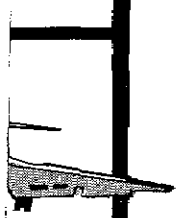

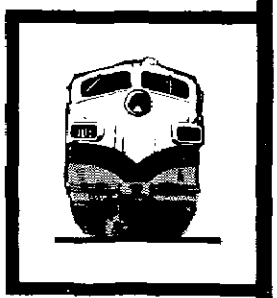

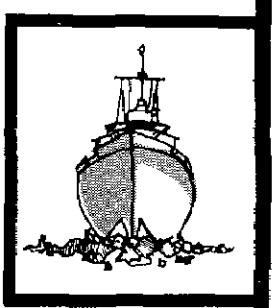

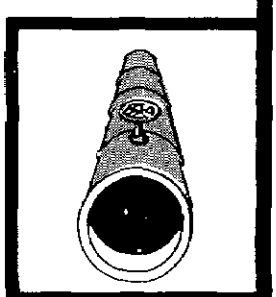

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

REAR-END COLLISION OF
UNION PACIFIC RAILROAD COMPANY
FREIGHT TRAINS
NEAR HERMOSA, WYOMING
OCTOBER 16, 1980

NTSB-RAR-81-3

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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16 Abstract About 3:06 p.m., on October 16, 1980, Union Pacific Railroad Company (UP) freight train Extra 3749 West (NPH-16) struck the rear of UP grain train Extra 3557 West (SGTLB-635) while it was standing about 100 feet west of intermediate signal No. 5517 near Hermosa, Wyoming. Two train crewmembers were killed and two crewmembers were injured. The 3 locomotive units of NPH-16 and 16 cars, including the caboose, of SGTLB-635 were derailed. Total damage was estimated to be $993,000.

The National Transportation Safety Board determines that the probable cause of this accident was the inadequacy of Union Pacific rules in explaining train handling and braking procedures, along with the engineer's lack of comprehension of those rules and his inadequate handling of the train's brakes which resulted in his failure to bring the train to a stop as required before reaching signal No. 5517. Further, there was a lack of necessary communication among train crewmembers and with the dispatcher.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: April 7, 1981

REAR-END COLLISION OF UNION PACIFIC RAILROAD COMPANY FREIGHT TRAINS NEAR HERMOSA, WYOMING OCTOBER 16, 1980

SYNOPSIS

About 3:06 p.m., on October 16, 1980, Union Pacific Railroad Company (UP) freight train Extra 3749 West (NPH-16) struck the rear of UP grain train Extra 3557 West (SGTLB-635) while it was standing about 100 feet west of intermediate signal No. 5517 near Hermosa, Wyoming. Two train crewmembers were killed and two crewmembers were injured. The 3 locomotive units of NPH-16 and 16 cars, including the caboose, of SGTLB-635 were derailed. Total damage was estimated to be $993,000.

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INVESTIGATION

The Accident

On October 16, 1980, Union Pacific Railroad Company (UP) westbound grain train Extra 3557 West (SGTLB-635), consisting of 3 locomotive units, 76 loaded cars, and a caboose, departed Cheyenne, Wyoming, at 10 a.m. for Rawlins, Wyoming. Between Cheyenne and Dale Junction, Wyoming, SGTLB-635 operated over main track No. 3. At Dale Junction, SGTLB-635 was routed by the dispatcher onto the No. 2 track as it continued to East Hermosa, Wyoming. (See figure 1.)

According to the engineer and head brakeman, who were in the lead locomotive unit, the home signals at East Hermosa and West Hermosa, Wyoming, continuously displayed clear 1/ and advance approach 2/ aspects, respectively,

1/ "Clear" requires that a train proceed at authorized speed.
2/ "Advance approach" requires that train speed not exceed 40 mph when passing the next signal.

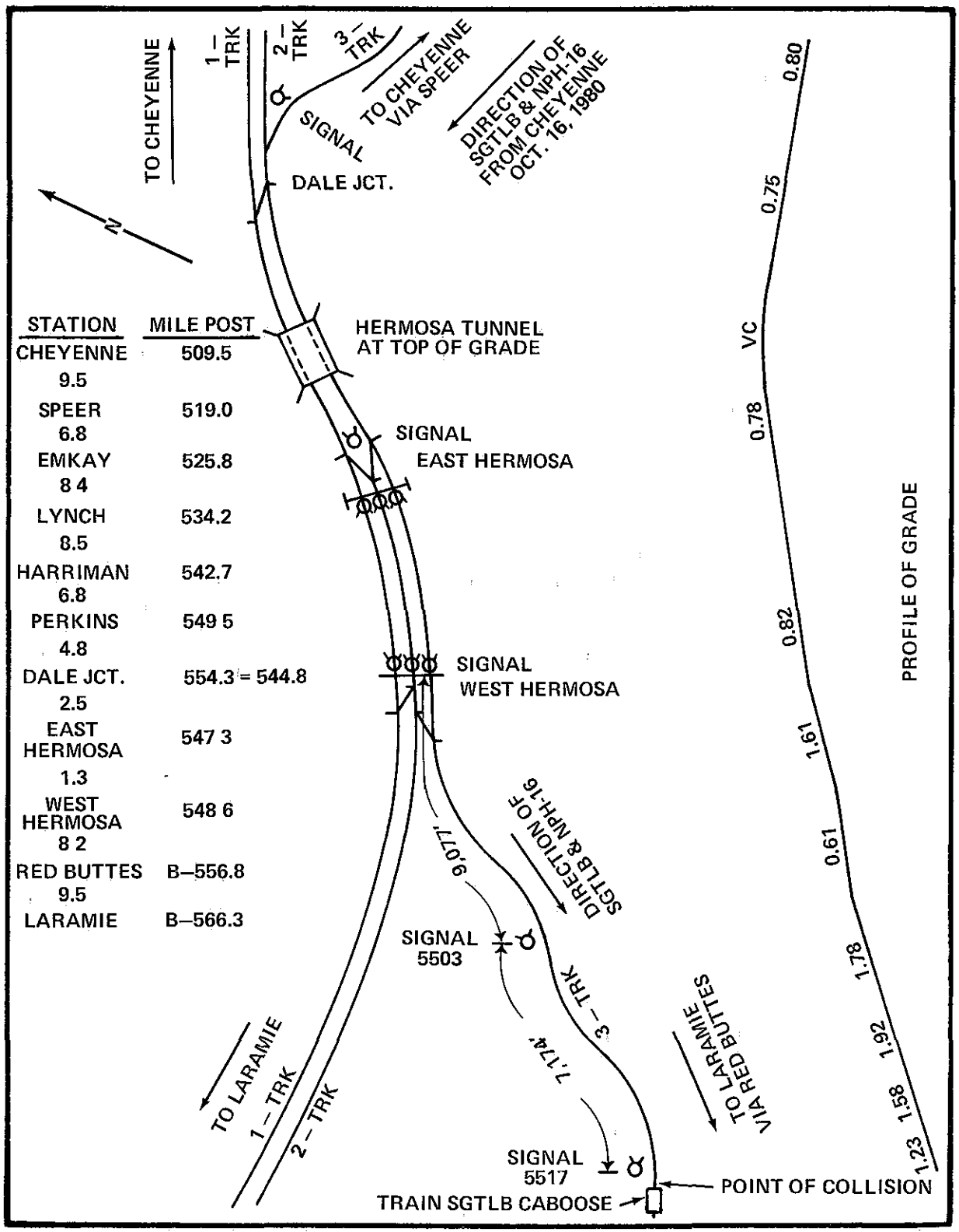


Figure 1.--Sketch of Hermosa area track alignment and grade.

as SGTLB-635 approached and until the lead locomotive unit passed each signal. These aspects were properly repeated by the locomotive cab signals. About 1:32 p.m., the train had been routed back onto track No. 3 at East Hermosa, and shortly after the engineer had acknowledged the more restrictive cab signal at West Hermosa, the train had an uncalled for emergency application of the brakes. The conductor, who was in the caboose with the rear brakeman, immediately radioed the engineer to determine why the train had stopped. The engineer said it may have been caused by his application of the brakes entering a descending grade. The rear brakeman then radioed the dispatcher in Cheyenne to notify him of the emergency brake application and to determine if any trains were approaching on the adjacent tracks. The dispatcher acknowledged the radio message by advising that no trains were approaching. Meanwhile, the conductor had begun to walk toward the locomotive to inspect the train, but when he heard the air begin to recharge the brakepipe, he returned to the caboose.

About 1:45 p.m., the engineer began operating the train down a 1.8-percent descending grade toward Red Buttes, Wyoming. The engineer and head brakeman said that when the train approached the next two intermediate signals, Nos. 5503 and 5517, the signals continuously indicated approach 3/ and stop-and-proceed 4/ aspects, respectively. These aspects were properly repeated by the locomotive cab signals and acknowledged by the engineer. As the train approached the stop-and-proceed signal, the engineer could see several miles in the distance, and he noticed what appeared to be other trains stopped on the track ahead near Red Buttes. After stopping and passing signal No. 5517, the engineer operated the train under 20 mph until he stopped about 500 feet from the caboose of a train ahead. This stop, which occurred about 2 p.m., left the caboose of SGTLB-635 about 100 feet west of, and inside the block protected by, signal No. 5517. The conductor said he did not send the rear brakeman eastward to protect the rear of the train because protection is not required in signalized territory and the rear-facing red signal light on the roof of the caboose was illuminated.

The conductor remained in the cupola of the caboose during the following hour while the rear brakeman remained below at the conductor's desk. About 3:06 p.m., the conductor said that he heard a voice on his radio say "look out in the caboose." When he stood up to look to the east, the caboose was struck by the lead locomotive unit of westbound UP freight train Extra 3749 West (NPH-16). The impact of the collision propelled the conductor from the caboose. The rear brakeman, still seated at the conductor's table, was killed in the collision.

NPH-16 had arrived at Cheyenne about 10:25 a.m. from North Platte, Nebraska, where it had been given a 500-mile inspection and brake test. The arriving crewmembers told the relieving crewmembers that they had experienced no problems with the train en route. No brake test was required before departing Cheyenne, and the outgoing engineer took no exceptions to the condition of the train. NPH-16 departed Cheyenne westbound about 10:35 a.m. for Rawlins with a

3/ "Approach" requires that a train's speed be immediately reduced to 30 mph after passing the signal and that the train stop short of the next signal.
4/ "Stop and proceed" requires that a train stop before any part of the train or engine passes the signal and then proceed at restricted speed through the entire block stopping before any train or obstruction.

maximum authorized speed of 50 mph shown on its clearance form. The train consisted of 3 locomotive units, 68 loaded cars, and a caboose. The engineer and head brakeman were in the lead locomotive unit, which was operated by the engineer from the right side, and the conductor and rear brakeman were in the caboose. At West Cheyenne the cab signals operated as intended when the locomotive passed over the test circuits.

Between Cheyenne and Dale Junction, NPH-16 operated over the No. 3 main track. En route the train was stopped three times to comply with signals displaying stop aspects. The signals which preceded the stop signals displayed advance approach and approach aspects, respectively. The engineer said these signal aspects were properly repeated by the locomotive cab signals. When approaching Dale Junction about 1:30 p.m., NPH-16 was stopped by an uncalled for emergency application of the brakes. The engineer radioed the conductor that when applying the brakes to stop for the stop signal at Dale Junction, there may have been a penalty application from the cab signal acknowledging device. The crewmembers did not notify the dispatcher about this emergency application because the air began to quickly recharge the brakepipe.

Departing Dale Junction, NPH-16 was routed on track No. 2 to East Hermosa and about 2 p.m. was stopped just east of East Hermosa because the home signal displayed a stop aspect. At 2:19 p.m., the dispatcher activated the routing for NPH-16 on track No. 3 to Red Buttes and Laramie. The home signal changed immediately to a clear aspect, indicating that the train could proceed. At 2:45 p.m., the dispatcher attempted to radio NPH-16 crewmembers because his train graph indicated that NPH-16 had not yet moved; the crewmembers said later that they did not hear the radio message. At 2:58 p.m., the train graph indicated that NPH-16 had begun to move, so the dispatcher did not attempt to contact the engineer to determine why the train had not moved earlier. The engineer later told investigators that the head brakeman was not feeling well and that he had gone to the second locomotive unit to use the lavatory. He said that he waited until the head brakeman returned before moving the train. The engineer said that he did not attempt to notify the dispatcher of the head brakeman's illness and that he was never contacted by the conductor about the delay at East Hermosa.

The engineer said that after departing East Hermosa he made a minimal test application of the dynamic brake 5/ near the road crossing at West Hermosa as required before reaching the 1.8-percent descending grade. He said the signal at West Hermosa displayed a clear aspect and that the cab signal corresponded. He recalled his speed to be about 25 mph and that the visibility was good. According to the engineer, the next signal, No. 5503, displayed a clear aspect and that after passing the signal he made a minimum application of the airbrakes to control the speed of the train on the descending grade. The engineer said that when the next signal, No. 5517, came into view about 1,000 feet ahead, it was displaying a clear aspect, and that he also immediately saw the red marker light of a caboose just beyond the signal. He said that while he applied the brakes in emergency, he may have quickly radioed a warning to the crewmembers to get off the caboose. He

5/ Dynamic braking is obtained only on the locomotive units when the electric traction motors are changed to generators which cause a retardation in the speed of the locomotive.

recalled that his train speed was about 35 mph when the lead locomotive unit of NPH-16 collided with the caboose of SGTLB-635. The head brakeman of NPH-16 was killed and the engineer was critically injured. The engineer did not recall the actions of the head brakeman during the trip from East Hermosa or what occurred after the collision.

Shortly after the accident, the conductor of SGTLB-635 climbed into the second unit of NPH-16 and radioed the enginer of SGTLB-635 to find out if an ambulance was on the way. The engineer, however, was not immediately aware that an accident had occurred until he heard this request for an ambulance. He recalled that his locomotive had moved forward a few feet several minutes before the radio message and that the train's airbrakes had applied in emergency. However, he was not overly concerned because of the train's earlier uncalled-for emergency brake application at West Hermosa. While he was evaluating the train's condition, the engineer heard the message from the conductor. He quickly radioed the operator at Laramie and the dispatcher about the collision. The time was about 3:10 p.m.

UP supervisors immediately notified local emergency rescue personnel while uninjured crewmembers from SGTLB-635 and NPH-16 went to the accident site to aid the injured. Ambulances and a helicopter were quickly dispatched to the scene, and the UP sent a vehicle that could operate in snow from Laramie with two company supervisors. The vehicle was used in assisting the emergency personnel to carry the injured to the helicopter and ambulances which had to remain some distance from the scene because of snow conditions.

Injuries to Persons

	SGTLB-635 Crewmembers	NPH-16 Crewmembers	Total
Fatal	1	1	2
Nonfatal	1	1	2
None	2	2	4
Total	4	4	8

Damage

The caboose and three rear cars of SGTLB-635 were derailed. Most of the collision force was absorbed by the caboose, which was demolished. Only a portion of the cupola and the windows on its right side were still intact. The two rear cars of grain were heavily damaged when they were derailed and overturned, one to the south and one to the north of the track. The third rear car of grain was upright in the track with its rear truck derailed.

The 3 locomotive units and lead 13 cars of NPH-16 were derailed. The lead unit left the track to the south and overturned onto its left side, stopping about 155 feet west of signal No. 5517. The lead unit sustained moderate damage to its forward hood and operating compartment. The two following units jackknifed and became crosswise with the track. The second unit was heavily damaged when struck by the following unit and derailed cars. The third unit sustained only minor

damage. Ten of the 13 derailed cars were demolished. About 360 feet of the track was destroyed. Westbound signal No. 5517 and eastbound signal No. 5318 were knocked down and were lying on the north and south sides of the track, respectively. The signal relay case was damaged and lying on its back on the north side of the track.

Damage was estimated to be as follows:

Train equipment	$598,000
Train lading	280,000
Track	75,000
Signal and communications	5,000
Clearing of wreckage	35,000
Total	$993,000

Crewmember Information

Each of the trains involved in the accident had an engineer, conductor, and two brakemen. All were qualified under UP operating rules.

The crewmembers of NPH-16 (see appendix B) reported for duty at 10:15 a.m. on October 16, 1980, and had been on duty about 4 hours 50 minutes when the accident occurred. The engineer and conductor were regularly assigned to the Cheyenne-Rawlins through-freight pool. The head brakeman and rear brakeman were extra employees working temporary vacancies from the extra list. The engineer had 30 years service as a fireman and engineer and had been qualified as an engineer on the Cheyenne-Rawlins territory in 1969. Prior to reporting to work on October 16, 1980, the engineer had been off duty for 22 hours. He stated that on October 15 1980, he had spent a normal day at home and that on October 16 1980, he awoke about 7 a.m. after a full night's sleep. Immediately after the accident, the engineer's attending physician at the Laramie hospital reported that he found no evidence of alcohol in his examination. The engineer of NPH-16 was required to wear glasses with corrective lenses while on duty. He stated that he was wearing his glasses at the time of the accident.

The head brakeman had 2 years of service as a brakeman and had last worked on October 15, 1980. A postmortem toxicological and drug screen examination was negative for alcohol and drugs.

The conductor had been off duty for more than 48 hours and the rear brakeman had been off duty for 18 hours 15 minutes before reporting to work. The conductor said he noticed nothing unusual about the condition or behavior of the engineer or head brakeman at the time they reported.

The crewmembers of SGTLB-635 had reported for duty at 9:30 a.m., October 16, 1980, and had been on duty about 5 hours 40 minutes when the accident occurred. All crewmembers had been off duty more than 24 hours before reporting for duty.

Train Information

NPH-16 originated in North Platte, and the original makeup of the train had never been altered. At the time of the accident, the train consisted of 3 General Motors Model SD40-2, diesel-electric locomotive units, Nos. 3749, 3363, and 3521; 68 cars of mixed freight; and a caboose. The train was about 4,000 feet long and had about 5,450 trailing tons. It was authorized to operate at a maximum speed of 50 mph except in areas with speed restrictions and on descending grades according to special instructions. The lead locomotive unit, No. 3749, had its short low hood forward and was equipped with functioning headlights, speed indicator, and an operable cassette-type event recorder capable of recording elapsed time, speed and distance, amperage, direction of movement, throttle position, airbrake applications, dynamic braking, and independent braking. The unit was also equipped with an operable UP radio, overspeed control, floor-mounted deadman pedal, and cab signals with acknowledging lever and warning device. If a more restrictive cab signal was not acknowledged, an automatic full service application of the airbrakes would occur. The warning device was mounted on the forward wall adjacent to the cab signal indicator near the center of the cab. The cab signals could be seen from both the engineer and the brakeman positions. The brakeman position was provided with an emergency airbrake valve. The caboose had bay windows in lieu of a cupola. Both lead unit and caboose had functioning permanent radios using the UP frequency.

SGTLB-635 consisted of 3 General Motors Model SD40-2 locomotive units, 76 loaded hopper cars of grain, and a caboose. The lead unit was equipped with functioning cab signals, speed indicator, speed recorder, floor-mounted deadman pedal, and an operable UP radio. The train had about 9,400 trailing tons, was about 4,280 feet long, and was authorized to operate at a maximum speed of 50 mph. The caboose was a cupola type with a red marker light mounted on the roof.

Method of Operation

Trains are operated over the three main tracks between Cheyenne and Laramie by automatic wayside signals of a centralized traffic control system (CTC) supplemented by locomotive cab signals. Train crewmembers are also directed in their duties by radio-transmitted instructions from the dispatcher in Cheyenne. The tracks are numbered 1, 2, and 3 from north to south. Tracks Nos. 1 and 2 parallel each other from Cheyenne to Laramie. Track No. 3 follows a different alignment some distance south of Tracks Nos. 1 and 2 between Cheyenne and Dale Junction. At Dale Junction, track No. 3 joins track No. 2. Only tracks Nos. 1 and 2 are between Dale Junction and East Hermosa. At East Hermosa, track No. 3 begins again and parallels tracks Nos. 1 and 2 to West Hermosa. At West Hermosa, track No. 3 begins to follow a different and southwesterly alignment some distance south of tracks Nos. 1 and 2. After about 5 miles, track No. 3 curves to the northwest and again meets tracks Nos. 1 and 2 where they enter Laramie.

Through the use of crossover tracks, the dispatcher can route a train over any of the three main tracks between control points to allow the train to overtake and pass another train. The tracks are signaled in both directions and the intermediate signals are of the approach-lighted, four-aspect, color-light type. The

intermediate signals do not illuminate until a train passes the preceding signal or the circuitry in the preceding block is otherwise shunted. The signals are each mounted on a single pole to the right side of the track in the direction of travel. The home signals at East Hermosa and West Hermosa are bridge-mounted over the three tracks, except the westbound home signal for track No. 2 at East Hermosa. This signal controls movement from track No. 2 to either tracks Nos. 2 or 3 and is mounted on a single pole. Once the dispatcher has established the route for a train between home signals at switch locations called control points, the intermediate signals governing the route are automatically established for that train. The dispatcher can change the routing for a train through the switch only if the switch and track between insulated joints at clearance points is not occupied. However, the switch position and home signal will not change unless the block beyond the signal is not occupied.

If the block beyond an intermediate signal is occupied by a train, the signal will display the following aspect:

Aspect	Name	Indication
Red or red over red (with number plate)	Stop and Proceed	Stop before any part of train or engine passes the signal, then proceed at restricted speed through entire block.

If the block governed by the signal is clear and the block in advance of that block is occupied, the signal will display the following aspect:

Aspect	Name	Indication
Yellow	Approach	Proceed prepared to stop before any part of train or engine passes the next signal. Trains exceeding 30 mph must immediately reduce to that speed.

If two blocks in advance of the signal are unoccupied, but the third block ahead of the signal is occupied, the signal will display the following aspect:

Aspect	Name	Indication
Flashing Yellow	Advance Approach	Proceed. Speed passing signal must not exceed 40 mph.

If three blocks in advance of the signal are unoccupied, and the route was established for the train at the last control point, the signal will display the following aspect:

Aspect	Name	Indication
Green	Clear	Proceed

The automatic cab signal system (ACS) in locomotive unit No. 3749 of NPH-16 was designed to repeat the four basic wayside signal aspects--clear, advance approach, approach, and stop--which a train would encounter. Whenever the cab signal changed to a more restrictive aspect, the engineer was required to move the three-position acknowledging device from the "normal" to the "acknowledge" position. Failure of the engineer to do this would result in the continuous sounding of a horn located above and between the front cab windows. If the engineer failed to acknowledge within 6 seconds, the airbrakes would apply automatically at a service rate.

A dispatcher at Cheyenne directed operations over the territory in which the accident occurred. He monitored the movements of trains as they reached and passed the control points, represented by lights on the panel of his CTC console. In addition, the console was equipped with a recording graph that tracked the movements of trains by time and location. The dispatcher, according to UP instructions Nos. 100 and 101 for train dispatchers (see appendix C), was required to check the graph's timing device against the standard clock, adjust the graph for any time discrepancy, and to identify and indicate movement of each train on the graph.

The dispatchers at Cheyenne work shifts of 7 a.m. to 3 p.m., 3 p.m. to 11 p.m., and 11 p.m. to 7 a.m. According to UP instruction No. 145, before changing shifts the outgoing dispatcher is required to brief the oncoming dispatcher. Dispatchers are required to keep trains moving in an expeditious and safe manner. If trains are not moving, or are having difficulties, the dispatcher is required to determine what may be the problem. According to instruction No. 1, dispatchers must provide proper protection for all trains and guard against dangerous conditions in train movements. Instruction No. 12 requires that when weather conditions endanger the safety of trains, the dispatcher shall issue proper slow or cautionary orders and arrange for trains to be stopped or spaced to insure safety of operation.

A Superintendent's Bulletin Order A-9, which was an addition to the tables on page 148 of System Timetable No. 3, was in effect on October 16, 1980. (See appendix D.) The bulletin listed speed restrictions for trains, based on tons per operative brake, westward between Hermosa and Laramie on track No. 3. The timetable special instructions listed the amount of horsepower for the various types of locomotive units on the UP. Trains with between 60 to 80 tons per operative brake, with 1 horsepower per trailing ton of effective dynamic brake on units providing dynamic braking, were not to exceed timetable speeds from Hermosa to Laramie. Trains providing less than 1 horsepower per trailing ton of effective dynamic brake on units providing dynamic braking were not to exceed 30 mph from Hermosa to Red Buttes.

The UP notes the authorized speed of a train on clearance form No. 2643 for an engineer. The maximum authorized speed for NPH-16 on October 16, 1980, was

listed as 50 mph. This maximum speed did not apply in areas with speed restrictions and on descending grades except if authorized by special instructions.

UP "Rules and Instructions Governing the Operation of Air Brakes," on which student engineers are examined and engineers are reexamined every 2 years, contains 10 rules for the use of the dynamic brake and 2 rules for grade braking. (See appendix E.) The rules applicable to handling the brakes of a train while descending the grade on track No. 3 between Hermosa and Laramie are as follows:

> 1039A. Dynamic brake must be supplemented by use of train air brakes to extent necessary to properly control speed of train.
>
> * * *
>
> 1043. When starting freight trains from summit of heavy descending grades and pressure maintaining method of braking is to be used, care must be used to avoid making first reduction too heavy as this would reduce speed of train to extent brakes would have to be released.
>
> If first reduction was not sufficient to hold train, further brake pipe reductions of one or two pounds each may be made until amount is reached where train will be held at desired speed.
>
> Equalizing reservoir guage must be frequently observed and if any increase in pressure is shown on this gauge during time brakes are applied, this pressure should be promptly reduced to the amount indicated by this gauge before increase occurred.

A special rule listed in the UP timetable stated:

> 1042 (RW) The tables on page 148 [of the timetable] govern operation of freight trains and use of retaining valves, in territories shown. This does not modify the requirements of Air Brake Rule 1042:
>
> 1. Dynamic brake must be placed in operation and tested at a convenient location prior to reaching designated descending grades.

Meteorological Information

At 1:50 p.m., October 16, 1980, the weather station at Laramie, 15 miles west of the accident site, recorded snow showers; pockets of fog; barometric pressure, 29.63 inches; winds, 18 knots; visibility 8 miles; and temperature, 25° F. According to train crewmembers, there was no atmospheric restriction to visibility in the accident area.

Survival Aspects

The caboose on SGTLB-635 was completely crushed as a result of the collision. However, the conductor survived the accident with comparatively few injuries because he apparently was ejected through a cupola window and landed in a snowbank. The roof of the cupola was torn back from the right side where the conductor was located. (See figure 2.)

The rear brakeman in the caboose was found near the conductor's desk at the front of the caboose where he had been seated at the time of the collision. He received multiple severe crushing injuries that were instantly fatal.

The left side of the lead locomotive unit of NPH-16 was the most heavily damaged. (See figure 3.) The head brakeman was found lying on the left cab wall where the unit came to rest. He received severe multiple head and chest injuries that were instantly fatal.

Tests and Research

The recording graph from the dispatcher's CTC machine (see appendix F) was inspected to determine the routing of westbound trains and their times passing the various control points on October 16, 1980, before and just after the accident. The graph indicated that seven trains were stopped on track No. 3 ahead of SGTLB-635. Because of a snowstorm during the night, a switch west of Laramie had frozen, causing trains such as SGTLB-635 to stop and close up within blocks.

The graph indicated that SGTLB-635 arrived at Dale Junction at 1:18 p.m., and the caboose passed the signal at 1:24 p.m. The train arrived at East Hermosa at 1:29 p.m., and the caboose passed the signal at 1:32 p.m. The train arrived at West Hermosa at 1:32 p.m., and the caboose passed the signal at 1:54 p.m.

The graph indicated that NPH-16 arrived at Dale Junction at 1:36 p.m. and its caboose passed the signal at 1:42 p.m.; that the route was lined for movement from track No. 2 to track No. 3 at East Hermosa and the signal cleared at 2:19 p.m.; that NPH-16 arrived at East Hermosa at 2:58 p.m. and the caboose passed the signal at 3:02 p.m.; and that NPH-16 arrived at West Hermosa at 3:02 p.m., and its caboose passed the signal at 3:04 p.m.

The event recorder printout of NPH-16 was inspected to determine how the train was actually operated between Dale Junction and the point of collision. (See figure 4.) The printout indicated that after approximately a 4-minute stop at Dale Junction, the throttle was progressively increased from idle to 8th run position. Maximum speed between Dale Junction and East Hermosa in 8th run position was approximately 22 mph. Throttle was then reduced progressively to idle, and at approximately 10 mph, the dynamic brake was applied. A very short time later, minimum brakepipe application was made and held until the train came to a stop. After the train stopped, an additional 4-pound brakepipe reduction, for a total of 10 pounds, was made. The brake valve was released and the locomotive brakes were applied. The train remained stopped for approximately 1 hour 6 minutes. Then the independent brakes were released, and throttle was increased between 1st and 2nd run until a speed of approximately 28 mph was obtained, at which time

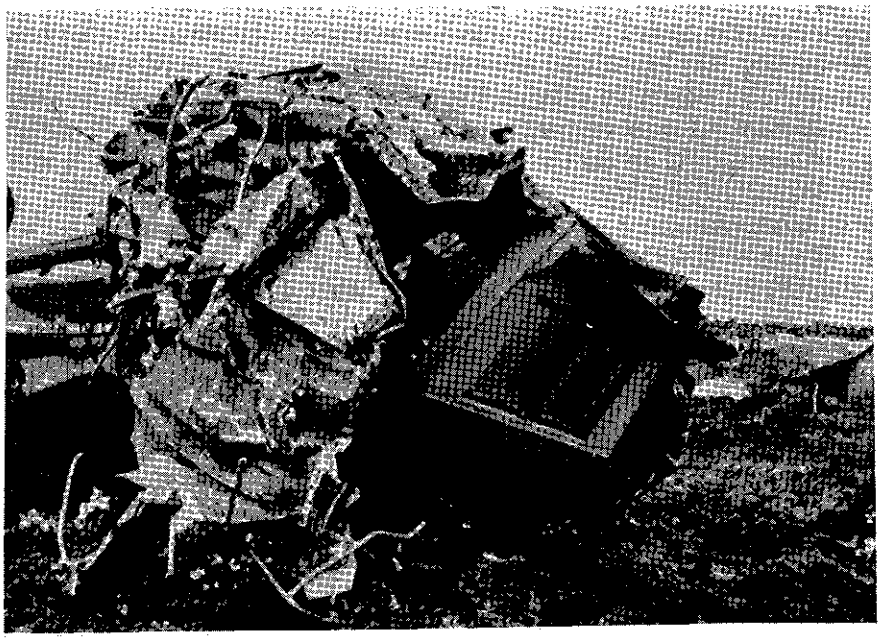


Figure 2.--Caboose of SGTLB-635.

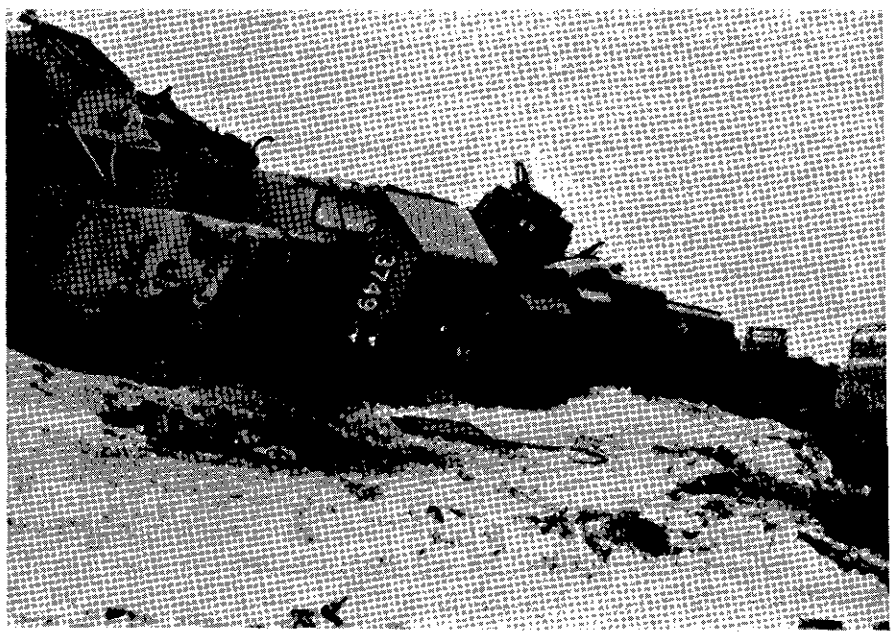


Figure 3.--Locomotive unit No. 3749 of NPH-16.

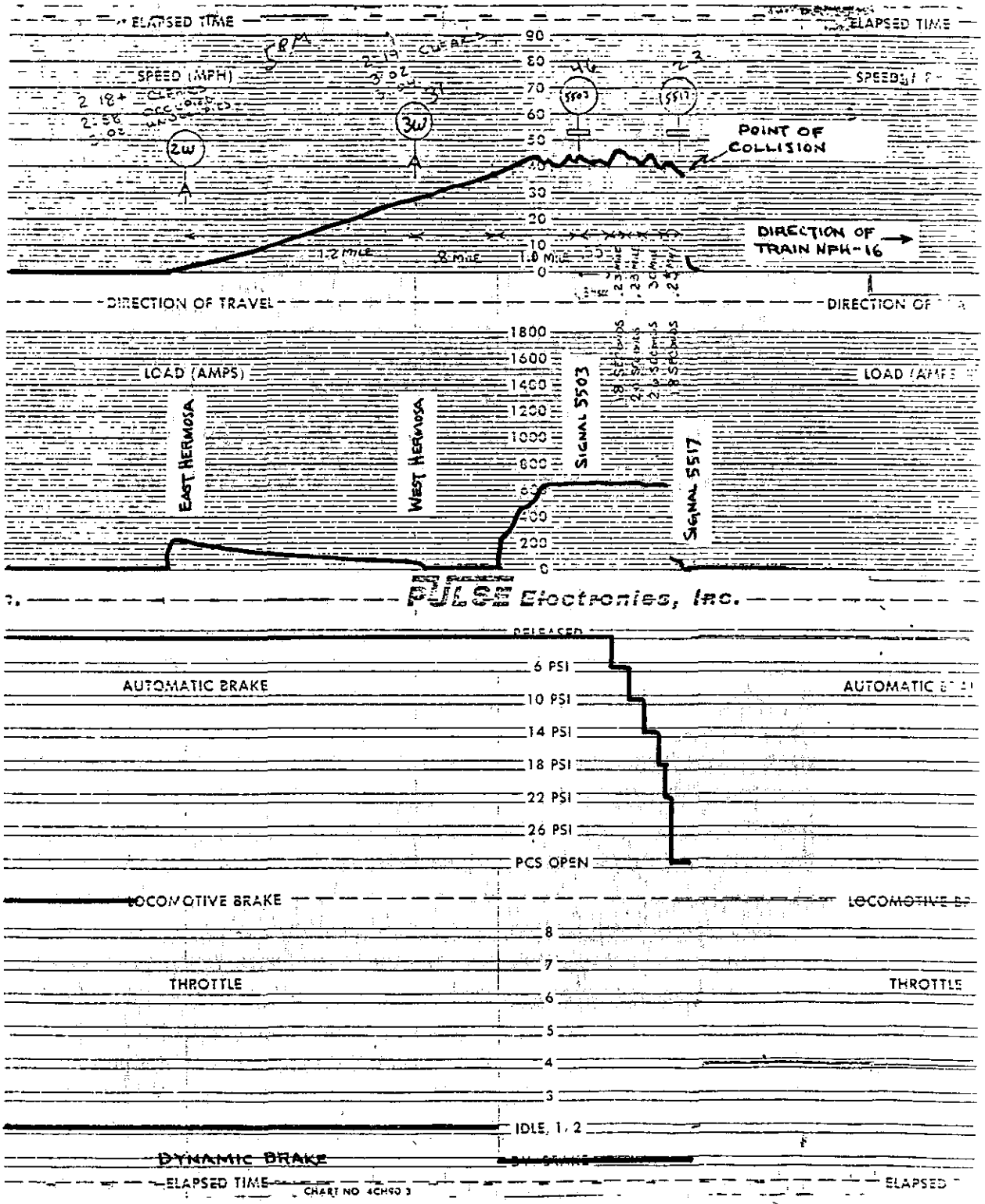


Figure 4.--Event recorder printout of NPH-16.

throttle was reduced to idle position. The train drifted for approximately 0.8 mile immediately after passing the signal at West Hermosa. Then dynamic braking was applied about 1 mile east of signal No. 5503 and progressively increased to full dynamic braking while the train accelerated to a speed of about 35 mph during the next 0.5 mile. At signal No. 5503, speed had increased to about 42 mph. After approximately 0.35 mile of continued dynamic braking west of signal No. 5503, a minimum brakepipe reduction was made. This was held for approximately 18 seconds. At this time, the speed was approximately 47 mph. Then an additional brakepipe reduction of 4 pounds, for a total of approximately 10 pounds, was made; this was held for approximately 20 seconds. Then an additional brakepipe reduction of 4 more pounds, for a total of approximately 14 pounds, was made and held for approximately 21 seconds. Then brakepipe reduction of an additional 2 or 3 pounds was made and held for approximately 5 seconds. The train's brakes were then placed into emergency about 0.25 mile east of signal No. 5517 while the train's speed was approximately 40 mph. The train continued in emergency for approximately 18 seconds, at which time there was a total loss of speed signal on the event recorder, which would indicate the point of impact.

An inspection of the cab of locomotive unit No. 3749 of NPH-16 made shortly after the accident disclosed that the automatic brake valve was in full-release position, the independent brake valve was in release position, the emergency brake handle on the brakeman's side had not been applied, the deadman foot pedal was depressed with a metal object which nullified the pedal's function, the brakepipe cut-off valve was cut in, and the brake application valve was in the lead position. The cab signal control valve was cut into the cab control system and sealed. The event recorder, manufactured by Pulse Electronics, Inc., was located inside a compartment under the deck on the left side of the locomotive. The batteries, located under the left front walkway of the locomotive, were destroyed in the accident, resulting in the loss of electrical power to the event recorder, cab lighting, and other auxiliary electrical circuits.

On October 17, 1980, a test was made of the airbrake equipment on the cars of NPH-16 that were not derailed. This test was conducted in the UP's Cheyenne Yard and observed by investigators. In the test and inspection of 55 cars, 4 cars would not make a brake application with a full service reduction and 1 car was missing a dead lever pin, which rendered the brakes ineffective on that car. Of the 55 cars inspected, 9 had ABDW brake equipment, 19 had AB brake equipment, and 27 had ABD brake equipment.

All controlling relays and circuits for the signal at West Hermosa and intermediate signals Nos. 5503 and 5517 were tested by UP and Federal investigators soon after the accident. The equipment was found to be free of defects, no evidence of tampering was found, and the equipment functioned as designed with the signals displaying proper aspects. The signal case and relays from the damaged case at signal No. 5517 were taken to Laramie and individually tested; no exceptions were noted. Circuiting for the locomotive cab signals was tested and found to be operating in accordance with the wayside signals.

On November 17, 1980, signal tests were made of the signals on track No. 3 between East Hermosa and Red Buttes. These tests, which simulated train occupancy of the various blocks similar to the occupancy on the day of the

accident, were conducted by qualified UP signalmen accompanied by Federal investigators. All signals functioned properly and no exceptions were noted.

On November 19, 1980, three stopping distance tests were made with a test train assembled to simulate NPH-16 with approximately the same tonnage, the same type and number of locomotive units, and approximately the same number of cars. (See figure 5.) The test train consisted of UP locomotive units Nos. 3747 3673, and 3773; 67 loaded freight cars and 3 empty freight cars; and the trailing tonnage was estimated to be 5,436 tons. Each unit was equipped with a Pulse tape event-recording device which was capable of recording on a magnetic tape the last 48 hours of the following functions: elapsed time, speed and distance, direction of travel, loads or amps, automatic brake application, throttle settings, dynamic braking, and independent braking.

The first test was prearranged to simulate the Pulse tape event recording data removed from locomotive unit No. 3749 on the day of the accident. In this test, the train's speed was allowed to reach 30 mph before the dynamic brake was initially applied about 0.8 mile west of West Hermosa. The throttle was advanced in dynamic braking to 6th position, about 0.5 mile from the signal at a speed of 38 mph. At signal No. 5503, the throttle was in 8th dynamic position and the speed was 46 mph. Five-tenths of a mile west of the signal, and 39 seconds later, a 6-pound brakepipe reduction was made; 32 seconds later, a further reduction of 4 more pounds was made; 35 seconds later, a further reduction of 4 pounds was made, totaling 14 pounds; and 22 seconds later, the airbrakes were applied in emergency. At the collision point, the test train's speed was 25 mph, according to the speed indicator. The lead locomotive unit of the test train stopped 1,500 feet west of signal 5517, about 1,400 feet beyond the collision point.

A second test was made to determine how the train would react if the dynamic brake was tested for effectiveness between East and West Hermosa, then later applying the dynamic brake to prevent passing signal No. 5503 at a speed not exceeding 40 mph, and immediately applying the airbrakes to reduce to a speed of 30 mph prepared to stop for signal No. 5517. After the test train was started at East Hermosa, the dynamic brake was applied about 0.25 mile west of the signal at West Hermosa at a speed of 28 mph. The speed was controlled with the dynamic brake in 7th position, and a 6-pound brakepipe reduction was made while the train passed signal No. 5503 at 40 mph. The speed decreased from 40 mph to 26 mph in 2,490 feet and then another 4-pound brakepipe reduction was made, increasing the total to 10 pounds. The lead locomotive unit of the test train stopped 4,980 feet west of signal No. 5503 and 2,194 feet east of signal No. 5517.

A third test was made to determine compliance with UP Superintendent's Bulletin A-9 of March 12, 1980, which was an additional listing to the tables on page 148 of UP System Timetable No. 3. The table required that trains of between 60 to 80 tons per operative brake, using airbrakes only, must not exceed 30 mph between Hermosa and Red Buttes. Tons per operative brake for the NPH-16 were obtained by dividing the train's tonnage (5,450) by the number of cars (69) in the train. After the test train was started at East Hermosa, the engineer allowed the speed to increase to 30 mph; about 0.4 mile west of the signal at West Hermosa, a 6-pound brakepipe reduction was made. The train, with the brakes applied, passed signal No. 5503 with the throttle in 6th position; while moving at 32 mph, the

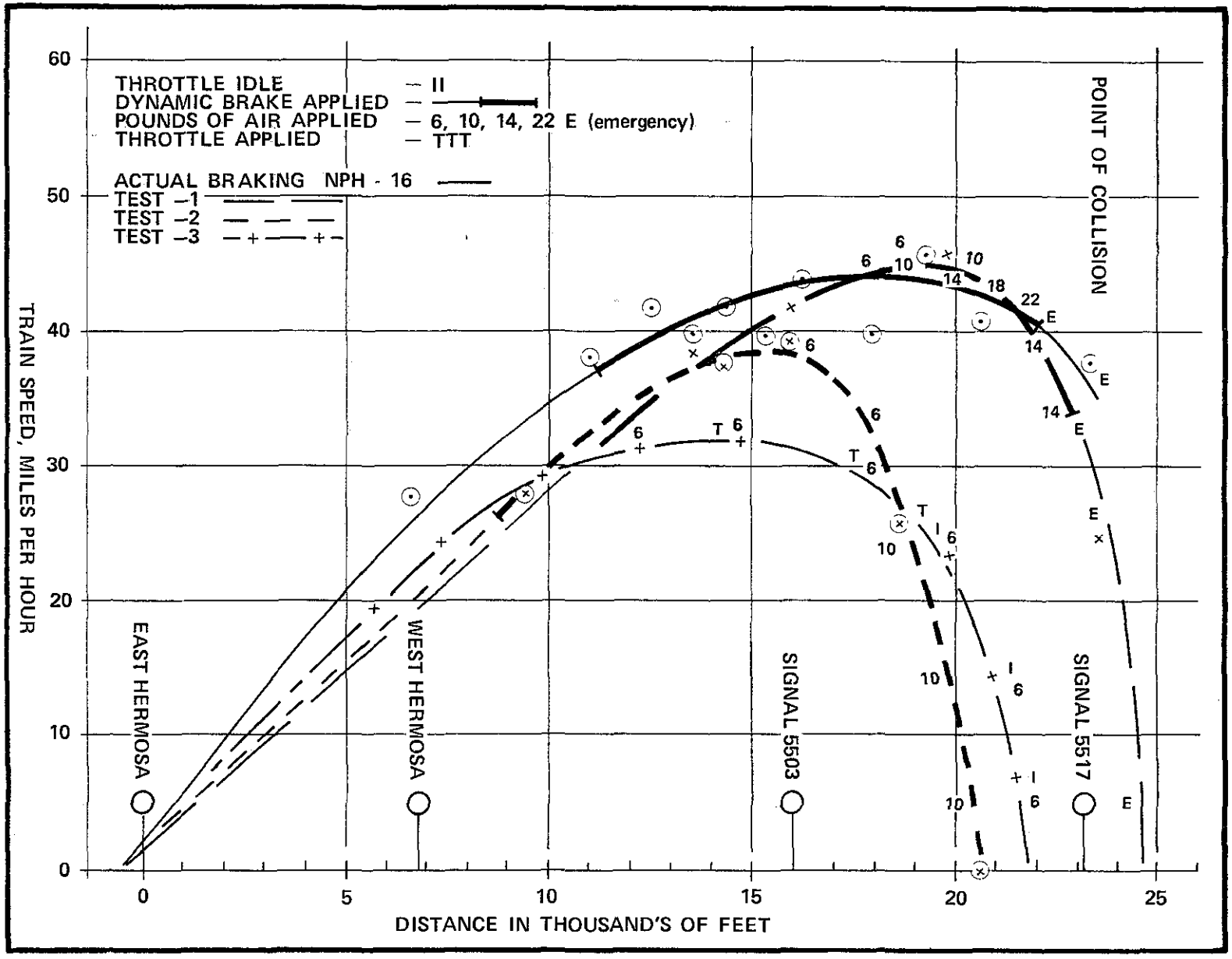


Figure 5.--Stopping distance tests of test trains.

throttle was gradually reduced to idle, 3,960 feet west of signal No. 5503. The train stopped in 2,000 feet with the lead unit 1,214 feet east of signal No. 5517.

The Air Brake Association stresses the importance of immediate action on grades when the dynamic brake is inoperative or a part of the dynamic brake becomes inoperative. 6/ A safe practice, according to the association, is to stop the train quickly. The association states that, on heavy grades, train speed can get out of control in a very short time and when use of emergency braking is apparent, a crewmember should not hesitate to use it. Service applications usually react too slowly and allow too much speed increase before the braking becomes effective. The dynamic brake is most effective prior to and at about 25 mph.

Locomotive unit No. 3749 of NPH-16 was given a series of tests on October 19, 1980, in Cheyenne to determine if the cab signals functioned as intended. The cab signal air release valve was also checked to see if the ports were open and free of obstruction. Although the locomotive unit was damaged, these test results indicated that the cab signals and safety features were functioning as intended. UP signal and mechanical personnel conducted these tests with Federal investigators.

Sight-distance tests were conducted by UP signal officials and Federal investigators on October 21, 1980, to determine where signal No. 5517 would come into view and where the caboose would come into view. The signal aspect became visible at 1,300 feet, and the caboose was sighted 1,200 feet from impact.

Other Information

The engineer of NPH-16 said that he understood the special instruction table listed in the Superintendent's Bulletin Order A-9 and that he had a "50-mph train." However, when asked how he knew this and to explain the table, he was unable to do so. In addition, he stated that he had blocked the deadman pedal because of a foot problem and also to allow him to stand when meeting trains on an adjacent track that might have a protruding, shifted load.

An engineer on an eastbound train that passed the accident site about 20 minutes after the accident said he looked back and saw the westbound signal for track No. 3 at West Hermosa with a flashing yellow aspect while NPH-16 was standing in the next block beyond. Investigators could not determine why this signal aspect would have been displayed. The signal should have displayed a steady yellow aspect after the accident. The engineer on a train that followed NPH-16 into the block about 40 minutes after the accident said the signals were working as intended.

The head brakeman of an eastbound train on track No. 2, which passed the moving NPH-16 on track No. 3 while between East and West Hermosa, said he saw both the engineer and head brakeman seated and awake in the cab of the lead locomotive unit as their locomotives passed each other.

6/ Air Brake Association, "Management of Train Operation and Train Handling," Fourth Edition, 1977. (See appendix G.)

ANALYSIS

Train Delay

Since the normal running time between Dale Junction and East Hermosa is about 10 minutes, as indicated by the movement of SGTLB-635, NPH-16 should have arrived at East Hermosa at about 1:46 p.m. after leaving Dale Junction at 1:36 p.m. Because SGTLB-635 did not leave West Hermosa until 1:53 p.m. because of the emergency brake application, the signal at East Hermosa would have been displaying a stop aspect for the approaching NPH-16. Because the signal at East Hermosa is a home signal, the engineer properly kept NPH-16 east of the signal and did not close up on SGTLB-635 while it was in the block ahead. However, when the East Hermosa signal changed to a green aspect at 2:19 p.m., and NPH-16 did not begin to move past the signal until 2:58 p.m., it suggests that both the engineer and conductor may have been inattentive to their duties.

First, according to UP operating rule 269, both the engineer and conductor of NPH-16 should have contacted each other and then radioed the dispatcher to determine why the East Hermosa signal was remaining at a stop indication for such a long time. Second, when the engineer saw the aspect change to green, he should have notified the conductor and the dispatcher of his decision not to move NPH-16 because the head brakeman was ill and not in the lead locomotive unit. If the crewmembers had communicated with each other and the dispatcher to determine why the signal at East Hermosa was remaining at stop for such a long time, they would probably have been told of the trains stopped ahead on track No. 3. The crewmembers then would have operated their train more cautiously after leaving East Hermosa and might have tried to contact SGTLB-635 to determine its stopped location. Also, if the crewmembers had known the location of SGTLB-635, any problem with the signal aspects would have become obvious to the crewmembers in the locomotive.

Since the dispatcher was unable to contact either the engineer or conductor of NPH-16 after the dispatcher had cleared the East Hermosa signal, and since both the locomotive and caboose had working radios, it becomes all the more apparent that the crewmembers were inattentive to their communication duties. However, for the dispatcher not to have radioed NPH-16 again before and after he noticed on his train graph that the train had begun to move at 2:58 p.m. indicates an inadequate concern on his part for the train's operation. This lack of action, because of handling other train problems near Laramie and possibly due to the briefing of the next shift dispatcher who was coming on duty at 3 p.m., allowed the engineer of NPH-16 to advance his train after having been stopped for over an hour, unmindful of all the trains stopped on the track ahead. This inappropriate regard by the dispatcher for NPH-16 was a factor in the accident.

The Safety Board believes that the continued dispatching of trains westbound from Cheyenne in the face of a known storm and stopped trains, which eventually had some crewmembers remaining with their trains up to 20 hours of continued service because of an inability of the UP to relieve the crews, 7/ is an operating

7/Federal regulations (49 CFR 228) permit only a maximum of 12 hours of continued service.

practice which will strain the ability of a dispatcher and train crewmembers to function at a safe level of competence. Under such adverse conditions, more communication among crewmembers and the dispatcher becomes a necessary supplement to the signal system, a system which would be allowing trains to proceed under the possible tired or anxious watchfulness of their crewmembers. In addition, this communication should include any problems encountered by the crewmembers and the dispatcher and should be automatically recorded, if possible, for corrective action.

As a result of its investigation of the head-on collision of two Penn Central freight trains near Pettisville, Ohio, on February 4, 1976 8/ the Safety Board recommended that the Federal Railroad Administration (FRA) require enginecrews to communicate fixed signal aspects to conductors while trains are en route on signalized track to help keep each other alert. The FRA responded that such a requirement would be difficult to regulate, and the FRA has not established such a requirement.

Signal Operation

The engineer of SGTLB-635 stated that he received a flashing yellow aspect at West Hermosa, a yellow aspect at signal No. 5503, and a red aspect at signal No. 5517 before proceeding beyond signal No. 5517 and stopping his train within the block behind another train. None of the previous trains during the morning of October 16, 1980, had reported any problems with the signals between East Hermosa and Laramie even though the storm had been more severe at that time. The engineer of NPH-16 should have received the same signal aspects as SGTLB-635 when leaving East Hermosa about 1 hour after SGTLB-635 had stopped with its caboose about 100 feet west of signal No. 5517. The engineer of the train following NPH-16 said that he stopped east of signal No. 5503 because it was displaying a red aspect; the rear portion of NPH-16 would have been occupying the block ahead at the time. Postaccident tests of the signal system after the accident indicated that the signal system was functioning properly. Therefore, the Safety Board concludes that the signal system was working properly at the time of the accident.

The Safety Board is unable to determine why the engineer of NPH-16 could have seen green aspects, as he said he did, on the signal at West Hermosa and the two intermediate signals Nos. 5503 and 5517. In addition, the Safety Board cannot determine why the engineer of an eastbound train, when looking back at the westbound signal for track No. 3 at West Hermosa would have seen a flashing yellow aspect on the signal instead of a constant yellow. A flashing yellow at West Hermosa would indicate that signal No. 5503 was displaying a yellow aspect and that signal No. 5517 was displaying a red aspect. A constant yellow aspect should have been displayed after the accident, and it apparently was according to the engineer of the following eastbound train on track No. 3.

8/"Railroad Accident Report--Head-on Collision of Two Penn Central Transportation Company Freight Trains Near Pettisville, Ohio, February 4, 1976" (NTSB-RAR-76-10).

Instances of a signal displaying a so-called "false-clear" 9/ aspect have been reported at times and confirmed each year throughout the country on various railroads. However, these circumstances are rare and, when investigated, it has been found that the signal will continue to display the improper aspect under the reported circumstances. These conditions normally are caused by worn relays or contacts in signal equipment, and at times by improper repair or rewiring. Postaccident tests in this case did not disclose any malfunctioning signal equipment or conditions and the train following NPH-16 did not encounter any improperly displayed signal aspects.

Train Handling

Since the locomotive crewmembers of NPH-16 were observed to have been seated in their lead unit when about halfway between East and West Hermosa by crewmembers of an eastbound train that was moving on the adjacent track No. 2, and more importantly because it is an unsafe practice and against UP rules, the need for the deadman safety pedal of NPH-16 to have been blocked and nullified to allow the engineer to stand for safety reasons when meeting trains on his side is questionable. However, since the engineer was continually awake, as indicated by the event recorder, the nullifying of the deadman pedal did not contribute to the accident.

Since NPH-16 had started from a stop at East Hermosa and was only moving about 28 mph when the locomotive passed the West Hermosa signal, it was not possible to determine from the event recorder if the train was moving for either a green aspect, which allows 50 mph, or a flashing yellow aspect, which should have been displayed and which allows 40 mph. However, regardless of which signal aspect was displayed at West Hermosa, the engineer should have tested and begun applying the dynamic brakes before entering the average 1.8-percent descending grade after West Hermosa at over 30 mph. Since the event recorder, contrary to the engineer's statement, indicates that he did not apply the dynamic brake until his train was moving over 35 mph, he had by then lost more than 30 percent of their effective braking capability. This braking capability also would have continued to decrease to approximately 50 percent as the speed increased to about 47 mph at 0.35 mile west of signal No. 5503. According to UP airbrake rules, if the dynamic brake is less than 1 horsepower per trailing ton, the maximum allowable speed for a train such as NPH-16 down the descending grade at Hermosa would have been 30 mph. Consequently, the engineer should have begun applying the dynamic brake before reaching 25 mph for better control on the grade and pending use of the airbrakes when moving between 30 and 50 mph, or he should have begun using the airbrakes sooner and not have allowed the train to obtain a speed greater than 30 mph on the descending grade. In either case, the engineer would have been able to stop the train short of the SGTLB-635's caboose according to the postaccident braking tests.

Since the event recorder indicated that the train was moving about 42 mph when it passed signal No. 5503, an engineer not properly informed about the use of the dynamic brake and its ability to stop a train on a 1.8-percent descending grade could still have believed he was not exceeding the authorized speed if the signal

9/Displaying a green or less restrictive aspect than should have been shown.

was displaying either a green or yellow aspect. According to the event recorder, it was only after passing signal No. 5503 that the engineer may have become aware that there was difficulty controlling the train's speed. This was evident when the engineer began to apply only the dynamic brake and the train speed continued to increase to about 47 mph even though the dynamic braking had been quickly increased to its maximum. If signals Nos. 5503 and 5517 had displayed green aspects allowing 50 mph, there would have been no need for the engineer to have quickly made a number of successive and increasing applications of the train's airbrakes which reduced the train's speed to 40 mph about 1,200 feet before signal No. 5517. Since a 10 pound or less airbrake application would have been sufficient to maintain the train's speed under 50 mph, the airbrake applications of more than 10 pounds indicate that the engineer was braking the train for a stop beginning about 0.5 mile east of and before he saw signal 5517.

The postaccident sight distance tests indicated that the engineer of NPH-16 would have been able to first see signal No. 5517 and the red marker light on the caboose of SGTLB-635 from about 1,200 feet, which is the point at which he first made an emergency brake application. Since the engineer was unable to do anything more to reduce the speed of his train, he was most likely the person who radioed the crewmembers of SGTLB-635 to get off of the caboose just prior to the collision.

Since the Safety Board believes that the signals were functioning properly, and since the postaccident tests of locomotive unit No. 3749's cab controls indicated they were operating properly, the Safety Board concludes that the engineer properly acknowledged the restrictive cab signals as the train passed the flashing yellow signal aspect at West Hermosa and the yellow aspect at signal No. 5503. The engineer of NPH-16 apparently thought that his maximum application of the locomotive's dynamic brakes would reduce the 42-mph speed of his train after it passed signal No. 5503. Instead, the brake application was ineffective and allowed the train's speed to actually increase. The Safety Board concludes that when the engineer first realized that the dynamic brakes were not going to slow his train, the train had traveled too far into the approximate 7,000-foot block for the train to stop with use of the train's airbrakes before reaching signal No. 5517.

Airbrake Rules and Speed Instructions

As an experienced engineer, the engineer of NPH-16 should have known that the dynamic brake is most effective up to 25 mph, a speed the train was traveling between East and West Hermosa. Had he made an initial application of the dynamic brake at that time, as required by rule 1042 (RW), he would have known how effective the dynamic brake was. Therefore, he would have known what actions were required to properly control the train's speed descending the 1.8-percent grade if the dynamic brake was not functioning properly. Since the locomotive units of NPH-16 were extensively damaged, it was not possible to determine how effective the dynamic brake may have been prior to the collision. However, in the braking test which duplicated the engineer's handling of the train, the test train with the effective dynamic brake was also unable to slow or stop before signal No. 5517. Therefore, the dynamic brake on NPH-16 apparently was working properly.

It was important that the engineer understand how to determine how many tons per operative brake his train had before descending the steep grade over 1.5 percent. However, the airbrake rules of the UP do not adequately explain when the dynamic brake is effective, nor do the timetable special instructions adequately explain how to determine a train's tons per operative brake. The Safety Board believes that if engineers and other crewmembers are supposed to know how to interpret and apply the special instructions which are related to the use of the dynamic brake, there should be additional train handling and airbrake rules which supplement these instructions.

Rules and Examinations

The inability of the engineer of NPH-16 to explain how he would apply the special instructions to his train indicates that the UP rules and the engineer's examination of the rules may have been inadequate. Since the UP requires its engineers to be reexamined on the "Operating Rules and Instructions Governing Operation of Air Brakes" only once every 2 years, and because the engineer of NPH-16 had not received either instruction or examination of these rules since May 18, 1978, it is evident that the engineer of NPH-16 probably was not adequately instructed or kept abreast of changes such as those stressed by the Air Brake Association. Since the Safety Board has investigated four other accidents on the UP since March 1979, 10/ and is currently investigating another major accident on the UP, 11/ all of which have involved either improper train handling, poor equipment inspection, or human factors, the Safety Board concludes that UP employees are apparently not adequately instructed concerning UP rules, nor are they properly examined on the rules.

Event Recorder

The Safety Board commends the UP for the installation of the event recorders on its locomotives. The event recorder was very helpful in determining the actual speed of NPH-16, the use of the dynamic brake, the airbrake applications, the throttle positions, and the time elapsed as the train approached the point of collision. However, it did not record the engineer's acknowledgment of the restrictive signals when they were passed. If movement of the acknowledging lever had been recorded, it would have been possible to confirm which signals had restrictive aspects. In its investigation of the derailment of Amtrak train No. 4 at Lawrence, Kansas, on October 2, 1979, 12/ the Safety Board also found that it

10/ "Railroad Accident Report--Rear-End Collision of Two Union Pacific Freight Trains, Ramsey, Wyoming, March 29, 1979" (NTSB-RAR-79-9);
"Railroad Accident Report--Derailment of Union Pacific Railroad Freight Train, Granite, Wyoming, July 31, 1979" (NTSB-RAR-79-12);
"Railroad Accident Field Investigation--Derailment of Union Pacific Freight Train, Albany, Wyoming, February 11, 1980" (NTSB-DEN-80-FR-013);
"Railroad Accident Field Investigation--Derailment/Collision of Union Pacific Freight Trains, Granite, Wyoming, October 13, 1979" (NTSB-DEN-80-FR-001).
11/ Rear-end collision of two Union Pacific Railroad Company freight trains at Kelso, California, on November 17, 1980.
12/ "Railroad Accident Report--Derailment of Amtrak Train No. 4, on the Atchison, Topeka and Santa Fe Railway Company, Lawrence, Kansas, October 2, 1979" (NTSB-RAR-80-4).

would have been possible to determine if the engineer had acknowledged the automatic train stop (ATS) inductor if the event recorder had been adapted to record that event. Since such information would be useful in determining if signal systems or ATS equipment is functioning properly, the Safety Board concludes that acknowledgment of such safety systems should be recorded.

Although the event recorder was not damaged in this collision, it was located in a forward area of locomotive unit No. 3749 that was easily damaged in the collision. Also, the locomotive batteries were destroyed in the accident, causing a loss of power to the recording device, radio, and cab lights. Even if the engineer had been able to summon help on the radio, he could not have done so because of the loss of power from the batteries. As a result of its investigation of the Lawrence, Kansas, accident, the Safety Board recommended to the FRA that emergency lights and power be provided on passenger train equipment. The FRA responded that it is evaluating necessary emergency requirements and hopes to complete its study in the near future. The Safety Board believes that emergency power and lights should also be provided on locomotives.

CONCLUSIONS

Findings

1. The crewmembers of NPH-16 were inattentive to their communication duties while stopped at East Hermosa for about 1 hour and should have had radio communication with one another and the dispatcher concerning the signal delay and any other problems.

2. The dispatcher should have shown more concern and tried more often to have radio communication with NPH-16 crewmembers to determine why the train did not move promptly after the signal was cleared at East Hermosa.

3. It may be beneficial that radio communications between crewmembers and the dispatcher be recorded for identifying and recording problems.

4. Because of the storm and train delays, the burdens of the job increased and the dispatcher may not have been able to function at the level of expertise required by his job.

5. Other train movements and signal tests indicate that the wayside signals and the locomotive cab signals which governed the movement of NPH-16 from East Hermosa to the accident location functioned properly.

6. The engineer of NPH-16 did not adequately use the train's dynamic brake and airbrakes for controlling the speed of the train after leaving West Hermosa.

7. The engineer of NPH-16 was unaware that his delayed use of the dynamic brake long after entering the descending grade at West Hermosa required that the train's speed should not increase over 30 mph.

8. UP train handling rules do not include instructions on when to apply the dynamic brake on descending grades, at what speeds the dynamic brake is most effective, and what procedure to follow when the dynamic brake fails on a descending grade.

9. The nullifying of the deadman safety control pedal by the engineer of NPH-16 had no effect on the accident.

10. The engineer of NPH-16 had not been examined on the UP rules within the required previous 2 years, and he did not adequately know the UP special instructions.

11. The human-failure type of accidents that have occurred on the UP during the past 2 years indicate inadequate instructions, training, and rules examinations of operating employees.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the inadequacy of Union Pacific rules in explaining train handling and braking procedures, along with the engineer's lack of comprehension of those rules and his inadequate handling of the train's brakes, which resulted in his failure to bring the train to a stop as required before reaching signal No. 5517. Further, there was a lack of necessary communication among train crewmembers and with the dispatcher.

RECOMMENDATIONS

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

--to the Union Pacific Railroad Company:

Establish rules and procedures which require enginecrews to communicate fixed signal aspects to conductors while trains are en route on signalized track. (Class II, Priority Action) (R-81-41)

Amend and clarify rules to require dispatchers and train crewmembers to communicate with each other about conditions affecting the movement of their train. (Class II, Priority Action) (R-81-42)

Expand the rules and instructions governing the use of the dynamic brake to include conditions of when to apply the dynamic brake on a descending grade, at what speeds the brake is most effective, and what action to take when the dynamic brake has

failed prior to or while being applied. (Class II, Priority Action) (R-81-43)

Improve training, evaluation, and examination of train crewmembers so that they become and remain proficient in the train handling and special instruction aspects of their territories. (Class II, Priority Action) (R-81-44)

Modify event recorders to record activation of the cab signal acknowledging lever. (Class II, Priority Action) (R-81-45)

Relocate event recorders so as to lessen the likelihood of their becoming damaged in an accident. (Class II, Priority Action) (R-81-46)

Provide the cabs of locomotives with emergency power so that emergency lights, radios, and event recorders continue to operate when normal power is lost. (Class II, Priority Action) (R-81-47)

--to the Association of American Railroads:

Encourage member railroads to establish rules that require enginecrews to communicate fixed signal aspects to conductors while trains are en route on signalized track. (Class II, Priority Action) (R-81-48)

Encourage member railroads to have event recorders which record activation of cab signal, automatic train stop, or other similar safety system devices. (Class II, Priority Action) (R-81-49)

Encourage member railroads to install or relocate event recorders so as to lessen the likelihood of their becoming damaged in an accident. (Class II, Priority Action) (R-81-50)

Encourage member railroads to provide the cabs of locomotives with emergency power so that emergency lights, radios, and event recorders continue to operate when normal power is lost. (Class II, Priority Action) (R-81-51)

In addition to these recommendations, the Safety Board reiterates and reemphasizes the importance of the following recommendations which were made to the Federal Railroad Administration as a result of other train collisions:

"Promulgate rules to require engine crews to communicate fixed signal aspects to conductors while trains are en route on signalized track. (R-76-50)"

"Promulgate regulations which require an adequate backup system for mainline freight trains that will insure that a train is controlled as required by the signal system in the event that the engineer fails to do so. (R-76-3)"

"Promulgate regulations to require locomotives used in trains on main tracks outside of yard limits to be equipped with operating event recorders. (Class II, Priority Action) (R-78-44)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

ELWOOD T. DRIVER, Vice Chairman, and G. H. PATRICK BURSLEY, Member, did not participate.

April 7, 1981

APPENDIX A

INVESTIGATION

Investigation

The National Transportation Safety Board was notified of the accident about 7 p.m., e.d.t., on October 16, 1980. The Safety Board immediately dispatched an investigator from its Denver Field office and an investigator from Washington, D.C., to the scene. The investigation was completed with assistance from the Federal Railroad Administration and the Union Pacific Railroad Company.

Depositions

A 2-day deposition proceeding was held in Cheyenne, Wyoming, on December 9 and 10, 1980. Parties which participated in the proceeding were the Union Pacific Railroad Company, Brotherhood of Locomotive Engineers, and the United Transportation Union. Statements were taken from 13 witnesses.

APPENDIX B

TRAIN CREWMEMBER INFORMATION
EXTRA 3749 WEST (NPH-16)

Engineer Leonard E. Rottman

Engineer Rottman, 51, was employed as a student fireman by the UP at Cheyenne on June 23, 1950. He was promoted to fireman on July 13, 1950. On July 30, 1954, he was promoted to hostler, and on May 1, 1969, he passed the examination for promotion to engineer.

Mr. Rottman's service record indicates he had been disciplined four times since becoming an engineer. In 1971 he was given 45 demerits for damage to a yard engine. During April 1974 he was held responsible for a collision between his yard engine and another engine and a Jordan Spreader. During November 1974 he was dismissed for 6 months because of two incidents: failure to properly control the speed of his train between Laramie and Medicine Bow, and backing his locomotive into another train. He was last disciplined in April 1978 after he failed to control the speed of his train at 50 mph and passed a location at 61 mph. He passed a company physical examination on May 2, 1978, and was required to wear eyeglasses while on duty. He passed his last airbrake rules examination on May 18, 1978, and his last operating rules examination on April 10, 1980.

Conductor Keith D. Jacobs

Conductor Jacobs, 60, was employed as a brakeman by the UP at Cheyenne on November 20, 1941. He was promoted to conductor on September 25, 1950. Mr. Jacobs' service record indicates he had been disciplined three times since becoming a conductor. He was dismissed for about 19 months because of being drunk and resisting arrest on April 22, 1958. He was again dismissed for about 14 months because of being absent from his assignment on October 5, 1978. He was given a reprimand on September 9, 1980, for failure as conductor to notify his engineer or dispatcher of two cars in his train which were restricted to 40 mph while his train was given clearance for 50 mph. He passed his last airbrake rules examination on October 10, 1979, and his last operating rules examination on the same date. He passed his last physical examination on October 13, 1980, without any restrictions.

Head Brakeman Isaac K. Ortiz

Brakeman Ortiz, 22, was employed as an extra gang laborer in the UP track department at Cheyenne on September 21, 1977. He transferred to switchman at Cheyenne on March 3, 1978. He was promoted to sectionman on August 15, 1978, and later relinquished his sectionman rights to become a brakeman on December 21, 1978. He entered brakeman training on December 26, 1978, and became a brakeman on January 13, 1979.

Mr. Oritz's service record indicates he had been disciplined three times since becoming a brakeman. In July 1979 he was given 30 demerits for failure to properly line a derail which caused a locomotive to derail. In July 1979 he was

given 30 demerits for failure to report for duty. In August 1979 he was given a reprimand for being responsible for a run-through switch resulting in a derailment. He passed his last physical examination on December 21, 1978, without any restrictions. He passed his entrance and last airbrake rules examinations on January 13, 1979, and passed his last operating rules examination on the same date.

Rear Brakeman Ray A. Fernandez

Brakeman Fernandez, 26, was employed as an extra gang laborer in the UP track department at Cheyenne on August 7, 1973. He became a sectionman on August 11, 1977, at Hermosa, and was reemployed as a brakeman on December 11, 1978, at Cheyenne.

Mr. Fernandez's service record indicates he had been disciplined four times as an extra gang and sectionman, and once since becoming a brakeman. On May 15, 1975, he was dismissed for leaving work without authorization. He was given 30 demerits in June 1978 for being late to work, 30 demerits in July 1978 for failure to report to work, and 30 demerits and dismissed on July 31, 1978 for failure to report to work. As a brakeman, he was given 30 demerits for failure to report to work June 1980. He passed his last physical examination on November 9, 1978, without any restrictions. He passed his entrance and last airbrake examinations on December 11, 1978, and his last operating rules examination on November 1, 1979.

APPENDIX C

EXCERPTS FROM UNION PACIFIC RULES FOR TRAIN DISPATCHERS

Form 2274

INSTRUCTIONS

FOR

TRAIN DISPATCHERS

EFFECTIVE MAY 1, 1972

DUTIES OF TRAIN DISPATCHERS

1 Train dispatchers must provide proper protection for all train movements in accordance with rules or special instructions They must guard against dangerous conditions in train movements and unsafe or confusing combinations of train orders.

2 Train dispatchers must not authorize or instruct agents, operators, maintenance of way employes or others to handle switches for trainmen except when such employe is assigned that duty

3. Train orders, messages, line-ups and instructions must be transmitted with care and at a speed regulated to the capacity of the person receiving them. Special care must be used when working with new or inexperienced employes

4 A bulletin book must be maintained in each train dispatchers' office in which all superintendent's bulletins in effect in the territory assigned that office must be maintained Train dispatchers must review bulletins before going on duty and must record the number of the last bulletin on the train sheet

One bulletin book will be sufficient at each location where train dispatchers are employed unless local conditions indicate that more than one book is desirable or necessary.

5 Train dispatchers must be courteous in their conversations with other employes They must not engage in arguments with operators, conductors, engineers or others regarding train orders or rules but must issue such instructions or train orders as are necessary to clarify and report the facts to the chief train dispatcher

6 Train dispatchers must maintain such records as are required by rules, instructions or by law Such records must be neat and legible and must be kept in the manner prescribed It must be borne in mind that it may be necessary to produce these records in a court of law

7. The following Maintenance of Way and Signal Rules pertain, either directly or indirectly, to the duties of a train dispatcher. Train dispatchers must be familiar with these rules

3	101	765	1501(D)	1601
12(A)	101(B)	771	1501(E)	1604
12(B)	715	777	1501(L)	1605
12(C)	751	779	1502	1811
99(P)	758	790	1502(B)	
99(Q)	759	1501	1502(C)	
99(R)	762(A)	1501(A)	1502(D)	
99(S)	763	1501(B)	1509(A)	

MOVEMENT OF TRAINS

12. When weather conditions, high water, defects in track or signals endanger the safety of trains, train dispatcher must issue proper slow or cautionary orders, arrange for trains to be stopped or spaced, or take whatever action is necessary and appropriate to insure safety of operation

* * *

AUTOMATIC CAB SIGNALS

98. When report is received by the train dispatcher that cab signal devices on an engine are inoperative, he may verbally authorize the engineer to cut out such devices in the following form

"You may cut out cab signal devices on Eng _____and proceed being governed by Rule 458"

Record of authority granted to cut out cab signal devices must be made on the train sheet.

99. When it is known in advance that ACS will be inoperative in a specified territory, authority to cut out cab signal devices will be furnished trains affected by train order in the following form

"From eight one 801 AM until four one 401 PM April 4 cab signals will be inoperative between _____and _____ Be governed by Rule 457"

CENTRALIZED TRAFFIC CONTROL

100 As soon as practicable after going on duty, each train dispatcher operating a CTC control machine must check the traingraph with a standard clock. He must record on the graph date and time comparision was made, accuracy of the graph at that time, and sign the graph

When traingraph is running fast or slow, it must be adjusted to correct time and notation of correction made on graph

101. The train dispatcher must indicate on the traingraph the identification of each train and must draw lines connecting automatic recordings to show the movement of each train.

102. Within CTC territory controlled signals must be displayed at their most restrictive indication except that signals must be cleared sufficiently in advance of a movement to avoid giving an unnecessary restrictive indication

Switches must be restored to normal position as soon as practicable after a movement has been completed.

103. Controls must not be operated to change position of a switch while a train or engine is occupying "OS" section.

104. When switches or signals are undergoing repairs, train dispatcher must block switches or signals affected and must not remove blocks until advised that repairs have been completed.

When safe to do so and it will not interfere with movement of trains, switches and signals may be operated upon request from signal maintainer or maintenance of way foreman for test purposes or for movement of heavily loaded track cars

E-105. Reference Rule 270, track and time limits

After the train or engine has entered the specified limits, the train dispatcher must block signals controlling movement into the specified limits and must not permit any other train or engine to enter those limits during period track and time limits are in effect except as provided in Rule 270 (A). Blocks must not be removed until track and time limits have expired or have been released by conductor or by the member of the crew to whom they were given.

106. Form C clearance to authorize a train or engine to proceed from a Stop signal must be handled as follows:

If train dispatcher knows there is no opposing movement or any movement holding track and time limits between that signal and the next Stop signal in advance, instructions must be given thus.

"C&E_____
This clearance is authority to proceed on _____ track from Stop signal at _____ at restricted speed to the next signal"

E-106 (A). When the train dispatcher is not positive that there is no opposing movement between the Stop signal and the next Stop signal in advance, or when track and time limits for another train or engine are in effect, and it is necessary to permit the train or engine to proceed, the train dispatcher must instruct that train or engine be moved forward until leading wheels are 100 feet past Stop signal and wait 10 minutes before acting on Form C clearance. After acknowledgment of these instructions has been received from the employe requesting authority to proceed, Form C clearance may be issued as provided in Item 106 above

O-106 (B). When the train dispatcher is not positive that there is no opposing movement between the Stop signal and the next Stop signal in advance, or when track and time limits are in effect, and it is necessary to permit train or engine to proceed, instructions must be given thus·

"C&E_____
This clearance is authority to proceed on _____ track from Stop signal at _____ under flag protection"

* * *

AIR BRAKES

144. Air brake rules require that each train must have all air brakes in operation, except in emergency, but at no time may the number of operative brakes be less than permitted by Federal requirements.

When air brakes fail, an engine must not be permitted to move itself, or cars, except to clear main track, and then only if it can be safely done.

DISPATCHER'S TRANSFER

145 When a train dispatcher is relieved, he must make written transfer, in ink, on a separate page in train order book

Train dispatcher going off duty must show the number of each train order in effect (including slow or cautionary orders) and relieving train dispatcher going on duty must write opposite each order number a brief synopsis of his understanding of the order This synopsis may be abbreviated but not to the extent that it cannot be read and understood by another person if necessary.

Transfer must show track car operator's line-ups still in effect and, in CTC territory, must show location of trains, motor car permits which have not expired, any irregularities in equipment and any movements being made under authority of Form C clearance.

Train dispatcher going off duty must verbally call attention of relieving train dispatcher to position of trains, any unusual work they have to do, orders they will probably need, or any unusual situation When unusual conditions exist, train dispatcher going off duty must explain to relieving train dispatcher what has been done or may be necessary in the way of spacing or otherwise protecting train movements Both train dispatchers must be sure that any unusual condition is understood.

Transfer must be initialled and timed by both train dispatchers

* * *

EASTERN AND
SOUTH-CENTRAL DISTRICTS
AND IDAHO DIVISION

OPERATING RULES

EFFECTIVE MAY 1, 1972

85. When a train is delayed, other trains must be allowed to pass promptly Conductors and engineers will be held jointly responsible for unnecessary delays to trains

85 (A). The train dispatcher must be advised in advance of any known condition that will delay the train or prevent it from making usual speed

101. Trains and engines must be fully protected against any known condition which interferes with their safe passage at normal speed.

When conditions are found which may interfere with safe passage of trains or engines at normal speed and no protection has been provided, the radio, telegraph or telephone must not be depended on to notify other trains; protection must be provided in accordance with Rule 99 and a report must be made to train dispatcher by quickest means of communication

If any member of a train or engine crew has reason to believe that their train or engine has passed over any dangerous defect, the train or engine must be stopped at once and protection provided.

101 (A). During severe storms or when there is indication of high water or any condition which threatens damage, trains must move at restricted speed. Conductors and engineers must make inquiries at stopping places and when, in their judgment it is necessary, must make extra stops to ascertain the extent and severity of storms and to examine bridges, culverts or other places subject to damage

When a train is flagged by a track patrolman, in case of storm or indication of storm or high water, patrolman must patrol track ahead of train through the storm area.

101 (B) Trains or engines must not pass over broken rail on curve until joint bars have been securely fastened on both sides of rail at the break. On straight track, trains and engines must stop not less than 200 feet from broken rail and, if considered safe to do so, may proceed if a responsible employe, prepared to give stop signal, watches the movement over the break, but a speed of five miles per hour must not be exceeded

102. When a train becomes disabled or is stopped suddenly by an emergency application of the brakes or other causes, a lighted red fusee must be immediately displayed on adjacent track at front and rear of train, and adjacent track as well as tracks of another railroad that are liable to be obstructed must immediately be protected in both directions in accordance with Rule 99 until it is ascertained they are safe and clear for the movement of trains After lighted fusee has been displayed at front of train, headlight must be extinguished.

In such cases, it must be determined by inspection that the train involved and the track to be used are safe for the train to proceed Train involved must not proceed nor may flagmen be recalled until engineer has been definitely advised by conductor that it is safe to do so

A train on an adjacent track must not pass the disabled train unless it is preceded by a flagman or unless definitely assured by the conductor of the disabled train that the track is clear and it is safe to proceed

* * *

RULES GOVERNING OPPOSING AND FOLLOWING MOVEMENT OF TRAINS BY BLOCK SIGNALS

261. On portions of the railroad and on designated tracks so specified in the time-table, trains will be governed by block signals, whose indications will supersede the superiority of trains for both opposing and following movements on the same track.

262. The reverse movement of a train or engine must not be made except by signal indication or as prescribed by Rule 270, without permission of control operator

263. Movement of trains will be supervised by the train dispatcher who may also operate the control machine

When the control machine is operated by other than the train dispatcher, the train dispatcher will issue necessary instructions to the control operator

264. Except as affected by Rules 261 through 263, all Operating Rules remain in effect.

CENTRALIZED TRAFFIC CONTROL SYSTEM RULES

265. Centralized Traffic Control System Rules apply only in CTC territory as specified in the time-table or in special instructions

Rules 261 through 264 apply in CTC territory

Except as affected by Rules 261 through 271, all Operating Rules remain in effect.

266. A train or engine must not enter CTC territory unless the governing signal displays an indication to proceed or authority is obtained from the control operator

267. A train or engine must not foul or enter the main track or a controlled siding at a hand operated switch unless the governing signal displays an indication to proceed, or authority to occupy such track has been received from the control operator

268. A train or engine must not clear the main track at a hand operated switch not equipped with a mechanical time lock or an electric lock except as follows.

(1) Where maximum authorized speed on main track over such switch is 20 MPH or less, or

(2) When main track switch is kept open

269. When a train or engine is stopped by a Stop signal and no conflicting movement is evident, a member of the crew must immediately communicate with the control operator and be governed by his instructions Authority to proceed will be given by Form C Clearance which must be copied by a member of the crew, repeated to the control operator and delivered to the engineer

When authorized to proceed, train or engine may proceed at once at restricted speed to the next signal except that when so instructed by the control operator, train or engine must be moved forward until leading wheels are 100 feet past the Stop signal, wait ten minutes, then proceed at restricted speed to the next signal

Exception: – Clearance Form C will not be required when movement is leaving the main track, is leaving CTC territory, or the entire movement is within yard limits.

269 (A) When stopped by a Stop signal and communication with the control operator has failed, train or engine must not proceed except on signal indication or until communication is restored and authority is received from the control operator

Exception: A train or engine stopped by a Stop signal at the entering signal at a station and unable to communicate with the control operator may move forward, when preceded by a flagman, to the leaving signal at that station, clearing main track when practicable.

269 (B) Emergency push buttons installed in telephone booths of relay houses at dual control switch locations may be used in an attempt to obtain proceed signal indication only when so instructed by the control operator, or when communication has failed

When instructed by the control operator to use emergency push button for the desired direction, if indication permitting train to proceed is received on governing signal, train or engine may proceed in accordance with the signal indication.

When stopped by a Stop signal and communication has failed, proper emergency push button may be used, and if indication permitting train to proceed is then received, train or engine may proceed but must move at restricted speed to the next Stop signal, keeping a close look out for track car or for men and equipment on track without flag protection

269 (C). If a train or engine fails to stop before passing a signal displaying Stop indication, front of train must be protected immediately as prescribed by Rule 99. A member of crew must communicate with control operator at once and be governed by his instructions.

APPENDIX D

EXCERPTS FROM UNION PACIFIC OFFICE OF SUPERINTENDENT BULLETIN ORDER NO. 9 AND EXCERPTS FROM SYSTEM TIMETABLE NO. 3

UNION PACIFIC RAILROAD COMPANY
OFFICE OF SUPERINTENDENT
BULLETIN ORDER

No. A-9 CHEYENNE, WYOMING-March 12, 1980

TO: TRAINMEN, ENGINEMEN AND YARDMEN

TO BE POSTED AT: WYOMING DIVISION BULLETIN BOOKS

Tables listed on Page 148 of System Timetable No. 3, covering operation of freight trains and use of retaining valves are cancelled and following tables apply:

WESTWARD

HERMOSA to LARAMIE
No. 3 Track

TONS PER OPERATIVE BRAKE	EFFECTIVE DYNAMIC BRAKE ON UNITS PROVIDING	RETAINING VALVES	SPEED MUST NOT EXCEED
Less Than 60		Refer to Special Rule 1042(R-1) P.139	Timetable speeds.
60-80	1 HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	Timetable speeds.
	Less Than 1 HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	30 MPH Hermosa to Red Buttes.
80-100	1 HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	35 MPH Hermosa to Red Buttes.
	½ HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	25 MPH Hermosa to Red Buttes.
	Less Than ½ HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	20 MPH Hermosa to Red Buttes
Over 100	1 HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	30 MPH Hermosa to Red Buttes
	Less Than 1 HP Per Trailing Ton	Refer to Special Rule 1042(R-1) P.139	20 MPH Hermosa to Red Buttes

SYSTEM TIMETABLE NO. 3

Effective 12:01 A.M., March 9, 1980

APPENDIX 11
TONNAGE RATINGS FOR ONE LOCOMOTIVE UNIT
FOR FREIGHT TRAINS AVERAGING 50 GROSS TONS PER CAR
RATINGS APPLY AT THE INDICATED MINIMUM CONTINUOUS SPEED

EASTERN DISTRICT		70-988 5000 HP EMD DD35	100-129 1500 HP EMD GP7	131-349 1750 HP EMD GP9	305-347 470-499 2000 HP GP9M GP20	400-448 2400 HP EMD SD24	450-459 1500 HP EMD SD7	700-739B 800-875 2250 HP EMD GP40	740-763 2500 HP EMD GP35	1400-1409 2500 HP EMD SDP35	2000-2059 2000 HP GP38-2	2800-2809 2800 HP GE U28C	2810-2959 2400-2459 3000 HP U30C C30-7	3000-3658 99 3000 HP SD40 SD40-2	1-59 3600 HP EMD SD45	6980-6844 6600 HP EMD DD40X	8000-8099 3000 HP EMD SD40-2	9000-9005 3500 HP EMD GP40X
		12 MPH	12 MPH	12 MPH	14 MPH	10 MPH	6 MPH	12 MPH	12 MPH	12 MPH	11 MPH	11 MPH	10 MPH	11 MPH	11 MPH	11 MPH	9 MPH	11 MPH
Co. Bluffs	To Valley	6000	2250	2650	2550	4050	2700	2950	3000	3650	3150	4500	5250	4900	4950	5800	4150	2900
Valley	To No. Platte	9700	3650	4250	4100	6550	4350	4750	4850	5900	5050	7250	8500	7850	7950	9350	6700	4700
No. Platte	To Sidney	6900	2600	3000	2950	4650	3100	3400	3450	4200	3600	5150	6050	5600	5650	6650	4750	3300
Sidney	To Cheyenne	5350	2000	2350	2250	3600	2350	2600	2650	3250	2800	4000	4650	4300	4350	5150	3650	2550
Valley	To Valparaiso	3350	1250	1450	1450	2250	1450	1650	1700	2050	1750	2500	2950	2750	2750	3200	2300	1600
Valparaiso	To Lincoln	9700	3650	4250	4100	6550	4350	4750	4850	5900	5050	7250	8500	7850	7950	9350	6700	4700
Lincoln	To Beatrice	3950	1500	1750	1700	2650	1750	1950	2000	2400	2050	2950	3450	3200	3250	3800	2700	1900
Beatrice	To Marysville	6000	2250	2650	2550	4050	2700	2950	3000	3650	3150	4500	5250	4900	4950	5800	4150	2900
Julesburg	To LaSalle	9700	3650	4250	4100	6550	4350	4750	4850	5900	5050	7250	8500	7850	7950	9350	6700	4700
Cheyenne	To Archer	5350	2000	2350	2250	3600	2350	2600	2650	3250	2800	4000	4650	4300	4350	5150	3650	2550
Valley	To Co. Bluffs	6900	2600	3000	2950	4650	3100	3400	3450	4200	3000	5150	6050	5600	5650	6650	4750	3300
Marysville	To Beatrice	8050	3050	3500	3400	5450	3600	3950	4050	4900	4200	6050	7050	6550	6600	7750	5600	3900
Beatrice	To Valparaiso	6900	2600	3000	2950	4650	3100	3400	3450	4200	3600	5150	6050	5600	5650	6650	4750	3300
Valparaiso	To Valley	3350	1250	1450	1450	2250	1450	1650	1700	2050	1750	2500	2950	2750	2750	3200	2300	1600
Cheyenne	To Buford	2700	1000	1200	1150	1800	1200	1350	1350	1650	1400	2050	2400	2200	2250	2600	1850	1300
Cheyenne	To Dale	4700	1750	2050	2000	3150	2050	2300	2350	2850	2450	3500	4100	3800	3850	4500	3200	2250

WYOMING DIVISION

WESTWARD			SECOND SUBDIVISION			EASTWARD		
STATION NUMBER	LENGTH OF SIDINGS FEET	FIRST CLASS TRAIN DAILY	Timetable No 3 STATIONS		MILE POST	FIRST CLASS TRAIN DAILY	RULE 6(B)
510			DN R CHEYENNE YL		509.5		FPTXY
			1.1 WEST CHEYENNE YL		510.6		PX
			0.2 CP511		511.0		PX
			3.5 WYCON (SPUR E)		514.5		P
			4.4 CP519		518.9		PX
	5164		0.2				
519	1314	2.10PM	BORIE		519.1	A3.25PM	PX
			9.5				
529	4173		GRANITE		528.6		PX
			1.5 CP530		529.9		PX
			6.7				
537	C5852		BUFORD		536.6		P
			3.8				
540	1250		SHERMAN (SPUR W)		540.4		PY
			2.6				
545	2171		DALE (SPUR E)	TRACKS 1 2	543.0		P
			1.6 DALE JCT.		544.8		PX
			2.5				
			CP547		547.3		PX
			0.6				
548			HERMOSA		547.9		PX
			0.7 CP549		548.6		PX
			5.4				
554	572		COLORES (SPUR E)		554.0		P
			9.0				
563	519		FORELLE (SPUR E)		563.0		P
			2.4 CP565		565.3		PX
			0.7				
566			DN R LARAMIE		566.0		FPXY
548			HERMOSA	TRACK 3	B547.9		PX
			8.9				
557	5849		RED BUTTES		B556.8		P
			9.5				
566			DN R LARAMIE		B566.3		FPXY
510			DN-R CHEYENNE	TRACKS 1 2 3 4	509.5		FPTXY
			0.5				
15-518	C6489		SPEER		519.0		PXY
			CP517		517.2		PX
			1.1				
			CP518		518.3		PX
			0.7				
15-518	C6489		SPEER		519.0		PXY
			6.8				
15-526	6217		EMKAY		525.8		P
			8.4				
15-534	6408		LYNCH	TRACK 3	534.2		P
			8.5				
15-543	6722		HARRIMAN		542.7		P
			6.8				
15-550	6134		PERKINS		549.5		P
			4.8				
			DALE JCT.		554.3		PX
			CP565		565.3		PX
			0.7				
565		ø3.35	DN-R LARAMIE		566.0	ø2.25	FPXY
			4.5				
			CP570		570.5		PX
			11.7				
			CP582		582.2		PX
			3.1				
585	C4301		BOSLER		585.3		P
			5.3				
590	753		COOPER LAKE (SPUR E)		590.6		P
			3.3				
594	1585		LOOKOUT (SPUR W)		593.9		PX
			7.1				
			CP601		601.0		PX
			4.3				
605	C5944		ROCK RIVER		605.3		PY
			3.7				
609			WILCOX		609.0		PX
			7.8				
			CP617	TRACKS 1 2	616.8		PX
			6.1				
623	C5985		D MEDICINE BOW		622.9		PY
			1.6				
			CP624		624.5		PX
			7.5				
			CP632		632.6		PX
			6.3				
639			RAMSEY		638.9		PX
			4.2				
642	11772		DN R HANNA		643.1		PXY
			7.1				
			DURRANT		650.2		PX
			6.4				
657	403		EDSON (SPUR W)		656.6		P
			5.6				
662			WALCOTT		662.2		PXY
			9.9				
672			BENTON		672.1		PX
			4.2				
676			SINCLAIR		676.3		P
			4.0				
			CP680		680.3		PX
			2.5				
683	11602 19126	A5.05PM	DN R RAWLINS		682.8	12.30PM	FPXY

(VIA SHERMAN 173.3)
(VIA HARRIMAN 182.8)

Note 2 to Rule 99 is in effect on Second Subdivision

CLEARANCE AND REGISTER REQUIREMENTS

Clearance need not be received by trains entering or leaving Second Subdivision at Speer or Borie

Train movements on Medicine Bow and Energy Spurs must be authorized by train order Unless authorized by train dispatcher eastward trains on Medicine Bow Spur must stop west of Energy Spur switch

Trains from Encampment Branch need not receive clearance at Walcott but must receive verbal authority from train dispatcher before occupying Second Subdivision tracks

Only trains which originate or terminate at Laramie or Hanna need register at Laramie or Hanna

On Coal Spurs westward trains are defined as those trains moving to coal tipples and eastward trains as those trains moving from coal tipples

SPEED RESTRICTIONS — SECOND SUBDIVISION

LOCATION	MPH Psgr	MPH Frt
Between Mile Posts —		
Cheyenne		
509 1 and 510 0 until engine passes these locations	20	20
510 1 and 511.5	40	40
Reduce speed signs located North side No 1 track and South side No. 4 track also apply to tracks 2 and 3.		
Cheyenne yard:		
Yard lead at east end	15	15
All yard leads at the west end	15	15
North 1 2 6 and 7 tracks	15	15
South 1 2 4 and 6 tracks	15	15
All other tracks	5	5
Maximum speeds between Cheyenne and Dale Junction No. 1 and No 2 tracks	70	55
Maximum speeds between Dale Junction and East Laramie No 1 and No 2 tracks:	40	40
All eastward trains with tonnage in excess of 100 tons per operative brake must not exceed 20 MPH on No. 1 and No 2 tracks from MP 536 to Cheyenne and must not use less than the times shown below between the designated points:		
MP 536 0 to MP 528 5 — 22 mins		
MP 528 5 to MP 519 1 — 28 mins		
MP 519 1 to MP 510 8 — 25 mins		
Important — For movement on descending grades see Special Rule 1042 (RW) page 146.		
Maximum speed on Borie Cut-Off between Speer and Borie	50	50
102.6 and 103.3	35	35
Maximum speed between Cheyenne and Dale Junction on No 3 track and between Cheyenne and Speer on No 4 track	60	55
Less than 100 tons per operative brake with operative dynamic brake		55
without operative dynamic brake		45
Maximum speed on No 3 track between Hermosa and Laramie B 548 7 and B 565 5*	70	60
Important — For movement on descending grades see Special Rule 1042 (RW) page 146		
Maximum speed between Laramie and Rawlins	90	70
Laramie		
Tie yard lead between MP 565.6 and MP 565.85		10
Laramie Scale Track		
Live Scale Track		5
Between Scale House and MP 568 0.		20
Between MP 568 0 and MP 569 3		30
Warehouse Tracks 2, 3, 4		5

Note — Between West Hermosa and East Laramie via Red Buttes mile post numbers are prefixed with letter B

WY DIVISION

WY DIVISION

WYOMING DIVISION

SPECIAL RULES—ALL SUBDIVISIONS

Movement at Stations

96 (RW). At the following locations, yard engines and light engines may move between "A" signals and switching limit signs without clearance Form 2643 on signal indication and authority from train dispatcher:

Location	Between Mile Posts
Cheyenne	506 25 and 511 81
Laramie	564 82, Track 1 or 563 59 Track 3 and 570 43
Rawlins	680 10 and 685 16
Rock Springs	800 8 and 804.0
Green River	814 15 and 818 49

Block Clearance

96 (RW 1) Train and engine movements on Jim Bridger Spur will be controlled by train dispatcher through issuance of block clearances, Form 2643 BC via radio or phone to conductor and engineer of train to be moved All train and engine movements between Point of Rocks and Pacific Power and Light Plant must be authorized by block clearance and no portion of track between these points may be occupied unless conductor and engineer have a valid block clearance in their possession

All block clearances must be copied by conductor and engineer and must be repeated by each of them to the train dispatcher and the repeated time given by train dispatcher must be entered, as well as name of person copying block clear ance in spaces provided Train dispatcher must record block clearances in train order book in the following form, assigning a train order number to each, preceding it with the letters BC thus:

BC 1

Point of Rocks to C&E Work Extra 201

This is your authority to occupy track between Point of Rocks and Prospect Point

Additional instructions — Do not exceed 20 MPH between MP 2 and MP 3

TAW

R 1247 PM Condr Jones
R 1248 PM Engr Smith
Reported clear at 215 PM

Proper receipt of block clearance by a train or engine is authority for movement from the first named station to the second named station only Protection of rear of train as prescribed by Rule 99 is not required in block clearance territory When train or engine authorized by block clearance has arrived in clear at destined sta tion conductor must report arriv al to train dispatcher and enter the time reported clear on the block clearance No further movement between stations may be made without receipt of another block clearance

Additional instructions such as "Do not exceed 10 MPH between MP 2 and MP 3," must be entered on block clearance as transmitted by the train dispatcher If no additional instructions the word "NONE" must be entered Only one block clearance may be issued for a block at one time

Dispatcher's transfer must include block clearances still in effect

Block clearance must not be issued until the preceding movement has reported clear of the track

96 (RW 2) All movements between Ramsey and East Switch are governed by signal indication

Train and engine movements on Ramsey Spur will be controlled by train dis patcher through issuance of block clearances, Form 2643 BC, via radio or phone to conductor and engineer of train to be moved All train and engine movements between East Switch and Carbon County must be authorized by block clearance and no portion of track between these points may be occupied unless conductor and engineer have a valid block clearance in their possession

All block clearances must be copied by conductor and engineer and must be repeated by each of them to the train dispatcher and the repeated time given by train dispatcher must be entered, as well as name of person copying block clearance in spaces provided. Train dispatcher must record block clearances in train order book in the following form, assigning a train order number to each preceding it with the letters BC, thus:

BC 1

Ramsey to C&E Extra 201 West

This is your authority to occupy track between East Switch and Carbon County

Additional instructions — Do not exceed 20 MPH between MP 2 and MP 3 on Arch siding

TAW

R 1247 PM Condr Jones
R 1248 PM Engr Smith
Reported clear at 215 PM

Proper receipt of block clearance by a train or engine is authority for movement from the first named station to the second named station only Protection of rear of train as prescribed by Rule 99 is not required in block clearance territory

Additional instructions such as, Do not exceed 10 MPH between MP 2 and MP 3 Arch Siding' must be entered on block clearance as transmitted by the train dispatcher If no additional instructions the word 'NONE" must be entered Only one block clearance may be issued for a block at one time

Conductor or engineer must report to train dispatcher when clear of locations listed on block clearance and must enter time reported clear at destined station on block clearance form No further movements between stations may be made without receipt of another block clearance

All eastward movements must communicate with train dispatcher before depart ing East Switch Movements to Rosebud and Carbon County must remain clear of west end of Arch siding and Main track unless block clearance states otherwise

Block clearance must not be issued until the preceding movement has reported clear of the track

Dispatcher s transfer must include all block clearances still in effect

Air Brake Rules

1030 (RW) At Rawlins air brake rule 1030 (C) is in effect

Retaining Valves

1042 (RW) The tables on page 148 govern operation of freight trains and use of retaining valves in territories shown This does not modify the requirements of Air Brake Rule 1042:

1 Dynamic brake must be placed in operation and tested at a convenient loca tion prior to reaching designated descending grades
2 When use of retaining valves is required these valves must be placed in HEAVY HOLDING" position on all cars in train
3 On branch lines retaining valves must be used on all cars in train descending grades 1 50 % or more unless handled by locomotive with effective dynamic brake on units providing not less than one horsepower per trailing ton

MofW Block Clearance

1500 (RW) Movement of MofW equipment or work to be performed by MofW forces on Ramsey Spur and Jim Bridger Spur will be controlled by train dispatcher through issuance of block clearances Form 2643 BC via radio or phone to MofW foreman or supervisor in charge of work or movement to be made

Movement of track motor cars, MofW equipment or MofW work to be performed on either spur may be authorized by block clearance and no portion of track on either spur is to be occupied unless MofW foreman or supervisor in charge has a valid block clearance in his possession

Block clearance must be copied by foreman or supervisor in charge and must be repeated by him to the train dispatcher and the repeated time given by train dis patcher must be entered in the space provided as well as name of person copying block clearance Train dispatcher will record block clearance in train order book in the following form assigning a train order number to each, preceding it with the letters BC thus:

BC 2

Ramsey (Point of Rocks) to Foreman A B Smith

This is your authority to occupy track between East Switch (Prospect Point MP 6 58) and Rosebud (Pacific Power & Light)

Additional instructions — Men and machines must be clear of track at 215 PM

TAW

R 1250 PM by Foreman Smith
Reported clear at 210 PM

Proper receipt of block clearance by Mof W foreman or supervisor is authority to occupy track between stations named only Protection as prescribed by MofW Rule 99(E) is not required when foreman or supervisor possesses a valid block clearance in block clearance territory

Additional instructions will specify when all MofW men and machines must be clear of track and must be entered on block clearance as transmitted by train dispatcher

Prior to the time specified in additional instructions all men and machines must be clear of track ready for movement of trains Foreman or supervisor who was issued the block clearance must observe that all equipment is in the clear and notify all personnel that the track is to be released and must report to train dispatcher time track cleared and ready for movement of trains and enter the time reported clear on block clearance No further work may be performed or movement made on track without receipt of another block clearance

Train dispatcher must not permit a train or engine to enter a block occupied by MofW forces holding a valid block clearance Block clearance for a train waiting to move must not be issued until MofW foreman or supervisor who was issued the block clearance has reported men and machines are clear of the track and the track is ready for movement of trains

* * *

SPECIAL RULES—SECOND SUBDIVISION and BRANCHES

Signal Indications

241 (RW). At Hanna, westward movement on Coal Spur MP 2 0 will be governed by three-unit Stop signal as follows:

Westward signal aspect displayed for a straight track movement to Energy Spur will be a green over red over red with a dark (E) Indicator If this track is lined for Medicine Bow Spur, indication will be a red over red over red with illuminated (E) Indicator Operating Rule 241 A governs After train has stopped, lined the switch for Energy Spur, the illuminated (E) will go out and a green over red over red aspect will be received

With the dispatcher requesting move to the Medicine Bow Track, with the switch properly lined, the westward signal aspect will be red over red over green to go through the No. 10 turnout with a dark (MB) Indicator If the switch is not lined for Medicine Bow Track, a red over red over red with illuminated (MB) Indicator will be displayed Operating Rule 241 A governs After switch is lined for the turnout the switch aspect will change to a red over red over green with (MB) Indicator darkened

End of the block signs will be located at MP 2 0 on Energy and Medicine Bow Tracks

267 (RW) At Durrant when signal governing movement to Arch Mineral Spur No 1 and at Ramsey, when signal governing movement to Arch Mineral Spur No 2 display proceed indication, movement is authorized on spur in either direction without flag protection

If signal fails to display proceed indication, movement on spur must be autho-rized by Form C Clearance, which must be copied by a member of crew, repeated to train dispatcher and delivered to engineer

Weigh-In-Motion Scale

804 (RW) At Laramie, weigh in motion scale is located on yard track No 1. I ights located on north side of track govern movement approaching scale and when weighing cars and display the following indications:

Green	Moving at proper speed
Flashing yellow	Caution, approaching maximum weighing speed
Red	Unless otherwise instructed stop movement, back train up and start weighing operation again

Speed of 5 MPH must not be exceeded while weighing over scale Wheels on units must not be allowed to slip or slide while on scale

Air Brake Rules

1029 (RW 1) On passenger trains, running air test as required by Air Brake Rule 1029 must be made at Sherman, by eastward and westward trains, and at Speer by eastward trains

APPENDIX E

EXCERPTS FROM UNION PACIFIC RULES AND INSTRUCTIONS GOVERNING OPERATION OF AIR BRAKES

BRAKING FREIGHT TRAINS

1038. When making a service stop or reducing speed of a freight train, initial brake pipe reduction must be made, after which, sufficient time must be allowed for proper adjustment of slack in train before further brake pipe reduction is made to required amount After initial brake pipe reduciton is made, throttle must be reduced gradually as speed of train reduces. When train has reached point where it is evident it will stop within the next forty (40) feet, a further brake pipe reduction must be made of sufficient amount to have air exhausting from automatic brake valve, throttle must be closed, rails sanded, and independent brake fully applied on all locomotives on head end as train comes to stop

DYNAMIC BRAKING

1039. When starting use of dynamic brake, wait 10 seconds before moving selector lever to "OFF" position and wait 10 seconds before moving from "OFF" to "B" position. When going to power operation from dynamic braking, wait 10 seconds before moving selector lever from "B" to "OFF" position, and wait 10 seconds before moving from "OFF" to throttle 1 position In order to avoid excessive current surges, selector lever must be moved slowly into and out of dynamic braking ranges When dynamic brake is first applied, extreme care must be used to avoid rough handling of train

1039(A). Dynamic brake must be supplemented by use of train air brakes to extent necessary to properly control speed of train

1039(B). Under no circumstances must locomotive air brake be allowed to apply when dynamic brake is in use, except when making stop, and brake cylinder gauge on locomotive must be frequently observed to insure that locomotive air brake is kept released.

1039(C). Load indicating meter and warning light or buzzer must be closely observed during time dynamic brake is in use to avoid excessive braking force which would result in damage to traction motors and grids Engineer must not permit use of current in excess of maximum permissible and must be governed by first indication of reaching maximum as indicated by either load indicating meter, warning light or warning buzzer.

1039(D). Under no circumstances may the dynamic brake warning light be covered with paper cups, cloth or any other material.

1039(E). When stopping freight train with dynamic brake in use, dynamic brake operating lever must be moved to "OFF" position immediately when train comes to a stop and independent brake applied slowly to prevent slack from running out.

1039(F). When a unit in the consist is to be isolated, unit must be out of dynamic braking before isolating

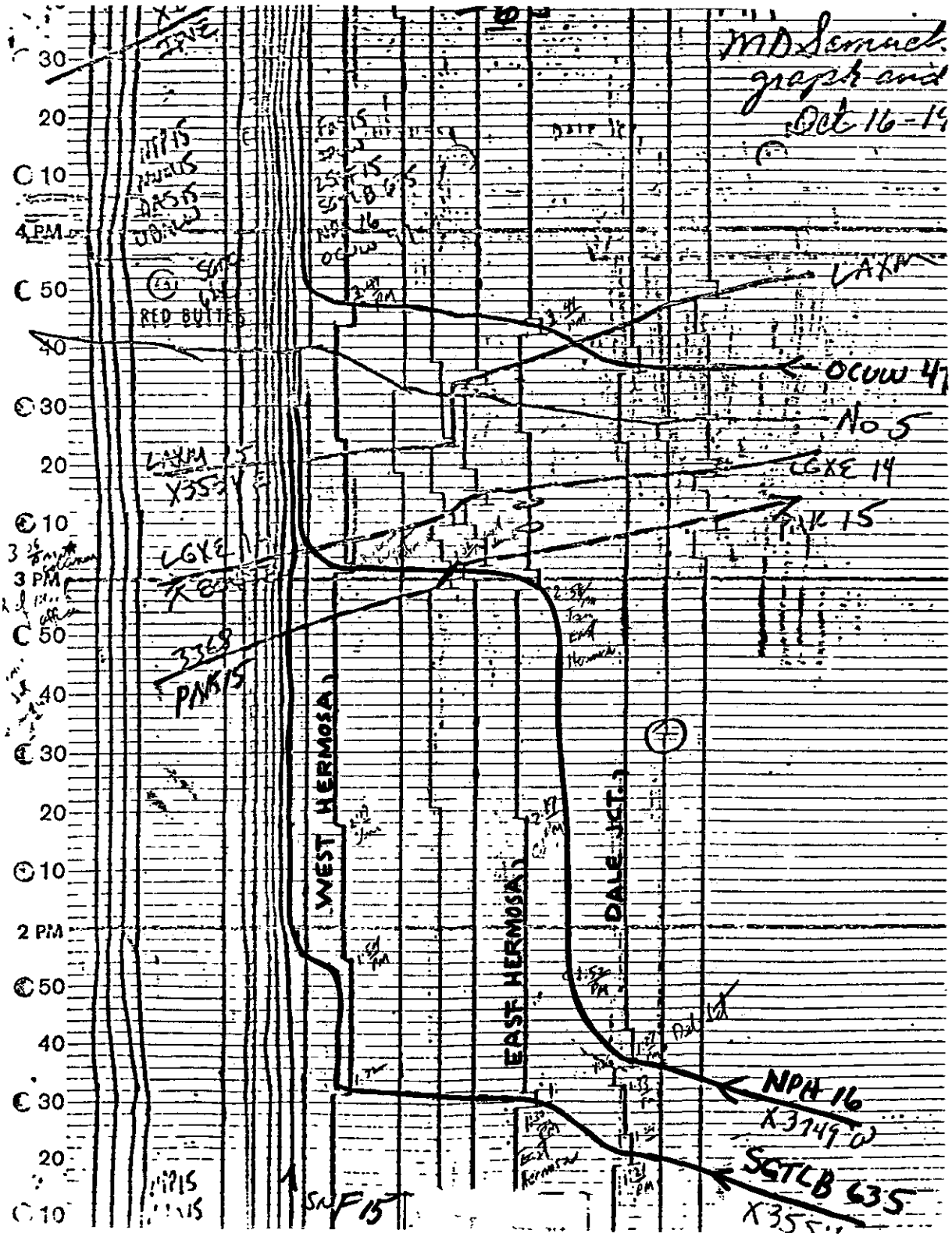
1039(G). If dynamic brake is inoperative on any unit of multiple unit locomotive, the unit selector switch must not be changed unless defective unit is set out

1039(H). If dynamic brake warning light comes on or buzzer sounds immediately after placing transition lever in braking zone, lever must be promptly removed from braking zone and dynamic brake must not be used.

1039(I). On descending grades, when handling freight trains having light loads or empties on head end and heavy loads on rear end, not more than one-half of maximum dynamic brake may be used while such head end cars are passing through turn-out or cross-over where speed is 30 M.P.H or less Speed of train must be controlled by application of air brakes as necessary, and use of maximum dynamic brake must not be permitted until after all such head end cars have passed through turn-out or cross-over

APPENDIX F

EXCERPTS FROM
TRAIN DISPATCHER'S TRAIN GRAPH



APPENDIX G

EXCERPTS FROM MANAGEMENT OF TRAIN OPERATION AND TRAIN HANDLING (REPRINTED WITH PERMISSION OF THE AIR BRAKE ASSOCIATION)

K. Pressure Maintaining and Dynamic Brake Operation

a. This is the most common combination of braking on grades.

b. When the train is going over the apex (top) or crest of a grade, it is optional to use either the train air brake or dynamic brake first.

1. With short light trains, it is the general practice to apply the dynamic brake first. If necessary, the train air brake is added as a supplement to control train speed.

2. With heavy trains, it is preferable to apply the train air brake first. The brake pipe reduction should not be started until the throttle has been reduced to idle and train speed starts to increase. Start the air brake application so that all car brakes will be applied as the rear end passes over the summit This will allow brake shoes and wheels to warm up to provide effective retardation. The dynamic should be then applied as required to assist in controling speed The total brake pipe reduction should be slightly less than that required to handle the train with air alone, so that dynamic can be varied to regulate train speed with dynamic help

c. Depending upon particular grade conditions, try to make the air brake application of such degree that the train will keep rolling (will not stall) through curves and lesser grade portions of the area Vary the dynamic to control speed on other sections of the grade.

d. Plan brake operation so that maximum or heavy dynamic is not used when rounding sharp curves. Be careful when going through turnouts and switches that too much dynamic is not used.

e. If dynamic brake helpers are used in the train, they should not use dynamic until actually close to the crest or on the descending grade If too much helper dynamic is applied too soon, severe slack action may result.

f. On grades where a large portion of the retarding force is provided by the dynamic brake, prompt action is imperative if all or a part of the dynamic suddenly becomes inoperative If this situation arises, probably evidenced by a severe slack-run, loss of dynamic brake amperage, etc., safe practice is to get the train stopped quickly On heavy grades, speed can get out of control in a very short time, use emergency application without hesitating. Service applications usually react too slowly and allow too much speed increase while they are becoming effective.

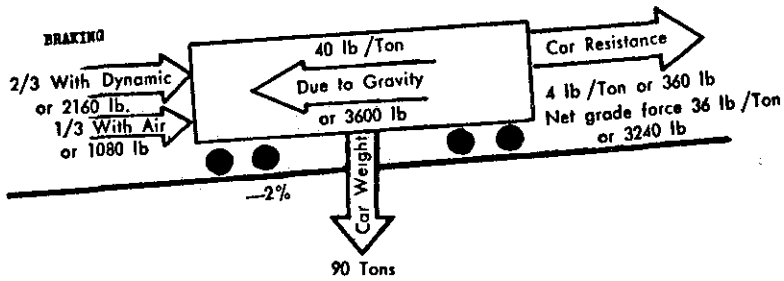


FIG. 117 RELATIONSHIP OF AIR AND DYNAMIC BRAKE

In the example above, Fig. 117 a 90-ton car moving down a 2% grade is under sufficient braking force to balance the pull of gravity downgrade. If 1/3 the braking force is due to the air brake and 2/3 from dynamic brake, and the dynamic brake fails, the car will be subject to an accelerating force due to gravity of 2160 lb. This will cause speed to increase at about 24 mphps. After one minute the car speed will have increased about 14 mph. This situation becomes much more critical with heavier cars on steeper grades.

Even if the addition of 10 psi more brake pipe reduction would eventually balance the grade, at the higher speed, the brake horsepower may be high enough to be excessive for a long grade. Both brake shoes and wheels will probably be overworked

Again, if dynamic is lost or becomes overworked and ineffective for any reason on a heavy grade:

1. Get the train stopped quickly.
2. Use emergency application.
3. Follow safe practice and local rules before proceeding after such an unplanned stop on the grade.

* * *

SECTION 7. DYNAMIC BRAKING SYSTEM

Dynamic braking is an electrical arrangement used to change some of the mechanical power developed by the momentum and downhill force of a moving train into electrical power. The electrical power is converted into heat which is blown out through a hatch at the top of the locomotive.

Traction motor armatures, being geared to the axles, rotate whenever the locomotive is moving. During dynamic braking the motors become electrical generators, and the electrical output of the motor armatures is connected across fan cooled resistor grids of fixed ohmic value. Armature output is determined by the speed at which the armatures rotate (track speed) and by the amount of excitation current flowing in the motor fields (stationary coils).

Excitation current in the motor fields is controlled by braking lever (throttle) position and by a regulating device. This device, the dynamic brake regulator DBR, senses voltage across one-half a braking grid, interprets it as armature/grid current, and operates to reduce field current in order to hold armature current (and grid voltage) at the maximum permitted by equipment design. It does this whenever maximum current level is attained, regardless of braking lever (throttle) position.

The graph in Fig. 149 shows that with maximum traction motor field current (braking lever in position 8), braking effort increases as track speed increases from zero to about 25 mph. Thereafter, braking effort lessens as track speed increases.

Braking effort may be considered as negative tractive effort or "drawbar push." This effort can be interpreted as weight, with both grade force and the momentum of the moving train going to make up what is being called weight. *The weight by itself performs no function;* it merely has the ability to perform useful work. During dynamic braking the use of the work is to maintain train speed or to slow down a train. This work results in heat at the dynamic braking grids rather than at brake shoes.

To understand the term "braking effort," consider the terms:

1. Mass or weight.
2. Work—the energy required to lift the weight a given distance.
3. Power—the energy required to lift the weight a given distance in a given amount of time. For example, a very small output of energy can lift a tremendous weight if given sufficient time.

Fig. 149 indicates that braking effort falls off as train speed increases above the optimum. This is so because of design limitations in the equipment involved. Theoretically, braking effort could increase along the dash-dotted line extending to the top of the graph, but regulation occurs to protect the equipment.

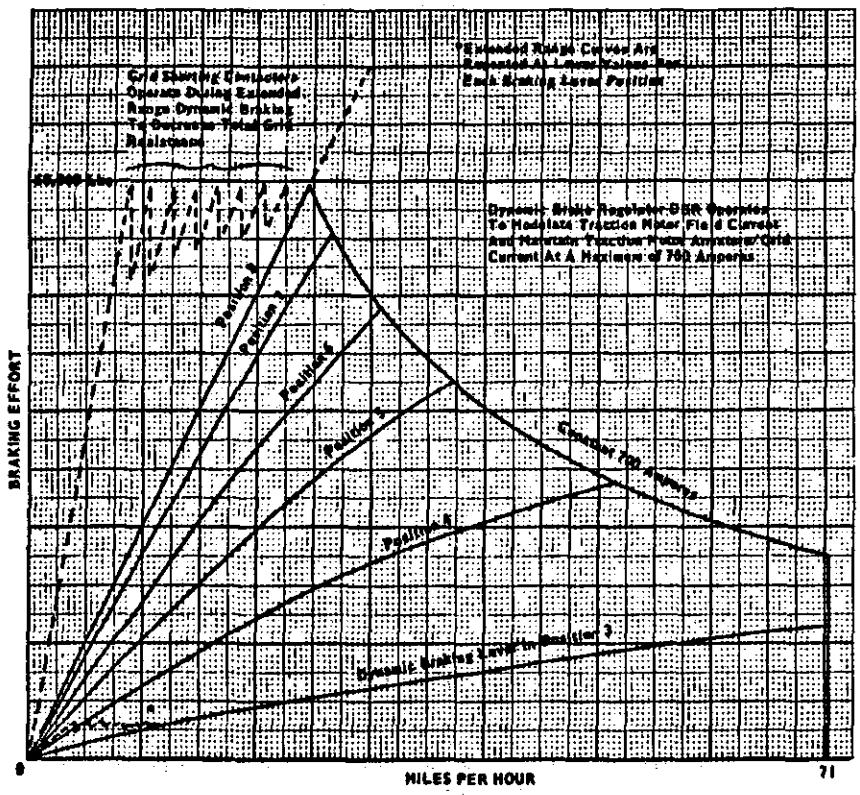


FIG. 149 DYNAMIC BRAKING CURVES—62:15 GEARING
BRAKING EFFORT/MILES PER HOUR

To determine why braking effort does not remain at the maximum value, but falls with increased track speed, note the following:

1. At maximum braking lever position, grid voltage and current are regulated and constant above approximately 25 mph; consequently the power (volts × amperes) dissipated as heat is constant.
2. Power, electrically expressed as volts × amperes, may also be expressed as foot pounds per second or, in railroad terms, ton miles per hour.

$$1 \text{ Horsepower} = \frac{375 \text{ pound miles}}{\text{hour}}$$

Since design limitations require that the current in the dynamic braking resistors does not exceed maximum, an increase in the speed factor (miles/hours) of the horsepower formula must be accompanied by a decrease in the weight factor (pounds) of the formula in order to maintain the maximum current limitation. This weight factor is reduced by decreasing the retarding force of the traction motor fields.

In other words, a decrease in the magnetic flux induced by motor field current, brings about a reduction of the resistance to the turning of the motor armature. Less effort is required to turn the armature, but since it turns faster at higher track speed, the resulting power remains the same while braking effort decreases.

EXTENDED RANGE DYNAMIC BRAKES

Below optimum speed of about 25 mph, braking effort declines. This is because the voltage developed by the motor armatures falls below maximum even though motor field excitation is at its upper limit.

By Ohm's law $I = \frac{E}{R}$ or

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

It can be seen that when voltage drops, current can be maintained at a high level only by reducing grid resistance. The extended range dynamic braking system reduces grid resistance in steps as track speed decreases.

In the extended range dynamic braking system all resistor grids are connected in series with all motor armatures. Cables carrying dynamic braking current pass through the frames of two transductors, and coils carrying AC from the D14 alternator are wound on the cores of the transductors. The impedance of these coils is controlled by the amount of current passing in cables through the transductor frames. The output from the AC coils passes through the primary windings of transformers and is transformed to a usable value. The output from the transformers is rectified and loaded upon resistors and potentiometers.