of the B-end tank shell of UTLX 820 was enveloped by ELTX 1425 (see figure 5); (5) the tank head on the B-end of UTLX 820 was punctured and the entire lading of isopropyl alcohol was released.

One locomotive unit of Helper 1, MRL 205, was damaged in the collision. MRL officials reported extensive damage to the cab compartment, pilot and electrical controls and freeze damage to coolant piping to the engine (see figure 6). The MRL superintendent stated that based on his observations of other collisions where the speed was from 15 to 20 mph, "...this [impact speed] was in excess of that...."

The City of Helena received 154 reports of property damage from residents within a 3-mile radius of the accident. Twelve residents who lived within 1/4 mile of the accident reported fragments on their property; four of these 12 residents reported that their homes were penetrated by fragments

²⁸The medical protocol defined by the Lewis and Clark County Hazardous Materials Emergency Plan



Figure 5.--ELTX 1425 penetrated by UTLX 820.

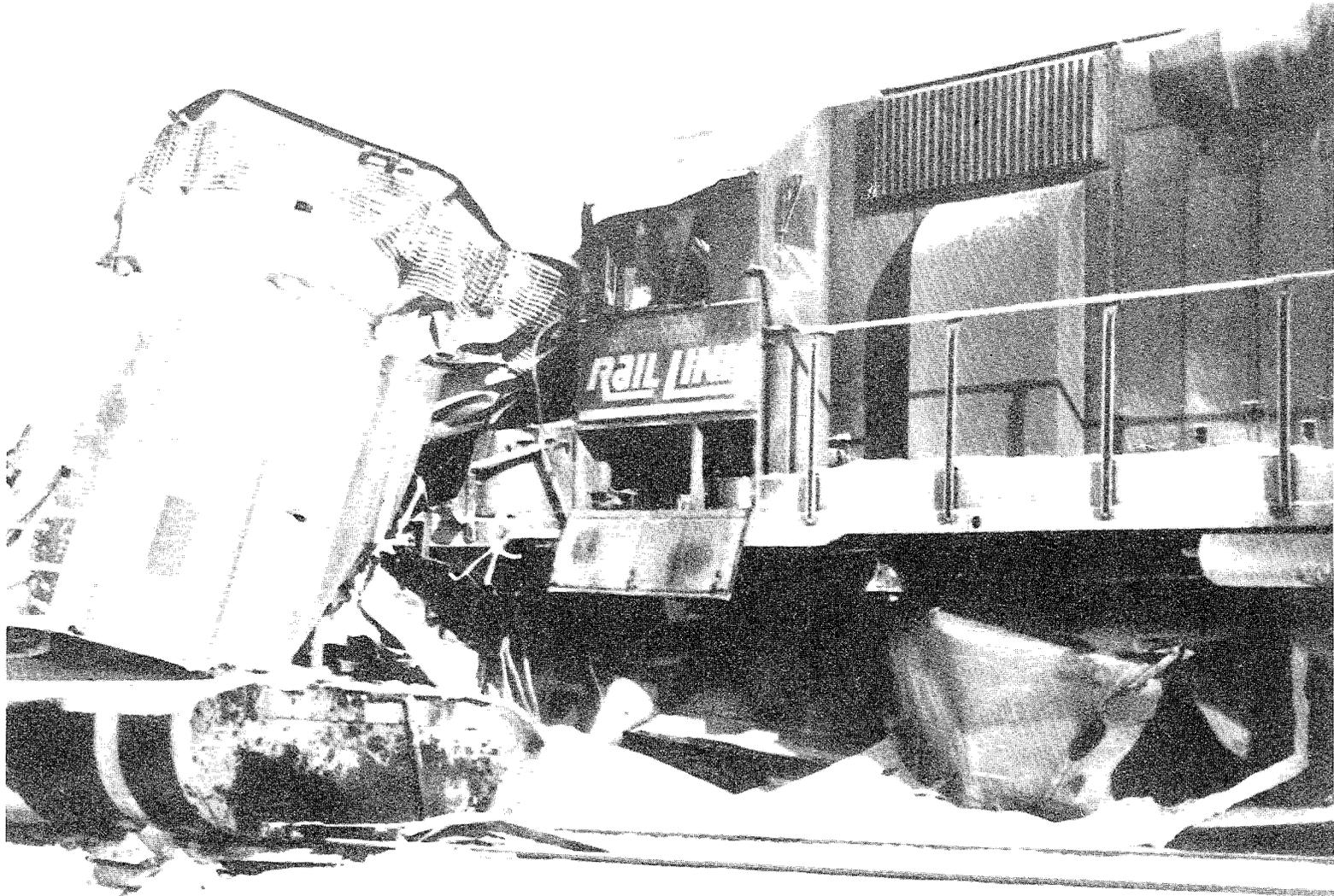


Figure 6A.--MRL 205 locomotive damage--helper 1.



Figure 6B.--MRL 205 locomotive damage--helper 1.

weighing about several hundred pounds (see appendix P). One home, located about 1/2 mile from the accident site, was penetrated by a section of the liquid eduction tube²⁹ from GATX 14247. (See figure 7.) The Elk River Concrete Products Company plant, located adjacent to the MRL tracks at Benton Avenue, sustained major structural damage along with multiple fragment penetration holes in walls and piping. Carroll College reported major damage to all of its buildings (10 buildings), with the greatest damage at the Physical Education facility; damage consisted of broken windows, roof penetrations, cracked walls and ceilings, and water damage due to the sub-zero temperatures and the power outage.

About 485 feet of both main tracks and siding, including two turnouts, and a signal were damaged on the MRL at the Benton Avenue crossover. The BN reported damage to the turnout at Tobin.

The City of Helena and MRL provided the following estimate of damages:

Railroad Equipment	\$ 869,535	(based on depreciated value)
Railroad track/signals	\$ 64,800	
City of Helena	\$ 120,000	
Elk River Concrete	\$ 500,000	
Carroll College	\$ 2,500,000	
Other railroad cost	<u>\$ 1,945,665</u>	(clean-up, lading, etc.)
Total	\$ 6,000,000 *	

* Damage costs to private property were unavailable.

Meteorological Information

Upon the arrival of the road crew in Helena about 2330, on January 31, there had been heavy snow and temperatures dropped from a high of 45° F early that morning to -18° F by 2353 with wind and light snow. On February 1, temperatures in Helena continued to fall with a high of only -18° F recorded at 0050 and a low of -28° F at 2248 with wind and light snow. When the road crew reported for work at the Helena yard office about 0130 on February 2, the temperature was about -26° F with wind and light snow. From 0352 to 0452, the temperature was about -27° F with 1 1/2 miles of visibility, a wind of 14 knots and light snow. At 0551, the temperature decreased to -29° F with light winds and snow. About 1052, the snow had stopped and the temperature was -26° F, and at 2353 the temperature was -25° F.

On January 31, at Billings, Montana, approximately 15 miles northeast of Laurel, the NWS reported the temperature as 48° F at 0549 with winds of 21 knots gusting to 27 knots. At 0649, the temperature decreased to 26° F and continued decreasing, reaching 6° F at 0950, 0° F at 1200, and -12° F at 2350 with light winds and snow. At 0849 on February 1, the temperature was -17° F with light snow and winds gusting to 21 knots.

²⁹The liquid eduction tube is used to off-load hydrogen peroxide. It is mounted on the top of the tank car and extends inside to the bottom, where it is held in place by a support bracket.

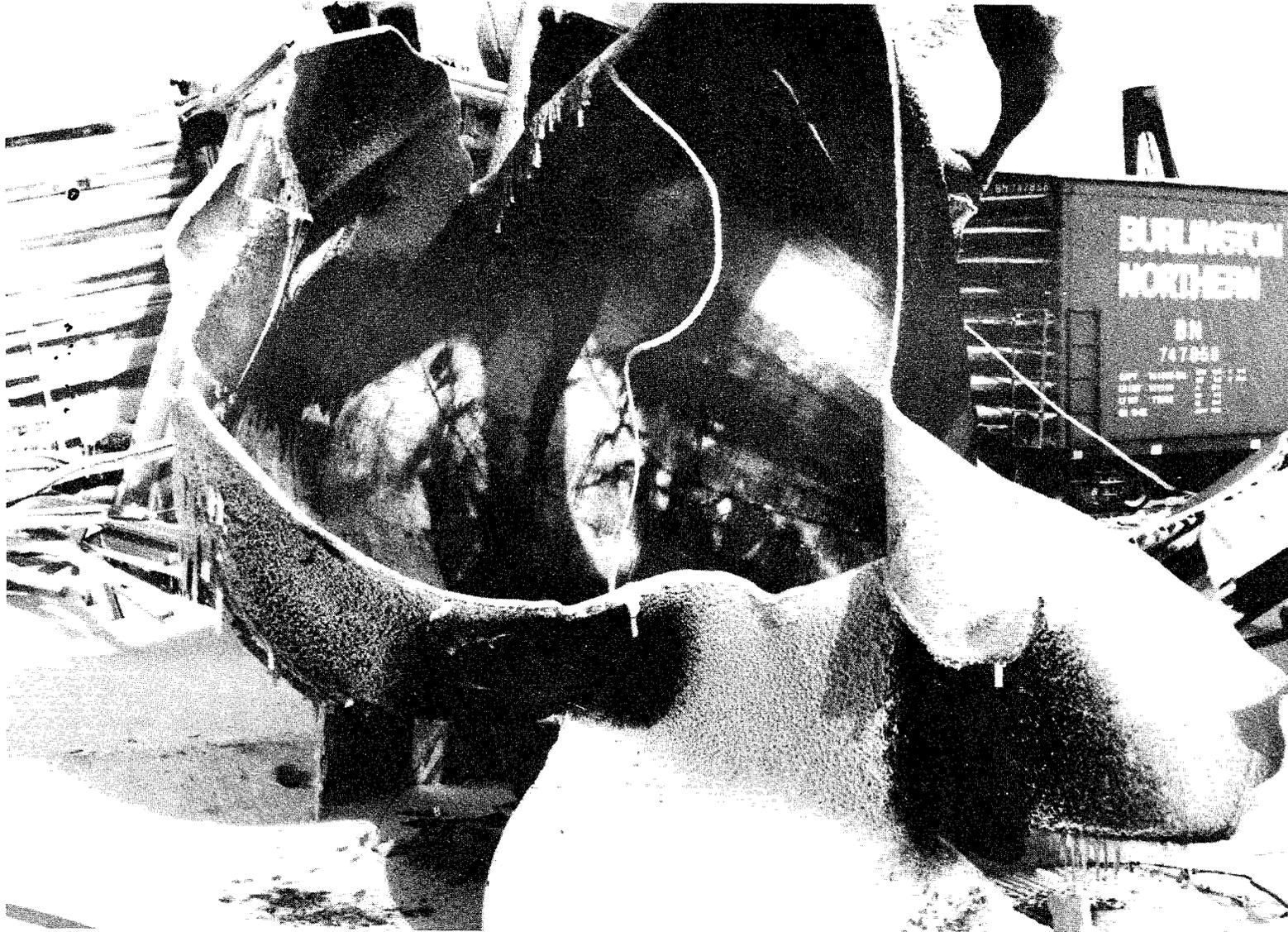


Figure 7A.-- Tank car GATX 14247.



Figure 7B.--Liquid education tube from tank car GATX 14247.

When the road crew of train 121 left Missoula on January 31, the weather conditions were different than those in Helena on February 1 and 2. The temperatures normally experienced in Helena according to National Oceanic and Atmospheric Administration data indicate that the normal daily maximum temperature for January is 28.8° F with the normal daily minimum temperature of 8.4° F; the corresponding maximum and minimum temperatures for February are 33.7° F and 12.7° F, respectively.

Train Information

Train 121.--When train 121 departed Helena, it consisted of Helper 2 (MRL 208/6346/202) on the head end, followed by the road power (BN 8061/8009/7163) and 49 cars. The train consist provided to the crew showed that train 121 had 4,288 trailing tons and was 2,869 feet in length. However, SBD 121466, which was added after the consist had been furnished to the crew, changed the make-up of train 121 to 4,375 trailing tons and 2,924 feet long.

Helper 2 consisted of three MRL 3,000-hp, diesel electric units, type SD-40. The road power consisted of three BN 3,000-hp diesel electric units, type SD-40-2. All locomotive units were manufactured by the Electro-Motive Division (EMD) of the General Motors Corporation. Each locomotive unit was equipped with 26L brake equipment, cab radio, and a multi-event recorder manufactured by Pulse Electronics, Inc. (Pulse); the BN units were additionally equipped with a Pulse "Train Sentry II" alerter device and a train line air flow indicator. Only BN 8061 was equipped with an EOT telemetry receiving device made by Pulse. The 26C automatic brake valve of the 26L locomotive brake from the lead helper unit, MRL 202, was removed for testing. (See discussion under Testing of 26C Automatic Brake Valve.)

Of the 49 cars in train 121, 6 cars were transporting hazardous materials regulated under USDOT Hazardous Materials regulations. Five were tank cars: one of phenol, two of hydrogen peroxide at 70 percent concentration, one dual compartment tank car of isopropyl alcohol and acetone, and one of liquid coal tar pitch. The sixth was a box car containing 7 drums of paint classified as a flammable liquid and 233 drums of solid coal tar pitch classified as an ORM-E material.

Helper 1.--Helper 1 (MRL 205/6493/6686) consisted of three 3,000-hp, diesel-electric units, type SD-40 manufactured by EMD. Each locomotive unit was equipped with 26L brake equipment, cab radio, and a Pulse multi-event recorder.

Mechanical Information

Postaccident Train Leakage.--A postaccident leakage test was conducted on February 5, 1989, on the 28 cars of train 121 which were not involved in the accident with a result of 10 psi/min leakage. The temperature at the time of the testing was -15° F. Postaccident inspection by investigators of these 28 cars showed 20 brake shoes required replacement and 17 cars with overheated wheels. MRL inspected 42 pairs of wheels from the derailed

equipment and found 17 pairs with indication of overheating; however, it was not possible to match wheels to their respective car.

EOT Operation.--The receiver (front unit) of the Pulse "TrainLink" EOT telemetry device was in the locomotive cab compartment of BN 8061; the transmitter (rear unit) was mounted on the coupler of the last car and was connected to the train line. The EOT device transmits information to the engineer such as: train line pressure at the last car, movement, battery condition, and status of the operation of the flashing marker light. The president of Pulse stated at the Safety Board's public hearing that transmitting limitations are set by the Federal Communications Commission (FCC) for a maximum output power to the antenna of two watts with a center frequency stability of .0005 percentage points over a stated temperature range of -40°C to 85°C (-40°F to 185°F).

The EOT transmitter sends a signal to the front unit every minute unless there has been a change in conditions being monitored and then a signal is sent at that time. A three beep audible alert is sounded on each change of status or pressure change and a lighted display will flash for 10 seconds. The alarm will not sound if the display is still flashing from a previous change. The receiver will beep one time for each 2 psi change of train line pressure. Absence of a radio transmission for 5 minutes will give a continuous flashing "RAD BRK" (radio break) indication and a 6 beep audible alert. After a further 5 minute silent period with no radio transmission, the display will go blank, except for the continuous display of "RAD BRK." The president of Pulse further stated that a radio break can occur when the signal transmission is obstructed by such items as terrain and structures, and the signal transmission may also be affected by the length of train or loss of battery power.

The power for the EOT device front unit is supplied by the locomotive while the rear unit is powered by a battery.³⁰ The Pulse EOT specifications for battery life, with the rear flashing marker light operating 50 percent of the time, are 150 hours at 70°F and 60 hours at -20°F .

MRL officials informed Safety Board investigators that during their company investigation a mechanical foreman at Laurel stated that EOT transmitters are inspected and the battery removed and recharged/replaced when trains arrive in Laurel. The Chief Mechanical Officer testified at the Safety Board's public hearing that he did not know of any policy for his general foreman, at Laurel, to routinely change batteries of EOT transmitters. There were no records to show when and if the batteries of the EOT transmitter on the rear of train 121 were changed.

The EOT telemetry device on train 121 did not have the capability for the road engineer to transmit a signal to confirm that the rear unit was operating or to initiate an emergency application of the train airbrakes from the rear of the train. Two-way transmitting EOT telemetry devices are not in

³⁰Pulse Electronics Inc "TrainLink" EOT telemetry device uses a sealed lead acid battery that employs a gel as the electrolyte.

use on railroads in the United States nor are they required. The president of Pulse stated at the Safety Board's public hearing that a two-way transmitting EOT telemetry device, which has the capability to allow the engineer to issue an emergency brake application from the locomotive cab as well as operate the rear marker lights, is available and is being marketed for use on Canadian railroads.³¹ The signal for the emergency application of the train brakes to the EOT telemetry device will continue to be transmitted until the signal has been acknowledged by a drop in pressure.

Locomotive Heaters.--The cab compartment heaters of the lead helper unit of train 121, MRL 208, had been converted from the circulating warm water type to an electric heater; the two remaining MRL units in the locomotive consist still had circulating warm water heaters. All three BN units had electric heaters. The circulating warm water heaters use water from the diesel engine cooling system. Both types of heaters use electricity from the auxiliary generator for forced air blowers. Since 1973-74 when EMD introduced the SD-40-2 series, an 18 KW auxiliary generator has been used for electric heaters. Earlier locomotives with 10 KW auxiliary generators usually only have warm water heaters. The MRL units had 10 KW auxiliary generators and two BN units had 18 KW auxiliary generators. The two electric heaters are 3,000 watt capacity with electrical protection through one 50 amp circuit breaker. MRL has planned to install two electric auxiliary side wall heaters (strip heaters) to provide supplemental heating capacity in the locomotive cab. The supplemental heaters are rated at 1320 watts each with electrical protection through one 30 amp circuit breaker. However, none of the units in train 121 had side wall heaters.

The MRL mechanical supervisor stated that the helper consist had working heaters on each end on the afternoon before the accident. While the middle unit had a working cab heater, it was reported by previous train crews that the cab compartment was cold while moving. The problem of repairing heaters was reported by MRL mechanical officers to be a recurring one. During the previous winter, difficulties had been encountered in supplying fully functional cab heaters in all units. The mechanical supervisor stated that this winter (1988/1989) heater problems were being reported to him with greater frequency. Most reports were made verbally to either the mechanical supervisor or through the labor union; no formal or written complaint had been made by the labor union to the MRL. The helper engineer stated that he made up his own written form for reporting inoperative cab compartment heaters and on one occasion had made a written notice.

On February 13, 1989, the cab compartment heater of MRL 208 was inspected and tested by MRL mechanical personnel in Livingston, Montana. The inspection report stated that the control circuit breaker, fuel pump circuit breaker, and the 15 amp turbo lube pump circuit breaker were "open." All other circuit protection devices were in the normal position - "closed." No

³¹The Safety Board was informed that Canada has enacted legislation, effective November 1, 1989, to require that caboosless trains are to be equipped with two-way transmitting EOT devices.

mechanical discrepancies were found. It was determined by MRL mechanical personnel that when both cab compartment heater blower fans were in the "high" operating position, the auxiliary generator fuse would "open." A "negative low voltage ground" was found in the "fireman" side cab heater motor. MRL mechanical personnel also reported that the electrical requirement when both electrical heaters were operated on "high" exceeded the rated fuse capacity causing it to "open." This caused the fuel pump to stop operating which in turn caused the circuit breaker for the turbo lube pump to "open;" when this occurred the unit's engine (motor) stopped operating.

The facilities at Helena Yard are limited in what mechanical repairs can be made to cab heaters. One supervisor and three service workers are employed to handle all mechanical repairs in the yard. Further, the facilities are only equipped to service electrical heaters. When replacement locomotives are available, locomotives with warm water heaters needing repair are sent to a facility in Livingston, Montana, that is equipped to make the necessary repairs. The helper engineer stated that on his last trip on January 31; he was in locomotives without working cab heaters for 14 hours and 45 minutes while deadheading to relieve another crew.

Title 49 CFR 229.119(d) addresses the subject of locomotive cab heaters and states in part "...The cab shall be provided with proper ventilation and with a heating arrangement that maintains a temperature of at least 50° F 6 inches above the center of each seat in the cab...." The FRA is responsible for oversight of this regulation and civil penalties may be imposed by the FRA on railroads for violations of this regulation.

Event Recorders.--The data packs removed from six locomotive units³² were sent to the Safety Board's laboratory for a printout of "expanded" strip charts for the movement of train 121 from its departure from Helena to the accident scene and the movement of Helper 1 at Benton Avenue. The multi-event recorders record speed, distance, elapsed time, and an eight-bit digital word monitoring throttle position, direction of unit movement, and locomotive automatic and dynamic braking.

The combination of data from the stripcharts of five of the event recorders of train 121 showed that train 121 was brought to a stop by systematic stepped reduction of the throttle from the 8 throttle position to idle/1/2 position with a simultaneous 18 psi automatic airbrake reduction. Total distance traveled was shown as 13.25 miles from Helena to Austin with an elapsed time of 43 minutes.

After train 121 had been stopped for about 3 minutes, the automatic airbrake application was increased to 22-25 psi. About 7 minutes after stopping (4 minutes after increasing the airbrake application), Helper 2 (208/6346/202) made two short moves, neither more than 1 minute in duration nor more than 1/4 mile in length including a change in direction. About 2 minutes after these moves, the road locomotive (8069/8009/7163) made

³²Data packs were removed from Helper 2 (6346/202); road power (8061/8009/7163); and Helper 1 (6686).

similar moves of the same duration, direction, and distance. About 12 minutes and 10.5 minutes, respectively, had elapsed from the time Helper 2 and the road locomotive had separated from train 121 before both moved together. This movement, of both Helper 2 and the road locomotive together, occurred about 19 minutes after train 121 had come to a stop, but before the airbrake application had been increased.

Following one short move with a change in direction, the locomotive units accelerated to 35 mph with the throttle in the 8 position and within 5 minutes stopped with the indication of an emergency brake application. The throttle was then reduced to idle/1/2 and after being stopped for 30 seconds the airbrakes were released and the locomotive accelerated to 35 mph in less than 1 minute with the throttle in the 8 position. The maximum speed recorded was about 45 mph. During the last 10 minutes, the throttle was left in the idle/1/2 position. Twenty-one minutes elapsed from the emergency brake application to the stopping of the locomotive with another emergency brake application (from a speed of 25 mph); no dynamic braking was used preceding either emergency brake applications. The return trip toward Helena took about 28 minutes.

Tank Car Information.--Both hydrogen peroxide tank cars (GATX 14247 and GATX 73782) were owned by General American Transportation Corporation and leased to Interox. The tank cars were DOT specification 111A60ALW2 built in 1980 and 1986, respectively. The tanks were ASTM B-209 5254 aluminum with 1/2-inch head and shell thickness, each with a capacity of about 20,500 gallons. Neither car was insulated nor equipped with head shields. Both cars had type "E" top and bottom shelf couplers. Both cars had continuous sills underneath with all closure fittings located on the top of the car. Both cars had 2-inch continuous vents, 60 psig rupture discs (safety vent), liquid education tubes, and 20-inch inner diameter hinged and bolted manways. Interox indicated that only routine maintenance was performed in 1988 and that neither car had been involved in any accidents.

Tank car UTLX 820 was a two compartment DOT specification 111A60W1 tank car built in 1969. Compartment "A" (8,000 gallon capacity) contained acetone and compartment "B" (12,000 gallon capacity) contained isopropyl alcohol. It was owned by Union Tank Car Company and was leased to Exxon Chemical America, a division of Exxon Corporation. The tank shell was ASTM A-285 Grade C and the tank heads were ASTM A-515 Grade 70. The tank car was uninsulated and did not have head shields. It was equipped with type "E" top and bottom shelf couplers. Each compartment was equipped with a pressure relief valve that would begin to discharge at 35 psig, a bottom outlet valve, and a manway. The tank car had not had any major repairs in the 12-month period prior to the accident.

Tank Car Protection

Current Tank Car Standards.--DOT specification rail tank cars authorized for the transportation of hydrogen peroxide solutions exceeding 52 percent are listed in 49 CFR 173.266(f). Authorized rail tank cars must be constructed of aluminum or type 304L, 316, or 316L stainless steel. The

regulations require shelf couplers, but do not require that the tank cars be equipped with head shields or puncture resistant features.

DOT specification rail tanks authorized for the transportation of isopropyl alcohol and acetone are listed in 49 CFR 173.119(a) and (b). The regulations do not include any special requirements or specify that tank cars be equipped with head shields or puncture resistant features other than shelf couplers for the transportation of either product.

In a 1981 report,³³ the Safety Board discussed the evolution of the hazardous materials regulatory programs, and noted that before the formation of the DOT in 1966, the Interstate Commerce Commission (ICC) was the Federal agency with primary responsibilities for developing safety regulations for the transportation of hazardous materials. The ICC depended on and accepted industry-developed standards for surface transportation. The ICC relied on the regulated shippers and carriers to provide the expertise for developing regulations which resulted in nongovernment entities performing governmental functions. With the formation of DOT, the regulatory authority passed from the ICC to DOT; however, the existing industry-oriented standards developed during the ICC regulatory oversight period remained essentially unchanged.

Evaluation of Product Hazards and Container Protection.--RSPA has established a hierarchy of hazards for the various DOT hazard classes. Of the 16 hazard groups (see appendix J) listed in order of greatest hazard to least hazard, flammable liquids such as acetone and isopropyl alcohol are listed as no. 5, oxidizers such as hydrogen peroxide as no. 6, and ORM-E as no. 16. In addition to the hierarchy of product hazards, RSPA container protection requirements are based on the survivability of the container and a cost-benefit ratio calculated using shipping records, effects of product release or comparable products based on accident history, economic information with respect to construction of containers, and anticipated safety benefits.

Puncture Protection Standards.--Regulatory requirements for puncture protection systems such as head shields on tank cars were first implemented in the 1970s. RSPA, through the former Materials Transportation Bureau (MTB), issued the regulations in response to Safety Board recommendations and numerous serious accidents that occurred between 1968 and 1979. These accidents involved DOT specification 105, 111, 112, and 114 tank cars transporting flammable gases such as propane, toxic gases such as anhydrous ammonia, and extremely flammable products such as ethylene oxide. As a result of its investigation of several of these accidents, the Safety Board had concluded that puncture protective systems were needed for tank cars

³³Safety Report--"Status of Department of Transportation's Hazardous Materials Regulatory Program" (NTSB-SR-81-2).

carrying high-risk hazardous commodities.³⁴ Between 1974 and 1981, RSPA proposed and issued regulations for tank head puncture protection standards under four separate regulatory dockets. (See appendix O.) Collectively, the regulations published under these dockets required tank head puncture protection standards on newly constructed DOT specification 105 tank cars and all 112 and 114 tank cars transporting flammable gases, anhydrous ammonia, and ethylene oxide. In each of these regulatory dockets, RSPA justified new tank car puncture protection standards such as head shield protection for these tank cars and commodities on the basis of accidents involving these specification tank cars carrying the specific commodities and in which the tank cars sustained tank head or shell punctures.

In 1980, RSPA issued an Advanced Notice of Proposed Rule Making (ANPRM)³⁵ to consider extending the puncture and thermal protection levels of DOT specification 112 and 114 tank cars to existing DOT specification 105 tank cars carrying flammable gases, anhydrous ammonia, ethylene oxide, butadiene, poisons, and combustible and flammable liquids or solids. Extending these requirements to DOT specification 111 tank cars carrying the same commodities was also to be considered. With the publication of the Notice of Proposed Rule Making (NPRM) under HM-175 on April 14, 1983,³⁶ the Secretary of Transportation announced on April 13, 1983, that DOT planned to continue the review of its safety rules governing rail tank cars used for other hazardous cargoes. (See appendix H.) The Secretary added that even though these cargoes move in smaller amounts and less frequently than flammable gases, these cargoes represent a "...real and substantial risk in accident situations...." The review was to include aluminum tank cars "such as the one that was punctured April 3, 1983, in a Denver rail yard, releasing 20,000 gallons of nitric acid."³⁷ DOT's most current regulatory agenda,³⁸ a semiannually summary of all current and projected rulemakings, lists one

³⁴For a listing of accidents and background information, refer to "Safety Report on the Progress of Safety Modification of Railroad Tank Cars Carrying Hazardous Materials" (NTSB-SR-79-2); and Railroad Accident Report--Derailment of Seaboard System Railroad Train No. F-690 with Hazardous Material Release, Jackson, South Carolina, February 23, 1985, and Collision of Seaboard System Railroad Train No. F-481 with Standing Cars, Robbins, South Carolina, February 25, 1985" (NTSB-RAR-85-12).

³⁵RSPA, 49 CFR Parts 173 and 179, Docket No. HM-175, "Specifications for Tank Cars," Vol. 45 Federal Register, p. 48668, July 21, 1980.

³⁶RSPA, 49 CFR Parts 173 and 179, Docket No. HM-175, Notice No. 83-1, "Specifications for Railroad Tank Cars Used to Transport Hazardous Materials," Vol. 48 Federal Register, p. 16188, April 14, 1983.

³⁷Railroad Accident Report--"Denver and Rio Grande Western Railroad Company Train Yard Accident Involving Punctured Tank Car, Nitric Acid and Vapor Cloud, and Evacuation, Denver, Colorado, April 3, 1983" (NTSB/RAR-85/10).

³⁸DOT, "Department Regulations Agenda; Semiannual Summary", Vol. 54 Federal Register, p. 44884, October 30, 1989.

rulemaking project concerning inspections following certain tank car repairs, but does not include any projects to review the safety rules for tank cars.

Track and Signals

Track.--The MRL operates over its own trackage and by trackage rights over the BN between Helena and Elliston, Montana (MP 28.9). MRL owns and maintains the main track No. 1 from MP 0.0 to Helena Jct. (MP 3.1) and the main track No. 2 from MP 0.0 to, but not including, the control point at Tobin (MP 5.0). BN owns and maintains main track No. 1 from MP 3.1 up to and beyond Austin (MP 13.0). (See figure 2.) Yard limits on MRL track extend from MP 0.0 to MP 3.1 on main track No. 1 and from MP 0.0 to MP 5.0 on main track No. 2. The track is maintained and inspected to meet the minimum requirements for the FRA Track Safety Standards of class 4 track and was last inspected between January 27 and 30, 1989, with no defects noted. The maximum authorized track speed is specified in the MRL Timetable No. 2 and the BN Timetable No. 1. (See appendix I.)

The accident occurred on the main track No. 2 at about MP 1.1 at the Benton Avenue crossover. (See figure 3.) There are two crossovers at Benton Avenue. The east crossover is a trailing point crossover and the west crossover is a facing point crossover in a westbound movement. The turnout at Tobin is a trailing point switch for westward trains. The track is 115 lb jointed rail in the vicinity of the derailment on both tracks. Between MP 0.0 and MP 5.0, the track structure is a combination of 131 lb. jointed, 112 lb. jointed, and 132 lb. continuous welded rail (CWR).

The track gradient westward from Helena (MP 0.0) to Elliston (MP 28.9) is considered mountain territory. The surrounding terrain is generally steep with narrow valleys and numerous rock outcroppings. Westward from the Benton Avenue crossover, the track gradient varies from 0.0 percent to 0.75 percent descending for westward trains on a straight track to about MP 2.1. From MP 2.1 to about MP 3.4, west of Helena Jct., the track is level (0.0 percent) with one curve. From MP 3.4 to Tobin, the track gradient ascends westward varying from 0.0 percent to 1.8 percent on straight track. From Tobin to Austin, the track gradient ascends westward varying from 1.8 percent to 2.2 percent with sixteen curves.

Signals.--Centralized traffic control (CTC) begins at MP 1.0 on both tracks and extends westward beyond Austin. The track east of MP 1.0 is Absolute Block System (ABS)³⁹ territory. Austin (MP 13.0) is a controlled siding about 6,825 feet in length with dual control turnouts⁴⁰ designated as East Austin (MP 11.5) and West Austin (MP 12.9). Each railroad dispatches their own trackage. The MRL dispatcher (located in Missoula, Montana) controls train movements from Helena westward to Helena Jct. on main track No. 1 and to Tobin on main track No. 2. The BN dispatcher (located in

³⁹A block system that allows only one train at a time in the block.

⁴⁰A power-operated turnout which is also equipped for manual operation

Billings, Montana) controls train movements from the end of MRL dispatching points westward to Phosphate, which includes Austin.

Between Helena and Austin, there are four absolute⁴¹ and five intermediate⁴² signals on MRL main track No. 2 and the BN main track for westward trains. For trains moving eastward there are four absolute and four intermediate signals. For trains moving westward from Austin to Elliston, there are eight absolute and four intermediate signals.

Train Graph and Dispatcher Event Recordings.--The BN utilizes a train graph to show the passing times of trains by designated control points. The BN chief dispatcher reported that the dispatcher on duty calibrates and resets the clock time as required each day at noon. The control points between Austin and Tobin are the East Austin power switch and the Tobin power switch. The BN dispatcher who was on duty the day of the accident interpreted the train graph for the movements of train 121 at the Safety Boards' public hearing. He stated that train 121 moved westward through Tobin at about 0339 and passed over the control point at East Austin from 0356 to 0358; he identified a train movement recorded at East Austin at about 0419 and at Tobin at about 0426 as the runaway portion of train 121, and the eastward movement of the locomotives of train 121 at East Austin at 0429 and at Tobin at 0442. (See appendix E.)

The MRL reports train movement information with a computerized reporting log using an internal clock to generate a chart for train movements, signal indications, and switch position with respect to the time the event occurred. The MRL dispatcher testified that he had no indication of the runaway train on main track No. 2 because "...The track [signal circuit] was already occupied, and there would only be one indication, and that would be that of the helper [Helper 1] that was sitting west of Benton Avenue [crossover]..." The dispatcher stated that train 121 was shown as going west through the Benton Avenue crossover at 03:27:47 and leaving MRL dispatching control at Tobin at 03:37:13. Helper 1 was reported at Benton Avenue crossover at 04:19:40. At 04:30:15, the reporting system showed "...alarm-Helena west-OS on west crossover, south main, is indicating an unexpected [occupancy], account track occupied without signal allowing movement [into] track section..." The dispatcher stated that an alarm is registered any time an unexpected change takes place and that this occurred when Helper 1 was struck by the eastbound runaway and pushed into another track circuit.

⁴¹An absolute signal is a block signal designated by the absence of a number plate. The most restrictive signal displayed is "stop." It designates a length of track in which no other train or engine is permitted to enter while it is occupied by another train or engine. The dispatcher authorizes movement into an absolute block in CTC operation.

⁴²An intermediate signal on the MRL and BN is an approach signal with a number plate that governs the approach into a length of track on a automatic block signal system. Its most restrictive signal is "restricted proceed" (proceed at restricted speed)

Dispatcher Communications.--The MRL and BN routinely record the radio communications between the dispatcher and train crews. At 04:29:46, a crewmember of train 121, later identified as the assistant engineer, contacted the MRL dispatcher stating "...121 we're up here at Austin...head end power with the helper units...we're [going to] be moving eastward...our train is down the hill...we've got an emergency situation...we'll be going by the east block at Austin..." The dispatcher requested that this be repeated and it was repeated again at 04:30:29. There was no request by the crewmembers from either the BN or MRL dispatcher for authority to proceed eastward without acknowledging signals during the pursuit of the runaway train. At 04:30:46, the UOE from Helper 1 at Benton Avenue crossover reported to the MRL dispatcher that they had just been hit by a train.

Method of Operations

General.--The MRL began operating as a regional railroad⁴³ on October 1, 1987, between Huntley, Montana, and Spokane, Washington, over property formerly operated by the BN. The BN retained portions of the property with MRL operating with trackage rights between Sandpoint Jct., Idaho, and Spokane (Yardley), Washington, and Helena Jct., Montana, and Phosphate, Montana. The MRL's 3rd Subdivision included operations over the 6th Subdivision, Montana Division, of the BN by trackage rights. According to MRL officers, the BN's operating rules were in effect when MRL operated over the BN 6th Subdivision. The Montana Division was part of the Northern Region of the BN between Tobin, Montana, 5 miles west of Helena and Phosphate, Montana, a distance of 49.6 miles. MRL's total mainline mileage is 651.4 miles including 108.9 miles of BN trackage rights.

The operation of the MRL, including the 3rd subdivision between Helena and Missoula, Montana, was under the supervision of the superintendent at Laurel, Montana. Reporting to the superintendent were an operational supervisory staff at Helena consisting of a trainmaster and two assistant trainmasters. The trainmaster was responsible for road operations as well as yard operations, and the assistant trainmasters were assigned primarily to supervise yard operations at Helena.

According to MRL General Order No. 1 dated January 1, 1989, MRL Timetable No. 2 dated January 29, 1989, was in effect. The MRL had adopted the General Code of Operating Rules (GCOR) and adopted the Safety Rules, Maintenance of Way Rules, and the Air Brake, Mechanical and Train Handling Rules of the BN. MRL officers stated that it was expedient for them to use the BN rules at the beginning of operations since most of the MRL operating officers and the property had formerly been BN. MRL was in the process of

⁴³Although there is no set definition, a regional railroad is considered a railroad larger than a short line railroad (usually with more than 200 route miles), but smaller than a Class I railroad and usually considered a Class II railroad. Since 1975, approximately 30 regional railroads have begun operation as newly created railroads or railroads with new ownership.

writing their own rules to replace the BN rules. The BN Montana Division Timetable No. 1, dated October 30, 1988, as well as the General Code of Operating Rules was in effect on the 6th Subdivision.

Train Crew Responsibilities.--After the accident, the train crew stated their understanding of which engineer was in charge of train 121 to Safety Board investigators. The helper UOE stated that the helper engineer was in charge of the train when the decision to switch the locomotive consist around at Austin siding was made because the helper engineer was in the lead. However, the road engineer stated he believed that he was in charge of the train. The assistant engineer and the road UOE stated that they agreed that the helper engineer seemed to take charge.

Rule 106, paragraph (1), of the GCOR concerning the responsibility of operating crewmembers states in part, "The general direction and government of a train is vested in the conductor..."; however, the position of conductor does not exist on the MRL. MRL's superintendent's bulletin no. 2 dated January 1, 1989, read in part, "Terms of reference as to conductor, brakeman, switchman, fireman, etc. exist in some publications used by Montana Rail Link and have become standard in our industry. These positions do not exist on Montana Rail Link. Responsibilities traditionally associated with those positions are incorporated in the positions of engineer, assistant engineer and utility." MRL does not have a written policy regarding who is in charge when helper units are placed at the head end of a train. The superintendent told Safety Board investigators that "...[It has] always been just that the train engineer is basically in charge of the train. It's more or less of a mutual agreement between the engineers..." and "...In my opinion, the engineer of the train being helped would be the engineer to make final decisions...If there were a problem and a confrontation developed, there are rules to cover that wherein they are to contact the supervisor who is on duty to resolve the problem..." Neither the engineer or the helper engineer contacted the on duty supervisor or the train dispatcher.

According to the testimony of the inbound (relief) engineer of train 121, he did not perform a roll-by inspection of train 121 as it departed Helena, stating that "...I was under the impression I had been relieved from duty on this train, which the company [MRL] informed me that I was wrong." Another engineer testified at the Safety Board's public hearing that he did a roll-by inspection as train 121 departed and, observing no defects, radioed this information to the Helper 2 engineer. Neither the engineer of Helper 2 nor the road engineer remembered receiving a radio communication of a roll-by inspection.

Roll-by inspections are required by MRL Notice #9, dated January 1, 1989:

A member or members of inbound crews on through trains operating caboosless will give the outbound train a "roll-by" inspection and advise the outbound crew the condition of the train, unless outbound crew will not be immediately available, or inbound crew is otherwise relieved of duties.

Stopping Trains on Grades.--Rule 100 of the GCOR states in part, "When an engine leaves part of its train on the main track, a sufficient number of hand brakes must be set to keep the detached portion from moving." Testimony from the train crew was that no hand brakes were applied and no instructions were given to set hand brakes. The BN superintendent of operations stated during the Safety Board's public hearing with regard to the application of rules 100 and 103 (L) that "If a train is to be left unattended the rules specify that the airbrakes must not be relied upon to hold the train, and that hand brakes must be applied." When asked if hand brakes should have been applied on train 121 at Austin he stated "I think it may have been appropriate."

Rule 103 (L) of the GCOR states in part:

The air brakes must not be depended upon to hold a train, engine or cars in place when left unattended.

When train, engine or cars are left standing, a sufficient number of hand brakes must be applied to prevent movement with air brakes released. If hand brakes are not adequate, wheels must be blocked.

Before an engine is detached from a train or cut of cars that are to be left standing on a grade, slack must be bunched and a sufficient number of hand brakes must be set on the descending end of train or cars to secure the detached portion. When engine is recoupled to train or cars, the hand brakes must not be released until the air brake system is fully recharged.

The BN's Manager of Locomotive Operations and Air Brakes stated that an unattended train is "...a train that's left without power attached." The MRL's Director of Operation Services stated that, "There is no definition for unattended...There is no definition for train left standing." Concerning the MRL interpretation of rules 100 and 103 (L) he stated, "Hand brakes would not have been necessary on train 121-28 had the airbrakes been applied properly, and the train was not unattended."

The MRL superintendent stated: "If they're going to leave the train unattended, and by that I mean they're going to leave the train standing on mountain grade and go off and go somewhere, they have to tie [set] hand brakes. If they're just cutting off to pick up a car or set out a car or something where they're going to stay there in the vicinity of the train and it's attended, they're required to leave brakes in emergency...."

Rule 219 of the BN Air Brake, Mechanical and Train Handling Rules provides requirements for cutting off the locomotive from freight trains. This rule states in part, "Before locomotive is detached or angle cock(s) are closed, brakes must be applied as covered by Rule 412." Rule 412 covers the procedure for the application of airbrakes to avoid an undesired release of the airbrakes from an improper operation of the angle cock.

According to testimony of the MRL superintendent, the procedure of partially turning angle cocks was a practice on the BN 10 to 15 years before the use of ABDW control valves on cars and pressure maintaining features on locomotives. It was not sanctioned by the MRL, except per rule 412 of the BN Air Brake, Mechanical and Train Handling Rules, in instances where trains were arriving at a terminal where an initial terminal airbrake test or 1,000-mile inspection was to be made. Rule 412, second paragraph, part 4, states in part, "Leave angle cock open on portion of cars or train to be left standing and when a cut is made, brakes will apply in Emergency on portion of the cut of cars or train to be left standing...Where required, a sufficient number of hand brakes must be applied in accordance with Rule 470." Rule 470 prescribes the provisions for setting out cars and use of hand brakes when trains are left standing on specific grades. (See appendix L.)

The superintendent was initially notified of the accident by the MRL dispatcher about 0441. He was informed of the events that occurred at Austin and the crew involved. The superintendent stated to the dispatcher that he could not understand why the airbrakes did not set. He also expressed his concern with the cold weather and that the crew may have "bottled" the air. Rule 227 of the BN Air Brake, Mechanical, and Train Handling Rules states in part, "...'Bottling the air' is prohibited..."; the only exception being when a train is at a terminal where facilities are available and at which instructions provide for immediate brake inspection. Rule 413 of the BN Air Brake, Mechanical, and Train Handling Rules states in part, "Angle or end cocks must NEVER be left in a PARTIALLY OPEN/CLOSED position."

Rules 100 and 103 (L) of the General Code of Operating Rules and rules 219, 227, 412, 413 and 470 of the BN Air Brake, Mechanical, and Train Handling Rules had not been modified or cancelled by either the BN or the MRL. (See appendix L.)

Federal regulations covering the use of airbrakes and hand brakes on grades are addressed in 49 CFR 232.13 (f) which states:

The automatic air brake must not be depended upon to hold a locomotive, cars or train, when standing on a grade, whether locomotive is attached or detached from cars or train. When required a sufficient number of hand brakes must be applied to hold train, before air brakes are released. When ready to start, hand brakes must not be released until it is known that the air brake system is properly charged.

Train Documents.--When the road engineer accepted train 121 in Helena, the consist showed that the fifth car (ACDX 816007) behind the locomotive was listed as "CHEMLS DAN"; upon checking its physical location he found that it was the sixth car because the first car, SBD 121466, was not on his list. In checking for waybills,⁴⁴ the road engineer stated that the waybill for ACDX 816007 was missing from the documentation carried on the train.

⁴⁴A waybill is the primary written documentation of every freight shipment that forms the basis for railroad freight revenue accounts.

Federal regulations and railroad operating procedures require that train crews are to have a copy of the train consist and a waybill for every car in the train. Waybills for cars containing hazardous materials may also contain emergency response information. The emergency response information on MRL-issued waybills is taken from the Association of American Railroad (AAR) Emergency Response Guides that have been incorporated into MRL's computer data base.

The superintendent stated that MRL does not issue a waybill for any car unless the shipment and billing originate on the MRL. They receive and accept waybills issued by the originating carrier and do not as a rule receive the shipper's bill of lading. MRL depends upon the accuracy of waybills issued by others since these are the only information available to them. The superintendent stated that although inaccurate waybills for hazardous materials cars have not been a frequent occurrence, MRL has contacted both the AAR and BN about problems in the past. He acknowledged that the inaccurate waybills for UTLX 820 and ATSF 621566 would not have been discovered if the accident had not occurred. Both cars had waybills issued by the BN. Waybills for UTLX 820 and ATSF 621566 were incomplete for the identification of product being transported. (See appendix J.) MRL officers informed Safety Board investigators that the FRA has initiated enforcement action against both the MRL and BN for the inaccurate waybills.

Train consists are generated in Laurel, Montana. When a train is received in interchange from the BN and no cars are removed from that train, the MRL consist generated will be the same. When cars are switched, the crew performing the switching will report the order of the cars on the track to the yardmaster for generating the consist.

Under the provisions of 49 CFR 174.3, a shipment of hazardous material that is not prepared in accordance with the regulations may not be accepted for transportation by rail. Further, 49 CFR 174.24 requires that no person [carrier] is to accept for transportation by rail any DOT-regulated hazardous material unless the person [carrier] has received a shipping paper⁴⁵ as prescribed in 49 CFR Part 172. Under 49 CFR 174.26(b), a train crew must have a document, such as the train consist that indicates the position of each placarded car in the train that contains hazardous materials. Placards, which are affixed to a rail car containing hazardous materials and describe the nature of the commodity, are not required for shipments of ORM-E materials according to 49 CFR 172.500. Further, 49 CFR 174.26(c) requires that a train crew have in its possession a copy of the shipping papers for all hazardous materials on the train.

⁴⁵shipping paper means shipping order, bill of lading, manifest or other shipping document serving a similar purpose and containing the required hazardous material descriptions and certifications. (49 CFR 171 8)

Oversight of Montana Rail Link Operations

MRL Oversight.--When the MRL began operations, it complied with the applicable Federal regulations of filing its timetable, operating rules, and operational testing procedures with the FRA. The MRL's efficiency testing program requires that operating officers make and report a minimum of 10 group "A", 15 group "B", and 16 group "C" tests per month covering a prescribed list of rules in each group. Efficiency tests are physical checks of the performance of operating employees while they are actually engaged in the performance of their duties. Group "A" covers 9 categories of signal rules; group "B" covers train protection, use of radio, speed compliance, and certain airbrake and train handling tests; and group "C" covers other tests such as: rule G, rule of the day, inspection of train, and other rules as specified by the testing officer. Testing intervals for operating employees are not to exceed a 180-day cycle. According to the testimony of the trainmaster responsible for rules compliance and efficiency testing at Helena, he had not performed any efficiency tests of the crewmembers involved in this accident because he had recently been promoted to this territory within the last 3 months prior to the accident.

MRL efficiency test records for the road crew of train 121 showed that the engineer had three efficiency tests in the prior 180-day period; the assistant engineer had been tested four times and given a verbal warning for mounting/dismounting equipment improperly; and the UOE had been tested eight times while performing engineer and/or UOE duties and given a verbal warning for moving his train into a block without the dispatcher's authority. The helper crew of train 121 had not been tested during the period.

BN Oversight.--Between Helena Jct. and Phosphate, where MRL operates on BN trackage, the BN has jurisdiction over MRL operating employees and oversees the compliance of BN operating rules by performing efficiency tests. The BN superintendent of operations stated that since the MRL began operations in 1987, they have conducted efficiency tests on 13 occasions with only a couple of failures and had generally found compliance. MRL operating officials can also perform efficiency tests between these locations and did so on 18 occasions during the 6-month period prior to the accident. There were no records for BN efficiency testing for the crewmembers involved in the accident.

FRA Oversight.--FRA oversight of the MRL began with the initiation of MRL's operation. FRA personnel from the Billings, Montana, district office met with MRL officials to discuss: (1) the Federal requirements of the regulations; (2) documents to file with FRA headquarters in Washington, D.C.; (3) FRA policy; (4) FRA inspection procedures; (5) FRA drug and alcohol testing, preemployment testing, and 49 CFR Part 219; and (6) signal and train control, hours of service, motive power and equipment requirements, and operating practices. Meetings were held between FRA, BN and MRL to discuss the interchange requirements of freight cars, locomotives, and hazardous materials inspections. FRA provided MRL with USDOT Emergency Response Guidebooks. Seminars on FRA Track Safety Standards were conducted with MRL at three locations including a field investigation of railway procedures, policies and standards, and track buckling prevention measures. The FRA

district supervisor stated that the reason that FRA was intensely involved with the MRL was because MRL began its "...operation with fairly heavy traffic density with people who had been trained on other railroads...."

Personnel Information

Helper 2.--The engineer and UOE reported for work about 0130 on February 2, 1989 at the Helena yard office. They had been off duty for about 12.25 hours prior to reporting for work. Helper assignment personnel work a 7-day-a-week schedule with time off on request. Both had met the hours of service requirements when they reported for work.

Road Crew.--The engineer, assistant engineer, and UOE reported for work about 1800 on January 31, 1989, at Missoula, Montana, and worked 5 1/2 hours before going off duty at 2330 in Helena, where they each were provided lodging at a motel. According to MRL records, no discipline had been assigned to any of these crewmembers for previous rules violations.

The engineer stated that he went to bed about 0015 on February 1 and got up between 0900 and 1000 and spent the day walking around town, eating and watching television. He stated that he went to bed about 1800 and was called at 2330 to report at 0130 for duty.

The assistant engineer stated that he went to bed at 0130 on February 1 and got up about 1100 and spent the day visiting and having dinner with his parents. He was called about 2330 by MRL, ate breakfast and reported for duty at 0130.

The UOE stated that he went to bed at 0200 on February 1 and slept about 7 hours. During the day, he stayed in his motel room, ate and watched television. He went to bed again in the evening and reported to work with the engineer and assistant engineer at 0130.

Qualification and Training of Operating Employees

Prior to being employed by the MRL, potential employees had to meet certain selection criteria. Engineers had to have previous experience as an engineer with a Class I railroad.⁴⁶ UOE's were required to have previous experience in any railroad craft. MRL's operating employees were either former BN employees or former employees from other Class I railroads. Except for the road UOE, who also worked as an MRL engineer, both engineers of train 121 were former BN engineers. All crewmembers met the selection criteria.

Training consisted of on-the-job training, rules classes and rules examinations. All employees that began working prior to March 1988 were examined on the General Code of Operating Rules during March and were given a

⁴⁶As defined by the Interstate Commerce Commission, U.S. Class I railroads are those with average annual operating revenues of \$87.9 million or more.

written examination on the operating rules which included questions regarding certain rules from the BN Air Brake, Mechanical, and Train Handling Rules.

MRL requires only engineers to be qualified on the BN Air Brake, Mechanical, and Train Handling Rules; there is no requirement to qualify assistant engineers and UOEs. At the time of the accident, MRL policy (regarding the frequency of rules classes and examinations) required designated personnel to pass an examination on the General Code of Operating Rules at least every 2 years. Following the accident, this policy was changed to a 1-year interval with examinations and/or reexaminations beginning March 1989.

Several 2-hour voluntary formal training programs for engineer review and instructional classes were held at various locations during 1988. Records furnished by MRL indicated that 48 engineers, 23 UOEs, 3 trainees, and 1 trainmaster attended. The engineers involved in the accident had attended these classes; neither the assistant engineer, the road locomotive UOE, nor the helper UOE had attended.

Hazardous Materials Identification and Information

Release and Dispersion of Hazardous Material.--All of the hydrogen peroxide (about 18,950 gallons) in GATX 14247 and all the isopropyl alcohol (about 12,136 gallons) in UTLX 820 were released. About 38 percent (7,300 gallons) of the hydrogen peroxide in GATX 73782 and less than 1 percent (55 gallons) of the acetone in UTLX 820 were released. Hazardous materials from the three remaining cars were not released. Environmental sampling was conducted on the liquid pools that collected from the fire suppression streams that drained to the north and to the west of the accident scene. The greatest concentrations of isopropyl alcohol and acetone were found in a sample drawn from an excess water run-off stream that drained west along the south side of the tracks. The only soil contaminated by the isopropyl alcohol and acetone was in the immediate area under tank car UTLX 820 which had derailed west of the tank cars containing hydrogen peroxide. Concentrations of hydrogen peroxide as high as 11 percent were found in the run-off streams that flowed west along the south side of the railroad tracks, and concentrations of 7.9 percent were found in a run-off stream that flowed north onto the driving range of the golf course. (See appendix N.)

DOT Emergency Response Guidebook (ERG).--A RSPA representative acknowledged at the Safety Board's public hearing that it was an oversight that RSPA had not recommended an evacuation distance for hydrogen peroxide in the ERG. RSPA is now considering the addition of an evacuation distance for hydrogen peroxide in the 1990 publication of the ERG.

The RSPA official stated that RSPA uses committees composed of representatives from industry, interested associations, and other government agencies to review and draft revisions to the ERG. Generally every 2 years a revised printing is issued. Corrections or errata sheets between printings are not issued. The RSPA official explained that given the wide

distribution of the ERG it would be difficult to distribute corrections; consequently, RSPA does not plan to issue corrections or updates between printings.

Toxicology and Medical

Toxicology.--The five crewmembers of train 121 were taken by an assistant trainmaster to St. Peter's Hospital in Helena about 0800 and blood and urine samples according to FRA regulations were completed about 1130. The samples were forwarded to the Center for Human Toxicology (CHT) in Salt Lake City, Utah, for testing. The urine samples were tested for the presence of amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine and metabolite, methaqualone, opiates, and phencyclidine. The blood was tested for ethanol. Blood and urine samples tested negative for drugs and alcohol.

Neither the BN nor the MRL dispatchers on duty at the time of the accident were requested to submit to toxicological testing.

Medical.--None of the individuals at the accident site when the explosions occurred experienced or mentioned having problems with their eyes or respiratory tracts during or immediately after the explosions. However, the UOE of Helper 1 experienced stinging in his eyes and nostrils 3 to 4 hours after the explosions. He went to the hospital about 1030, and was examined and released. The engineer of Helper 1 received a mild neck injury.

Except for an emergency response technician admitted for overnight observation and released the next day, about six individuals reporting injuries were treated and released the same day from St. Peter's Hospital. The injuries were attributed to minor smoke inhalation, headaches, dizziness, sore throats, lacerations, anxiety, and fainting.

Environmental Factors

Employee Preparedness.--The road crew of train 121 left Missoula, their home terminal, before the temperatures began to drop and had dressed according to the weather conditions at that time. The road crew UOE stated that he believed the temperature to be 25° F when he left home in Missoula and dressed with that temperature in mind. When they arrived in Helena, an away-from-home terminal, the crew was provided facilities in a local motel used by MRL crews. The only cold weather clothing the crew had was what they wore or brought from Missoula.

The road crew UOE stated he was unaware of the weather forecast when he left Missoula; he wore a canvas type shirt, sweatpants and uninsulated cowboy boots; he had brought with him a hooded insulated sweatshirt, coveralls, a stocking hat and gloves. He stated to Safety Board investigators that he believed he was adequately dressed except for his boots.

The assistant engineer wore jeans, a flannel shirt, a wool sweater, and a ski jacket. While visiting with his parents, he picked up a cap and additional socks, and, concerned that he was still not fully prepared, had taken a towel from the motel to use as a neck scarf. Following the accident,

he told investigators that he was concerned with the cold weather and for frostbite if one of the crew had left the locomotive to set hand brakes.

The road engineer wore layered clothing of insulated underwear, a cotton tee shirt, a cotton jersey, a hooded sweatshirt, and a jacket. He also had insulated boots, hat and gloves.

The helper crew lived in Helena and had been at home since the cold weather began. Both stated they wore long underwear, bib overalls, hooded sweatshirt (engineer only), insulated gloves, and boots. The engineer had a snowmobile suit and the UOE had an insulated coat.

The MRL safety rule book⁴⁷ provides some guidelines for clothing, but they are primarily general in nature. Rule 3 states in part, "Employees must be suitably dressed and shod to perform their duties safely...." Rule 6 is concerned with employee awareness in cold weather and states "During the winter season, or in adverse weather when ear covering may impair hearing, it is of the utmost importance to maintain a sharp lookout in all directions." No rule prescribes or gives guidelines for appropriate cold weather wear. MRL officers stated that clothing is an employee's individual responsibility and MRL does not get involved in oversight of employee preparations for cold weather operating conditions.

Other Information, Tests, and Research

Previous Hydrogen Peroxide Release.--On December 26, 1987, two hydrogen peroxide tank cars of DOT specification 111AL60W1 were involved in an accident in Missoula, Montana, on the MRL. The tank cars were supposedly empty and were being returned to Deer Park, Texas, to Interlox. The tank cars were in a train that was leaving the yard when one tank car was sideswiped by another car being switched in the yard. The hydrogen peroxide tank car derailed and was ruptured. According to a Hazardous Materials Incident Report to the DOT, approximately 2,500 gallons of 70-percent hydrogen peroxide solution was spilled. The hydrogen peroxide ignited several crossties and the fire department was contacted to extinguish the fire. An Interlox follow-up accident report showed that this occurred during "bitter cold conditions."

Reactivity of Hydrogen Peroxide.--According to Interlox, hydrogen peroxide is highly reactive with metals such as iron, chromium, copper, and nickel, with alkalis, with acids, and with other contaminants. Hydrogen peroxide will also react with carbon steel. Hydrogen peroxide is compatible with aluminum and ASTM A304 and ASTM A316 grades of stainless steel, each of which is a DOT-approved material for hydrogen peroxide containers. Interlox chemical experts have indicated that dirt, grease, rusted metal and most materials are contaminants to hydrogen peroxide, and will lead to decomposition of the hydrogen peroxide resulting in a chemical reaction with the contaminant.

⁴⁷MRL has adopted for its use the BN Safety Rules and General Rules dated August 1, 1981.

Explosion Mechanisms.--The physical state of an exploding material distinguishes between two categories of explosions: a vapor and condensed phase explosion. A vapor phase explosion is the explosion of vapor in the normal atmosphere. The energy released from a vapor phase explosion occurs in a time span of seconds. An Interlox chemist stated at the Safety Board's public hearing that the description of the first explosion is consistent with the propagation of an unconfined vapor phase explosion. (See appendix J.)

A condensed phase explosion is the explosion of material that is in either a liquid or solid form, such as dynamite or TNT (tri-nitro-toluene), and releases a high energy level within a time span of microseconds (one-one millionth of a second). The Interlox chemist stated that the description of the second explosion is consistent with a condensed phase explosion. He characterized the description of the flames provided by the railroad employees--the orange flame indicates there was not enough oxygen for complete combustion, whereas the whitish-blue flames indicates an oxygen rich explosion and that both can occur with vapor and condensed phase explosions. Hydrogen peroxide by itself will not initiate a condensed phase explosion. However, the Interlox chemist indicated that a condensed phase explosion may be possible with a mixture of hydrogen peroxide and molten polyethylene, based on testing done by an independent laboratory.⁴⁸

Interlox estimated the force of the second explosion based on the damages, injury data, and fragmentation scatter data reported, to be equivalent to approximately 10 tons of TNT. Interlox calculated that for this explosive force to occur it would require a reaction between about 9.1 tons of 70 percent hydrogen peroxide solution and 0.9 tons of polyethylene. According to the waybills, tank car GATX 14247 contained about 105 tons of hydrogen peroxide, and covered hopper car ACFX 57358 contained about 91 tons of polyethylene pellets. Interlox also considered what might result from the penetration into the tank car by a metal object which resulted in local decomposition of the hydrogen peroxide. Interlox determined that the rupture would not exceed an explosive force of 55 pounds of TNT.

Single Car Air Tests.--On February 8, 1989, MRL car repair personnel performed single car air tests on the 28 non-derailed cars (cars 1 - 28 from the locomotive of train 121) in accordance with MRL "Single Car Testing Instructions Air Brake Equipment". The purpose of these tests was to evaluate the operation of the airbrake system equipment. The MRL chief mechanical officer provided a list of 7 cars that failed the single car air test to the Safety Board during the public hearing; the cars, with their location from the locomotives, were SLSF 88637 (2), MP 356773 (3), NATX 71560 (4), ACDX 816007 (6), BN 751066 (8), UTLX 66884 (23), and SOU 14831 (24). The reason given was a "B O Valve" (bad order control valve) for 6 of the cars. Prior to moving the 28 cars from the accident site, car ACDX 816007 was noted as having sufficient brake pipe leakage at several locations

⁴⁸These tests were done with a 90% hydrogen peroxide solution mixed with molten polyethylene and was initiated by mechanical shock.

that car repair personnel assumed that it would not pass a single car air test; it was therefore repaired before being tested.

Airbrake Performance Tests.--The airbrake test rack⁴⁹ of the New York Air Brake Company (NYAB) in Watertown, New York, was used on September 12 and 13, 1989, to simulate the operation of the airbrake system of train 121. The tests were to determine the effect on the airbrake system when leaving the angle cock: (1) in the half-way open position, and (2) in the open position, when train 121 was uncoupled from the road locomotive by the road UOE.

Two sets of tests were performed using a 50-car simulated train with the train line pressure at 90 psi and two separate values of train line leakage. (See appendix M.) The first set of tests included two tests with about 10 psi/min leakage distributed within the first 30 cars; the first test (ML 1022) was with the angle cock left opened half-way to simulate the procedure reported by the road UOE; and the second test (ML 1023) was with the angle cock placed in the open position. The second set of tests included two tests with about 21 psi/min leakage (with 10 psi/min distributed within the first 30 cars and the balance of the leakage in the last 20 cars); the first test (ML 1025) was with the angle cock opened half-way to simulate the procedure reported by the road UOE; and the second test (ML 1026) was with the angle cock placed in the open position.

All tests began with an automatic brake reduction of about 25 psi and after the air ceased exhausting (about 1 min) both angle cocks were closed simulating the uncoupling of the helper locomotive from train 121. A 3-minute period simulated the elapsed time between the uncoupling of the helper locomotive and the uncoupling of the road locomotive from the train before the angle cock was manipulated. During this 4-minute period, it was observed that the automatic brake reduction resulted in the application of the train brakes and no unintentional release of the train brakes occurred.

Both tests with the angle cock left half-way open resulted in a reduction of train line (brake pipe) pressure with no effect on brake cylinder pressure. The two tests with the angle cock left open had different results; an emergency application was initiated on the 10 psi/min leakage test train with about 40 psi train line pressure, but the 21 psi/min leakage test train had a train line pressure of about 24 psi and no emergency application could be initiated. (See appendix M.)

Tests of Airbrake Control Valve.--The ABDW control valve from GATX 75782 was tested at the airbrake testing facilities of the NYAB on September 12 and 13, 1989. The tests included a bench test on an AB

⁴⁹The airbrake test rack simulates the train line and can be set up to represent various train lengths of 50-foot cars in 10-car increments up to 200 cars total. Train line leakage is created by inserting an orifice device in a valve opening; this simulates leakage in the freight car pipe, hose, and fittings only. The airbrake test rack is located indoors and can only simulate tests at the ambient room temperature.

(airbrake) test rack and environmental testing in a temperature controlled chamber. The environmental tests consisted of: (1) a 3 psi reduction - hold for two minutes - slow release; (2) service stability - emergency - release; and (3) a manual release. The tests were performed at temperatures of (1) 70° F to 75° F and (2) -35° F to -40° F.

The ABDW control valve is made up of two portions - a service and an emergency portion. Both the service and emergency portions of GATX 75782's control valve failed the bench test. A small crack discovered in a housing cover of the service portion was determined to be consistent with derailment damage; however, upon disassembly it was noticed that the slide valve had lengthwise scratches and small plastic type chips in the brake cylinder release portion. Later disassembly of the emergency portion found crosswise scratches on the slide valve, contaminants in the area of the accelerated release spool valve, wear marks on the emergency piston, and a brass chip on the emergency accelerated release spool valve. Although the control valve had excessive leakage, the tests for a minimum brake application and emergency application showed that the brake application was maintained and an emergency application was made in both temperature conditions.

Environmental testing was performed on a recently rebuilt control valve furnished by NYAB. The control valve passed the AB bench test and the single car air test performed at 75° F; however, the control valve released (brake cylinder pressure went to zero) the brake application when the minimum brake application (3 psi) and emergency application were made at the coldest temperature condition of about -35° F. Inspection of the control valve installation did not show any anomalies. Later the control valve was disassembled and inspected by NYAB and it was noted that there was no lubricant on the slide valve. The control valve was retested at 75° F and passed.

Testing of 26C Automatic Brake Valve.--Helper 2 lead unit, MRL 202, was equipped with a 26L locomotive airbrake equipment; the 26C automatic brake valve is the primary controlling device in this airbrake equipment arrangement. The valve was tested by Comet Industries, Kansas City, Missouri, on February 13, 1989 for possible failure, according to Westinghouse Air Brake Code of Tests (# T-2422-0 issue 9) and New York Air Brake Code of Tests (# T-2961-C). The results of all tests of the 26C valve were within the specified limits.

Inspection and Operation of Angle Cock From SBD 121466.--The first car on the west end of train 121 was SBD 121466. The angle cock valve on the end of the car that was coupled to the locomotives was removed by MRL mechanical personnel for testing and inspection by investigators. Normal operation requires that the valve handle be raised and moved to either the full open/closed position or to the full closed/open position until the tab on the underside of the handle is positioned against the tab stops on the valve body. The valve when opened to the half open/closed position could not be moved or forced to the closed/open position without raising and turning the handle to allow the stop tab to clear a fastener head on the valve body. This was demonstrated by the MRL's CMO during the Safety Board's public

hearing. No mechanical operating defects were found that affected the normal operation of the angle cock.

Testing of EOT Telemetry Device.--The EOT receiving device was a "TrainLink" receiver manufactured by PULSE Electronics, Inc., during October 1985 and was owned by BN (serial #105014); this device was a portable unit and was mounted in the lead road unit, BN 8061, of train 121. It had been repaired by PULSE on May 5, 1986, and again on October 24, 1986; the unit showed typical "wear and tear" consistent with its age according to PULSE. The unit was tested by PULSE for MRL on February 13, 1989, for proper operation. It was determined that the unit operated properly with a simulated axle drive input of 20 pulses per revolution (ppr). The axle drive input on BN 8061 was arranged for 20 ppr. PULSE noted that the unit had been opened in the field since four screws were stamped "field". A BN officer stated that BN records showed that the unit was modified on March 19, 1988, to replace the PULSE computer "PROM" (programmable read only memory) module with an AAR computer "PROM" module. The unit checked out per PULSE guidelines and was returned to service. The EOT transmitting device (rear unit) was completely destroyed in the collision with Helper 1; only a portion of a computer printed circuit board was found by investigators.

ANALYSIS

General

No aspects of the track structure or the signal system were a causal factor in the accident. The 26C automatic brake valve from the lead locomotive of train 121 was fully functional in responding to the braking application made by the helper engineer when he brought the train to a stop at Austin. The angle cock from SBD 121466, the first car coupled to the locomotives, was not defective and therefore not a factor in the accident. The crewmembers physical and medical condition were not a factor in this accident.

The events leading to the collision between train 121 and the standing locomotive units of Helper 1 were set in motion after train 121 was uncoupled from the road locomotive. At some point shortly after that, the retarding force of the automatic brakes applied to secure the train on the grade decreased. The Safety Board examined the stopping of the train on the mountain grade, the crew's action to secure the train, the effects of cold temperatures on the train airbrake system, and the crew's activities following their discovery that the train was gone. Other areas examined included testing of the airbrake system, interpretation of operating rules, role of helper engineers in train operations, operating trains with an EOT device, adequacy of locomotive cab heaters and employee preparedness for cold weather, efficiency testing, and crew training. Finally, the Safety Board examined the factors involved in the explosion that followed the collision and the adequacy of the preparedness for and the response to the explosion.

The Accident

Stopping the Train on the Mountain Grade.--After departing Helena about 0320 on February 2, 1989, the lead helper unit lost power, the cab compartment heater ceased operating, and the cab windows began to fog over affecting the crew's visibility. After overhearing the instructions on his radio from the BN dispatcher to the road engineer to stop and hand operate the switch at West Austin (because of the cold), the helper engineer decided on his own to tell the BN dispatcher that he intended to rearrange the locomotives at West Austin because of the loss of power and heat on the lead helper unit.

The helper engineer brought train 121 to a stop at West Austin by gradually reducing the throttle position and applying the train brakes with a service reduction of 5-7 psi and increasing to 22-25 psi. Although the helper engineer stated he made a full service application (26 psi) of the train brakes, the event recorders did not record a full service application.

The Safety Board questions the decision of the helper engineer to bring the train to a stop on the ascending grade for the purpose of rearranging locomotive units. The relief engineer stated that he had taken exception to the train line pressure between Townsend and Helena and that he had told the helper engineer and the Helena yard office "...that the airflow indicator was at 14..." Even though MRL, unlike BN, does not have an FRA waiver to use the airflow indicator for required airbrake testing and, consequently, does not train its crews for its use, the helper engineer, by virtue of his experience as a former operating officer (trainmaster and rules officer) on both the MRL and the BN should have been sufficiently familiar with the airflow information to have recognized the possibility of excessive train line leakage on train 121. The BN manager of locomotive operations and air brakes stated that a "14" reading indicated that train 121 had a high air flow into the train line and equated the reading to a leakage of about 21 psi/min for a 50-car train. Furthermore, the helper engineer knew, or should have known, that the pressure maintaining feature on his locomotive, would be eliminated during the uncoupling maneuver. As a result, the train line pressure would continue to decrease due to the leakage. The helper engineer should also have known, again as a result of his experience as a rules officer on both the MRL and the BN, that both company rules, as well as Federal regulations, would require that a sufficient number of hand brakes be applied if the train is left standing on the ascending grade and that the automatic airbrake must not be depended upon to hold the train on the grade. Further, the helper engineer should have recognized that to set hand brakes, the crewmembers would have been exposed to extreme cold weather conditions for some time. Nevertheless, the helper engineer decided to stop the train on the ascending grade and rearrange the locomotive units. The Safety Board, therefore, attempted to determine what factors influenced the helper engineer's decision.

When the helper locomotive was positioned ahead of the road locomotive at Helena, the road engineer informed the helper engineer that the train line pressure was being restored after the required set and release of the train brakes. Because the train line pressure was being restored, the helper

engineer may have concluded that the relief engineer's report of an airflow reading of "14" and his concern for train line pressure may have been unfounded. It was well known that the malfunctioning of locomotive cab heaters was of great concern to the helper engineer. He had made the majority of the complaints the previous winter about heater problems and had even developed his own heater deficiency reporting form to record such problems. Because of the loss of power and the lack of heat in the lead helper unit, the helper engineer decided on his own, once he realized that the train had to stop at Austin to align a switch, to rearrange the locomotive units. The Safety Board concludes that the helper engineer was preoccupied with the malfunctioning locomotive cab heater and did not properly consider discussing alternative actions with the road engineer and the adverse effects of the extreme cold on the airbrake system.

Crew Actions to Secure the Train.--When the road assistant engineer separated the helper from the road locomotive, he closed both angle cocks bottling the air in the train line. Had he left the angle cock open on the road locomotive, as he should have, the train brakes would have applied in emergency. He did so because he believed that they would not be there long and he did not want to be out in the extreme cold weather looking for stuck brakes when it came time for them to leave.

The road UOE admitted manipulating the angle cock so as not to initiate an emergency application of the train brakes when he uncoupled the road locomotive from the train. The airbrake performance tests indicated that an emergency application could still have been made by the road UOE when he uncoupled the road locomotive from the train if the leakage rate had been 10 psi/min. However, at a leakage rate of 21 psi/min, based on the airflow indicator reading of between "12" and "14", as stated by the relief engineer, no emergency application could be initiated because the train line pressure would have already dropped below the air pressure that would initiate the emergency application. The Safety Board concludes that train line leakage was at such a high rate that the road UOE probably could not have initiated an emergency application of the train brakes as required by company rules even had he left the angle cock in the open position. Regardless of the outcome, the road UOE's action when he uncoupled the road locomotive from the train was not in compliance with company rules.

MRL and BN operating rules, as well as Federal regulations, require that a sufficient number of hand brakes be applied when trains are to be left standing on grades and that the automatic airbrake must not be depended upon to hold the train on the grade. When train 121 was left standing on the 2.2 percent grade at Austin, hand brakes should have been applied, but were not. Had the hand brakes been applied before the locomotives were uncoupled from train 121, the retarding force applied through the hand brakes would have been sufficient to hold the train on the grade even with an unintended release of the train airbrakes. It is unclear whether the crewmembers knowingly failed to comply with company rules or had misinterpreted them. Since setting hand brakes and the subsequent release of the hand brakes is accomplished manually, the crewmembers would have been exposed to extreme weather conditions. The Safety Board cannot rule out the possibility that the extreme cold weather was a factor that influenced the crew's decision to

not set the hand brakes. However, since MRL indicated that hand brakes did not have to be set in this instance, the crew may never have been instructed to do so. In any event, the crewmembers did not properly secure train 121 when they uncoupled the locomotives and left the train unattended.

Effects of Cold Temperatures on the Train Airbrake System.--The airbrake simulation tests on NYAB's test rack showed increases in brake cylinder pressure with simulated train line leakages of 10 psi/min and of 21 psi/min (when leakage was confined to the freight car piping, air hoses, and fittings). Further, there was no unintended release of the train brakes as train line pressure between the rear of the train and the front of the train was being equalized. This indicates that the release of train brakes was a result of leakage through other airbrake system components. Although the airbrake system on railroad equipment must operate satisfactorily over a range of temperatures (-40^o F to +150^o F), as specified by the AAR, individual airbrake components, once in service on railroad equipment, are not required to be tested further unless they fail in service or have an expired service date. Further, repaired airbrake components (control valves, brake cylinders, etc.) are not required to be retested over a specific range of temperatures. The repair parts, however, must satisfy AAR specifications which include the previously stated temperature range. Cold temperatures affect the train airbrake system by freezing moisture in the train line, thickening valve lubricant, and contracting or "shrinking" sealing materials. This can result in increased train line leakage, inconsistent valve operation, or an undesired release of brakes.

When brake cylinder pressure is developed in each car, the air pressure is increased in the pressure side of the brake cylinder causing the brake piston to move and apply the brakes on each car. Any leakage from the pressure side of the brake cylinder to the non-pressure side will reduce the effectiveness or even nullify the brake application. As the brake shoes press against the wheel treads, they grip the wheels and produce a retarding force. When the helper engineer made an automatic airbrake application of the train brakes at Austin to hold the train on the grade, the brake shoes applied with a sufficient retarding force to overcome the effects due to gravity on the train on the 2.2 percent gradient (about 192,500 lbs). For the brakes to be released by the engineer, he must place the brake handle (located on the control stand) in the release position, thus the air pressure on the pressure side of the brake cylinder is reduced and the train brakes release; however, leakage around the rubber packing cup within the brake cylinder or leakage within the airbrake control valve may also cause brake cylinder pressure to reduce, resulting in an unintended release of the brakes. The rubber packing cup provides a seal to prevent leakage between the pressure side and non-pressure side of the brake cylinder, but extreme cold temperatures can cause shrinkage of the rubber packing cup and, the combination of extreme cold temperatures with a worn rubber packing cup could result in the loss of the effectiveness of the seal thus allowing for leakage to the non-pressure side of the brake cylinder resulting in an unintended release of the brakes. Further, the environmental tests performed at -35^o F demonstrated that it is also possible for an airbrake control valve to have internal leakage which can result in an unintended release.

An unintended release of the brakes will result in a reduction of the available retarding force of the train to a point that it becomes less than the retarding force required to hold the train on a grade. This was demonstrated when overheated wheels on 17 non-derailed cars and 17 pairs of overheated wheels from derailed cars were found as the only evidence of a braking application on the train; the remaining cars did not have overheated wheels. The Safety Board concludes that the extreme cold temperatures, possibly combined with worn seals, shrinkage of rubber packing cups in several brake cylinders, and internal leakage in several airbrake control valves resulted in the unintended release of the brakes on a sufficient number of cars of train 121 allowing it to move. The Safety Board is also investigating other accidents that occurred during these same weather conditions on other carriers.⁵⁰

Crew's Activities After the Train was Gone.--The first concern for the unattended train occurred when the road engineer moved the road locomotive into the siding, where the helper locomotive had moved earlier. The road engineer reported that he had a "RAD BRK" (radio break) displayed on the EOT telemetry receiving device during this movement. As a result he began looking for the train and realized it was gone. The event recorder shows that it took about 10.5 minutes from the time train 121 came to a stop (before the automatic brake application was made by the helper engineer) for the road locomotive to uncouple from train 121 and move into the siding. The radio break described by the road engineer was the second radio break that would have been displayed by the EOT telemetry receiver. The road engineer may not have seen or heard the first radio break which would have occurred 5 minutes earlier because he was occupied explaining the movement to the UOE and/or watching for signals from his UOE, who was uncoupling the road locomotive from the train during that period. Since the road engineer had assumed that the receiving device was not working, he may not even have looked at the receiver display until he was moving the road power into the siding.

The event recorder showed that about 7 minutes elapsed before the locomotives were reconnected and the crew began to chase after the train. The BN train graph recorded the movement of the runaway train over the East Austin control point with the first car at 0419 and the last car at 0424; the locomotives from train 121 passed this same control point at 0429 or about 5 minutes after the runaway train. By that time the crew had already gone by the stop signal at East Austin and realized that they were not going to catch the runaway train. They then radioed the MRL dispatcher to warn of the runaway train and continued after the train. The crew of Helper 1, which was

⁵⁰Between February 2 and February 7, the Safety Board was notified of three other accidents (LAX89FR014, February 2; FTW89FR006, February 5; CH189FR012, February 7) that occurred in the same weather conditions and on mountain grades in Montana and Colorado. The preliminary reports show two of the accidents reported the crewmembers' inability to control the speed of the train while descending the grade and the other was a train separation resulting in the runaway of the rear portion of the train down a mountain grade. These accidents are still under investigation.

stopped at the Benton Avenue crossover on main no. 2 track, overheard the message to the dispatcher when their locomotive was struck by the runaway train. The MRL computerized train log shows that the derailment and collision with the standing Helper 1 locomotive occurred about 0430.

The approximate 15-minute delay in reporting the runaway train prevented any opportunity for the MRL dispatcher to provide an advance warning to other railroad personnel in the area or to the City of Helena to alert their key emergency response officials. The delay also prevented any immediate action by the MRL dispatcher to arrange for information about the hazardous materials on train 121 so that it would be available for any response effort.

The Safety Board believes that the crewmembers' pursuit of the runaway train, particularly without receiving authority to do so, was not prudent. Had the runaway train derailed before reaching Helena, the pursuing locomotives could have collided with the derailed equipment resulting in either serious or fatal injuries to the crewmembers in addition to the possible destruction of property from a hazardous materials release.

The reported times from the BN train graph, the MRL computerized train log, and the MRL dispatcher radio communications along with the distances between the recording points were used to determine the average speed of the runaway train. The average speed based on elapsed time and distance as recorded by the BN train graph and MRL computerized train log was about 56 mph. The Safety Board could not accurately determine the actual impact speed of the runaway train with the standing helper locomotive, but believes the damage to be consistent with an impact speed probably at least 15 to 25 mph.

Method of Operation

Testing of the Train Airbrake System.--Train 121 had the required initial terminal road train airbrake test before departing Laurel to determine train line leakage. The MRL Train Activity/Delay Report dated February 1, 1989, showed that the failure of the 64-car train to pass the air test was "due to cold." To pass the required airbrake test, a block of 16 cars was removed from the train as interchanged from the BN. The engineer stated that the train line leakage after a second air test (following the removal of the 16 cars) was 4 psi/min (49 CFR 232.12 requires 5 psi/min or less train line leakage). However, the relief engineer stated that he had taken exception to the train line pressure between Townsend and Helena, and told the Helper 2 engineer and Helena yard office "...the fact that the air flow indicator was at 14...." (A high flow of air into the train line indicates that air is being lost from the train line.) Because the MRL, unlike the BN, does not have an FRA waiver to use the air flow indicator for required airbrake testing, it does not train its crews for its use. Although the helper engineer was made aware of the train line pressure concerns of the relief crew engineer, he did not take any action nor were there any instructions that required him to do so.

In accordance with MRL operating practices for mountain grade territory, the Helper 2 engineer increased the feed valve setting increasing train line

pressure from 80 psi to 90 psi prior to departing Helena. This had the effect of increasing the air flow and thus the leakage rate. However, leakage tests were not required and none were performed. At intermediate terminals such as Helena, when the train consist is not changed, Federal regulations⁵¹ only require that the train line be charged to within 15 psi of the feed valve setting on the locomotive. After making a 20-psi automatic brake reduction and release, it must be determined that the brakes on the rear car apply and release. Crews of trains with an EOT telemetry device must make the same 20-psi automatic brake reduction and release, but they only need to determine that the train line pressure reduces and then is being restored; they do not need to check the rear car to determine that its brakes have applied and released. Neither the Federal regulations nor the MRL operating practices require additional airbrake testing or provide specific procedures such as more stringent leakage requirements, increased frequency of airbrake testing, or diagnostic devices for airflow, when extreme cold weather conditions exist, even in mountain grade territory or when the feed valve setting has been increased. The Safety Board believes that had there been requirements to perform leakage tests in extreme cold weather, the outbound crew would have done so while train 121 was at Helena and the high air flow reported by the inbound engineer might have been verified providing an opportunity for a decision to either correct the cause of the high air flow or not operate train 121.

Rules Interpretation.--Because train 121 was operating between Helena Jct. and Phosphate en route to Missoula over BN trackage, the BN rules applied. Although both BN and MRL use the same operating and airbrake rules, during testimony it was clear that BN and MRL operating officers differed in their interpretation of these rules as they applied to an unattended train and the need for hand brakes by MRL crewmembers at Austin. The Safety Board recognizes that it is an accepted practice in the railroad industry for each railroad to interpret the rules on their property; however, when the interpretations are not the same, management must take steps to make certain that train crews operate in accordance with the interpretation of the rules as they apply for that property -- in this case the BN's interpretation.

Rule 100 in the General Code of Operating Rules states in part:

Leaving Portion of Train: When an engine leaves part of its train on the main track, a sufficient number of hand brakes must be set to keep the detached portion from moving. Torpedoes must be placed one fourth mile in advance of the detached portion to serve as a warning to returning crewmembers. Unless return movement is otherwise authorized, crew member must remain to provide protection against movements which may enter main track between detached portion and returning front portion.

MRL contended that this rule did not apply as the wording in the second and third sentences implied application only in cases where the locomotives were

⁵¹Road Train and Intermediate Terminal Train Air Brake Tests, 49 CFR 232.13.

detached and the train was left standing behind for a considerable distance; however, no definition of a "considerable distance" was offered by MRL.

Rule 103(L) of the General Code of Operating Rules concerning securing cars or engines states in part "...the air brakes must not be depended upon to hold a train, engine or cars in place when left unattended..." According to the BN interpretation of "unattended," the cars of train 121 were unattended when the power was detached at West Austin. The MRL interpreted the rule differently; MRL contended that the train was not left unattended because the crew remained in the general vicinity. MRL did state that had a crewmember been in attendance, timely notification of the runaway would have been probable, although MRL did not state, however, what action the crewmember could have taken to prevent the runaway train.

According to the BN's interpretation, rules 100 and 103(L) had not been complied with because the train had been left unattended, on a grade, and without sufficient hand brakes applied when the locomotives were detached at West Austin.

Rules 470 of the BN Air Brake, Mechanical, and Train Handling Rules also addresses the application of hand brakes and leaving airbrakes applied in emergency on the portion of the train left standing. Rule 470 is more specific than rules 100 and 103(L) of the General Code in that it provides for the number of hand brakes to be set on a standing train for specific grades. In the case of the 2.2 percent grade at Austin, rule 470 required that the hand brakes be applied on 27 cars of train 121 when it was left standing on the main track. Although employees may consider it unreasonable to set hand brakes on a standing train when the temperature is -27° F with a wind chill of -70° F, had the hand brakes been applied as required the accident would have been prevented.

An FRA regulation (49 CFR 232.13(f)) provides the basis for some of the pertinent operating rules used by both BN and MRL for the use of airbrakes and hand brakes on trains left standing on a grade. This regulation does not make an exception for a locomotive being attached or detached from the cars or train. As such, the MRL's interpretation of "unattended" and the requirement for applying hand brakes, as specified by rules 100 and 103 (L) of the General Code of Operating Rules and rule 470 of the BN Air Brake, Mechanical, and Train Handling Rules, is incorrect and may have resulted in train 121's crewmembers believing that they were complying with the rules. The Safety Board believes that the MRL should revise its interpretation and provide training on the rules requiring the use of hand brakes and assure that all operating employees know the proper interpretation and application of the rules.

Engineers' Responsibilities.--The MRL's operating agreement provides for an engineer, assistant engineer, and utility operating employee (UOE) to be responsible for the duties traditionally associated with an engineer, brakeman, and conductor. Generally, in the traditional arrangement, the conductor is responsible for the general direction and government of the train. The MRL's operating agreement, however, does not delineate specific responsibilities to crewmembers.

The nonspecific assignment of responsibilities was compounded when Helper 2 was positioned on the head end of train 121. Both engineers believed they were in charge of the train and had the final authority in decisionmaking. The road engineer was displeased when the helper engineer rejected his offer to continue to operate the train from the lead helper unit. He stated he felt control being taken away. The Safety Board believes that he may have deferred to the helper engineer because of the helper engineer's assertive personality, his aggressive demeanor regarding the issue of cab heat, and his previous experience in an MRL management position. In doing so, the road engineer abrogated his own responsibility to participate actively in any decisionmaking. The road engineer did not agree with the helper engineer's decision to rearrange the locomotive consist, but he failed to articulate any misgivings. A more determined effort may have persuaded the helper engineer to alter the way the locomotive consist was to be rearranged, perhaps even avoiding the accident. Likewise, the helper engineer, once having taken authority, failed to follow sound judgement by not discussing the feasibility of the move with the road engineer. Furthermore, if there was a concern about who was in charge of the train, the MRL superintendent had stated a supervisor could have been called to resolve the concern.

The Safety Board believes that had a discussion taken place prior to rearranging the locomotive the accident may have been avoided. The helper engineer could have made known the information he received from the relief engineer regarding the concern for train line pressure, and the crew could have discussed other available options such as rotating engineers in the unheated cab to continue on to Elliston, or moving only one of the road units to the head end of the train. The crew could have also discussed the consequences of leaving the train standing on a 2.2 percent mountain grade in extreme cold weather conditions and the effect of exposure to the weather conditions on the crewmembers having to set hand brakes.

No written policy exists to define which engineer has the decisionmaking responsibility when helper units are positioned on the head end of a train. The MRL superintendent indicated that the road engineer was in charge; however, he believed that in practice decisions are made by mutual agreement. The superintendent believed that if a confrontation developed and it became necessary to determine who was in charge, the engineers would contact a supervisor for an interpretation; however, the engineers of train 121 did not contact a supervisor. The conduct of the crewmembers on train 121 on February 2, 1989, demonstrated that with multiple engineers it can be unclear where the authority and responsibility lies. The Safety Board believes that to improve crew coordination and to provide for resolution of conflict, MRL needs to develop and implement instructions clearly designating crewmembers' responsibilities and defining the role of engineers when helper locomotives are positioned on the head end of a train.

End-of-Train-Device.--While paramount in this accident was the failure of the train crew to properly secure their train when it was left unattended on a mountain grade, the Safety Board was concerned with the operation of the

EOT telemetry device, the placement of the EOT telemetry receiver, and the inability of the EOT device to allow the engineer to initiate an emergency application of the train brakes.

Testing of the receiver did not indicate any anomalies. The condition of the battery in the EOT transmitter could not be determined because the transmitter was destroyed in the accident and neither the battery nor the transmitter could be tested; however, train crewmember statements verified its operation. The relief crew engineer stated that the EOT receiver indicated only minor train line pressure fluctuations during his trip to Helena; the road crew that began in Helena had used the EOT device to successfully perform the airbrake test requirement (set and release of train brakes) and also to determine when train 121 had cleared the crossover at Benton Avenue as it departed Helena. When the train was stopped at Austin and the automatic brake application made, the EOT display did not change to show that the train line pressure had reduced at the rear of the train. The road engineer suspected that the EOT telemetry device was not operating, but he did not consider that the EOT device may have experienced a radio break or loss of signal. Since the EOT device sends a signal from the transmitter at the rear of the train to the receiver in the locomotive, any obstruction such as changes in terrain or structures, could momentarily block the signal and the display for a radio break ("RAD BRK") would not occur at the EOT telemetry receiver until after 5 minutes had elapsed or the signal was no longer obstructed. The terrain approaching Austin, where train 121 stopped, is mountainous with narrow valleys and rock outcroppings. In addition the track has numerous curves. The Safety Board believes that train 121 probably came to a stop in a location where the signal from the EOT transmitter was obstructed.

MRL does not equip its helper locomotives with receivers for EOT devices; therefore, the Helper 2 engineer, although at the head end of train 121 and in control of the train, had to rely on receiving EOT telemetry information by radio from the road engineer. This arrangement is not practical as it requires the road engineer to constantly monitor the EOT telemetry receiver and to radio the helper engineer of any changes displayed. However, once the road engineer had radioed the helper engineer that their train had cleared the Benton Avenue crossover, he provided no further information from the EOT telemetry display to the helper engineer. The road engineer did not inform the helper engineer that the EOT display had not changed when the automatic airbrake application was made at Austin. Had this information been radioed to the helper engineer, he might have suspected that there had either been a radio break or that there was a train line blockage and that all of the brakes may not have applied. Knowing this, the helper engineer could have decided that it was a dangerous risk to disconnect the locomotives from the train and rearrange the locomotive consist. The Safety Board believes that MRL should equip all helper locomotives operating at the head end of a train with an EOT telemetry receiver.

The EOT telemetry device on train 121 did not have the capability to transmit a signal to confirm the status of operation of the rear unit or to initiate an emergency application of the train brakes from the rear of the train. When the road engineer saw that the automatic airbrake application

made by the helper engineer was not reflected by a reduction in train line pressure from the 75 psi originally shown on the EOT receiver, he assumed that the device had either "quit transmitting" or "froze up." The road engineer did not consider whether or not the train brakes had applied or if the EOT transmission signal was being obstructed. When the road locomotive UOE uncoupled the train from the road locomotive, the EOT receiver still displayed 75 psi and again the road engineer did not question whether or not the expected emergency brake application had occurred. In both instances, the road engineer had no way to verify the status of EOT telemetry. A two-way EOT telemetry device would have allowed the road engineer to verify the status of the EOT transmitter. Furthermore, in the first instance, when the train line pressure did not change after the automatic airbrake application by the helper engineer, the road engineer could have initiated an emergency application of the train brakes from the rear of the train with a two-way EOT telemetry device before proceeding to uncouple from the train. In the second instance, when the UOE uncoupled the train from the road locomotive without initiating an emergency application of the train brakes and the train line pressure still did not show the reduction in train line pressure, the road engineer could have attempted to initiate an emergency application of the train brakes from the rear of the train with a two-way EOT telemetry device. The two-way EOT telemetry device would have continued to transmit a signal until acknowledged by a drop in train line pressure and would have afforded at least two opportunities for the road engineer to attempt to initiate an emergency application of the train brakes although it probably may not have stopped the train once it began moving down the mountain.

The Safety Board found in its investigation of a derailment of a Union Pacific freight train in Granite, Wyoming,⁵² on July 31, 1979, that the train line was blocked by a closed angle cock behind the sixth car and the engineer could not slow the train because he could not apply the brakes behind the sixth car. Although the train had a caboose and the capability to initiate an emergency application of the train brakes, this was not done. The Safety Board determined in that accident that,

Had the crewmembers in the caboose put the train brakes in emergency when the train speed became excessive, the train would have stopped and the derailment would have been avoided.

The Safety Board believes that the Federal Railroad Administration should amend 49 CFR 232.19 to require the use of two-way EOT telemetry devices on all cabooseless trains for the safety of railroad operations.

Adequacy of Locomotive Cab Heaters and Employee Preparedness for Cold Weather Operations.--The weather conditions that existed in the 48-hour period prior to the accident were extreme. On January 31, 1989, a severe cold front passed through Helena resulting in a 72° F temperature drop, from a high of 45° F early that morning to -27° F on February 2, about 0430, the time of the accident. Similar temperature drops were experienced in

⁵²Railroad Accident Report--"Derailment of Union Pacific Railroad Freight Train, Granite, Wyoming, July 31, 1979" (NTSB-RAR-79-12)

Missoula, the home terminal of the road crew of train 121, and in Laurel, the interchange point where MRL received train 121 from the BN. The temperatures were unusually cold for the area as the normal temperatures for that time of the year are usually 35 to 40 degrees higher.

The MRL operates locomotives with either electric or warm water heaters. Both were considered by mechanical personnel to be adequate for heating locomotive cab compartments in cold weather if they operate optimally. MRL mechanical personnel have tried to minimize the inoperative or insufficient heater capacity problems by arranging the locomotive consist such that there are at least two units with operable heaters, the leading and last unit. MRL has also started a program to replace the warm water heaters with electric heaters much like the replacement performed on the lead unit of Helper 2, MRL 208, and to install auxiliary electric side wall heaters.

During MRL's first two winters of operation, the Helena mechanical supervisor received increasing complaints about cab heaters and he had some difficulty providing adequate functional cab heaters in all helper locomotives. This was primarily a result of malfunctions occurring in older locomotives and insufficient heater capacity. Also, a colder winter may have contributed to the increase in complaints.

Air leakage into the cab compartment of a moving locomotive counteracts the output of each heater. Crewmembers will attempt to stop the leakage with towels or rags. Often when train crews complain about malfunctioning cab heaters, maintenance personnel will check the cab heaters while the locomotive is stationary and determine that the cab heater is functional. Investigators determined that the second and third units of Helper 2 may have fit that category. Nevertheless, the cab heater in the lead unit of Helper 2 did fail to operate as a result of an electrical malfunction.

An electrical overload caused by the operation of the cab heaters in MRL 208 resulted in the shutdown of the power for the lead helper unit. This occurred because the 10 KW auxiliary generator supplied power to the electric heaters from the load side of the generator fuse. The electrical requirements for the two electric heaters, 45 amp with a 50-amp circuit breaker, should have been adequate, but a negative low voltage ground caused the circuit to "open" resulting in the control circuit breaker, fuel pump circuit breaker, and the 15-amp turbo lube pump circuit breaker to "open" causing the unit's motive power to shutdown. The electrical requirements of two 3,000 watt main electric heaters combined with the electrical requirements for normal support circuits, lights, excitation, electrical control, and electric side wall heaters place the 10 KW auxiliary generator at its supply limit.

The extreme cold weather required the helper crew to operate the cab heaters at their maximum rating to maintain comfort in the operating cab. Because of the inadequacy of the heaters, and the resultant electrical problem, the lead helper unit's motive power shut down and the helper engineer, who had been complaining about inadequate cab heater operations, made the decision to rearrange the locomotive units. Had these events not occurred, there would not have been an accident.

The Safety Board believes that the replacement of warm water heaters with electric heaters and the installation of side wall heaters in locomotive units with only 10 KW auxiliary generators should be given extra consideration to make certain that the auxiliary generator has the capacity to meet the electrical requirements. Furthermore, MRL should expedite its program to upgrade existing cab heaters and seal the cab compartment to reduce air leakage.

The extreme cold weather conditions had the greatest effect on the road crew of train 121. The crewmembers had left Missoula, their home terminal, on January 31, 1989, before the temperatures dropped significantly due to the severe cold weather front. When they left Missoula, the temperature was about 25^oF and the crewmembers had dressed in accordance with the temperatures at the time. When the crewmembers departed Helena on February 2, the temperature was -27^o F with a wind chill of -70^o F. Such extreme conditions can place humans in danger from the possibility of freezing exposed flesh and thus have an effect on the decisions they make in performing their duties. The MRL does not provide its employees with winter apparel even when conditions become extreme as they were in this accident. Some railroads have addressed the cold weather operating conditions by offering to participate with special programs that make suitable winter apparel available at the employees option.

Because of his duties, the UOE is exposed to the elements for various amounts of time depending on the nature of the work involved. If unexpected problems occur, such as occurred at Austin, the exposure time could be quite long. The road UOE was inadequately dressed to perform his duties. He later admitted that his feet were cold because he wore uninsulated cowboy boots. However, he made no effort in the 26 hours he was off duty between the inbound and outbound trip to improve his situation. For the trip from Helena to Missoula, he anticipated that he would not have to leave the heated cab compartment of the locomotive. The road assistant engineer was also inadequately dressed. Although he was aware of the weather forecast when he left Missoula, he still did not provide for adequate clothing if operational situations dictated he leave the locomotive cab as he did at Austin. He had access to additional clothing when he visited his parents in Helena, but took only a cap and socks. He made an additional concession, when prior to reporting to work that morning, he took a towel from the motel to use as a neck scarf. Still later, he expressed concern about frostbite if any crewmember spent too much time outside. The road engineer was adequately dressed for the cold weather operations, especially considering the nature of his duties which would primarily keep him in a heated cab compartment.

The Helper 2 crew was well prepared for the weather conditions. They both lived in Helena and experienced the weather change before leaving home. Consequently each wore insulated items and had multiple layers of clothing.

There are few general guidelines in the MRL safety rule book that address proper clothing and none deal with appropriate cold weather attire. The Safety Board believes that MRL should provide information to all

employees on the potential dangers of cold weather and on the proper selection of appropriate clothing.

Management Oversight

Efficiency Testing.--Both BN and MRL operating officers conducted efficiency tests of MRL train crews operating between Helen Jct. and Phosphate. MRL records showed that no efficiency tests were performed on either the engineer or the UOE of Helper 2 during the 6-month testing period prior to the accident; however, the engineer had been a trainmaster during the first 3 months of the testing period and was not subject to efficiency testing. The engineer, assistant engineer, and UOE of the road power had each been individually tested on at least three occasions during this period, but only the engineer had been tested on the airbrake rules from the group "B" category for rules 219 through 224. Further, the road power UOE was working as an engineer when the efficiency tests were made on him, but he had not been tested on any airbrake rules.

Since the beginning of MRL's operation in 1987, BN operating officers conducted only 13 efficiency tests of MRL train crews operating between Helena Jct. and Phosphate over BN trackage, or less than one test per month. Such infrequent testing cannot result in any meaningful evaluation of rules compliance by operating personnel. The Safety Board believes that the BN and MRL need to establish and implement procedures to improve their testing for rules compliance when MRL train crews are operating over BN trackage.

Training and Qualifications.--Neither of the engineers of train 121 initially received any training from MRL for train operations when they entered train service, except for an engineer instructional up-date class in 1988. However, the employment criteria when MRL operations began in 1987 included previous experience on a Class 1 railroad; statements by MRL officers indicated that MRL assumed all engineers had already acquired the necessary operating skills and knowledge. The employment criteria also accepted prior qualification on the General Code of Operating Rules from a former railroad. It was not until March of 1988 that the MRL began testing its operating employees on the General Code of Operating Rules; however, employees, such as the road locomotive UOE who began service after that date, were not tested.

The MRL accepted the UOE's resume for his qualifications on the General Code of Operating Rules in 1987 and for an engineer while with the Washington Central Railroad and for his experience as an engineer on the Alaska Railroad and Milwaukee Railroad. The MRL did so without verifying his qualifications. There was no record that the UOE received any training from the MRL. The Safety Board is concerned that the MRL hiring criteria was an expedient measure for the start-up of operations and appears to have been used to substitute for a comprehensive operating employee training program.

The Safety Board has similar concerns with the MRL adoption of the BN Air Brake, Mechanical, and Train Handling Rule Book. There is no evidence to suggest that the rules are inappropriate for the present MRL operation, given that BN had operated the same trackage at an earlier time. Because of the

adoption of these rules and the hiring of former BN employees as well as employees formerly with other class I carriers, MRL apparently must have concluded that orientation on these rules was unnecessary. However, MRL employees who had previously worked for BN may not have had consistent interpretations of the BN rules. Likewise, employees that worked for other Class I railroads may or may not have used the General Code of Operating Rules and would only be familiar with the rules interpretation of their former employer. Rules interpretation and their application may differ from railroad to railroad or even division to division on the same railroad, and only training, operating experience, or both can produce uniformity. The Safety Board believes that the MRL must ensure through requalification and training programs that rules interpretations are disseminated and internalized systemwide so that employees have a clear understanding of the application of rules and procedures.

Federal Activity

Start-up of Operations.--The discussions, meetings, and added oversight inspections provided by the FRA's Billings, Montana, district personnel were necessary to provide essential information and guidance to MRL personnel during the initial start-up of operations to assure compliance with the federal regulations. The Safety Board recognizes the extra effort made by the FRA in this respect and encourages the FRA to provide such extra attention to all regional and short line railroads during the start-up of their operations. However, the circumstances of this accident indicate that the FRA must also direct additional attention to the operating practices of the regional and short line railroads. The Safety Board found in its investigation of an accident on the Iowa Interstate Railroad (IAIS) in Altoona, Iowa, on July 30, 1988,⁵³ that the FRA failed to oversee adequately the railroad operations on the IAIS and failed to take enforcement action for noncompliance with federal regulations.

USDOT Emergency Response Guidebook.--The preparation, review, accuracy, and issuance of the DOT Emergency Response Guidebook (ERG) is the responsibility of the Research and Special Programs Administration (RSPA). The ERG is important to emergency responders during the initial on-scene decisionmaking process because it provides guidance for emergency action such as evacuation limits and potential hazards such as health hazards, fire, and explosion capabilities of a released hazardous material. The ERG is used by police and fire departments throughout the country, including the Helena police and fire departments. These agencies depend on the ERG to be complete and accurate for the hazardous materials listed.

However, RSPA has taken the position that corrections or errata sheets between printings are not issued because they cannot identify all the users of the ERG. RSPA acknowledged an oversight error of not including an evacuation distance for hydrogen peroxide in the 1987 publication of the ERG.

⁵³Railroad Accident Report--"Head-On Collision Between Iowa Interstate Railroad Extra 470 West and Extra 406 East with Release of Hazardous Materials Near Altoona, Iowa, July 30, 1988" (NTSB/RAR-89/04).

Although RSPA is now taking action to develop an evacuation distance in the scheduled publication of the next edition of the USDOT ERG in 1990 and will also include a review of all commodities to correct any other oversights from prior publications of the ERG, the Safety Board believes that it is necessary for RSPA to change its position and develop procedures to update and correct errors in the ERG between printings in a prompt manner to assist the response efforts of emergency personnel in managing hazardous materials accidents.

Explosion Mechanism

While the Safety Board considered several possible reactions that could have initiated the explosions and subsequent damage, the Board believes that the most likely sequence of events follows:

Hydrogen peroxide from the GATX 14247 combined with contaminants on the ground following the derailment and puncture of the tank. A chemical reaction resulted in a fire; the fire heated the polyethylene pellets causing the release of volatile organic vapors, which exploded with sufficient energy to initiate a second explosion.

The series of events began with the release of hydrogen peroxide from GATX 14247 due to collision damage. It was most likely that this was the tank car that was observed by the crewmembers of Helper 1 in an upright position and at an angle to the tracks, with one end on the covered hopper, ACFX 57358, which contained polyethylene pellets. Punctures in one or more locations in GATX 14247 would have allowed the hydrogen peroxide to spill onto the track structure and possibly into one of the compartments of ACFX 57358. Once the hydrogen peroxide was on the ground, it could mix and react with contaminants, the most likely being the railroad crossties, which are treated with a creosote-coal tar solution. (The 1986 incident in Missoula demonstrated that a 70-percent solution of hydrogen peroxide can ignite crossties even in extremely cold weather.) The crossties would have then been ignited, with the flames impinging upon the covered hopper with sufficient heat to melt the polyethylene pellets causing the release of volatile organic vapors. The heat from the fire, oxygen from decomposing hydrogen peroxide, and the organic vapors from the now molten polyethylene pellets could accumulate in a compartment and with the proper proportion to initiate a vapor phase explosion. The energy from this explosion would be sufficient to initiate the second explosion; a condensed phase explosion of a mixture of hydrogen peroxide with molten polyethylene pellets within ACFX 57357. This force would be powerful enough to lift GATX 14247 and cause it to disintegrate with a large dispersion of fragments.

The Safety Board also considered the possibility that the 70-percent solution of hydrogen peroxide may have become unstable and generated a runaway decomposition reaction in GATX 14247, following the derailment. The tank then overpressurized and exploded. However, the natural tendency of hydrogen peroxide to decompose cannot account for the catastrophic explosions

that occurred. Experts from Interlox and four other hydrogen peroxide producers agreed that a 70-percent solution is not normally shock or temperature sensitive, and therefore would not become unstable, unless contaminated.

The Board next considered that contamination of hydrogen peroxide in GATX 14247 occurred before loading and shipment, leading to a runaway decomposition reaction in the tank and overpressure. This is not likely because the quality control tests conducted on the remaining car of hydrogen peroxide showed that it was still within Interlox's specifications. Since both cars were loaded from the same storage tank, the hydrogen peroxide was stable and uncontaminated prior to the accident.

The Board also considered that contaminants were introduced into GATX 14247 following the derailment, and puncture of the tank. A runaway decomposition reaction was initiated within the tank, leading to overpressure and catastrophic failure. The contamination of the hydrogen peroxide in GATX 14247 likely did occur when it was punctured in the collision. However, the large volume of liquid hydrogen peroxide relative to the amount of any contaminant introduced through a puncture of the tank would dissipate any heat generated, leading to only localized decomposition, rather than a runaway decomposition reaction. The time required to generate the amount of heat needed to produce an accelerated decomposition rate under this condition far exceeds the 18 minutes that was stated to have passed between the derailment and the first explosion.

Finally, the Board considered the possibility that the mixing of hydrogen peroxide following the derailment with isopropyl alcohol released from the puncture of UTLX 820 resulted in a chemical reaction and explosion. One of the potential contaminants was the isopropyl alcohol released when UTLX 820 was punctured. However, UTLX 820 was derailed west of GATX 14247 and the isopropyl alcohol released pooled beneath the car and drained west, away from GATX 14247; therefore, the isopropyl alcohol did not react with the hydrogen peroxide to initiate the explosion. However, the isopropyl alcohol was probably the liquid flowing in the trackside ditch observed by the railroad employees at the Benton Avenue grade crossing. The hydrogen peroxide released from GATX 73782 also drained to the west and probably mixed with the isopropyl alcohol from UTLX 820 to produce the blue flames coming through the ice as observed by Interlox and MRL personnel during the salvage operation on February 3, 1989.

Transportation of Hazardous Materials

Tank Car Performance and Protection.--Although tank car GATX 14247 was probably punctured during the derailment and collision, the total disintegration from the explosion precluded any determination of the number and locations of the punctures. Since the speed at which the runaway cars struck Helper 1 is also not certain, the ability of GATX 14247 to have survived the collision cannot be determined. During its investigation of the accident in the Denver and Rio Grande Western Railroad Company yard in Denver, Colorado, the Safety Board determined that an aluminum tank car was punctured in the tank head by a second car at an impact speed of 10 to

12 mph.⁵⁴ The tank car in the Denver accident was also a DOT specification 111 aluminum tank car that was not equipped with head shield protection.

Aluminum is used for the construction of tank cars in hydrogen peroxide service because it is compatible with the product. The potential reactivity of hydrogen peroxide with ordinary combustibles and organic materials is such that prevention of contamination is critical. Consequently, a rail tank that is used to transport hydrogen peroxide or other high-risk products, such as high strength acids, must provide a sufficient level of protection to prevent the release of product. Unnecessary safety risks are taken when hydrogen peroxide and other high-risk products are transported in tank cars that do not have puncture resistant protection such as head shields.

In the Denver accident, fuming nitric acid spilled from the aluminum tank car resulting in the evacuation of 9,000 people. The Safety Board concluded that head shields on the tank car may have prevented the accident, and recommended that RSPA:

R-85-61

In consultation with the Federal Railroad Administration and the Association of American Railroads conduct a full testing and evaluation program to develop a head shield to protect DOT specification aluminum tank car ends from puncture and mandate installation of the head shield at an early date.

Corresponding recommendations, R-85-63 and R-85-64, calling for joint cooperation in the testing and evaluation program, were also issued to the AAR and the FRA. The FRA has indicated that small scale testing was completed in January 1988 and that full scale testing was to be completed in September of 1989. The status of the RSPA, AAR, and FRA recommendations is "Open--Acceptable Action."

The catastrophic events of this accident underscore the need to provide puncture resistant protection for aluminum tank cars that transport high-risk hazardous materials. RSPA, AAR, and the FRA are urged to expedite the testing and evaluation program, and implementation of needed tank car head puncture protection.

The entire lading of tank car UTLX 820 containing isopropyl alcohol was released due to the puncture in the B-end of the tank car. The tank heads were not protected with head shields nor were they required. If the tank car had not been a dual compartment tank car, the total tank capacity of 20,000 gallons would have been released. The puncture likely occurred when the tank car collided with the hopper car ELTX 1425 in the derailment. Since the hand brake wheel had been pushed into the tank head, the B-end received the full impact of the collision force. The Safety Board concludes that the tank head probably would not have been punctured if the tank car had been equipped with head shield protection.

⁵⁴See Rail Accident Report (NTSB/RAR-85/10)

DOT Tank Car Protection Standards.--Since the existing tank car standards for hydrogen peroxide and flammable liquids such as isopropyl alcohol and acetone predate the existence of RSPA and DOT, they were developed under the authority of the ICC. As noted in the Safety Board's 1981 report on DOT's hazardous materials regulatory program,⁵⁵ the ICC relied upon and accepted industry-developed standards without analysis or established criteria. Consequently, the existing tank car standards for hydrogen peroxide, isopropyl alcohol, acetone, and most other hazardous materials were based upon industry-developed standards. While the performance history of tank cars transporting these products has generally been good, RSPA has not indicated that there has been any reassessment of these pre-DOT tank car standards. Since more and different hazardous materials are being shipped through more densely populated areas than in the past, a greater danger to the public exists. Thus safety factors considered, if any, when the industry standards were initially developed may no longer be appropriate.

The regulatory changes made by RSPA in the last 15 years have been in response to tank car accidents. These changes include vertical restraint couplers for all tank cars transporting hazardous materials and tank head protection for specification 105, 111, 112, and 114 tank cars transporting flammable gases, anhydrous ammonia, and ethylene oxide. The use of tank car performance history and accident analysis is a valid method, in part, for evaluating the adequacy of protection afforded tank cars with respect to the hazards of the product. However, RSPA's almost total reliance upon this method to modify tank car standards has placed RSPA in the position of continually reacting to individual safety problems rather than identifying in advance potential problems through safety analyses and developing solutions prior to an accident.

Determination of the degree of protection for tank cars transporting hazardous materials is most effectively accomplished through a safety analysis that determines: (1) the acceptable level of risks; (2) the level of risk from a release; and (3) the protection requirements needed to reduce identified risks to an acceptable level.

In a letter dated October 15, 1980, to the Materials Transportation Bureau (MTB) of RSPA concerning proposed specification 105 tank car standards, the Safety Board stated:

The amended request should call for information about the danger areas resulting from releases of various types of products in DOT 105 tank cars, the time in which danger areas evolve, the radius of exposure to people and property to the danger, and the ultimate harmful effects to those exposed persons and properties. With this information, and numerous models of dispersion patterns that are available...a 'probable harm' rank ordering of the different types of shipments in 105 tank cars could be devised.

⁵⁵Safety Report (NTSB-SR-81-2).

When this type of ranking is developed, and available, a second step is needed. That step is to review these rankings and make a finding by the Secretary that the transportation of certain hazardous materials may pose unreasonable risk to health and safety or property....

Once the decision is reached that risks are unacceptably high action must be taken to reduce such risks to an acceptable level.⁵⁶

In its 1981 safety report, the Safety Board further noted that as a result of its evaluation of DOT's efforts to assess the threat posed to the public safety from derailments of trains carrying hazardous materials:

DOT 112A/114A tank cars were designed by the tank car and railroad industries to maximize economies, and no specific safety methodology to determine unreasonable risk to the public was employed.

No adequate safety methodology has been developed by Federal regulatory agencies in order to determine risk for the transportation of hazardous materials by rail as a basis for regulation.⁵⁷

Consequently, in December 1981, the Safety Board recommended that the Secretary, Department of Transportation:

I-81-12

Require the development of safety analysis guidelines and standards appropriate for identifying unreasonable transportation safety risks and require their use by all DOT Administrations when analyzing potential safety problems and evaluating the effectiveness of hazardous materials regulations.

In March of 1982, the DOT responded that due to the complexity of the DOT's hazardous materials safety programs and the realignment of staff and resources, this recommendation and five other related recommendations were still under review. In January 1983, the DOT advised the Safety Board that DOT would respond to the recommendation after further consideration with no date specified. DOT notified the Safety Board in June 1987, that RSPA had been directed to respond to the recommendation. In December 1987, RSPA responded by agreeing with the need for safety analyses, but only mentioned studies, selected rulemakings, and international standards work conducted in past years. In a March 1988 letter to DOT, the Safety Board stated it had not seen any changes to indicate that DOT was using safety analyses to

⁵⁶NTSB letter dated October 15, 1980, to Materials Transportation Bureau, DOT, Comments on ANRPM "Shippers; Specifications for Tank Cars," Docket No. HM-175, Vol 45 Federal Register p. 48668, July 21, 1980

⁵⁷Safety Report NTSB-SR-81-2, p. 12.

identify hazards and evaluate the effectiveness of applied safeguards. Since DOT had failed to act upon and implement this recommendation, it was classified as "Closed--Unacceptable Action."

Although RSPA has a scheme for determining the hazard class to be assigned to a commodity with dual or multiple hazards, the scheme does not rank the various commodities on a basis of relative "probable harm" to those exposed to it. While these items may be a beginning, they do not constitute the safety analysis approach envisioned by the Safety Board. Implementation of such a safety analysis process would allow RSPA to identify potential safety problems in a more effective manner. Tank car performance history and accident analyses can then be used to continually evaluate the adequacy of the safety analysis decisions made.

Despite the assurances of the Secretary in 1983 that DOT would continue its review of the safety rules governing tank cars used for hazardous materials, the lack of any active or projected regulatory efforts does not suggest that the DOT is making such a review. Although the impact testing of aluminum tank cars is not yet completed, this program was initiated as a result of a previous Safety Board recommendation rather than a DOT-initiated review. DOT is again urged to initiate its review of its safety standards for the transportation of hazardous materials in rail tank cars by employing the safety analysis methods long advocated by the Safety Board. The DOT should first be able to identify which of the currently authorized product/tank car combinations fail to provide adequate protection of the public, and then be able to modify existing regulations to achieve an acceptable level of safety for each authorized product/tank car combination. Since DOT is presently conducting a review to develop national transportation policies and goals, the development and implementation of safety analysis methods to evaluate the transportation of hazardous materials in rail tank cars should be incorporated into this effort.

Hazardous Materials Documentation.--Under Federal regulations a carrier is not to accept a non-complying shipment (for example a shipment not packaged or labeled in accordance with the regulations) of hazardous material for transportation and is required to check the shipping papers and placards at interchange for accuracy. Because train crews are responsible for the placement and location of hazardous material cars within the train, they must check the product identification number on the DOT placard against that on the waybill to carry out their duties. If this had been done at Laurel, it would have been noted that the waybill for UTLX 820 was not consistent with the placards on the tank car and this conflict could have been corrected.

Because these cars were not of immediate concern, the lack of a waybill for ACDX 816007 and the inaccurate data on the waybill for ATSF 621566 did not become an issue in the emergency. Emergency response actions taken because of the isopropyl alcohol in UTLX 820 were also appropriate for the acetone since both are flammable liquids. Therefore, the fact that the waybill for UTLX 820 did not indicate the tank car contained acetone was not sufficient to lead the fire department to take inappropriate response measures, but may have lead firefighters to falsely believe that the tank car released its entire lading. Since the waybills are also used to generate the

consist, any errors in the waybills will be carried over to the consist as was the case in this accident. The accuracy of the consist was further compromised by the failure to list the first car behind the locomotive.

The missing and inaccurate waybills and consist did not directly affect the ability of the fire department to identify those cars and commodities involved in the derailment and fire. However, inaccurate or the lack of sufficient information can be of critical importance, particularly if the faulty information relates to cars directly involved in the accident.

The MRL superintendent stated that as far as he was aware inaccurate waybills received from other carriers are an infrequent occurrence. However, he also stated that the inaccurate waybills for UTLX 820 and ATSF 621566 were discovered only because of the accident. It is apparent that there is no system by which such errors would be detected without an accident. This suggests that MRL has no means to determine the magnitude of the problem. The accuracy of a waybill depends on the accuracy and completeness of the information provided by a shipper and the attention of the originating carrier to properly enter this information on the waybill. Although the MRL officials stated that they had discussed inaccurate waybill information for hazardous materials cars with the AAR and the BN, the problem still persists. Without making a systematic periodic effort to verify the accuracy of waybills received from other carriers or shippers, there is little opportunity to know how prevalent the problem may be. Had this accident not occurred, the MRL would have never known about the inaccurate waybills. Inaccurate waybills or the lack of sufficient information can be of critical importance, particularly if the information relates to cars directly involved in an accident. The Safety Board believes that BN and MRL need to develop and implement procedures to verify the accuracy and completeness of hazardous material shipping documentation for cars received at interchange from other carriers or shippers.

Emergency Response

Initial Shipper Notification and Response.--Several technical experts from Exxon and Interlox arrived on scene during the afternoon of the day of the accident to provide expertise to the emergency response personnel and railroad officials in handling the hazardous materials. The Montana DES had made the initial contact with CHEMTREC and request for information concerning products on the train. Subsequent requests for information were made from CHEMTREC later by officials from MRL. However, the Helena Fire Department, the lead emergency response agency in this accident, made no calls to CHEMTREC for information or assistance. Although the City reported to the Safety Board that the HPD dispatcher had been given instructions to contact CHEMTREC, the city offered no reason for the dispatcher not contacting CHEMTREC. The Safety Board believes that the Helena Fire Department did not use all the resources available in seeking shipper and product information, particularly the capability of CHEMTREC soon after the explosion to establish a direct communications link between the fire department and the shippers.

City of Helena Response.--The initial notice from MRL was made to the HPD dispatcher about 0431 by the yard clerk. Although the clerk did not

request assistance at that time, he said he would call back if there was anything else to report. During this period, the HPD dispatcher did not advise the HFD or request the assistance of the HPD or HFD to investigate the accident. Following the explosion the MRL yard clerk could not contact the HPD dispatcher. The yard clerk and the assistant trainmaster then drove to the HPD headquarters; however, they could not get in to see the dispatcher. This delay resulted in the loss of time and hampered the emergency response personnel. About 5 to 15 minutes before the explosion occurred, the HPD dispatcher received two "complaints" of a "small accident" at the railroad's Benton Avenue crossing. Still the HPD dispatcher did not dispatch personnel to investigate the accident. Primarily due to the disruption of the radio and telephone communications in Helena, local safety officials were not advised by MRL of the hazardous materials involvement in the derailment until after 0500, 30 minutes following the derailment, when another yard office clerk called the HPD dispatcher and requested that someone come to the yard office to pick up hazardous materials information.

Although MRL did not initially request assistance, the HPD dispatcher should have dispatched the HPD to investigate the situation to determine if the city needed to be involved. The Safety Board believes that the City of Helena and MRL should cooperate to develop specific instructions and procedures for responding to reports of railroad accidents. At a minimum, these procedures should address the initial notification, the actions to take when responding to a release of hazardous materials, the identification of key contact personnel, the need for emergency drills, and the identification of resources and actions to be taken by railroad personnel and the city.

Command and Control.--During the first several hours, the incident commander was without the benefit of effective telephone/radio communications. As a result, command and control were adversely affected by the lack of effective communications links between all of the responding agencies. The power outage disrupted the power supply of the radio repeater on Mt. Helena, which provided radio communications to city emergency response personnel, and also the telephone switchboard in the city/county building. The Safety Board believes that the City of Helena needs to install a reliable independent emergency power supply source at its Mt. Helena radio repeater for radio/telephone communications.

The Hazardous Materials Emergency Response Plan (HMER) designates the [acting] fire chief as the incident commander and all response actions are to be under one command. The incident commander could not implement the incident command system⁵⁸ during the absence of radio communications and therefore was unable to effectively exercise control over the multiple command posts for the city, county, and state. As a result, there was a break down in communications and lack of coordination at the communications center, command posts, and operations center. The lack of training of some

⁵⁸The incident command system provides for emergency management by the incident commander who has liaison with other agencies, directs the use of equipment, designates management of activities through other qualified officers, and has liaison with on-scene technical experts.

of the responding agencies on the incident command system further compounded problems as some of the responding agencies did not know that with the incident command system the [acting] fire chief was the incident commander. As a result, many of the emergency responding agencies were unaware of the HFD command post, had difficulty obtaining information, and did not recognize anyone as being in overall command. The Safety Board believes that the City of Helena needs to coordinate with Lewis and Clark County DES and Montana DES and revise the Hazardous Materials Emergency Response Plan defining the role of each agency, the duties and authority of the incident commander, and the training for personnel to implement the plan.

Toxicological Testing

MRL officers stated that analyses of toxicological specimens obtained from the five crewmembers were obtained between 4 and 8 hours after the accident. The crewmembers had met with and had given the required train documents to the trainmaster, a company officer, at about 0530, but did not arrive at the hospital, which was about 3 to 4 miles away, until about 0800. Although the results showed that no drugs or alcohol were present in the samples, the Safety Board believes that to have positively determined the use of alcohol, specimens should have been taken in a more timely manner given the proximity of the hospital in this accident. The BN dispatcher and the MRL dispatcher were not requested to submit to toxicological testing. While there is no evidence to indicate that these individuals were impaired, the Safety Board is concerned that all individuals in safety sensitive positions were not requested to submit to toxicological testing, as required by Federal regulations. The position of train dispatcher is critical for safe operations of trains and communications concerning train movements.

CONCLUSIONS

Findings

1. No anomalies or deficiencies were evident in the track structure, track geometry, or operation of the signal system that would have contributed to the accident.
2. The automatic brake valve of the lead helper locomotive was operative.
3. The angle cock from SBD 121466, the first car coupled to the locomotives, was not defective.
4. According to the airflow indicator, train 121 had a train line leakage of at least 21 psi/min when it arrived at Helena.
5. The engineer of Helper 2 unilaterally decided to rearrange the locomotive consist and leave the cars standing on the mountain grade when train 121 had to stop at Austin.
6. The engineer of Helper 2 was preoccupied with the malfunctioning locomotive cab heater and did not properly consider discussing alternative actions with the road engineer and the adverse effects of the extreme cold on the airbrake system.

7. The road assistant engineer and the road utility operating employee did not want to make an emergency application of the train brakes when they uncoupled the locomotives from the train to prevent the train brakes from becoming stuck due to the cold weather.
8. An emergency application of the train brakes would have been possible when the helper locomotive was uncoupled from the train, and had an emergency application of the train brakes been made, the train may have remained stationary for a longer period of time.
9. An emergency application of the train brakes could not have been made when the road locomotive was uncoupled from the train because of the high rate of train line leakage.
10. The crewmembers did not properly secure train 121 by placing the train brakes in emergency and applying the hand brakes when they uncoupled the locomotives and left the train unattended.
11. The extreme cold temperatures, combined with worn seals, shrinkage of rubber packing cups in brake cylinders, and internal leakage in airbrake control valves resulted in the release of the brakes on a sufficient number of cars of train 121, allowing it to move.
12. The delay in reporting the runaway train precluded the opportunity to provide an advance warning to railroad personnel or to the City of Helena.
13. The impact speed of the runaway train with the standing helper locomotive was probably at least 15 to 25 mph, although the Safety Board could not determine the actual impact speed.
14. There are no operating rules or Federal regulations requiring additional airbrake testing or specific operating procedures when extreme cold weather conditions exist, even in mountain grade territory or when the feed valve setting has been increased.
15. Rules 100 and 103(L) of the General Code of Operating Rules and rule 470 of the Burlington Northern Air Brake, Mechanical, and Train Handling Rule Book, concerning the application of hand brakes, were sufficient for the circumstances of train 121 if applied as written. The crew should have applied the hand brakes which would have caused the train to remain stationary preventing the accident. It is unclear whether the crewmembers of train 121 knowingly failed to comply or did not have a clear understanding of the rules for leaving a train standing unattended on a grade.
16. The Montana Rail Link does not have a clear policy to define the responsibilities of the engineers when helper locomotives are positioned at the head end of a train.

17. Montana Rail Link helper locomotives are not equipped with end-of-train telemetry receivers thus requiring the road engineer to radio information to the helper engineer when the helper locomotives are positioned at the head end of the train.
18. The telemetry receiver in the road locomotive did not show the reduction in train line pressure from the automatic airbrake application made by the helper engineer because the signal from the end-of-train telemetry device was obstructed by the terrain when train 121 approached West Austin.
19. A two-way transmitting end-of-train telemetry device would have allowed the road engineer to verify the status of the telemetry device on the rear of the train and to attempt to initiate an emergency application of the train brakes from the rear of the train.
20. The replacement of the warm water heaters with electrical heaters in the lead helper locomotive cab was done without determining the adequacy of the auxiliary generator for the additional electrical load.
21. The road crew utility operating employee and assistant engineer were inadequately dressed to perform their duties in extreme cold weather conditions.
22. The actions and decisions of the crewmembers of train 121 were affected by the extreme cold weather conditions.
23. The Federal Railroad Administration, through its Billings, Montana, district office, made extra efforts to provide information and guidance to Montana Rail Link at the start-up of operations.
24. The 1987 Emergency Response Guidebook did not specify an evacuation distance for the release of hydrogen peroxide.
25. A chemical reaction of the released hydrogen peroxide with contaminants resulted in a fire that heated the polyethylene pellets causing a release of volatile organic vapors which exploded with sufficient energy to initiate the second more violent explosion.
26. Safety risks are taken when hydrogen peroxide and other high-risk products are transported in tank cars that do not have puncture resistant protection.
27. The tank head of UTLX 820 probably would not have been punctured if the tank car had been equipped with head shield protection.
28. Safety analysis methods have not been used by the U.S. Department of Transportation to identify unacceptable levels of risks in transporting hazardous materials and the degree of risk presented by the release of hazardous materials.

29. Montana Rail Link and Burlington Northern's procedures to verify hazardous material shipping documentation for cars received in interchange were inadequate.
30. The City of Helena did not have specific instructions or procedures for responding to reports of railroad accidents.
31. The City of Helena did not have a reliable independent emergency power supply to provide emergency radio and telephone communications when the commercial power supply was interrupted.
32. The Hazardous Materials Emergency Response Plan did not provide for the coordination nor define the role of participating agencies, the duties and authority of the incident commander, and provide for training for personnel to implement the plan.
33. The firefighting efforts were performed in a professional manner.
34. Toxicological samples should have been taken in a more timely manner given the close proximity of the hospital in this accident.
35. Neither the Burlington Northern nor the Montana Rail Link dispatchers, which are safety sensitive positions, were requested to submit to toxicological testing.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the crew of train 1-121-28 to properly secure their train by placing the train brakes in emergency and applying hand brakes when it was left standing unattended on a mountain grade.

Contributing to the accident was the decision of the engineer of Helper 2 to rearrange the locomotive consist and leave the train unattended on the mountain grade, and the effects of the extreme cold weather on the airbrake system of the train and the crewmembers. Also contributing was the failure of the operating management of the Montana Rail Link to adequately assess the qualifications and training of employees placed in train service. Contributing to the severity of the accident was the release and ignition of hazardous materials.

RECOMMENDATIONS

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

--to the Montana Rail Link Railroad:

Develop and implement additional airbrake testing and specific operating procedures for train crews when they are operating trains during extreme cold weather conditions. (Class II, Priority Action) (R-89-68)

Provide training on rules requiring the use of hand brakes to all operating employees. (Class II, Priority Action) (R-89-69)

Develop and implement instructions clearly identifying the engineer in charge when helper locomotives are positioned on the head end of a train and the role of other crewmembers in the decisionmaking process. (Class II, Priority Action) (R-89-70)

Equip all helper locomotives operating at the head end of a train with an end-of-train receiving device. (Class II, Priority Action) (R-89-71)

Expedite the program to upgrade existing cab heaters with an adequate power supply and seal the locomotive cab compartment to reduce air leakage. (Class II, Priority Action) (R-89-72)

Provide information on the potential dangers of cold weather and the proper selection of appropriate clothing to all employees. (Class II, Priority Action) (R-89-73)

Improve the efficiency testing procedures and provide training on Burlington Northern (BN) operating rules for Montana Rail Link train crews when operating over BN trackage. (Class II, Priority Action) (R-89-74)

Establish and implement a program to requalify and train all operating employees on the operating rules, airbrake, and train handling procedures. (Class II, Priority Action) (R-89-75)

Develop and implement procedures to verify the accuracy and completeness of hazardous material shipping documentation for cars received at interchange from other carriers or shippers. (Class II, Priority Action) (R-89-76)

Cooperate with the City of Helena in developing specific instructions and procedures for responding to reports of rail accidents. (Class II, Priority Action) (R-89-77)

--to the Burlington Northern Railroad Company:

Improve the efficiency testing procedures and provide training on Burlington Northern (BN) operating rules for Montana Rail Link train crews when operating over BN trackage. (Class II, Priority Action) (R-89-78)

Develop and implement procedures to verify the accuracy and completeness of hazardous material shipping documentation for cars received at interchange from other carriers or shippers. (Class II, Priority Action) (R-89-79)

--to the Secretary, U.S. Department of Transportation:

Evaluate present safety standards for tank cars transporting hazardous materials by using safety analysis methods to identify the unacceptable levels of risk and the degree of risk from the release of a hazardous material, and then modify existing regulations to achieve an acceptable level of safety for each product/tank car combination. (Class II, Priority Action) (R-89-80)

--to the Federal Railroad Administration:

Amend the Road Train and Intermediate Terminal Train Air Brake Tests, 49 CFR 232.13, to require additional testing of a train airbrake system when operating in extreme cold weather, especially when the feed valve setting is changed and the train will be operated in mountain grade territory. (Class II, Priority Action) (R-89-81)

Require the use of two-way end-of-train telemetry devices on all cabooseless trains for the safety of railroad operations. (Class II, Priority Action) (R-89-82)

--to the Research and Special Programs Administration:

Develop procedures to update and correct, in a timely manner, errors in the Emergency Response Guidebook. (Class II, Priority Action) (R-89-83)

--to the City of Helena:

Develop, in cooperation with Montana Rail Link, specific instructions and procedures for responding to reports of rail accidents. (Class II, Priority Action) (R-89-84)

Review and revise, in cooperation with Montana Rail Link, the emergency response procedures to address handling the unintentional release of hazardous materials. (Class II, Priority Action) (R-89-85)

Install a reliable independent emergency power supply source for the Mt. Helena radio repeater for radio/telephone communications. (Class II, Priority Action) (R-89-86)

Cooperate with Lewis and Clark County Disaster and Emergency Services (DES) and Montana DES, to revise the Hazardous Materials Emergency Response Plan to define the role of each agency, the duties and authority of the incident commander, and the training for personnel to implement the plan. (Class II, Priority Action) (R-89-87)

--to the State of Montana (Montana Disaster and Emergency Services Division):

Cooperate with Lewis and Clark County Disaster and Emergency Services and the City of Helena, to revise the Hazardous Materials Emergency Response Plan to define the role of each agency, the duties and authority of the incident commander, and the training for personnel to implement the plan. (Class II, Priority Action) (R-89-88)

--to Lewis and Clark County Disaster and Emergency Services:

Revise, in coordination with the City of Helena and Montana Disaster and Emergency Services, the Hazardous Materials Emergency Response Plan to define the role of each agency, the duties and authority of the incident commander, and the training for personnel to implement the plan. (Class II, Priority Action) (R-89-89)

--to the Association of American Railroads:

Inform its membership of the circumstances of the train accident and release of hazardous materials at Helena, Montana, on February 2, 1989. (Class II, Priority Action) (R-89-90)

Develop and implement procedures for the additional testing of a train airbrake system when operating in extreme cold weather, especially when the feed valve setting is changed and the train will be operated in mountain grade territory. (Class II, Priority Action) (R-89-91)

Encourage its membership to equip all helper locomotives operating at the head end of a train with an end-of-train telemetry receiving device. (Class II, Priority Action) (R-89-92)

As a result of its investigation of this accident, the Safety Board also reiterated the following Safety Recommendations to the Research and Special Programs Administration, the Association of American Railroads, and the Federal Railroad Administration, respectively:

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

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

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

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Acting Chairman

/s/ Jim Burnett
Member

/s/ John K. Lauber
Member

/s/ Joseph T. Nall
Member

/s/ Lemoine V. Dickinson, Jr.
Member

Adopted: December 6, 1989

APPENDIXES**APPENDIX A****INVESTIGATION AND HEARING****Investigation**

The National Transportation Safety Board was notified at 7:30 a.m., eastern standard time, on February 2, 1989, of a collision and derailment of a runaway Montana Rail Link freight train with a standing locomotive. The collision was followed by an explosion and release of hazardous materials with an evacuation in progress at Helena, Montana. The investigator-in-charge and other members of the investigative team were dispatched from the Washington, D.C. office and the field office in Fort Worth, Texas. Committees for engineering, mechanical, operations, human performance, survival factors, and hazardous materials were established for conducting the investigation.

The Safety Board was assisted in the investigation by Montana Rail Link Inc., City of Helena, Interox-America, Exxon Chemical, Pulse Electronics Inc., Brotherhood of Locomotive Engineers, Montana Public Service Commission, and the Federal Railroad Administration.

Public Hearing

A public hearing was conducted in Helena, Montana, on May 24, 25, and 26, 1989, to take sworn testimony to obtain the facts of the accident. Twenty-three witnesses testified.

APPENDIX B

PERSONNEL INFORMATION

Engineer - Helper 2

Engineer Robert M. Estes, age 37, had 18 years of experience in railroad operations. He had been qualified as an engineer on the BN in 1973 and was a trainmaster and road foreman prior to his employment with MRL. While with the BN, he was involved in the revision of the Air Brake, Mechanical, and Train Handling Rulebook particularly in the area of EOT devices and the airflow method of testing air brakes because of his familiarity of train operations in cold weather. He began service with MRL as a trainmaster and road foreman on October of 1988, a position he held until November 1988 when he exercised his seniority as an engineer. He was last qualified on the MRL operating rules February 16, 1988, according to MRL records no discipline has been assigned for rules violations. He advised that he was in good health on the day of the accident and was not suffering from any chronic or acute ailments or illnesses which could have affected his performance. His last physical examination was in 1987 when he was hired by the Montana Rail Link.

Utility Operating Employee - Helper 2

UOE Daniel Peressini, age 50, had resigned in 1968, after 5 years as a brakeman with the former Great Northern Railway (predecessor of BN). He had been self employed until hired by the MRL on November 3, 1987. He had worked the helper assignment since November 1988 with the helper engineer. He was last qualified on the MRL operating rules on February 26, 1988. He reported he was in good health on the day of the accident and was not suffering from any chronic or acute illnesses. His last physical examination was by the Montana Rail Link on February 20, 1988, which indicated he was healthy and noted his vision was corrected to 20/20 with glasses.

Engineer - Road Crew

Engineer Jody McCloud had 12 years of railroad experience. He began with the BN as a track laborer in 1977 and was promoted to engineer in 1980 after completion of the BN engineer school. On October 31, 1987, he began working with the MRL as an engineer. His normal assignment was between Missoula and Helena. He was qualified on the General Code of Operating Rules and Air Brake, Mechanical, and Train Handling Rules on March 1, 1988. He reported that he was in good health on the day of the accident. His last physical examination was by the Montana Rail Link on February 10, 1988, which indicated he was healthy and noted his vision was corrected to 20/20 with glasses.

Assistant Engineer - Road Crew**APPENDIX B**

Assistant engineer Stephen Delaney began working for the former Great Northern Railway in 1969 as a switchman. In 1972, he worked with the Milwaukee Road as a trainman and returned to the BN in 1980 and was laid off for lack of work. Between 1980 and 1987, he was employed in various non-railroad work. He began with the MRL in 1988 as a UOE assigned to an assistant engineer position. He described his duties as switching service, performing paper work, and any other duties assigned by the engineer; he was not permitted to operate a locomotive unless supervised by a qualified engineer. He was qualified on the MRL operating rules in March 1988.

His regular work assignment was the same as the engineer. A Montana Rail Link physical examination conducted on January 19, 1988, indicated that he was healthy, but that he suffers from hypertension which is controlled by medication.

Utility Operating Employee - Road Crew

UOE Eric Hubbard began with the Milwaukee Road in 1964 as a fireman and was a promoted engineer from 1968 until 1980 when the railroad ceased operations. From 1980 to 1983, he was employed in non-railroad work. From 1983 to 1986, he worked part-time for the Alaska Railroad as a fireman and had completed a 5-day training program, passing the required exam to be promoted to engineer in 1986. In 1987, he worked various positions as an engineer, brakeman, and conductor on a small shortline, the Washington Central, in Yakima, Washington. In March 1988, he started with the MRL working as an engineer, assistant engineer, and a UOE. He worked various assignments and was not assigned to regular duties. He stated that he had not been qualified or examined by the MRL on the General Code of Operating Rules or the BN Air Brake, Mechanical, and Train Handling Rules, but had performed service on the MRL as an engineer. He stated that he was last qualified on the General Code of Operating Rules in June 1987 while employed by the Washington Central. He did not report suffering from any chronic or acute ailments or illnesses on the day of the accident. No record of physical examination was on file with the Montana Rail Link. He stated that he was too busy to get a physical examination. While employed by the Alaska Railroad, he had three physical exams (April 1984, December 1985, and September 1986) with no conditions found limiting his railroad employment.

APPENDIX C

MONTANA RAIL LINK TRAIN ACTIVITY/DELAY REPORT
TRAIN 121, FOR FEBRUARY 1, 1989

Montana RAIL LINK TRAIN ACTIVITY / DELAY REPORT	TRAIN I.D.	(By I.D.)	section	manifest	date	report date	
	CONSENT	8061-8009-7163					
	MARKING DEVICE	front display console	rear of train marker / transformer		caboose No.		
	OR DUTY AT:	Janel		OFF DUTY AT: Helena			
crew information							
names of crew members	occupation	on duty date / time	inbound arrival	train departure time	off duty date / time	total time on duty	total time off duty
DR. MC CANDELLES	engineer	1/19/89 0630	1945	0840	2/1/89 1945	1315	2100
OB. PRITCHER	conductor	1/1/89	1/1/89	1/1/89	1/1/89	1/1/89	1/1/89
	U.O.E.						
	U.O.E. other						
All out of initial terminal:	Train made up at:	power on train: 0620		air test completed at: 0830		tested by: CAMPBELL	

station name	arrival time	departure time	description of activity or cause of delay	loads	empties	total	tons
Janel		0840	30 AIR TEST DUE TO COLD CUT BACK 16 CARS	50	14	64	6065
				-15	-1	-16	-1948
				35	13	48	4117
Chubb	0935	0940	20 MIN + METAL - 636PS-29 9083"				
CONNET	0955	1010	STOPPED ON MAIN FOR A.H.I. RAIL				
Big Tim BAY	1035	1040	METAL - 530PS-30 - 6320"				
Emp 88.5	1045	1050	10 MPH RESTRICTION, OVERSIGHT				
LIVINGSTON	1125	1415	PROBLEMS WITH TRAIN BROKE RAIL AHEAD AT MILLER				
DELRAND	1545	1620	ON MAIN STOPPED FOR DOUBLE TRACK FOR 841 LOCAL TO DO AIRSET OUT IN DELGRADE				
TRAVISDALE	1800		RELIEVED OF DUTY, DEAD- HEADED BY 841 LOCAL TO HELENA				
HELENA	1945	1945					
			length of train: 2847				
engineer must sign this report when hours of service have been exceeded				35	13	48	4117
IF DEAD UNDER HOURS OF SERVICE SHOW LOCATION AND TIME RELIEVED FROM DUTY							

APPENDIX C

TRAIN ACTIVITY/DELAY REPORT



2nd

DIVISION

TO SUPERINTENDENT AT HELENA FROM HELENA DATE 2-1-89

TRAIN NO EX. H. ENGINE NO 1925T ENGINEER P. J. LANE SR. FIREMAN S. C. SUTTON FROM STATION NO HY TO STATION NO HY

RADIO NO YES TYPE OF RADIO _____ LEFT RADIO AT: _____

A NAMES OF TRAIN CREW MEMBERS	OCCU	TIME WENT ON DUTY		TRAIN DEPARTED		TIME F.T.D STARTS		TRAIN ARRIVED		WENT OFF DUTY		TOTAL TIME ON DUTY		OFF DUTY PRICE TO THIS TRIP	
		DATE	TIME	DATE	TIME	DATE	TIME	DATE	TIME	DATE	TIME	HOURS	MIN	HOURS	MIN
P. J. LANE SR.	COND	2/1	2115	2/1	2155			2/2	1130	2/2	1145	14	30	24	+
S. C. SUTTON	REAR BRKMN	2/1	2115	↓	↓			↓	↓	↓	↓	↓	↓	↓	↓
	HEAD BRKMN														
	OTHER														

B TIME TRAIN MADE UP M: _____ TIME ENGINE DEPARTED ROUNDHOUSE M: _____ TIME ENGINE ON TRAIN M: _____ TIME TERMINAL AIR TEST MADE M: FROM _____ M: TO _____ M: _____

C STATION NAME	ARRIVAL TIME	DEPARTURE TIME	DESCRIPTION OF ACTIVITY OR CAUSE OF DELAY	NO. OF CARS DEPARTED WITH		TOTAL	TONS
				LOADS	EMPTY		
HELENA	2115	2155	DEAD HEAD TO TOWNSEND ON EMPTY GRAIN				
TOWNSEND	2230	2355	01-121-28, RELEASE BRAKES, WEST SWITCH RULE 315 SIDING-MAIN	35	13	48	4117
MP 214.4 WINSTON	0045	0145	GAP IN RAIL AT JOINT (4")				
WINSTON	0200	0230	STOP + INSPECT EAST + WEST SWITCHES				
HELENA	0310	0340	SWITCH POWER TO GO TO TOSTON TO GET L.M. (CHANGE IN PLANS → TOSTON)				
TOSTON	0450		01-122-01 STOPPED - WEST SWITCH FROZEN				
LOMBARD	0655	0915	WENT DEAD - DEADHEAD TO HELENA ON 01-0211A-01				

ENGINEER MUST SIGN THIS REPORT WHEN HOURS OF SERVICE HAVE BEEN EXCEEDED _____ LENGTH OF TRAIN _____ MAXIMUM NO. OF CARS HANDLED _____

D ROAD SWITCHING _____ TERMINAL SWITCHING _____ TOTAL SWITCHING _____ E ENGINE TO ROUNDHOUSE _____ TIME ENGINE CREW OFF DUTY _____ M _____ M _____

F TERMINAL SWITCHING _____ HOURS _____ MIN _____

APPENDIX F

OPERATION OF TRAIN BRAKES

The airbrake system consists of operating devices such as control valves, brake cylinders, relay valves and pipes, hoses, fittings, and foundation brake gear. The locomotive air compressors provide compressed air for the train line, at feed valve settings determined by each railroad's operating requirements for airbrakes. The feed valve setting on the MRL for mountain operations is 90 psi. The locomotives on train 121 were equipped with a pressure maintaining feature that was designed to continually maintain the pressure gradient (difference between the air pressure at the head of a train and the rear of the train) in the train line with allowances for train line leakage. The pressure gradient on train 121 when it departed Helena was 15 psi with 75 psi on the rear of the train. Tests for train line leakage are conducted as part of the initial terminal airbrake test and are limited to 5 psi/minute by 49 CFR 232.12 and also specified in the BN Air Brake, Mechanical, and Train Handling Rules, which MRL has adopted. However, since Helena was not the initial terminal for train 121, and since no changes were made to the consist except for the addition of helper power, no airbrake leakage test was required according to 49 CFR 232.13. All that was required was a set and release of the train brakes, with the crew confirming from the EOT receiving unit, that the air was being restored on the rear of the train.

A service brake application reduces train line pressure slower than an emergency application and is responded to by the control valve directing air pressure from the auxiliary reservoir to the brake cylinder. A maximum service brake application develops when a full service brake application is made. An emergency brake application also reduces train line pressure, but at a more rapid rate and the control valve responds by directing air pressure from both the auxiliary and emergency reservoirs to the brake cylinder. BN Air Brake, Train Handling and Mechanical Rule 330 part 5 states in part "...emergency quick action can be obtained at any time except when brake pipe (train line) has been reduced to 40 psi or below, at which point it becomes questionable whether emergency application and resulting increased brake cylinder pressure will be obtained on the entire train...." Airbrake industry sources have reported initiating an emergency application at minimum brake pipe (train line) pressures of 30 psi to 40 psi depending on the type of control valve (AB, ABD, or ABDW) under test rack conditions.

The application of the train airbrakes results in the brake cylinder, through a series of rods and levers, providing the force to push the brake shoes against the wheels of the cars to slow or stop the train. The application of either a full service or emergency brake application differs only in the amount of air pressure. According to a Westinghouse Air Brake manual for freight car airbrake equipment (AB single capacity),¹ the available emergency brake cylinder air pressure is approximately 20 percent higher than that obtainable from a full service brake application.

¹AB single capacity freight car air brake equipment with ABD or ABDW control valves.

APPENDIX F

The calculated retarding force required to hold train 121 on the 2.2 percent grade is about 192,500 lbs. To determine the actual retarding force of train 121 would require complex calculations and information unique to the braking components of each car; however, an Air Brake Association manual² provides graphs of nominal retarding force per wheel for both cast iron and composition brake shoes at both a full service application and emergency application. For a full service application (64 psi brake cylinder pressure), the greatest retarding force with composition brake shoes would have been 940 lbs. per wheel, and at an emergency application (77 psi brake cylinder pressure), the greatest retarding force with composition brake shoes would have been 1,080 lbs. per wheel. The greatest retarding force available at a full service application for the 49 cars of train 121 would be the equivalent of 368,480 lbs. at full service and 423,360 lbs. in an emergency application, respectively; however, train 121 did not have an emergency application of the train brakes or a full service application nor did all cars have composition brake shoes. A full service application of the train brakes is 26 psi. The event recorder showed only a 22-25 psi automatic airbrake application. Although train line leakage may cause an over reduction with a resultant increase in brake cylinder pressure to a full service brake application, it would not necessarily be uniform throughout the train. The tests performed on the NYAB AB test rack showed a 2 psi variation in brake cylinder pressure from the first car to the last car in the simulated uncoupling of the helper power from the train. As such, the available retarding force would have been less than what was available for the full service application.

²"Management of Train Operation and Train Handling", 1972, The Air Brake Association.

APPENDIX G

BURLINGTON NORTHERN AIR FLOW INDICATORS

Only the three BN units of the road locomotive were equipped with a train line (brake pipe) air flow indicator (AFI). The train line air flow indicator is a dial type gauge with numbers indexed to indicate the rate of air flow into the train line. The dial on locomotive unit BN 8061 was numbered from 1 to 14. According to the BN Air Brake, Mechanical, and Train Handling Rule Book, rule 522, these numbers are reference points related to an orifice calibration indicating a 60-cubic-foot-per-minute (CFM) air flow as close to the "8" mark on the gauge as possible. The BN is one of several railroads testing the train line air flow indicator in conjunction with airbrake leakage tests required by 49 CFR Part 232 under a waiver from the FRA (since December 1, 1982). However, the MRL does not have a waiver from the FRA to use the AFI method of train line testing and therefore does not provide any training to its engineers concerning the use of the AFI. The BN Manager of Locomotive Operations and Air Brakes testified at the Safety Board's public hearing that the reference made by the MRL inbound relief engineer of train 121 of an AFI reading of "14" and only going down to "12" "...would indicate that he [train 121] had high flow into his [train 121] brake line...." According to rule 522, paragraph no. 9, a "14" AFI reading equates to 81.8 CFM air flow and for a 50-car train the BN manager stated that this would equate to "...approximately 21 pounds [psi] per minute leakage."

APPENDIX H

UNITED STATES DEPARTMENT OF TRANSPORTATION NEWSLETTER
FOR RELEASE WEDNESDAY APRIL 13, 1983



U.S. Department of
Transportation

News:

Office of Public Affairs
Washington, D.C. 20200

FOR RELEASE WEDNESDAY
APRIL 13, 1983

DOT 21-83
Contact: Tom Blank
Dick Schoenfeld
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DOLE PROPOSES RAIL CAR SAFETY RULES

Secretary of Transportation Elizabeth Hanford Dole today announced that the Department has proposed new rules to complete the retrofit of railroad tank cars that carry flammable gases.

The rules would require that some 3,000 tank cars be equipped with high-temperature thermal insulation, head shields to resist puncture, and large-capacity safety relief valves. Previously issued DOT regulations required the retrofit of some 20,000 rail cars which carry 85 percent of the flammable gases in rail transport in this country.

Since these rules were implemented, there has been a measurable decline in the number of serious rail accidents involving flammable gases. Before the rules were implemented, such accidents were recognized as posing the greatest hazardous cargo risk in rail transport.

Secretary Dole said that in implementing these rail tank car rules, DOT "has focused first on those types of cars that represented the most serious safety problems."

"While we are completing the rulemaking process for flammable gas tank cars, the Department plans to continue to review its safety rules governing rail tank cars used for other hazardous cargoes," she said. "These cargoes move in smaller amounts and less frequently than flammable gases, but they nevertheless represent a real and substantial risk in accident situations, the Secretary said.

This review will include tank cars such as the one that was punctured April 3 in a Denver rail yard, releasing 20,000 gallons of nitric acid, Secretary Dole said.

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The proposed rules, under development in the Department's Federal Railroad Administration and Materials Transportation Bureau for two years, would require the retrofit of certain tank cars by Dec. 31, 1985. The revised standards would apply to DOT specification 105 and 111 tank cars with a capacity of more than 18,500 U.S. gallons. The cars are used to transport such flammable gases as propane and butane, as well as several other hazardous materials.

In the early 1970s, a number of serious railroad accidents demonstrated a need for additional safety features on tank cars carrying flammable gases. In 1977, DOT issued the first rules to require improved standards for new and existing cars. Today's proposed rule represents the third and final phase of that rulemaking effort.

DOT is seeking public comment on the proposed regulation, which will be published in the Federal Register Thursday April 14, 1983. The deadline for public comments is June 7, 1983. All comments should be addressed to the Dockets Branch, Materials Transportation Bureau, U.S. Department of Transportation, Washington, D.C. 20590.

#

APPENDIX I

EXCERPTS FROM BURLINGTON NORTHERN TIMETABLE NO. 1
AND
EXCERPTS FROM MONTANA RAIL LINK TIMETABLE NO. 2

TIMETABLE NO. 2

Length of Siding in Feet	Station No.	Line Segment	Mile Post Location	3rd Subdiv MAIN LINE STATIONS			Distance from Helena
				Office Calls	Rate (A)	ABS	
0.000	31070	14	210.4	NY HELENA	BKRTY	ABS	0.0
			0.5				0.5
			1.0				1.0
			1.5				1.5
			2.0				2.0
			2.5				2.5
			3.0				3.0
			3.5				3.5
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APPENDIX J

PRODUCTION INFORMATION

The product information on the MRL and BN consist, the waybills, and the shipper's bill of lading for the three hazardous materials cars (UTLX 820, ATSF 621566, and ACDX 816007) were inconsistent from one document to the other. For the remaining three cars (GATX 14247, GATX 73782, and GAPX 6013), the product identification on the consist was the same as that appearing on the waybill or the shipper's bill of lading for each car.

Both the MRL and BN consist indicated that tank car UTLX 820 was only loaded with isopropyl alcohol and identified the product as "ALCO DAN." The handling instructions included on the MRL consist for the car were only for isopropyl alcohol which was further identified as a flammable liquid, and by its chemical abstract (CAS) number and a commodity number. These instructions and waybill information did not specify an evacuation distance if the car was exposed to fire. By comparison, the DOT's Emergency Response Guide (ERG) recommends a 1/2-mile evacuation radius if the tank car is involved in a fire. The AAR Emergency Action Guide does not recommend an evacuation distance. The BN waybill indicated "Flammable Liquid UN 1219" was carried in the 12,000 gallon compartment A, and a "deficit" in the 8,000 gallon compartment B. However, the shipper's bill of lading indicated that compartment A had 12,136 gallons of isopropyl alcohol and compartment B had 8,106 gallons of acetone. Loading weights were shown for both the isopropyl alcohol and acetone on the waybill.

Box car ATSF 621566 was listed on both the MRL and BN consist as carrying "CBLLIQ", to indicate combustible liquid and included hazardous materials handling instructions for a combustible liquid. According to the BN waybill, the product was described as "Paint (Combustible)" and classed as a "Combustible Liquid" under DOT regulations. The waybill called for the display of combustible liquid placards. However, the shipper's bill of lading showed that the car was loaded with paint classified as a "Flammable Liquid" and solid coal tar classified as an "ORM-E Material."

Tank car ACDX 816007 was identified on both the MRL and BN consist as carrying "CHEMLS DAN." Under the hazardous materials handling instructions included with the MRL consist list, the cargo was further identified as a "Hazardous substance, liquid, n.o.s. [not otherwise specified] or ORM-E liquid," and as an environmentally hazardous substance. The waybill from the originating carrier (Birmingham Southern Railroad) only identified this material as "Hazardous substance, liquid or solid n.o.s., ORM-E." The handling instructions were the same as those on the MRL consist. The shipper's bill of lading identified the product as "Electrode Binder (Coal Tar Pitch)" containing benzo(a)pyrene.

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Tank cars GATX 14247 and GATX 73782 were shown on both the MRL and BN consist as "OXMTRL DAN." The waybills identified the product as "Hydrogen peroxide solution (over 52 percent peroxide), Oxidizer, UN 2015." The emergency handling instructions appearing on the waybill and the consist recommended a 1/2-mile evacuation radius in the event the tank car is exposed to direct flame. While the DOT's ERG does not recommend an evacuation radius, the AAR Emergency Action Guide recommends an evacuation radius of 1,500 feet.

Tank car GAPX 6013 was shown on both consists as carrying "PHENOL DAN" and on the waybill as "Carbolic acid (Phenol), Poison B, UN 1671." The waybill contained emergency handling information, but no evacuation instructions. Neither DOT's ERG or the AAR Emergency Action Guide have recommendations for an evacuation distance for a phenol tank car involved in a fire.

Hydrogen Peroxide (70 percent solution).-- Under the DOT regulations, a hydrogen peroxide solution at a concentration greater than 52 percent is classified as an "Oxidizer" and has a secondary hazard classification as a "Corrosive." Hydrogen peroxide is a clear, colorless liquid that is soluble in water in all proportions. Hydrogen peroxide at concentrations exceeding 35 percent may also have a sharp odor.

Hydrogen peroxide naturally decomposes at a very slow rate. The decomposition reaction generates water, oxygen gas and releases heat. According to Interlox, the decomposition rate is so low that commercial grades (35 percent or greater) normally lose less than 1 percent of the hydrogen content per year. Impurities can greatly increase the rate of decomposition. The increase rate of decomposition releases more oxygen and heat. Rapid decomposition can develop and result in rapid pressure build-up from oxygen gas generated leading to pressure ruptures of containers. Also, decomposition of hydrogen peroxide generates both heat and an oxygen-rich environment which together can promote combustion of organic materials. Producers will add a chemical stabilizer to inactivate the small amounts of impurities that may be present in storage and handling systems. However, the addition of a stabilizer cannot prevent the rapid decomposition when excessive contamination occurs.

Although hydrogen peroxide is a nonflammable liquid, it will support combustion of burnable materials. A Material Safety Data Sheet (MSDS) from Interlox for a 70-percent solution of hydrogen peroxide states in part:

...can initiate spontaneous combustion of paper, wood, cloth, and other organic materials. Ignition may be rapid, but can be delayed for several hours. Rapid oxygen evolution from decomposing hydrogen peroxide may increase the intensity of a fire. Oxygen

APPENDIX J

enrichment of poorly ventilated organic atmospheres increases the potential for a vapor phase explosion.

The Safety Board invited five domestic producers to a meeting in Washington, D.C. on March 17, 1989, to discuss properties and hazards of highly concentrated solutions of hydrogen peroxide. The producers as a group agreed that a 70-percent solution of hydrogen peroxide is not a shock-sensitive material. Also, in the absence of gross contamination, hydrogen peroxide at this strength is not temperature sensitive. Interlox indicated that the hydrogen peroxide can be heated to its boiling point of 258° F and not undergo accelerated decomposition.

Exposure of skin or eyes to a 70-percent concentration of hydrogen peroxide may cause chemical burns, irritation, blisters, and whitening of the skin due to a bleaching effect. Breathing of mist or vapor may cause irritation and inflammation of the mucous membranes and the respiratory system.

Isopropyl Alcohol.--Under DOT's hazardous materials regulations, isopropyl alcohol is classified as a "flammable liquid." It is a clear, colorless liquid that can release vapors that form flammable mixtures at or above its flashpoint of 54° F. According to the AAR's Emergency Action Guides, the flammable limits for isopropyl alcohol are 2.3 percent to 12.7 percent. The product is stable, and is stored at ambient temperatures at atmospheric pressure.

High vapor concentrations are irritating to eyes and respiratory systems, it may cause headaches and dizziness and is anesthetic. It may have other central nervous system effects. The MSDS for this product shows that inhalation hazards are "...negligible...at ambient temperatures (0° F to 100° F)...."

Acetone.--DOT classifies acetone as a "flammable liquid." It is a clear, colorless liquid with a flashpoint of 0°F. The MSDS for the product describes it as an "extremely flammable material [that] will readily ignite at ambient temperatures...can release vapors that form flammable mixtures at temperatures at or above the flashpoint." The flammable limits of acetone, according to the AAR Emergency Action Guides, are 2.5 percent to 12.8 percent. It is a stable material stored at ambient pressures and temperatures.

According to the AAR's guides, vapors at concentrations of 1,000 to 6,000 parts per million (0.1 to 0.6 percent) may cause mild eye irritation of the nose and throat.

APPENDIX J

Polyethylene Plastic Pellets.--ACFX 57358, a cover hopper car that was next to GATX 14247, was loaded with polyethylene plastic pellets manufactured by Quantum Chemical Company. The pellets are made of high density polyethylene, are about 3/8 inch in diameter, and white to opaque in color. They are used for the manufacture of milk containers and are not a regulated commodity according to DOT regulations.

The melting point for the pellets is from 257⁰ F to 284⁰ F; at temperatures greater than 600⁰ F, high density polyethylene will decompose, producing by-products such as carbon, carbon dioxide, carbon monoxide, water, and organic vapors such as acrolein, formaldehyde, and other organic vapors. DOT's hazardous material regulations classify acrolein as a "flammable liquid" and formaldehyde as a "combustible liquid." The temperature at which high density polyethylene will ignite without a spark or flame is about 645⁰ F.

The manufacture has no specific knowledge of the reactivity of high density polyethylene with high strength solutions of hydrogen peroxide having concentrations of 30 percent.

Classification of Material Having More than One Hazard.--The following are the 16 hazard groups:

1. Radioactive material (except a limited quantity).
2. Poison A.
3. Flammable gas.
4. Non-flammable gas.
5. Flammable liquid.
6. Oxidizer.
7. Flammable solid.
8. Corrosive material (liquid).
9. Poison B.
10. Corrosive material (solid).
11. Irritating materials.
12. Combustible liquid (in containers having capacities exceeding 110 gallons).
13. ORM-B.
14. ORM-A.
15. Combustible liquid (in containers having capacities of 110 gallons or more).
16. ORM-E.

APPENDIX K

DISASTER PREPAREDNESS

City of Helena.--Public Law 99-499, "Title III: The Superfund Amendments and Reauthorizations Act of 1986 (SARA)" or "The Emergency Planning and Community Right-To-Know Act of 1986" established requirements for Federal, state and local governments and industry regarding emergency planning and community right-to-know reporting on hazardous materials. "...The emergency planning sections are designed to develop state and local government emergency preparedness and response capabilities through better coordination and planning, especially at the local level..."¹ In response to Title III legislation and its subsequent codification, "Lewis and Clark County, Helena, Helena East-Hazardous Materials Emergency Response Plan" was completed October, 1988. This plan was current for contacts furnished by the railroad at the time of the accident. Upon notification of the accident, the City of Helena implemented the Hazardous Materials Emergency Response (HMER) plan. This plan called for the HFD chief to become the "incident commander" and for the police department along with the sheriff's office to conduct the evacuation. Additional support is provided by the EOC. The incident commander is to make major decisions, such as evacuation limits, perimeter security and identification of hazardous materials. Assigned to assist the incident commander in the identification of hazardous materials and recommendations for the safe handling of the emergency is a HFD hazardous materials officer (HMO). The HMO was notified by an off duty fireman about 0550, and he arrived on scene about 0630. At the Safety Board's public hearing, the HMO testified that although the HFD had training in the use of the incident command system the incident command system had not been adopted under the city's HMER plan.

Railroad.--The MRL Timetable No. 2, dated Sunday, January 29, 1989, has specific instructions in the event of a derailment or incident in which hazardous material may be involved. The employees' role following a hazardous materials incident is to determine the status of the incident and communicate that information to those who need it and to be specific when reporting damage or leakage information. In addition, MRL has pre-established procedures that require that the trainmaster or his representative notify local emergency response personnel. As recent as January and February, 1989, the FRA had inspected Helena Yard covering the yard's operating practices along with 49 CFR compliance of individual tank car waybills in the yard at the time of inspection. While 49 CFR has no specific provisions requiring rail carriers to develop hazardous materials yard incident plans, the FRA inspector noted that the MRL had a hazardous materials response notification list and that the U.S. Department of Transportation (DOT) Emergency Response Guidebooks (ERG) were available, and as a result no exceptions were taken.

¹NRT-1: "Hazardous Materials Emergency Planning Guide," National Response Team, March 1987.

APPENDIX L

EXCERPTS FROM BURLINGTON NORTHERN AIR BRAKE, MECHANICAL, AND TRAIN HANDLING RULES

SETTING OUT CARS AND USE OF HAND BRAKES ON CARS

470 A. When car(s) are set out en route a sufficient number of hand brakes must be applied and air from the brake cylinder drained or air brakes released to determine if hand brake is sufficient to hold the car(s).

Setting the hand brake with the air brakes applied may result in a broken chain when the air brakes leak off, or if the chain does not break it will cause the hand brake to be difficult to release.

When necessary to apply a hand brake on a car that has air brakes applied it is generally only necessary to take up the slack in the hand brake chain and not apply any further pressure to secure the hand brake. However, sufficient pressure must be applied to hold the car(s).

B. When setting cars out on grades the slack must be bunched hand brakes applied on the low end of the out of cars.

C. The number of hand brakes to be applied on the number of cars to have wheels securely blocked if the hand brake is defective in order to hold a group of cars at train stationary without air brake being applied depends on a number of factors including:

- Grade
- Load condition of cars (empties and loads)
- Roller or friction bearings
- Weather (wind and temperature)
- Adhesion

Ordinarily a hand brake applied with 125 pounds of force at the hand brake wheel rim or lever will hold a car on the same grade as the air brake. The hand brake can be applied harder than the nominal 125 pound force.

470 (Cont.)

Following is the minimum number of hand brakes to be applied or the number of cars to have wheels securely blocked if the hand brake is defective to hold a train on grades as indicated unless otherwise specified by local instructions. The number of hand brakes to be applied on trains with loads and empties will be between those shown for empties and loads and will depend on the number of loaded cars. Locomotives are to be considered the same as a loaded car and must be included in the number of cars in the train.

Grade	Empties	Loads
Level	1% of cars	2% of cars
1%	1% of cars	2% of cars
2%	3% of cars	5% of cars
3%	4% of cars	6% of cars
4%	6% of cars	11% of cars
5%	7% of cars	14% of cars
6%	9% of cars	17% of cars
7%	10% of cars	20% of cars
8%	12% of cars	23% of cars
9%	13% of cars	26% of cars
10%	15% of cars	29% of cars
11%	16% of cars	32% of cars
12%	18% of cars	35% of cars
13%	19% of cars	38% of cars
14%	21% of cars	41% of cars
15%	23% of cars	45% of cars
16%	24% of cars	48% of cars
17%	26% of cars	51% of cars
18%	27% of cars	54% of cars
19%	29% of cars	57% of cars
20%	30% of cars	60% of cars
21%	32% of cars	63% of cars
22%	33% of cars	66% of cars
23%	35% of cars	69% of cars
24%	36% of cars	72% of cars
25%	38% of cars	75% of cars
26%	39% of cars	78% of cars

470 (Cont.)

Grade	Empties	Loads
27%	40% of cars	81% of cars
28%	42% of cars	84% of cars
29%	44% of cars	87% of cars
30%	45% of cars	90% of cars
31%	47% of cars	93% of cars
32%	48% of cars	96% of cars
33%	50% of cars	99% of cars
34%	51% of cars	100% of cars
35%	53% of cars	100% of cars
36%	54% of cars	100% of cars
37%	56% of cars	100% of cars
38%	57% of cars	100% of cars
39%	58% of cars	100% of cars
40% and over	100% of cars	100% of cars

To determine the minimum number of cars requiring hand brakes multiply the percent by the number of loaded and empty cars. For example on a 5% grade with 40 empties and 60 loads:

$$07 \times 40 = 28 \text{ cars}$$

$$14 \times 60 = 84 \text{ cars}$$

112 or a minimum of 12 hand brakes to be applied

D. When necessary to apply hand brake on multi platform cars all hand brakes on the car must be applied.

E. If hand brake is defective on a car which requires hand brakes wheels must be securely blocked.

F. When blocking of wheels is required wood or chain blocking must be procured locally and placed in front and back of a sufficient number of wheels to prevent movement. If blocking is unavailable train dispatcher must be contacted to assist in contacting those who can supply blocking.

UNATTENDED TRAIN

471 Except when charging a train in preparation for and while performing a train air brake test prior to leaving a train unattended with locomotive attached a brake pipe reduction must be made as follows:

System Charge on Head Car	Reduce Brake Pipe Pressure to
60 psi	35 psi
70 psi	40 psi
80 psi	45 psi
90 psi	50 psi
100 psi	55 psi

For pressures between system charge levels shown reduce as indicated by the lowest charge.

After required brake pipe reduction is completed on 26 type brake equipment leave the automatic brake valve cut out valve in PASS position if equipped and if not equipped IN position. Non-maintaining automatic brake valve must be left in LAP position.

When leaving a train unattended the locomotive must remain attached unless required to separate about operating conditions.

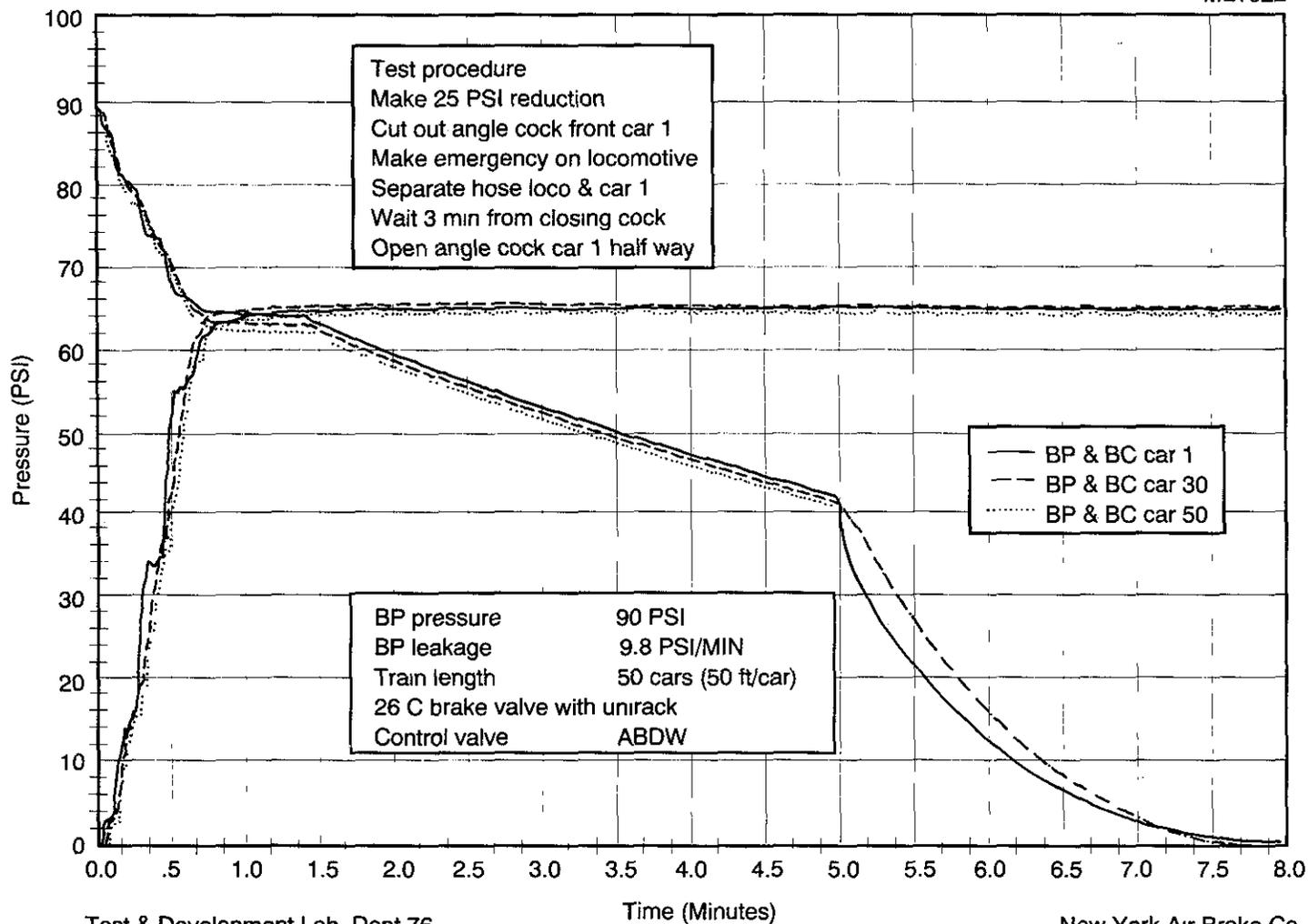
The automatic air brake must not be depended upon to hold unattended trains whether locomotive is attached or detached from train. A sufficient number of hand brakes must be applied as indicated in Rule 470 to hold the train.

When ready to proceed hand brakes must not be released until it is known the air brake system is properly charged.

Unattended locomotives must be prepared as shown in Rule 465.

Montana Rail Link 50 Car Train Performance Test

9/12/89
ML1022



Test procedure
 Make 25 PSI reduction
 Cut out angle cock front car 1
 Make emergency on locomotive
 Separate hose loco & car 1
 Wait 3 min from closing cock
 Open angle cock car 1 half way

BP & BC car 1
 BP & BC car 30
 BP & BC car 50

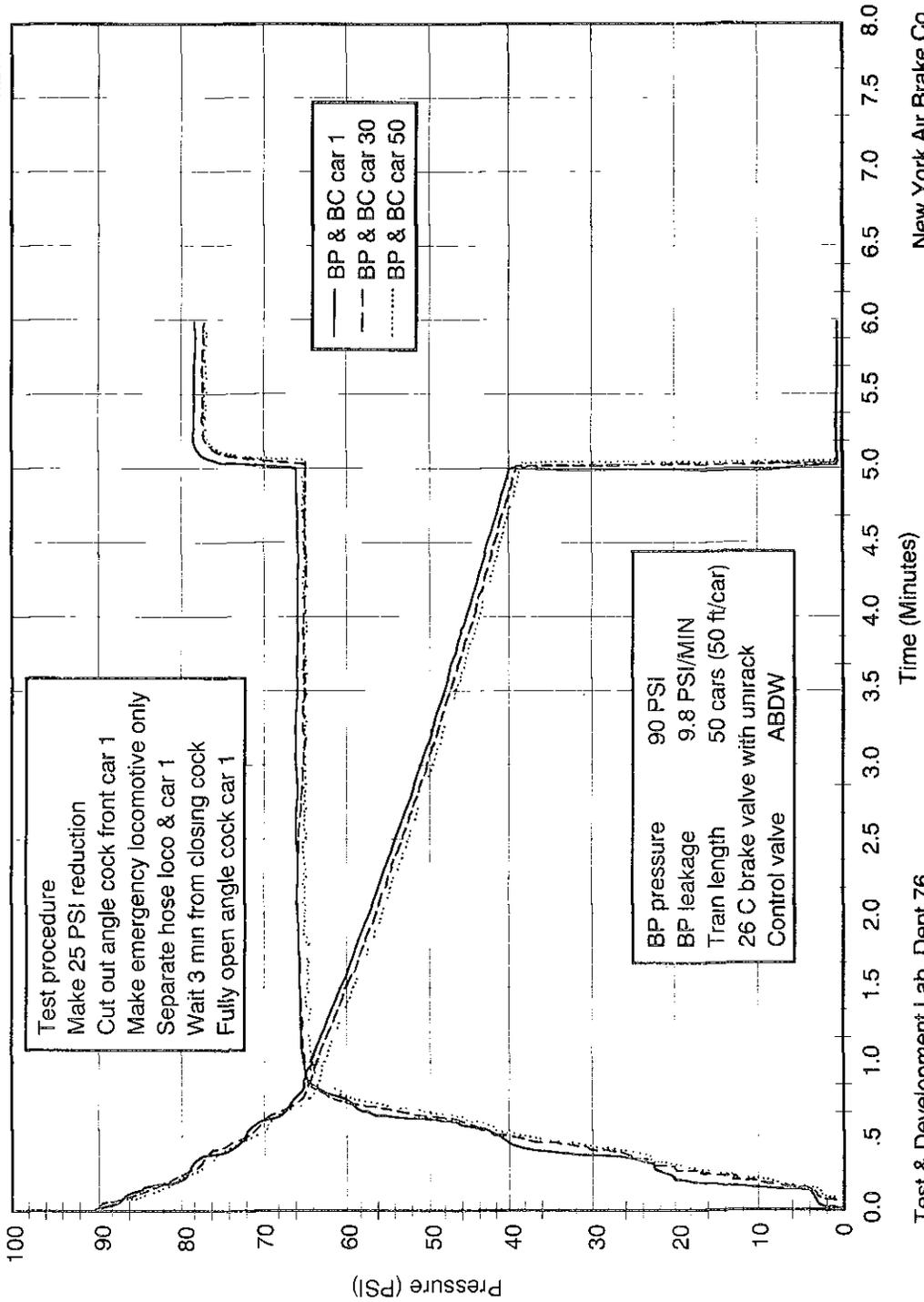
BP pressure 90 PSI
 BP leakage 9.8 PSI/MIN
 Train length 50 cars (50 ft/car)
 26 C brake valve with unrack
 Control valve ABDW

Test & Development Lab. Dept 76

New York Air Brake Co.
 A Unit of General Signal

Montana Rail Link 50 Car Train Performance Test

9/12/89
ML1023



Test procedure
Make 25 PSI reduction
Cut out angle cock front car 1
Make emergency locomotive only
Separate hose loco & car 1
Wait 3 min from closing cock
Fully open angle cock car 1

BP pressure 90 PSI
BP leakage 9.8 PSI/MIN
Train length 50 cars (50 ft/car)
26 C brake valve with unirack
Control valve ABDW

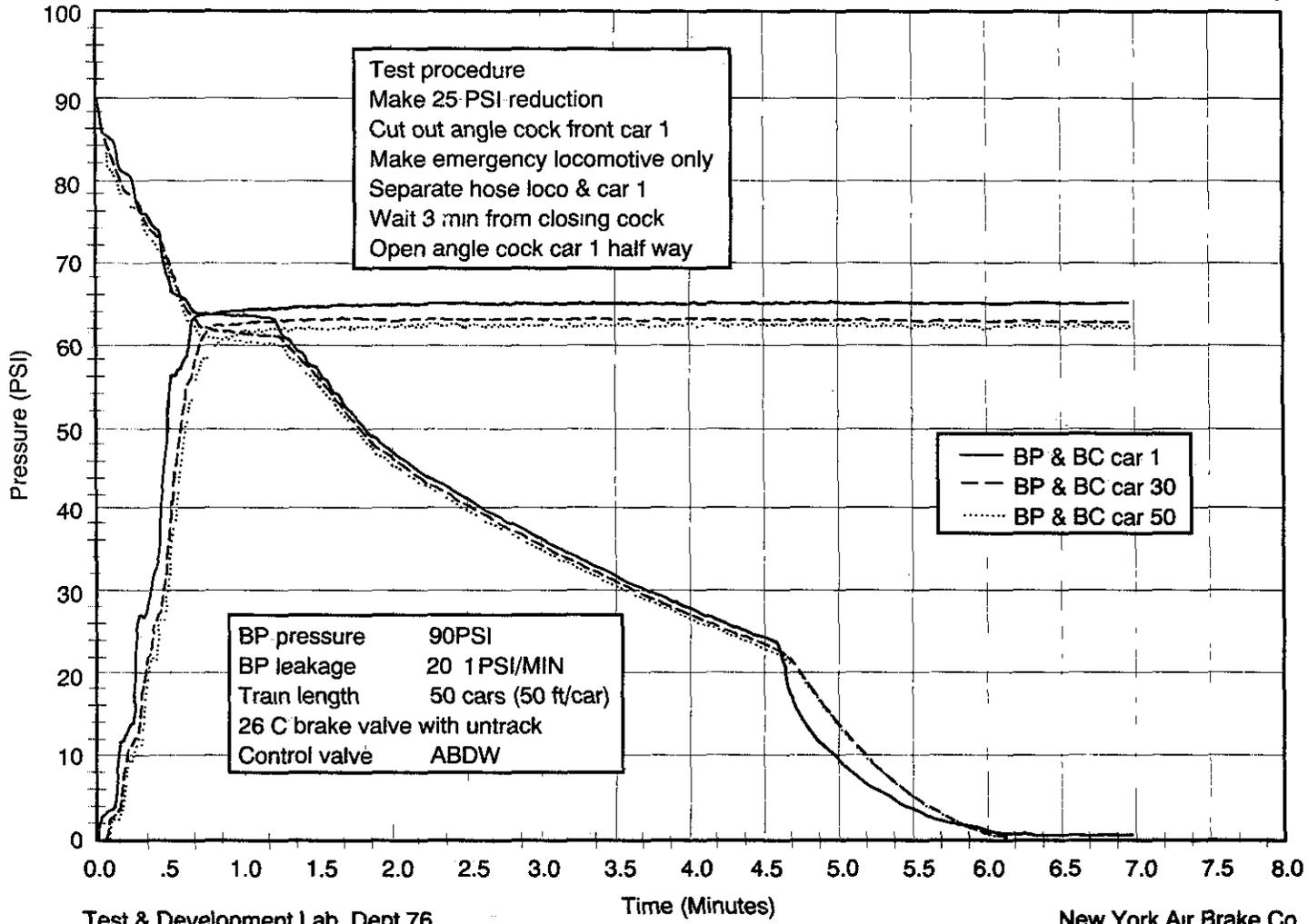
— BP & BC car 1
- - - BP & BC car 30
..... BP & BC car 50

New York Air Brake Co.
A Unit of General Signal

Test & Development Lab. Dept 76

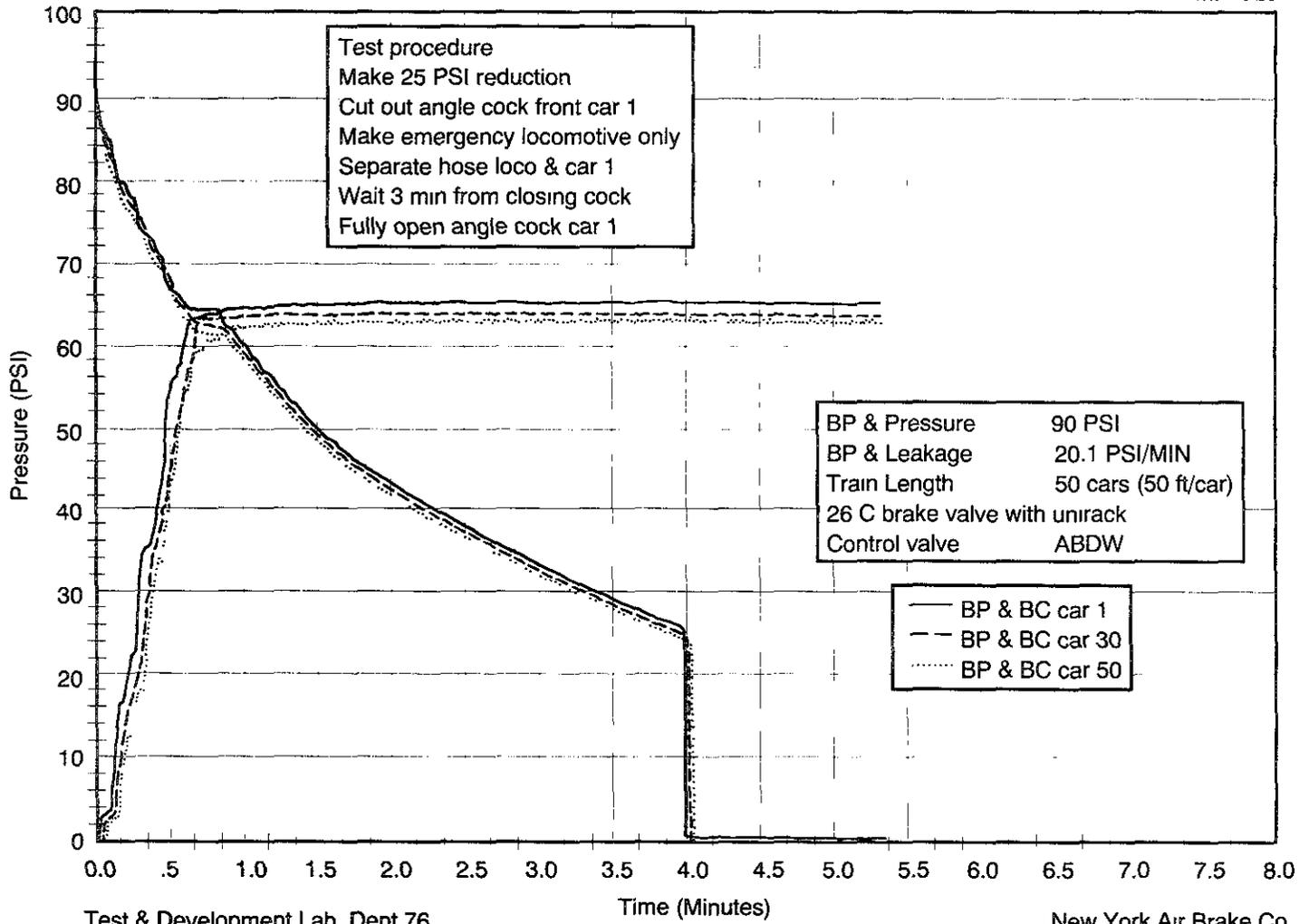
Montana Rail Link 50 Car Train Performance Test

9/12/89
ML1025



Montana Rail Link 50 Car Train Performance Test

9/12/89
ML1026



Test & Development Lab. Dept 76

New York Air Brake Co.
A Unit of General Signal

PAGE 4/4 ML 1026 21 PSI/MIN ANGLE COCK OPEN FULLY - NO EMERGENCY APPLICATION

APPENDIX M

APPENDIX N

SALVAGE AND CLEANUP

Rerailing of derailed equipment began about 0900 on February 3, 1989. At 1635, Interlox personnel noticed what appeared to be steam generated hydrogen peroxide decomposing around the leaking hydrogen peroxide car, GATX 73782. About 1820, Interlox personnel observed "...several small explosions and blue flames..." coming through the ice underneath the alcohol/acetone tank car, UTLX 820, while salvage crews were attempting to move a box car (ICG 151546) away from the tank car. MRL officers later stated that "...a small blue flame..." was present, but there were no explosions; however, because of their concern, they notified the HFD to standby before starting to reraill UTLX 820. Interlox representatives expressed concern about moving the damaged hydrogen peroxide car which was positioned on its side about 90 degrees from vertical. Interlox personnel inspected GATX 73782 after the MRL had removed ice¹ around the fittings on the top of the tank car. Interlox noted that the car was leaking around the rupture disc² and possibly the manway. While ice was being removed, Interlox personnel noted that the spilled hydrogen peroxide that was decomposing appeared to be increasing. Several attempts were made by MRL to right GATX 73782 to stop the leaking. MRL distributed large quantities of sand underneath UTLX 820 to absorb the alcohol. About 1400 February 4, the tank car was righted and the leaking stopped.

Off-Loading of Chemicals.--Before off-loading the remaining chemical product for UTLX 820 and GATX 73782, Exxon and Interlox submitted written procedures that were approved by the on-scene coordinator (OSC) from the Environmental Protection Agency (EPA) and the Montana DES. Transfer of acetone from the "A" compartment of UTLX 820 was completed on February 5 with 7,961 gallons of the initial lading of 8,016 gallons being recovered. The entire lading of isopropyl alcohol in the "B" compartment was released as a result of the puncture of the head end of the tank car. Transfer of hydrogen peroxide from GATX 73782 began on February 5 and was completed on February 6, with 11,700 gallons of the initial lading of 18,990 gallons being recovered.

¹A thick coating of ice covered the tank car resulting from the fire suppression stream and sub zero temperatures.

²A rupture disc is a pressure relief device with a membrane that breaks or "ruptures" when internal tank pressure exceeds the rated pressure limit of the membrane. When the membrane ruptures, the tank will vent.

APPENDIX O

EXCERPTS FROM DEVELOPMENT OF RSPA TANK CAR
PUNCTURE PROTECTION REGULATIONS FOR TANK CARS FROM 1974 to 1981

On July 30, 1974, the former Materials Transportation Bureau (MTB) of RSPA issued regulations that required the retrofiting of uninsulated pressure DOT specification 112A and 114A tank cars with head shields.¹ Existing tank cars were to be retrofitted by December 31, 1977, and tank head protection was required for all new cars built after August 30, 1974, by January 1, 1978. However, the regulations were challenged in court, and the retrofit program was effectively blocked.

On September 15, 1977, the MTB again issued regulations that required the retrofiting of DOT specification 112 and 114 tank cars used to transport anhydrous ammonia and flammable gases such as propane, vinyl chloride, and butane.² The new regulations required in part:

1. Existing and newly built specification 112 and 114 tank cars used to transport flammable gases were required to have thermal and tank head protection. Existing tank cars were required to be retrofitted by January 1, 1982, and newly built cars similarly equipped as of January 1, 1978.
2. Existing and newly built specification 112 and 114 tank cars used to transport anhydrous ammonia were required to have tank head protection. Cars built after December 31, 1977, were to be equipped with this protection, while previously built cars were to be retrofitted by December 31, 1981.

These regulations also required that all specification 112 and 114 tank cars be equipped with vertical restraint couplers on new cars built after December 31, 1977, and on previously built cars by July 1, 1979. In issuing the new regulations, RSPA indicated they were developed as a result of a series of accidents involving uninsulated 112 and 114 tank cars transporting these types of materials. RSPA further cited three specific accidents in which tank cars of propane sustained tank head or shell punctures, or thermal ruptures.

¹RSPA, 49 CFR Parts 173 and 179, Docket No. HM-109, Amdt. Nos. 173-83, 179-15, "Tank Car Head Shields," Vol. 39 Federal Register, p.27572, July 30, 1974.

²RSPA, 49 CFR Parts 173 and 179, Docket No. HM-144, Amdt. Nos. 173-106, 179-15, "Shippers; Specification for Pressure Tank Car Tanks," Vol. 42 Federal Register, p 46306, September 15, 1977.

APPENDIX O

On July 21, 1980, RSPA issued a Notice of Proposed Rulemaking (NPRM)³ to apply the identical tank head protection standards for DOT specification 112 and 114 tank cars to DOT specification 105 tank cars. RSPA also proposed full tank head protection resistance and the need for shelf couplers on all existing and newly built DOT specification tank cars.

In the preamble to the NPRM, RSPA cited 10 previous accidents that occurred between 1963 and 1979 and involved specification 105 tank cars transporting liquified petroleum gas, butadiene, ethylene oxide, vinyl chloride, and chlorine. In seven of the cited accidents, the tank cars sustained head or shell punctures. RSPA also noted that specification 105 tank cars were used to transport other products such as anhydrous ammonia and flammable liquids.

RSPA issued the final regulations on January 26, 1981,⁴ that required (1) vertical restraint couplers on existing and newly built specification 105 tank cars, (2) a tank head puncture resistance system on specification 105 tank cars built after August 31, 1981, and used to transport flammable gases, anhydrous ammonia, and ethylene oxide, and (3) vertical restraint couplers on all DOT specification tank cars by March 1, 1985.

On July 21, 1980, RSPA also issued an Advance Notice of Proposed Rulemaking (ANPRM)⁵ to consider extending the puncture and thermal protection levels of specification 112 and 114 tank cars to existing specification 105 tank cars that carry flammable gases, anhydrous ammonia, ethylene oxide, butadiene, poisons, and combustible and flammable liquids or solids. Extending these requirements to other DOT specification tank cars, such as specification 111 tank cars, that carry the same commodities as specification 105 tank cars was also to be considered.

³RSPA, 49 CFR Parts 173 and 179, Docket No. HM-174, Notice No. 80-6, "Shippers; Specifications for Tank Cars," Vol. 45 Federal Register, p. 48671, July 21, 1980.

⁴RSPA, 49 CFR Parts 173 and 179, Docket No. HM-174, Amdt. Nos. 173-145, 179-27, "Shippers; Specifications for Railroad Tank Cars," Vol. 46 Federal Register, p. 8005, January 26, 1981.

⁵RSPA, 49 CFR Parts 173 and 179, Docket No. HM-175, "Specification for Tank Cars," Vol. 45 Federal Register, p. 48668, July 21, 1980.

APPENDIX O

In the NPRM⁶ published under docket HM-175 on April 14, 1983, RSPA proposed retrofitting only those existing specification 105 tank cars with capacities exceeding 18,500 gallons. In the preamble to the NPRM, RSPA stated:

MTB and FRA do not believe a rule requiring a retrofit of existing specification 105 tank cars having capacities less than 18,500 gallons carrying the identified hazardous materials is warranted on a cost/benefit basis. Many of these cars are nearing the end of their service life. Hence, the cost of retrofit might not be recovered in the remaining tank car life. More importantly, these smaller capacity cars have a lower utilization rate, reducing their exposure to potential accident situations. Finally, their smaller capacity presents a smaller safety risk should they be involved in an accident...

The MTB and FRA also considered increased puncture resistance for existing cars carrying hazardous materials such as chlorine, motor fuel anti-knock compound and sulfur dioxide. The MTB and FRA are not convinced that an increase puncture resistance requirement is justified based on accident experience and the current protection levels built into the cars authorized to transport these materials. The primary basis for this view is the fact that these hazardous materials are required to be shipped in tank cars with pressure ratings in excess of that needed to contain these products. Although this tank head puncture resistance may not be the equivalent to HM-144/HM-174 performance levels, the safety record of these cars is such that MTB and FRA cannot now justify their retrofit or redesign to achieve an incremental amount of additional protection...

With the exception of ethylene oxide, MTB did not find sufficient threats to safety, nor cost-benefit justification, for proposing an extension of thermal and head protection for tank cars to materials other than those addressed in dockets HM-144 and HM-174.

⁶RSPA, 49 CFR Parts 173 and 179, Docket No HM-175, Notice No 83-1, "Specifications for Railroad Tank Cars Used to Transport Hazardous Materials", Vol 48 Federal Register, p. 16188, April 14, 1983

APPENDIX O

RSPA published new regulations under this docket on January 27, 1984.⁷ Under the new regulations, specification 105 tank cars built before September 1, 1981, and that have a capacity exceeding 18,500 gallons and are used to transport flammable gas, anhydrous ammonia, and ethylene oxide were to be equipped with lower tank head protection after December 31, 1986. Also, specification 111 tank cars with a capacity exceeding 18,500 gallons and used to transport a flammable gas or ethylene oxide were to be equipped with lower tank head protection after December 31, 1986.

⁷RSPA, 49 CFR Parts 173 and 179, Docket No. HM-175, Amdt. Nos. 173-173, 197-35, "Specifications for Railroad Tank Cars Used to Transport Hazardous Materials," Vol. 49 Federal Register, p. 3468, January 27, 1984.

APPENDIX P

FRAGMENT DISTRIBUTION
FRAGMENT DESCRIPTION AND LOCATION

Fragment No.	Description	Location
T-1	Curved piece of steel 24" long.	Carroll College, gym floor, pieces came through roof.
T-2	Two pieces of steel 12"x9"x1".	Carroll College, embedded in gym floor, pieces came through roof.
T-3	Section of steel plate 33"x24", gray-blue in color with hole puncture 3"x7", inside to outside.	Carroll College, on roof of gym.
T-4	Top section of GATX 14247, 14'x7' w/top mounting flange for continuous vent.	Carroll College. Near northeast wall of gym.
T-5	Bent section of aluminum sheet of GATX 14247, 32"x21". Puncture hole from inside to outside, 4"x10".	Carroll College. Roadway northeast of gym.
T-6	Irregularly shaped aluminum shell from GATX 14247, 41"x24".	Carroll College. South side of tennis courts.
T-7	Manway section from GATX 14247.	Carroll College. Southeast side of gym.
T-8	Section of aluminum tank shell, GATX 14247, 10'-8"x2'-10"; 3-holes 1 1/2" from inside to outside.	Carroll College. Parking area west of gym.
T-9	Piece of aluminum from GATX 14247 tank shell 3'x2'-6".	Carroll College. Northeast wall of library building.
T-10	Piece of aluminum from GATX 14247 tank shell, 1'x1'x1'.	Carroll College. Northeast wall of library building.

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T-11	Section of aluminum tank shell from GATX 14247, 84"x88".	North of railroad south of baseball field.
T-12	Section of aluminum tank shell from GATX 14247, 69"x31", punctured from outside to inside.	North of railroad west of Elk River Concrete Plant.
T-13	Section of aluminum tank shell from GATX 14247, 108"x50", and pieces of tank car walkway, puncture holes 1"x2" from outside to inside.	North of railroad against south side of fence.
T-14	Unidentified piece of steel 13"x10" with letter "N" in a circle and stencilled "59S-71E".	North of railroad on golf course near Benton Avenue.
T-15	Section of aluminum tank shell from GATX 14247, 78"x48".	Northeast of accident location, between golf course and railroad.
T-16	Section of steel plate 100"x105" painted gray on exterior surface and light blue on interior surface, with manway opening; same color scheme as covered hopper cars from train.	Northeast of accident location, between golf course and railroad.
T-17	Section of aluminum tank shell from GATX 14247 with weld intersection and two external welded fitting seats. Puncture hole, 7", from outside to inside.	Northeast of accident location, between golf course and railroad.
T-18	Rectangular section of aluminum tank shell from GATX 14247, 52"x76", with one puncture hole from outside to inside.	Northeast of accident location at north end of golf course.
T-19	Section of aluminum tank shell from GATX 14247, 20' long with irregular shape. One puncture hole 4"-5" in diameter made from outside to inside.	In middle of baseball field north of railroad.
T-20	Steel plate light blue in color, attached to sheet metal.	Against fence of baseball field north of railroad.

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T-21	Section of aluminum plate 77"x27" with one puncture 7"x12" made from outside to inside.	Southwest of accident location near Elk Creek Concrete Plant.
T-22	Piece of 3/8" steel plate 18"x17", with "50 K" stencilled to exterior surface and plastic pellets adhering to interior surface.	South of railroad in concrete plant storage yard.
T-23	Section of aluminum, 6"x48".	South of railroad in concrete plant storage yard.
T-24	Section of aluminum tank shell from GATX 14247 10"x10" with long narrow puncture from outside to inside.	South of railroad in concrete plant storage yard.
T-25	Section of aluminum tank shell from GATX 14247 92"x72" with 2 puncture holes; one inside to outside the other outside to inside.	South of railroad in concrete plant storage yard.
L-1	"L" shaped piece of steel with "DC1087", raised 3/4 long arrow shape and date "9/24/71".	On a path between garage and house (504 Peosta Ave.)
L-2	Piece of 5/8" steel plate 22"x32".	Adjacent to "L-1".
L-3	Heavy steel ring 3/4"x2'-10", collapsed, had threaded 1" diameter bolts.	On residential property (538 Peosta Ave).
L-4	Steel rod eyelets 3/4"x24".	On residential property (538 Peosta Ave.).
L-5	Steel wedge shape 5"x9" tapered from 3/4" to 1-1/2" with raised letters "5A90" and "34x12--NCT". Object penetrated roof of house ending in basement.	On residential property (1716 Harrison Ave.).
L-6	3" diameter stainless steel liquid education tube from GATX 14247.	Residential property (165 Ralph Street).
L-7	Steel plate, 8"x5"	On roof of residence at 501 Peosta Ave.

APPENDIX P

