FREIGHT TRAIN SPEED CONTROL ON THE NORTHEAST CORRIDOR

FINAL REPORT

IITRI PROJECT E06589

CONTRACT NO. DTFR53-82-C-00254

TASK ORDER NO. 3

IITRI

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21 - Freight Operations

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Prepared for:

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IIT RESEARCH INSTITUTE

PREFACE

The work described in this report was conducted by IIT Research Institute (IITRI) under authorization of Federal Railroad Administration (FRA) Contract No. DTFR53-82-C-00254, Task Order No. 3. The period of performance was from August 10, 1987 to December 31, 1987. The work included the application of Train Operation Models, which have been developed for the Research and Locomotive Evaluator/Simulator, to the analysis of longitudinal in-train forces associated with the braking of long freight trains in the Northeast Corridor.

Dr. Milton R. Johnson was the IITRI Project Manager for this work. He was assisted by Mr. Graydon F. Booth. Messrs. M. Clifford Gannett and Garold R. Thomas were the FRA Contracting Officers Technical Representatives on this project. Their assistance throughout the course of the work is gratefully acknowledged.

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1. INTRODUCTION

1.1 OBJECTIVE AND SCOPE

This report presents results from an analytic study of the transient draft and buff forces which can be developed during the braking of long freight trains. A wide variety of braking conditions were considered. The work was conducted to provide guidance in the establishment of optimum Automatic Train Control (ATC) procedures for freight trains operating on the Northeast Corridor.

The analysis of the transient draft and buff forces was made using advanced train operations models which have been developed for the Research and Locomotive Evaluator/Simulator (RALES) which is located at IIT Research Institute (IITRI) in Chicago. Ninety-one analytical simulations of freight train braking were conducted. Sixty-seven of the simulations were made assuming straight and level track. Twenty-four of the simulations were conducted at specific locations on the Northeast Corridor. Four different train consists were considered.

1.2 BACKGROUND

1.2.1 Automatic Train Control on the Northeast Corridor

All AMTRAK trains operating on Northeast Corridor tracks are equipped with ATC devices that will automatically initiate braking in the event that the cab signal indicates a reduction in train speed or a stop is necessary and such action has not been initiated by the locomotive engineer. Freight trains operating on the Northeast Corridor are not equipped with ATC. ATC devices have been ordered installed on all controlling locomotives of trains operating in the Northeast Corridor. The differences in the stopping characteristics of freight trains with respect to passenger trains needs to be further investigated to determine the performance specifications of freight train ATC devices. Freight trains generally have much longer stopping distances and the effects of slack run-in and run-out need to be considered because excessive slack action can lead to train derailment. Also, since most freight cars have single capacity brakes, deceleration rates of freight trains for a given brake pipe reduction are highly dependent on the average gross weight per car. Once the optimum braking procedures for freight trains are properly understood it will be possible to specify the desired performance characteristics of freight train ATC devices.

1.2.2 Simulation of Train Braking

The computer simulation model which is used in conjunction with the operation of the RALES facility represents all aspects of the operation of the locomotive controls and the resulting consequences on the operation of the train as a whole and on each car in the train. The length and weight of each car are considered individually. The external forces acting on each car are also considered individually. The braking forces, if the brakes are applied, are calculated from the brake cylinder pressure, the characteristics of the brake rigging, the type of brake shoe and the speed-dependent coefficient of friction between the brake shoe and wheel. Rolling resistance forces are calculated from the Davis equation. The forces due to track grade (gravity force of 20 lbs per ton per percent grade) and the added rolling resistance due to the track curvature are determined by the position of each car on the track. The coupler forces at each end of the car are determined from a longitudinal train force model.

The RALES train operations model utilizes a series of subsidiary models to determine braking forces, longitudinal train forces, locomotive operation, etc. The brake model uses parametric relationships to determine the braking forces on each car based on the brake handle position on the locomotive control stand and the time which had elapsed from its last movement. The structure of the model and the results from its use are similar to the Association of American Railroads (AAR) TOS model. Transient forces between cars are determined by a longitudinal train force model which considers representative standard draft gear properties and coupler free clearances between cars.

Because of the limitations of the original RALES models, more advanced brake and longitudinal train force models have been developed. The new brake model removes the restriction of a single brake valve type. It is based on a fluid mechanic representation of the train brake system. The AAR is also using this model in its new TOES model which will supercede TOS (See Ref. 1).

A new version of the longitudinal train force model has also been developed. It allows representation of the individual coupler/draft-gear characteristics on each car of the train. These characteristics are represented by a force displacement curve. The force displacement curve which represents conventional friction draft gear (e.g., AAR Specification M901E) is shown in Figure 1. This curve is based on properties obtained from AAR tests (Ref. 2).

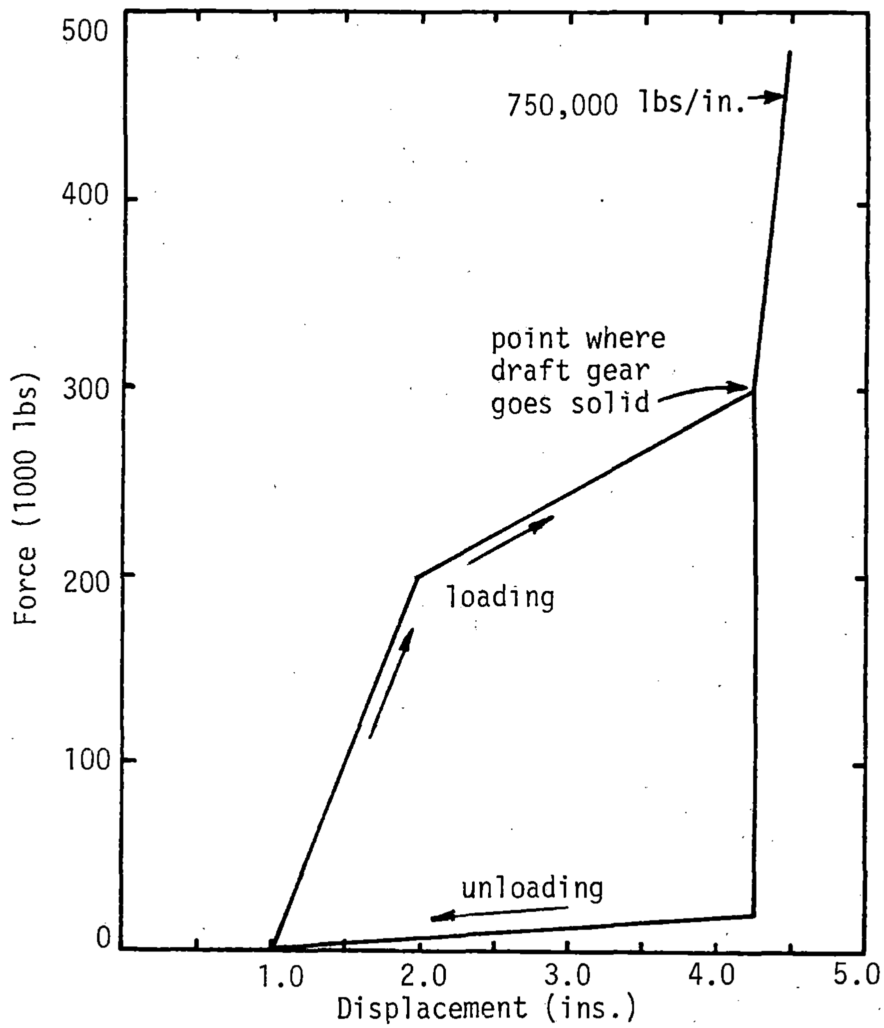

Figure 1. Coupler/Draft-Gear Properties for Friction Draft Gear (Effects of one draft gear shown)

2 PROCEDURE

This section describes the range of conditions which were considered in the study. The principal variables were the type of train, the braking procedures and the track characteristics.

2.1 TRAIN CONSISTS

Four trains were identified for these simulations. Their characteristics are briefly summarized as follows:

1. PYSE1: A train of three SD 40-2 locomotives and 115 cars, 96 loads and 19 empties. The cars range from 23 to 135 tons in gross weight. This train has 9,161 trailing tons, 9,746 total tons and a total length of 7,521 feet. Ninety cars are equipped with AB brake valves and 25 cars are equipped with ABD brake valves. Fifty-three cars are equipped with cast iron brake shoes and 62 cars are equipped with composition shoes.
2. TV24: A train consisting of three SD 40-2 locomotives and 60 cars. This train has a uniform consist of 60 loaded flat cars, each with a gross weight of 75 tons and 93 feet long. This train has 4,500 trailing tons, 5,085 total tons and a total length of 5,787 feet. All of the cars are equipped with ABD brake valves and composition brake shoes.
3. CRCOAL: A train consisting of four SD 40-2 locomotives and 110 cars. This train has a uniform consist of 110 loaded hopper cars each with a gross weight of 130 tons and 50 feet long. This train has 14,300 trailing tons, 15,080 total tons and a total length of 5,776 feet. All of the cars are equipped with AB brake valves and cast iron brake shoes.

4. <u>CRMIX:</u> A train consisting of four SD 40-2 locomotives and 135 loaded cars. The cars range from 63 to 140 tons in gross weight. This train has 14,500 trailing tons, 15,280 total tons and a total length of 7,697 feet. Sixty-four cars are equipped with AB brake valves and 71 cars are equipped with ABD brake valves. Sixty cars are equipped with cast iron brake shoes and 75 cars are equipped with composition shoes.

Although the improved RALES longitudinal model used in the analysis has the capabilities of considering various coupler/draft-gear characteristics, the analyses were conducted assuming that all cars were equipped with friction draft gear. This was done so that comparisons could be made with TOS simulation runs which are restricted by the assumption of friction draft gear for all types of cars. The force displacement characteristics assumed for the friction draft gear used in this study are those shown in Figure 1. The braking ratios assumed for each of the cars were those used on previous TOS simulations conducted by CONRAIL.

2.2 BRAKE APPLICATION PROCEDURE

Seven different braking scenarios were analyzed. With each of these scenarios it was assumed that the initial brake pipe pressure was 90 psi with train leakage of 5 psi/min. It was also assumed that the brakes were bailed off on the locomotive units until the speed was reduced to 1 mph or less when the independent brake was applied to give a 25 psi brake cylinder pressure. The throttle handling varied with the individual cases, but it was reduced to idle when the speed fell below 4 mph. The details of the individual cases are described as follows:

<u>Case 1: Full Service Reduction.</u> In this scenario a reduction of 26 psi was made in the brake pipe pressure. The throttle was gradually reduced using the following procedure. At the time of the brake application the motor current was noted and the throttle position was reduced by one. As the speed decreased and the current increased, the throttle was reduced one notch at a time when the current built up to the original value. Four different simulation runs were made with initial speeds of 53, 43, 33 and 18 mph.

Case 2: Penalty Application with 20 Second Delay. In this scenario a split service reduction was made. A 7 psi reduction was made at the initiation of the braking and then after a 20 second delay the brake pipe reduction was intensified to 26 psi. The throttle was reduced to the Number 1 position at the initiation of braking. Four different simulation runs were made with initial speeds of 50, 40, 30 and 15 mph.

Case 3: Penalty Application with 30 Second Delay. In this scenario a split service reduction was made. A 7 psi reduction was made at the initiation of the braking and then after a 30 second delay the brake pipe reduction was intensified to 26 psi. The throttle was reduced to the Number 1 position at the initiation of braking. Four different simulation runs were made with initial speeds of 50, 40, 30 and 15 mph.

Case 4: Temporary Suppression. In this braking scenario a 7 psi brake pipe reduction was made at the initiation of braking which was gradually increased to 17 psi over 70 seconds. The initial reduction was held for 30 seconds and then additional 2 psi reductions were made at 10 second intervals until the total brake pipe reduction was 17 psi. The throttle was gradually reduced following the procedure used in Case 1. At the beginning of the braking the motor current was noted and the throttle was reduced by one position. Subsequently, every time the current increased to the initial value the throttle was reduced one position. Four simulation runs were made at initial speeds of 50, 40, 30 and 15 mph.

Case 5: Temporary Suppression with Release. This scenario considered speed reduction braking. The same procedures in Case 4 were used for braking and when a target speed was reached the brakes were released. Six simulation runs were made: an initial speed of 50 mph with release at 15 mph, an initial speed of 50 mph with release at 30 mph, an initial speed of 50 mph with release at 40 mph, an initial speed of 40 mph with release at 15 mph, an initial speed of 40 mph with release at 30 mph, and an initial speed of 30 mph with release at 15 mph.

Case 6: Temporary Suppression with Release and Second Application. This braking scenario included several train control procedures. First there was a temporary suppression application following the procedures given in Case 4 at 50 mph except that after the throttle was reduced by one position it was not reduced further. When the speed decreased to 40 mph a release was initiated and the train was allowed to continue for 1.9 miles. Then a second temporary suppression reduction was made again following the procedures given in Case 4 including the successive throttle reductions based on motor current until the train came to a stop.

Case 7: CONRAIL Operating Procedure. This simulation of CONRAIL operating procedures considered an initial 6 psi brake pipe reduction that was held for 20 seconds and then a further reduction was made to a total of 15 psi. After the second reduction the throttle was reduced to idle, one position at a time, in 2 second increments. Three simulation runs were made with initial speeds of 50, 40 and 30 mph.

2.3 TRACK CONDITIONS

Braking simulations for each of the trains were run assuming straight and level track. The PYSE1 train was examined for all 7 braking scenarios. Selected braking scenarios were considered for the other three trains.

Braking of the PYSE1 train was also analyzed at several Northeast Corridor locations. These locations were selected by considering the results of train operation simulations made by CONRAIL using the AAR TOS program.

2.4 SIMULATION OF TRAIN PYSE1 UNDER PROFILE CURVE RESTRICTIONS

Six simulation runs of the PYSE1 train were made at four locations on the Northeast Corridor to simulate train operations in adherence to proposed preliminary speed profile curves. These curves are shown in Figure 2. Each curve corresponds to a different set of signal aspects. These are indicated on page 10.

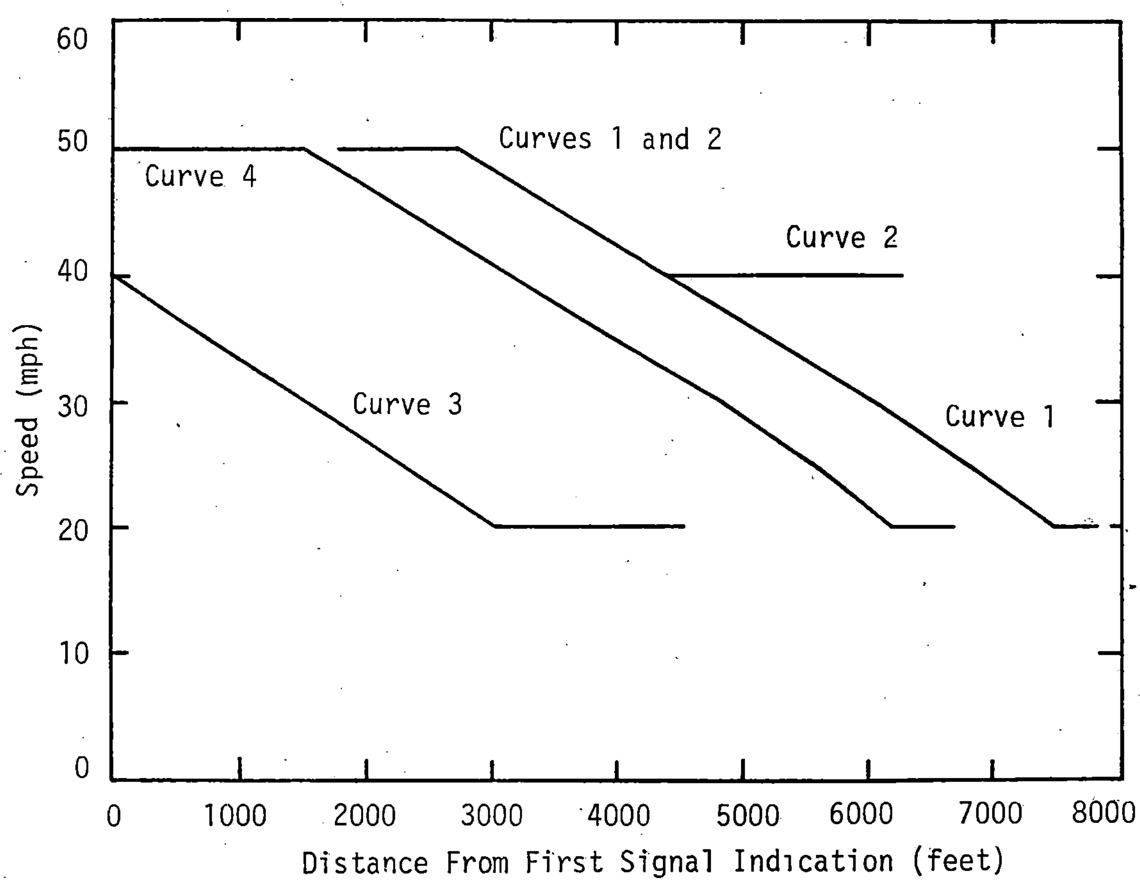

Figure 2. Preliminary Speed Profile Curves for the Northeast Corridor

Signal Aspect Previous	Current	Applicable Profile Curve	Change in Speed Restriction (mph)
Clear	Approach-Medium	2	50 to 40
Clear	Approach	1	50 to 20
Clear	Restricting	4	50 to 20
Approach-Medium	Approach	3	40 to 20
Approach-Medium	Restricting	4	50 to 20

The six simulation cases are described as follows:

Case SP1 - There is a drop from clear to restricting of Signal No. 1102 at 110.23 miles when the train is running northbound at 110.6 miles. The initial speed is 40 mph and Profile Curve No. 4 governs. An initial brake pipe reduction of 6 psi is made to reduce speed. This is subsequently increased in steps to 15 psi.

Case SP2 - This case is the same as Case SP1 except that there is no attempt to control the speed of the train and the throttle is kept in the initial Run 7 position. The profile speed curve is violated at approximately 109.4 miles while running at 32 mph and a penalty application is initiated.

Case SP3 - There is an approach indication at Signal No. 1102 at 110.23 miles while running northbound. Initially dynamic braking is used to reduce speed. The air brakes are applied to stop the train after the speed has been reduced to 19 mph. The block is entered at 39 mph and Profile Curve No. 1 governs.

Case SP4 - There is an approach indication at Signal No. 1164 at 116.39 miles while running northbound. The block is entered at 37 mph and Profile Curve No. 1 governs. Dynamic braking is used to reduce speed. This is sufficient to stop the train because of the added resistance from the grade of the track.

Case SP5 - There is an approach indication at Signal No. 1185 at 118.31 miles while the train is running southbound. The block is entered at 34 mph and the train speed is governed by Profile Curve No. 1. Dynamic braking is used to reduce speed.

Case SP6 - A code change to approach-medium occurs at 117.4 miles at a speed of 40 mph while the train is running southbound. The speed is reduced to 27 mph at Signal No. 1185 at 118.31 miles where there is an approach indication. Profile Curve Nos. 2 and 3 govern.

3. RESULTS

Three data summaries were developed for each simulation run. The first presented run summary data. The speed, distance, throttle position, motor current along with the brake pipe reduction and the brake pipe pressure at three locations in the train and the brake cylinder pressure on the lead locomotive and three locations in the train were provided at two second intervals. The second summary displayed the state of slack in the train as a function of time. This was done by printing out a line of characters where each character represented one car in the train. A dash ("-") was used to indicate that the car is blocked in a draft condition. An "X" was used to indicate the car is blocked in a buff condition. Numbers from 1 to 5 were used to indicate whether the car was moving in a buff region, moving in a draft region or whether it was in a centered free slack condition. This information was displayed at two second intervals. The third summary described the maximum coupler forces on each car in the train in a four second interval. A line of characters was again used to represent each car in the train. A numerical designation from 0 to 9 was used to indicate a range in the absolute magnitude of the force on each coupler. The preceding line was used to indicate the sign of this force. An illustration of these data summaries is presented for one of the simulation runs in the Appendix of this report.

3.1 STRAIGHT AND LEVEL TRACK SIMULATION RUNS

The results from the braking scenarios on straight and level track are summarized in Table 1. The maximum transient draft and buff forces, stop distance, and stop time are tabulated for each simulation. The car number associated with the maximum transient draft and buff forces and the speed of the train at the time the force was developed are also given. A brief description of the blocking phenomenon in the train is included for each case.

The table indicates that severe run-in forces were obtained at the locomotives for the CRMIX train with temporary suppression braking at initial speeds of 40 and 30 mph. This is due to the formation of a large buff block at the rear of the train which moves forward and produces high buff forces when it reaches the locomotives units. The large run-in forces are associated with the draft gear going solid and are of short duration.

TABLE 1. SUMMARY OF RESULTS, STRAIGHT AND LEVEL TRACK

Train		Case and Description	Initial Speed at Braking (mph)	Stop Distance (ft)	Stop Time (sec)	Maximum Transient Draft and Buff Forces: Maximum Forces (1000 lbs)	Car Number	Speed (mph)	Remarks
PYSE1	1A	Full Service Reduction	53	5789	105	163	55	0.1	Buff block builds in center of train and then makes transition to draft
						-78	109	25	
			43	4219	93	161	48	23	
						-85	109	14	
			33	2746	78	143	8	9	
						-121	84	27	
			18	1116	58	65	4	5	
						-156	74	14	
PYSE1	2A	Penalty Application with 20 Second Delay	50	5448	104	153	55	0.1	Buff block builds in center of train and makes transition to draft as train comes to stop
						-167	78	44	
			40	3924	92	144	48	13	
						-170	78	34	
			30	2569	79	173	55	1	
						-174	73	24	
			15	990	59	62	4	4	
						-131	84	7	
PYSE1	3A	Penalty Application with 20 Second Delay	50	5927	111	148	55	0.1	Buff block builds in center of train and makes transition to draft as train comes to stop
						-160	84	42	
			40	4302	99	162	55	11	
						-162	84	32	
			30	2844	87	197	55	0.1	
						-159	84	22	
			15	1112	66	59	4	4	
						-126	54	6	
PYSE1	4A	Temporary Suppression	50	7989	153	115	55	1	Train stays mostly in draft except for buff block which forms on approximately last 15 cars
						-30	108	33	
			40	5712	133	106	55	1	
						-35	112	28	
			30	3586	111	88	55	1	
						-43	114	13	
			15	1317	80	70	55	2	
						-28	71	8	
PYSE1	5A	Temporary Suppression with Release	50-	---	---	198	55	0.1	Train stops
			15 release	---	---	-42	106	44	
			50-	---	---	181	55	15	Train slows to 13 mph
			30 release	---	---	-42	106	44	
			50-	---	---	106	55	29	Train slows to 26 mph
			40 release	---	---	-42	106	44	
			40-	---	---	192	39	0.1	Train stops
			15 release	---	---	-36	114	35	
			40-	---	---	125	55	18	Train slows to 15 mph
			30 release	---	---	-36	114	35	
			30-	---	---	158	39	4	Train stops
			15 release	---	---	-41	114	14	
									For all cases, train stays mostly in draft except for small buff block at rear which makes transition to draft after release
PYSE1	6A	Temporary Suppression with Release and Second Application	50- 40 release 32 2nd applic.	5752	161	113	55	30	Train slows to 27 mph; maximum draft occurs at release; maximum buff at 2nd application when buff block forms because of delay in brakes coming on at rear of train
						-130	72	29	
PYSE1	7A	Conrail Procedure	50	6950	141	124	75	34	Three isolated buff blocks form in train and make transition to draft at stop
						-48	20	45	
			40	4869	120	124	75	35	
						-58	109	17	
			30	3037	98	154	75	17	
						-69	78	24	

TABLE 1. SUMMARY OF RESULTS, STRAIGHT AND LEVEL TRACK (continued)

Train		Case and Description	Initial Speed at Braking (mph)	Stop Distance (ft)	Stop Time (sec)	Maximum Transient Draft and Buff Forces: Maximum Forces (1000 lbs)	Car Number	Speed (mph)	Remarks
CRCOAL	1A	Full Service Reduction	33	3613	105	104 -120	109 113	9 26	Buff block forms but does not reach front of train
			18	1316	67	96 -173	5 111	4 13	
CRCOAL	2A	Penalty Application with 20 Second Delay	30	3273	102	106 -176	5 114	4 23	Buff block forms and almost reaches front of train
			15	1167	68	97 -166	24 114	5 8	
CRCOAL	3A	Penalty Application with 30 Second Delay	30	3642	112	105 -178	5 110	4 24	Buff block forms and almost reaches front of train
			15	1348	77	98 -172	22 114	5 8	
CRCOAL	4A	Temporary Suppression	30	5188	164	76 -12	5 82	4 23	Train stops mostly in draft for 30 mph run; buff block in rear half of train on 15 mph run
			15	1719	100	71 -61	5 114	4 2	
TV24	1A	Full Service Reduction	53	5173	97	59 -80	61 63	18 49	Buff block forms mid-train working way almost to front
			43	3748	84	52 -91	10 62	39 39	
			33	2480	71	55 -96	7 63	30 30	
			18	952	50	35 -124	2 63	16 16	
TV24	2A	Penalty Application with 20 Second Delay	50	5090	98	78 -128	63 6	5 46	Buff block forms mid-train and reaches to front of train
			40	3675	87	67 -99	45 5	4 36	
			30	2488	76	61 -141	2 6	27 26	
			15	1017	57	86 -140	7 9	12 11	
TV24	3A	Penalty Application with 30 Second Delay	50	5616	106	79 -144	63 2	4 45	Buff block forms mid-train and reaches front of train
			40	4110	95	63 -146	5 7	36 34	
			30	2814	84	73 -208	5 5	27 27	
			15	1167	65	91 -165	8 10	10 9	
TV24	4A	Temporary Suppression	50	7099	143	40 -9	62 60	32 40	Buff block forms on rear half of train; for 15 mph run it moves all the way to front
			40	4973	121	35 -23	62 63	17 31	
			30	3158	99	34 -43	41 63	12 24	
			15	1065	67	25 -70	2 63	13 12	
CRMIX	1A	Full Service Reduction	53	6259	116	160 -210	2 14	50 48	Buff block forms and moves quickly to front of train
			43	4453	100	150 -207	2 5	40 38	
			33	2888	84	140 -203	2 8	30 29	
			18	1135	59	131 -209	2 112	15 15	

TABLE 1. SUMMARY OF RESULTS, STRAIGHT AND LEVEL TRACK (continued)

Train		Case and Description	Initial Speed at Braking (mph)	Stop Distance (ft)	Stop Time (sec)	Maximum Transient Draft and Buff Forces: Maximum Forces (1000 lbs)	Car Number	Speed (mph)	Remarks
CRMIX	2A	Penalty Application with 20 Second Delay	50	5853	113	115	5	4	Buff block forms and moves to front of train
						-247	5	45	
			40	4181	99	114	5	4	
						-263	5	34	
			30	2688	84	110	5	4	
						-242	5	24	
			18	1021	60	165	9	11	
						-256	5	8	
CRMIX	3A	Penalty Application with 30 Second Delay	50	6442	122	118	5	4	Buff block forms and moves to front of train
						-274	5	43	
			40	4605	107	117	7	36	
						-270	5	33	
			30	3004	92	120	7	26	
						-265	5	23	
			15	1133	67	167	2	9	
						-238	85	8	
CRMIX	4A	Temporary Suppression	50	9350	180	197	22	44	Buff block forms and moves to front of train
						-277	8	42	
			40	6468	153	180	22	34	
						-525	5	32	
			30	4110	127	154	7	26	
						-668	2	22	
			15	1458	90	153	9	10	
						-270	5	7	
CRMIX	6A	Temporary Suppression with Release and Second Application	50- 40 release 32.5, 2nd applic.	6570	185	197	22	44	Buff block forms and moves to front of train on both applications
						-277	8	42	

The development of the buff block in the temporary suppression case for the CRMIX train is highly dependent upon the way the train is operated and other assumptions which are made in the analysis. For example, if the throttle reduction were to be delayed by allowing the motor current to build up an additional 50 amps before the reduction of the throttle begins the maximum run-in forces would be reduced to -280 kips on the 30 mph run and -248 kips on the 40 mph run. However, the run-in forces would be increased on the 15 and 50 mph runs. Again, if it were to be assumed that there was an additional one inch of free clearance in the coupler/draft-gear system on each car of the train, the maximum run-in forces would be reduced to -280 kips on the 30 mph run and -437 kips on the 40 mph run. This results from the delay in the movement of the buff block forward in the train because more free clearance has to be taken up. The corresponding forces for the 50 mph run would also be reduced, but they would be increased on the 15 mph run. If both of these assumptions are made, namely, the delay in the throttle reduction and the increased free clearance, it again results in a reduction of the forces on the 30, 40 and 50 mph runs, but increases them on the 15 mph runs. These results show that throttle handling and other assumptions in train characteristics are quite significant in affecting the magnitude of predicted forces.

3.2 TRAIN PYSE1 SIMULATION RUNS ON THE NORTHEAST CORRIDOR

Two sets of simulation runs were made with the PYSE1 train on the Northeast Corridor, one in the vicinity of 110.6 miles and the other in the vicinity of 115.9 miles. The track profiles in the vicinity of these locations are shown in Figures 3 and 4. The results of these runs are summarized in Tables 2 and 3. Prior to making simulation runs with braking, runs without braking (except for speed control) were made from 112.3 to 109.2 and 119 to 114 miles. These are designated as "0" cases. The train control procedures used on a CONRAIL TOS simulation, which was designated as a northbound "PYSE-DRY" run, were followed when operating between 112.3 to 109.2 miles. The CONRAIL simulation indicated a maximum run-in force of -233 kips at car 115 at 110.38 miles. The train control procedures used on the CONRAIL northbound "PYSE-CMD" run were followed when operating between 119 to 114 miles. This run used some light braking to control speed between 118.6 and 117.8 miles. The CONRAIL simulation for this run indicated a maximum run-in force of -240 kips at car 115 at 115.35 miles.

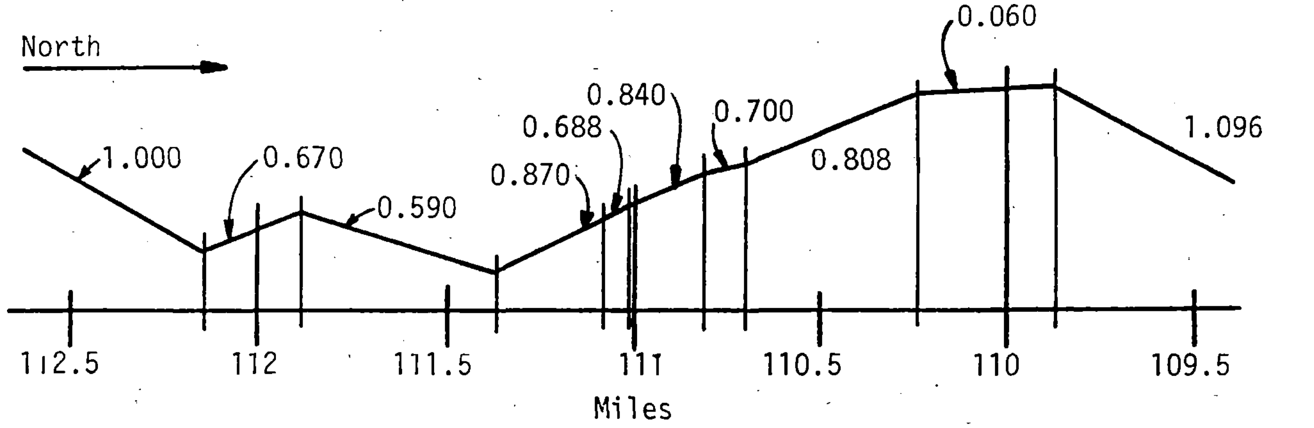

Figure 3. Northeast Corridor Track Profile 109.5 to 112.5 miles, Track Grade Shown in Percent

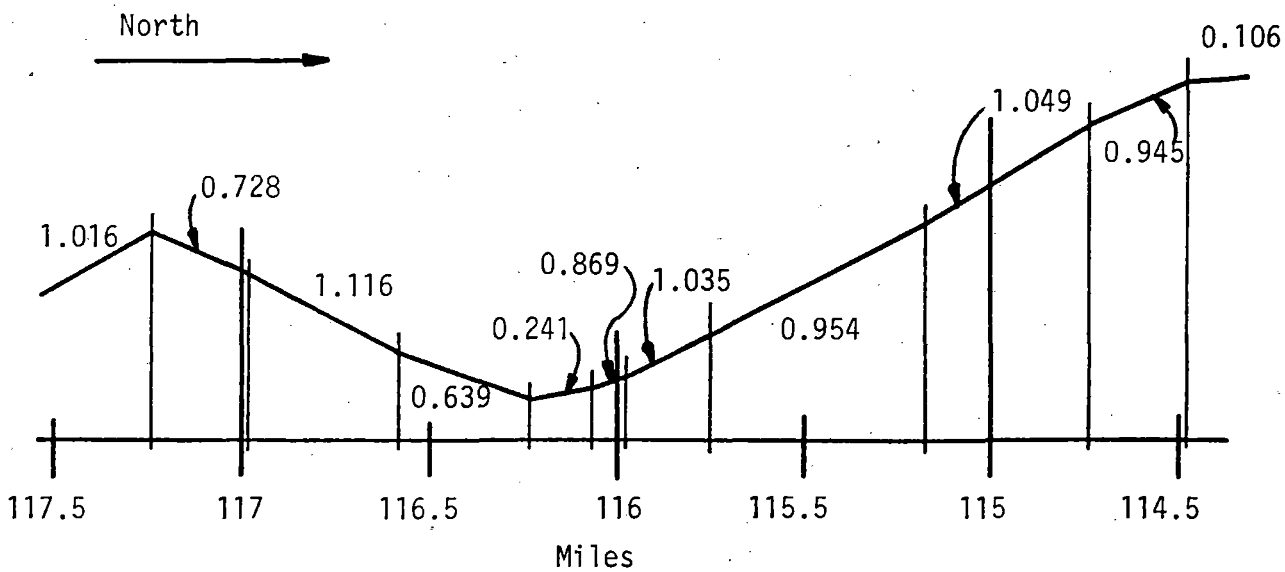

Figure 4. Northeast Corridor Track Profile 114.5 to 117.5 miles, Track Grade Shown in Percent

TABLE 2. SUMMARY OF RESULTS, NORTHBOUND PYSE1 NORTHEAST CORRIDOR RUNS IN THE VICINITY OF 110.6 MILES

Train	Case and Description		Initial Speed at Braking (mph)	Stop Distance (ft)	Stop Time (sec)	Maximum Transient Draft and Buff Forces: Maximum Forces (1000 lbs)	Car Number	Speed (mph)	Train Location (miles)
PYSE1	0B	Northbound 112.3-109.2 No Braking	40.0	---	---	184 -208	115 115	47 46	110.7 110.4
PYSE1	1B	Full Service Reduction at 110.4 miles	46.2	3970	85	184 -208	115 115	47 46	110.7 110.4
	1B	Full Service Reduction at 110.6 miles	46.5	4350	88	214 -373	75 4	29 45	109.9 110.4
	1B	Full Service Reduction at 110.8 miles	47.6	4491	89	211 238	75 4	25 44	110.0 110.5
PYSE1	2B	Penalty Application with 20 Second Delay Braking at 110.6 miles	46.5	4357	89	208 -449	5 4	20 44	109.8 110.5
PYSE1	3B	Penalty Application with 30 Second Delay Braking at 110.6	46.5	4717	96	193 -449	5 4	20 44	109.7 110.5
PYSE1	4B	Temporary Suppression at 110.4 miles	46.2	5745	128	197 -208	115 115	40 46	109.9 110.4
	4B	Temporary Suppression at 110.6 miles	46.5	6168	129	184 -299	115 4	47 45	110.7 110.4
	4B	Temporary Suppression at 110.8 miles	47.6	6061	126	183 -198	115 115	47 46	110.7 111.1
PYSE1	4B	Temporary Suppression at 110.195 miles	45.6	5715	133	184 -208	115 115	47 46	110.7 110.4
PYSE1	1B	Full Service Reduction at 110.6 miles, Throttle Reduced to Run 1 at Beginning of Braking	46.5	4027	83	213 -377	5 4	17 47	109.9 110.5

TABLE 3. SUMMARY OF RESULTS, PYSE1 NORTHEAST CORRIDOR RUNS IN THE VICINITY OF 115.9 MILES

Train	Case and Description		Initial Speed at Braking (mph)	Stop Distance (ft)	Stop Time (sec)	Maximum Transient Draft and Buff Forces: Maximum Forces (1000 lbs)	Car Number	Speed (mph)	Train Location (miles)
Northbound Runs									
PYSE1	0C	Northbound 119.0-114.0 miles No braking (except speed control)	42	---	---	130 -207	115 3	41 45	114.6 115.6
PYSE1	1C	Full Service Reduction at 115.7 miles	44.1	4387	91	199 -218	76 115	12 46	114.9 115.5
	1C	Full Service Reduction at 115.9 miles	43.3	4664	96	171 -219	4 115	13 44	115.0 115.6
	1C	Full Service Reduction at 116.1 miles	41.6	4726	100	125 -217	55 114	43 42	118.9 115.7
PYSE1	4C	Temporary Suppression at 115.9 miles	43.3	7334	146	125 -208	55 115	43 46	118.9 115.5
PYSE1	4C	Temporary Suppression at 116.392 miles	40.2	8321	169	125 -208	55 115	43 44	118.9 115.6
Southbound Run									
PYSE1	4D	Temporary Suppression at 118.314 miles	40	6657	128	187 -198	115 115	47 47	117.7 118.7

Both of the IITRI "0" case simulation runs gave results which were in general agreement with the CONRAIL TOS runs. The speed profiles were similar. The maximum force indicated by the IITRI run from 112.3 to 109.2 miles was a run-in force of -208 kips at vehicle 115 at 110.38 miles. This compares to the CONRAIL TOS result of -233 kips at vehicle 115 at 110.38 miles. The maximum force indicated by the IITRI run from 119 to 114 miles was a run-in force of -207 kips at the front of the rear locomotive unit at 115.6 miles, and -202 kips at vehicle 115 at 115.5 miles. This compares to the maximum run-in force predicted by the CONRAIL TOS run of -240 kips at vehicle 115 at 115.35 miles. An examination of the IITRI blocking diagram shows that a buff block forms about one-third of the way back in the train and moves forward. The fact that it reaches the locomotive is sensitive to train handling procedures and grade forces. The IITRI run, showing the block moving all the way forward to the locomotives and resulting in a large run-in force, could be due to the grade data used in the IITRI simulation runs which was slightly different from that used by CONRAIL. IITRI used the grade information that had been recently provided by AMTRAK.

Both of the IITRI "non-braking" runs were examined to determine locations where brake applications might accentuate the slack action in the train leading to higher force levels. For the 112.4 to 109.2 miles case, a brake application at 110.6 miles was selected and full service reduction (Case 1) and temporary suppression (Case 4) simulation runs were made at this location. Runs were also made at 110.4 and 110.8 miles in order to determine the sensitivity of results to location. The results showed that the largest run-in forces were experienced at the rear locomotive unit for both the full service reduction and temporary suppression cases at 110.6 miles indicating that this was the most critical location for brake application. The draft gear went solid resulting in run-in forces over 300 kips. Subsequently the penalty application cases with both 20 and 30 second delay were also run at 110.6 miles and they also indicated large run-in forces at the trailing locomotive unit because the run-in was sufficiently severe to cause the draft gear to go solid.

For the 119 to 114 miles case, 115.9 miles was selected as the location for the full service brake application. Maximum forces did not differ significantly from the non-braking run. Full service reduction runs were also made at 115.7 and 116.1 miles to determine the sensitivity to location. These runs showed minor differences from the forces predicted for the brake application at 115.9 miles. The forces predicted for the temporary suppression run, Case 4C, also did not differ significantly from the non-braking run. In this case the brake application on the rear of the train was delayed because the brake pipe pressure had not reached a steady state after the speed control brake application, which was made from 118.6 to 117.8 miles.

3.3 SIMULATION OF TRAIN PYSE1 UNDER PROFILE CURVE RESTRICTIONS

The results from the simulation runs which were conducted to examine the behavior of train PYSE1 under profile curve restrictions are summarized in Table 4. These results do not show any large transient draft or buff forces associated with the dynamic or air braking which was used to meet profile curve restrictions.

TABLE 4. SUMMARY OF RESULTS, PYSE 1 NORTHEAST CORRIDOR RUNS TO PROFILE CURVE SPEED RESTRICTIONS

Train	Case and Description		Initial Speed (mph)	Maximum Transient Draft and Buff Forces: Maximum Forces (1000 lbs)	Car Number	Speed (mph)	Train Location (miles)
PYSE1	SP1	Northbound, Clear to Restricting at Signal No. 1102, when Train is at 110.6 miles	40	124 -170	55 115	0.1 40	109.7 110.4
PYSE1	SP2	Northbound, Clear to Restricting at Signal No. 1102, Penalty Application from Violation of Profile Curve	40	163 -174	55 115	0.5 40	108.9 110.4
PYSE1	SP3	Northbound, Approach Indication at Signal No. 1102	40	115 -193	45 65	2.7 14	107.5 108.8
PYSE1	SP4	Northbound, Approach Indication a Signal No. 1164	40	200 -156	115 31	11 38	114.6 115.7
PYSE1	SP5	Southbound, Approach Indication at Signal No. 1185	40	227 -160	4 29	13 36	119.9 118.6
PYSE1	SP6	Southbound, Code change to Approach-Medium at 117.4 miles, then Approach Indication at Signal No. 1185	40	181 -143	4 115	12 33	119.9 118.7

4. CONCLUSIONS

Several conclusions are evident from reviewing the results of the analyses. First, long trains are more susceptible to severe slack action. This is shown by comparing the results from the braking simulations on straight and level track for the PYSE1 train with 115 cars with the CRMIX train with 135 cars. Several of the CRMIX train case results indicated significantly higher forces with severe run-ins progressing through the train and reaching the locomotives. Second, if brake applications are made when the state of slack is changing in the train, the transient forces associated with the slack action may be intensified. This is shown by the PYSE1 train simulations at 110.6 miles on the Northeast Corridor. There is a run-in that is propagated through the train at this region when it is operated without braking, which is intensified if a brake application is made at 110.6 miles. Third, the simulations made to control speed in accordance with the speed restrictions imposed by the preliminary profile curves showed that there is ample time to control speeds by moderate application of either the dynamic or air brake so that large transient longitudinal forces are not generated in the train.

5. REFERENCES

1. Johnson, M.R., Booth, G.F. and Mattoon, D.W., "Development of Practical Techniques for the Simulation of Train Air Brake Operation," American Society of Mechanical Engineers Technical Paper 86-WA/RT-4, December 1986.

2. Punwami, S.K., "Draft-Gear/Cushioning Unit Optimization for Train Action," Association of American Railroads, Track Train Dynamics Phase II Report No. R-363, September 1980.

APPENDIX

The detailed data summaries for the simulation run of a full service reduction on train PYSE1 northbound on the Northeast Corridor at 115.9 miles are presented in this appendix. This train has three SD 40-2 locomotive units and 115 cars.

Three data summaries are developed for each simulation run. The first presents run summary data and is shown on pages 27 to 32. The speed; distance; throttle position; motor current; brake pipe reduction; the brake pipe pressure at vehicles 4 (the first car), 40, and 118; and the brake cylinder pressure on the lead locomotive and vehicles 4, 40, and 118 are shown at two second intervals. Note that there is a brake application from 118.578 to 117.789 miles, which was made to control the speed of the train. Note also that the release on the last car is not complete until the train has reached 116.563 miles. The full service reduction is initiated at 115.900 miles, 242.0 seconds into the simulation. The train comes to a stop at 115.016 miles at 337.6 seconds. The stop distance is 4,664 feet and the stop time is 95.6 seconds.

The first data summary also gives a list of the maximum draft and buff forces on each car of the train during the simulation. This list is presented on pages 31 and 32. The time and the position of the front of the train when each maximum and minimum force occurs are also included. At the end of the table, on page 32, the throttle and changes in brake pipe pressure are listed. The maximum draft and buff forces in the train are also identified for speeds over 5 mph and under 5 mph.

The second data summary, pages 33 to 36, displays the state of slack in the train. A dash ("-") is used to indicate that the car is blocked in a draft condition. An "X" is used to indicate that the car is blocked in a buff condition. Numbers from 1 to 5 are used to indicate whether the car is moving in a buff region (1 or 2) or moving in a draft region (4 or 5) or whether it is in a centered condition. The number 3 indicates a coupler/draft-gear displacement less than ±1.2 inches, numbers 1 or 5 indicate displacements, greater than ±3.6 inches, and numbers 2 or 4 displacements between -1.2 and -3.6 inches or +1.2 and +3.6 inches, respectively.

The third data summary, pages 37 to 40, describes the maximum coupler forces on each car in the train in four second intervals. This is done by printing out a line of characters where each character represents one car in the train. A numerical designation from 0 to 9 is used to indicate a range in the absolute magnitude of the force on each coupler. Zero is used to represent a force less than 20,000 lbs absolute magnitude, "1" a force between 20,000 and 40,000 lbs absolute magnitude, etc. The character on the preceding line (+ or -) is used to indicate the sign of this force.

TRAIN BRAKE SIMULATION RUN – FULL SERVICE REDUCTION
NORTHBOUND RUN, BRAKES APPLIED AT 115.9 MILES
TRAIN DESIGNATION: PYSE1-CASE 1C, INITIAL SPEED 42.0 (mph
3 LOCOMOTIVE UNITS 115 CARS
5psi LEAKAGE

RUN SUMMARY FOLLOWS

TIME (sec)	SPEED (mph)	DISTANCE (ft)	(miles)	THROTTLE POSITION	MOTOR CURR. (Amp)	B. P. REDUCT. (psi)
0.0	42.0	-2687.	119.000	8	388.	0.
2.0	42.6	-2563.	118.976	8	384.	0.
4.0	43.0	-2437.	118.953	8	382.	0.
6.0	43.0	-2310.	118.929	8	382.	0.
8.0	43.1	-2184.	118.905	8	382.	0.
10.0	43.4	-2057.	118.881	8	380.	0.
12.0	43.7	-1929.	118.856	7	328.	0.
14.0	44.0	-1800.	118.832	7	327.	0.
16.0	44.3	-1670.	118.807	7	326.	0.
18.0	44.6	-1539.	118.783	7	325.	0.
20.0	45.0	-1408.	118.758	7	323.	0.
22.0	45.3	-1275.	118.732	7	322.	0.
24.0	45.6	-1141.	118.707	7	321.	0.
26.0	46.0	-1007.	118.682	7	320.	0.
28.0	46.3	-871.	118.656	7	318.	0.
30.0	46.7	-734.	118.630	7	317.	0.
32.0	47.1	-596.	118.604	7	316.	0.
34.0	47.4	-457.	118.578	6	276.	6.
36.0	47.8	-318.	118.551	6	275.	6.
38.0	48.1	-177.	118.524	6	274.	6.
40.0	48.5	-34.	118.498	6	273.	6.
42.0	48.9	109.	118.470	6	272.	6.
44.0	49.2	253.	118.443	6	271.	6.
46.0	49.5	398.	118.416	6	270.	6.
48.0	49.9	544.	118.388	6	269.	6.
50.0	50.2	691.	118.360	6	269.	6.
52.0	50.5	839.	118.332	6	268.	10.
54.0	50.7	988.	118.304	6	267.	10.
56.0	51.0	1137.	118.276	6	266.	10.
58.0	51.2	1288.	118.247	6	266.	10.
60.0	51.4	1438.	118.219	6	265.	10.
62.0	51.5	1590.	118.190	6	265.	10.
64.0	51.6	1741.	118.161	6	265.	10.
66.0	51.6	1893.	118.133	6	265.	10.
68.0	51.7	2045.	118.104	6	265.	10.
70.0	51.7	2197.	118.075	6	265.	10.
72.0	51.6	2349.	118.046	6	265.	10.
74.0	51.5	2500.	118.017	6	265.	10.
76.0	51.4	2651.	117.989	6	265.	10.
78.0	51.2	2802.	117.960	6	266.	10.
80.0	51.0	2952.	117.932	6	266.	10.
82.0	50.7	3102.	117.904	6	267.	10.
84.0	50.5	3250.	117.875	6	268.	10.
86.0	50.8	3399.	117.847	6	267.	10.
88.0	52.9	3553.	117.818	6	262.	10.
90.0	52.3	3708.	117.789	6	263.	10.
92.0	51.8	3861.	117.760	6	264.	0.
94.0	51.4	4013.	117.731	6	265.	0.
96.0	51.0	4163.	117.703	6	266.	0.

BRAKE PIPE PRESSURE(psi)			BRAKE CYLINDER PRESSURE(psi)			
Veh. 4	Veh. 40	Veh. 118	Veh. 1	Veh. 4	Veh. 40	Veh. 118
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0	0.	0.
89.	85.	84.	0.	0.	0.	0.
89.	85.	84.	0.	0.	0.	0.
85.	85.	84.	0.	5.	0.	0.
84.	85.	84.	0.	5.	0.	0.
84.	84.	84.	0.	5.	0.	0.
83.	83.	84.	0.	5.	0.	0.
83.	83.	84.	0.	6.	5.	0.
83.	82.	83.	0.	7.	5.	0.
83.	82.	81.	0.	7.	5.	5.
83.	81.	81.	0.	8.	5.	5.
83.	81.	80.	0.	9.	5.	5.
80.	80.	80.	0.	16.	5.	5.
80.	80.	79.	0.	17.	5.	5.
80.	79.	79.	0.	19.	7.	5.
79.	79.	78.	0.	20.	9.	6.
79.	78.	78.	0.	20.	10.	8.
79.	78.	78.	0.	21.	11.	9.
79.	78.	78.	0.	21.	11.	9.
79.	78.	78.	0.	21.	12.	9.
79.	78.	78.	0.	21.	12.	9.
79.	78.	77.	0.	21.	12.	9.
79.	78.	77.	0.	21.	12.	9.
79.	78.	77.	0.	21.	13.	9.
79.	78.	77.	0.	21.	13.	9.
79.	77.	77.	0.	21.	13.	9.
79.	77.	77.	0.	21.	13.	9.
79.	77.	77.	0.	21.	13.	11.
79.	77.	77.	0.	21.	13.	11.
79.	77.	77.	0.	21.	14.	11.
79.	77.	77.	0.	21.	14.	12.
79.	77.	77.	0.	21.	14.	12.
82.	77.	77.	0.	20.	14.	12.
85.	77.	77.	0.	16.	14.	12.
86.	77.	77.	0.	13.	14.	12.

RUN SUMMARY (CONTINUED)...TRAIN PYSE1-CASE 1C INITIAL SPEED

TIME (sec)	SPEED (mph)	DISTANCE (ft)	DISTANCE (miles)	THROTTLE POSITION	MOTOR CURR. (Amp)	B.P. REDUCT. (psi)
98.0	50.8	4313.	117.674	6	267.	0.
100.0	50.7	4462.	117.646	6	267.	0.
102.0	50.9	4611.	117.618	6	267.	0.
104.0	51.3	4762.	117.589	6	266.	0.
106.0	51.4	4913.	117.561	6	265.	0.
108.0	51.4	5064.	117.532	7	302.	0.
110.0	51.3	5215.	117.503	7	302.	0.
112.0	51.0	5365.	117.475	7	303.	0.
114.0	50.8	5515.	117.447	7	304.	0.
116.0	50.5	5664.	117.418	7	305.	0.
118.0	50.2	5812.	117.390	7	306.	0.
120.0	49.8	5959.	117.362	7	307.	0.
122.0	49.5	6105.	117.335	7	308.	0.
124.0	49.2	6250.	117.307	7	309.	0.
126.0	48.8	6394.	117.280	6	272.	0.
128.0	48.4	6537.	117.253	6	273.	0.
130.0	48.1	6678.	117.226	6	274.	0.
132.0	47.8	6819.	117.199	6	275.	0.
134.0	47.5	6959.	117.173	6	276.	0.
136.0	47.3	7099.	117.147	6	277.	0.
138.0	47.0	7237.	117.120	6	277.	0.
140.0	46.7	7375.	117.094	6	278.	0.
142.0	46.4	7512.	117.068	6	279.	0.
144.0	46.2	7648.	117.042	6	280.	0.
146.0	45.8	7784.	117.017	6	281.	0.
148.0	45.5	7918.	116.991	6	282.	0.
150.0	45.1	8051.	116.966	6	283.	0.
152.0	44.7	8183.	116.941	6	284.	0.
154.0	44.4	8314.	116.916	6	286.	0.
156.0	44.0	8444.	116.892	6	287.	0.
158.0	43.7	8573.	116.867	6	288.	0.
160.0	43.4	8701.	116.843	6	289.	0.
162.0	43.1	8828.	116.819	6	290.	0.
164.0	42.9	8954.	116.795	6	290.	0.
166.0	42.6	9080.	116.771	6	291.	0.
168.0	42.4	9205.	116.748	6	292.	0.
170.0	42.1	9329.	116.724	6	293.	0.
172.0	41.9	9452.	116.701	6	294.	0.
174.0	41.6	9575.	116.678	6	295.	0.
176.0	41.4	9697.	116.654	6	296.	0.
178.0	41.2	9818.	116.631	6	296.	0.
180.0	41.0	9939.	116.609	6	297.	0.
182.0	40.8	10059.	116.586	6	298.	0.
184.0	40.7	10179.	116.563	6	298.	0.
186.0	40.5	10299.	116.541	6	299.	0.
188.0	40.4	10418.	116.518	7	343.	0.
190.0	40.4	10536.	116.495	7	343.	0.
192.0	40.3	10655.	116.473	7	343.	0.
194.0	40.2	10773.	116.451	7	343.	0.
196.0	40.2	10891.	116.428	7	343.	0.

42.0 (mph)

BRAKE PIPE PRESSURE(psi)			BRAKE CYLINDER PRESSURE(psi)			
Veh. 4	Veh. 40	Veh. 118	Veh. 1	Veh. 4	Veh. 40	Veh. 118
86.	77.	77.	0.	11.	14.	13.
87.	77.	77.	0.	8.	14.	13.
87.	77.	77.	0.	6.	14.	13.
87.	77.	77.	0.	5.	14.	13.
87.	78.	77.	0.	5.	14.	13.
87.	78.	77.	0.	5.	14.	13.
87.	78.	77.	0.	5.	14.	13.
87.	78.	77.	0.	5.	14.	13.
87.	78.	77.	0.	5.	14.	13.
88.	78.	77.	0.	5.	13.	13.
88.	78.	77.	0.	5.	11.	13.
88.	78.	77.	0.	5.	8.	13.
88.	78.	77.	0.	5.	6.	13.
88.	78.	77.	0.	5.	5.	13.
88.	79.	77.	0.	5.	5.	13.
88.	79.	77.	0.	5.	5.	13.
88.	79.	77.	0.	0.	5.	13.
88.	79.	77.	0.	0.	5.	13.
88.	79.	77.	0.	0.	5.	13.
88.	79.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	5.	13.
88.	80.	77.	0.	0.	0.	13.
88.	80.	77.	0.	0.	0.	11.
88.	81.	78.	0.	0.	0.	9.
88.	81.	78.	0.	0.	0.	7.
88.	81.	78.	0.	0.	0.	5.
88.	81.	78.	0.	0.	0.	5.
88.	81.	79.	0.	0.	0.	5.
88.	81.	79.	0.	0.	0.	5.
88.	81.	79.	0.	0.	0.	5.
88.	81.	79.	0.	0.	0.	5.
88.	81.	79.	0.	0.	0.	5.
88.	81.	80.	0.	0.	0.	5.
88.	81.	80.	0.	0.	0.	5.
88.	81.	80.	0.	0.	0.	5.
88.	81.	80.	0.	0.	0.	5.
88.	81.	80.	0.	0.	0.	5.
88.	81.	80.	0.	0.	0.	5.
88.	82.	80.	0.	0.	0.	0.
88.	82.	80.	0.	0.	0.	0.
88.	82.	80.	0.	0.	0.	0.
88.	82.	80.	0.	0.	0.	0.
88.	82.	80.	0.	0.	0.	0.
88.	82.	81.	0.	0.	0.	0.
88.	82.	81.	0.	0.	0.	0.

[redacted]

RUN SUMMARY (CONTINUED)...TRAIN PYSE1-CASE 1C

TIME (sec)	SPEED (mph)	DISTANCE (ft)	DISTANCE (miles)	THROTTLE POSITION	MOTOR CURR. (Amp)
198.0	40.2	11010.	116.406	7	344.
200.0	40.2	11128.	116.383	7	344.
202.0	40.2	11246.	116.361	7	343.
204.0	40.2	11364.	116.339	7	343.
206.0	40.3	11483.	116.316	7	343.
208.0	40.3	11601.	116.294	7	343.
210.0	40.4	11720.	116.271	7	342.
212.0	40.5	11839.	116.249	7	342.
214.0	40.6	11958.	116.226	7	342.
216.0	40.8	12078.	116.204	7	341.
218.0	40.9	12198.	116.181	7	340.
220.0	41.1	12318.	116.158	7	340.
222.0	41.2	12439.	116.135	7	339.
224.0	41.4	12561.	116.112	7	338.
226.0	41.6	12683.	116.089	7	337.
228.0	41.8	12805.	116.066	7	336.
230.0	42.0	12929.	116.042	7	335.
232.0	42.3	13053.	116.019	7	334.
234.0	42.5	13177.	115.995	7	333.
236.0	42.7	13302.	115.972	7	332.
238.0	42.9	13428.	115.948	7	331.
240.0	43.1	13555.	115.924	7	331.
242.0	43.3	13682.	115.900	6	289.
244.0	43.4	13809.	115.876	6	289.
246.0	43.4	13937.	115.851	6	289.
248.0	43.4	14064.	115.827	6	289.
250.0	43.3	14192.	115.803	6	289.
252.0	43.1	14319.	115.779	6	290.
254.0	42.8	14445.	115.755	6	291.
256.0	42.7	14570.	115.731	6	291.
258.0	43.5	14697.	115.708	6	289.
260.0	44.9	14827.	115.683	6	284.
262.0	44.9	14960.	115.658	6	284.
264.0	44.8	15091.	115.633	6	284.
266.0	44.5	15223.	115.608	6	285.
268.0	44.3	15353.	115.583	6	286.
270.0	44.4	15484.	115.559	6	285.
272.0	44.4	15614.	115.534	6	285.
274.0	44.1	15744.	115.509	6	287.
276.0	43.5	15873.	115.485	6	288.
278.0	42.8	16000.	115.461	6	291.
280.0	42.2	16125.	115.437	6	293.
282.0	41.5	16248.	115.414	6	295.
284.0	41.0	16369.	115.391	6	297.
286.0	40.4	16489.	115.368	6	299.
288.0	39.7	16607.	115.346	6	302.
290.0	38.9	16722.	115.324	6	305.
292.0	38.0	16835.	115.302	6	308.
294.0	37.0	16946.	115.282	6	313.
296.0	36.0	17053.	115.261	6	317.

INITIAL SPEED 42.0 (mph)

B.P. REDUCT.	BRAKE PIPE PRESSURE(psi)			BRAKE CYLINDER PRESSURE(psi)			
(psi)	Veh.4	Veh.40	Veh.118	Veh.1	Veh.4	Veh.40	Veh.118
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
0.	88.	82.	81.	0.	0.	0.	0.
26.	88.	82.	81.	0.	0.	0.	0.
26.	84.	82.	81.	0.	5.	0.	0.
26.	81.	82.	81.	0.	10.	0.	0.
26.	79.	81.	81.	0.	16.	0.	0.
26.	77.	80.	81.	0.	22.	0.	0.
26.	76.	79.	81.	0.	26.	5.	0.
26.	75.	79.	81.	0.	30.	5.	0.
26.	73.	78.	78.	0.	34.	5.	5.
26.	72.	77.	78.	0.	37.	5.	5.
26.	71.	77.	77.	0.	40.	5.	5.
26.	70.	76.	76.	0.	43.	8.	5.
26.	70.	75.	75.	0.	46.	10.	5.
26.	69.	75.	75.	0.	48.	12.	7.
26.	68.	74.	74.	0.	51.	14.	9.
26.	67.	73.	74.	0.	53.	16.	10.
26.	67.	73.	74.	0.	55.	18.	10.
26.	66.	72.	73.	0.	57.	19.	12.
26.	65.	72.	73.	0.	59.	21.	13.
26.	65.	71.	73.	0.	60.	22.	14.
26.	65.	71.	72.	0.	60.	24.	16.
26.	65.	70.	72.	0.	61.	25.	17.
26.	65.	70.	71.	0.	61.	27.	18.
26.	65.	70.	71.	0.	61.	28.	19.
26.	65.	69.	71.	0.	61.	29.	21.
26.	65.	69.	70.	0.	62.	31.	22.
26.	65.	68.	70.	0.	62.	32.	23.
26.	65.	68.	69.	0.	62.	33.	25.
26.	64.	68.	69.	0.	62.	34.	26.

RUN SUMMARY (CONTINUED)...TRAIN PYSE1-CASE 1C INITIAL SPEED 42.0 (mph)

TIME (sec)	SPEED (mph)	DISTANCE (ft)	DISTANCE (miles)	THROTTLE POSITION	MOTOR CURR.(Amp)	B.P. REDUCT. (psi)	BRAKE PIPE PRESSURE(psi) Veh.4	BRAKE PIPE PRESSURE(psi) Veh.40	BRAKE PIPE PRESSURE(psi) Veh.118	BRAKE CYLINDER PRESSURE(psi) Veh.1	BRAKE CYLINDER PRESSURE(psi) Veh.4	BRAKE CYLINDER PRESSURE(psi) Veh.40	BRAKE CYLINDER PRESSURE(psi) Veh.118
298.0	35.0	17157.	115.241	6	322.	26.	64.	67.	69.	0.	62.	35.	27.
300.0	33.9	17259.	115.222	6	327.	26.	64.	67.	68.	0.	62.	36.	28.
302.0	32.7	17357.	115.204	5	290.	26.	64.	67.	68.	0.	62.	37.	30.
304.0	31.4	17451.	115.186	5	295.	26.	64.	66.	67.	0.	63.	38.	31.
306.0	30.1	17541.	115.169	5	302.	26.	64.	66.	67.	0.	63.	39.	32.
308.0	28.8	17628.	115.152	5	308.	26.	64.	66.	67.	0.	63.	40.	33.
310.0	27.5	17711.	115.137	5	316.	26.	64.	66.	66.	0.	63.	40.	34.
312.0	26.1	17789.	115.122	5	325.	26.	64.	65.	66.	0.	63.	41.	35.
314.0	24.6	17864.	115.108	4	292.	26.	64.	65.	66.	0.	63.	42.	36.
316.0	23.1	17934.	115.094	4	321.	26.	64.	65.	65.	0.	63.	43.	37.
318.0	21.5	17999.	115.082	3	290.	26.	64.	65.	65.	0.	63.	43.	38.
320.0	19.8	18060.	115.071	3	312.	26.	64.	64.	65.	0.	63.	44.	39.
322.0	18.2	18116.	115.060	2	262.	26.	64.	64.	64.	0.	63.	45.	40.
324.0	16.4	18167.	115.050	2	278.	26.	64.	64.	64.	0.	63.	45.	41.
326.0	14.7	18212.	115.042	2	294.	26.	64.	64.	64.	0.	64.	46.	41.
328.0	12.6	18253.	115.034	2	311.	26.	64.	64.	64.	0.	64.	46.	42.
330.0	10.0	18285.	115.028	1	226.	26.	64.	64.	64.	0.	64.	47.	43.
332.0	7.8	18312.	115.023	1	237.	26.	64.	63.	63.	0.	64.	47.	43.
334.0	5.5	18331.	115.019	1	248.	26.	63.	63.	63.	0.	64.	48.	44.
336.0	2.6	18343.	115.017	0	0.	26.	63.	63.	63.	0.	64.	48.	44.
337.6	0.0	18346.	115.016	0	0.	26.	63.	63.	63.	25.	64.	49.	44.

RUN SUMMARY (CONTINUED)...TRAIN PYSE1-CASE 1C INITIAL SPEED

MAXIMUM AND MINIMUM VEHICLE COUPLER FORCES(LBS) WITH TIME(sec) AN

VEH	FRCMAX	TMAX	DISTANCE	FRCMIN	TMIN	DISTANCE	VEH
1	0.	0.00	0.	0.	0.00	0.	51
2	85534.	88.44	3587.	-202790.	86.13	3408.	52
3	127225.	328.23	18257.	-203384.	85.87	3389.	53
4	170789.	328.22	18256.	-200986.	85.57	3366.	54
5	168499.	328.23	18257.	-166584.	85.60	3369.	55
6	163967.	328.24	18257.	-150102.	85.87	3389.	56
7	158761.	328.25	18257.	-142293.	85.87	3389.	57
8	153312.	328.27	18257.	-135334.	85.82	3385.	58
9	148585.	328.30	18258.	-129548.	86.13	3408.	59
10	144955.	328.32	18258.	-125280.	86.13	3408.	60
11	139693.	328.34	18259.	-120885.	86.13	3408.	61
12	136284.	328.34	18259.	-116522.	86.14	3409.	62
13	132965.	328.34	18259.	-112937.	86.14	3409.	63
14	129736.	328.34	18259.	-109613.	86.15	3410.	64
15	126594.	328.34	18259.	-106997.	86.15	3410.	65
16	123537.	328.34	18259.	-104191.	86.16	3411.	66
17	120561.	328.34	18259.	-101565.	86.16	3411.	67
18	117667.	328.34	18259.	-98742.	86.16	3411.	68
19	114849.	328.34	18259.	-95848.	86.07	3404.	69
20	112107.	328.34	18259.	-93922.	257.59	14670.	70
21	109437.	328.34	18259.	-94251.	259.14	14770.	71
22	107654.	327.20	18237.	-97627.	259.12	14769.	72
23	106413.	327.16	18236.	-100154.	259.09	14767.	73
24	104796.	327.11	18235.	-102949.	259.07	14766.	74
25	103315.	327.04	18234.	-105272.	259.07	14766.	75
26	101972.	326.99	18233.	-107433.	259.04	14764.	76
27	101976.	173.68	9555.	-109747.	258.95	14758.	77
28	103558.	173.68	9555.	-111934.	259.04	14764.	78
29	105139.	173.68	9555.	-113840.	259.03	14763.	79
30	106519.	173.68	9555.	-115238.	258.99	14760.	80
31	125968.	326.37	18220.	-116134.	258.95	14758.	81
32	111508.	326.84	18230.	-117099.	258.95	14758.	82
33	108973.	173.68	9555.	-117999.	268.03	15354.	83
34	109229.	173.68	9555.	-119812.	268.03	15354.	84
35	109313.	7.27	-2231.	-120947.	268.03	15354.	85
36	111088.	7.26	-2231.	-121970.	268.03	15354.	86
37	112765.	7.24	-2233.	-122958.	268.04	15355.	87
38	114461.	7.24	-2233.	-124513.	268.04	15355.	88
39	116200.	7.23	-2233.	-126187.	268.04	15355.	89
40	116364.	7.22	-2234.	-127745.	268.04	15355.	90
41	116355.	7.20	-2235.	-128711.	268.04	15355.	91
42	117199.	7.17	-2237.	-129681.	268.04	15355.	92
43	118064.	7.15	-2238.	-130513.	268.04	15355.	93
44	118878.	7.13	-2239.	-131597.	262.52	14993.	94
45	119961.	7.11	-2241.	-133170.	262.52	14993.	95
46	120579.	7.09	-2242.	-134557.	262.72	15006.	96
47	122330.	335.24	18340.	-135887.	262.72	15006.	97
48	124639.	335.19	18339.	-137113.	262.72	15006.	98
49	127281.	335.10	18339.	-139703.	263.02	15026.	99
50	130049.	335.04	18338.	-142365.	263.02	15026.	100

42.0 (mph)

D DISTANCE(ft) AT POINT OF OCCURRENCE

FRCMAX	TMAX	DISTANCE	FRCMIN	TMIN	DISTANCE
129755.	335.06	18339.	-145107.	257.16	14643.
128773.	335.11	18339.	-147548.	263.02	15026.
130205.	335.11	18339.	-149050.	263.02	15026.
132445.	335.16	18339.	-150616.	263.02	15026.
135152.	335.18	18339.	-152172.	263.02	15026.
128761.	335.18	18339.	-152957.	263.02	15026.
124269.	6.74	-2264.	-154230.	263.01	15025.
124159.	6.68	-2268.	-156599.	263.01	15025.
124041.	6.64	-2270.	-158872.	263.01	15025.
123932.	6.60	-2273.	-160559.	263.01	15025.
123914.	6.56	-2276.	-162782.	263.01	15025.
123930.	6.53	-2277.	-164432.	263.01	15025.
123902.	6.50	-2279.	-166259.	263.01	15025.
123761.	6.48	-2281.	-167515.	263.01	15025.
123978.	6.45	-2282.	-190863.	258.24	14712.
124165.	6.43	-2284.	-174202.	258.46	14726.
124234.	6.41	-2285.	-182705.	258.68	14740.
124247.	6.40	-2286.	-178830.	262.96	15022.
124104.	6.39	-2286.	-179853.	262.96	15022.
123921.	6.38	-2287.	-180632.	262.96	15022.
123694.	6.37	-2288.	-204354.	259.45	14791.
123593.	6.37	-2288.	-205375.	259.69	14806.
141062.	333.49	18327.	-202990.	259.89	14820.
141866.	333.40	18326.	-201422.	260.11	14834.
121247.	6.35	-2289.	-204892.	260.31	14847.
119799.	6.33	-2290.	-203957.	260.53	14862.
118102.	6.29	-2293.	-207387.	260.74	14876.
116079.	6.25	-2295.	-207953.	260.97	14891.
113796.	6.24	-2296.	-199020.	262.51	14993.
112906.	6.24	-2296.	-199878.	262.51	14993.
109906.	6.25	-2295.	-204217.	261.63	14934.
106898.	6.26	-2294.	-206555.	261.85	14949.
103551.	6.28	-2293.	-207287.	262.07	14963.
99881.	6.30	-2292.	-208370.	262.28	14977.
97212.	336.26	18344.	-210018.	262.51	14993.
103301.	336.24	18344.	-207497.	262.96	15022.
106981.	336.25	18344.	-209727.	262.96	15022.
111343.	336.19	18344.	-146377.	268.37	15377.
106030.	336.19	18344.	-146551.	268.37	15377.
98695.	336.19	18344.	-146707.	268.37	15377.
89821.	336.17	18344.	-147818.	268.37	15377.
81614.	336.06	18343.	-160284.	263.88	15083.
82439.	336.06	18343.	-179390.	264.10	15097.
83676.	336.06	18343.	-188695.	264.31	15111.
86254.	336.10	18343.	-150263.	268.37	15377.
82603.	336.10	18343.	-150614.	268.35	15375.
78976.	336.10	18343.	-150924.	268.33	15374.
75371.	336.10	18343.	-151356.	268.33	15374.
74673.	335.71	18342.	-151777.	268.33	15374.
72593.	335.71	18342.	-152206.	268.31	15373.

RUN SUMMARY (CONTINUED)...TRAIN PYSE1-CASE 1C INITIAL SPEED 42.0 (mph)

MAXIMUM AND MINIMUM VEHICLE COUPLER FORCES(LBS) WITH TIME(sec) AND DISTANCE(ft) AT POINT OF OCCURRENCE

VEH	FRCMAX	TMAX	DISTANCE	FRCMIN	TMIN	DISTANCE	VEH	FRCMAX	TMAX	DISTANCE	FRCMIN	TMIN	DISTANCE
101	72029.	335.03	18338.	-153925.	268.31	15373.	110	52768.	175.10	9642.	-174949.	268.29	15371.
102	72134.	335.36	18340.	-155650.	268.31	15373.	111	53912.	175.10	9642.	-176881.	268.29	15371.
103	67698.	335.70	18342.	-157658.	268.30	15372.	112	55486.	175.10	9642.	-195418.	267.34	15309.
104	56967.	336.08	18343.	-160927.	266.12	15230.	113	60843.	174.24	9589.	-193888.	267.75	15336.
105	53728.	7.07	-2243.	-198506.	266.09	15228.	114	70883.	173.75	9559.	-213463.	267.72	15334.
106	48881.	7.14	-2239.	-205484.	266.31	15242.	115	79583.	174.24	9589.	-218941.	267.93	15348.
107	47786.	175.16	9645.	-207943.	266.48	15253.	116	74794.	175.10	9642.	-205057.	268.28	15371.
108	50110.	170.81	9378.	-209412.	266.71	15268.	117	62326.	175.12	9643.	-205769.	268.20	15366.
109	52308.	175.14	9644.	-173545.	268.30	15372.	118	36062.	175.12	9643.	-105625.	268.37	15377.

THROTTLE AND BRAKE CHANGES DURING RUN

INITIAL THROTTLE POSITION WAS 8

THROTTLE POSITION	TIME OF CHANGE (sec)	POINT OF CHANGE (ft)
7	10.88	-2001.
6	32.32	-575.
7	106.05	4916.
6	125.29	6342.
7	187.84	10407.
6	241.99	13681.
5	300.88	17302.
4	313.10	17830.
3	316.61	17954.
2	321.67	18107.
1	329.80	18282.
0	335.08	18339.

B.P. REDUCTION (psi)	TIME OF CHANGE (sec)	POINT OF CHANGE (ft)
6.0	32.32	-575.
10.0	50.74	745.
0.0	90.62	3755.
26.0	241.99	13681.

THE MAXIMUM DRAFT FORCE OVER 5 (mph) WAS 170789.(lbs) ON VEHICLE 4 AT 328.2(sec)
THE MINIMUM BUFF FORCE OVER 5 (mph) WAS -218941.(lbs) ON VEHICLE 115 AT 267.9(sec)

THE MAXIMUM DRAFT FORCE UNDER 5 (mph) WAS 135152.(lbs) ON VEHICLE 55 AT 335.2(sec)
THE MINIMUM BUFF FORCE UNDER 5 (mph) WAS -42383.(lbs) ON VEHICLE 105 AT 334.3(sec)

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        TRAIN BRAKE SIMULATION RUN - FULL SERVICE REDUCTION
        NORTHBOUND RUN, BRAKES APPLIED AT 115.9 MILES
        TRAIN DESIGNATION: PYSE1-CASE 1C,  INITIAL SPEED  42.0 (mph)
                3  LOCOMOTIVE UNITS      115 CARS
                                   5psi LEAKAGE

                  BLOCKING DIAGRAM FOLLOWS
      "X" BLOCKED BUFF; "-" BLOCKED DRAFT; "3" CENTER FREE SLACK REGION
     "1" OR "2" MOVING IN BUFF REGION; "4" OR "5" MOVING IN DRAFT REGION
   DIRECTION OF TRAVEL------>                                                                        FRONT OF TRAIN
    110->!    100->!     90->!     80->!     70->!     60->!     50->!     40->!     30->!     20->!     10->!
SPEED(MPH)= 42.00  DISTANCE= -2688.(FT)     119.000 (MILES)   TIME(SEC)    0.00      THROTTLE= 8
------------3333333333333333333333333333333444444444444444444333333333333333333-3-333444444444444444444444444444444-3
-------333333333333444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444------3
-----------33444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444444--3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
SPEED(MPH)= 44.96  DISTANCE= -1408.(FT)     118.758 (MILES)   TIME(SEC)   20.00      THROTTLE= 7
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
SPEED(MPH)= 48.49  DISTANCE=   -35.(FT)     118.498 (MILES)   TIME(SEC)   40.00      THROTTLE= 6
-3-------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
---------------------------------------------------------------------------------------------------------------------3
-3-------------------------------------------------------------------------------------------------------------------3
-3-3333------4-------------------------------------------------------------------------------------------------------3
-3-3----3-43444------------------------------------------------------------------------------------------------------3
-3-33--33-333334---------------------------4----4-----4--------------------------------------------------------------3
-3-33-333--3-3----------------------------44444-4-4------------------------------------------------------------------3
SPEED(MPH)= 51.36  DISTANCE=  1438.(FT)     118.219 (MILES)   TIME(SEC)   60.00      THROTTLE= 6
-3333-33---3-3-------------------------------------------------------------------------------------------------------3
333X3-33---33X3------------------------------------------------------------------------------------------------------3
3X3XX333--3X3X3---------------------------------------4----------------------------44--------------------------------3
333XX333-33XXX3--------------------------------------44--------------------------4444444-----------------------------3
3X3XX3XX33XXXXX3-4-----------------------4----44444-444----------------------4--44434444444--------------------------3
3XXXXXXXXXXXXXXX34-------------------------4444444444444-------------------4444-4433333334444444------------------3
3XXXXXXXXXXXXXXXX3--44-------------------4444444444--434-4-----------------4444444--3-3333333333444444--------------3
3XXXXXXXXXXXXXXXXXX33--334--------------4-4443333433334443----4---------------4344--3X33333333333333344-------------3
3XXXXXXXXXXXXXXXXXX3-----------------4444--33---3------3--44-------------4------33XXX333333333333----------------3
3XXXXXXXXXXXXXXXXX3---------------------33X3---3------3------------------4433343XXXXXXXX2333333XX3----------------3
SPEED(MPH)= 50.97  DISTANCE=  2952.(FT)     117.932 (MILES)   TIME(SEC)   80.00      THROTTLE= 6
3XXXXXXXXXXXXXXXXX3---------------------3XXX3--3------3------------------44--333XXXXXXXXXXXXXXXXXXXXX234-------------3
3XXXXXXXXXXXXXXXX3---------------------3XXXX333X33343X---444------4-----443XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23--------3
3XXXXXXXXXXXXXXXX3---------------------3XXXXXX3X33--3X-----------444444---3XXXXXXX32XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2233
```

BLOCKING DIAGRAM (CONTINUED)..TRAIN PYSE1-CASE 1C   INITIAL SPEED   42.0 (mph)

```
   110->!    100->!     90->!     80->!     70->!     60->!     50->!     40->!     30->!     20->!     10->!
3XXXXXXXXXXXXXX3-------------------------3XXXXXXXXX333X------4--444-------3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23-333
3XXXXXXXXXXXXXX3-------------------------3XXXXXXXXXX3XX3444-----------443XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23---------3
3X3XXXXX3XXXXXX3-------------------------3XXXXXXXXXXXXX33-344--4432XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23------------3
3XXXXXXXXXXXXXX3--------------------------3XXXXXXXXXXXXX3X33333XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3---------------3
3XXXXXXXXXXXXXXXX3------------------------3XX322222XXXXXXXXXXXXX2X2XX2222222222XXXXXXXXXXXXXXXXXXX3---------------3
3XXXXXXXXXXXXXXXXXX33-----------------43X2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3------------3
3XXXXXXXXXXXXXXXXXX333----44-----432XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3--------3
SPEED(MPH)= 50.75  DISTANCE=  4461.(FT)     117.646 (MILES)    TIME(SEC)  100.00     THROTTLE= 6
3XXXXXXXXXXXXXXXXXXX3333333-4333XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-----3
3XXXXXXXXXXXXXXXXXXX333333XX3333XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-----3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXX3333XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23--------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXX2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXX222XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234---------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXX22222XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234-------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXX22322XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234-----------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXX333X2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234---------------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2333------------------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234---------------------------------3
SPEED(MPH)= 49.83  DISTANCE=  5958.(FT)     117.363 (MILES)    TIME(SEC)  120.00     THROTTLE= 7
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23X3---------------------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23-----------------------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2X3-----------------------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX33------------------------------------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX233-------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX233----3--------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23---------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23-----------------------------------------3
SPEED(MPH)= 46.74  DISTANCE=  7374.(FT)     117.094 (MILES)    TIME(SEC)  140.00     THROTTLE= 6
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23--------------------44------4---------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234------------------------------------------4-----4--------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234---------------------------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234---------------------------------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234-----------------------------------------------4----4----4------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX234---------------------------------------------------------------4-------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23-4-----------------------------4-------4------4--4--4-----4-----------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2X334------------------------------------------------------------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXX233----------------------------------------------------------------------------------3
3XXXXXXXXXXXXXXXXXXXX2334----------------------------------------------------------------------------------------3
SPEED(MPH)= 43.41  DISTANCE=  8700.(FT)     116.843 (MILES)    TIME(SEC)  160.00     THROTTLE= 6
3XXXXXXXXXXXXXXXXX33---------------------------------------------------------------------------------------------3
3XXXXXXXXXXXXXXXX2333--------------------------------------------------------------------------------------------3
3XXXXXXXXXXXX2233------------------------------------------------------------------------------------------------3
3XXXXXXXXXXX23----------------------------------------------------------------4-----------------------------------3
3XXXXXXXXX2334----------------------------------------------------------44---444----4----------------------------3
3XXXX3333--------------------------------------------------------------------------------------------------------3
3333---------------------444--4--------------------------4----4---44-4-44------------------------------------------3
344-------------------------------------------------------------------------------4444444-44-4--------4-----------3
-----------------------------------------------------------------------------------------------------------------3
-----------------------------------------------------------------------------------------------------------------3
SPEED(MPH)= 40.98  DISTANCE=  9939.(FT)     116.609 (MILES)    TIME(SEC)  180.00     THROTTLE= 6
-----------------------------------------------------------------------------------------------------------------3
-----------------------------------------------------------------444444-------------------------------------------3
----------------------------------------------------------4-4--4-44444-------------------------------------------3
--------------------------------------------------------444-44444444-----4----------------------------------------3
```

BLOCKING DIAGRAM (CONTINUED)..TRAIN PYSE1-CASE 1C INITIAL SPEED   42.0 (mph)

```
   110->!     100->!     90->!      80->!      70->!      60->!      50->!      40->!      30->!      20->!      10->!
-----------------------------------------------------44-4-4444444444444444-4-4------------------------------------------------3
---------------------------------------------------444444444444444444---------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
SPEED(MPH)= 40.20  DISTANCE= 11127.(FT)     116.384 (MILES)    TIME(SEC)  200.00      THROTTLE= 7
------------------------------------------------------------------------------------------------------------------------------3
-------------------------------------------4--4-4-4---------------------------------------------------------------------------3
-------------------------------------------4--444-----------------------------------------------------------------------------3
----------------------------------------4--4-444------------------------------------------------------------------------------3
---------------------------------------44-44----------------------------------------------------------------------------------3
---------------------------------------44444----------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
SPEED(MPH)= 41.07  DISTANCE= 12318.(FT)     116.158 (MILES)    TIME(SEC)  220.00      THROTTLE= 7
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
------------------------------------------------------------------------------------------------------------------------------3
-----------------------------------------------------------------------------------4------------------------------------------3
SPEED(MPH)= 43.12  DISTANCE= 13554.(FT)     115.924 (MILES)    TIME(SEC)  240.00      THROTTLE= 7
--------------------------------------------------------------------------------44-44-4444--------------4---------------------3
---------------------------------------------------------------------------444-4-4444444444444444444444444--------------------3
------------------------------------------------------------------------44444444444444444444444444333333344------------------3
---------------------------------------------------------------------4433333333333344443333333333333333--44-------------------3
---------------------------------------------------------------443333333333333333333333333333333333X333-----------------------3
----------------------------------------------------------44433333333333333333333333-3333333XXXXXXXXX33334--------------------3
-------------------------------------------------------44-3-33333X333333333333333X332XXXXXXXXXXXXXXXXXXXXX234-----------------3
---4---------------------------------------------44444---3--333XX3333333333XXXXXXXXXXXXXXXXXXXXXXXX22X22XXXXXXXXXXXX23--------3
-33-4-----------------------------------------4443-3333322222XXXXXXXXXXXXXXXXX222222222222XX2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2233
--------------------------------------------44432XXXXXXXXXXXXXXXXXXXXXXXXXXXX2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-333
SPEED(MPH)= 44.89  DISTANCE= 14827.(FT)     115.683 (MILES)    TIME(SEC)  260.00      THROTTLE= 6
-----4------------------------------42XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3------3
---333-4-----334--------432XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3--------3
33--------4333XX2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3--------3
-33XXXXXXXXXXXXXXX2X22XXXXX222XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2XXXXXXXXXXXXXXXXXXXXXXXXXXXX333-------3
3322XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3------3
3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2---------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2----------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-----------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-----------3
SPEED(MPH)= 42.15  DISTANCE= 16124.(FT)     115.437 (MILES)    TIME(SEC)  280.00      THROTTLE= 6
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3----------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3----------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-----------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3---------------3
```

BLOCKING DIAGRAM (CONTINUED)..TRAIN PYSE1-CASE 1C INITIAL SPEED   42.0 (mph)

```
   110->!    100->!    90->!     80->!     70->!     60->!     50->!     40->!     30->!     20->!     10->!
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3--------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2----------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23----------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3-----------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23----------------3
SPEED(MPH)= 33.88  DISTANCE= 17258.(FT)     115.222 (MILES)    TIME(SEC)  300.00      THROTTLE= 6
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23-------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX22XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX23--------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXX22222XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3--------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXX22222XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3--------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXXX33X2XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2XXXXXXXXXXXXXXXXXXXXXXXX3--------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXXX3--3XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX22XXXXXXXXXXXXXXXXXXXX23------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXXX3----32XXXXXXXXXXXXXXXXXXXXXXXXXXXX2XXXXX23322XXXXXXXXXXXXXX23-------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXX3------32XXXXXXXXXXXXXXXXXXXXXXXXXXX222XXX23-32XXXXXX2XXXXXXX223---------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXX223--------32XXXXXXXXXXXXXXXXXXXXXXXXXXX3XXXXX3--3X2XXXX2XXXXXX2X3---------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXX223---------3XXXXXXXXXXXXXXXXXXXXXXXXXX3--32X33-----332X232XXXXXXX3---------------------------3
SPEED(MPH)= 19.82  DISTANCE= 18060.(FT)     115.071 (MILES)    TIME(SEC)  320.00      THROTTLE= 3
XXXXXXXXXXXXXXXXXXXXXXXXXX3---------3XXXXXXXXXXXXXXXXXXXXXXXXXX3---444333-----323-2XXXXXXX3----------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXX3---------32XXXXXXXXXXXXXXXXXX22-4--4-----------------32XX22X3----------------------------3
XXXXXXXXXXXXXXXXXXXXXXXXXX3---------3XXXXXXXXXXXXXXX223---------------------------3--33-----------------44-----------3
XXXXXXXXXXXXXXXXXXXXXXXXX3-----------3X2XXXXXXX2X22---3------44-4------------4----------------------------44444444-3
XXXXXXXXXXXXXXXXXXXXXXX223------------332XXXX2344-4-------------------------------------------------------------------3
3XXXXXXXXXXXXXXXXXX2XXX3---------------33223--------------------------------------------------------------------------3
3XXXXXXXXXXXXXXXXXX23----3--444444-4-4----------444--444444444--4-4-------------------------------------------------3
-XXXXXXXX22XXX3-----------------4-----------------------------------------------------------------------------------3
SPEED(MPH)=  0.00  DISTANCE= 18346.(FT)     115.016 (MILES)    TIME(SEC)  337.60      THROTTLE= 0
```

```
         TRAIN BRAKE SIMULATION RUN - FULL SERVICE REDUCTION
         NORTHBOUND RUN, BRAKES APPLIED AT 115.9 MILES
         TRAIN DESIGNATION: PYSE1-CASE 1C,  INITIAL SPEED  42.0 (mph)
                 3  LOCOMOTIVE UNITS      115 CARS
                                         5psi LEAKAGE

                   FORCE DIAGRAM FOLLOWS
        "+" DRAFT FORCE; "-" BUFF FORCE; "BLANK" CENTER FREE SLACK REGION
        "1" TO "9" ABSOLUTE VALUE OF FORCE LEVEL IN 20000 LB      RANGES
        (e.g. O is 0-20,000 lb range, 1 is 20,000-40,000 lb  range, etc.)
  DIRECTION OF TRAVEL------>                                                           FRONT OF TRAIN
   110->!    100->!     90->!     80->!     70->!     60->!     50->!     40->!     30->!     20->!     10->!
SPEED(MPH)= 42.00  DISTANCE= -2688.(FT)     119.000 (MILES)    TIME(SEC)    0.00     THROTTLE= 8
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++!+++++++++
0000000111111111111111222222222222333333333333333344444444444444444444444443333333333333333333333333333333333333333333210
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
0000111111112222222333333333333344444555555556666666666666666666666666666665555555555555555555554444444444444444444433210
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++
000000000111111111111111222222222222233333333333333333333333333333333333333333333333333333333333333333333333333333333210
+++++++++++++++++++++++++++++!++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++
0000000000111111111111111222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222100
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++!+++
0000000000111111111111112222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222100
SPEED(MPH)= 44.96  DISTANCE= -1408.(FT)     118.758 (MILES)    TIME(SEC)   20.00     THROTTLE= 7
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++
0000000000111111111111111112222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222100
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++++++!+++++++++++++++
0000000000111111111111111111111111111111111111111111111111111111111111222222222222222222222222222222222222222222222100
+++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++
0000000000111111111111111111111111111111111111111111111111111111111111111111111111111111222222222222222222222222222100
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++!++++++++++++!++!+++++++
0000000000000000000000000111111111111111111111111111111111111111111111111111111111111111111111111111122222222222222222100
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++
0000000000000000000000000000000000000000000000000000000000000111111111111111111111111111111111111111111111111111111111100
SPEED(MPH)= 48.49  DISTANCE=   -35.(FT)     118.498 (MILES)    TIME(SEC)   40.00     THROTTLE= 6
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
0000000000000000000000000000000000000000000000000000000000000000000000000000000000001111111111111111111111111111111100
++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++!+++++++++!+++++++++
0000000000000000000000000000000000000000000000000000000000000011111111111111111111111111111111111111111111111111111100
++++++++++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++
0000000000000000000000000000000000000000000000000000000000000111111111111111111111111111111111111111111111111111111100
++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++!++++++!++!+++
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000011111111111111111111111100
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++!+++++++++++++++++++!++++++
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000011111111111100
SPEED(MPH)= 51.36  DISTANCE=  1438.(FT)     118.219 (MILES)    TIME(SEC)   60.00     THROTTLE= 6
+-+-+++++++ +-+++++++++++++++++)++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++)++++++
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000111111100
+----+-+++----+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++!+++
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000001111100 0
+-------------+++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++!++++++!+++++++++!+++
0000011111100000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000111000
+---------------++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++-+++++++++++++++++++++++++++++++++!+++
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000011000
+----------------- ++++++++++++++++++++++++-++++++++++++++++++++++++++++++++++++----------      --- +!+++++++++++++++
0000000000000000000000000000000000000000000000000000000000000000000000000000000001000011111000000000000000000000000111000
SPEED(MPH)= 50.97  DISTANCE=  2952.(FT)     117.932 (MILES)    TIME(SEC)   80.00     THROTTLE= 6
+-----------------+++++++++++++++++++++++-----++-+++++-++++++++++++++++++++++++------------------------------------ ---+++++++++
0000000000000000000000000000000000000000000000000000000000000000000000000000111111111122222223433333344445550000111000
```

FORCE DIAGRAM (CONTINUED)...TRAIN PYSE1-CASE 1C INITIAL SPEED 42.0 (mph)

```
  110->!    100->!     90->!     80->!     70->!     60->!     50->!     40->!     30->!     20->!     10->!
+------------------++++++++++++++++++++++++++-------------+ -+++++++++++++++++++++++----------------------------- ----- ---
0000000000000000000000000000000000000000000100010000000000000000000000000000001112222233333334444444455555566667789990
+-------------- ++++++++++++++++++++++++++ ----------------++++++++++++----------------------------- --------- -- ++++++!++++++
0000000000000000000000000000000000000000000000001000000000000024333222222222222222222222221111111111233333433340
+-------------------+++++++++++++++++++++!+++--------------------------------------------------- ------------ -- ----- ++!++++++!++++++
0000000000000000000000000000000000000012344444555555444444444433333333322222222222222111111110001122222222222100
+-------------------++++++++++++++++-----------------------------------------------------------------------------+++++!+++`
0000000000000000000000000000000000033333343333334444444444444444444444433333333333333333333333333322222222222222220001111000
SPEED(MPH)= 50.75  DISTANCE=  4461.(FT)    117.646 (MILES)   TIME(SEC)  100.00     THROTTLE= 6
+----------------------+++---+++---------------------------------------------------------------------------------- -+++++
0000000000000000000000000001000012333333333333333333333333333333333333333333333333333333333333332222222222222221111000
-------------------------------------- ---------------------------------------------------------- ----- ---+++++!++!+++
0000111111222333332222233333333454444444444444444444444433333333333333333333333333332222222222111111110000002232222222100
--------------------------------------- ---------------- ----------------------------------------+++++++++!++++++++!+++
0000000000000000000000000000000000000000011111111111111111111111111111111111111111111111111111100000232323333322222222100
--------------------------------------------------------------------------------------------++++++++++++++++++!+++++++++
0000000000000000000000000000000000000000011111111111111111111111111111111111111111111111111000002222222222222222222222222100
------------------------------------------------------ ----------------------------+++++++++++!++++++++++++!++!+++++++++
0000000000000000000000000000000000000000111111111111111111111111111111111111111111000000000021112222222222222222222222222222100
SPEED(MPH)= 49.83  DISTANCE=  5958.(FT)    117.363 (MILES)   TIME(SEC)  120.00     THROTTLE= 7
------------------------ -------- ---------------------------------------------+++++++++++++++++++++++++++!+++++++++++++++
0000000000000000000000000000000000000011111111111111111111111111111111111110000000000111111111111111111122222222222222222100
---------------------------------- ------------------------------------------+++++++++++++++++++++++!++++++++++++++!+++
0000000000000000000000000000000000001111111111111111111111111111111111111000000000000011111111111111111111111111111112222100
---------------------------------------- ----- ------------------------------ +++++++!+++++!++++++++++++++++++++++++!+++
00000000000001100000000000000000000011111111111111111111111111111111100000000000000000000000000000000111111111111111111111100
-------------------------------------------------------------------- -------------++++++++++++++++++++++!+++++++++++++!++!+++
000000000000111100000000000000000001111111111111111111111111111111000000000000000111111111111111111111112222222222222222222100
---------------------------------------- -------------------------- ---------+++++++++++++++++++++++++++++++++++++++++++++++++
0000000000001111100000000000000000011111111111111111111100000000000000032222222222222222222222222222222222222222222222222222100
SPEED(MPH)= 46.74  DISTANCE=  7374.(FT)    117.094 (MILES)   TIME(SEC)  140.00     THROTTLE= 6
------------------------------------------------------------ ---+++++++++++++++++++++++++++++++++++++++!++++++++++++++++++
0000000000001111100000000000000000000001111111110000000000000000322233233222222222222222222222222223333333333333333222222100
------------------------------------------------ -------------++++++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++
00000000000011111000000000000000000000000000000000002444333333333333333333333333333333333333333333333333333333333332222100
--------------------------------------- -+++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++++++++++!+++++++++!+++
00000000000001100000000000000000000000000444444544444443333333333333333333333333333333333444444444444444433333333333222100
-------------------------------+++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++++++!++!+++
000000000000000000000000000000444434333333333333333333333333334444444444444444444444444444444444444444444333333333332100
-------------------------+++++++++++++++++++++!+++++++++++++++++++++++++++!+++++++++++++++++!++++++++++++++++++!+++++++++!+++
000000000000000000000000022111111112222222222222222222223333333333333333333334444444444444444444444444444444444433333333332100
SPEED(MPH)= 43.41  DISTANCE=  8700.(FT)    116.843 (MILES)   TIME(SEC)  160.00     THROTTLE= 6
-------------------------+++++++++++++++++++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
0000000000000000000000000011111111111111112222222222222222223333333333333333333344444444444444444444444444444444333333333322100
----------------++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++!++++++!+++
00000000000000111111111111111111111112222222222222222223333333333333333333333444444444444444444444444444444443333333333322100
--------+++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++
00000000112222111111111111122222222222222222222333333333333333333333444444444444444444455555555555444444444444433333333322100
++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++!+++++++++++++++++++++++++++++++++++++++!+++++++++!++++++++!+++
133333222222222222222222222222222223333333333333333333344444444444444444455555555555555555555555555444444444444433333333332100
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++++++++++++++!+++++++++
00000000000001111111111111111112222222222222333333333333333344444444444444445555555555555555555555555444444444444433333333332100
SPEED(MPH)= 40.98  DISTANCE=  9939.(FT)    116.609 (MILES)   TIME(SEC)  180.00     THROTTLE= 6
++++++++++++++++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++!+++++++++++++++
0000000000000111111111111111111112222222222223333333333334444444444444445555555555555555555555554444444444444444433333333333222100
```

```
     FORCE DIAGRAM (CONTINUED)...TRAIN PYSE1-CASE 1C INITIAL SPEED    42.0 (mph)

   110->!    100->!     90->!     80->!     70->!     60->!     50->!     40->!     30->!     20->!     10->!
+++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++++++!++!+++++++++
00000000000011111111111111111222222222333333333333444444444444455555555555555555544444444444444444433333333333332100
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++
0000000000011111111111111222222222223333333333444444444455555555555555555555555555555554444444444444444433333333333333210
++++++++++++++++++++++++++++++++++++!++!+++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++!+++++++
0000000000111111111111112222222222233333333344444444445555555555555555555555555555555554444444444444444443333333333333333210
+++++++++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++!+++
000000000011111111111112222222222233333333334444444445555555555555555555555555555554444444444444444444433333333333333333322100
SPEED(MPH)= 40.20  DISTANCE= 11127.(FT)     116.384 (MILES)    TIME(SEC)  200.00      THROTTLE= 7
+++++++++++++++++++++++++++++!++++++++!+++++++++++++++++++++++++++++!++++++++++++++++++++++++++++!+++++!+++++++++!++++++
00000000001111111111112222222222333333333344444444555555555555555555555555554444444444444444444444333333333333333333332222100
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++!+++
0000000001111111111122222222222233333333344444444455555555555555555555555554444444444444444444444333333333333333333333322222100
++++++++++++++++++++++!+++++++++++++++++++++++++++++++++++++++++++!+++++++++++++!++++++++++++++!++++++++++++++++++
000000001111111111122222222222222333333344444444445555555555555544444444444444444444444433333333333333333333333322222222222100
++++++++++++++++++++++++++++++++++++++!++++++++++!+++++!+++++++++++++++++++++++++++++++++!+++++!+++++++!+++++++++!++++++
00000001111111111122222222222222233333333444444444444444444444444444444444444444333333333333333333333322222222222222222222100
+++++++++++++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++!+++
00000001111111111222222222222222233333333444444444444444444444444444444444433333333333333333333322222222222222222222222222222100
SPEED(MPH)= 41.07  DISTANCE= 12318.(FT)     116.158 (MILES)    TIME(SEC)  220.00      THROTTLE= 7
+++++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++!+++
00000001111111112222222222222222223333333333333333333333333333333333333333333322222222222222222222222222222222222222222222222100
+++++++++++++++++++++++++++++++++++++++!+++++++++!+++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++
00000001111111112222222222222222223333333333333333333333333333333333322222222222222222222222222211111111111111111111111111122100
++++++++++++++++++++++++++++++++++++++!++++++!+++++++++++++++++!++++++++++++++++++++++++++++++!+++++++++++++++!++++++!++++++
000000011111111222222222222222222222222222222222222222222222222222222222222221111111111111111111111111111111111111111111100
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++++++++++++++++++++!+++++++++++++++++++++++!++++++!+++
0000000111111112222222222222222222222222222222222222222222222222211111111111111111111111111111111111111111111111111111111100
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++++++++++++++++!++++++
000000011111111111111112222222222222222121111111111111111111111111111111111100000000000000000000000000000000000000011111111100
SPEED(MPH)= 43.12  DISTANCE= 13554.(FT)     115.924 (MILES)    TIME(SEC)  240.00      THROTTLE= 7
++++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++++++
000000011111111111111111111111111111111111111111111111111100000000000000000000000000000000000000000000000000000001111100
+++++++++++++++++++++++++++++++++++++!++!++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++
0000000000011111111111111111111111111111111111110000000000000000000000000000000000000000000000000000000000000000000111000
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++!++++++++++++++++++-++ -----------+++++++++++++++++++++
00000000000000000000000000000000000000000000000000000000000000000000000000000001211111111110000000000000000000001111100
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++----   +    ------------------------------------------+++++
0000000000000000000000000000000000000000000000000000000000001000000000000444433333333333333333333333333344444555565511111100
+++++++++++++++++++++++++++++++++++++++++++!+++----------- ---------------------------------------------------------
00000000000000000000000000000000000000000000009998889897777666666666766666555555555555555555555555554444444445555555556556440
SPEED(MPH)= 44.89  DISTANCE= 14827.(FT)     115.683 (MILES)    TIME(SEC)  260.00      THROTTLE= 6
+++++++++++++++++++++++++----------- -------------------------------------------------------- ----------+++!+++
00000000000000000000000008655599999999999999999999988888888887777777777766666666666665555555555444444333332222111222230
++--------------------------------------------------- ------------------------------------------ ------ ---!++++++
0009999886899998777777777987777777777777777777777777777777777666666666666666666666665555555554444433333222211100011100
-------------------------------------------------------- --------------------------------------------------------++++++
599998888388887777777777777777777777777777777777777777777777666666666666666666666666555555555444443333322222111122100
---------------------------------------------- ------------------------------- --------- -------------------++++!++!+++
000111111111121111111111111211112222223333333333333333334443444443344444444444444444444444443333333222222111111222222100
------------------------------------------------------------------------------------------------ -- --+!+++++++++
00000000001111111111111111111111111122222223333333333333333333333333333333333333333333333333332222222211111000000000011112100
SPEED(MPH)= 42.15  DISTANCE= 16124.(FT)     115.437 (MILES)    TIME(SEC)  280.00      THROTTLE= 6
------------------------------------ --- ------------------------------------------------------------- -------- --+++!++++++
000000011111111111111111111111111111222222333333333344444444444444444444444444444444444444444433333333322222221111100000111112100
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      FORCE DIAGRAM (CONTINUED)... TRAIN PYSE1-CASE 1C INITIAL SPEED    42.0 (mph)

    110->!    100->!     90->!     80->!     70->!     60->!     50->!     40->!.    30->!     20->!     10->!
-------------------------------------------- ---------------------------------------------------- ----- ---------+++++!++++++
000000111111111111111111111111111111112222223333333333334443444443333333333333333333333333333332222222211111100111112222100
----------------------------------------- ----- ------------------------------------------------------------++++:+++++:+++
000000111111211111111111111111111111122222333333333333343333333333333333333333333333333322222222111111000111111122222223210
----------------------------------------------------------------------------------------------- ----------- ------++++++++!++!++!+++
000000111111211111111111111100001111122222333333333333333333333322223222222222222222222222111111110000001111111222222223210
-------------------------------------------- -------------------- --------------------- --- -----++++++++++++:++!+++
000000111111211111111111111000000111112222233333333333322222222222222222111112221111111111111110000000000111111222222233210
SPEED(MPH)= 33.88  DISTANCE= 17258.(FT)     115.222 (MILES)    TIME(SEC)  300.00      THROTTLE= 6
---------------------------- ------------------------------------------------------------ --++++++++++!+++++++++
000000111111211111111111100000000000111122222222222222223222222221111111111111111111111111110000000000011111111222223321 0
---------------------------------------- ------------ ----- -------- -------------------------------++!++++++!++!++++++!+++
000000111111211110000000000000000000111112222222222222222222211111111111110000011111011111100000000000000000111112222233210
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000000111111211110000000000000000000111112222222222222221111110000100000000000000011100000000111111111111222223333210
------------------------------+++++------ --------------- ---------- ----+---------------------++++++++++++++++++++++!+++
000000111111211110000000000000121001111122222222222211121111100000000000100000000000000000000111111111111122222223333210
----------------------------+++++++++------------------- ------------!+------++++------------------++++++++++++++!+++++++++++
000000111111211110000000000111111100001111121111111111111100000000000111110000000000000000000000111111111112222222223333210
SPEED(MPH)= 19.82  DISTANCE= 18060.(FT)     115.071 (MILES)    TIME(SEC)  320.00      THROTTLE= 3
----------------------------++++++++++-------------------------+++++++++++++++++++++++:------- !+++++++++++:+++++++++++++++
00011111111122222111111100000011111100000011111111111111110022222222243222222222222240000000000000001111111222222233333210
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000011111111222221100000000011111111000000111111111121212222223333333444554444444444445555655455555555556666666677776420
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000010111112222211000000011111222222111112200011333222222233434344454444444444444434444334444444444555555666666677777888630
+------ ------------++++++++++++++++++++++++!++++++++++++++++++++++++++++++++++++++++++++++++++++++!+++++!++!+++++++++:+++
00001111111122133333333433334455554444444444557754455555455555566666666666665555455554454444444444444444444444444444310
SPEED(MPH)=  0.00  DISTANCE= 18346.(FT)     115.016 (MILES)    TIME(SEC)  337.60      THROTTLE= 0
```