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of Transportation
Federal Railroad Administration

ICE/U.S. DEMONSTRATION VEHICLE DYNAMICS TESTS TEST REPORT

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13. ABSTRACT (Maximum 200 words)
This test report documents the procedures, events, and results of vehicle dynamic tests carried out on the German ICE trainset in the U.S. during July 1993. These tests, sponsored by Amtrak and supported by the FRA, were conducted to assess the suitability of the ICE trainset for safe operation at elevated speeds and modest cant deficiencies in Amtrak's Northeast Corridor under existing track conditions in a revenue service demonstration.

The report describes the safety criteria used to evaluate the performance of the ICE/U.S. test train, the instrumentation used, the test locations, and the track conditions. Results are presented from tests conducted on Amtrak lines between Washington DC and New York NY, and between Philadelphia and Harrisburg, PA, in which speeds of 162 mph and average cant deficiencies of 7 inches were reached in a safe and controlled manner. The significance of the results is discussed. Conclusions and recommendations are presented.

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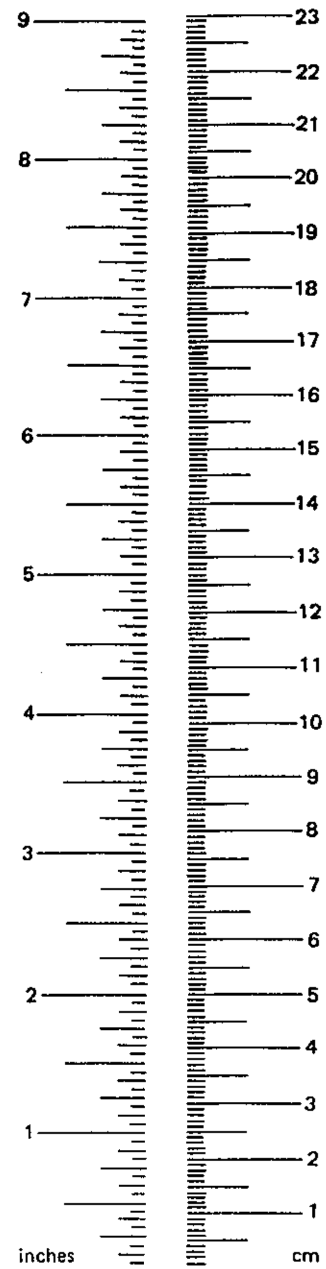
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

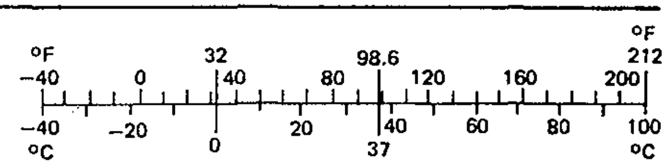
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

Several advanced intercity high-speed train technologies have become operating reality overseas in recent years. Though of foreign origin, these new trains have potential for immediate application in the United States to lessen trip times and improve ridership. Each high-speed train has been developed to meet the particular operating environment and in accordance with the parent country's transportation policy. Therefore a candidate train must be evaluated with regard to applicability to U.S. practices and expectations to ensure that safety levels are maintained in the U.S. environment. The responsibility for such evaluation rests with the Federal Railroad Administration (FRA), U.S. Department of Transportation (U.S. DOT), which is charged with ensuring the safety of rail systems in the United States under the Federal Railroad Safety Act of 1970, as amended.

The German ICE train, manufactured by a consortium led by Siemens AG, offers potential for application over the existing rail infrastructure. For evaluation purposes, a representative ICE trainset was provided to Amtrak by Siemens AG and the Deutsche Bundesbahn (DB) for test and revenue service demonstration in the U.S. Northeast Corridor. A cooperative test effort was conducted under the direction of Amtrak and supported by the FRA Office of Research and Development, with test instrumentation supplied and operated by DB, data analysis support provided by DB and ABB Henschel, and test monitoring maintained by the FRA Office of Safety. Based on the results of the performance testing, the trainset was entered into a revenue service demonstration.

This report summarizes the procedures and results of the vehicle dynamics tests carried out with the ICE trainset in the Northeast Corridor and on the Philadelphia - Harrisburg line, during the month of July, 1993. Instrumented wheelsets, installed on the coach car directly adjacent to a power car, provided direct and immediate measurement of the wheel/rail forces experienced during high speed and moderate cant deficiency operation. In order to attain maximum speeds in tangent and curved track, the tests were conducted incrementally, with analysis of forces and accelerations evaluated against safety criteria during and at the conclusion of each test run before proceeding to the next stage. The principal results and conclusions from these test are discussed.

The authors wish to thank Arne Bang and Thomas Tsai of the FRA Office of Research and Development, for their direction and support in realizing the test and demonstration. Valuable information during the test program and in the preparation of this document was provided by Amtrak, under the direction of Ed Lombardi, by Al Shaw, Michael Trosino and Conrad Ruppert.

The authors also wish to thank Al MacDowell and William O'Sullivan of the FRA Office of Safety, and Herbert Weinstock of the Volpe National Transportation Systems Center for their careful monitoring and judgement in the progression of all tests.

In the conduct of tests, the personnel of Siemens, led by Josef Fischer and Jürgen Prem, and the personnel of DB, lead by Petr Dolezel are gratefully acknowledged for their careful preparation, proficient data collection and presentation.

ICE/U.S. DEMONSTRATION VEHICLE DYNAMICS TESTS TEST REPORT

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1. INTRODUCTION

1.1 BACKGROUND

The Federal Railroad Administration (FRA) is evaluating the technological advances made in railroad passenger transportation in Europe for their application in the United States. Under the Federal Railway Safety Act of 1970, it is the responsibility of the FRA to assure the safety of rail systems in the U.S. The German Intercity Express (ICE) is one of several high speed integral trainsets presently operating in Europe. A series of reports, including "Safety Relevant Observations on the ICE High Speed Train,"[1] were prepared based upon brief visits and literature reviews sponsored by the FRA, which provided a brief description of high speed systems being considered for use on new passenger service lines by regional transportation authorities.

Concurrently, Amtrak has been searching for new passenger equipment to replace its aging fleet for its existing passenger routes and to satisfy the increasing demand of the United States public for modern high speed ground transportation. Amtrak is particularly interested in the possibility of operating passenger trains at higher speeds than are presently permitted. The fastest existing Amtrak train, the Metroliner, is presently limited to a line speed of 125 mph on the Northeast Corridor (NEC).

The German ICE, manufactured by a consortium led by Siemens AG, is designed for speeds in excess of 170 mph. Amtrak wished to explore the potential of the ICE concept in the United States and, accordingly, one ICE trainset was made available for test and demonstration under American conditions. A cooperative effort was initiated with Siemens, Amtrak, and the Deutsche Bundesbahn (DB), the train operator in Germany, to help identify potential concerns of the FRA's Office of Safety in implementation of the procedures for the demonstration and to help identify technical data that can be applied to address these concerns.

The testing and demonstration of the ICE/U.S. trainset described in this report represents measures being taken by Amtrak to permit specification and acquisition of a modernized rail passenger car fleet. In the planning of this program, the approach to proving safety was to first conduct a test program which provided an estimate of the limits of safe performance under conditions that were more severe than those to be used in the demonstration. Based upon the test results, limits and procedures for the demonstration program, carrying paying passengers, were established. The test program using instrumented wheelsets and other instrumentation was conducted in carefully controlled increments. The test proceeded incrementally from known safe conditions to increasingly severe conditions. At each step, the data was carefully evaluated against established safety conditions and used as the basis for the next test condition.

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[1] Safety Relevant Observations on the ICE High Speed Train, U.S. DOT, FRA OR&D Report Series " Moving America, New Directions, New Opportunities", July 1991.

1.2 TEST AND DEMONSTRATION OBJECTIVES

In order to evaluate the safety of the ICE trainset in operations on United States track typical of Amtrak operation, special testing was conducted to provide data to establish the range of safe operation, providing a basis for Amtrak to request a waiver from the FRA for conduct of their in-service evaluations.

The objective of this demonstration was to determine the suitability of the ICE/U.S. trainset for operation at elevated speeds and moderate cant deficiencies in Amtrak's Northeast Corridor. The primary objective of the test program was to determine that the ICE trainset was safe while running in the United States. The results of the technical tests were used to support Amtrak's request for FRA approval to run the ICE/U.S. in a revenue service demonstration.

1.3 TEST PROGRAM SUMMARY

The evaluation program for the ICE trainset involved a series of different technical tests followed by several pre-revenue service demonstration runs. Each test in sequence was dependent upon successful completion and analysis of the performance from previous tests. The general test sequence was as follows:

1) Commissioning - to confirm operational readiness.
2) Cant Deficiency - to establish safe curving limits.
3) High Speed Stability - to establish maximum safe speed.
4) Pre-Revenue Service Demonstration Runs - to demonstrate the safety of the intended revenue service operation.

Commissioning Tests in Northeast Corridor

The purpose of the commissioning tests was to confirm operational readiness, up to a speed of 125 mph, with particular interest in:

1- Propulsion systems
2- Safety equipment (i.e.- lights, horns, etc.)
3- Brake systems and stop distances
4- Cab signal system

Operational checkout was also performed for:

- Clearances and tight switch/curve negotiation
- Basic vehicle stability
- Electromagnetic Interference (EMI), including that during regenerative braking
- Pantograph uplift forces
- Acceleration/current draw and transformer in-rush current.

Dynamic Performance Test

A single round-trip test run was made from Philadelphia to Harrisburg, PA, at line speeds up to 90 mph and cant deficiencies to 3 inches, to assess the general performance and safety of the ICE/U.S. trainset on representative U.S. track.

Cant Deficiency Tests

Test runs from 3" up to 7" cant deficiency were made on the Northeast Corridor (NEC) between New Brunswick and Metro Park, NJ.

Additional test runs, at cant deficiencies of 4" and 5" were made on the Philadelphia - Harrisburg line between Parkesburg and Lancaster, PA.

High Speed Stability Tests

Tests of high speed stability were conducted on the NEC mainline east of Trenton, NJ, between MP 34 and MP 54. Tests were scheduled to a maximum speed of 160 mph. Stop distance checks, using air brakes only, were conducted during these runs at speeds of 130 mph to 160 mph.

Pre-Revenue Service Demonstration Runs - Round Trip Washington to New York City

A recommended revenue speed profile run between Washington, DC, and New York City was submitted by Amtrak and approved by the FRA. Following the tests described above, several round trips were made between Washington and New York City. The first test was undertaken at the proposed revenue service cant deficiency/speed profile, with speeds up to 135 mph and cant deficiencies to 5 inches. A second test run was made at a speed profile 5 mph faster in curves, not exceeding the 135 mph speed limit.

The instrumented wheelsets were removed from the trainset following these round trips and replaced with conventional wheelsets.

National Tour

The ICE/U.S. trainset was taken on a nationwide tour for evaluation, towed by conventional Amtrak diesel-electric locomotives, from 4 August until 24 September, 1993.

Revenue Service Operation

Following successful completion of the tests described above and a review of results, approval was given by the FRA for revenue service operation of the ICE/U.S. trainset at cant deficiencies up to 5 inches, and speeds up to 135 mph in selected tangent sections and curves located in the present 125 mph territory, provided that 5 inches of cant deficiency was not exceeded. A final pre-revenue round-trip check run was made at Amtrak's intended speed profile, and the ICE/U.S. trainset was placed in service in the Northeast Corridor between Washington and New York City from 4 October, 1993 until 17 December, 1993.

1.4 TEST REPORT OBJECTIVES AND ORGANIZATION

The purpose of this test report is to document the process, procedures, events and results from the overall test program that were required to support Amtrak's request for FRA approval to safely demonstrate and operate the ICE/U.S. trainset in revenue service.

Preparations for the test, including the train modifications and configuration for the U.S. demonstration, shipping and unloading of the trainset, and the commissioning tests are given in **Section 2.**

The safety and stop test criteria established for the ICE/U.S. trainset test, together with pre-test dynamic analysis and predictions of safety assurance, are given in **Section 3.**
Vehicle performance tests, procedures and test locations, are described in **Section 4**, and results of test runs in the Northeast Corridor between Washington and New York City and on the Philadelphia - Harrisburg line are given in **Section 5.**

The significance of the results is discussed in **Section 6**, and recommendations and conclusions are presented in **Section 7.**

2. TEST PREPARATION

The test program was planned to meet the stated objectives and provide estimates of the limits of safe performance of the ICE trainset in the United States. Test preparations included: provision of sufficient information to enable Amtrak to petition the FRA for a waiver to test and demonstrate the ICE under conditions exceeding criteria currently permitted; essential modifications to the trainset for compatibility with Amtrak's operating environment in the U.S.; safe shipment of the trainset from Germany to the U.S.; and commissioning tests to initiate operation in the U.S.

2.1 WAIVER PROCESS

The ICE trainset employs different equipment and operating procedures than those customarily seen in the U.S. It was not practical, and in some cases, not possible to bring the trainset into full compliance with all the requirements of Section 49 of the Code of Federal Regulations. In addition, test and demonstration of the equipment was requested at speeds and cant deficiencies greater than are presently permitted within the Code. As a result, a waiver of some requirements by the FRA was necessary before the train could be operated for test and demonstration purposes in the U.S.

Amtrak petitioned the FRA for the necessary waiver in March and April, 1993. Based on the text of the petition, the FRA published a notice in the Federal Register[2] which provided information regarding the receipt of the petition, its content, and an explanation of how the FRA proposed to ensure safety during the tests and demonstration. Accounting for comments received, the FRA prepared a brief for consideration by the FRA Safety Board. The brief provided complete details of the tests proposed, described measures to be taken to minimize the risk of an accident, gave the justification for such measures, and also described measures taken by Amtrak to ensure that performance limits of the test trainset would not be exceeded during the test and demonstration operations. Based on this brief, a waiver to test with provisos for revenue service demonstration was granted.

A detailed test plan[3] was prepared which included the test objectives, procedures, instrumentation to be employed, data analysis techniques to be used and the general test methodology, together with the designation of responsibilities and a test schedule. At the completion of testing and before the test trainset was operated in revenue service, a review of the test data, procedures, and results was conducted. Speed and cant deficiency limitations were established to ensure complete compliance with the requirements of the initial waiver, and revenue service approval was granted.

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[2] Petition for Exemption or Waiver for Test Program and Demonstration Program; National Railroad Passenger Corp., FRA Docket No. H-93-1, Federal Register, Vol. 58, No. 101, Thursday, May 27, 1993, p30846.

[3] Test Plan for the Evaluation of the ICE/US, ENSCO Report No. DOT-FR-93-06, July 1993.

2.2 TRAINSET MODIFICATIONS

Several changes and modifications were made to the ICE trainset leased from DB in order to operate the equipment in the U.S. infrastructure. The majority of these changes were made in Germany before shipment to the U.S.

2.2.1 Electrical and Control System

Electrical modifications included changes to the power collection and propulsion systems to accommodate the 11 kV, 25 cycle catenary on Amtrak's NEC and Philadelphia - Harrisburg, PA lines. Amtrak supplied pantographs for the two power cars which were installed in Germany. Amtrak's cab signaling equipment was also installed.

2.2.2 Power Car Front Coupler

The front coupler of each power car of the ICE/U.S. trainset was modified for coupling to a conventional U.S. locomotive when required for yard movements or propulsion in non-electrified regions. The coupler connected to either a type "E" or a type "H" tightlock coupler.

The nominal compressive and tensile load of the modified coupler was on the order of 127,000 lbs. The maximum speed of the locomotive at coupling was specified at 1 mph in order that the strength of the adapter coupler not be exceeded. The modified coupler was used to couple a pair of Amtrak's diesel locomotives to the ICE/U.S. trainset for propulsion during the National Tour.

2.2.3 Wheel Profile

The wheelsets of the ICE/U.S. test trainset were provided throughout with the wheel profile used by Amtrak's passenger equipment. This profile is identical to the AAR 1B wheel profile, with the exception of the tread taper being modified from 1:20 to 1:40. Because the 1:40 profile gives an effective conicity of 0.025, which is below the range of values specified by DB (0.05 - 0.5), some modifications were necessary to the vehicle suspensions to suppress a potential lateral 1 - 1.5 Hz carbody mode at 125 mph (200 km/h). These modifications are discussed in **Section 2.2.5.**

ABB Henschel evaluated the suitability of this wheel profile on the ICE vehicles to conditions on the Northeast Corridor (NEC) for the 140 RE rail profile. Analyses were done using a "new" rail profile and using actual worn rail profiles measured on the NEC and Philadelphia - Harrisburg Lines. The combinations of wheel profile on new and worn rail were predicted to provide an adequate margin of safety, with the critical speed for truck hunting well above 160 mph for all conditions. The analysis did conclude that a wheel profile more suited to the prevailing U.S. rail conditions should be considered in future.

A second important consideration was the back-to-back distance of the wheel flanges; the back-to-back distance for Amtrak's equipment is nominally, at most, 1356 mm (53 3/8 inches), while the ICE back-to-back distance was nominally 1360 mm for the power cars and 1357 mm for the coach cars. For the same thin flange thickness of about 30 mm, there was at least 4 mm (0.25") less total flange clearance for the ICE power car wheelsets than for Amtrak's wheelsets; that is, for a minimum allowable track gauge of 1422.4 mm (56 inches), the ICE/U.S. wheelset has a flange clearance remaining, each side, of about 2.4 mm as compared with the conventional U.S. wheelset having about 4.8 mm. It was expected that in tight track gauge situations, the ICE/U.S. trainset would be more responsive to track disturbances because of the increased probability of flange contact.

2.2.4 Instrumented Wheelsets

Two instrumented wheelsets, with wheels profiled as discussed above, were installed on a coach car of the ICE/U.S. trainset before shipment to the U.S. The instrumented wheelsets are further described in **Section 4.1**.

2.2.5 Suspension Modifications

Some changes were made to the suspension of the ICE/U.S. trainset vehicles for the U.S. demonstration. These changes were within the range of conditions previously tested during ICE-V prototype train trials.

For the power cars, the lateral damping, carbody to truck, was increased by about 40% and the longitudinal axle box guiding-stiffness was decreased slightly to assist the damping of body modes arising from the modified low wheel conicity. A pair of outer and inner coil springs were used instead of solid coil springs for the primary suspension; in this manner, the vertical stiffness was decreased to about 2/3 of the original value, in order to meet a potential dip of 3 inches (which could be encountered on lower Class track in the U.S.) with acceptable static unloading. This also effected a primary lateral stiffness decrease to about 3/4 of the original value.

For the coach cars, only the vertical stop clearance for movement of the primary suspension was increased by about 0.3 inches to accomodate the potential 3 inch rail dip for lower Class U.S. track. Resilient wheels were also used on 5 of the 6 coaches, the exception being the car fitted with the instrumented wheelsets.

2.3 SHIPPING AND UNLOADING

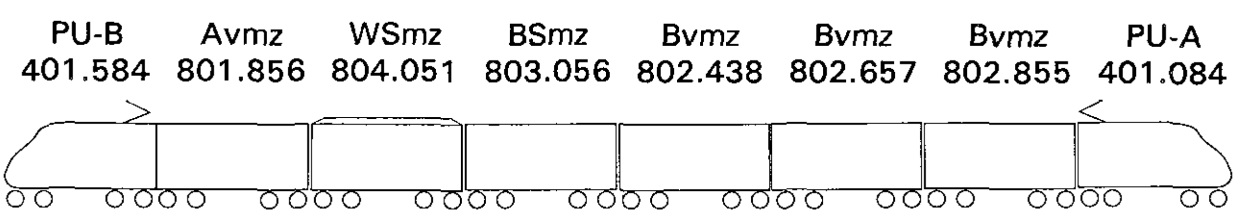
The ICE/U.S. trainset was shipped during the second half of June 1993 from the German port city of Bremerhaven, and arrived at the port of Baltimore, MD, 30 June. The vehicles were unloaded individually and assembled into a trainset at the dock-side track served by Conrail. The trainset, pulled by an Amtrak diesel locomotive, was then moved to the Amtrak's Ivy City Maintenance Facility in Washington, DC, for final preparations and commissioning.

2.4 TRAIN CONFIGURATION

The ICE/U.S. trainset consisted of 8 vehicles: power unit A (PU 401.084), three 2nd class coaches (Bvmz 802.855, Bvmz 802.657, Bvmz 802.438), one 2nd class coach with handicapped toilets and special compartments (BSmz 803.056), one restaurant coach (WSmz 804.051), one 1st class coach (Avmz 801.856), and power unit B (PU 401.584).

Two Amtrak F69PH EMD/Siemens diesel-electric locomotives were used for motive power during the national tour. An adaptive coupler was installed on the front of the power unit of the ICE/U.S. trainset for towing purposes.

CAR TYPE	CAR CLASS	CAR NUMBER
Power Unit A	PU	401.084
2nd Class Coaches	Bvmz	802.855
	Bvmz	802.657
	Bvmz	802.438
2nd Class Coach with handicapped toilets and special compartments	BSmz	803.056
Restaurant Coach	WSmz	804.051
1st Class Coach	Avmz	801.856
Power Unit B	PU	401.584



(See also, Figure 4.1, p. 15)

2.5 COMMISSIONING TESTS

2.5.1 Braking

The braking system of the ICE trainset consists of electrodynamic (regenerative), pneumatically actuated disc, and electromagnetic track brakes. Under normal service braking, most of the braking force is generated by the electrodynamic braking action of the asynchronous three-phase motors, with the disc braking blended and becoming predominant at low speed. The electromagnetic track brakes are used for emergency braking only. The traction and braking systems are designed for 280 km/h maximum speed; the ICE operates in revenue service in Germany at 250 km/h (153 mph).

The air brake system of the ICE/U.S. trainset was modified to Amtrak and U.S. standards, including new airbrake pressures, valves, and software. As part of the commissioning of the ICE/U.S. trainset, a series of tests were carried out to verify the braking capabilities, in both full service and emergency modes, with and without dynamic (regenerative) braking. To simulate conditions for a fully loaded trainset, the brakes on one axle of the trainset (axle #5, Figure 4.1) were disabled for the majority of the tests. Stop distances were determined using the pulse counter/speed sensor system installed by DB on wheelset #7 (Figure 4.1) for the vehicle dynamic testing. Stop times were recorded using a hand-help stop watch.

A summary of the results is given in **Table 2.1**. Average deceleration rates vary from about 0.09 g using disk brakes only to 0.15 g during emergency braking. By measuring both stopping distance and stopping time, two values of average deceleration were calculated independently. Differences in the two values indicate that the braking force and deceleration were not constant but varied during the braking process.

Stops were made using the **air brake equipment only** from speeds of 30 mph up to 141 mph during the course of the test runs in order to assess the performance of the air brake equipment and to ensure that stopping distances were within the allowable limits established for Amtrak's NEC signaling system. Results of these tests are highlighted in **Table 2.1**. A plot of the stopping distances is shown in **Figure 2.1**, together with Amtrak's maximum braking distance specification, Amtrak Standard S-603. The maximum acceptable braking distance for unrestricted operation throughout the NEC signaling system is 7848 feet. The plot indicates that the ICE/U.S. braking performance is within the acceptable envelope for speeds up to 137 mph.

The onboard tests included multiple starts and stops as well as high speed running, accelerations, and decelerations/braking. The trainset typically used regenerative braking but at least one high speed stop was made using only the disc brakes. All measurements were recorded on tape during each test period, and spectra of the AC current and voltage and the time domain waveforms of the signal circuits were monitored in real-time during these runs on a spectrum analyzer. The recorded data were then processed in the laboratory to further investigate the potential EMI effects on the signaling circuit.

The track rail-to-rail voltage measurements were made on track 3 at a wayside location north of Baltimore as the ICE/U.S. trainset passed over the rail clamp test points at speed, accelerating, decelerating/braking, and while stopped with the main power car over the rail clamp test points. The wayside rail-to-rail voltage measurements were also recorded on tape and viewed simultaneously on the spectrum analyzer; data plots were produced as required.

The principal results and conclusions from these EMI tests are summarized below[4]:

- No interference related to the operation of the ICE/U.S. train cab signaling system was found in the track signaling voltages (100 Hz filter input/output).
- Spectrum analysis of the in-coming pantograph current indicated that the peak levels in the critical frequency band of 90 to 110 Hz were typically at or below 1 amp (the experience-based EMI limit in this frequency range is 1 amp rms); levels at 250 Hz were typically above 0.5 amp and could potentially interfere with future cab signaling systems operating at this frequency.
- The measured rail-to-rail voltage levels with the ICE Train present, accelerating and decelerating, were well below the 500 mV_{rms} levels specified in the test plan for the 0-500 Hz range.
- Measurements of the pantograph current before and after modifications to the ICE control software, July 14th, indicated that the changes may have resulted in an increased level of peak interference in the 75 Hz to 100 Hz band. The mean interference levels remained unchanged.
- Additional processing and analysis of the existing data should be performed to determine whether or not changes made to the ICE system caused the occurrence of a moving tone in the 100 Hz band.
- Future modifications to the ICE control system should be reviewed. Additional testing on the ICE may be warranted depending on the change and the results of the analysis.

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[4] EMI Testing of a High Speed Trainset, German Inter-City Express (ICE), ENSCO Report No. DOT-FRA-94-06, June 1994.

3. SAFETY REQUIREMENTS

The fundamental basis for safe operation at higher speeds and cant deficiencies is the satisfactory control of forces acting at and across the wheel/rail interface. Safety criteria are concerned with assessing the risk of vehicle derailment through vehicle overturning, wheel climb, track gage widening (rail rollover, lateral deflection), lateral panel shift, and truck instability (hunting).

3.1 SAFETY CRITERIA

Two instrumented wheelsets for the ICE/U.S. trainset were installed on the truck of Coach Car, Bvmz 802.855, directly adjacent to the Power Car, PU 401.084, to directly measure wheel/rail forces during these tests. The measured wheel forces were assessed against safety criteria established prior to testing based on experience, judgement, and previous tests conducted in the NEC.[5] The following parameters and limits were used to monitor all test operations:

1) **Track Panel Shift: Net Axle Lateral Force (NAL) < 0.5 x Static Axle Load**

   - for the ICE coach Bvmz, NAL < 65.0 kN (Note: 1 kN = 224.8 lb)

2) **Wheel Climb Derailment[6]:** L/V Ratio (Nadal), Single Wheel < 0.8

   - conditions considered safe if each wheel L/V is less than 0.8; if any wheel exceeded 0.8, then:

     Axle Sum L/V Ratio (Weinstock) < 1.0
     - examine axle sum if single wheel L/V exceeds 0.8; conditions are considered safe if sum is less than 1.0

3) **Rail Rollover: Truck Side L/V Ratio (T-L/V) < 0.5**

4) **Vehicle Overturn: Minimum Vertical Wheel Force (Vmin) > 10% of Static Wheel Load**

   - for the ICE coach Bvmz, Vmin > 6.5 kN

5) **Truck Hunting: Truck Frame Acceleration < 0.8 g peak to peak**

   - no sustained oscillations

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[5] Railroad Passenger Ride Safety, Report No. DOT-FRA/ORD-89/06, April 1989.

[6] A Review of Literature and Methodologies in the Study of Derailments Caused by Excessive Forces at the Wheel/Rail Interface, AAR Report No. R-717, December 1990.

Measurements of safety parameters 1 - 4 were displayed using a 25 Hz, 4 pole low-pass filter; measurements of parameter 5, truck frame acceleration, were band-pass filtered at 0.5 - 8 Hz, the frequency range over which truck hunting might be expected to occur. During any test run, these safety criteria were monitored to ensure that none of the above limits were exceeded. Data projections were used to minimize the likelihood that any safety limit would be exceeded. If any stop test criterion was met or exceeded during the test period, that condition was used to define the limiting speed for that particular curve.

The instrumented wheelsets were installed under a Coach Car; previous testing of the ICE in Germany and dynamic performance analyses for both the Power Car and Coach Car indicated that the Coach would be more sensitive to the above safety limits. The truck adjacent to a Power Car was chosen because it would be most affected by the dynamic motions of the Power Car (e.g. high speed transit over flexible bridges).

Vertical and lateral accelerations were recorded at various carbody locations throughout the trainset. For future test considerations, it may be desirable to correlate carbody accelerations versus instrumented wheelset measurements.

3.2 DYNAMIC ANALYSIS AND PREDICTIONS

Computer simulations were conducted by ABB Henschel to examine the safety and performance of the ICE trainset as modified for the U.S. demonstration and on representative U.S. track. Measured track data from the NEC and Philadelphia-Harrisburg lines with perturbations in space-curve form were provided by Amtrak.

Simulation results included time histories of the predicted wheel-rail force signals on perturbed track for both the power car and coach car. Speeds to 160 mph (257.5 km/h) and cant deficiencies to 9 inches were examined at selected locations on the NEC and Harrisburg line.[7,8] In all of the examined curves, no safety criteria limits were predicted to be exceeded at cant deficiencies up to 7 inches. At a cant deficiency of 9 inches, the coach car was predicted to have unacceptable transient wheel unloadings and lateral accelerations in curves 265 and 266 on the NEC near Metro Park NJ.

Some wheel force transients with very short individual peak values above the safety criteria were predicted at speeds of 160 mph near some switches; however, the track space-curve data used as input were inconclusive in the area of the switch tongue and frog. A list of limit excursions and locations was preserved to permit precise monitoring of the measurements during the actual test runs.

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[7] Nonlinear Calculations, ICE Power Car on AMTRAK Line, ABB HENSCHEL Lokomotiven GmbH Report No. LOK/ TFB-K1, June 1993.

[8] Nonlinear Calculations, ICE Coach on AMTRAK Line, ABB HENSCHEL Lokomotiven GmbH Report No. LOK/ TFB-K1, June 1993.

4. VEHICLE PERFORMANCE TEST PROCEDURES

Test instrumentation was installed on the trainset in Washington, DC, by DB technical personnel. The test methods, procedures, locations, and the sequence of events for the vehicle performance tests are described in this Section. Included are the methods for measurement and determination of cant deficiency, the particular test zones chosen, and a summary list of conducted test runs.

4.1 INSTRUMENTATION

Two instrumented wheelsets were installed in Germany before the ICE trainset was shipped to the U.S. These wheelsets were of the bending moment type, with strain gauges on the axle used to resolve the lateral and vertical wheel/rail forces. The two instrumented wheelsets were installed on the front truck of the Coach Car, 802.855, directly adjacent to Power Unit 401.084 ("A" end of trainset). In terms of trainset definitions, this corresponds to Axles 5 and 6 on Truck #3, as shown in **Figure 4.1**. These wheelsets were removed and replaced with regular wheelsets, 25 July 1993, at the conclusion of Test Run 52.

Accelerometers were installed to measure selected carbody and truck frame accelerations and cant deficiency. A lateral accelerometer was located on each of the 16 truck frames to monitor for any signs of truck hunting. Accelerometers in both the lateral and vertical direction were placed at selected carbody locations on the trainset:

- Power Unit, PU-A 401.084 ("A" end of consist), above truck #1
- Power Unit, PU-B 401.584 ("B" end of consist), above truck #16
- Instrumentation Car Bvmz 802.855, directly above Truck #3
- Restaurant Car WSmz 804.051, directly above Truck #11

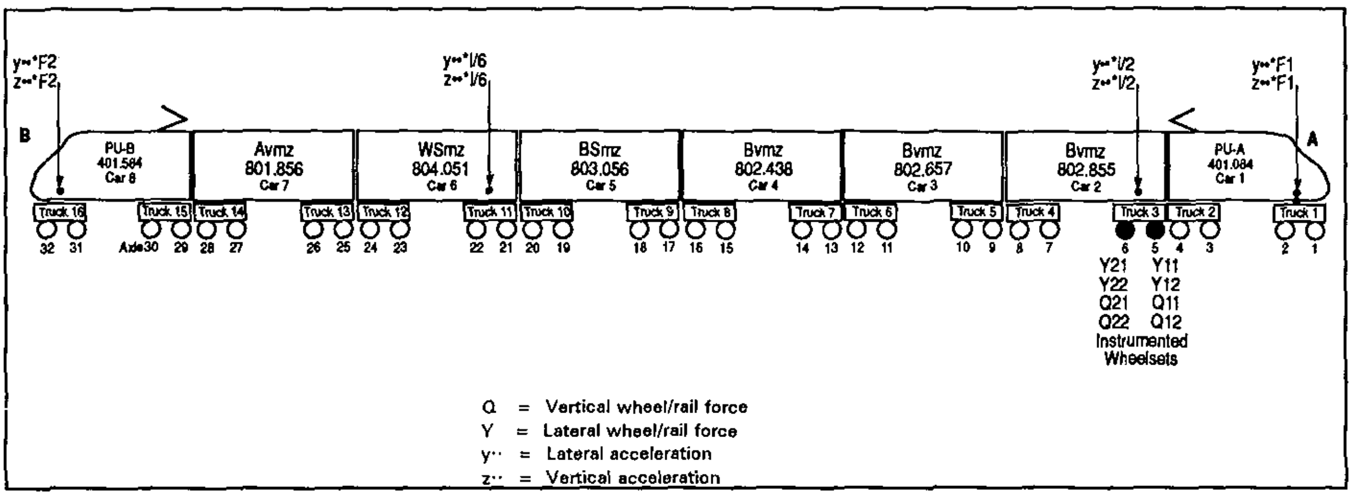

Figure 4.1: Transducer Configuration, ICE Tests USA

A description of the measurement transducers and their locations on the vehicle are depicted in **Figure 4.1** and detailed in **Appendix A**.

Safety criteria parameters were displayed in real time during the test runs using two 22-channel strip chart recorders. Distance-based strip charts with vertical time lines were produced using the vehicle speed and distance pulses to govern the chart speed. The channel allocations and descriptions are included in **Appendix A**.

An onboard computer system was used for digital data recording and onboard data analysis. Summary histogram plots giving the peak values of the safety parameters, the vehicle speed, and cant deficiency recorded over each kilometer were produced at the conclusion of each test run.

The nomenclature used to define each safety parameter name was as follows:

Q_{11} = Vertical force, right wheel, instrumented wheelset 1 (axle 5 of trainset)
Q_{12} = Vertical force, left wheel, instrumented wheelset 1 (axle 5 of trainset)
Q_{21} = Vertical force, right wheel,instrumented wheelset 2 (axle 6 of trainset)
Q_{22} = Vertical force, left wheel, instrumented wheelset 2 (axle 6 of trainset)

SY1 = Net Axle Lateral Force, instrumented wheelset 1 (axle 5 of trainset)
SY2 = Net Axle Lateral Force, instrumented wheelset 2 (axle 6 of trainset)

SY_r/SQ_r = Truck Side L/V, right side (Truck #3 of trainset)
SY_l/SQ_l = Truck Side L/V, left side (Truck #3 of trainset)

Y/Q_{11} = L/V ratio, right wheel, instrumented wheelset 1 (axle 5 of trainset)
Y/Q_{12} = L/V ratio, left wheel, instrumented wheelset 1 (axle 5 of trainset)
Y/Q_{21} = L/V ratio, right wheel,instrumented wheelset 2 (axle 6 of trainset)
Y/Q_{22} = L/V ratio, left wheel, instrumented wheelset 2 (axle 6 of trainset)

4.2 METHOD FOR DETERMINATION OF CANT DEFICIENCY/UNBALANCE

Unbalance was calculated from the lateral acceleration signal generated by an accelerometer installed on the truck frame above axle 8 of the Coach Car. Location magnets were installed on the track at the entry and exit spirals of each test curve on which a detailed analysis was to be performed. These magnets were sensed by a detector on the instrumented wheelset of the passing train; the output pulse was used to inform the onboard computer of the time each curve was entered and exited for each test run on a consistent basis.

4.3 TEST REGION AND TEST ZONES

The cant deficiency and high speed test runs were carried out in three principal test zones within the test region shown in **Figure 4.2**:

- Northeast Corridor (NEC) Mainline (Philadelphia - New York) **between New Brunswick and Metro Park**; Cant Deficiency Tests to 7" (speeds to 115 mph)

- NEC Mainline (Philadelphia - New York) **between Trenton and New Brunswick**; High Speed Stability Tests, speeds to 160 mph

Philadelphia - Harrisburg Line **between Parkesburg and Lancaster;** Cant Deficiency Tests to 5" (speeds to 100 mph)

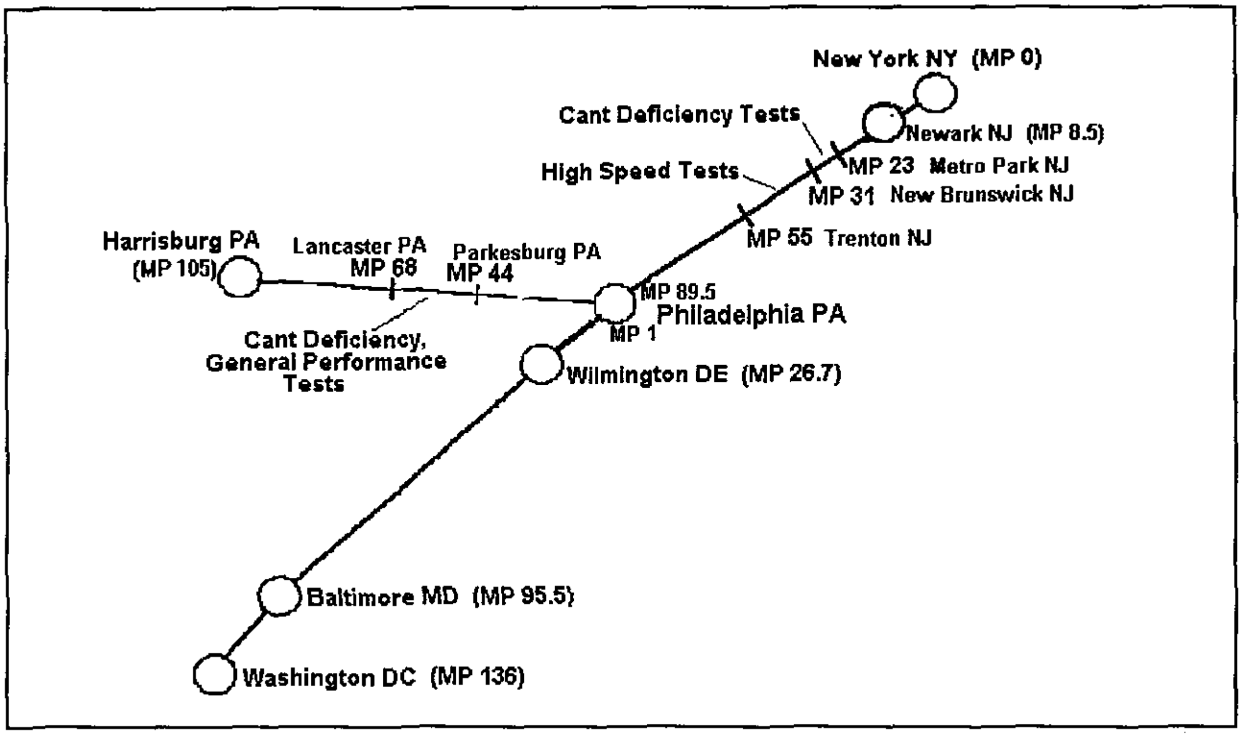

Figure 4.2: Test Region and Zones for ICE/US Vehicle Performance Tests

In each of the test zones, the majority of rail is continuously welded (CWR) with a 140 RE profile. At approximate intervals of two miles, a 30 foot cut section (insulated joint) is welded into the track for signalling (cab signal) purposes. The track is well bedded in stone ballast.

4.3.1 NEC, New Brunswick to Metro Park, MP 31 - 22; Cant Deficiency Tests
(Test Runs 14 - 25)

Specific zone location magnets (a total of 4) were placed trackside at MP 27 and MP 23, Tracks 2 and 3.

This test zone between New Brunswick (MP 31) and Metro Park (MP 23) is comprised of 10 miles (16 km) of electrified quadruple track. The two center high speed tracks consist of concrete mono-block ties with Pandrol rail fasteners. The interlockings (cross-overs) are on wooden ties with tieplates and cut spike rail fasteners.

There are 12 curves within this test zone on each track. Three particular test curves were selected for more detailed analyses in two groups comprising one reversed pair and a singlet for each of the high speed Tracks #2 and #3. The details for each curve in the order in which they are encountered are given below.

Travelling EASTBOUND on TRACK #2 (in the direction of Metro Park NJ)

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	7" UB Speed	Direction
268	1st Curve west of Lincoln	27 - 26	1° 52′ [934 m]	6"	80 mph	101 mph	Left
266	Curve west of MP 24	25 - 24	1° 33′ [1127 m]	5 3/4"	90 mph	108 mph	Right
265	Curve east of MP 24	24 - 23	1° 27′ [1204 m]	5 1/4"	90 mph	110 mph	Left

Travelling WESTBOUND on TRACK #3 (in the direction of New Brunswick NJ)

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	7" UB Speed	Direction
265	Curve east of MP 24	23 - 24	1° 26′ [1221 m]	6"	90 mph	115 mph	Right
266	Curve west of MP 24	24 - 25	1° 30′ [1164 m]	5 3/8"	90 mph	109 mph	Left
268	1st Curve west of Lincoln	26 - 27	1° 56′ [905 m]	6"	80 mph	98 mph	Right

4.3.2 NEC, Trenton to New Brunswick, MP 55 - 32; High Speed Stability Tests (Test Runs 25 - 36)

Specific zone location magnets (a total of 4) were placed trackside at MP 54 and MP 33, Tracks 2 and 3.

This test zone between Trenton (MP 55) and New Brunswick (MP 32) is comprised of 22 miles (35 km) of electrified quadruple track. The two center high speed tracks consist of concrete mono-block ties with Pandrol rail fasteners. The interlockings (cross-overs) are on wooden ties with tieplates and cut spike rail fasteners.

Of the 6 curves within this test zone, two large radius curves are passed at the eastern one-third of the test zone on each of the high speed Tracks #2 and #3. The details for these higher radius curves are given below.

Travelling EASTBOUND on TRACK #2 (in the direction of New Brunswick NJ)

Curve Number	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	UB at 160 mph	Direction
276	41 - 39	0° 32′ [3274 m]	3 5/8"	125 mph	5.8"	Left
275	39	0° 19′ [5514 m]	2"	125 mph	3.6"	Right

Travelling WESTBOUND on TRACK #3 (in the direction of Trenton NJ)

Curve Number	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	UB at 160 mph	Direction
275	39	0° 20′ [5238 m]	2 1/8"	125 mph	3.8"	Right
276	39 - 41	0° 31′ [3379 m]	3 1/2"	125 mph	5.6"	Left

4.3.3 Philadelphia - Harrisburg Line, MP 44 - 68; Cant Deficiency Tests (Test Runs 12,13; 37 - 40)

Specific zone location magnets (a total of 4) were placed trackside at MP 47 and MP 66, Tracks 1 and 4.

The test zone between Parkesburg (MP 44) and Lancaster (MP 68) is comprised of 24 miles (39 km) of electrified double track on wooden ties with tie-plates and cut spike rail fasteners. The majority of rail is CWR or long welded rail with a 140 RE profile. Some sections of jointed (bolted) rail exist with 39 foot rail lengths and staggered joints. 155 RE rail profiles also occur on this test zone.

There are 23 curves within this test zone on each track. Four particular test curves were chosen for closer examination in two groups of reversed pairs for each track.

Travelling WESTBOUND on TRACK #4 (in the direction of Lancaster PA)

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	7" UB Speed	Direction
662 (A&B)	Gap	51	4° 10′ [419 m]	5 1/2"	55 mph	66 mph	Left
663	Eby's	52 - 53	4° 12′ [416 m]	6"	55 mph	67 mph	Right
671	Ronks	60 - 61	2° 4′ [845 m]	6"	75 mph	94 mph	Right
672	Bird-in-Hand	61 - 62	2° 2′ [859 m]	6"	75 mph	95 mph	Left

Travelling EASTBOUND on TRACK #1 (in the direction of Parkesburg PA)

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	7" UB Speed	Direction
672	Bird-in-Hand	62 - 61	2° 4′ [845 m]	5 3/4"	75 mph	93 mph	Right
671	Ronks	61 - 60	2° 1′ [866 m]	5 3/4"	75 mph	95 mph	Left
663	Eby's	53 - 52	4° 6′ [426 m]	5 1/2"	50 mph	67 mph	Left
662 (A&B)	Gap	51	4° 16′ [409 m]	5 1/2"	50 mph	66 mph	Right

4.3.4 NEC, Washington DC to New York NY; Pre-Revenue Service Demonstrations (Test Runs 41 - 52)

The test zone between Washington and New York comprised 225 miles (362 km) of electrified double track, quadrupled where possible between Washington DC and Newark, New Jersey. The two high speed tracks were supported predominantly by concrete mono-block ties with Pandrol rail fasteners. All but a few interlockings (cross-overs) were laid on wooden ties with tieplates and cut spike rail fasteners. The maximum line speed was normally 125 mph, although line speed was often restricted to less than this figure due to Metroliner trains not being allowed to operate at more than 4 inches of unbalance in curves. The 160 mph test speed for the ICE/U.S. trainset between Trenton and New Brunswick was not in force during the long distance test runs. Turnouts, crossovers and numerous curves of different radii and superelevation were encountered along the route. **Appendix B** provides additional track and curve information.

Track data in space-curve form was supplied by Amtrak for various portions of the test zones.

4.4 TEST SEQUENCE

A summary of the test runs and conditions is given in **Table 4.1**.

4.5 HIGH SPEED BRAKE TESTS

Stops were made periodically during the course of the test runs at speeds up to 161 mph using only the air brake equipment to assess the braking performance and to compare stopping distances with the allowable limits established for the NEC signaling system. Stop distance measurements are reported in **Section 2.5.1**.

4.6 CARBODY ACCELERATIONS AND RIDE QUALITY TESTS

Carbody accelerations in the lateral and vertical directions on each power unit, the instrumentation car, and the restaurant car were measured and displayed during the technical tests and during the demonstration revenue service runs between Washington and New York.

Immediately prior to revenue service (1 October 1993), lateral and vertical accelerations were measured on the instrumentation car over Truck 3 during a round-trip test run at 135 mph maximum speed between Washington and New York City.

Carbody acceleration measurements were continued at selected locations on the vehicle on a weekly basis during the revenue service period as a condition of the waiver.

TABLE 4.1 ICE TEST RUNS IN CHRONOLOGICAL ORDER

Date	Run #	Line	Direction/ Track	Track Condit	Scheduled Unbalance/Speed	Leading End/ Instr Wheelset Position
Jul 16/93	12	Ph - Hrsbg	W / Trk 4	Dry	3"	A-end / trk ldg, ax 5 ldg
"	13	Hrsbg - Ph	E / Trk 1	Dry	3"	B-end / trk trl, ax 6 ldg
Jul 17/93	14	Ph - NYP	E / Trk 2	Dry	3"	A-end / trk ldg, ax 5 ldg
"	15	NYP - Ph	W/ Trk 3	Dry	3"	B-end / trk trl, ax 6 ldg
"	16	Ph - NYP	E/ Trk 2	Dry	4"	A-end / trk ldg, ax 5 ldg
"	17	NYP - Ph	W/ Trk 3	Dry	4"	B-end / trk trl, ax 6 ldg
"	18	Ph - NYP	E/ Trk 2	Dry	5"	A-end / trk ldg, ax 5 ldg
"	19	NYP - Ph	W/ Trk 3	Dry	5"	B-end / trk trl, ax 6 ldg
"	20	Ph - NYP	E/ Trk 2	Dry	6"	A-end / trk ldg, ax 5 ldg
"	21	NYP - Ph	W/ Trk 3	Dry	6"	B-end / trk trl, ax 6 ldg
"	22	Ph - NYP	E/ Trk 2	Dry	7"	A-end / trk ldg, ax 5 ldg
"	23	NYP - Ph	W/ Trk 3	Dry	7"	B-end / trk trl, ax 6 ldg
"	24	Ph - NYP	E/ Trk 2	Dry	6"	A-end / trk ldg, ax 5 ldg
"	25	NYP - Ph	W/ Trk 2	Dry	6"	B-end/ trk trl, ax 6 ldg
		NYP - Ph	W/ Trk 3	Dry	130 mph	B-end/ trk trl, ax 6 ldg
July 18/93	26	Ph - NYP	E/ Trk 2	Dry	130 mph	A-end/ trk ldg, ax 5 ldg
"	27	NYP - Ph	W/ Trk 3	Dry	130 mph	B-end/ trk trl, ax 6 ldg
"	28	Ph - NYP	E/ Trk 2	Dry	135 mph	A-end/ trk ldg, ax 5 ldg
"	29	NYP - Ph	W/ Trk 3	Dry	135 mph	B-end/ trk trl ax 6 ldg
"	30	Ph - NYP	E/ Trk 2	Dry	145 mph	A-end/ trk ldg, ax 5 ldg
"	31	NYP - Ph	W/ Trk 3	Dry	145 mph	B-end/ trk trl, ax 6 ldg
"	32	Ph - NYP	E/ Trk 2	Dry	150 mph	A-end/ trk ldg, ax 5 ldg
"	33	NYP - Ph	W/ Trk 3	Dry	150 mph	B-end/ trk trl, ax 6 ldg
"	34	Ph - NYP	E/ Trk 2	Dry	155 mph	A-end/ trk ldg, ax 5 ldg
"	35	NYP - Ph	W/ Trk 3	Dry	155 mph	B-end/ trk trl, ax 6 ldg
"	36	Ph - NYP	E/ Trk 2	Dry	160 mph	A-end/ trk ldg, ax 5 ldg
July 19/93	37	Ph - Lanc	W/ Trk 4	Damp	4"	A-end/ trk ldg, ax 5 ldg
"	38	Lanc - Ph	E/ Trk 1	Wet	4"	B-end/ trk trl, ax 6 ldg
"	39	Ph - Lanc	W/ Trk 4	Dry	5"	A-end/ trk ldg, ax 5 ldg
"	40	Lanc - Ph	E/ Trk 1	Dry	5"	B-end/ trk trl, ax 6 ldg
July 21/93	41	Wa - Ph	N/ Trk 2	Dry	5", 135 mph	A-end/ trk ldg, ax 5 ldg
"	42	Ph - NYP	E/ Trk 2	Dry	5", 135 mph	A-end/ trk ldg, ax 5 ldg

Date	Run #	Line	Direction/ Track	Track Condit	Scheduled Unbalance/Speed	Leading End/ Instr Wheelset Position
"	43	NYP - Ph	W/ Trk 3	Dry	5", 135 mph	B-end/ trk trl, ax 6 ldg
"	44	Ph - Wa	S/ Trk 3	Dry	5", 135 mph	B-end/ trk trl, ax 6 ldg
July 22/93	45	Wa - Ph	N/ Trk 2	Dry	135 mph, 5" +5 mph in curves	A-end/ trk ldg, ax 5 ldg
"	46	Ph - NYP	E/ Trk 2	Dry	135 mph, 5" +5 mph in curves	A-end/ trk ldg, ax 5 ldg
"	47	NYP - Ph	W/ Trk 3	Dry	135 mph, 5" +5 mph in curves	B-end/ trk trl, ax 6 ldg
	48	Ph - Wa	S/ Trk 3	Dry	135 mph, 5" +5 mph in curves	B-end/ trk trl, ax 6 ldg
July 24/93	49	Wa - Ph	N/ Trk 2	Dry	VIP 5"	A-end/ trk ldg, ax 5 ldg
"	50	Ph - Newark	E/ Trk 2	Dry	5", 135 mph	A-end/ trk ldg, ax 5 ldg
"	51	Newark - Ph	W/ Trk 3	Dry	5", 135 mph	B-end/ trk trl, ax 6 ldg
"	52	Ph - Wa	S/ Trk 3	Dry	5", 135 mph	B-end/ trk trl, ax 6 ldg
Oct 1/93		Wa - NYP NYP - Wa	N,E/ Trk 2 W,S/ Trk 3	Dry	5", 135 mph	B-end/ no instr wsets A-end/ no instr wsets
Oct 5/93		Wa - NYP NYP - Wa	N,E/ Trk 2 W,S/ Trk 3	Dry	5", 135 mph	A-end/ no instr wsets B-end/ no instr wsets

5. DYNAMIC TEST RESULTS

Test results are presented to examine the safety aspects and the safety margin involved with the high speed operation of the ICE/U.S. trainset. During each test run, measured peak values of the safety parameters were compiled on a kilometer by kilometer basis. A summary of the peak values, closest to the safety limits, recorded during each cant deficiency and high speed stability test run (Test Zones 1 and 2) is given in **Table 5.1**; measured values exceeding the safety limits are highlighted. Each safety parameter will be addressed in this Section.

5.1 MAXIMUM SPEED AND MAXIMUM UNBALANCE RECORDED

The maximum speed recorded from the high speed test runs was **162 mph.** This occurred during Test Runs 36 and 50 in high speed Test Zone 2 on the NEC between Trenton and New Brunswick while travelling eastbound on Track 2 under dry track conditions. This speed was sustained over two distances of approximately 3 miles each, between MP45 - MP42, and MP38 - MP35 (a moderate slow-down for track anomolies was mandated at MP41).

The lateral accelerometer installed on the truck frame adjacent to axle #8 of the instrumentation Coach Car Bvmz 802.855 was used to indicate the degree of unbalance or cant deficiency. The maximum quasi-steady lateral acceleration recorded from all test runs was 1.50 m/s^2. This occurred during Test Run 23 on the NEC in Test Zone 1 (New Brunswick - Metro Park) while travelling westbound on Track #3 in curve 266 (1.5° curvature) at a speed of 114 mph on dry track. This lateral acceleration translates to an unbalance or **cant deficiency of 9 inches**; this resulted from an overspeed of 5 mph during a planned cant deficiency test run of 7 inches.

5.2 CANT DEFICIENCY TEST RUNS

Cant deficiency tests (Test Runs 14 - 25) were conducted in Test Zone 1 between Metro Park and New Brunswick, NJ, with scheduled cant deficiencies ranging from 3 inches to 7 inches. During these test runs, cant deficiencies up to 9 inches and vehicle speeds up to 115 mph were measured over the 10 mile length test zone, travelling eastbound on Track #2 and westbound on Track #3.

From each cant deficiency test run, the peak values measured for each of the key safety parameters **anywhere** within the 10 mile length test zone (not always measured within a curve) were extracted from the kilometer-by-kilometer computer charts for closer examination. These peak values, together with the trainset location, speed, and cant deficiency at which the peak was measured, are tabulated in **Table 5.1** (also includes the high speed test runs, **Section 5.3**). At the locations where these peaks occurred, computer/strip chart recordings of the wheel/rail forces and safety parameters were analyzed in more detail. Peaks that were flagged by the computer but, on strip chart examination, were attributed to signal noise or were measured to be at amplitudes below the safety limits, are denoted by an asterisk in the Table.

TABLE 5.1(a): PEAK VALUES OF SAFETY PARAMETERS, CANT DEFICIENCY AND HIGH SPEED TEST RUNS

NEC (Metro Park - Trenton NJ), WESTBOUND, TRACK 3 - "B" END LEADING

(Instrumented Wheelset 2 Leading)

Run #/ [test]	Track Milepost	Location	Measured Speed/ Cant Def	SY_1 [kN]	SY_2 [kN]	Q_{11} [kN]	Q_{12} [kN]	Q_{21} [kN]	Q_{22} [kN]	Y/Q_{11}	Y/Q_{12}	Y/Q_{21}	Y/Q_{22}	T-L/V_{rgt}	T-L/V_{lft}
			Safety Limits	≤65	≤65	≥6.5	≥6.5	≥6.5	≥6.5	≤0.8	≤0.8	≤0.8	≤0.8	≤0.5	≤0.5
15 [3"]	23.6	tangent, before curve 265	87 mph										0.6		0.33
	24.3	in curve 266	89 mph / 3.4"	38											
	25.7	tangent, Lincoln Itlk	84 mph		40										
17 [4"]	24.3	in curve 266	93 mph / 4.5"	39											
	25.7	tangent, Lincoln Itlk	87 mph						26						
	26.7	exiting curve 266	84 mph / 0.6"									0.55		0.32	
19 [5"]	24.3	in curve 266	96 mph / 5.1"	39											0.28
	25.8	tangent, Lincoln Itlk	93 mph		39	27						0.65		0.3	
	26.4	in curve 268	90 mph / 4.8"	39											
21 [6"]	23.6	tangent near curve 265	106 mph										0.48		0.28
	24.3	in curve 266	106 mph / 6.7"	41						0.42					
	25.8	tangent, Lincoln Itlk	95 mph		40		24								
	26	tangent	95 mph					13							
	26.4	in curve 268	93 mph / 5.2"	39							0.4				
	26.7	exiting curve 268	93 mph / 0.9"									0.51		0.3	
23 [7"]	24.3	in curve 266	113 mph / 9"	51						0.58				0.32	
	25.8	tangent, Lincoln Itlk	102 mph					26						0.3	
	26.6	exiting curve 268	102 mph / 1.3"											0.3	
25 [130 mph]	41.4	tangent (Midway)	131 mph		65							0.8		0.48	
	44.7	tangent	131 mph					20							
27 [130 mph]	41.4	tangent (Midway)	131 mph		47		20					0.6		0.38	
29 [135 mph]	36.3	tangent	135 mph				10								
	41.4	tangent (Midway)	135 mph		41							0.75		0.33	
31 [145 mph]	37.5	tangent	144 mph				21								
	41.4	tangent (Midway)	146 mph		48							0.98		0.46	
33 [150 mph]	40	in curve 276	152 mph / 5.7"				22								
	41.4	tangent (Midway)	151 mph		60							0.78		0.45	
35 [155 mph]	40	in curve 276	155 mph / 6"	36											0.36
	41.4	tangent (Midway)	155 mph						14				0.81		
			Safety Limits	≤65	≤65	≥6.5	≥6.5	≥6.5	≥6.5	≤0.8	≤0.8	≤0.8	≤0.8	≤0.5	≤0.5

TABLE 5.1(b): PEAK VALUES OF SAFETY PARAMETERS, CANT DEFICIENCY AND HIGH SPEED TEST RUNS
NEC (Trenton - Metro Park NJ), EASTBOUND, TRACK 2 - "A" END LEADING
(Instrumented Wheelset 1 Leading)

Run #/ [test]	Track Milepost	Location	Measured Speed/ Cant Def	SY_1 [kN]	SY_2 [kN]	Q_{11} [kN]	Q_{12} [kN]	Q_{21} [kN]	Q_{22} [kN]	Y/Q_{11}	Y/Q_{12}	Y/Q_{21}	Y/Q_{22}	$T\text{-}L/V_{rgt}$	$T\text{-}L/V_{lft}$
			Safety Limits	≤65	≤65	≥6.5	≥6.5	≥6.5	≥6.5	≤0.8	≤0.8	≤0.8	≤0.8	≤0.5	≤0.5
14 [3"]	26.7	entering curve 268	84 mph / 1.9"	42										0.4	
	25.7	tangent, Lincoln Itlk	87 mph				25								
	24.8	exit from curve 267	90 mph / 0.8"								0.82				
	24.5	in curve 266	90 mph / 2.2"												0.4
	23.8	exit from curve 265	89 mph / 1"	46											
16 [4"]	25.7	tangent, Lincoln Itlk	93 mph				6.5				1.6*				0.42
	24.5	in curve 266	94 mph / 3"												0.38
	23.9	in curve 265	93 mph / 3.9"							0.63				0.38	
	23.8	exit from curve 265	94 mph / 1.1"	46											
18 [5"]	26.6	in curve 268	94 mph / 3"	49						0.6				0.42	
	25.6	entering curve 267	100 mph / 0.4"					20							
	25.5	entering curve 267	104 mph / 3.4"							0.62					
	24.5	in curve 266	100 mph / 4.3"	48							0.6				0.42
	23.9	in curve 265	101 mph / 5.6"							0.6					
20 [6"]	26.7	in curve 268	98 mph / 3.2"	51						0.62				0.42	
	25.5	in curve 267	102 mph / 3.4"							0.62				0.40	
	24.8	exiting curve 267	104 mph / 1.3"								0.6				
	24.5	in curve 266	104 mph / 4.8"	51											0.42
	23.9	in curve 265	107 mph / 1.7"				24			0.63				0.42	
22 [7"]	26.7	in curve 268	104 mph / 3.9"	52						0.61				0.42	
	25.8	tangent, Lincoln Itlk	105 mph				7.5				1.9*				0.5
	24.3	in curve 266	113 mph / 7.7"	52							0.62				0.48
24 [8"]	26.7	in curve 268	97 mph / 3"	52						0.6				0.4	
	25.8	tangent, Lincoln Itlk	101 mph				14				0.6				
	24.5	in curve 266	107 mph / 4.7"								0.58				0.42
	23.9	in curve 265	106 mph / 5.6"							0.6				0.4	
26 [130 mph]	41.1	tangent (Midway)	129 mph	38				27		0.6	0.62				0.44
	39.6	in curve 276	129 mph / 2.8"											0.38	
28 [135 mph]	41.5	tangent (Midway)	134 mph	39			23			0.62	0.68				0.45
	40	in curve 276	133 mph / 3"	37										0.39	
	39.4	entering curve 275	133 mph	40											

TABLE 5.1(b): PEAK VALUES OF SAFETY PARAMETERS, CANT DEFICIENCY AND HIGH SPEED TEST RUNS
NEC (Trenton - Metro Park NJ), EASTBOUND, TRACK 2 - "A" END LEADING
(Instrumented Wheelset 1 Leading)

Run #/ [test]	Track Milepost	Location	Measured Speed/ Cant Def	SY_1 [kN]	SY_2 [kN]	Q_{11} [kN]	Q_{12} [kN]	Q_{21} [kN]	Q_{22} [kN]	Y/Q_{11}	Y/Q_{12}	Y/Q_{21}	Y/Q_{22}	$T\text{-}L/V_{lgt}$	$T\text{-}L/V_{lft}$
30 [145 mph]	41.5	tangent (Midway)	146 mph	46			11			0.64	0.78			0.38	**0.51**
	40	in curve 276	148 mph / 4.3"											0.42	
	39.4	entering curve 275	148 mph	48	40										
32 [150 mph]	51.2	tangent	142 mph				10								
	41.5	tangent (Midway)	148 mph	44			20			0.68	0.78			0.4	**0.55**
	40	in curve 276	150 mph / 4.7"											0.43	
	39.4	entering curve 275	149 mph	49							0.58				
34 [155 mph]	41.5	tangent (Midway)	153 mph	47						0.71	**0.8**			0.42	**0.62**
	41	tangent	152 mph				24								
	40	in curve 276	154 mph / 5.2"											0.47	
	39.4	entering curve 275	154 mph	47	50						0.55				0.4
36 [160 mph]	41.5	tangent (Midway)	160 mph	51				10		0.7	**0.82**			0.48	**0.63**
	40	in curve 276	160 mph / 6"											0.49	
	39.4	entering curve 275	159 mph	53											0.47
			Safety Limits	≤65	≤65	≥6.5	≥6.5	≥6.5	≥6.5	≤0.8	≤0.8	≤0.8	≤0.8	≤0.5	≤0.5

* - denotes peak values flagged by the onboard computer on a kilometer-by-kilometer basis, but, from strip chart recordings, attributed to signal noise or measured to be below the safety limits.

A summary of the highest peak values related to each safety criterion from both the cant deficiency and high speed test runs is given in **Table 5.2**. Peak values attributed to signal noise are not included in this Table.

Composite plots of these safety parameter peak values measured during the cant deficiency test runs are shown in **Figures 5.1 - 5.4** as a function of scheduled test run cant deficiency. In each plot, the relevant safety limit is indicated.

These plots convey the number of tests carried out and the magnitudes of the safety parameter peak values experienced over a particular range of track alignments, geometries, and conditions. No trend lines should be drawn from these composites; the peak values may or may not have occurred within a curve and are plotted against the intended or scheduled test run cant deficiency and not the actual cant deficiency when the peak was recorded.

TABLE 5.2 PEAK VALUES MEASURED FROM CANT DEFICIENCY AND HIGH SPEED TEST RUNS

Safety Criteria	Measured Value	% of Limit	Vehicle Element/ (Position)	Run No	Direct/ Track	Track Milepost	Track Condit	Intended Cant Def	Measured Cant Def	Measured Speed	Comments
Min Vertical Wheel Force Vmin	6.5 kN	100%	Left Wheel Wheelset 1 (leading)	16	East Track 2	25.7	Dry	4"	0"	93 mph	tangent track (Lincoln) between curves 267 & 268
	7.5 kN	98%	Left Wheel Wheelset 1 (leading)	22	East Track 2	25.8	Dry	7"	0"	105 mph	tangent track (Lincoln) between curves 267 & 268
	11 kN	92%	Left Wheel Wheelset 1 (leading)	30	East Track 2	41.5	Dry	-	0"	146 mph	tangent track (Midway)
	10 kN	94%	Left Wheel Wheelset 1 (leading)	32	East Track 2	51.2	Dry	-	0"	142 mph	tangent track
	10 kN	94%	Right Wheel Wheelset 2 (trailing)	36	East Track 2	41.5	Dry	-	0"	160 mph	tangent track (Midway)
Max Net Axle Lateral Force NAL	65 kN	100%	Wheelset 1 (trailing)	25	West Track 3	41.4	Dry	-	0"	131 mph	tangent track (Midway)
	60 kN	92%	Wheelset 2 (leading)	33	West Track 3	41.4	Dry	-	0"	151 mph	tangent track (Midway)
	53 kN	82%	Wheelset 1 (leading)	36	East Track 2	39.4	Dry	-	0"	159 mph	entering Curve 275
	52 kN	80%	Wheelset 1 (leading)	24	East Track 2	26.7	Dry	6"	3"	97 mph	in Curve 268 (1.4°)
	52 kN	80%	Wheelset 1 (leading)	22	East Track 2	24.3	Dry	7"	7.7"	113 mph	In Curve 266 (1.5°)
Max Wheel L/V Ratio L/V	0.82	103%	Left Wheel Wheelset 1 (leading)	14	East Track 2	24.8	Dry	3"	0.8"	90 mph	exit from curve 267
	0.80	100%	Left Wheel Wheelset 1 (leading)	34	East Track 2	41.5	Dry	-	0"	153 mph	tangent track (Midway)
	0.82	103%	Left Wheel Wheelset 1 (leading)	36	East Track 2	41.5	Dry	-	0"	160 mph	tangent track (Midway)
	0.80	100%	Right Wheel Wheelset 2 (leading)	25	West Track 3	41.4	Dry	-	0"	131 mph	tangent track (Midway)
	0.98	123%	Right Wheel Wheelset 2 (leading)	31	West Track 3	41.4	Dry	-	0"	146 mph	tangent track (Midway)
	0.81	101%	Left Wheel Wheelset 2 (leading)	35	West Track 3	41.4	Dry	-	0"	155 mph	tangent track (Midway)

TABLE 5.2 (con't): PEAK VALUES MEASURED FROM CANT DEFICIENCY AND HIGH SPEED TEST RUNS

Safety Criteria	Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Intended Cant Def	Measured Cant Def	Measured Speed	Comments
Max Truck-Side L/V	0.48	96%	Right Side	25	West Track 3	41.4	Dry	-	0"	131 mph	tangent track (Midway)
T-L/V	0.50	100%	Left Side	22	East Track 2	25.8	Dry	7"	0"	105 mph	tangent track (Lincoln) between Curves 267 & 268
	0.48	96%	Left Side	22	East Track 2	24.3	Dry	7"	7.7"	113 mph	in Curve 266 (1.5°)
	0.51	102%	Left Side	30	East Track 2	41.5	Dry	-	0"	146 mph	tangent track (Midway)
	0.55	110%	Left Side	32	East Track 2	41.5	Dry	-	0"	148 mph	tangent track (Midway)
	0.62	124%	Left Side	34	East Track 2	41.5	Dry	-	0"	153 mph	tangent track (Midway)
	0.63	126%	Left Side	36	East Track 2	41.5	Dry	-	0"	160 mph	tangent track (Midway)
	0.46	92%	Right Side	31	West Track 3	41.4	Dry	-	0"	146 mph	tangent track (Midway)
	0.45	90%	Right Side	33	West Track 3	41.4	Dry	-	0"	151 mph	tangent track (Midway)

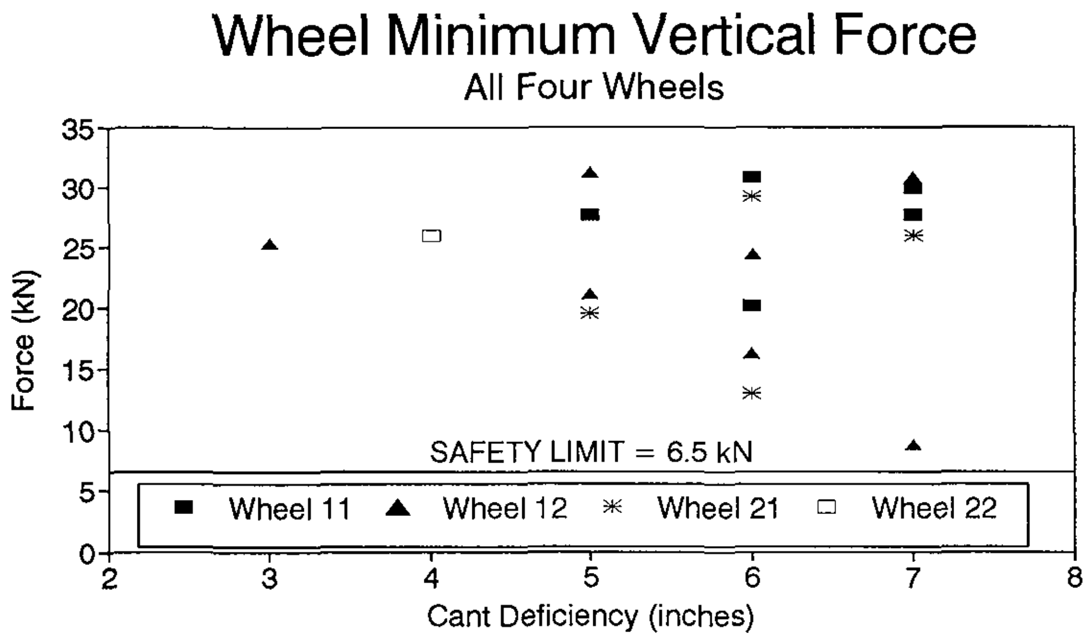

Figure 5.1: Peak Minimum Vertical Wheel Forces During Cant Deficiency Runs

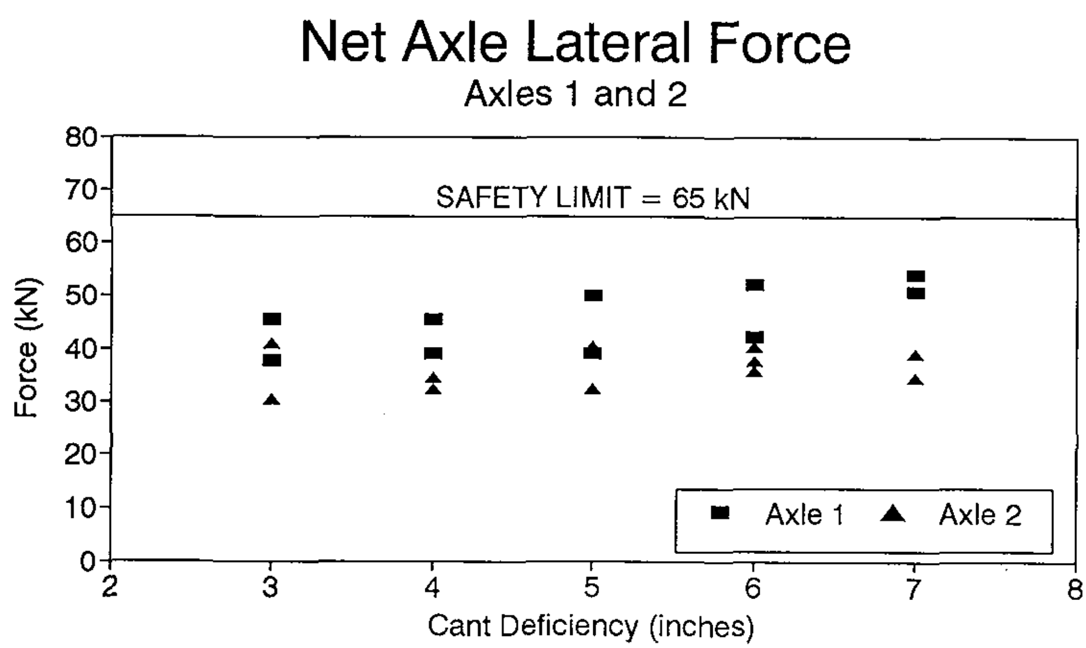

Figure 5.2: Peak Net Axle Lateral Forces During Cant Deficiency Runs

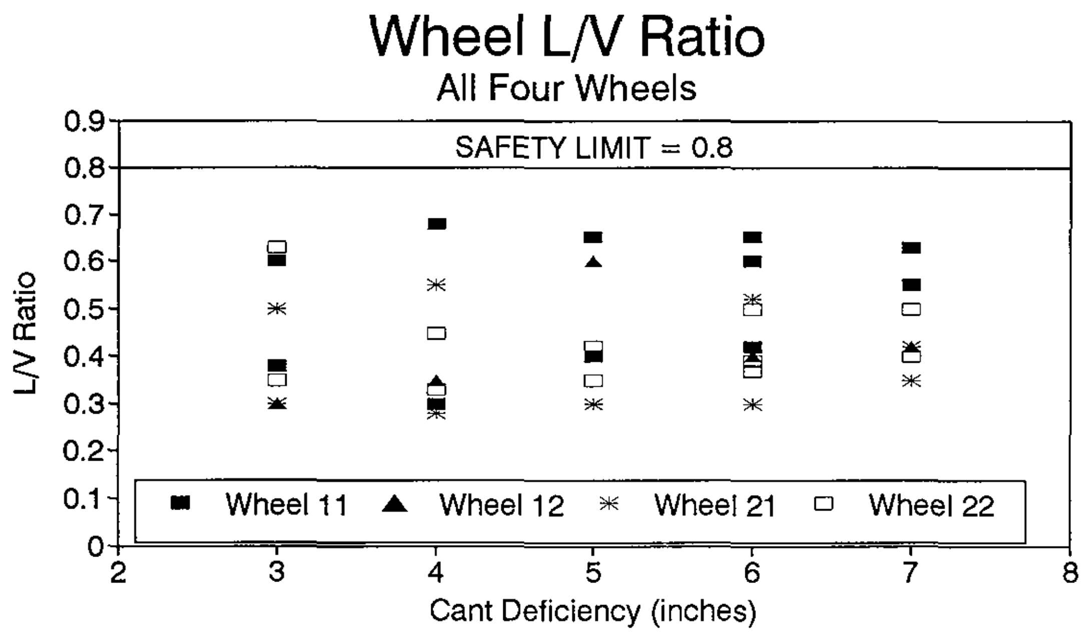

Figure 5.3: Peak Values of Wheel L/V During Cant Deficiency Runs

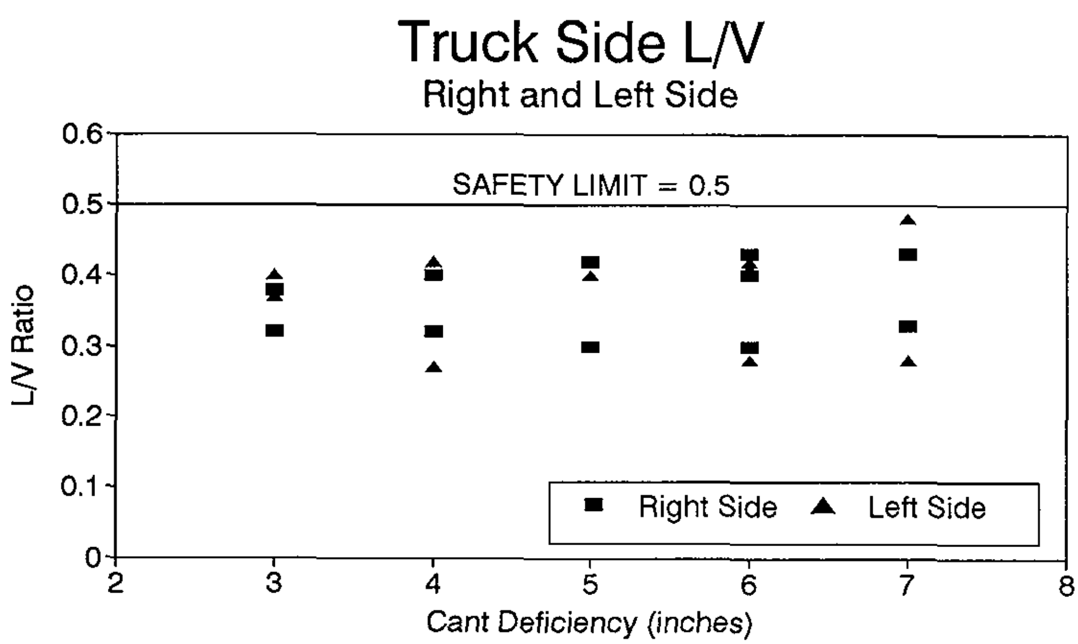

Figure 5.4: Peak Values of Truck Side L/V During Cant Deficiency Runs

For the cant deficiency test runs, no safety limit was exceeded within the curves and transitions. However, a singular tangent track disturbance on Track #2 at Lincoln interlocking (MP 25.7) did result in transient peaks (duration < 50 ms) approaching the safety limits on occasion. Specific information on the peaks closest to the safety limits are included in **Tables 5.1 - 5.2.**

A closer examination of the safety parameters for the ICE/U.S. trainset as a function of cant deficiency for a particular curve and track is given in **Figures 5.5 - 5.8.** In these plots, both the average value and the peak value of each safety parameter measured in test curve 266 (1.55° curvature) while travelling eastbound on Track #2 are plotted from the 6 relevant test runs as a function of the measured quasi-steady cant deficiency. The track was dry in each of these test runs and the general track geometry is considered to be above average Class 7.

Figure 5.5 illustrates the safety from **vehicle overturn** as cant deficiency increases, using the vertical wheel force, **Vmin**, measured on the inside wheel (right side in this case) of instrumented wheelset 1 within this curve and transition as an indicator. It can be seen that, for this curve, there is a considerable margin of safety above the minimum safe limit of 6.5 kN. A trend line drawn through the peak minimum vertical measurements as cant deficiency increases indicates that, for the track conditions in this curve, the safety limit would be approached at a cant deficiency of about 17 inches. No appreciable crosswinds were encountered during these test runs.

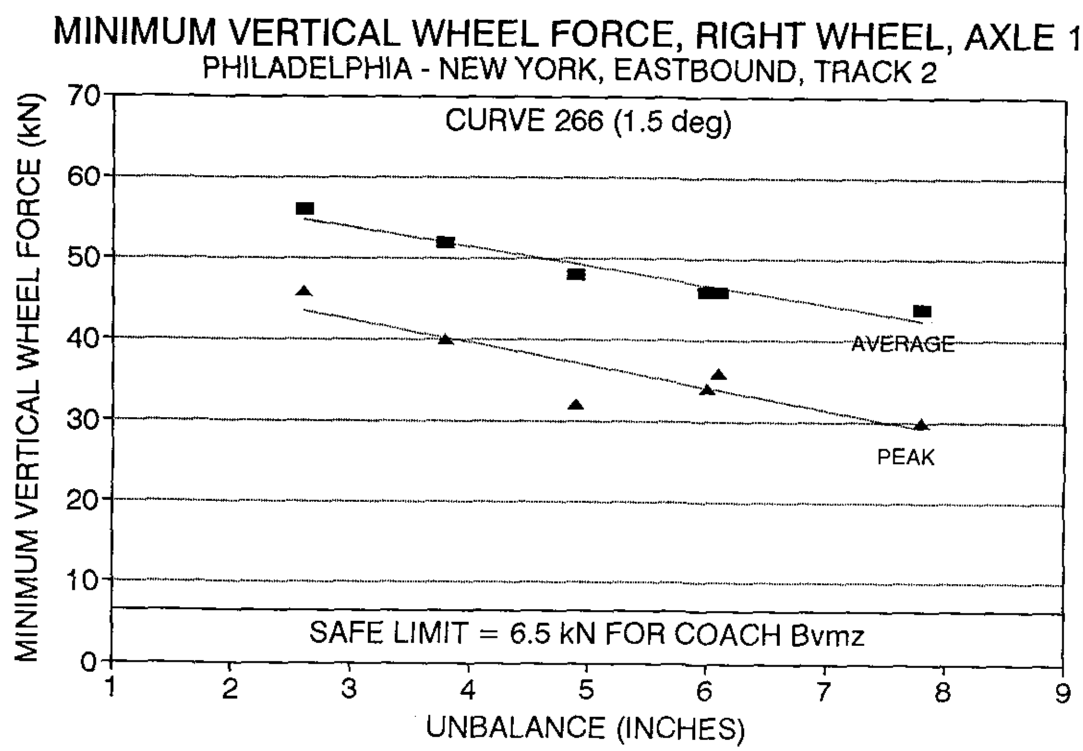

Figure 5.5: Minimum Vertical Wheel Force, Measured In Curve 266, Eastbound

Representative lateral track shift forces are indicated in **Figure 5.6**, in which the net axle lateral force, **NAL**, measured on the leading instrumented wheelset 1, is shown as cant deficiency increases in this curve. A trend line drawn through the peak measurements of **NAL** in this curve as cant deficiency increases indicates that the safety limit of 65 kN for this axle would be reached at a cant deficiency of about 12.5 inches. (N.B. by linear extrapolation, the **average** NAL would reach 65 kN at a cant deficiency of about 26 inches.)

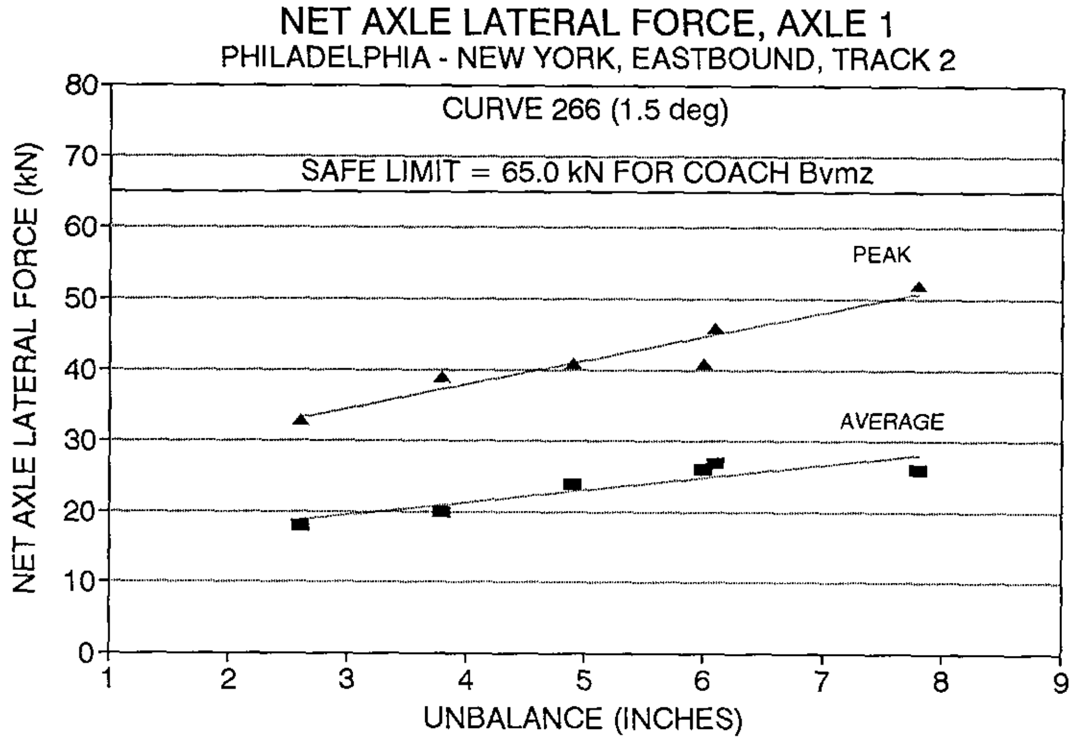

Figure 5.6: Net Axle Lateral Force, Instrumented Wheelset 1, In Curve 266

To examine the safety from wheel climb, the **single wheel L/V** ratio measured on the left wheel (high side wheel) of leading instrumented wheelset 1 in this curve is plotted versus cant deficiency in **Figure 5.7**. The measured values in this curve are well below the allowable Nadal single wheel limit of 0.8, and both the peak values and average values show very little dependence on the cant deficiency.

To assess the safety from rail roll-over, the truck-side lateral force to vertical force ratio, **T-L/V**, measured on the high side (left side) of the instrumented truck in this curve is shown in **Figure 5.8**. A peak value of 0.48 at 7.7" cant deficiency was measured in this curve, which is just below the safety criterion of 0.5. The trends indicate that the safety limit would be reached at a cant deficiency of about 10 inches.

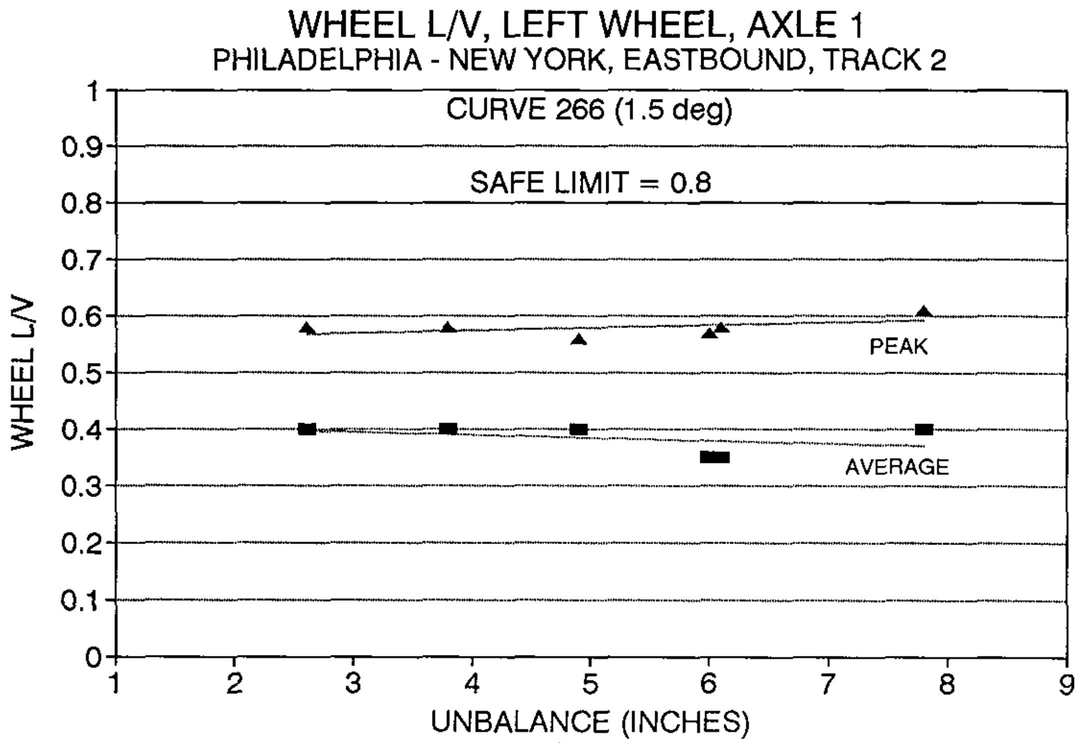

Figure 5.7: Wheel L/V Ratios, Left Wheel, Instrumented Wheelset 1, In Curve 266

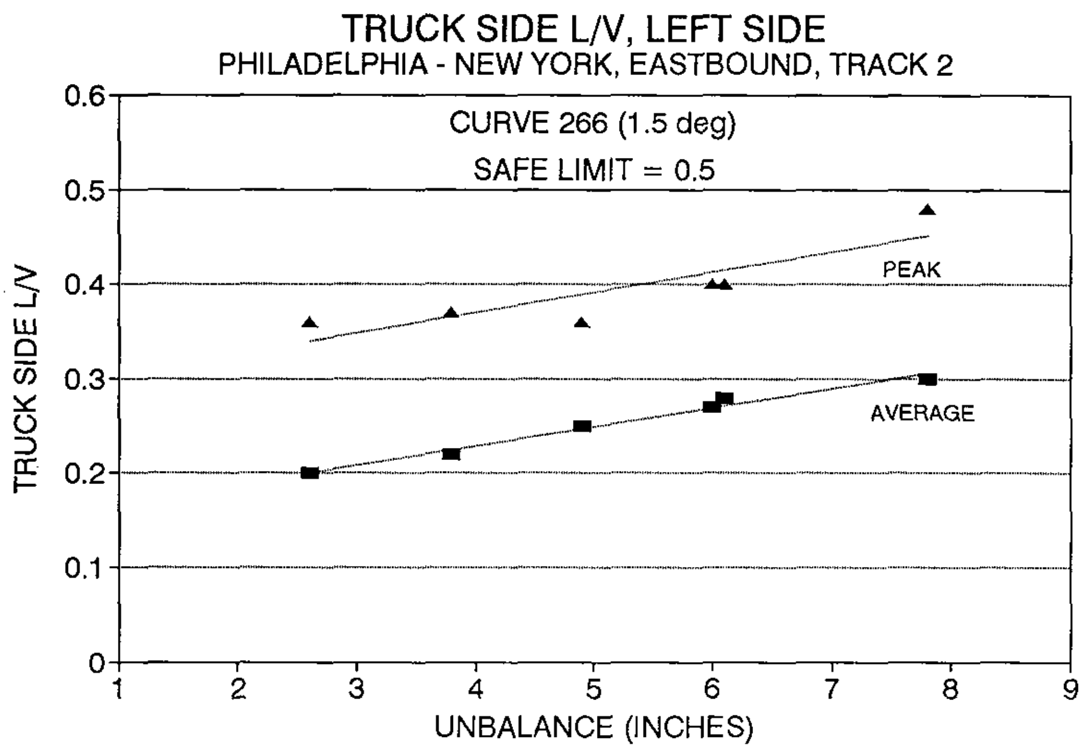

Figure 5.8: Truck Side L/V Ratio, Left Side, Instrumented Truck 3, In Curve 266

5.3 HIGH SPEED STABILITY TEST RUNS

High speed stability runs (Test Runs 25 - 36) were carried out in Test Zone 2 between Trenton and New Brunswick, NJ, with scheduled speeds of 130 mph to 160 mph. During these test runs, speeds up to 162 mph and cant deficiencies up to 6 inches (in Curve 276, 0.53° curvature) were measured over the 23 mile length test zone. No evidence of truck hunting was observed from any of the 16 truck lateral acceleration signals during any high speed test run.

From each high speed test run, the peak values measured for each of the safety parameters **anywhere** within the 23 mile length test zone were tabulated and are included in **Table 5.1**. Composite plots of these safety parameter peak values are displayed in **Figures 5.9 - 5.12** as a function of the scheduled test run vehicle speed. In each plot, the relevant safety limit is indicated.

For speeds in excess of 130 mph, safety criteria were approached and exceeded at "Midway" interlocking, MP 41.5. Other than at Midway, the nearest safety criterion which was approached at high speed was the truck-side L/V, on Track #2, travelling eastbound through Curve 276 (32' curvature, MP 40.3 -39.5), as shown in **Figure 5.13**.

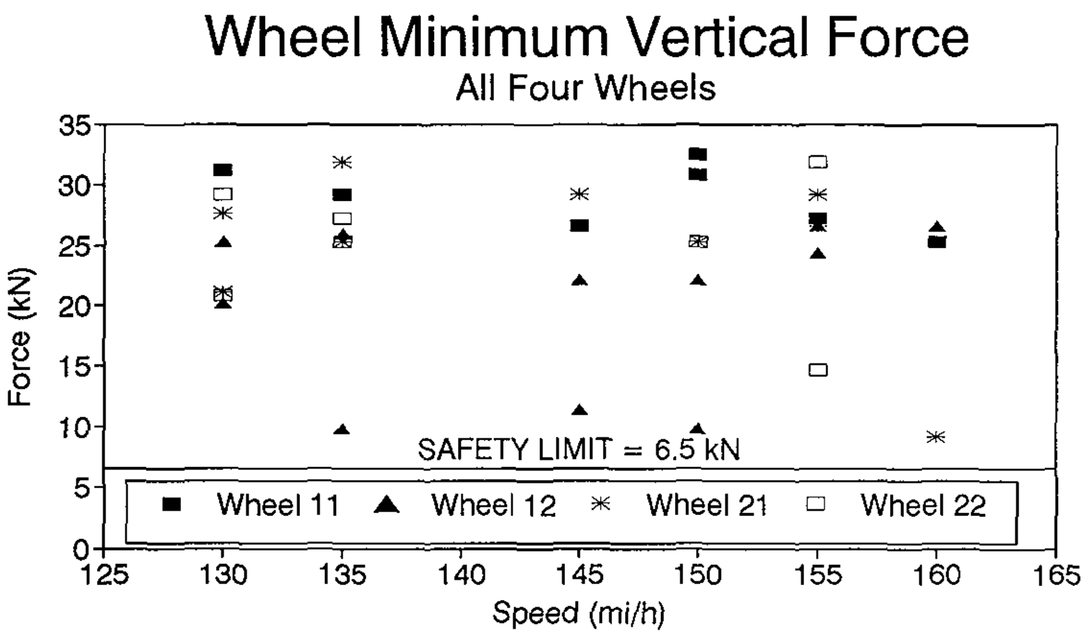

Figure 5.9: Peak Minimum Vertical Wheel Forces During High Speed Runs

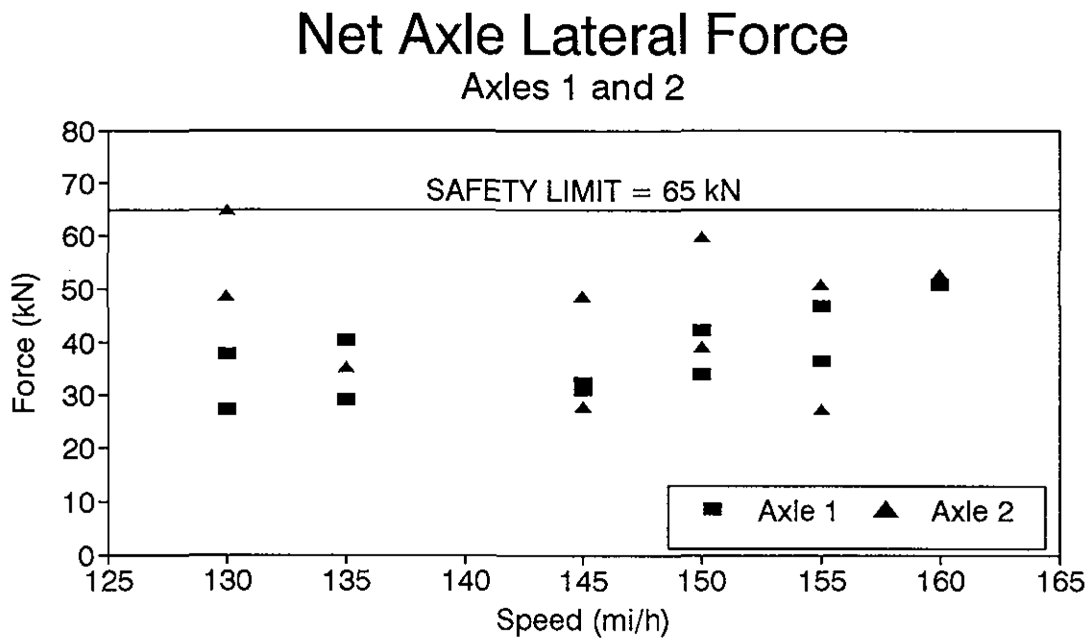

Figure 5.10: Peak Net Axle Lateral Forces During High Speed Runs

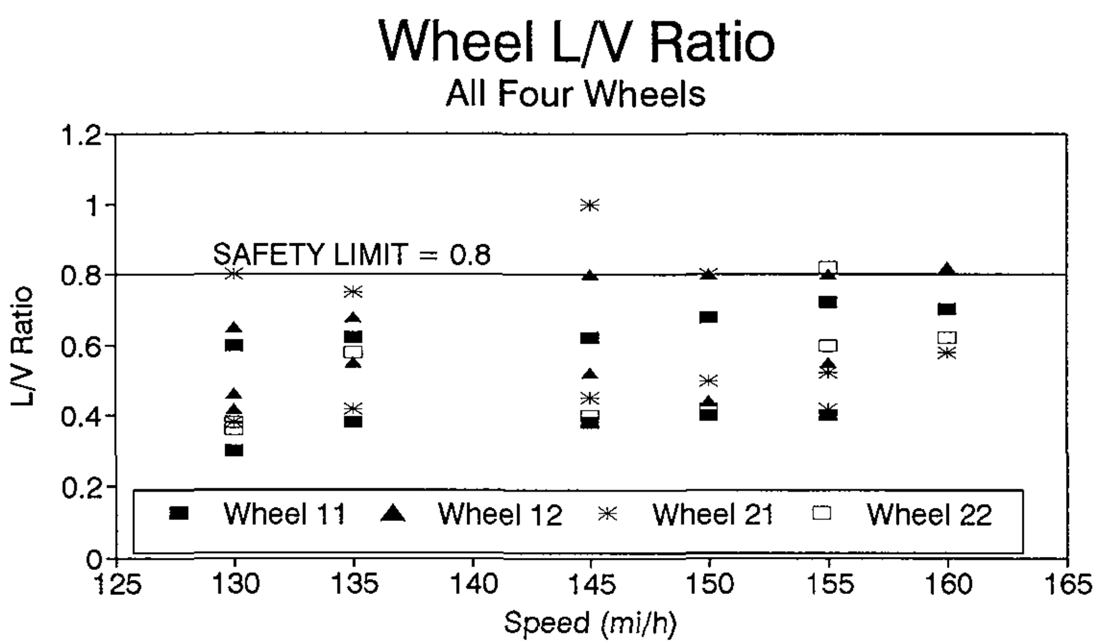

Figure 5.11: Peak Values of Wheel L/V During High Speed Runs

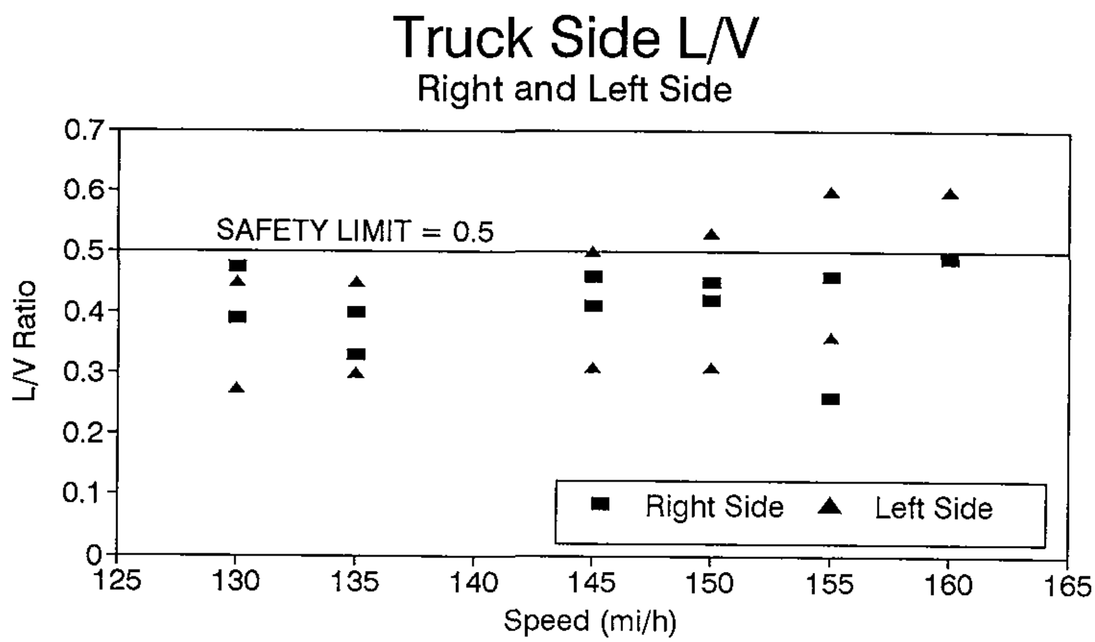

Figure 5.12: Peak Values of Truck Side L/V During High Speed Runs

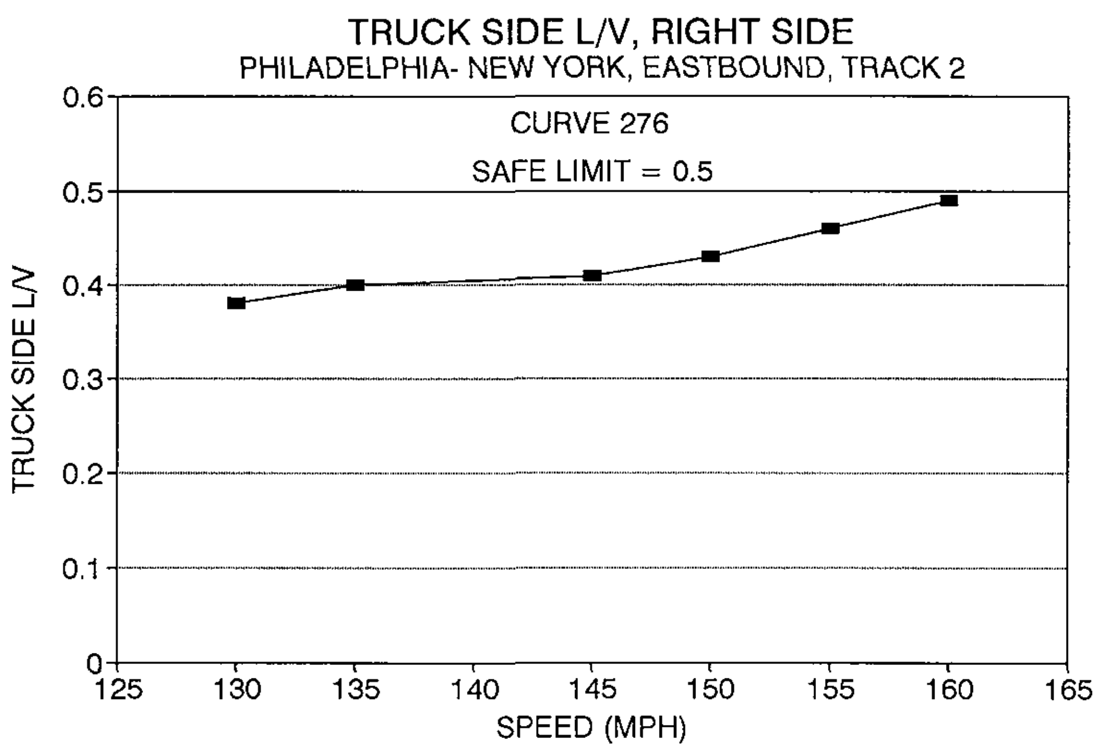

Figure 5.13: Truck Side L/V Ratio (Peak) versus Speed, Truck 3, In Curve 276

5.4 PRE-REVENUE SERVICE DEMONSTRATION RUNS

After a data review of the cant deficiency and high speed test runs, a speed profile was prepared by Amtrak for a pre-revenue service demonstration round trip from Washington to New York City. This speed profile was based on a maximum speed of 135 mph and a maximum cant deficiency of 5 inches, and accounted for actual allowable speeds dependent on signal spacings and other local restrictions.

In total, three round trip demonstration runs with full instrumentation were made based on this speed profile. For data recording, each trip was segmented into 4 test zones and corresponding test runs. In addition to strip chart recordings, the peak values of each safety parameter were plotted across each test zone on a general kilometer-by-kilometer basis.

1) PRE-REVENUE DEMONSTRATION, 135 mph, 5" Cant Deficiency

Test Run 41	Washington - Philadelphia, Northbound, principally on track 2
Test Run 42	Philadelphia - New York City, Eastbound, principally on track 2
Test Run 43	New York City - Philadelphia, Westbound, principally on track 3
Test Run 44	Philadelphia - Washington, Southbound, principally on track 3

2) PRE-REVENUE DEMONSTRATION, 135 mph, 5" Cant Deficiency + 5mph

The second round trip was made at speeds 5 mph above the 5 inch cant deficiency baseline speeds, except where other restrictions applied.

Test Run 45	Washington - Philadelphia, Northbound, principally on track 2
Test Run 46	Philadelphia - New York City, Eastbound, principally on track 2
Test Run 47	New York City - Philadelphia, Westbound, principally on track 3
Test Run 48	Philadelphia - Washington, Southbound, principally on track 3

3) PRE-REVENUE DEMONSTRATION, 135 mph, 5" Cant Deficiency + 5mph

The third round trip was similar to trip 2, but also served as a VIP demonstration run; thus, speeds up to 160 mph were attained in the high speed test zone for demonstration purposes and the trainset was taken only as far as Newark, NJ:

Test Run 49	Washington - Philadelphia, Northbound, principally on track 2
Test Run 50	Philadelphia - Newark, Eastbound, principally on track 2
Test Run 51	Newark - Philadelphia, Westbound, principally on track 3
Test Run 52	Philadelphia - Washington, Southbound, principally on track 3

It should be noted that, at a few locations in some test runs, speeds were lower than intended because of line traffic or local restrictions. In addition, "slip-ring" problems with the instrumented wheelsets negated some wheel/rail force recordings during Test Run 43, from MP 29 to MP 89, and Test Run 47, from MP 52 to MP 89.

A summary of peak values recorded for the safety parameters over these Test Runs 41-52 indicated that there were multiple cases where safety criteria limits were exceeded:

	No of Exceptions Recorded
Vmin < 6.5 kN	3
Net Axle Lateral Force > 65 kN	3
Single Wheel L/V > 0.8	36
Truck Side L/V > 0.5	12

The majority of exceptions involved transient wheel unloading in tangent track and were not related to cant deficiency or high speed. None of these recorded peak values occurred at cant deficiencies greater than 2 inches, and only 15 of these peak values were measured at speeds in excess of 110 mph (180 km/h). The higher speed exceptions are listed in **Table 5.3.**

The momentary single wheel unloading and high L/V recorded by the computer in Test Run 47 at MP37 was attributed to signal noise and not included since many other high speed test runs (25 - 35, 51) over the same track location gave no indications of high forces. The very high amplitude peaks measured at "Wood" interlocking during Test Run 49 were attributed to switch impact. A single, momentary force peak, about 40 milliseconds in duration, was detected at each wheel in both the lateral and vertical directions; the amplitude of the peaks on instrumented wheelset 2 were exceptionally high. During similar Test Runs 41 and 45, peaks were also observed at this switch location but the measured amplitudes were well below the safety limits.

It is possible that the amplitudes of the momentary impact forces measured at the interlockings given in Table 5.3 were exacerbated through shock loadings on the slip rings and connectors for the wheelset (which had failed previously). In the interest of safety during the revenue service operation of the ICE/U.S. trainset, speed restrictions of 125 mph were imposed for the intended 135 mph locations at which these exceptions were observed.

TABLE 5.3: PEAK VALUES OF SAFETY PARAMETERS, PRE-REVENUE SERVICE DEMONSTRATION RUNS EXCEPTIONS, SPEEDS > 110 mph

Run #	Track Milepost	Location	Measured Speed/ Cant Def	SY_1 [kN]	SY_2 [kN]	Q_{11} [kN]	Q_{12} [kN]	Q_{21} [kN]	Q_{22} [kN]	Y/Q_{11}	Y/Q_{12}	Y/Q_{21}	Y/Q_{22}	$T\text{-}L/V_{rgt}$	$T\text{-}L/V_{lft}$
			Safety Limits	**≤65**	**≤65**	**≥6.5**	**≥6.5**	**≥6.5**	**≥6.5**	**≤0.8**	**≤0.8**	**≤0.8**	**≤0.8**	**≤0.5**	**≤0.5**
44	112.6	Ph - Wa, Track 3 "Grove" interlocking	115 mph				6				1.4				
45	29.9	Wa - Ph, Track 2 "Ragan" interlocking	121 mph							0.82					
46	32.8	Ph - NY, Track 2 "County" interlocking	134 mph									0.82			
47	37.7	NY - Ph, Track 3 tangent	135 mph				6.5*				1.4*				
48	38.4	Ph - Wa, Track 3 "Davis" interlocking	134 mph						6.5			0.82			
	55.8	Ph - Wa, Track 3 exit from Curve 346 (.2°)	118 mph										1.02		
49	75.4	Wa - Ph, Track 2 "Wood" interlocking	131 mph									0.98	1.8**	1.4**	1.8**
50	41.4	Ph - Newark, Track 2 tangent (Midway)	155 mph												0.5
52	55.8	Ph - Wa, Track 3 exit from Curve 346 (.2°)	118 mph										0.8		
			Safety Limits	**≤65**	**≤65**	**≥6.5**	**≥6.5**	**≥6.5**	**≥6.5**	**≤0.8**	**≤0.8**	**≤0.8**	**≤0.8**	**≤0.5**	**≤0.5**

* - Concluded to be signal noise from the slip ring assembly which failed 14 miles after this reading

** - Single, momentary (~40 msec) high amplitude peak at switch impact; peak amplitudes measured in similar Test Runs 41 & 45 at this location were below safety limits

6. DISCUSSION OF RESULTS

The Amtrak ICE/U.S. test program was conducted to examine the limits of safe performance under more extreme conditions than those to be used in revenue service. Valuable data was gathered, particularly from the instrumented wheelset measurements, on which to base limits and procedures for the revenue service demonstration. The following provides a brief review of the key results from the test, with some insight into the basis for establishing the safety limits for revenue service operation. Limited discussion and recommendations are provided as appropriate.

6.1 TEST HIGHLIGHTS AND SIGNIFICANT EVENTS

Test runs were conducted on the NEC, with measured speeds in tangent track up to 162 mph (260 km/h), and measured average cant deficiencies up to 7 inches (in one instance up to 9 inches).

Safety Criteria

- No truck hunting was observed from any truck frame-mounted lateral accelerometer (1 accelerometer on each truck), for measured speeds as high as 162 mph (260 km/h).
- No measured Net Axle Lateral Force exceeded the safety limit of 14,610 lbs (65 kN) (instrumented wheelsets, axles 5 and 6, truck 3); peak forces up to 12,590 lbs (56 kN) were observed (e.g. Midway interlocking).
- Several instances of individual wheel L/V $\geq$ 0.8 were observed, mainly at tangent track locations where track anomalies involved gauge narrowing combined with line variation. Some high values of wheel L/V were the result of momentary wheel unloading with no significant lateral force involved; other high values were measured at lower speeds (50 mph) in interlockings.
- Several instances of truck-side L/V $\geq$ 0.5 were observed, generally at the same track locations where individual wheel L/V values were high.
- There were occasional instances where an individual vertical wheel force, Vmin, approached but did not fall below the limiting value of 1,461 lb (6.5 kN), mainly on tangent track; these appear to be momentary unloadings, predominantly at "cut" sections.

Braking Requirements

Tests were conducted to assess the performance of the ICE braking system as modified for U.S. operation with new brake pressures, valves, and software. Stopping distances, using air (disk) braking only, were measured with brakes on one axle disabled to simulate effects of full load. In this condition, the stopping distance, from an initial speed of 124 mph, was measured to be 5827 ft (1776 m); the stopping distance from 141 mph was measured to be 8,406 ft (2,562 m). The unrestricted requirement based on the current signalling block in the NEC is 7,848 ft. (The stopping distance, with brakes disabled on two axles, from 135 mph was measured to be 8,000 ft.)

Based on these measurements, and with no changes to the signalling blocks, a maximum speed limit of 135 mph is applicable for the ICE/U.S. trainset to operate within the existing signalling restrictions on the NEC.

6.2 HIGH SPEED TESTS

The key results from tests conducted in the 23 mile length high speed test zone between Trenton and New Brunswick, NJ, at speeds of 125 mph to 162 mph, were:

- No truck hunting was observed at any speed.

- Multiple safety criteria were exceeded at one location, Midway interlocking, when approached in either direction at speeds of 145 mph or greater; safety criteria were not exceeded at any other location within the test zone.

- A sustained periodic carbody "yaw" oscillation (~0.4 g body lateral acceleration, peak to peak), was observed and measured in the power cars, (most pronounced in the trailing power car), at speeds above 135 mph. This condition was repeatable with speed.

Track Anomalies at Midway

The peak response for all runs and most parameters was associated with track geometry anomalies occurring in both tracks in the vicinity of Midway interlocking. Test measurements indicated a single track disturbance on Track 2 (eastbound) and a single disturbance on Track 3 (westbound) yielding pronounced peaks in the wheel/rail forces. Safety criteria were exceeded at these locations at speeds of 145 mph and above.

Examination of track geometry data and on-the-ground inspection indicated tight gauge (~56.0 inches) situations near these locations. It had been anticipated that the ICE wheelset, as modified for the U.S. demonstration, would be more susceptible to narrow gauge disturbances (Section 2.2.3) because of the lower flange clearance. As a result, a speed restriction of 125 mph was imposed on the ICE/U.S. through Midway interlocking in both directions.

Although some trackwork maintenance was done on the disturbance on Track 3 at Midway after the high speed test runs, the vehicle speed of 125 mph was maintained through this disturbance for the remaining test runs. As expected, no safety criterion was exceeded (this was also the case for previous runs at speeds of 135 mph or less). During a subsequent test run (Test Run 50) through the disturbance on Track 2, a truck-side L/V = 0.5 was again measured at a speed of 155 mph.

Results from the high speed test runs indicated safe operation at speeds of 135 mph on NEC track currently approved for 125 mph Metroliner operations.

6.3 CANT DEFICIENCY TEST

The key results from the test runs, conducted at cant deficiencies up to 7 inches, were:

- No safety criteria were exceeded within the curves or transitions at any cant deficiency.

- Truck side L/V exceeded the 0.50 limit during a 7" cant deficiency test run near curve entry (cannot be directly related with cant deficiency); a peak truck side L/V of 0.48 was observed, however, in this curve.

- As cant deficiency increases, trends from the measured data indicate that the limiting safety criterion may be the peak truck side L/V (related to rail roll-over).

- Carbody lateral acceleration exceeded 0.40 g (peak to peak) in the spiral transition during the 7" cant deficiency run.

- Some transient vertical wheel unloading (down to nearly 10% remaining) was observed, but primarily in tangent track. These events must be investigated further but are not related to cant deficiency.

From passenger comfort considerations, the ICE trainset, which does not tilt, generally operates at cant deficiencies up to 6 inches. Results from the cant deficiency tests indicated that, from safety considerations, operation at cant deficiencies up to 6 inches was within the safety limits on NEC track.

7. RECOMMENDATIONS AND CONCLUSIONS

As previously stated, the purpose of this report was to provide a basis for establishing procedures and limits for the safe operation of the ICE by Amtrak in the NEC. In developing the conclusions and recommendations presented here, a balance was attempted between performance and safety. Where either the available data or time for analysis was limited, conservative judgement was applied in the interest of safety.

The ICE has been thoroughly analyzed and tested, and has compiled a successful operating and safety record in service in Germany. The fundamental question addressed by the tests and analysis supporting operations in the United States is how the ICE/U.S. trainset would respond to the track conditions here.

The tests in the U. S. were conducted by Amtrak over specific test zones on Amtrak's NEC and Harrisburg line. Specific test curves chosen for analysis ranged from 4° 16′ (409m radius) to 1° 26′ (1221m radius) giving a nominal cant deficiency of 7" at speeds ranging from 66 mph to 115 mph respectively. Trials were carried out in these selected curves at up to 7" of cant deficiency in the NEC and up to 5" on the Harrisburg line. During the 29 test runs, some safety limits were approached and exceeded for momentary intervals. The highest average cant deficiency recorded by the truck frame-mounted accelerometer through an entire curve during trials was 9". The test runs were generally made in dry conditions, with wet or damp conditions experienced only during 3 test runs on the Harrisburg line.

The following recommendations were developed from the preliminary analysis of the test results. A brief reference to the relevant and supporting analysis, test results and conclusions is included with each recommendation.

7.1 RECOMMENDATION FOR OPERATION AT 6" OF CANT DEFICIENCY

Test results showed the ICE rigid truck to be capable of operation at moderate cant deficiency. Vertical load transfer and vehicle overturning were effectively controlled by the truck design. These design features allowed the ICE to operate in regular service at 6 inches of cant deficiency in Germany (1.0 m/s^2 lateral acceleration), based on the design curve geometry.

Several factors, which were not evaluated during the test, affect the margin of safety for high cant deficiency operation. A summary of these factors and their estimated likely contributions, in terms of equivalent cant deficiency, is shown on the following page. Taken in combination, these effects would yield an equivalent increase in cant deficiency of 5.9 inches. While the probability of each of these negative factors existing simultaneously is considered extremely remote, planned operations at 6 inches of cant deficiency based on average geometry might conceivably produce a total equivalent cant deficiency of just below 12 inches.

Primary Factors Influencing the Margin of Safety for High Cant Deficiency Operations

Factor	Calculated/Estimated Equivalent Cant Deficiency
- 45 mph Side Wind	2.0"
- Track Geometry Variations (FRA cant deficiency enforcement limit)	1.0"
- 5 mph Overspeed	1.4"
- Vehicle Maintenance Condition (Preliminary estimate based on worst likely vehicle condition with sub-standard maintenance)	1.5"

While it is impossible to know the precise contribution of each of these factors and their combinations under actual service conditions, this type of assessment demonstrates that operating the ICE at 6 inches of cant deficiency over Amtrak track can be considered safe with the conditions described below. There is no justification in the data to support operation at a higher unbalance. It should be noted that, for the revenue service demonstration of the ICE/U.S., approval was given to operate at cant deficiencies up to 5 inches.

7.2 RECOMMENDED CONDITIONS FOR 6 INCH CANT DEFICIENCY OPERATION

Condition #1 - Track Geometry/Structure for 5" Cant Deficiency - The track geometry in the curves over which operation at 6" cant deficiency is allowed should meet all applicable FRA Track Safety Standards. The limiting speed for each curve is to be calculated based on a 6 inch cant deficiency using average geometry with a 1 inch tolerance limit for the worst case combination of curvature and crosslevel as measured by monthly inspections by an automated track geometry measurement car.

Track structure, ballast, ties and fasteners must meet the appropriate FRA regulations for the planned operating speed.

Condition #2 - Wind - When wind speeds are predicted to be in excess of 45 mph, ICE line speeds should be restricted to those applicable to Metroliner operations under the same conditions.

Condition #3 - Vehicle Conditions - While wheel wear has been reported from service experience in Germany to be very light, it is considered prudent, due to the different rail profiles which exist on Amtrak rail, that wheel profiles be monitored to ensure that accelerated wheel tread and flange wear do not occur.

Dampers are used more extensively on the ICE/U.S. than on existing Amtrak equipment to limit undesired vehicle response. Evaluating the effect of degraded dampers was not part of the test program; therefore it is considered prudent that the condition of all vehicle suspension dampers be monitored to ensure that they are functioning properly by measuring vehicle carbody accelerations on a regular basis.

Condition #4 - Track Geometry/Dynamic Response Analysis -

Analog plots of both the track geometry and vehicle response should be analyzed to confirm that the following conditions exist:

- Relatively smooth and coordinated spirals and spiral/curve transitions
- No special track work or structures within 200 feet of the curve along the track (i.e.- switches, crossings, undergrade bridges, etc.)
- Limited dynamic response during demonstration revenue test runs.

Condition #5 - Speed Control - Amtrak should take steps to ensure that the combined effects of speedometer error and engineer error will not result in more than 5 mph overspeed in the worst case. It is recommended that this be accomplished by careful implementation of Amtrak's and the equipment manufacturer's existing procedures for speedometer calibration and engineer training.

Condition #6 - Strict Speed Control - Steps should be taken to ensure that the 6" unbalance speed, based on the limiting track geometry conditions, is never exceeded. In this way, overspeed operation is prevented from impacting the margin of safety.

7.3 RECOMMENDATION FOR 135 MPH MAXIMUM OPERATION SPEED

The ICE/U.S. demonstrated stable operation at 160 mph over the NEC high speed stability test zone. Analysis performed by the equipment manufacturer has predicted stable performance, under normal conditions, for speeds above 200 mph.

Both the data and the analysis support the operation at elevated speeds. Operation at speeds up to 135 mph would be considered conservatively safe under conditions 2, 3 and 4 of **Section 7.2** together with the additional conditions given below. If Amtrak and Siemens can identify the specific track characteristics which produce the limiting forces and demonstrate their ability to detect, correct and maintain these spots, then 140 mph may be justified. However, it should be demonstrated that no wheel L/V ratios exceed 0.8 over the target track.

Condition #1 - Track Geometry/Structure for 125 mph - The track must meet the conditions currently approved for 125 mph Metroliner operations.

Condition #2 - Instability in Service - Any indications of instability during operation must be reported to the FRA. Speed for the ICE/U.S. would be restricted to 125 mph until the cause(s) of instability were identified and corrected.

7.4 CONCLUSIONS

Based upon the experimental work described in this Report and the results obtained, the following conclusions can be drawn:

- for a properly maintained vehicle, 6 inch cant deficiency operation can be safely achieved on NEC track; should wind conditions exceed 45 mph, line speeds should be restricted to those applicable to Metroliner operations under the same conditions.

- for a properly maintained vehicle, 135 mph operation can be permitted on NEC track in limited locations where track structure, geometry and rail profile satisfy the requirements currently approved for 125 mph Metroliner operation. To assure these conditions, it is recommended that:

  - Track structure, geometry, and ride acceleration should be monitored before revenue service begins, 1 week after service has been in operation, and henceforth on a monthly basis; examination should be focussed on changes, particularly in the high cant deficiency and high speed zones.

  - Vehicle wheel profiles and damper elements should be monitored for condition on a monthly basis.

  - Specifics of engineer training should be considered; precise control of overspeed may be required.

- The low effective conicity of the 1:40 wheel profile used by Amtrak's passenger equipment may not be the optimum for high speed trains; a wheel profile more suited to the prevailing U.S. rail conditions should be considered to avoid two-point contact and potential carbody "yaw" modes.

- Specific effects of track geometry, rail profile, and wet rail were not investigated in detail in this test; as requested speeds and cant deficiencies increase, more study and analysis of these effects must be considered.

APPENDIX A

TEST INSTRUMENTATION DETAILS

TRANSDUCERS AND SIGNAL NAMES FOR ICE/US TEST RUNS

Signal #	Transducer Type	Signal Name	Description
1	Instrumented Wheelset	Y11	W/R Lateral Force, axle 5, right wheel (Coach Car)
2	Instrumented Wheelset	Y12	W/R Lateral Force, axle 5, left wheel (Coach Car)
3	Instrumented Wheelset	Q11	W/R Vertical Force, axle 5, right wheel (Coach Car)
4	Instrumented Wheelset	Q12	W/R Vertical Force, axle 5, left wheel (Coach Car)
5	Instrumented Wheelset	Y21	W/R Lateral Force, axle 6, right wheel (Coach Car)
6	Instrumented Wheelset	Y22	W/R Lateral Force, axle 6, left wheel (Coach Car)
7	Instrumented Wheelset	Q21	W/R Vertical Force, axle 6, right wheel (Coach Car)
8	Instrumented Wheelset	Q22	W/R Vertical Force, axle 6, left wheel (Coach Car)
9	Accelerometer	y..*F1	Lateral Acceleration in car (PU-A)
10	Accelerometer	z..*F1	Vertical Acceleration in car (PU-A)
11	Accelerometer	y..+12/1	Lateral Acceleration, truck 1, above axle 1 (PU-A)
12	Accelerometer	y..+42/1	Lateral Acceleration, truck 2, above axle 4 (PU-A)
13	Accelerometer	y..+12/2	Lateral Acceleration, truck 3, above axle 5 (Coach 2)
14	Accelerometer	y..*I/2	Lateral Acceleration, in car over truck 3 (Coach 2)
15	Accelerometer	z..*I/2	Vertical Acceleration in car over truck 3 (Coach 2)
16	Accelerometer	y..+42/2	Lateral Acceleration, truck 4, above axle 8 (Coach 2)
17	Accelerometer	aq	Uncompensated acceleration, axle 8
18	Speed Pickup	v	Trainset forward speed
19	Accelerometer	y..+12/3	Lateral Acceleration, truck 5, above axle 9 (Coach 3)
20	Accelerometer	y..+42/3	Lateral Acceleration, truck 6, above axle 12 (Coach 3)
21	Accelerometer	y..+12/4	Lateral Acceleration, truck 7, above axle 13 (Coach 4)
22	Accelerometer	y..+42/4	Lateral Acceleration, truck 8, above axle 16 (Coach 4)
23	Accelerometer	y..+12/5	Lateral Acceleration, truck 9, above axle 17 (Coach 5)
24	Accelerometer	y..+42/5	Lateral Acceleration, truck 10, above axle 20 (Coach 5)
25	Accelerometer	y..+12/6	Lateral Acceleration, truck 11, above axle 21 (Coach 6)
26	Accelerometer	y..*I/6	Lateral Acceleration, in car over truck 11 (Coach 6)
27	Accelerometer	z..*I/6	Vertical Acceleration, in car over truck 11 (Coach 6)
28	Accelerometer	y..+42/6	Lateral Acceleration, truck 12, above axle 24 (Coach 6)
29	Accelerometer	y..+12/7	Lateral Acceleration, truck 13, above axle 25 (Coach 7)
30	Accelerometer	y..+42/7	Lateral Acceleration, truck 14, above axle 28 (Coach 7)
31	Accelerometer	y..+12/8	Lateral Acceleration, truck 15, above axle 29 (PU-B)
32	Accelerometer	y..+42/8	Lateral Acceleration, truck 16, above axle 32 (PU-B)
33	Accelerometer	y..*F2	Lateral Acceleration in car (PU-B)
34	Accelerometer	z..*F2	Vertical Acceleration in car (PU-B)

CHANNEL DESIGNATION

Safety criteria parameters were displayed in real time during the test runs using two 22-channel strip chart recorders. The channel allocations and descriptions are given in the following **Tables.**

STRIP CHART RECORDER CHANNEL DESIGNATIONS

Stripchart #1

Stripchart Channel #	Signal Name	Description
1.1	Sum Y1	Net Axle Lateral Force, Axle 5 (Coach 2) [kN] {0 to ±100 kN}
1.2	Sum Y2	Net Axle Lateral Force, Axle 6 (Coach 2) [kN] {0 to ±100 kN}
1.3	Y11	Lateral Wheel Force, Axle 5, right wheel (Coach 2) [kN] {0 to 200 kN}
1.4	Y12	Lateral Wheel Force, Axle 5, left wheel (Coach 2) [kN] {0 to 200 kN}
1.5	Y21	Lateral Wheel Force, Axle 6, right wheel (Coach 2) [kN] {0 to 200 kN}
1.6	Y22	Lateral Wheel Force, Axle 6, left wheel (Coach 2) [kN] {0 to 200 kN}
1.7	Q11	Vertical Wheel Force, Axle 5, right wheel (Coach 2) [kN] {0 to 200 kN}
1.8	Q12	Vertical Wheel Force, Axle 5, left wheel (Coach 2) [kN] {0 to 200 kN}
1.9	Q21	Vertical Wheel Force, Axle 6, right wheel (Coach 2) [kN] {0 to 200 kN}
1.10	Q22	Vertical Wheel Force, Axle 6, left wheel (Coach 2) [kN] {0 to 200 kN}
1.11	Y11/Q11	Wheel L/V Ratio, Axle 5, right wheel (Coach 2) {-0.1 to 0.9}
1.12	Y12/Q12	Wheel L/V Ratio, Axle 5, left wheel (Coach 2) {-0.1 to 0.9}
1.13	Y21/Q21	Wheel L/V Ratio, Axle 6, right wheel (Coach 2) {-0.1 to 0.9}
1.14	Y22/Q22	Wheel L/V Ratio, Axle 6, left wheel (Coach 2) {-0.1 to 0.9}
1.15	Sum Y1/Q1	Axle L/V Ratio, Axle 5 (Coach 2) {-0.1 to 0.9}
1.16	Sum Y2/Q2	Axle L/V Ratio, Axle 6 (Coach 2) {-0.1 to 0.9}
1.17	Sum Yr/Sum Qr	Truck Side L/V Ratio, Truck 3, right side (Coach 2) {-0.1 to 0.9}
1.18	Sum Yl/Sum Ql	Truck Side L/V Ratio, Truck 3, left side (Coach 2) {-0.1 to 0.9}
1.19	y..*I/2	Lateral Acceleration, car over Truck 3 (Coach 2) [m/s^2] {0 to ± 2.5 m/s^2}
1.20	z..*I/2	Vertical Acceleration, car over Truck 3 (Coach 2) [m/s^2] {0 to ± 2.5 m/s^2}
1.21	aq	Uncompensated acceleration, axle 8 (Coach 2) [m/s^2] {0 to ± 2.5 m/s^2}
1.22	v	Vehicle forward speed [mph] {0 to 250 km/h}

STRIP CHART RECORDER CHANNEL DESIGNATIONS

Stripchart #2

Stripchart Channel #	Signal Name	Description
2.1	y..*F1	Lateral Acceleration in car (PU-A) [m/s^2] {0 to ± 2.5 m/s^2
2.2	z..*F1	Vertical Acceleration in car (PU-A) [m/s^2] {0 to ± 2.5 m/s^2}
2.3	y..*I/6	Lateral Acceleration, car over Truck 11 (Coach 6) [m/s^2] {0 to ± 2.5 m/s^2
2.4	z..*I/6	Vertical Acceleration, car over Truck 11 (Coach 6) [m/s^2] {0 to ± 2.5 m/s^2
2.5	y..*F2	Lateral Acceleration in car (PU-B) [m/s^2] {0 to ± 2.5 m/s^2
2.6	z..*F2	Vertical Acceleration in car (PU-B) [m/s^2] {0 to ± 2.5 m/s^2}
2.7	y..+12/1	Lateral Acceleration, truck 1, above axle 1 (PU-A) [m/s^2] {0 to ± 10 m/s^2}
2.8	y..+42/1	Lateral Acceleration, truck 2, above axle 4 (PU-A) [m/s^2] {0 to ± 10 m/s^2}
2.9	y..+12/2	Lateral Acceleration, truck 3, above axle 5 (Coach 2) [m/s^2] {0 to ± 10 m/s^2}
2.10	y..+42/2	Lateral Acceleration, truck 4, above axle 8 (Coach 2) [m/s^2] {0 to ± 10 m/s^2}
2.11	y..+12/3	Lateral Acceleration, truck 5, above axle 9 (Coach 3) [m/s^2] {0 to ± 10 m/s^2}
2.12	y..+42/3	Lateral Acceleration, truck 6, above axle 12 (Coach 3) [m/s^2] {0 to ± 10 m/s^2}
2.13	y..+12/4	Lateral Acceleration, truck 7, above axle 13 (Coach 4) [m/s^2] {0 to ± 10 m/s^2}
2.14	y..+42/4	Lateral Acceleration, truck 8, above axle 16 (Coach 4) [m/s^2] {0 to ± 10 m/s^2}
2.15	y..+12/5	Lateral Acceleration, truck 9, above axle 17 (Coach 5) [m/s^2] {0 to ± 10 m/s^2}
2.16	y..+42/5	Lateral Acceleration, truck 10, above axle 20 (Coach 5) [m/s^2] {0 to ± 10 m/s^2}
2.17	y..+12/6	Lateral Acceleration, truck 11, above axle 21 (Coach 6) [m/s^2] {0 to ± 10 m/s^2}
2.18	y..+42/6	Lateral Acceleration, truck 12, above axle 24 (Coach 6) [m/s^2] {0 to ± 10 m/s^2}
2.19	y..+12/7	Lateral Acceleration, truck 13, above axle 25 (Coach 7) [m/s^2] {0 to ± 10 m/s^2}
2.20	y..+42/7	Lateral Acceleration, truck 14, above axle 28 (Coach 7) [m/s^2] {0 to ± 10 m/s^2}
2.21	y..+12/8	Lateral Acceleration, truck 15, above axle 29 (PU-B) [m/s^2] {0 to ± 10 m/s^2}
2.22	y..+42/8	Lateral Acceleration, truck 16, above axle 32 (PU-B) [m/s^2] {0 to ± 10 m/s^2}

APPENDIX B

TRACK CURVE INFORMATION

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Profile

EASTBOUND
Geometry Details

PREPARED BY: Conrad J. Ruppert, Jr.
Manager Field Engineering

7/21/93

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
ALL TRACKS		136.00	134.50	WASHINGTON TERMINAL to AVENUE								TIMETABLE SPEED
415	2	135.34	134.80		3.08	1.500	3.9	4.5	45	50	5	
TRACK # 2		134.50	133.00	AVENUE to MILEPOST 133.0								105
414	2	133.91	133.32		1.00	4.400	3.3	4.6	85	105	20	
TRACK # 2		133.00	99.80	MILEPOST 133.0 to FREDERICK ROAD								125
413	2	130.86	129.24		0.67	4.340	3.0	4.9	125	125	0	
412	2	128.89	128.78		0.35	1.040	1.9	3.4	100	110	10	
411	2	128.78	128.56		0.98	4.320	4.0	4.3	100	110	10	
411	2	128.56	128.53		0.17	0.790	0.6	0.6	100	110	10	
410	**2**	**127.74**	**127.42**		**0.37**	**2.280**	**1.7**	**1.7**	**110**	**125**	**15**	
409 M	**2**	**127.24**	**127.19**		**0.17**	**0.030**	**1.8**	**2.7**	**110**	**125**	**15**	
409	2	126.94	126.67		1.07	6.280	3.6	4.3	110	115	5	
408	2	126.29	126.25		0.50	2.450	2.6	3.2	110	120	10	
408	2	126.25	125.95		1.00	5.980	4.1	4.7	110	120	10	
407	2	125.55	125.21		1.03	6.020	4.4	4.9	110	120	10	
406	2	122.02	121.94		0.27	1.860	1.1	1.1	110	125	15	
405	2	120.25	120.20		0.55	3.630	2.4	2.7	115	125	10	
405	2	120.20	119.98		0.82	5.940	3.0	4.1	125	125	0	
404	**2**	**119.68**	**119.06**		**0.47**	**2.740**	**2.4**	**3.4**	**120**	**125**	**5**	
403	2	118.37	118.11		0.60	4.260	2.3	4.4	120	125	5	
402	2	117.76	117.61		0.55	3.020	3.0	4.6	120	125	5	
402	2	117.61	117.56		0.15	1.300	0.3	0.3	120	125	5	
401	2	117.47	117.43		0.40	2.530	1.9	3.2	120	125	5	
401	2	117.43	116.74		0.87	6.030	3.5	4.4	120	125	5	
400	2	116.67	116.25		0.78	5.270	3.3	5.0	120	125	5	
399	2	115.62	115.15		0.87	5.700	3.8	4.7	120	125	5	
398	2	114.39	113.82		0.85	6.010	3.3	4.5	120	125	5	
398	2	113.82	113.79		0.12	0.780	0.5	0.5	120	125	5	
397	2	113.49	113.19		0.82	5.920	3.0	3.8	120	125	5	
397	2	113.19	113.16		0.12	0.580	0.7	0.7	120	125	5	
396	2	111.22	111.17		0.48	3.170	2.1	3.0	120	125	5	
396	2	111.17	110.70		0.85	6.090	3.2	4.1	120	125	5	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY DEGREE [dec.degree]	CURVE GEOMETRY SUPER-ELEV. [inches]	UNBALANCE AVERAGE [inches]	UNBALANCE LIMITING [inches]	CURVING SPEEDS CURRENT [mph]	CURVING SPEEDS PROPOSED [mph]	CURVING SPEEDS INCREASE [mph]	MAXIMUM LINE SPEED [mph]
TRACK # 2		133.00	99.80	MILEPOST 133.0 to FREDERICK ROAD (continued)								125
395	2	110.45	110.20		0.83	5.780	3.3	4.3	120	125	5	
395	2	110.20	110.13		0.23	1.730	0.8	0.8	120	125	5	
392	2	108.49	108.07		0.47	2.950	2.2	3.1	125	125	0	
391	2	106.93	106.47		1.52	6.480	4.1	4.8	90	100	10	
390	2	106.01	105.42		1.00	6.030	3.2	4.8	110	115	5	
390	2	105.42	105.38		0.17	1.090	0.5	0.5	110	115	5	
389	2	104.71	104.40		0.42	2.470	2.1	3.1	110	125	15	
388	2	104.14	103.94		0.95	5.940	3.6	4.9	110	120	10	
388	2	103.94	103.87		0.62	4.650	1.6	2.5	110	120	10	
387	2	103.70	103.44		0.75	3.720	2.6	4.7	100	110	10	
386	2	103.01	103.00		0.25	1.250	1.5	2.8	110	125	15	
386	2	102.98	102.86		0.23	2.040	0.5	0.5	110	125	15	
385	2	102.12	101.45		1.02	5.020	3.6	4.3	105	110	5	
383	2	99.97	99.81		1.10	3.980	3.7	4.9	100	100	0	
TRACK # 2		99.80	98.10	FREDERICK ROAD to FULTON								80
382 B	2	99.78	99.37		1.72	4.580	3.1	3.9	75	80	5	
381 D	2	98.59	98.39		3.63	4.820	2.9	3.7	50	55	5	
381 C	2	98.39	98.37		1.98	3.970	0.2	1.1	50	55	5	
381 B	2	98.37	98.24		3.42	4.640	2.6	2.9	50	55	5	
381 A	2	98.24	98.17		0.70	0.700	0.8	1.3	50	55	5	
ALL TRACKS		98.10	94.60	FULTON to NORTH PORTALS OF UNION TUNNEL								TIMETABLE SPEED
380	2	98.09	97.63		4.20	1.790	2.9	3.7	40	40	0	
379	2	97.42	97.38		0.80	0.010	0.5	0.5	30	30	0	
378	2	97.20	96.94		7.45	1.920	2.8	3.3	30	30	0	
377 C	2	96.34	96.11		4.12	0.660	1.9	2.8	30	30	0	
377 B	2	96.11	95.93		7.78	2.190	2.7	3.2	30	30	0	
377 A	2	95.88	95.79		4.95	0.080	3.0	2.3	30	30	0	
377	2	95.75	95.71		1.85	0.430	0.7	-0.8	30	30	0	
376 C	2	95.52	95.48		2.30	0.180	1.3	1.0	30	30	0	
376 B	2	95.48	95.40		2.75	0.010	1.7	1.9	30	30	0	
376 A	2	95.37	95.31		4.30	0.430	2.3	0.6	30	30	0	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2		94.60	91.70	NORTH PORTALS OF UNION TUNNEL to BAY								70
375 B	1	94.52	94.27		4.90	3.920	3.0	3.6	45	45	0	
375 A	1	94.27	94.24		0.30	0.630	-0.2	0.3	45	45	0	
374	1	94.12	93.82		4.12	3.780	3.4	4.0	50	50	0	
373	1	93.22	92.88		2.07	2.870	4.2	4.8	60	70	10	
372	1	92.41	92.04		1.90	3.540	3.0	4.9	60	70	10	
372	1	92.04	91.99		0.98	1.660	1.7	2.0	60	70	10	
371	1	91.94	91.87		0.47	0.030	1.6	2.4	60	70	10	
TRACK # 2		91.70	85.00	BAY to MILEPOST 85.0								120
369 B	1	91.21	90.23		0.30	0.900	2.1	3.2	100	120	20	
365	1	89.89	89.73		0.47	1.130	3.2	4.6	110	115	5	
364	1	89.68	89.43		0.35	2.210	1.3	3.5	110	120	10	
364	2	89.33	88.39		0.70	5.490	1.6	2.8	110	120	10	
362	2	88.14	86.62		0.90	5.710	3.4	4.5	110	120	10	
362	2	86.62	86.58		0.17	1.020	0.7	0.7	110	120	10	
360	2	86.34	85.76		0.92	6.300	2.9	4.2	110	120	10	
360	2	85.76	85.73		0.18	1.450	0.4	0.4	110	120	10	
TRACK # 2		85.00	71.50	MILEPOST 85.0 to BUSH								135
358	2	82.78	82.41		0.28	2.290	1.3	1.3	125	135	10	
358	2	82.39	80.68		0.28	2.070	1.5	3.5	125	135	10	
358	2	80.66	80.51		0.25	2.050	1.1	1.1	125	135	10	
357 N	2	79.79	79.73		0.25	1.320	1.9	1.9	125	135	10	
357 M	2	79.63	79.57		0.28	1.200	2.4	3.4	125	135	10	
357	2	78.39	78.34		0.57	2.920	1.9	2.1	100	110	10	
357	2	78.34	77.87		1.22	6.530	3.8	4.5	100	110	10	
356	2	77.67	77.56		0.28	2.030	1.6	1.6	125	135	10	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2/1		71.50	60.70	BUSH to GRACE								135
354	2	71.29	69.75		0.25	2.700	0.5	4.7	125	135	10	
352	2	66.71	66.18		0.48	2.950	3.2	4.1	125	135	10	
351	2	65.39	64.60		1.02	6.050	3.4	4.2	110	115	5	
351	2	63.07	63.04		0.20	0.150	1.7	1.7	110	115	5	
350	1	62.80	62.06		0.65	4.240	2.9	4.1	125	125	0	
349	1	61.34	60.45		0.73	1.340	3.3	4.8	95	95	0	
TRACK # 2		60.70	59.70	GRACE to SOUTHWARD LIMITS OF PERRY								90
TRACK # 2		59.70	46.00	SOUTHWARD LIMITS OF PERRY to MILEPOST 46.0								125
348	2	57.90	57.59		0.45	1.620	3.3	4.2	110	125	15	
347	2	57.16	56.72		1.40	6.210	4.6	4.7	95	105	10	
345	2	54.14	53.81		0.50	2.760	1.5	2.1	110	110	0	
344	2	53.75	53.71		0.40	1.750	1.6	2.9	110	110	0	
344	2	53.71	53.26		1.13	5.850	3.8	4.8	110	110	0	
343	2	51.81	51.77		0.47	3.090	2.0	2.8	125	125	0	
343	2	51.77	51.13		0.77	5.440	3.0	4.4	125	125	0	
342	2	50.65	49.90		1.40	5.970	3.8	4.5	90	100	10	
341	2	49.12	48.63		0.95	5.680	3.9	4.8	110	120	10	
340	2	47.26	47.21		0.42	2.160	2.4	3.3	115	125	10	
340	2	47.21	46.71		0.92	5.680	4.4	4.9	115	125	10	
TRACK # 2		46.00	28.30	MILEPOST 46.0 to YARD								135
339	2	45.84	45.25		0.52	3.500	3.1	3.8	125	135	10	
338	2	44.39	43.82		0.22	1.000	1.8	1.8	125	135	10	
337	2	41.93	41.77		0.42	2.280	3.0	5.0	125	135	10	
336	2	40.50	39.40		0.52	2.730	3.9	5.2	110	135	25	
334	2	34.66	34.52		0.40	2.340	2.8	4.0	125	135	10	
333	2	33.74	33.30		0.48	2.680	3.5	4.3	125	135	10	
332	2	33.06	32.59		1.07	5.920	3.1	4.4	110	110	0	
331	2	30.99	30.80		0.50	2.980	2.5	3.8	125	125	0	
330	2	30.39	30.07		1.05	5.960	3.8	4.7	110	115	5	
330	2	30.07	30.03		0.15	1.130	0.3	0.3	110	115	5	
329	2	29.29	28.60		0.82	4.440	3.1	4.5	110	115	5	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2		28.30	27.00	YARD to BRANDY								80
328 B	2	27.53	27.09		3.87	2.850	1.5	2.0	40	40	0	
328 A	2	27.09	27.04		1.03	1.110	0.1	0.4	40	40	0	
328 A	2	27.04	26.98		3.50	0.050	3.9	3.9	40	40	0	
TRACK # 2		27.00	26.80	BRANDY to WINE								30
TRACK # 2		26.80	25.50	WINE to LANDLITH								80
327	2	26.91	26.80		2.43	1.750	1.0	2.2	40	40	0	
327	2	26.80	26.74		2.83	1.700	1.5	1.8	40	40	0	
327	2	26.74	26.73		2.02	1.540	0.7	1.0	40	40	0	
327	2	26.73	26.66		4.58	1.600	3.5	4.2	40	40	0	
327	2	26.66	26.29		1.65	2.460	-0.6	0.2	40	40	0	
TRACK # 2		25.50	16.50	LANDLITH to HOOK								115
326	2	25.13	24.13		0.45	2.060	2.1	4.2	105	115	10	
325	2	23.78	22.92		1.38	5.200	3.5	4.4	90	95	5	
323	2	22.27	22.22		0.50	2.080	2.6	3.1	110	115	5	
323	2	22.22	21.98		0.80	4.280	3.1	4.6	110	115	5	
323	2	21.98	21.92		0.22	0.840	1.2	1.2	110	115	5	
322	2	21.28	21.20		0.27	0.450	2.0	2.5	110	115	5	
321	2	21.03	20.98		0.62	2.460	3.3	3.6	110	115	5	
321	2	20.98	20.59		0.75	3.620	3.3	4.5	110	115	5	
320 N	2	20.26	20.21		0.30	0.410	2.4	3.3	110	115	5	
320	2	19.87	19.52		1.02	5.610	3.8	4.7	110	115	5	
319	2	18.48	17.96		1.05	5.670	4.1	4.6	110	115	5	
TRACK # 2		16.50	11.50	HOOK to BALDWIN								90
316	2	14.98	14.81		0.43	1.950	0.5	1.8	90	90	0	
315	2	13.92	13.74		0.82	2.730	1.9	3.3	90	90	0	
315	2	13.74	13.69		0.62	2.110	1.4	2.0	90	90	0	
314	2	12.72	11.79		0.82	2.430	2.2	4.1	90	90	0	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2		11.50	3.00	BALDWIN to MILEPOST 3.0								105
313	2	11.03	10.48		1.02	5.450	2.4	3.2	100	105	5	
313	2	10.48	10.45		0.23	0.630	1.2	1.2	100	105	5	
312	2	9.64	9.58		1.02	4.700	3.2	3.3	100	105	5	
312	2	9.58	9.41		1.05	5.510	2.6	4.4	100	105	5	
312	2	9.41	9.39		0.10	0.340	0.4	0.4	100	105	5	
311	2	7.21	6.79		1.00	3.110	3.2	4.1	80	95	15	
310	2	6.79	6.01		1.05	3.100	3.5	4.8	80	95	15	
308	2	6.01	5.37		1.05	2.840	3.8	4.5	80	95	15	
307 N	2	3.31	3.20		0.22	0.570	1.1	2.1	100	105	5	
ALL TRACKS		3.00	86.75	MILEPOST 3.0 to EASTWARDLIMITS OF ZOO								TIMETABLE SPEED
307	2	2.98	2.84		1.42	2.570	2.3	2.8	70	70	0	
306 B	2	2.84	2.43		2.38	5.270	2.9	3.7	70	70	0	
306 A	2	2.43	2.34		0.98	2.350	1.0	1.3	70	70	0	
305	2	2.31	1.96		2.05	2.840	2.3	2.7	60	60	0	
304	2	1.56	1.46		4.70	3.100	2.2	2.9	40	40	0	
304	2	1.46	1.31		3.58	2.980	1.0	2.0	40	40	0	
303 H	2	1.23	1.14		4.77	1.000	2.0	1.9	30	30	0	
303 G	1	0.88	0.72		6.07	1.610	2.2	3.1	30	30	0	
303 G	1	0.72	0.67		1.20	0.180	0.6	0.4	30	30	0	
303 F	1	88.99	88.88		0.57	1.510	-1.2	-1.0	30	30	0	
303 F	1	88.88	88.79		0.95	1.570	-1.0	-0.6	30	30	0	
303 E	1	88.73	88.43		2.80	2.370	-0.6	-0.3	30	30	0	
303 C	1	88.31	88.24		0.72	0.940	-0.5	-0.4	30	30	0	
303 C	1	88.24	87.93		5.20	2.260	1.0	1.3	30	30	0	
303 C	1	87.93	87.91		5.08	2.240	1.0	1.0	30	30	0	
303 C	1	87.91	87.72		6.50	2.210	1.9	2.1	30	30	0	
303 C	1	87.72	87.71		0.53	0.260	0.1	0.4	30	30	0	
303 C	1	87.71	87.64		2.90	0.270	1.6	0.9	30	30	0	
303 B	2	87.32	87.26		1.02	0.860	2.6	3.3	70	70	0	
303 A	2	87.24	87.17		0.85	1.280	1.6	2.1	70	70	0	
TRACK # 2		86.75	85.50	EASTWARD LIMITS OF ZOO to NORTH PHILADELPHIA								70
303	2	86.45	86.31		1.80	3.910	2.3	2.8	70	70	0	

NATIONAL RAILROAD PASSENGER CORPORATION

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CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2		85.50	84.50	THROUGH NORTH PHILADELPHIA INTERLOCKING								65
302	2	85.40	85.30		1.98	2.150	3.7	4.4	60	65	5	
301	2	85.06	85.00		1.47	1.530	2.8	3.3	60	65	5	
300	2	84.93	84.84		0.87	2.150	0.4	0.8	60	65	5	
299 W	2	84.77	84.70		1.02	1.090	1.9	2.9	60	65	5	
TRACK # 2		84.50	82.00	NORTH PHILADELPHIA to SHORE								70
299 B	2	83.82	83.55		2.57	5.180	3.6	5.0	65	70	5	
299 A	2	83.55	83.08		0.40	2.210	-0.8	-0.4	65	70	5	
TRACK # 2		82.00	76.00	SHORE to MILEPOST 76.0								115
298	2	81.75	81.37		4.05	5.130	3.5	4.0	50	55	5	
297	2	81.30	80.88		1.83	2.190	4.1	4.9	60	70	10	
296	2	79.69	79.19		0.60	2.000	3.6	4.9	100	115	15	
295	2	78.49	78.21		0.30	1.230	1.6	2.4	100	115	15	
294 A	2	77.05	77.00		0.55	2.380	2.7	2.9	100	115	15	
294 A	2	77.00	76.85		1.07	5.530	4.3	4.6	100	115	15	
294 A	2	76.85	76.66		0.40	1.880	1.8	3.1	100	115	15	
293	2	76.41	76.12		0.58	3.230	2.2	3.1	100	115	15	
TRACK # 2		76.00	58.40	MILEPOST 76.0 to MORRIS								125
292	2	75.40	75.09		0.80	4.710	4.0	4.7	120	125	5	
291	2	75.06	74.73		1.42	5.360	3.6	4.1	90	95	5	
291 A	2	74.73	74.62		0.70	2.620	1.8	2.3	90	95	5	
290	2	74.48	74.05		1.50	5.690	3.8	4.2	90	95	5	
289	2	72.57	72.17		0.33	1.780	1.9	1.9	125	125	0	
288	2	70.61	70.06		1.22	6.100	4.2	4.6	105	110	5	
286	2	67.89	66.71		0.47	2.310	2.8	3.5	125	125	0	
285	2	66.33	65.66		0.72	3.620	3.6	4.8	115	120	5	
285	2	65.66	65.62		0.12	0.890	0.3	0.3	115	120	5	
284	2	64.92	64.63		0.67	3.980	3.3	4.0	120	125	5	
284	2	64.63	64.59		0.15	1.150	0.5	0.5	120	125	5	
283	2	61.93	61.39		0.72	4.930	2.9	4.0	110	125	15	
282	2	60.53	60.23		0.35	1.360	2.5	3.3	110	125	15	
280	2	59.26	58.08		0.60	2.040	3.0	4.9	110	110	0	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profile

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CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2		**58.40**	**54.00**	**MORRIS to MILEPOST 54.0**								**115**
	2	58.40	58.00	Morris Interlocking					100	100	0	
279	2	57.12	57.00		0.67	1.860	4.3	4.9	110	115	5	
278	2	56.33	56.07		0.32	1.230	1.7	2.8	110	115	5	
TRACK # 2		**54.00**	**28.00**	**MILEPOST 54.0 to MILEPOST 28.0**								**135**
277	2	50.46	50.35		0.30	1.480	2.4	3.5	125	135	10	
276	2	40.24	39.46		0.52	3.730	2.9	4.0	125	135	10	
275	2	39.36	39.05		0.30	1.540	2.3	3.9	125	135	10	
274	2	34.20	33.77		0.45	3.060	2.7	3.8	125	135	10	
273	2	31.35	31.12		0.45	2.750	3.0	4.4	125	135	10	
272	2	30.66	30.26		0.47	2.780	3.2	4.1	125	135	10	
271	2	28.97	28.85		0.30	1.830	2.0	2.0	125	135	10	
TRACK # 2		**28.00**	**20.00**	**MILEPOST 28.0 to MILEPOST 20.0**								**120**
270	2	27.67	27.63		0.47	1.900	2.8	3.8	110	120	10	
270	2	27.63	27.44		0.77	3.740	4.0	4.5	110	120	10	
269	2	27.18	26.77		1.42	5.890	4.0	4.7	90	100	10	
268	2	26.66	26.39		1.90	6.250	4.5	5.0	80	90	10	
267	2	25.54	24.68		1.22	4.840	2.9	3.3	95	95	0	
266	2	24.53	24.11		1.55	5.730	4.1	5.0	90	95	5	
265	2	23.88	23.64		1.47	5.120	4.2	4.9	90	95	5	
265	2	23.64	23.61		0.15	0.350	0.6	0.6	90	95	5	
264	2	23.51	23.47		0.45	2.060	2.1	2.7	110	115	5	
264	2	23.47	22.88		0.83	5.100	2.6	4.3	110	115	5	
264	2	22.88	22.82		0.25	1.610	0.7	0.7	110	115	5	
263	2	22.78	22.42		0.70	4.270	2.2	4.0	110	115	5	
262	2	21.99	21.89		0.53	2.200	2.7	4.5	110	115	5	
261	2	21.85	21.69		0.68	3.160	3.7	4.5	110	120	10	
260	2	20.78	20.71		0.25	0.600	1.9	2.7	110	120	10	
259	2	20.69	20.38		0.43	1.870	2.5	3.6	110	120	10	

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ICEtrain Northeast Corridor Revenue Service Speed Profile

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED [mph]
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	
TRACK # 2		**20.00**	**15.10**	**MILEPOST 20.0 to ELMORA**								**125**
258	2	19.73	19.63		0.27	1.720	1.2	1.2	125	125	0	
256	2	19.41	19.27		0.43	3.300	1.4	1.4	125	125	0	
255	2	18.93	18.83		0.20	0.490	1.7	1.7	125	125	0	
TRACK # 2		**15.10**	**10.50**	**ELMORA to HUNTER**								**110**
	2	15.10	14.80	Elmora Interlocking					55	55	0	
253 C	2	14.66	14.55		0.53	2.180	-0.8	0.8	55	60	5	
253 B	2	14.55	14.45		1.53	3.030	0.8	1.7	55	60	5	
253 A	2	14.45	14.26		2.40	2.590	3.5	3.7	55	60	5	
252	2	14.26	14.03		1.98	4.280	2.5	2.9	65	70	5	
250	2	12.56	12.29		0.33	2.000	0.8	1.6	110	110	0	
249	2	10.49	10.22		1.02	2.780	0.7	1.7	70	70	0	
ALL TRACKS		**10.50**	**0.00**	**HUNTER to PENNSYLVANIA STATION, NEW YORK**								**TIMETABLE SPEED**
248	2	9.24	9.18		1.50	0.000	3.8	3.9	60	60	0	
247 M	2	8.96	8.88		0.47	0.040	0.4	-0.2	35	35	0	
247	2	8.82	8.70		1.42	0.000	1.2	1.0	35	35	0	
246	2	8.63	8.52		1.55	0.170	1.2	0.8	35	35	0	
245	2	8.44	8.30		0.60	0.100	0.4	0.6	35	35	0	
244	2	8.30	8.11		0.60	0.650	0.2	0.9	45	45	0	
243	2	8.03	7.77		3.30	3.300	5.0	4.8	60	60	0	
242	1	6.71	W7.33		0.45	2.180	0.4	1.1	90	90	0	
	2	W6.10	W6.10	Portal Moveable Bridge					70	70	0	
241	1	W5.75	W5.51		0.50	1.740	1.1	1.6	90	90	0	
240	1	W3.61	W3.08		1.93	6.040	1.6	4.4	75	75	0	
240	1	W3.08	W2.96		2.02	4.180	3.8	4.8	75	75	0	
239	1	W1.14	W1.11		0.40	0.280	0.7	1.2	60	60	0	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Profile

WESTBOUND
Geometry Details

PREPARED BY: Conrad J. Ruppert, Jr.
Manager Field Engineering

7/21/93

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profiles
(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
ALL TRACKS		0.00	10.50	PENNSYLVANIA STATION, NEW YORK to HUNTER								CURRENT TIMETABLE
239	2	W 1.26	W 1.30		0.33	0.070	0.9	1.0	60	60	0	
240	2	W 3.03	W 3.65	Curve west of the west portal North River Tunnels	2.22	4.110	4.4	4.9	75	75	0	
241	2	W 5.51	W 5.79		0.43	1.710	0.8	1.9	90	90	0	
	2	W 6.10	w 6.10	Portal moveable bridge					70	70	0	
242	2	W 7.38	W 8.11		0.47	1.850	0.6	1.2	90	90	0	
243	3	7.78	8.02		3.27	3.370	1.4	1.9	45	45	0	
244	3	8.11	8.44		0.67	0.180	0.7	1.1	45	45	0	
245	3	8.51	8.63		1.45	0.290	1.1	0.3	35	35	0	
246	3	8.69	8.82		1.47	0.300	1.1	1.3	35	35	0	
247	3	8.93	9.00		0.85	0.470	0.4	0.8	35	35	0	
248	3	9.20	9.30		0.97	0.820	2.4	3.0	70	70	0	
TRACK # 3		10.50	15.10	HUNTER to ELMORA								110
249	3	10.24	10.56	Curve at Hunter	0.97	3.040	0.4	2.0	70	70	0	
250	3	12.28	12.57		0.32	1.390	1.2	1.7	110	110	0	
251	3	13.00	13.15		0.25	0.750	1.4	1.4	110	110	0	
252	3	14.05	14.29	First curve west of MP 14.0	1.97	4.120	2.8	3.3	65	70	5	
253	3	14.29	14.70	Curve east of Elmora Interlocking	2.42	4.580	1.4	1.9	55	60	5	
		14.70	15.10	Elmora Interlocking					55	55	0	
TRACK # 3		15.10	20.00	ELMORA to MILEPOST 20.0								125
254	3	18.10	18.30		0.32	0.750	2.8	2.8	125	125	0	
256	3	19.10	19.25		0.38	1.500	2.7	2.7	125	125	0	
258	3	19.74	19.76		0.27	0.740	2.2	3.0	125	125	0	
TRACK # 3		20.00	28.00	MILEPOST 20.0 to MILEPOST 28.0								120
259	3	20.39	20.72		0.48	1.390	3.6	4.3	110	120	10	
260	3	20.74	20.81		0.30	1.100	2.0	2.5	110	120	10	
261	3	21.68	21.85		0.70	4.090	2.8	3.3	110	120	10	
262	3	21.90	22.05		0.68	2.920	3.5	4.6	110	115	5	
263	3	22.48	22.85		0.65	3.520	3.1	4.3	110	120	10	
264	3	22.88	23.55		0.77	4.540	3.4	4.5	110	120	10	
265	3	23.67	23.93	First curve east of MP 24.0	1.43	5.970	3.3	3.8	95	95	0	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profiles

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
266	3	24.15	24.59	First curve west of MP 24.0	1.50	5.130	3.4	4.1	90	90	0	
267	3	24.73	25.55	Curve at MP 25.0	1.18	4.260	3.2	4.3	95	95	0	
TRACK # 3		**20.00**	**28.00**	**MILEPOST 20.0 to MILEPOST 28.0 (continued)**								**120**
268	3	26.40	26.67	First curve west of Lincoln	1.93	6.210	3.9	4.4	80	85	5	
269	3	26.77	27.18	Second curve west of Lincoln	1.43	6.000	4.2	4.9	90	100	10	
270	3	27.46	27.67	Third curve west of Lincoln	0.77	3.900	3.8	4.5	110	120	10	
TRACK # 3		**28.00**	**54.00**	**MILEPOST 28.0 to MILEPOST 54.0**								**135**
271	3	28.87	29.07		0.20	1.680	0.9	0.9	125	135	10	
272	3	30.25	30.65		0.43	2.850	2.8	3.4	125	135	10	
273	3	31.13	31.34		0.45	3.000	2.8	3.5	125	135	10	
274	3	33.77	34.23		0.43	3.230	2.6	3.7	125	135	10	
275	3	39.08	39.35		0.30	1.630	2.1	2.1	125	135	10	
276	3	39.47	40.26		0.53	3.440	3.3	4.1	125	135	10	
277	3	50.38	50.52		0.28	1.080	2.5	3.5	125	135	10	
TRACK # 3		**54.00**	**58.40**	**MILEPOST 54.0 to MORRIS**								**115**
278	3	56.10	56.33		0.28	1.200	1.5	2.4	110	115	5	
279	3	56.99	57.12	First curve west of Trenton	0.68	2.510	3.8	4.4	95	115	20	
	3	58.00	58.40	Morris Interlocking					100	100	0	
TRACK # 3		**58.40**	**76.00**	**MORRIS to MILEPOST 76.0**								**125**
280	3	58.41	59.09	First curve west of Morris	0.77	3.680	3.0	4.3	110	110	0	
281	3	59.44	59.60		0.17	0.530	1.3	1.3	110	125	15	
282	3	60.24	60.56		0.38	2.490	1.5	1.5	110	125	15	
283	3	61.40	61.94	Curve between MP 61.0 and MP 62.0	0.75	4.920	3.2	3.9	110	125	15	
284	3	64.62	64.96	Curve east of Grundy	0.63	4.180	2.9	3.6	120	125	5	
285	3	65.63	66.33	Curve west of Grundy	0.75	4.990	3.2	4.3	115	125	10	
286	3	66.72	67.65		0.50	1.940	3.4	4.2	125	125	0	
288	3	70.03	70.60	Curve west of Croydon	1.05	5.330	3.7	5.0	105	110	5	
289	3	72.19	72.60		0.37	1.680	2.3	2.8	125	125	0	
290	3	74.08	74.50	Reverse curves between MP 74.0 and MP 75.0	1.45	5.820	3.5	4.0	90	95	5	
291	3	74.65	75.09	Reverse curves between MP 74.0 and MP 75.0	1.43	5.330	3.8	4.8	90	95	5	
292	3	75.13	75.42	First curve west of MP 75.0	0.73	4.030	4.2	5.0	110	125	15	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profiles
(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 3		**76.00**	**82.00**	**MILEPOST 76.0 to SHORE**								**115**
293	3	76.13	76.47		0.70	3.480	3.1	3.9	100	115	15	
294	3	76.70	77.04		0.67	2.730	3.4	4.6	100	115	15	
295	3	78.21	78.50		0.35	1.490	1.6	2.4	100	115	15	
296	3	79.23	79.72		0.60	1.690	3.4	4.7	100	110	10	
297	3	80.90	81.32	Curve eastwrd from Ford	1.75	2.470	3.6	4.5	60	70	10	
298	3	81.39	81.79	Curve between Shore and Ford	4.10	5.320	3.3	3.9	50	55	5	
TRACK # 3		**82.00**	**84.50**	**SHORE to NORTH PHILADELPHIA**								**70**
299	3	83.16	83.84	Curve MP 84 to 2nd Street OH Bridge	2.47	5.190	3.3	3.9	65	70	5	
TRACK # 3		**84.50**	**85.50**	**THROUGH NORTH PHILADELPHIA INTERLOCKING**								**65**
299 M	3	84.74	84.81	Curve at east end North Philadelphia Station platform	1.27	0.880	4.0	3.0	60	65	5	
300	3	84.89	85.01		0.80	2.370	0.7	1.1	60	65	5	
301	3	85.07	85.14	Curve at west end North Philadelphia Station platform	1.37	1.520	3.8	4.9	60	65	5	
302	3	85.38	85.49		1.90	2.300	3.1	3.8	60	65	5	
TRACK # 3		**85.50**	**86.75**	**NORTH PHILADELPHIA to EASTWARD LIMITS OF ZOO INTERLOCKING**								**70**
303	3	86.24	86.38	Curve at Bridge 86.11 (Ridge Ave.)	1.52	3.440	1.9	2.5	60	70	10	
ALL TRACKS		**86.75**	**3.00**	**EASTWARD LIMITS OF ZOO to SOUTHWARD LIMITS OF PENN (MP 3.0)**								**CURRENT TIMETABLE**
303 Z	4	87.68	89.76	All curves between Zoo and 34th St. OH Bridge	4.85	0.340	1.8	2.4	30	30	0	
304	3	89.80	90.04	All curves South St. OH Bridge to Signal Br. 2.0-2.1	4.32	1.340	3.8	4.1	40	40	0	
305	3	90.46	2.31	All curves South St. OH Bridge to Signal Br. 2.0-2.1	2.02	2.920	0.7	0.9	50	50	0	
306	3	2.31	2.84		2.47	6.130	2.5	3.0	70	70	0	
307	3	2.84	3.05		1.40	3.180	1.5	1.8	70	70	0	
TRACK # 3		**3.00**	**11.50**	**MILEPOST 3.0 to BALDWIN**								**105**
307 M	3	3.15	3.24		0.25	0.430	1.3	1.3	100	105	5	
308	3	5.38	6.02	Reverse curves between Brill and Sharon Hill	1.07	3.080	3.7	4.1	90	95	5	
309	3	6.02	6.81	Reverse curves between Brill and Sharon Hill	1.00	3.110	3.3	4.4	90	95	5	
311	3	6.81	7.22	Reverse curves between Brill and Sharon Hill	1.02	2.940	3.6	4.6	90	95	5	
312	3	9.41	9.66		1.02	5.650	2.3	3.3	100	105	5	
313	3	10.48	11.04		0.93	4.360	3.0	4.1	100	105	5	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profiles

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CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 3		11.50	16.50	BALDWIN to HOOK								90
314	3	11.81	12.73		0.85	2.260	2.5	3.2	90	90	0	
315	3	13.69	13.94		0.75	2.630	1.7	3.4	90	90	0	
316	3	14.79	14.98		0.47	0.860	1.8	3.0	90	90	0	
317	3	15.80	15.95		0.20	1.000	0.1	0.1	90	90	0	
318	3	16.40	16.50		0.20	1.000	0.1	0.1	90	90	0	
TRACK # 3		16.50	25.50	HOOK to LANDLITH								115
319	3	17.98	18.51		1.00	5.800	3.5	4.1	110	115	5	
320	3	19.43	19.79		1.02	5.280	4.3	4.6	110	115	5	
320 M	3	20.07	20.15		0.20	0.640	0.9	0.9	110	115	5	
320 N	3	20.22	20.28		0.20	1.030	0.7	0.7	110	115	5	
321	3	20.60	21.03		0.70	3.410	3.3	4.0	110	115	5	
323	3	21.86	22.18		0.97	4.880	3.3	4.8	110	110	0	
324	3	22.94	23.77	First curve south of Bell	1.40	4.820	4.1	5.0	90	95	5	
326	3	24.20	25.16		0.42	2.030	1.9	3.1	105	115	10	
TRACK # 3		25.50	26.80	LANDLITH to WINE								80
327	3	26.19	26.80	Curve north of Wilmington Station	3.42	1.210	3.6	3.8	45	45	0	
TRACK # 3		26.80	27.00	WINE to BRANDY								30
327 M	3	26.88	26.93		1.37	0.580	0.4	0.7	30	30	0	
327 N	3	26.93	26.97		1.10	0.320	-0.1	0.5	30	30	0	
TRACK # 3		27.00	28.30	BRANDY to YARD								80
328	3	27.09	27.53	Curve at MP 27.0	3.95	2.960	2.4	3.1	45	45	0	
TRACK # 3		28.30	59.70	YARD to MILEPOST 46.0								135
329	3	28.63	29.30	Curve at MP 29.0	0.85	4.850	3.1	4.6	110	115	5	
330	3	30.07	30.41	Curve at MP 30.0	1.05	5.930	3.8	4.4	110	115	5	
331	3	30.84	30.99		0.47	3.530	1.4	2.6	125	125	0	
332	3	32.61	33.09	Curve north of MP 33.0	1.02	5.790	3.7	4.6	110	115	5	
333	3	33.33	33.75		0.50	2.950	3.4	4.4	125	135	10	
334	3	34.53	34.65		0.40	2.090	2.9	4.1	125	135	10	
335	3	35.80	35.90		0.20	0.750	1.8	1.8	125	135	10	
336	3	39.42	40.52	First curve south of Davis	0.50	3.110	3.3	4.7	125	135	10	

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					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
337	3	41.79	41.93		0.47	3.100	2.7	4.0	125	135	10	
338	3	44.01	44.21		0.22	1.760	0.0	0.0	125	135	10	
339	3	45.27	45.83		0.57	3.520	3.7	4.7	125	135	10	
TRACK # 3		**46.00**	**59.70**	**MILEPOST 46.0 to SOUTHWARD LIMITS OF PERRY**								**125**
340	3	46.72	47.29	Curve at MP 47.0	0.95	6.040	3.5	4.2	115	120	5	
341	3	48.62	49.07	Curve at MP 49.0	0.83	4.800	3.5	4.6	110	115	5	
342	3	49.85	50.67	Curve at MP 50.0	1.40	5.170	3.8	4.3	90	95	5	
343	3	51.18	51.85		0.80	6.150	2.7	3.8	125	125	0	
344	3	53.28	53.76	Curves between MP 53.0 and 1,000 feet south of MP 54.0	1.12	5.780	3.5	4.5	105	110	5	
345	3	53.83	54.17	Curves between MP 53.0 and 1,000 feet south of MP 54.0	0.50	2.390	2.1	3.4	105	115	10	
346	3	55.62	55.64		0.30	0.500	2.5	3.6	125	125	0	
347	3	56.74	57.20	Curve at MP 57.0, north of Prince	1.37	6.130	4.4	4.9	95	105	10	
348	3	57.61	57.93		0.47	1.590	3.5	4.7	110	125	15	
TRACK # 3		**59.70**	**60.70**	**SOUTHWARD LIMITS OF PERRY to GRACE**								**90**
TRACK # 4		**60.70**	**71.50**	**GRACE to BUSH**								**135**
349	4	60.53	61.35	First curve south of Grace	0.77	2.110	2.8	4.5	95	95	0	
350	4	62.05	62.78		0.65	3.780	3.2	4.5	125	125	0	
351	4	64.63	65.40		0.97	5.980	4.0	4.6	110	120	10	
352	4	66.21	66.72		0.52	3.350	3.2	4.1	125	135	10	
353	4	69.83	71.30	Curve north of Bush	0.28	1.440	2.3	5.0	120	135	15	
TRACK # 3		**71.50**	**85.00**	**BUSH to MILEPOST 85.0**								**135**
355	3	73.65	73.80		0.20	0.500	2.1	2.1	125	135	10	
356	3	77.61	77.67	First curve south of Magnolia	0.25	1.940	1.2	1.2	125	135	10	
357	3	77.90	78.42	First curve north of Gunpow Interlocking	1.17	6.460	3.4	4.5	100	110	10	
357 M	3	79.48	79.52		0.25	0.940	2.2	3.3	125	135	10	
358	3	80.57	82.82		0.32	1.290	3.0	3.9	125	135	10	
TRACK # 3		**85.00**	**91.70**	**MILEPOST 85.0 to BAY**								**120**
359	3	85.78	86.37		0.95	5.360	4.3	4.7	110	120	10	
361	3	86.62	88.16		0.87	5.390	3.4	4.8	110	120	10	
363	3	88.41	89.71		0.65	3.840	2.1	5.0	110	115	5	
365	3	89.77	89.93		0.47	3.480	1.3	3.3	110	120	10	

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(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
369	3	90.18	91.03		0.37	0.790	1.5	4.6	100	105	5	
370	3	91.16	91.27		0.37	0.900	1.8	2.9	100	105	5	
TRACK # 3		91.70	94.60	BAY to NORTH PORTALS OF UNION TUNNEL								70
371	3	91.87	92.00	Reverse curves at Bay Interlocking	1.00	1.850	1.7	2.4	60	70	10	
372	3	92.00	92.42	Reverse curves at Bay Interlocking	2.02	3.040	4.1	4.9	60	70	10	
373	3	92.88	93.27		2.02	4.440	2.8	3.8	60	70	10	
374	3	93.85	94.12	Curve at MP 94.0	4.10	4.300	4.3	4.8	50	55	5	
375	3	94.22	94.53	First curve north of Union Tunnels	4.43	3.350	3.0	3.7	45	45	0	
ALL TRACKS		94.60	98.10	NORTH PORTALS OF UNION TUNNEL to FULTON								CURRENT TIMETABLE
376	3	95.25	95.48		4.95	0.420	2.8	2.7	30	30	0	
377	3	95.69	96.34		7.20	1.990	2.5	3.2	30	30	0	
378	3	96.98	97.12		7.65	1.510	3.2	3.7	30	30	0	
379	3	97.31	97.36		0.82	0.230	0.4	0.4	30	30	0	
380	3	97.59	98.10	Curve at Fulton	4.15	1.940	2.8	3.6	40	40	0	
TRACK # 3		98.10	99.80	FULTON to FREDERICK ROAD								80
381	3	98.19	98.60	First curve south of Bridge	3.88	2.820	4.1	4.5	50	50	0	
382	3	99.38	99.79	First curve north of Frederick Road Station	1.72	4.650	3.0	4.1	75	80	5	
TRACK # 3		99.80	133.00	FREDERICK ROAD to MILEPOST 133.0								125
383	3	99.83	99.99	First curve south of MP 100.0	1.18	3.360	4.6	5.0	100	100	0	
384	3	100.20	100.30		0.20	0.500	1.7	1.7	100	125	25	
385	3	101.46	102.10	First curve south of MP 101.0	1.00	4.320	3.5	4.3	105	105	0	
386	3	102.90	103.03		0.27	1.730	1.2	1.2	110	125	15	
387	3	103.48	103.74	Curve at Winans	1.10	5.500	4.1	4.7	100	110	10	
388	3	103.90	104.15		0.97	6.550	3.7	4.4	110	125	15	
389	3	104.43	104.74		0.47	2.620	2.6	3.3	110	125	15	
390	3	105.40	106.03		0.40	2.040	4.1	4.8	110	120	10	
391	**3**	**106.49**	**106.95**	**Curve south of MP 106.0**	**1.55**	**6.000**	**4.3**	**4.7**	**90**	**100**	**10**	
392	3	108.11	108.48		0.47	2.980	2.2	4.1	125	125	0	
395	3	110.17	110.46	All curves MP 110.0 to MP 118.0	0.80	5.570	3.1	4.3	120	125	5	
396	3	110.72	111.24	All curves MP 110.0 to MP 118.0	0.87	6.070	3.3	4.9	120	125	5	
397	3	113.18	113.54	All curves MP 110.0 to MP 118.0	0.83	5.820	3.1	4.1	120	125	5	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Northeast Corridor Revenue Service Speed Profiles

(135 mph Maximum Speed - 5 inch Cant Deficiency)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [dec degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
398	3	113.82	114.39	All curves MP 110.0 to MP 118.0	0.83	5.740	3.5	4.7	120	125	5	
399	3	115.15	115.63	All curves MP 110.0 to MP 118.0	0.80	5.550	3.3	3.8	120	125	5	
400	3	116.25	116.67	All curves MP 110.0 to MP 118.0	0.83	6.030	2.9	4.1	120	125	5	
TRACK # 3		**99.80**	**133.00**	**FREDERICK ROAD to MILEPOST 133.0 (continued)**								**125**
401	3	116.76	117.46	All curves MP 110.0 to MP 118.0	0.83	6.050	3.2	4.2	120	125	5	
402	3	117.58	117.74	All curves MP 110.0 to MP 118.0	0.55	3.910	2.4	3.3	120	125	5	
403	3	118.10	118.34	First curve south of MP 118.0	0.70	5.190	2.6	3.5	120	125	5	
404	3	119.10	119.69		0.48	1.620	3.6	5.0	125	125	0	
405	3	120.01	120.24	Curve south of MP 120.0	0.82	6.250	2.9	3.9	115	125	10	
406	3	121.96	122.08		0.28	1.930	1.0	1.0	110	125	15	
407	3	125.26	125.59		1.02	6.160	3.9	5.0	110	120	10	
408	3	126.01	126.69		0.98	6.200	3.7	4.6	110	120	10	
409	3	126.64	126.92		1.12	6.050	4.3	4.9	110	115	5	
410	3	127.44	127.82		0.42	2.110	2.1	2.9	110	125	15	
411	3	128.57	128.94	Curve at Landover	0.60	2.720	3.4	4.5	100	110	10	
413	3	129.26	130.88		0.68	4.540	3.1	3.9	125	125	0	
TRACK # 3		**133.00**	**134.50**	**MILEPOST 133.0 to AVENUE**								**105**
414	3	133.34	133.91		0.97	4.450	3.1	4.5	85	105	20	
ALL TRACKS		**134.50**	**136.00**	**AVENUE to WASHINGTON TERMINAL**								**CURRENT TIMETABLE**
415	3	134.82	135.19		2.80	1.750	2.3	3.0	45	45	0	

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Test Program

Calculated Curving Speeds for the HARRISBURG Test Zone

PREPARED BY: Conrad J. Ruppert, Jr.
Mgr. Field Engineering

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Calculated Curving Speeds for the HARRISBURG Test Zone

CURVE NUMBER	TRACK NUMBER	MILEPOST LOCATION		AVERAGE CURVE GEOMETRY					CALCULATED CURVING SPEED				
				Degree	Curve Radius		Super-Elevation		3"ub	4"ub	5"ub	6"ub	7"ub
		[east]	[west]	[dec.deg.]	[feet]	[meters]	[inches]	[mm]	[mph]	[mph]	[mph]	[mph]	[mph]
683	2	74.86	75.21	1.00	5,729.7	1,746.4	2.650	67.3	90	97	105	111	117
685	2	77.13	77.34	0.98	5,826.8	1,776.0	2.130	54.1	86	94	102	109	115
686	2	77.70	77.86	1.02	5,635.7	1,717.8	3.020	76.7	92	99	106	113	119
687	2	79.24	79.35	0.47	12,277.8	3,742.3	0.890	22.6	109	122	134	145	155
688 *	2	79.83	80.19	0.92	6,250.5	1,905.2	1.600	40.6	85	93	101	109	116
689	2	80.95	81.18	0.55	10,417.5	3,175.3	2.220	56.4	116	127	137	146	155
690	2	81.59	82.01	1.02	5,635.7	1,717.8	2.730	69.3	90	97	104	111	117
691	2	82.54	83.24	0.43	13,222.3	4,030.1	0.410	10.4	106	121	134	145	156
692	2	83.67	84.26	0.70	8,185.2	2,494.9	1.670	42.4	98	108	117	125	133
693	2	84.70	85.35	2.07	2,772.4	845.0	6.440	163.6	81	85	89	93	96
694	2	85.51	85.79	0.85	6,740.8	2,054.6	2.630	66.8	97	106	113	120	127
695	2	85.88	86.21	2.03	2,817.9	858.9	5.510	140.0	77	82	86	90	94
696	2	87.76	87.96	0.47	12,277.8	3,742.3	0.950	24.1	110	123	135	146	156
697	2	90.51	90.85	0.87	6,611.1	2,015.1	2.930	74.4	99	107	114	121	128
698	2	91.25	91.94	1.05	5,456.8	1,663.2	3.720	94.5	96	102	109	115	121
699	2	92.58	93.20	2.07	2,772.4	845.0	6.150	156.2	80	84	88	92	95
700	2	93.24	93.66	1.40	4,092.6	1,247.4	4.510	114.6	88	93	99	104	108
701 *	2	94.35	95.25	2.07	2,772.4	845.0	5.700	144.8	78	82	86	90	94
702	2	95.46	95.64	0.57	10,111.1	3,081.9	1.880	47.8	111	122	132	141	150
704	2	96.61	97.00	1.03	5,544.8	1,690.1	3.590	91.2	95	102	109	115	121
706	2	98.65	99.19	0.52	11,089.6	3,380.1	1.610	40.9	113	125	135	145	154
707	2	101.62	102.00	0.35	16,370.4	4,989.7	1.110	28.2	130	144	158	170	182
708	2	102.49	102.75	0.85	6,740.8	2,054.6	2.140	54.4	93	102	110	117	124
710	2	103.35	103.53	2.08	2,750.2	838.3	2.740	69.6	63	68	73	77	82

NOTE: A ' * ' next to the Curve Number denotes a compund curve.

EASTBOUND

Track No. 1

PREPARED BY: Conrad J. Ruppert, Jr.
Mgr. Field Engineering

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Calculated Curving Speeds for the HARRISBURG Test Zone

CURVE NUMBER	TRACK NUMBER	MILEPOST LOCATION		AVERAGE CURVE GEOMETRY					CALCULATED CURVING SPEED				
				Degree	Curve Radius		Super-Elevation		3"ub	4"ub	5"ub	6"ub	7"ub
		[east]	[west]	[dec.deg.]	[feet]	[meters]	[inches]	[mm]	[mph]	[mph]	[mph]	[mph]	[mph]
706	1	102.19	101.57	0.30	19,098.8	5,821.3	1.540	39.1	147	162	176	189	202
705	1	100.44	99.88	0.45	12,732.6	3,880.9	1.410	35.8	118	131	143	153	163
704	1	99.23	98.83	1.00	5,729.7	1,746.4	3.420	86.9	96	103	110	116	122
703	1	97.87	97.67	0.72	7,994.9	2,436.8	1.420	36.1	94	104	113	122	130
702	1	97.49	97.29	0.40	14,324.1	4,366.0	1.330	33.8	124	138	150	162	172
701 *	1	97.20	96.55	2.20	2,604.4	793.8	6.030	153.2	77	81	85	88	92
700	1	95.89	95.47	1.45	3,951.5	1,204.4	4.380	111.3	85	91	96	101	106
699	1	95.43	94.82	2.00	2,864.8	873.2	5.870	149.1	80	84	88	92	96
698	1	94.15	93.72	0.97	5,927.2	1,806.6	3.360	85.3	97	104	111	118	124
697	1	93.30	92.80	1.03	5,544.8	1,690.1	3.430	87.1	94	101	108	114	120
696	1	88.25	88.04	0.52	11,089.6	3,380.1	1.460	37.1	111	123	134	144	153
695	1	86.53	86.20	2.08	2,750.2	838.3	5.920	150.4	78	82	87	90	94
694	1	86.09	85.81	0.97	5,927.2	1,806.6	3.280	83.3	96	104	111	117	123
693	1	85.66	85.01	1.98	2,888.9	880.5	5.880	149.4	80	84	89	93	96
692	1	84.59	83.97	0.75	7,639.5	2,328.5	2.220	56.4	100	109	117	125	133
691	1	83.55	82.86	0.52	11,089.6	3,380.1	0.700	17.8	101	114	126	136	146
690 *	1	82.33	81.90	0.97	5,927.2	1,806.6	2.410	61.2	89	97	105	111	118
689	1	81.47	81.25	0.55	10,417.5	3,175.3	2.270	57.7	117	128	137	147	155
688	1	80.23	79.77	0.57	10,111.1	3,081.9	1.610	40.9	108	119	129	139	147
687	1	79.25	79.16	0.38	14,946.9	4,555.8	1.070	27.2	123	137	150	162	173
686 *	1	77.80	77.63	1.05	5,456.8	1,663.2	3.380	85.9	93	100	107	113	119
685	1	77.27	77.06	1.07	5,371.5	1,637.2	2.590	65.8	87	94	101	107	113
683	1	75.15	74.80	0.97	5,927.2	1,806.6	2.610	66.3	91	99	106	113	119
682 *	1	74.69	74.15	1.05	5,456.8	1,663.2	2.450	62.2	86	94	101	107	113
681	1	72.77	72.32	0.97	5,927.2	1,806.6	3.440	87.4	98	105	112	118	124
680 *	1	72.16	71.69	1.05	5,456.8	1,663.2	3.510	89.2	94	101	108	114	120
679 *	1	71.00	70.56	1.03	5,544.8	1,690.1	3.520	89.4	95	102	109	115	121

NOTE: A ' * ' next to the Curve Number denotes a compound curve.

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Calculated Curving Speeds for the HARRISBURG Test Zone

CURVE NUMBER	TRACK NUMBER	MILEPOST LOCATION		AVERAGE CURVE GEOMETRY					CALCULATED CURVING SPEED				
				Degree	Curve Radius		Super-Elevation		3"ub	4"ub	5"ub	6"ub	7"ub
		[east]	[west]	[dec.deg.]	[feet]	[meters]	[inches]	[mm]	[mph]	[mph]	[mph]	[mph]	[mph]
678 *	1	69.93	68.40	1.00	5,729.7	1,746.4	3.490	88.6	96	103	110	116	122
677 *	1	66.57	66.25	0.97	5,927.2	1,806.6	3.550	90.2	98	106	112	119	125
676 *	1	66.21	64.78	0.35	16,370.4	4,989.7	0.730	18.5	123	139	153	166	178
675	1	63.85	63.49	1.00	5,729.7	1,746.4	3.090	78.5	93	101	108	114	120
674	1	63.20	62.96	0.47	12,277.8	3,742.3	0.650	16.5	106	119	132	143	153
673	1	62.07	61.61	1.05	5,456.8	1,663.2	3.550	90.2	94	101	108	114	120
672	**1**	**61.45**	**60.94**	**2.10**	**2,728.4**	**831.6**	**5.590**	**142.0**	**76**	**81**	**85**	**89**	**93**
671	**1**	**60.59**	**59.94**	**2.00**	**2,864.8**	**873.2**	**5.720**	**145.3**	**79**	**83**	**88**	**91**	**95**
670	1	59.65	59.51	1.07	5,371.5	1,637.2	3.580	90.9	94	101	107	113	119
669	1	58.95	58.39	1.57	3,657.2	1,114.7	5.660	143.8	89	94	99	103	107
668	1	57.62	57.34	0.62	9,291.3	2,832.0	1.390	35.3	101	112	122	131	139
667	1	56.60	55.75	0.97	5,927.2	1,806.6	2.570	65.3	91	99	106	113	119
666	1	54.54	54.36	0.48	11,854.4	3,613.2	1.050	26.7	109	122	134	144	154
665	1	53.96	53.63	0.50	11,459.3	3,492.8	0.910	23.1	106	118	130	141	150
664	1	53.21	52.70	2.08	2,750.2	838.3	5.650	143.5	77	81	85	89	93
663	**1**	**52.40**	**51.97**	**4.05**	**1,414.7**	**431.2**	**5.550**	**141.0**	**55**	**58**	**61**	**64**	**67**
662 *	**1**	**51.36**	**50.72**	**4.30**	**1,332.5**	**406.1**	**5.500**	**139.7**	**53**	**56**	**59**	**62**	**64**
661	1	50.56	50.14	2.00	2,864.8	873.2	5.700	144.8	79	83	87	91	95
660	1	50.02	49.78	1.05	5,456.8	1,663.2	3.550	90.2	94	101	108	114	120
659	1	49.11	48.81	0.98	5,826.8	1,776.0	3.400	86.4	96	104	110	117	123
658	1	48.68	48.30	1.05	5,456.8	1,663.2	3.480	88.4	94	101	107	114	119
657	1	48.24	47.45	2.02	2,841.1	866.0	5.300	134.6	77	81	85	89	93
656	1	46.90	46.75	0.32	18,093.6	5,514.9	0.500	12.7	126	142	158	171	184
655	1	45.35	45.25	0.37	15,626.3	4,762.9	0.810	20.6	122	137	150	163	174
654 *	2	44.81	43.61	0.48	11,854.4	3,613.2	0.960	24.4	108	121	133	143	153
653	2	41.64	41.34	0.67	8,594.5	2,619.6	2.020	51.3	104	114	123	131	139
652	2	41.04	40.87	0.85	6,740.8	2,054.6	2.150	54.6	93	102	110	117	124

NOTE: A ' * ' next to the Curve Number denotes a compound curve.

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Calculated Curving Speeds for the HARRISBURG Test Zone

CURVE NUMBER	TRACK NUMBER	MILEPOST LOCATION		AVERAGE CURVE GEOMETRY					CALCULATED CURVING SPEED				
				Degree	Curve Radius		Super-Elevation		3"ub	4"ub	5"ub	6"ub	7"ub
		[east]	[west]	[dec.deg.]	[feet]	[meters]	[inches]	[mm]	[mph]	[mph]	[mph]	[mph]	[mph]
651	2	39.89	39.43	0.65	8,814.8	2,686.8	2.430	61.7	109	119	128	136	144
650	2	39.10	38.39	0.57	10,111.1	3,081.9	1.940	49.3	112	122	132	141	150
649	2	37.92	37.33	1.05	5,456.8	1,663.2	3.180	80.8	92	99	105	112	118
648	2	37.27	36.79	0.95	6,031.2	1,838.3	2.560	65.0	91	99	107	113	120
647	2	35.81	35.69	0.35	16,370.4	4,989.7	1.890	48.0	141	155	168	179	190
646	2	35.09	35.07	0.27	21,486.2	6,549.0	1.180	30.0	150	167	182	196	209
645 *	2	35.06	34.83	0.47	12,277.8	3,742.3	1.550	39.4	118	130	142	152	162
644 *	1	34.47	34.06	0.88	6,486.4	1,977.1	3.120	79.2	99	107	115	121	128
643 *	1	34.01	33.49	0.77	7,473.5	2,277.9	2.770	70.4	104	112	120	128	135
642	1	33.10	32.84	0.80	7,162.1	2,183.0	2.580	65.5	100	108	116	124	131
641 *	1	32.55	32.11	1.05	5,456.8	1,663.2	3.520	89.4	94	101	108	114	120
640	1	31.53	31.22	1.68	3,403.8	1,037.5	5.840	148.3	87	91	96	100	104
639	1	30.78	30.28	2.45	2,338.6	712.8	5.830	148.1	72	76	79	83	86
638	1	30.22	29.79	3.00	1,909.9	582.1	5.630	143.0	64	68	71	74	78
634	1	25.68	25.46	0.47	12,277.8	3,742.3	1.690	42.9	120	132	143	153	163
631	1	24.47	24.19	0.47	12,277.8	3,742.3	1.440	36.6	117	129	140	151	161
630	1	22.70	22.30	2.12	2,706.9	825.1	5.830	148.1	77	81	85	89	93
629	1	22.26	21.94	2.05	2,795.0	851.9	5.860	148.8	79	83	87	91	95
628	1	21.82	21.57	2.05	2,795.0	851.9	5.570	141.5	77	82	86	90	94
627 *	1	20.41	19.96	1.40	4,092.6	1,247.4	2.690	68.3	76	83	89	94	99
626	1	19.30	19.17	0.97	5,927.2	1,806.6	1.410	35.8	81	89	97	105	111
625	1	18.69	17.62	0.50	11,459.3	3,492.8	1.020	25.9	107	120	131	142	151
624	1	17.52	17.17	4.27	1,342.9	409.3	4.880	124.0	51	55	58	60	63
623	1	16.97	16.59	2.33	2,455.6	748.5	5.260	133.6	71	75	79	83	87
622 *	1	15.94	14.88	1.42	4,044.5	1,232.8	4.220	107.2	85	91	96	102	106
621	1	14.68	14.42	1.32	4,351.6	1,326.4	4.200	106.7	88	94	100	105	110
620	1	13.58	13.35	3.12	1,838.4	560.3	5.860	148.8	64	67	71	74	77

NOTE: A ' * ' next to the Curve Number denotes a compound curve.

NATIONAL RAILROAD PASSENGER CORPORATION

ICEtrain Calculated Curving Speeds for the HARRISBURG Test Zone

CURVE NUMBER	TRACK NUMBER	MILEPOST LOCATION		AVERAGE CURVE GEOMETRY					CALCULATED CURVING SPEED				
				Degree	Curve Radius		Super-Elevation		3"ub	4"ub	5"ub	6"ub	7"ub
		[east]	[west]	[dec.deg.]	[feet]	[meters]	[inches]	[mm]	[mph]	[mph]	[mph]	[mph]	[mph]
619 *	1	13.27	12.41	2.10	2,728.4	831.6	4.560	115.8	72	76	81	85	89
618 *	1	12.30	11.70	0.57	10,111.1	3,081.9	0.490	12.4	94	106	118	128	137
617	1	11.25	10.96	2.07	2,772.4	845.0	4.950	125.7	74	79	83	87	91
616	1	10.96	10.59	2.00	2,864.8	873.2	5.040	128.0	76	80	85	89	93
615	1	9.52	9.28	1.02	5,635.7	1,717.8	3.630	92.2	97	104	110	116	122
614	1	8.97	8.72	0.33	17,189.0	5,239.2	1.080	27.4	132	148	161	174	186
613	1	8.03	7.37	1.48	3,862.7	1,177.3	4.040	102.6	82	88	93	98	103
612 *	1	6.92	5.97	2.40	2,387.4	727.7	4.780	121.4	68	72	76	80	84
611	1	5.88	4.80	1.15	4,982.3	1,518.6	2.720	69.1	84	91	98	104	110
606 *	1	3.37	3.22	0.98	5,826.8	1,776.0	2.380	60.5	88	96	104	110	117
603	4	2.89	2.75	0.95	6,031.2	1,838.3	0.920	23.4	77	86	94	102	109
602	4	2.66	2.56	1.50	3,819.8	1,164.3	2.340	59.4	71	78	84	89	94
601	4	2.17	2.08	1.38	4,141.9	1,262.5	1.040	26.4	65	72	79	85	91
600 *	4	1.98	1.75	4.55	1,259.3	383.8	0.560	14.2	33	38	42	45	49

NOTE: A ' * ' next to the Curve Number denotes a compound curve.