RAILROAD ACCIDENT INVESTIGATION

REPORT NO 4177

DULUTH, MISSABE AND IRON RANGE RAILWAY COMPANY

DULUTH, MINN

JANUARY 30, 1971

FEDERAL RAILROAD ADMINISTRATION

BUREAU OF RAILROAD SAFETY

Washington, D. C. 20590

Summary

DATE:	January 30, 1971	
RAILROAD:	Duluth, Missabe & Iron Range	
LOCATION:	Duluth, Minn	
ACCIDENT TYPE:	Collision	
EQUIPMENT INVOLVED:	Transfer train	Cut of cars
LOCOMOTIVE NUMBERS:	Diesel-electric units 163, 166, 173	
CONSISTS:	15 cars, caboose	26 cars
SPEEDS:	44 m p h	Standing
OPERATION:	Yard-limit rules	
TRACK:	Ore-dock track; tangent; level	
WEATHER:	Clear; -26°F	
TIME:	7:45 a m	
CASUALTIES:	2 killed; 1 injured	
CAUSE:	Defective condition of the locomotive dynamic brake equipment; the engineer's mishandling of the train air brakes, and crew's failure to turn up retainers	

DEPARTMENT OF TRANSPORTATION

FEDERAL RAILROAD ADMINISTRATION

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Synopsis

On January 30, 1971, an ore train moved out of control on a descending grade of the Duluth, Missabe and Iron Range Railway, and collided with a cut of cars standing on an ore-dock track at Duluth, Minn The collision resulted in death to two, and in injury to one, members of the train crew

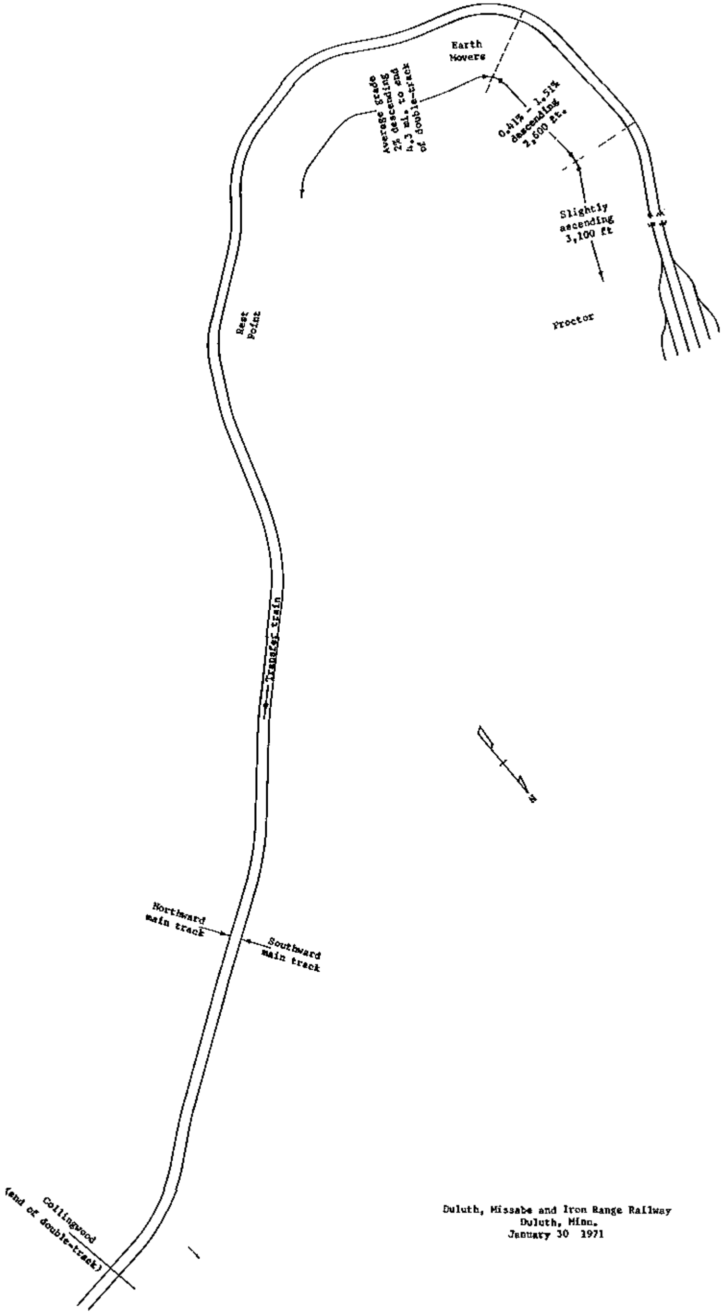
Cause

The accident was caused by a defective condition of the locomotive dynamic brake equipment; the engineer's mishandling of the train air brakes, and crew's failure to turn up retainers

Location of Accident and Method of Operation

The accident occurred on that part of the railroad extending southward from Minntac to Ore Dock No 6 on the shore of Lake Superior at Duluth, Minn , a distance of 75 1 miles Ore Dock No 6 (see Plate No 2) is used to transfer rail shipments of iron ore and taconite pellets to lake vessels or winter storage areas It is 2438 feet long, extending over the shoreline of Lake Superior at a height of approximately 80 feet Four tracks, each 2419 feet long, are on the dock From the east, these tracks are identified as Nos 1, 3, 4 and 6

An interlocking, designated as Collingwood, is about 1 2 miles north of Ore Dock No 6 Proctor is 5 4 miles north of Collingwood Between Proctor and Collingwood, the railroad



Duluth, Missabe and Iron Range Railway
Duluth, Minn.
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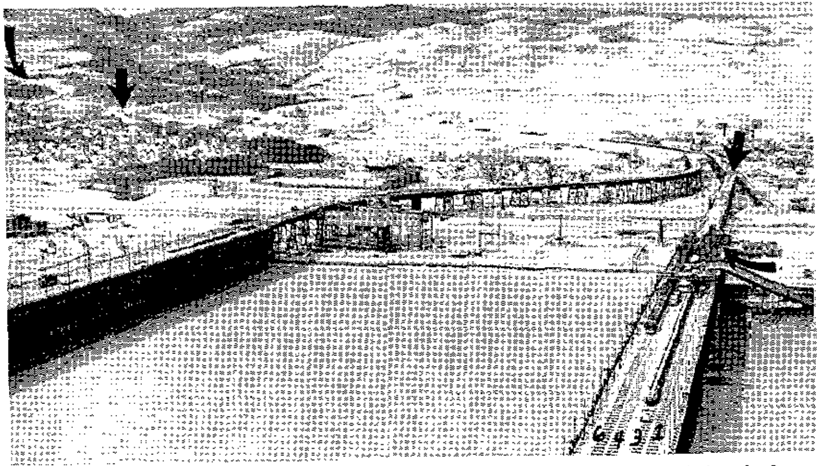
PLATE NO 2



From left to right (arrows), Proctor Hill, Collingwood, east lead track for Ore Dock No. 6, and collision point on track 3 of Ore Dock No. 6.

is a double-track line over which trains operate within yard limits by signal indications of an automatic block-signal system and yard-limit rules The current of traffic is to the left

Two auxiliary tracks, known as the east and west lead tracks, connect the tracks of Ore Dock No 6 to the south end of the double-track line at Collingwood The east lead track constitutes a continuation of the southward main track It leads to tracks No 1 and 3 of Ore Dock No 6, as shown in Plate No 2

The collision occurred on track No 3 of Ore Dock No 6, 1 2 miles south of Collingwood and 108 feet south of the north end of the dock

Tracks

Curves and Tangents

Southward on the double-track line from Proctor, there is a series of tangents and 2-to 4-degree curves, followed by a short tangent to the end of double track at Collingwood

Southward on the east lead track from its junction with the end of the southward main track at Collingwood there are, successively, a tangent about 1785 feet long; a 4°00' curve to the right 1634 feet, a tangent 835 feet; a 2°00' curve to the right 220 feet, and a tangent 1764 feet to the north end of Ore Dock No 6

Track No 3 of the ore dock constitutes a continuation of the east lead track From the north end of the dock, it is tangent 108 feet to the collision point and to the south end of the dock

Grades

Beginning in the immediate vicinity of the station at Proctor, the grade of the double-track line is slightly ascending southward to the summit, a distance of about 3100 feet Southward from the summit, the grade is 0 41 to 1 51% descending for about 2600 feet, then an average of 2 0% descending 4 3 miles to the end of double-track at Collingwood

Southward from Collingwood, the grade of the east lead track for Ore Dock No 6 is, successively, 2 0% descending 2265 feet, a vertical curve 420 feet, and level 3640 feet to the collision point

Proctor Hill

The grade between Proctor and the trestle approach to Ore Dock No 6 is known as Proctor Hill

Time and Weather

The collision took place about 7:45 a m , under clear weather conditions The temperature was 26 degrees below zero and snow covered the ground

Authorized Speed

The maximum authorized speed for all trains on Proctor Hill is 20 m p h

Carrier's Air Brake, Dynamic Brake & Train Handling Rules

Dynamic Braking: A means of employing the momentum of the locomotive and train to cause a braking effect Power is generated by the traction motors reconnected as generators and this power is dissipated in fan blown grids on the locomotive

Pressure Retaining Valve (Retainer): A valve by means of which a portion of the pressure in the brake cylinder may be retained to aid in retarding the acceleration of a train in descending long grades This permits the brake pipe pressure to be increased (after brake applications) to recharge the auxiliary reservoirs

206 Enginemen of trains must check with trainmen to insure that required number of retainers are turned to position stated before departure from outside or from intermediate points named herein

209 Retainers must be turned up on loaded cars before leaving Proctor Yard for Ore Docks as follows:

Position 2	20 Pound Retainer	45 degrees below horizontal
Position 3	10 Pound Retainer	Horizontal

Highest pressure retainer must ALWAYS be set on head end of train

	Position 1	Position 2	Position 3	Position 4
Proctor Hill Trains		70%	30%	

300 Dynamic brake on diesel-electric locomotive so equipped shall be used when braking trains on descending grades Dynamic brake may also be used to reduce speed or control train speed when time will permit, but shall not be considered as superseding the automatic brake

301 When using dynamic brake and speed of train cannot be properly controlled with dynamic brakes only, the train brakes will be used in conjunction with the dynamic brake The locomotive brakes shall not be allowed to apply when using dynamic brakes

303 During dynamic braking, if an automatic brake application is made, the dynamic brake interlock will prevent brakes from applying on the locomotive consist

If an emergency application of brakes is initiated from the automatic brake, the dynamic brake will be nullified and brakes will apply on the locomotive as well as on the train

Should emergency application of the brakes be made from the automatic brake valve, leave the automatic brake in emergency position until the train stops

Description of Train Equipment

Transfer Train Consist

The train consisted of road-switcher type diesel-electric units 163, 166 and 173, coupled in multiple-unit control, 15 cars and a caboose (2220 tons total)

Locomotive

All three units of the locomotive were built in 1959 and were of the same type, EMD SD-9 They had 26L air brake equipment The feed valve of the first unit, 163, was set to maintain 90 pounds brake pipe pressure

The three locomotive units had dynamic brake equipment connected for multiple-unit control from the cab of the first unit The circuitry of the dynamic brake system was of the field loop type Hence, any interruption in the circuitry would adversely affect the retardation effort of the dynamic brakes of all three locomotive units

The dynamic brake system of the locomotive was most effective at a speed of 21 m p h It was capable of producing 153,000 pounds retarding force at that speed

A dynamic brake interlock was associated with the 26L air brake equipment This interlock had no effect on the operation of the locomotive's independent air brake It functioned in such manner that when the engineer initiated a service application of the automatic air brakes while the dynamic brake was in operation, all the automatic brakes of the train applied except those of the locomotive If the engineer initiated an emergency application of the automatic brakes while the dynamic brake was in operation, the dynamic brake would release and all the automatic brakes of the train would apply, including those of the locomotive

Cars

All 15 cars of the transfer train were hopper cars, with each car having an approximate lightweight and capacity of 46,200 and 154,000 pounds, respectively The cars were in captive service, being used exclusively by the DM&IR to transport ore from mining areas to the ore docks at Duluth At the time of the accident, the cars were loaded to capacity with taconite pellets The gross weight of the 15 cars and cargo was approximately 1620 tons

Each car had two 4-wheel trucks, friction journal bearings, composition brake shoes, a retainer valve, and AC air brake equipment having an accelerated release feature In addition, each car was equipped with an air brake system known as the "Orinoco" variable retainer This system, used in conjunction with specially equipped locomotives, cars and cabooses, permits enginemen to retain full brake cylinder pressure on cars in a train when an application of the train automatic brake system is released, or to graduate such pressure as needed The "Orinoco" systems were not in use on the train involved due to the caboose not being so equipped

Circumstances Prior to Accident

On the day before the accident, a southbound ore train derailed while en route from Minntac to Proctor As a result, the locomotive proceeded with the first 15 cars to the yard at Proctor, where it stopped on yard track 2C at approximately 1:00 a m the day of the accident It then left the 15 cars standing on track 2C with their air brakes applied in emergency About 4 hours 30 minutes later, a yard locomotive attached a caboose to the north end of the 15 cars, in preparation for movement of the cars to a Duluth ore dock by a transfer train crew comprised of an engineer, fireman, front brakeman, conductor and flagman

At about 6:30 a m , the conductor, front brakeman and flagman reported on duty at the Proctor yard office, where the conductor received instructions to deliver the 15 cars on yard track 2C to Ore Dock No 6 at Duluth Soon thereafter, he and the flagman proceeded to the caboose at the north end of these cars, and the flagman coupled the air hoses between the caboose and the northernmost car Meanwhile, the front brakeman went to the enginehouse for the purpose of accompanying the assigned locomotive to its train on yard track 2C

The engineer had reported for duty at the Proctor enginehouse at 6:00 a m Shortly afterward, he proceeded to his assigned locomotive, which consisted of three road-switcher type diesel-electric units, and made a check which determined that all the controls were properly positioned for multiple-unit control from the cab of what was to be the first locomotive unit of the train Following this, he tested the independent and automatic brake systems of the locomotive and found both systems functioning properly, with the exception that the air gage indicated the brake cylinder pressure was about 30 pounds instead of the normal 40 pounds Feeling that the low brake cylinder pressure was due to accumulation of ice around the brake rigging and shoes, he moved the locomotive back and forth with the independent brake applied to free the brake rigging and shoes of ice This resulted in an increase of brake cylinder pressure to 35 pounds The dynamic brake selector switch of the first locomotive unit was in No. 3 position The engineer stated he tested the dynamic brake interlock of the first unit and found it to be functioning properly

At about 6:40 a m , after arrival of the fireman and front brakeman, the locomotive left the enginehouse area and proceeded to its train on yard track 2C The engineer stated that shortly after leaving the enginehouse, he applied the dynamic brake and found that it was functioning properly, as indicated by the ammeter and a retardation in speed While en route to yard track 2C, the engineer also applied the independent brake with the locomotive moving under power, to remove any ice accumulations remaining on the brake rigging and shoes This maneuver was successful, as indicated by his statements, in increasing brake cylinder pressure to the normal 40 pounds

The locomotive was attached to its train on yard track 2C at approximately 7:10 a m , after which the front brakeman coupled the air hoses between the locomotive and first car The locomotive then began to charge the air brake system of the train About 15 minutes later, when he saw the caboose air gage was indicating that the brake pipe was charged to 85 pounds, the flagman alighted from the caboose to participate in the required test of the train brakes The conductor remained inside the caboose and used the radio to instruct the engineer when to apply and release the brakes for the test The flagman stated that he and the front brakeman inspected each car during the test to see that its brakes applied and released However, according to the carrier's taped record of radio messages, the brakes were applied and released for the test within a 20-second period Because of this short interval, and the engineer's statement that the front brakeman was on the third locomotive unit when the brakes were released, it is apparent that the brakes of each car were not examined, as alleged by the flagman, and that the transfer train subsequently left Proctor without its air brakes having been tested in accordance with applicable provisions of the Power Brake Law of 1958 The investigation revealed that it also left Proctor without the retainers of the cars having been turned up, as prescribed by the carrier's air brake rules 206 and 209 In this connection, the engineer stated that he had no conversation with the front brakeman relative to use of the retainers on the cars According to his statements, the flagman asked the conductor whether he wanted the retainers turned up and the conductor replied, "We only got 15 cars, I don't think so "

The Accident

Southbound trains leaving Proctor yard tracks move on a slightly descending grade in approach to the Proctor station, then move on a slightly ascending grade until they reach the summit, about 3100 feet south of the station

The transfer train consisting of three locomotive units, 15 cars and a caboose, started southward on yard track 2C at approximately 7:30 a m , after the cars had been on that track for about 6 hours 30 minutes in snow-covered surroundings and extremely cold weather The engineer's statements indicate that after the train attained a speed of about 7 m p h on yard track 2C and the slightly descending grade, he applied the dynamic brake and initiated an 8-pound brake pipe reduction to de-ice the brake rigging and shoes on the cars According to his statements, the dynamic brake functioned properly and the 8-pound brake pipe reduction was maintained for about 1000 feet, until there was noticeable retardation of speed He then released both the dynamic brake and air-brake applications Soon thereafter, the train entered the southward main track, moved onto a slightly ascending grade, and passed the Proctor station

The speed tape indicates (after corrected in accordance with calibrations of the speed-recording device) the train increased speed to about 20 m p h while moving southward from the Proctor station to the summit of the ascending grade The engineer said that he initiated a 5-pound brake pipe reduction to keep the brake shoes warm while nearing the summit, and that he initiated another 5-pound reduction as the train moved over the summit He further said that when the train moved over the summit and onto the descending grade (Proctor Hill), he moved the throttle to idle position and applied the dynamic brake shortly afterward In this connection, the speed tape shows that the train began to reduce speed from 20 m p h in the area of the summit, and it decelerated to 16 m p h shortly after moving onto the descending grade Immediately afterward, apparently as it neared and moved onto that part of Proctor Hill where the grade averages 2% descending southward, the train began to increase speed

Locations known as Earth Movers and Rest Point are, respectively, about 1600 and 3600 feet north of the point where the grade begins to average 2% descending southward The speed tape shows the train had accelerated to about 35 m p h by the time it reached Earth Movers The engineer stated he initiated a third 5-pound reduction of brake pipe pressure in that area, and the train continued to increase speed He further stated he took no additional action to control the speed on the descending grade until the train reached a point about midway between Earth Movers and Rest Point, when it was moving at a speed of approximately 40 m p h as indicated by the speed tape At that time, according to his statements, the engineer initiated a fourth 5-pound brake pipe reduction, increasing the total reduction of brake pipe pressure to 20 pounds, and the train continued to increase speed

The engineer said that the dynamic brake was fully applied when he made the fourth 5-pound brake pipe reduction, and that the ammeter was indicating the dynamic brake was functioning properly However, the evidence is that the dynamic brake was in defective condition and was producing only about one-fifth of its potential retardation effort In any event, the transfer train continued to accelerate on the descending grade, to a speed of about 51 m p h by the time it reached the area of Rest Point At that time, according to his statements, the engineer moved the automatic brake valve to emergency position, causing the automatic brakes of the locomotive and cars to apply in emergency, and the dynamic brake application to be released Immediately afterward, he noticed the wheel-slip indicator was indicating that the locomotive wheels were sliding According to his statements, the engineer then stopped the locomotive wheels from sliding by simultaneously bailing off the application of the automatic brakes on the locomotive and applying the independent brake instead The speed tape supports the engineer's statements relative to the emergency brake application and actuation of the wheel-slip indicator The tape indicates the locomotive wheels started to slide while the train was moving at 51 m p h It further indicates that the train had reduced speed to 49 m p h when the locomotive wheels stopped sliding, and that it thereafter accelerated, at a lesser rate than previously, to a speed of about 55 m p h within a distance slightly less than one mile

After the train attained a speed of about 55 m p h , the engineer thought his previous manipulation of the automatic brake valve had been unsuccessful in producing an emergency application of the brakes on the cars As a result, he moved the automatic brake valve to release position in order to recharge the train air brake system sufficiently for another attempt at stopping the train by a second emergency brake application He said that, in addition, he released the locomotive's independent brake and reapplied the dynamic brake He further said the fireman left the control compartment about that time to go to the trailing locomotive units and see what he could do, if anything, to stop the train

The speed tape indicates that when the independent brake of the locomotive and the automatic brakes of the cars were released, the train's rate of acceleration on the 2% grade increased The engineer said that after the train moved approximately one mile farther southward, he again initiated an emergency brake application At the same time, according to his statements, he reapplied the locomotive's independent brake while bailing off the application of the automatic brakes on the locomotive The speed tape indicates the engineer took the aforesaid actions when the train had reached a speed of 66 m p h on the 2% grade and was approaching Collingwood at a distance of about one mile It further indicates the speed continued to increase for a short distance, then leveled off at 69 m p h The train maintained this speed as it proceeded through the Collingwood interlocking, entered the east lead track for Ore Dock No 6, and moved onto the vertical curve located a short distance north of the trestle approach to the dock It began to reduce speed rapidly as it moved off the vertical curve and onto the level grade of the trestle Approximately 30 seconds later, when the train had decelerated to 44 m p h , it entered track No 3 on Ore Dock No 6 and struck the north end of a cut of 26 empty hopper cars standing on that track

The front brakeman jumped from the third locomotive unit as the train moved on the curve leading to the trestle approach for Ore Dock No 6. The engineer jumped from the first locomotive unit soon afterward, on the trestle approach to the ore dock At that time, the fireman was seen to be standing on steps at the rear of the third locomotive unit It appears he was still there when the collision occurred

According to his statements, the conductor noticed before departure from Proctor that the caboose air gage was indicating 90 pounds brake pipe pressure The flagman said he noticed that the gage was indicating 85 pounds brake pipe pressure as the train moved over the summit of Proctor Hill and onto the descending grade About that time, according to the flagman, the conductor radioed the engineer and inquired as to whether he was "going to shoot any deer this morning," and the engineer replied that he hoped not Upon being asked, the conductor explained to the flagman that he was referring to a trip down Proctor Hill the previous day, when the engineer stopped a loaded ore-train on the hill by an emergency brake application

Immediately after he initiated the first emergency brake application, the engineer called over the radio "I guess we did shoot a deer " Soon thereafter, he informed the conductor by radio that he could not control the train on Proctor Hill The engineer then asked the conductor whether he could do anything to stop the train The flagman overheard this radio communication and immediately moved the conductor's valve in the caboose to emergency position but heard no exhaust of air, due to the engineer having already depleted the air in the brake pipe by the first emergency brake application Shortly thereafter, the flagman restored the conductor's valve to closed position He and the conductor then went to the front platform of the caboose, where the conductor closed the angle cock at the rear of the last car; separated the air hoses between that car and the caboose; re-opened the angle cock at the rear of the last car, and again closed that angle cock after hearing no exhaust of air A few seconds later, realizing the train was increasing speed and moving out of control, the flagman uncoupled the caboose from the last car He said the conductor then applied the hand brake of the caboose, and released it after the caboose reduced speed on Proctor Hill The caboose continued to move a short distance farther southward on the 2% grade, then stopped due to its air brake having been applied by the first emergency application initiated by the engineer The flagman released this brake by bleeding the air from the brake system, after which the caboose again moved southward on Proctor Hill with the conductor at the hand brake to control the speed It proceeded on the descending grade to the curve leading to the trestle approach for Ore Dock No 6, where the conductor stopped it to pick up the front brakeman, who had jumped from the third locomotive unit The caboose then proceeded a short distance farther southward on the descending grade and stopped again on the trestle approach to Ore Dock No 6, at which time the conductor and flagman began a search for the engineer and fireman While the caboose was en route to its final stopping point on the trestle approach, the front brakeman complained that his left leg felt cold and was advised by the conductor to go to a hospital for treatment

Damages

The train stopped with the front end 297 feet south of the collision point The three locomotive units and the first nine cars were derailed The locomotive units stopped upright on and in line with the structure of ore-dock track No 3

Of the cut of 26 empty hopper cars struck by the train, 11 cars at the north end were derailed The impact caused three of these cars to be thrown over the top of cars standing on ore-dock track No 1 and over the east side of the dock

At the time of the accident, ore-dock tracks No 1 and No 6 were occupied by 30 and 42 empty hopper cars, respectively Seven of the cars on track No 1 and four on track No 6 were derailed, as a result of being struck by derailed equipment of the train and the cut of cars on track No 3 In addition, 15 other cars were struck but not derailed

The derailed cars stopped in various positions, as shown in Plate No 3 The three locomotive units were heavily damaged, with the cab at the front of the first unit being demolished Of the 22 derailed cars and the 15 cars which were struck but not derailed, 10 were destroyed, 18 heavily damaged, and 9 slightly damaged

The dock and its track structures were damaged considerably

Damage Cost

The carrier estimated the cost of damages to the locomotive units, cars, track structures, and ore dock to be $505,525

Casualties

The engineer sustained contusions and abrasions on his face and chest, and lacerations of the left knee, as a result of jumping from the locomotive before the collision

The fireman was killed He was found alongside the first car behind the locomotive

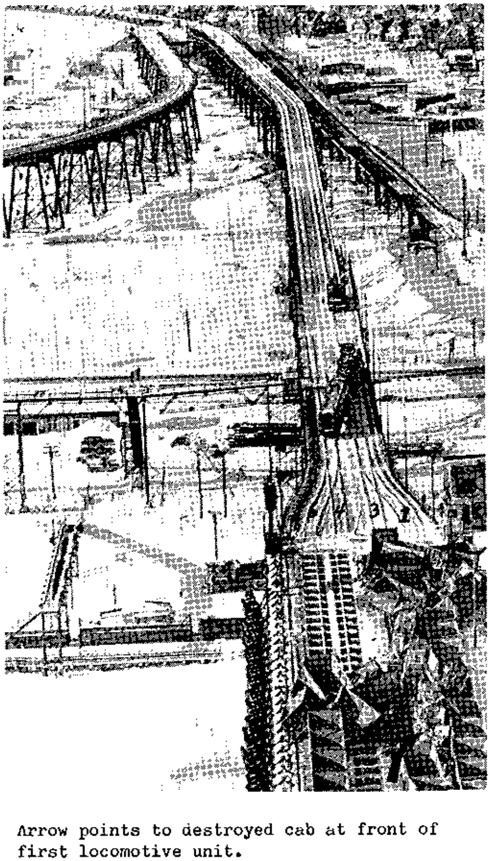
After being advised by the conductor to go to a hospital for treatment, the front brakeman walked about one-half mile to a waiting ambulance He died while en route to the hospital in the ambulance. A post-mortem examination revealed that serious heart conditions were causal factors in his death

Post-Accident Examinations and Tests

Cars

The first nine cars of the transfer train were damaged to the extent that their air brake systems could not be tested The air brake systems of the remaining six cars and ca-

PLATE NO. 3



Arrow points to destroyed cab at front of first locomotive unit.

boose were tested and found to be functioning properly There was no brake pipe leakage, and the piston travel on each car was within the prescribed limits

Locomotive

The control and brake stands of the first unit were found lying on the cab floor The hand brake of this unit was found applied The throttle was in Run 8 position; the reverser in forward position; the selector lever in power position; the emergency brake valve in closed position; the automatic brake in release, or running, position; and the independent brake valve in applied position It is probable that one or more of these valves and controls were moved to the positions shown as a result of impacts caused by the collisions All other controls of the locomotive were in proper position for multiple-unit control

The controls of the two trailing units were also found to be properly positioned, with the exception of the isolation switch of the second unit This switch was found in isolate position The investigation revealed, however, that the fireman of another locomotive evidently moved the switch to isolate position shortly after the accident, to silence the alarm bell associated with the engine of that unit The hand brake of each trailing unit was found to be in release position, and the emergency brake valves of those units were found in closed positions

Intermittent flat spots were found on all wheel treads of the first unit

The undamaged portion of the locomotive air brake system was tested and found to be functioning properly

Dynamic Brake Equipment

Examination of the locomotive's dynamic brake equipment revealed a cable connection of the field loop circuit was loose at the location of a terminal for electrical switch gear on unit 166, the second locomotive unit The screw for securing the cable to the terminal was loose and discolored from heat The field loop circuit was tested, and a discontinuity was detected at the location of the loose cable and terminal screw

Further tests revealed that the discontinuity in the field loop circuit caused a loss of about 80% of the normal dynamic braking effort of the three locomotive units under optimum conditions, i e with the dynamic brake applied, the throttle in Run 8 position, and the locomotive moving at a speed of about 21 m p h

The locomotive daily inspection report, dated January 6, 1971, for locomotive unit 166 shows that the dynamic brake was reported to be not functioning The report further shows this condition was corrected by cleaning a cable terminal

Test Train

A test train was assembled at Proctor four days after the accident to determine the charging and release characteristics of an air brake system similar to that of the transfer train involved in the accident The test train was comprised of 3 locomotive units, 15 cars and a caboose, similar to those of the transfer train The tests were conducted under -4°F weather conditions

Beginning with a fully depleted air brake system, brake pipe pressure was charged to 80 psi within 30 seconds In 60 seconds, the auxiliary and emergency reservoirs of the last car registered 34 and 18 psi, respectively After five minutes of charging, brake pipe pressure at the caboose registered 89 psi, and the auxiliary and emergency reservoirs of the last car were at 80 and 79 psi, respectively At the end of 10 minutes, the air pressures of the train brake pipe and the auxiliary and emergency reservoirs of the last car were 90, 88 and 86 psi, respectively

When the brake system was fully charged, the automatic brake valve was manipulated at proper intervals to simulate the engineer's account of how he handled that valve for brake applications and releases beginning with the leakage and brake tests performed before departure of the transfer train from Proctor After simulating the engineer's account of brake applications and releases up to and including the last service application made while descending Proctor Hill, the train brake pipe pressure registered 69 pounds psi, and the auxiliary reservoir of the last car 68 psi The brakes of the test train were then applied in emergency to simulate the engineer's first emergency brake application This resulted in brake pipe pressure being reduced to zero The auxiliary reservoir, emergency reservoir, and brake cylinder pressures of the last car registered at 69, 69 and 65 psi, respectively

Following the aforesaid emergency brake application, the automatic brake valve was moved to release, or running, position and returned to emergency position 1 minute 23 seconds later to simulate the engineer's actions after the first emergency brake application The air brake of the last car released 40 seconds after the automatic brake valve was moved to release position At that time air pressures of the train brake pipe and the auxiliary and emergency reservoirs of the last car were restored to 86, 70 and 62 psi, respectively The following emergency brake application resulted in the train brake pipe pressure being reduced to zero The auxiliary reservoir, emergency reservoir and brake cylinder pressures of the last car were 62, 60 and 59 psi, respectively

Considering the short interval between the time of the brake test at Proctor and the time of departure, and the engineer's application and release of the brake between the Proctor yard and the summit of Proctor Hill, the charging tests conducted with the test train indicate that the brake system of the transfer train was not fully charged before the train began to descend Proctor Hill and that, consequently, the service and emergency brake applications initiated by the engineer produced less than optimum retarding effort

Proctor Hill Crew Assignments

Crews of southbound ore trains arriving at Proctor are replaced by crews assigned to operate transfer trains between Proctor and the ore docks at Duluth Before an engineer is permitted to operate loaded trains on Proctor Hill, he must have had at least three years experience as an engineer on other assignments In addition, he is required to make student trips on ore trains descending Proctor Hill; make a qualifying trip on the hill under the supervision of a carrier official, and be approved by that official to operate trains on Proctor Hill

The engineer of the transfer train involved in the accident had 30 years experience in engine service and had qualified to operate trains on Proctor Hill in accordance with the requirements outlined above

Best information available indicates that loaded ore trains descending Proctor Hill average about 90 cars in length

Proctor Hill Safety Record and Operating Practices

Safety Record

According to carrier officials the accident of January 30, 1971, was the first collision or derailment resulting from a train moving out of control while descending Proctor Hill

Operating Practices

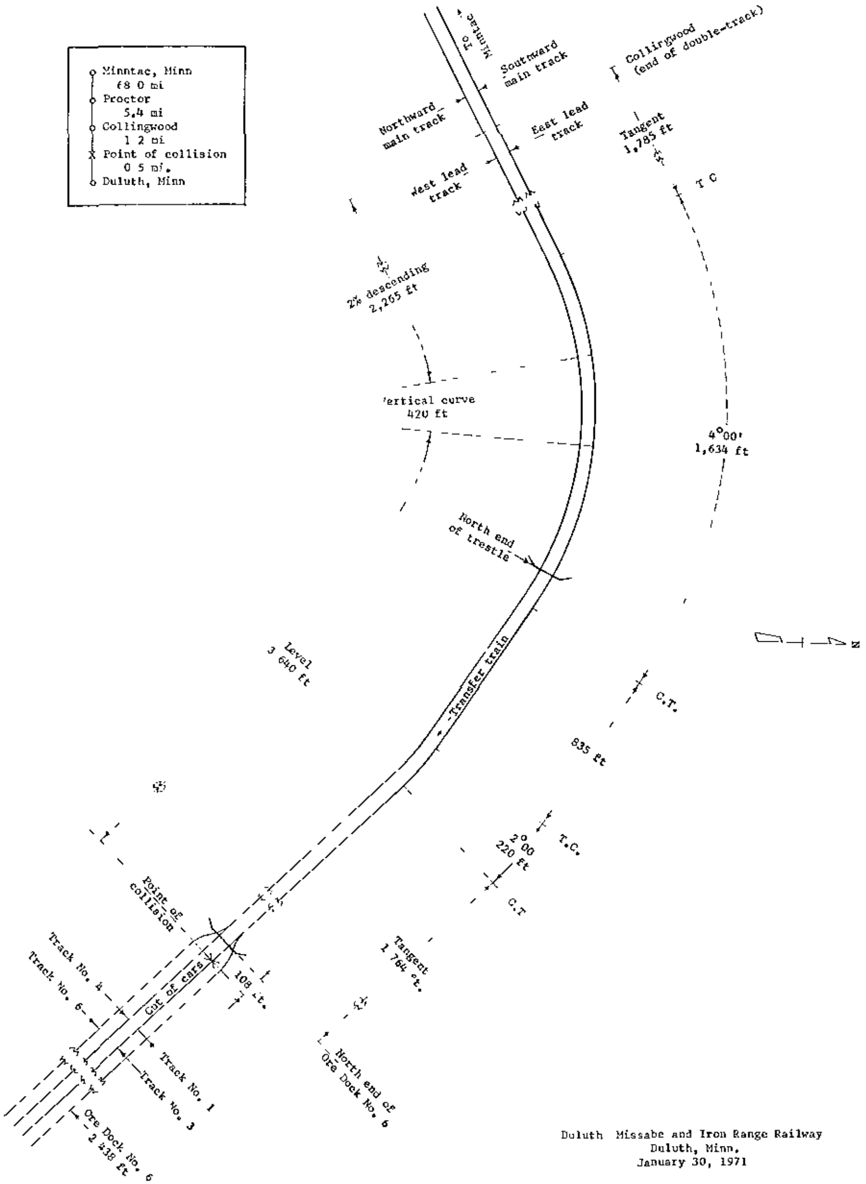
Recognizing the dangers inherent in the operation of ore trains down Proctor Hill, the carrier long ago issued stringent rules and regulations governing such movements The investigation developed conflicting information as to the train crews' compliance with, and the carrier's enforcement of, those rules and regulations However, taking everything into consideration, it appears to have been a rather common practice for trains descending Proctor Hill to exceed the prescribed speed limit It further appears that as a result of this practice, engineers often resorted to emergency brake applications to maintain control of their trains on the hill An official of the carrier stated that enginemen were not provided detailed instructions relative to handling of trains descending Proctor Hill, because of the peculiar operating characteristics of each train

Gravitational and Retarding Forces Involved

Gravitational Force

According to computations, the gravitational force exerted on the train as it moved on the approximately 2% grade of Proctor Hill was 88,800 pounds Thus, it is

PLATE NO. 1



Duluth Missabe and Iron Range Railway
Duluth, Minn.
January 30, 1971

apparent a braking or retarding force of 88,800 pounds was required to balance the force of gravity and prevent the train from accelerating on the grade. It is further apparent that any retarding force developed in excess of 88,800 pounds would cause the train to decelerate on the grade

Dynamic Brake Retarding Forces

The dynamic brake system of the three-unit locomotive was capable of producing, when functioning properly, 153,000 pounds retarding force at a speed of 21 m p h Its ability to produce retarding force diminished in relationship to increase of speed over 21 m p h or decrease below 21 m p h , diminishing, for examples, to production of 49,500 pounds retarding force at 65 m p h or 82,500 pounds at 10½ m p h Thus, it is apparent that when the engineer applied the dynamic brake shortly after moving onto Proctor Hill at a speed of about 20 m p h , that brake application should have been effective in properly controlling the train speed on the descending grade, provided the dynamic brake system was functioning properly

Locomotive Air Brake Retarding Force

Calculations indicate that the automatic brake of the locomotive was capable of producing about 125,000 pounds retarding force when applied in emergency at a speed of 50 m p h Consequently, it is apparent that when the engineer initiated the first emergency brake application on Proctor Hill, the application of the brakes on the locomotive alone should have effectively stopped the train, provided they remained applied in emergency

Air Brake Retarding Force of Cars in Train

The air brakes of the 15 cars in the train were calculated to be capable of producing approximately 113,565 pounds retarding force following an emergency application at 50 m p h , provided that the air brake system had been fully charged to 90 pounds brake pipe pressure It was further calculated that because of the shortness of the train, i e the ratio of the number of cars to the three locomotive units, approximately a 25-pound reduction of brake pipe pressure was required to develop sufficient retarding force by the brake system of the cars (excluding the locomotive) to balance the approximately 2% grade of Proctor Hill and prevent the train from accelerating Thus, it is apparent that more than a 20-pound service brake pipe reduction was required to reduce the speed of the train on the grade if only the air brakes of the cars were being utilized It is also apparent that a timely emergency application of the air brakes on the cars only should have been effective in stopping the train on Proctor Hill, provided that the train air brake system had been fully charged to 90 pounds brake pipe pressure

Findings

1 The transfer train left Proctor without its retainers having been turned up, or its air brakes tested in accordance

with applicable rules and regulations Had the retainers been turned up, their use would have provided the engineer considerable assistance in controlling the speed of the train on Proctor Hill Though they apparently were not tested in accordance with applicable rules and regulations, the indications are that all the train air brakes were operative

2 The engineer apparently took action to free the brake rigging and shoes of the cars from accumulations of snow and ice before moving onto the descending grade involved There is a probability, however, that some snow and/or ice remained on the brake rigging and shoes when the train moved onto the descending grade and thereby adversely affected functioning of the air brakes in the initial stages of the movement on the grade

3 Considering that the engineer said he applied the dynamic brake soon after moving onto Proctor Hill and the speed tape shows the train decreased speed to 16 m p h within a relatively short distance after entering the descending grade, it appears the dynamic brake equipment of the locomotive was functioning properly at that time

4 When the speed had decreased to 16 m p h , circuit interruption at a loose cable connection at a terminal for electrical switch gear caused an approximately 80% reduction in capacity of the dynamic brake equipment to provide retardation effort As a result of this and an insufficient application of the air brakes, the train began to increase speed About that time, it entered the 2% grade involved

5 The engineer initiated a third 5-pound reduction in brake pipe pressure when the train reached a speed of about 35 m p h on the 2% grade, and a fourth 5-pound brake pipe reduction upon attaining a speed of approximately 40 m p h Since the dynamic brake was applied, the dynamic brake interlock feature prevented the automatic brakes of the locomotive from being applied The retardation effort provided by the defective dynamic brake of the locomotive and the total 20-pound reduction in brake pipe pressure on the cars was insufficient to overcome the gravitational force exerted by the train on the 2% grade Consequently, the train continued to increase speed

6 The engineer's statement that the ammeter had indicated the dynamic brake was fully applied and functioning properly does not appear to be factual It is quite apparent this brake was malfunctioning, perhaps intermittently, and thereby incapable of producing more than a small percentage of its potential retardation force

7 When the train reached a speed of about 51 m p h , the engineer initiated an emergency application of the automatic air brakes on the locomotive and cars, causing the dynamic brake of the locomotive to be released automatically From all indications, he did not consider the train to be in an emergency situation at that time nor was overly-concerned about its excessive speed This apparently was due to the engineer being somewhat accustomed to permitting a train to

descend Proctor Hill at excessive speed and retaining control by stopping the train with an emergency brake application Consequently, when wheels of the locomotive began to slide as a result of the emergency brake application, he bailed off the emergency application of the automatic brakes on the locomotive and, according to his statements, applied the independent brake of the locomotive instead The extent to which the engineer applied the independent brake, or whether he actually applied that brake, could not be determined

8 The engineer's release of the emergency application of the locomotive's automatic air brake under the existing conditions was a mistake That action, which was contrary to the carrier's rules, eliminated a major portion of the retarding force that the automatic brake system of the entire train was producing It was perhaps the most significant causal factor in the accident

9 When the engineer released the automatic brake of the locomotive, the train started to re-accelerate on the heavy descending grade This indicates that the air brakes of the cars were not producing retarding force to or near the maximum of their capability, apparently due to the air brake system not having been fully charged to 90 pounds brake pipe pressure before the train moved onto Proctor Hill It further indicates the engineer may not have applied the independent brake, as alleged, or did not apply it heavily enough

10 Erroneously thinking he had not been successful in obtaining an emergency application of the train brakes, the engineer released the air brakes on the cars after the train had accelerated to 55 m p h , in preparation for another emergency brake application As a result, the train increased speed to about 66 m p h within a distance of approximately one mile, consuming valuable braking distance available to it In view of post-accident test findings, all the brakes of the cars were apparently released by the time the train reached a speed of 66 m p h , and brake pipe pressure was restored to about 80 psi

11 After initiating the second emergency application of the train brakes, the engineer again bailed off the application of the automatic brake on the locomotive and, according to his statements, applied the independent brake The train continued to accelerate for a short distance, until it attained a speed of 69 m p h on the 2% descending grade The speed remained unreduced on the remaining portion of the 2% grade, apparently due to the air brakes of the cars not producing retarding force to the maximum of their capability because of the train line not having been fully charged during the short period the brakes had been released and to the independent brake application, if applied, not compensating sufficiently for release of the locomotive's automatic air brake application

12 As the train moved on the vertical curve at the foot of Proctor Hill the grade lessened, permitting the brakes applied to begin reducing the speed At that time, there was

insufficient braking distance remaining on the vertical curve and on the level grade beyond for the brakes applied to reduce the speed greatly before the train reached Ore Dock No 6 As a result, the train struck the empty cars standing on track No 3 of the dock while moving at a speed of 44 m p h

13 The accident was the end result of the contributing factors outlined in the following:

(a) Cold, snow and/or ice conditions, which probably had somewhat of an adverse affect on the effectiveness of the air brakes

(b) Failure of crew to turn up the retainers on the cars, as required by rule

(c) Train moving onto Proctor Hill without its air brake system having been fully charged

(d) Failure of the locomotive dynamic brake equipment to function properly as the train moved on the descending grade

(e) Failure of the engineer to initiate a timely service brake application sufficiently enough to reduce brake pipe pressure as required to properly control the speed of the train on the descending grade, apparently due to the engineer being unaware of different braking characteristics of a 15-car train as opposed to an average 90-car train

(f) Excessive delay by engineer in applying the train brakes in emergency, resulting in the train attaining a speed of about 51 m p h before this action was taken

(g) Failure of engineer to leave the automatic air brakes of the locomotive and cars applied in emergency

(h) Carrier's lack of adequate supervision over the operation of trains descending Proctor Hill

Dated at Washington, D C , this 23rd
day of December 1971
By the Federal Railroad Administration

Mac E Rogers, Director
Bureau of Railroad Safety