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X2000 U.S. Demonstration Vehicle Dynamics Trials, Preliminary Test Report

Office of Research and Development
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13. ABSTRACT (Maximum 200 words)

This preliminary report documents the procedures, events, and results of vehicle dynamic tests carried out on the ASEA-Brown Boveri (ABB) X2000 tilt body trainset in the U.S. between October 1992 and January 1993. These tests, sponsored by Amtrak and supported by the FRA, were conducted to assess the suitability of the X2000 trainset for safe operation at elevated cant deficiencies and speeds in Amtrak's Northeast Corridor under existing track conditions in a revenue service demonstration.

The report describes the safety criteria against which the performance of the X2000 test train was examined, the instrumentation used, the test locations, and the track conditions. Preliminary results are presented from tests conducted on Amtrak lines between Philadelphia and Harrisburg, PA, and between Washington DC and New York NY, in which cant deficiencies of 12.5 inches and speeds of 154 mph were reached in a safe and controlled manner. The significance of the results is discussed, and preliminary conclusions and recommendations are presented.

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PREFACE

Many advanced intercity high-speed train technologies have become an operating reality in recent years. Though mostly of foreign origin, these new trains offer the 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 appropriate to the parent country's transportation policy, and must be evaluated with regards to applicability to U.S. practices and expectations to ensure that the safety levels are maintained in the U.S. environment. This responsibility 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 Swedish X2000 tilting train, manufactured by ASEA-Brown Boveri (ABB), offers opportunity for application over the existing rail infrastructure. For evaluation purposes, a representative X2000 trainset was provided to Amtrak by the Swedish State Railways (SJ) 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 SJ, data analysis support provided by ABB, 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 describes the procedures and results of the vehicle dynamics tests carried out with the X2000 trainset in the Northeast Corridor and on the Philadelphia - Harrisburg line, in a time period between October, 1992, and January, 1993. Instrumented wheelsets, installed on both the power car and cab car ends of the trainset, provided direct and immediate measurement of the wheel/rail forces experienced during high speed and high 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.

This test report, prepared for the U.S. DOT, FRA Office of Research and Development, is preliminary in nature. Its purpose was to provide the FRA Office of Safety Enforcement with timely technical data and test results on which to base decisions in establishing operating limits for the ensuing revenue service demonstration of the X2000 trainset in the Northeast Corridor. The final report describing the complete test program and results will be forthcoming in a separate document.

The authors wish to thank Arne Bang and Thomas Schultz of the FRA Office of Research and Development, for their direction and support in realizing the test and demonstration, and Ken Koehler who managed the program for Amtrak. Valuable information during the test program and in the preparation of this document was provided by Amtrak, under the test 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 ABB Traction, lead by Jan-Olof Häggblad and Roger Nilsson, and the personnel of SJ, lead by Lennart Kloow and Martin Bäfverfeldt are gratefully acknowledged for their careful preparation, proficient data collection and presentation.

Finally, the authors wish to thank Thomas Edwards of ABB Traction for his thorough, informed analysis and interpretation of the test data and valuable discussions throughout the program.

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in²	square inches	645.2	millimetres squared	mm²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
MASS (weight)				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

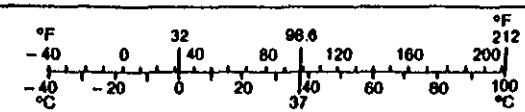
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
MASS (weight)				
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

X2000 U.S. DEMONSTRATION VEHICLE DYNAMICS TRIALS

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1. INTRODUCTION/BACKGROUND

1.1 SUMMARY

The evaluation program for the X2000 trainset involved a series of different technical tests followed by two simulated or demonstration revenue service operations. Each test in sequence was dependent upon successful completion and analysis of performance from previous tests.

The overall test sequence was as follows:

1) Commissioning - confirmed operational readiness.
2) Cant Deficiency - established safe curving limits.
3) High Speed Stability - established maximum safe speed.
4) Pre-Revenue Test Runs - demonstrated the safety of the intended revenue service operation.

The purpose of this preliminary test report is to document the procedures, events and results from the overall test program, to support Amtrak's request for FRA approval for operation in revenue service.

Current plans for revenue service type operations include approximately four months of revenue service between Washington, DC and New Haven (or New York City).

1.1.1 Commissioning Tests in Northeast Corridor

The purpose of the commissioning tests was to confirm operational readiness, up to 125 mph, with particular interest in: 1) propulsion systems, 2) safety appliances (i.e.- lights, horns, etc.), 3) brake systems, and 4) cab signals.

A stop test using only air brakes was performed from 125 mph.

Operational checkout was also performed for:

- tight switch/curve negotiation,
- clearances,
- ride quality of a coach and locomotive,
- basic vehicle stability,
- stop distance,
- EMI (including during regeneration braking),
- pantograph uplift forces, and
- acceleration/current draw and transformer in-rush current.

(NOTE: interior and wayside sound level, stop distances, and wheel and disc temperatures were assessed using data provided by ABB).

1.1.2 Cant Deficiency Tests

5" to 12" cant deficiency runs were conducted over a test zone between Harrisburg and Philadelphia (curves between MP 44 to MP 68 were identified as suitable test candidates.

7" to 12" cant deficiency tests were run between New Brunswick and Metro Park.

1.1.3 High Speed Stability Tests

Tests of high speed stability were conducted east of Trenton between MP34 and MP54 on the Northeast Corridor (NEC) Mainline. Tests were scheduled to a maximum speed of 150 mph.

Stop tests, using air brakes only, were performed during a run at which 135 mph was achieved and a run at which 151 mph was achieved.

1.1.4 Pre-Revenue Test Run - Round Trip Washington to New York City

A recommended revenue speed profile run between Washington and New York City was submitted by Amtrak and approved by the FRA. Following the above tests, two round trips were made between Washington and New York City, one at the proposed revenue service cant deficiency/speed profile and the second at a speed profile 5 mph faster where the 125 mph maximum speed would not be exceeded.

1.1.5 New York to Boston Demonstration

Following the successful completion of the above tests and approval by the FRA, the X2000 was operated on several demonstration runs at a maximum of seven inches of cant deficiency on Metro North and eight inches of cant deficiency elsewhere. This consist was powered by two RTL turbo locomotives, between New Haven and Boston.

1.1.6 Revenue Service Operation

Following successful completion of the above and approval by the FRA, the X2000 will be placed in service in the Northeast Corridor from New Haven and New York City to Washington and from New York City to Boston for approximately two (2) months.

1.2 INTRODUCTION AND AIMS

The objective of this test was to determine the suitability of the X2000 trainset for operation at elevated cant deficiencies and speeds in Amtrak's Northeast Corridor under existing track conditions. The results of the technical tests will be used as a basis for the FRA to assess and evaluate Amtrak's request to run the X2000 at higher cant deficiencies and speeds in a revenue service demonstration.

1.3 REPORT ORGANIZATION

The purpose of this preliminary test report is to document the procedures, events and results from the overall test program as a reference for the FRA to assess Amtrak's request for demonstration in revenue service.

The safety criteria against which the performance of the X2000 test train was examined during the tests are reviewed in **Section 2.** The train configuration, instrumentation, procedures, and test locations are discussed in **Section 3.** Preliminary results of testing on the Philadelphia - Harrisburg and NEC mainlines are presented in **Section 4.** In **Section 5,** the significance of the results are discussed, and in **Section 6,** preliminary conclusions and recommendations are drawn from the results.

2. SAFETY REQUIREMENTS

The fundamental basis for safe operation at higher cant deficiencies and speeds 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 hunting.

2.1 SAFETY CRITERIA

Instrumented wheelsets were installed on the locomotive and on the driving trailer (cab car) of the X2000 trainset (a total of 4) to directly measure wheel/rail forces during these tests. The safety criteria against which the measured wheel forces are assessed were established prior to testing and are given below. These 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 X2000 locomotive, NAL < 90 kN
- for the X2000 cab car, NAL < 78 kN

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

- conditions considered safe if each wheel L/V is less than 0.8; if any wheel exceeds 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 X2000 locomotive, Vmin > 9.0 kN
- for the X2000 cab car, Vmin > 7.8 kN

5) Truck Hunting: | Truck Frame Acceleration | < 0.8 g

- no sustained oscillations

Measurements of safety parameters 1) - 4) were low-pass filtered at 25 Hz; measurements of 5), truck frame acceleration, were band-pass filtered, 2 - 8 Hz.

During any test run, these safety criteria were monitored to ensure that none of the above limits were exceeded. Data projections had been used to minimize the likelihood that any safety limit would be exceeded. Prior to each run above five inches of cant deficiency, the track was visually inspected by Amtrak.

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.

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

Review of Test Safety Assurance

Prior to test initiation, ABB provided test results from previous X2000 trials carried out in Germany. It was demonstrated that, during these tests, no safety criteria limits were reached and that a substantial margin of safety was evident for all cant deficiencies. Issues of note included:

- top speed was 251 km/h; maximum cant deficiency was 12 inches.
- track in Germany is of better Class than in U.S.; measured lateral forces on U.S. track were expected to be somewhat higher, but the load limits are higher also.
- radial steering made a significant contribution to the reduction of wheel/rail forces in curves of 500 m radius and greater; for curve radii less than 500 m, partial radial steering was purported to reduce wear and wheel/rail noise.

Comparisons of simulation predictions and measurements taken from tests in Sweden were also provided; agreement was good (given the limitations of the simulation) and a good margin of safety was both predicted and observed.

For comparison purposes, measurements taken from previous tests on the NEC of a somewhat similar vehicle, the "banking Amcoach", at cant deficiencies up to 12 inches were reviewed. Again, a good margin of safety was observed.

A test zone of the Harrisburg Line, including 4 principal curves, was referenced for the presentation of simulation predictions. ABB provided model projections of the anticipated forces and L/V ratios using, as input, track data (specifically Track 4) from this test zone provided by Amtrak. Items noted include:

- a 2-point wheel-rail contact condition could occur in most curves of the Harrisburg Line, given the worn track profile; projections for both single and 2-point contact conditions were reviewed.
- significant track alignment deviations measured by Amtrak at the beginning and end of curve transition spirals were included in the simulation.

- the critical speed (hunting), even at an equivalent conicity of 0.4, is predicted to be well above 150 mph (~165 - 175 mph).

Extensive vehicle dynamic simulations were carried out for the X2000 configuration, the details of which are given in (proprietary) ABB Reports TRP 9224 and TRP 9226. The data used in these simulations are representative of the X2000 vehicle types that went to make up the actual X2000 trainset under test in the United States.

The relevant pages of TRP 9226 give an explanation of the main parameters used in the simulations mentioned above. Thereafter follow several tables giving the values of parameters for the different vehicles in the X2000 of the mathematical model.

3. TEST PROCEDURE

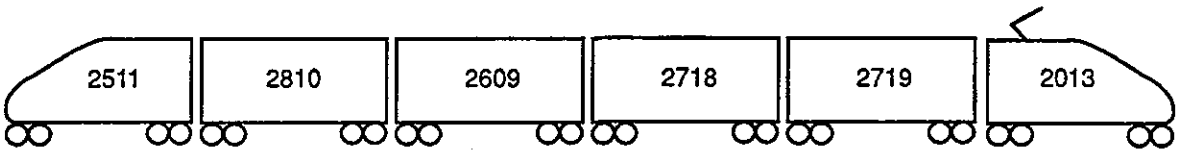
3.1 TRAIN CONFIGURATION

The X2000 trainset used during the trials was comprised of a 6 car consist as indicated below.

CAR TYPE	CAR CLASS	CAR NUMBER
Locomotive	X2	2013
Coaches	UA2	2719
	UA2	2718
	UA2	2810
First-Class Buffet	UAR2	2609
Driving Trailer (Cab Car)	UA2X	2511

UA2X + UA2 + URA + UA2 + UA2 + X2

Driving trailer + 1st Class Car + Bistro Car + 1st Class Car + 1st Class Car + Power Unit



Two RTL turbo power cars were coupled to the X2000 trainset for motive power in the non-electrified territory between New Haven and Boston only.

Wheel Profile

The X2000 demonstrated in the US was equipped throughout with S1002 wheel profiles with a thin 30mm flange. This profile had been chosen to approximate the AAR 1B, and to provide:

- o adequate conicity and thus steering of wheelsets in curves,
- o stable running at speed even on sections of tight gauge (no less than 1428mm), and
- o a stable wheel profile shape which should not change too much with wear.

The X2000 wheel profile was checked by superimposing it on the Amtrak standard wheel profile per drawing 246. The Amtrak wheel profile is identical to the AAR wheel profile, the only exception being the tread taper modified from 1:20 to 1:40. The comparison showed the X2000 and Amtrak profiles to be very similar, and the X2000 profile was approved for use on the Amtrak system.

The suitability of this profile to conditions on the North East Corridor (NEC) has been investigated by ABB for the 140 RE rail profile both as new and for actual worn rail profiles measured in curves 662 and 663 (track #4) at Gap and Eby's on the Harrisburg Line, and from worn rail head profiles for tangent track of the section of the NEC where 150 mph running was performed. An analysis of the profiles indicates that rail heads are worn slightly flatter than new 140RE rail which leads ABB to expect that equivalent conicities exceeding 0.4 are possible (continuous rail head profiles would be needed to enable a check of the entire route). Significant deviation of maximum likely equivalent conicity from the above values was not likely and did not occur as far as known.

For more detailed description and analyses of the probable wheel-rail combinations met during trails on the Harrisburg Line and for nominal conditions in the United States of America, see ABB Report TRP 9224, Section 3.3.

3.2 INSTRUMENTATION

A description of the measurement transducers and their locations on the vehicle is given in **Table 3.1**, and depicted in **Figure 3.1**.

The nomenclature used to define each signal name was as follows:

V = Vertical wheel/rail force
L = Lateral wheel/rail force
y = Lateral acceleration
z = Vertical acceleration
l = left side
r = right side
a = axle, on axle bearing
b = bogie (truck), on bogie
cb = car body, on car floor over bogie (truck) center

TABLE 3.1 TRANSDUCERS AND SIGNAL NAMES FOR X2000 TEST RUNS

Signal #	Transducer Type	Signal Name	Description
1	Instrumented Wheelset	L1l	W/R Lateral Force, Axle 1, left wheel (Locomotive)
2	Instrumented Wheelset	L1r	W/R Lateral Force, Axle 1, right wheel (Locomotive)
3	Instrumented Wheelset	V1l	W/R Vertical Force, Axle 1, left wheel (Locomotive)
4	Instrumented Wheelset	V1r	W/R Vertical Force, Axle 1, right wheel (Locomotive)
5	Instrumented Wheelset	L2l	W/R Lateral Force, Axle 2, left wheel (Locomotive)
6	Instrumented Wheelset	L2r	W/R Lateral Force, Axle 2, right wheel (Locomotive)
7	Instrumented Wheelset	V2l	W/R Vertical Force, Axle 2, left wheel (Locomotive)
8	Instrumented Wheelset	V2r	W/R Vertical Force, Axle 2, right wheel (Locomotive)
9	Instrumented Wheelset	L23l	W/R Lateral Force, Axle 23, left wheel (Cab Car)
10	Instrumented Wheelset	L23r	W/R Lateral Force, Axle 23, right wheel (Cab Car)
11	Instrumented Wheelset	V23l	W/R Vertical Force, Axle 23, left wheel (Cab Car)
12	Instrumented Wheelset	V23r	W/R Vertical Force, Axle 23, right wheel (Cab Car)
13	Instrumented Wheelset	L24l	W/R Lateral Force, Axle 24, left wheel (Cab Car)
14	Instrumented Wheelset	L24r	W/R Lateral Force, Axle 24, right wheel (Cab Car)
15	Instrumented Wheelset	V24l	W/R Vertical Force, Axle 24, left wheel (Cab Car)
16	Instrumented Wheelset	V24r	W/R Vertical Force, Axle 24, right wheel (Cab Car)
17	Servo Accelerometer	ycb1	Lateral Acceleration in car over Bogie 1 (Locomotive)
18	Servo Accelerometer	zcb1	Vertical Acceleration in car over Bogie 1 (Locomotive)
19	Servo Accelerometer	yb1	Lateral Acceleration, Bogie 1 (Locomotive)
20	Variable Capacitance Accelerometer	ya2	Lateral Acceleration, Axle 2 (Locomotive); used to measure unbalance or cant deficiency
21	Servo Accelerometer	ycb5	Lateral Acceleration in car over Bogie 5 (Coach)
22	Servo Accelerometer	zcb5	Vertical Acceleration in car over Bogie 5 (Coach)
23	Servo Accelerometer	yb5	Lateral Acceleration, Bogie 5 (Coach)
24	Servo Accelerometer	ycb12	Lateral Acceleration in car over Bogie 12 (Cab Car)
25	Servo Accelerometer	zcb12	Vertical Acceleration in car over Bogie 12 (Cab Car)
26	Servo Accelerometer	yb12	Lateral Acceleration, Bogie 12 (Cab Car)
27	Servo Accelerometer	ycbRTL	Lateral Acceleration in car over front Bogie of leading RTL unit (Boston - New Haven tests only)
28	Speed Pickup	v	Trainset forward speed

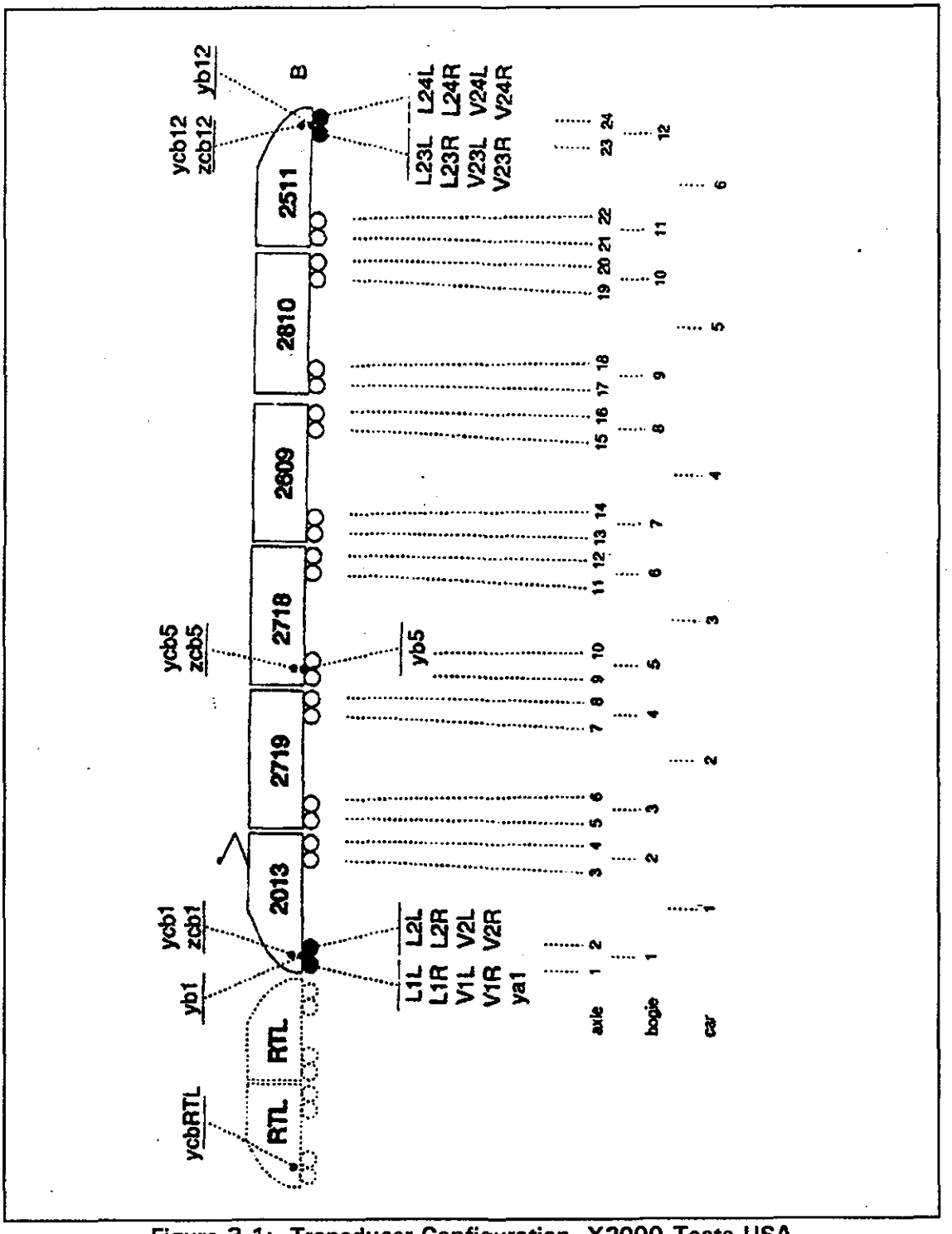


Figure 3.1: Transducer Configuration, X2000 Tests USA

3.3 CHANNEL DESIGNATION

Safety criteria parameters were displayed in real time during the test runs using five 6-channel strip chart recorders. The channel allocations and descriptions are given in **Table 3.2.**

TABLE 3.2 STRIP CHART RECORDER CHANNEL DESIGNATIONS

Stripchart Channel #	Signal Name	Description
1.1	NA1L	Net Axle Lateral Force, Axle 1 (Locomotive) [kN] {0 to ±100 kN}
1.2	V1l	Vertical Wheel Force, Axle 1, left wheel (Locomotive) [kN] {0 to 200 kN}
1.3	V1r	Vertical Wheel Force, Axle 1, right wheel (Locomotive) [kN] {0 to 200 kN}
1.4	NA2L	Net Axle Lateral Force, Axle 2 (Locomotive) [kN] {0 to ±100 kN}
1.5	V2l	Vertical Wheel Force, Axle 2, left wheel (Locomotive) [kN] {0 to 200 kN}
1.6	V2r	Vertical Wheel Force, Axle 2, right wheel (Locomotive) [kN] {0 to 200 kN}
2.1	L/V1l	Wheel L/V Ratio, Axle 1, left wheel (Locomotive) {-0.1 to 0.9}
2.2	L/V1r	Wheel L/V Ratio, Axle 1, right wheel (Locomotive) {-0.1 to 0.9}
2.3	L/V2l	Wheel L/V Ratio, Axle 2, left wheel (Locomotive) {-0.1 to 0.9}
2.4	L/V2r	Wheel L/V Ratio, Axle 2, right wheel (Locomotive) {-0.1 to 0.9}
2.5	T1-L/Vl	Truck Side L/V Ratio, Truck 1, left side (Locomotive) {-0.1 to 0.9}
2.6	T1-L/Vr	Truck Side L/V Ratio, Truck 1, right side (Locomotive) {-0.1 to 0.9}
3.1	NA23L	Net Axle Lateral Force, Axle 23 (Cab Car) [kN] {0 to ±100 kN}
3.2	V23l	Vertical Wheel Force, Axle 23, left wheel (Cab Car) [kN] {0 to 200 kN}
3.3	V23r	Vertical Wheel Force, Axle 23, right wheel (Cab Car) [kN] {0 to 200 kN}
3.4	NA24L	Net Axle Lateral Force, Axle 24 (Cab Car) [kN] {0 to ±100 kN}
3.5	V24l	Vertical Wheel Force, Axle 24, left wheel (Cab Car) [kN] {0 to 200 kN}
3.6	V24r	Vertical Wheel Force, Axle 24, right wheel (Cab Car) [kN] {0 to 200 kN}
4.1	L/V23l	Wheel L/V Ratio, Axle 23, left wheel (Cab Car) {-0.1 to 0.9}
4.2	L/V23r	Wheel L/V Ratio, Axle 23, right wheel (Cab Car) {-0.1 to 0.9}
4.3	L/V24l	Wheel L/V Ratio, Axle 24, left wheel (Cab Car) {-0.1 to 0.9}
4.4	L/V24r	Wheel L/V Ratio, Axle 24, right wheel (Cab Car) {-0.1 to 0.9}
4.5	T12-L/Vl	Truck Side L/V Ratio, Truck 12, left side (Cab Car) {-0.1 to 0.9}
4.6	T12-L/Vr	Truck Side L/V Ratio, Truck 12, right side (Cab Car) {-0.1 to 0.9}
5.1	ya2	Lateral Acceleration, Axle 2 (Locomotive) [m/s^2] {0 to ± 2.5 m/s^2}
5.2	ycb5	Lateral Acceleration, car over Truck 5 (Coach) [m/s^2] {0 to ± 2.5 m/s^2}
5.3	ycb12	Lateral Acceleration, car over Truck 12 (Cab) [m/s^2] {0 to ± 2.5 m/s^2}
5.4	yb12	Lateral Acceleration, Truck 12 (Cab Car) [m/s^2] {0 to ± 10 m/s^2}
5.5	v	Vehicle forward speed [mph] {0 to 150 mph}
5.6		Tractive effort

3.4 TEST ZONES

The trials run to date have been divided up into four main test zones:

100 Series Philadelphia - Harrisburg Line **between Parkesburg and Lancaster;** Cant Deficiency Tests up to 110 mph

200 Series Northeast Corridor (NEC) Mainline (Philadelphia - New York) **between New Brunswick and Metro Park;** Cant Deficiency Tests up to 125 mph

300 Series NEC Mainline (Philadelphia - New York) **between Trenton and New Brunswick;** High Speed Stability Tests up to 150 mph

400 Series NEC Mainline **between Washington, DC and New York Penn Station;** Simulated Revenue Earning Service Long Distance Runs up to 125 mph

3.4.1 100 Series Test Runs, Philadelphia - Harrisburg Line, MP 44 - 68

The test zone between Parkesburg (MP 44) and Lancaster (MP 68) comprised 24 miles (39 km) of electrified double track on wooden ties with tie-plates and cut spike rail fasteners. The majority of rail was 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. At approximate intervals of two miles, a 30 foot cut section (insulated joint) was welded into the track for signalling (cab signal) purposes. The track was well bedded in stone ballast. Although the wooden ties fully meet the FRA safety standards for the speeds run, there were a number of isolated locations where ties were allowing little gauge widening restraint.

There are 23 curves encountered within this test zone on each track as described in Appendix B. Four particular test curves were selected for more detailed computer analyses in two groups of reversed pairs for each track. Travelling west in the direction of Lancaster on Track #4, these particular test curves are encountered as follows:

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	12" UB Speed	Direction
662 (A&B)	Gap	51	4° 10′ [419 m]	5 1/2"	55 mph	77 mph	Left
663	Eby's	52 - 53	4° 12′ [416 m]	6"	55 mph	78 mph	Right
671	Ronks	60 - 61	2° 4′ [845 m]	6"	75 mph	112 mph	Right
672	Bird-in-Hand	61 - 62	2° 2′ [859 m]	6"	75 mph	112 mph	Left

Travelling East in the direction of Parkesburg on Track #1, the detailed test curves are encountered as follows:

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	12" UB Speed	Direction
672	Bird-in-Hand	62 - 61	2° 4′ [845 m]	5 3/4"	75 mph	111 mph	Right
671	Ronks	61 - 60	2° 1′ [866 m]	5 3/4"	75 mph	112 mph	Left
663	Eby's	53 - 52	4° 6′ [426 m]	5 1/2"	50 mph	78 mph	Left
662 (A&B)	Gap	51	4° 16′ [409 m]	5 1/2"	50 mph	77 mph	Right

3.4.2 200 Series Test Runs, New Brunswick to Metro Park, MP 31 - 21

The test zone, roughly between New Brunswick (MP 31) and Metro Park (MP 21) comprised 10 miles (16 km) of electrified quadruple track. The two center high speed tracks consisted of concrete mono-block ties with Pandrol rail fasteners. The majority of rail was CWR with a 140 RE profile. The interlockings (cross-overs) were on wooden ties with tieplates and cut spike rail fasteners. At approximate intervals of two miles, a 30 foot cut section (insulated joint) was welded into the track for signalling (cab signal) purposes. The track was well bedded in stone ballast. The maximum line speed in the zone was 125 mph.

There are 12 curves encountered within this test zone on each track as described in Appendix B. Three particular test curves were selected for more detailed computer analyses in two groups comprising one reversed pair and a singlet for each of the high speed Tracks # 2 and 3. Travelling East in the direction of Metro Park on Track #2, the particular test curves are encountered as follows:

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	12" UB Speed	Direction
268	1st Curve west of Lincoln	27 - 26	1° 52′ [934 m]	6"	80 mph	117 mph	Left
266	Curve west of MP 24	25 - 24	1° 33′ [1127 m]	5 3/4"	90 mph	128 mph	Left
265	Curve east of MP 24	24 - 23	1° 27′ [1204 m]	5 1/4"	90 mph	130 mph	Right

Travelling West in the direction of New Brunswick on Track #3, the detailed test curves are encountered as follows:

Curve Number	Curve Name	Location MP	Curvature/ [Radius]	Super elevation	Posted Speed	12" UB Speed	Direction
265	Curve east of MP 24	23 - 24	1° 26' [1221 m]	6"	90 mph	134 mph	Left
266	Curve west of MP 24	24 - 25	1° 30' [1164 m]	5 1/4"	90 mph	128 mph	Right
268	1st Curve west of Lincoln	26 - 27	1° 56' [905 m]	6"	80 mph	115 mph	Right

3.4.3 300 Series Test Runs, Trenton to New Brunswick, MP 55 - 32

The test zone between Trenton (MP 55) and New Brunswick (MP 32) comprised 22 miles (35 km) of electrified quadruple track. The two center high speed tracks consisted of concrete mono-block ties with Pandrol rail fasteners. The majority of rail was CWR with a 140 RE profile. The interlockings (cross-overs) were on wooden ties with tieplates and cut spike rail fasteners. At approximate intervals of two miles, a 30 foot cut section (insulated joint) was welded into the track for signalling (cab signal) purposes. The track was well bedded in stone ballast. The maximum line speed was normally 125 mph but had been raised to 150 mph for the X2000 tests only.

Of the 6 curves within this test zone, two large radius curves were passed at the Eastern one-third of the test zone on each of the high speed Tracks # 2 and 3. Travelling East in the direction of New Brunswick on Track # 2, these higher radius curves are encountered as follows:

Curve Number	Location MP	Curvature/ [Radius]	Super elevation	Ord Speed	UB at 150 mph	Direction
276	41 - 39	0° 32' [3274 m]	3 5/8"	125 mph	4.6"	Left
275	39	0° 19' [5514 m]	2"	125 mph	2.9"	Right

Travelling West in the direction of Trenton on Track #3, the higher radius curves are encountered as follows:

Curve Number	Location MP	Curvature/ [Radius]	Super elevation	Ord Speed	UB at 150 mph	Direction
275	39	0° 20' [5238 m]	2 1/8"	125 mph	3.0"	Right
276	39 - 41	0° 31' [3379 m]	3 1/2"	125 mph	4.5"	Left

3.4.4 400 Series Test Runs, Washington,DC to New York Penn Station

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 consisted predominantly of concrete mono-block ties with Pandrol rail fasteners. The majority of rail was CWR with a 140 RE profile. All but a few interlockings (cross-overs) were on wooden ties with tieplates and cut spike rail fasteners. At approximate intervals of two miles, a 30 foot cut section (insulated joint) was welded into the track for signalling (cab signal) purposes. The track was well bedded in stone ballast. The maximum line speed was normally 125 mph but was often restricted to less due to Metroliner trains not allowed linespeeds for more than 4 inches of unbalance. The 150 mph test speed for the X2000 between Trenton and New Brunswick was not in force during the 400 Series long distance test runs. Turnouts (switches) and numerous curves of different radii and superelevation were encountered along the route. See Appendix B for a full curve and speed profile description.

Track data in space-curve form has been supplied by Amtrak for various portions of the test zones. These data will be described in more detail in the final analysis.

3.5 TEST SEQUENCE

The test sequence is described in the Test Event Log of Appendix A and is summarized in **Table 3.3.**

3.6 METHOD FOR DETERMINATION OF CANT DEFICIENCY/UNBALANCE

Unbalance has been calculated from the lateral acceleration signal generated by an accelerometer installed on the axle box lower damper bracket of axle (wheelset) number 2 of the locomotive. 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 detected by the passing train and informed the onboard computer of the time each curve was entered and exited for each test run on a consistent basis. From such acceleration signals it has been possible to determine the duration of wheelset 2 in the full body of each test curve. The portion of the axle box lateral acceleration signal so identified was averaged in order to determine the mean track-plane lateral acceleration or cant deficiency of the train in the full body of each curve.

The effect of wheelset lateral displacement relative to the track causing a slight change in cant of the wheelset on the track (due to conical type wheel profiles) has been ignored. Where magnets did not identify curves, manual inspection of the signal was used to determine the duration of the full body of the curve.

The full body of any curve is judged to exist where the steady state values of both curvature and superelevation have been reached at two points in the curve between

which the sum of the fluctuations of the actual curvature and actual superelevation from their intended steady state values respectively tend to zero.

TABLE 3.3 X2000 TEST RUNS IN CHRONOLOGICAL ORDER

Date	Run #	Line	Direction/ Track	Track Condit	Scheduled Unbalance/Speed	Leading Car/ Axle
Nov 30/92	101	Ph - Hrsbg	W / Trk 4	Dry	3"	Cab Car / Axle 24
"	102	Hrsbg - Ph	E / Trk 1	Dry	5"	Locomotive / Axle 1
"	103	Ph - Hrsbg	W / Trk 4	Dry	6"	Cab Car / Axle 24
"	104	Hrsbg - Ph	E / Trk 1	Dry	6"	Locomotive / Axle 1
"	105	Ph - Hrsbg	W / Trk 4	Dry	7"	Cab Car / Axle 24
"	106	Hrsbg - Ph	E / Trk 1	Dry	7"	Locomotive / Axle 1
Dec 1/92	107	Ph - Hrsbg	W / Trk 4	Damp	7"	Cab Car / Axle 24
"	108	Hrsbg - Ph	E / Trk 1	Damp	7"	Locomotive / Axle 1
"	109	Ph - Hrsbg	W / Trk 4	Wet	8"	Cab Car / Axle 24
"	110	Hrsbg - Ph	E / Trk 1	Wet	8"	Locomotive / Axle 1
"	111	Ph - Hrsbg	W / Trk 4	Wet	9"	Cab Car / Axle 24
"	112	Hrsbg - Ph	E / Trk 1	Wet	9"	Locomotive / Axle 1
"	113	Ph - Hrsbg	W / Trk 4	Wet	10"	Cab Car / Axle 24
"	114	Hrsbg - Ph	E / Trk 1	Wet	10"	Locomotive / Axle 1
Dec 2/92	115	Ph - Hrsbg	W / Trk 4	Dry	10"	Cab Car / Axle 24
"	116	Hrsbg - Ph	E / Trk 1	Dry	10"	Locomotive / Axle 1
"	117	Ph - Hrsbg	W / Trk 4	Dry	11"	Cab Car / Axle 24
"	118	Hrsbg - Ph	E / Trk 1	Dry	11"	Locomotive / Axle 1
"	119	Ph - Hrsbg	W / Trk 4	Dry	12"	Cab Car / Axle 24
"	120	Hrsbg - Ph	E / Trk 1	Dry	12"	Locomotive / Axle 1
Dec 3/92	121	Ph - Hrsbg	W / Trk 4	Dry	9"	Locomotive / Axle 1
"	122	Hrsbg - Ph	E / Trk 1	Dry	10"	Cab Car / Axle 24
"	123	Ph - Hrsbg	W / Trk 4	Dry	10"	Locomotive / Axle 1
"	124	Hrsbg - Ph	E / Trk 1	Dry	11"	Cab Car / Axle 24
"	125	Ph - Hrsbg	W / Trk 4	Dry	9"	Locomotive / Axle 1
"	126	Hrsbg - Ph	E / Trk 1	Dry	9"	Cab Car / Axle 24
"	127	Ph - Hrsbg	W / Trk 4	Dry	12"	Locomotive / Axle 1

Date	Run #	Line	Direction/ Track	Track Condit	Scheduled Unbalance/Speed	Leading Car/ Axle
"	128	Hrsbg - Ph	E / Trk 1	Dry	12"	Cab Car / Axle 24
"	129	Ph - Hrsbg	W / Trk 4	Dry	9"	Locomotive / Axle 1
"	130	Hrsbg - Ph	E / Trk 1	Dry	9"	Cab Car / Axle 24
Dec 7/92	300	Ph - NYP	E / Trk 3	Dry	130 mph	Cab Car / Axle 24
"	200	Ph - NYP	E / Trk 3	Dry	5"	Cab Car / Axle 24
"	201	NYP - Ph	W / Trk 3	Dry	7"	Locomotive / Axle 1
"	202	Ph - NYP	E / Trk 3	Dry	9"	Cab Car / Axle 24
"	203	NYP - Ph	W / Trk 3	Dry	10"	Locomotive / Axle 1
"	204	Ph - NYP	E / Trk 3	Dry	11"	Cab Car / Axle 24
"	205	NYP - Ph	W / Trk 3	Dry	12"	Locomotive / Axle 1
"	301	NYP - Ph	W / Trk 3	Dry	140 mph	Locomotive / Axle 1
Dec 8/92	302	Ph - NYP	E / Trk 3	Dry	150 mph	Cab Car / Axle 24
"	206	Ph - NYP	E / Trk 3	Dry	9"	Cab Car / Axle 24
"	207	NYP - Ph	W / Trk 2	Dry	9"	Locomotive / Axle 1
"	208	Ph - NYP	E / Trk 2	Dry	10"	Cab Car / Axle 24
"	209	NYP - Ph	W / Trk 2	Dry	11"	Locomotive / Axle 1
"	210	Ph - NYP	E / Trk 2	Dry	12"	Cab Car / Axle 24
"	211	NYP - Ph	W / Trk 3	Dry	at profile	Locomotive / Axle 1
"	303	NYP - Ph	W / Trk 3	Dry	150 mph	Locomotive / Axle 1
Dec 12/92	304	Ph - NYP	E / Trk 3	Wet	140 mph	Cab Car / Axle 24
"	305	NYP - Ph	W / Trk 3	Wet	150 mph	Locomotive / Axle 1
Dec 14/92	400	Wa - Ph	N / Trk 2	Dry	9"	Cab Car / Axle 24
"	402	Ph - NYP	E / Trk 2	Dry	9"	Cab Car / Axle 24
"	401	NYP - Ph	W / Trk 3	Dry	9"	Locomotive / Axle 1
"	403	Ph - Wa	S / Trk 3	Dry	9"	Locomotive / Axle 1
Dec 15/92	404	Wa - Ph	N / Trk 2	Dry	9" + 5 mph	Cab Car / Axle 24
"	406	Ph - NYP	E / Trk 1,2	Dry	9" + 5 mph	Cab Car / Axle 24
"	405	NYP - Ph	W / Trk 3	Dry	9" + 5 mph	Locomotive / Axle 1
"	410	Ph - Tren	E / Trk 2	Dry	9" + 5 mph	Cab Car / Axle 24
"	411	Tren - Ph	W / Trk 3,4	Dry	9" + 5 mph	Locomotive / Axle 1
"	407	Ph - Wa	S / Trk 3	Dry	9" + 5 mph	Locomotive / Axle 1

4. RESULTS

Preliminary test results are presented herein to examine the safety aspects and the safety margin involved with the high cant deficiency operation of the X2000 train. During each test run, measured peak values of the safety parameters were compiled on a mile by mile basis. A summary of the peak values, closest to the safety limits, recorded over all the cant deficiency and high speed test runs and over all test zones is given in **Table 4.1**. Each safety parameter will be addressed in turn in this section.

4.1 MAXIMUM UNBALANCE RECORDED

The lateral accelerometer installed on Axle #2 of the locomotive was used to indicate the degree of unbalance or cant deficiency. The maximum quasi-steady lateral acceleration recorded from all test runs was 2.07 m/s^2. This occurred during Test Run 128 on the Philadelphia - Harrisburg line while travelling east on Track #1 in curve 662 (Gap, 4° curvature) at a speed of 78 mph. This lateral acceleration translates to an unbalance or cant deficiency of 12.5 inches.

4.2 MINIMUM VERTICAL WHEEL-RAIL FORCE (VEHICLE OVERTURN), Vmin

A composite plot of the minimum vertical wheel force peaks measured from each test run and over all test zones on both the Philadelphia - Harrisburg and NEC mainlines is shown in **Figure 4.1**. It should be noted in this plot that individual wheels are not distinguished; these peak values were drawn from each test run at any location within the test zone (not necessarily in a curve) and may be for any wheel (of the 8 instrumented wheels). In addition, the peak values are plotted against the intended or scheduled test run cant deficiency (not necessarily the actual cant deficiency when the peak was recorded) and no trend line should be drawn from this composite.

During these test runs, cant deficiencies up to 12.5 inches and speeds up to 154 mph were achieved. The results indicate that no measured wheel approached the minimum allowable unloading at any time throughout the tests. From the lowest values recorded, a safety margin of about 14% from the allowable limit is apparent for cant deficiencies up to 12.5 inches on representative track. No appreciable crosswinds were encountered during these test runs.

A more detailed examination of the minimum vertical wheel force is given as an example in **Figure 4.2**. Peak values on the left wheel of trailing axle 1 (locomotive) measured in test curve 671 (Ronks, 2° curvature) of the Philadelphia - Harrisburg Line, westbound on track #4, are plotted as a function of the quasi-steady cant deficiency measured in the circular portion of the curve. This plot includes the lowest vertical wheel force ever measured throughout the tests runs, and also includes values measured under both wet and dry track conditions. Extrapolation of these results indicate that the safety limit would be reached at a cant deficiency of about 15 inches for similar conditions.

TABLE 4.1 PEAK VALUES MEASURED FROM ALL TEST ZONES, HARRISBURG and NEC LINES

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	Leading Axle	Comments
Min Vertical Wheel Force Vmin	23 kN	83%	Left Wheel Axle 1 (Loco)	101 Hrsbg	West Track 4	51 - 52	Dry	3"	3.1"	57 mph	Axle 24 (Cab)	In curve 662 (Gap - 4°)
	20 kN	86%	Left Wheel Axle 1 (Loco)	113 Hrsbg	West Track 4	60 - 61	Wet	10"	11"	108 mph	Axle 24 (Cab)	In curve 671 (Ronks - 2°)
	22 kN	84%	Left Wheel Axle 1 (Loco)	119 Hrsbg	West, Track 4	60 - 61	Dry	12"	11.7"	111 mph	Axle 24 (Cab)	In curve 671 (Ronks - 2°)
	23 kN	83%	Left Wheel Axle 1 (Loco)	204 NEC	East Track 3	25 - 24	Dry	11"	12.4"	125 mph	Axle 24 (Cab)	In curve 266 (1.5°)
Max Net Axle Lateral Force NAL	66 kN	84%	Axle 24 (Cab)	113 Hrsbg	West Track 4	51 - 52	Wet	10"	11"	77 mph	Axle 24 (Cab)	In curve 662 (Gap - 4°)
	68 kN	87%	Axle 24 (Cab)	114 Hrsbg	East Track 1	62 - 61	Wet	10"	10"	106 mph	Axle 1 (Loco)	In curve 672 (Bd Hnd - 2°)
	-66 kN	85%	Axle 24 (Cab)	120 Hrsbg	East Track 1	53 - 52	Dry	12"	12.1"	80 mph	Axle 1 (Loco)	In Curve 663 (EBYs - 4°)
	63 kN	70%	Axle 1 (Loco)	204 NEC	East Track 3	25 - 24	Dry	11"	12.4"	125 mph	Axle 24 (Cab)	In curve 266 (1.5°)
Max Wheel L/V Ratio L/V	0.61	76%	Left Wheel Axle 1 (Loco)	120 Hrsbg	East Track 1	53 - 52	Dry	12"	12.1"	80 mph	Axle 1 (Loco)	In Curve 663 (EBYs - 4°)
	0.60	75%	Left Wheel Axle 24 (Cab)	122 Hrsbg	East Track 1	53 - 52	Dry	10"	9.8"	75 mph	Axle 24 (Cab)	In Curve 663 (EBYs - 4°)
	0.60	75%	Left Wheel Axle 24 (Cab)	128 Hrsbg	East Track 1	53 - 52	Dry	12"	10.9"	78 mph	Axle 24 (Cab)	In Curve 663 (EBYs - 4°)
	0.56	70%	Right Wheel Axle 1 (Loco)	205 NEC	West Track 3	23 - 24	Dry	12"	8.8"	125 mph	Axle 1 (Loco)	In curve 265 (1.5°)

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	Leading Axle	Comments
Max Truck Side L/V T-L/V	0.44	88%	Left Side Truck 12 (Cab)	113 Hrsbg	West Track 4	61 - 62	Wet	10"	10.1"	108 mph	Axle 24 (Cab)	In curve 672 (Bd Hnd - 2°)
	0.46	92%	Left Side Truck 12 (Cab)	122 Hrsbg	East Track 1	53 - 52	Dry	10"	9.8"	75 mph	Axle 24 (Cab)	In Curve 663 (EBYs - 4°)
	0.45	90%	Left Side Truck 12 (Cab)	126 Hrsbg	East Track 1	53 - 52	Dry	9"	9.2"	72 mph	Axle 24 (Cab)	In Curve 663 (EBYs - 4°)
	0.45	90%	Left Side Truck 12 (Cab)	128 Hrsbg	East Track 1	53 - 52	Dry	12"	10.9"	78 mph	Axle 24 (Cab)	In Curve 663 (EBYs - 4°)

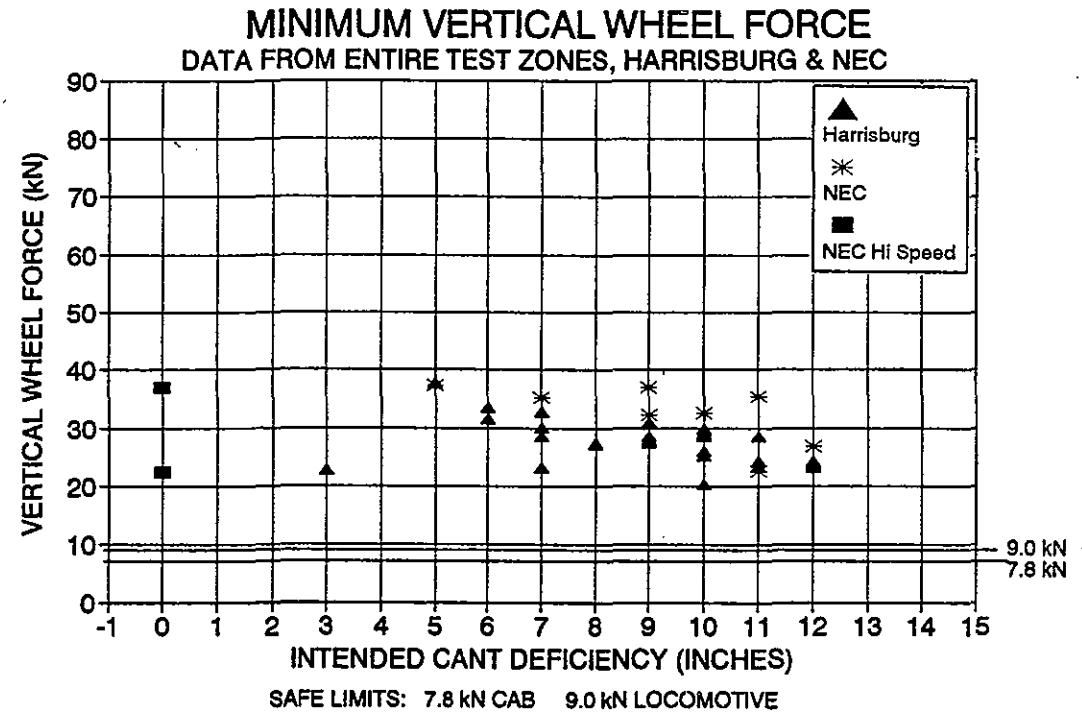


Figure 4.1: Minimum Vertical Wheel Forces Measured During X2000 Test Runs

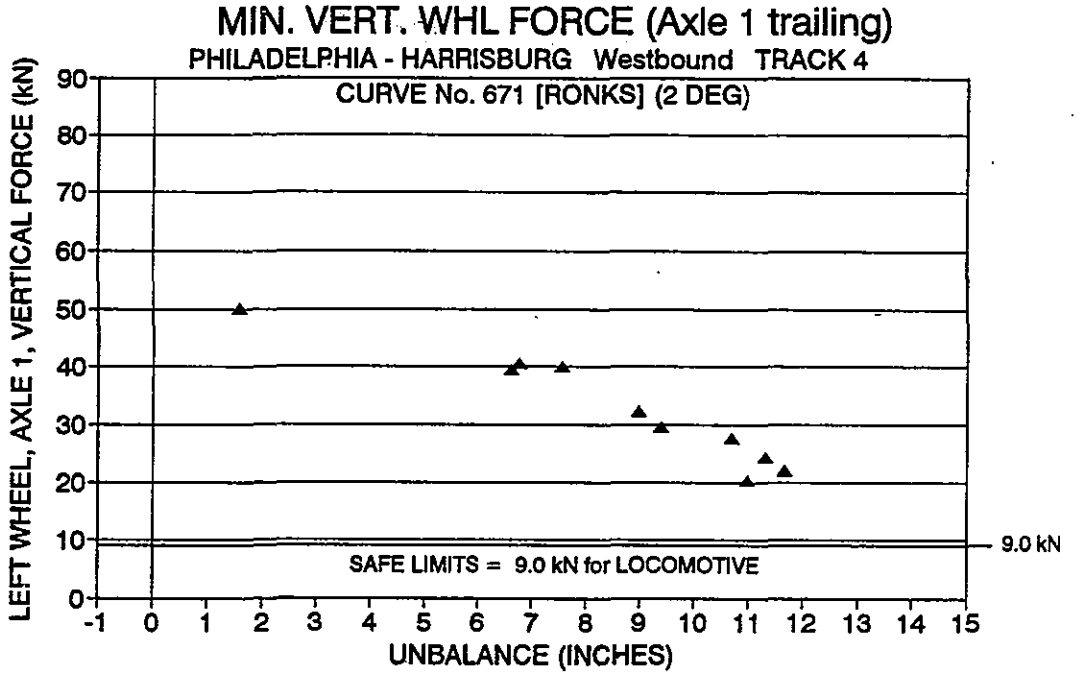


Figure 4.2: Minimum Vertical Wheel Force, Measured In Curve 671, Westbound

4.3 NET AXLE LATERAL FORCE (TRACK PANEL SHIFT), NAL

A composite plot of the peak net axle lateral forces measured for the locomotive (axles #1 and #2) from each test run and over all test zones is given in **Figure 4.3a.** A similar plot for the cab car axles (axle #23 and #24) is given in **Figure 4.3b.**

It is evident that the net lateral forces measured for the locomotive axles were significantly lower than the allowable safety limit of 90 kN, with a substantial margin of safety. For the axles of the lighter weight cab car, similar forces were observed although the allowable safety limit is less (78 kN). A margin of safety of about 15% is evident in this case.

A more detailed examination of the net lateral force for axle #24 (cab car) is given in **Figure 4.4.** Peak values measured in test curve 671 (Bird-in-Hand, 2° curvature) of the Philadelphia - Harrisburg line, westbound on track #4, are plotted as a function of the quasi-steady cant deficiency measured in the circular portion of the curve. This plot includes one of the highest forces measured throughout the tests runs during test run #113 under damp rail conditions. Extrapolation of these results indicate that the safety limit would be reached at a cant deficiency of about 14 inches for similar conditions.

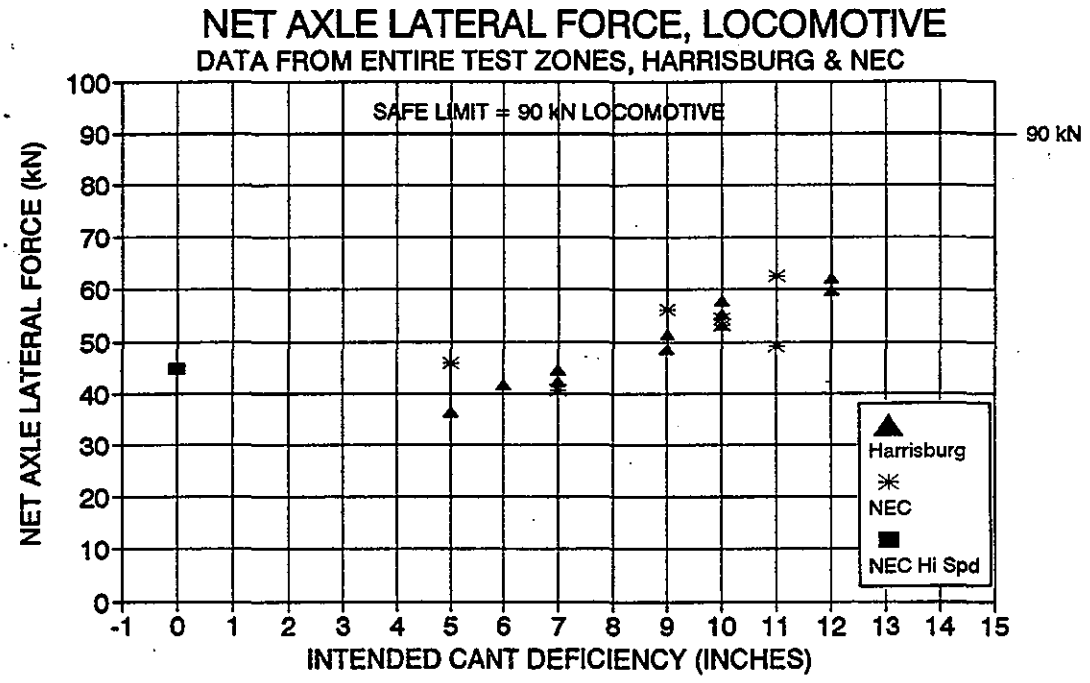


Figure 4.3a: Peak Net Axle Lateral Forces, Locomotive (Composite of Test Runs)

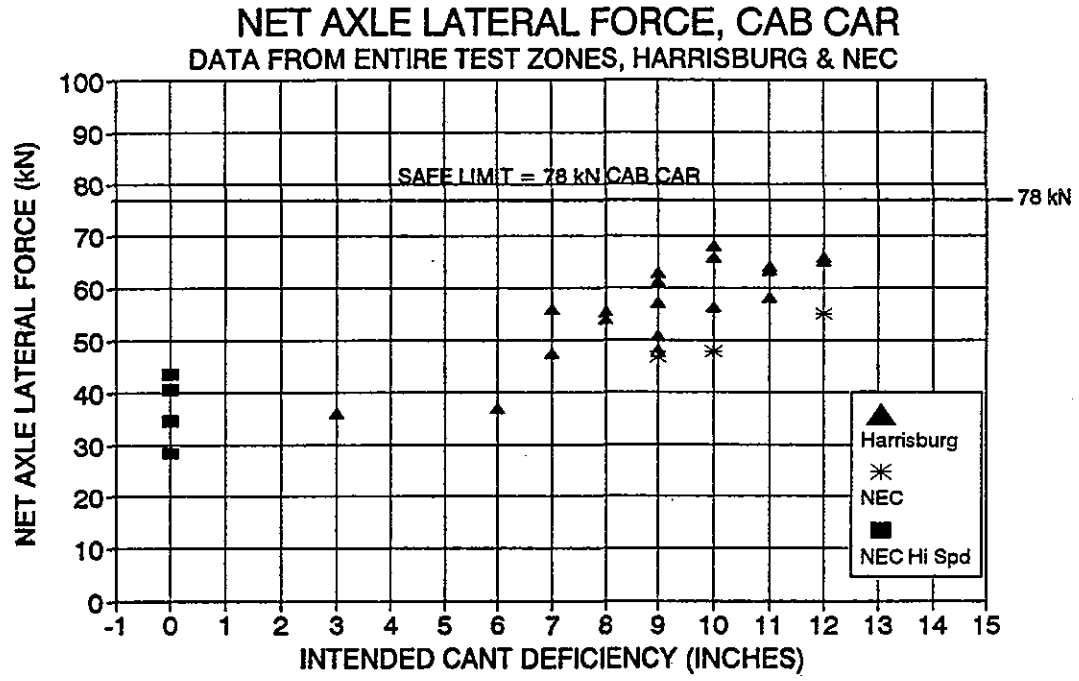


Figure 4.3b: Peak Net Axle Lateral Forces, Cab Car (Composite of Test Runs)

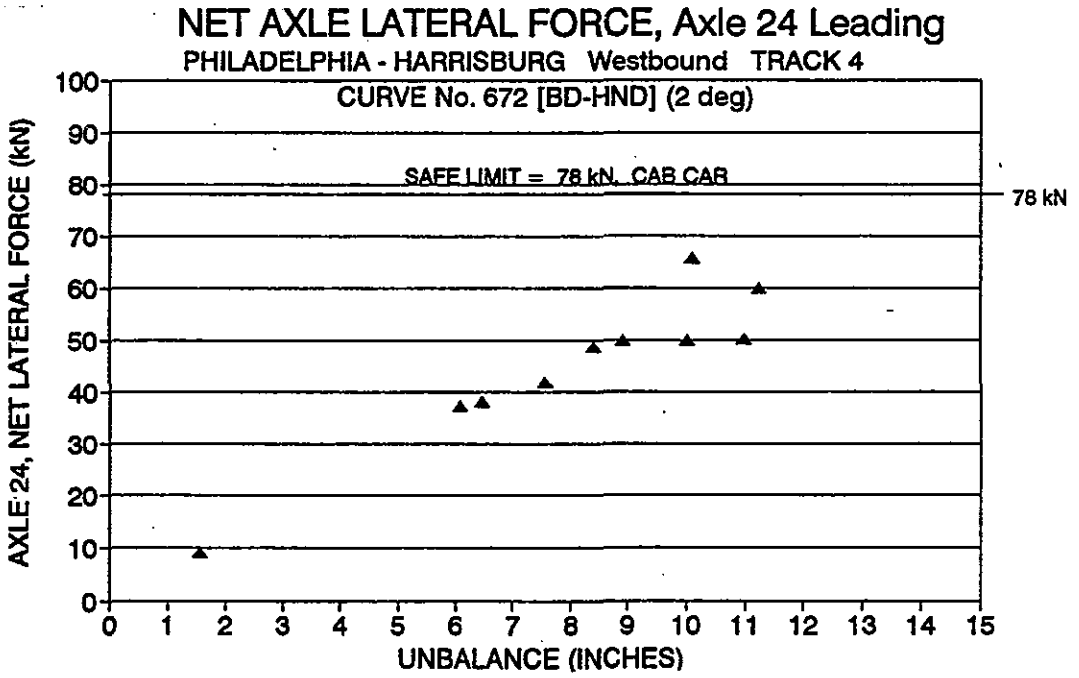


Figure 4.4: Peak Net Axle Lateral Force, Axle 24, In Curve 672, Track 4

4.4 L/V DERAILMENT QUOTIENT (WHEEL CLIMB), L/V

A composite plot of the maximum wheel L/V ratios measured from each test run and over all test zones is shown in **Figure 4.5**. It should again be noted that individual wheels are not distinguished in this plot; these peak values were drawn from each test run and may be for any wheel (of the 8 instrumented wheels). In addition, the peak values are plotted as a function of the intended test run cant deficiency (not measured cant deficiency when the peak occurred) and no trends should be drawn.

The highest wheel L/V ratios measured during the cant deficiency and high speed runs were about 0.6, approximately 75% of the allowable (Nadal) single wheel limit of 0.8. As a result, the axle sum L/V ratio (Weinstock) was not examined. A safety margin of about 25% is apparent for cant deficiencies up to 12.5 inches for similar track and vehicle conditions.

A more detailed examination of a single wheel L/V ratio is given in **Figure 4.6** for the left wheel of axle #1 (locomotive). Peak values measured in test curve 663 (Eby's, 4° curvature) of the Philadelphia - Harrisburg line, eastbound on track #1, in which axle #1 was the leading axle, are plotted as a function of the quasi-steady cant deficiency measured in the circular portion of the curve. This plot includes two of the highest wheel L/V values measured throughout the tests runs, with cant deficiencies up to 12 inches. For similar conditions, extrapolation of these results indicate that the safety limit would be reached well above a cant deficiency of 15 inches.

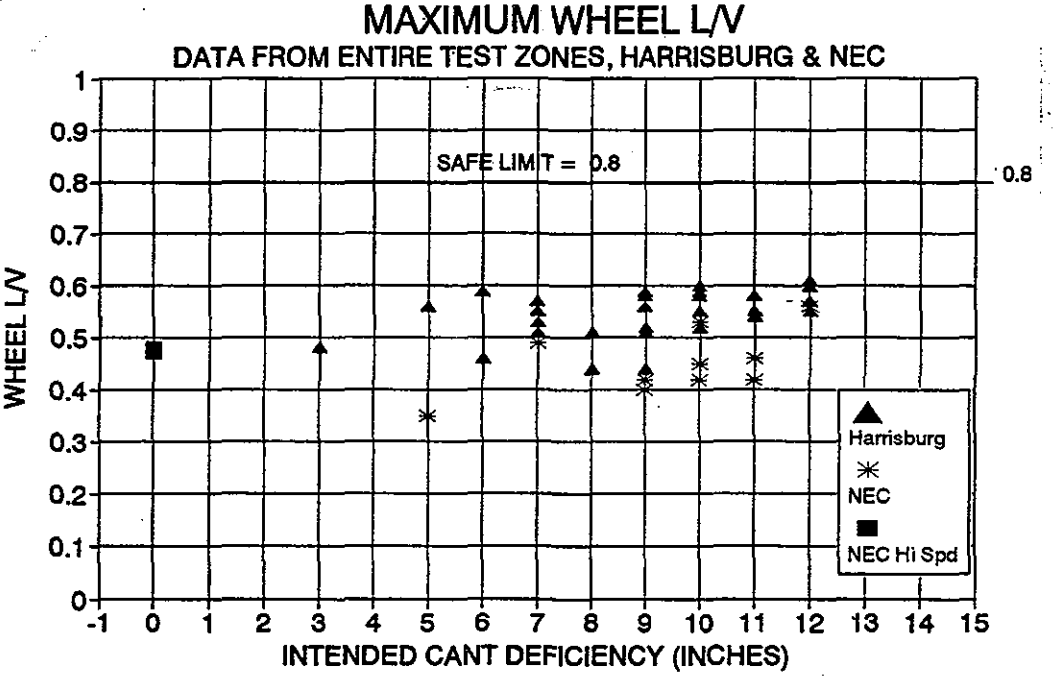


Figure 4.5: Peak Maximum Wheel L/V Ratios (Composite, All Wheels, Test Runs)

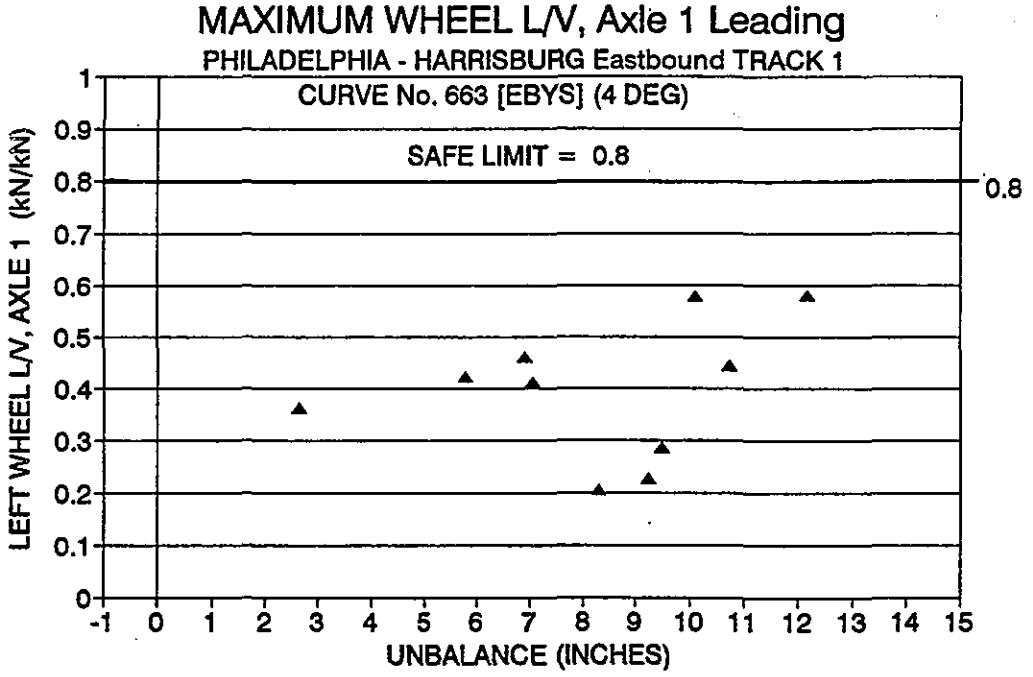


Figure 4.6: Peak Maximum Wheel L/V Ratios, Left Wheel, Axle 1, Curve 663

4.5 TRUCK-SIDE L/V RATIO (RAIL ROLL-OVER), T-L/V

A composite of the maximum truck side L/V ratios, which includes both left and right sides for truck #1 (locomotive) and truck #12 (cab car), measured from each test run and over all test zones, is given in **Figure 4.7**. No peak values were measured that exceeded the allowable limit of 0.5. At cant deficiencies above 9 inches, some peak values of truck side L/V were observed around 90% of the allowable limit during test runs on the Philadelphia - Harrisburg line.

A more detailed examination of the truck side L/V ratio is given in **Figure 4.8**. Peak values on the left side of truck #12 (cab car) measured in test curve 672 (Bird-inHand, 2° curvature) of the Philadelphia - Harrisburg Line, westbound on track #4, are plotted as a function of the quasi-steady cant deficiency measured in the circular portion of the curve. This plot includes one of the highest truck side L/V ratios measured throughout the tests runs, and also includes values measured under both wet and dry track conditions. A margin of safety of about 10% is apparent for cant deficiencies up to 12 inches for similar track and vehicle conditions.

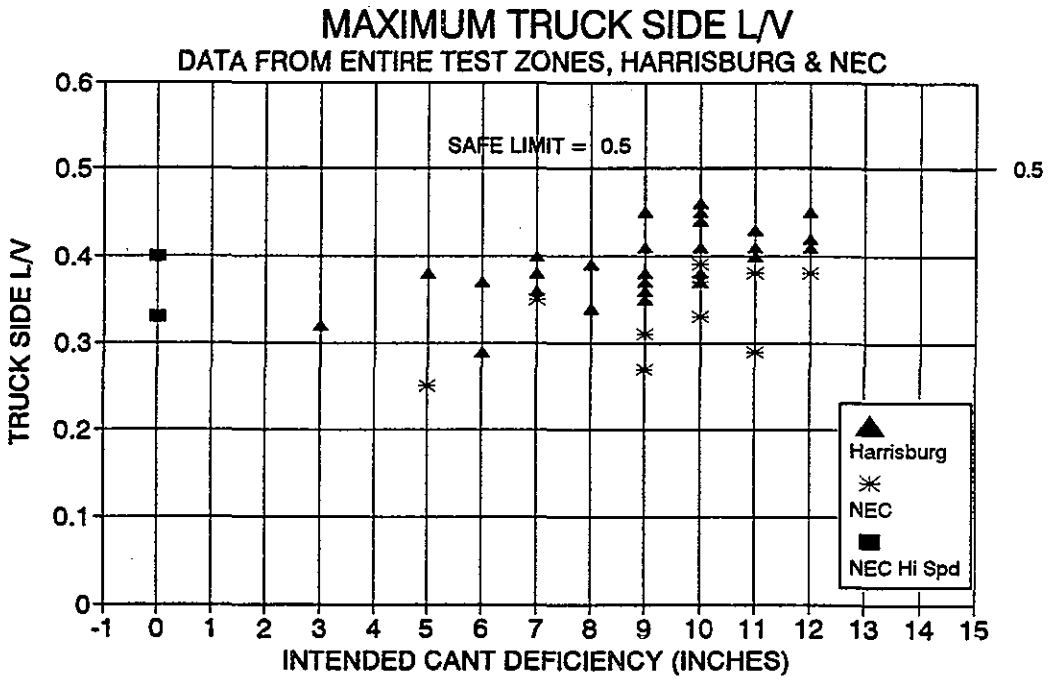


Figure 4.7: Peak Maximum Truck Side L/V Ratios (Composite of Test Runs)

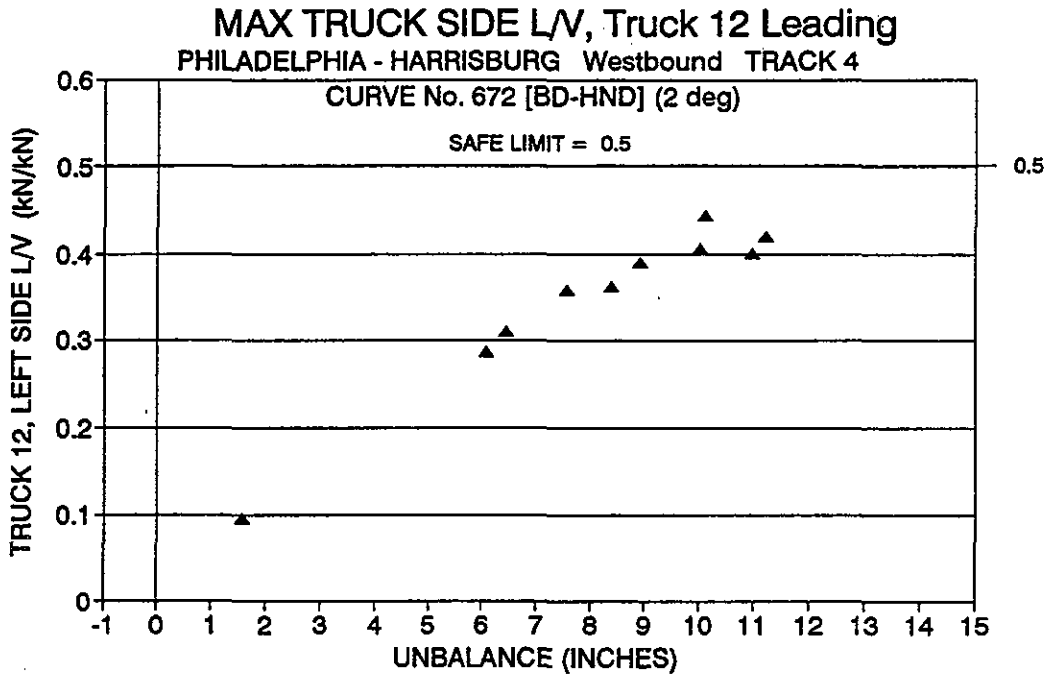


Figure 4.8: Peak Maximum Truck Side L/V Ratios, Truck 12 (Cab) in Curve 672

4.6 FIELD OBSERVATIONS OF TRACK PANEL AND TIE-PLATE SHIFT

Track panel shift and rail movement were monitored during high cant deficiency test runs by surveying from lineside structures. No permanent deformation of track or rail was registered during any of the trials on both wooden ties with cut spikes and tie plates or concrete monoblock ties with pandrol fasteners.

4.7 MAXIMUM SPEED RECORDED

The maximum speed recorded from the high speed test runs was 154 mph. This occurred during Test Run 305 on the NEC Philadelphia - New York Penn line while travelling west on Track #3 at MP 51 near Trenton. This was a scheduled 150 mph run under wet track conditions, in which a 150 mph or greater speed was sustained for over 8 miles. A speed of 152 mph was also recorded at the same location under dry track conditions during Test Run 303.

4.8 TRUCK FRAME ACCELERATION, TA

The truck frame lateral accelerations of truck #1 (locomotive), truck #5 (coach car), and truck #12 (cab car) were monitored throughout the trial period. No evidence of truck instability (hunting) was observed in any test run, including high speed test runs at speeds up to 152 mph in tangent track under dry track conditions.

4.9 SIMULATED REVENUE EARNING SERVICE RUNS

After a data review of the cant deficiency and high speed test runs, a speed profile was prepared by Amtrak for a simulated revenue service round trip from Washington to New York Penn Station. This speed profile was based on a maximum cant deficiency of 9 inches, and accounted for actual allowable speeds dependent on signal spacings and other local restrictions.

Using this speed profile, a simulated revenue service round trip was made with full instrumentation. For data recording, the trip was segmented into 4 test zones (runs):

1) Washington - Philadelphia, northbound, principally on track 2
2) Philadelphia - New York Penn, eastbound, principally on track 2
3) New York Penn - Philadelphia, westbound, principally on track 3
4) Philadelphia - Washington, southbound, principally on track 3

On a mile-by-mile basis, the peak values of each safety parameter were recorded in each test zone. A composite plot of the four highest recorded values of each safety parameter in each test zone is shown in **Figures 4.9 - 4.12** as a function of vehicle speed. More detailed information on the location and conditions for these peak values are given in **Table 4.2.**

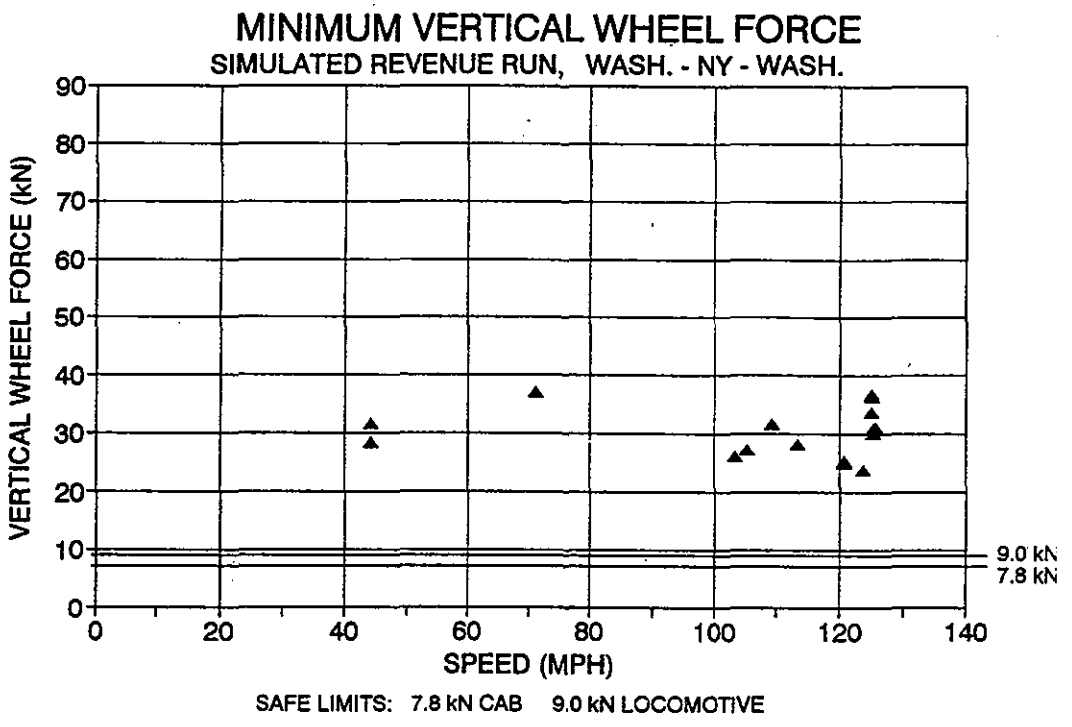


Figure 4.9: Minimum Vertical Wheel Forces, Simulated Revenue Service Run

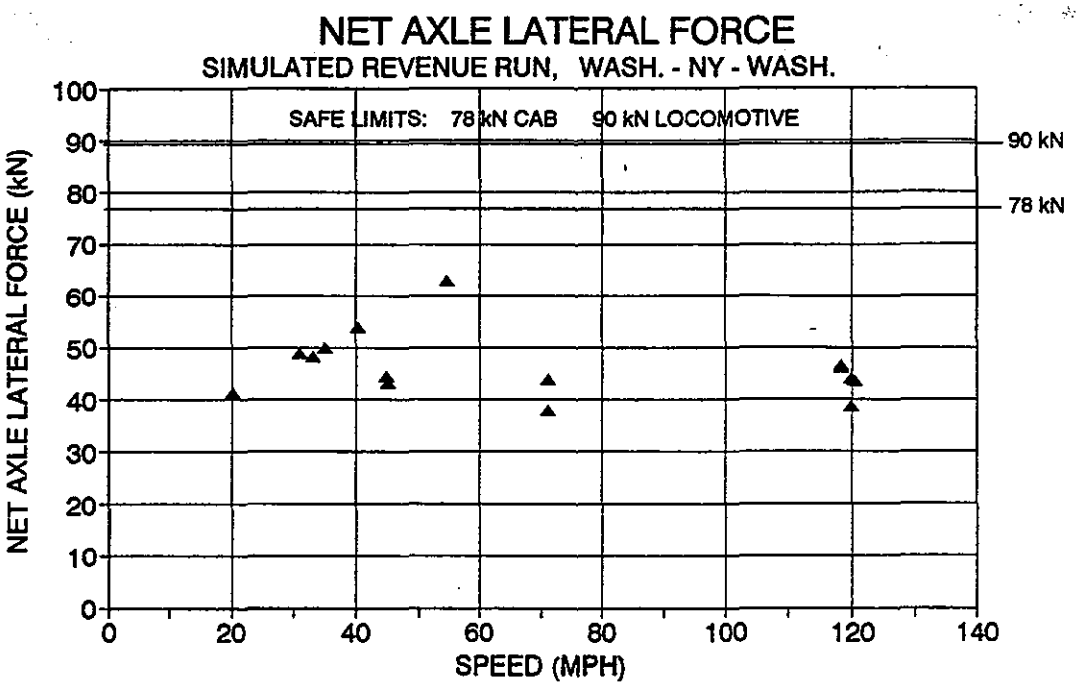


Figure 4.10: Peak Net Axle Lateral Forces, Simulated Revenue Service Run

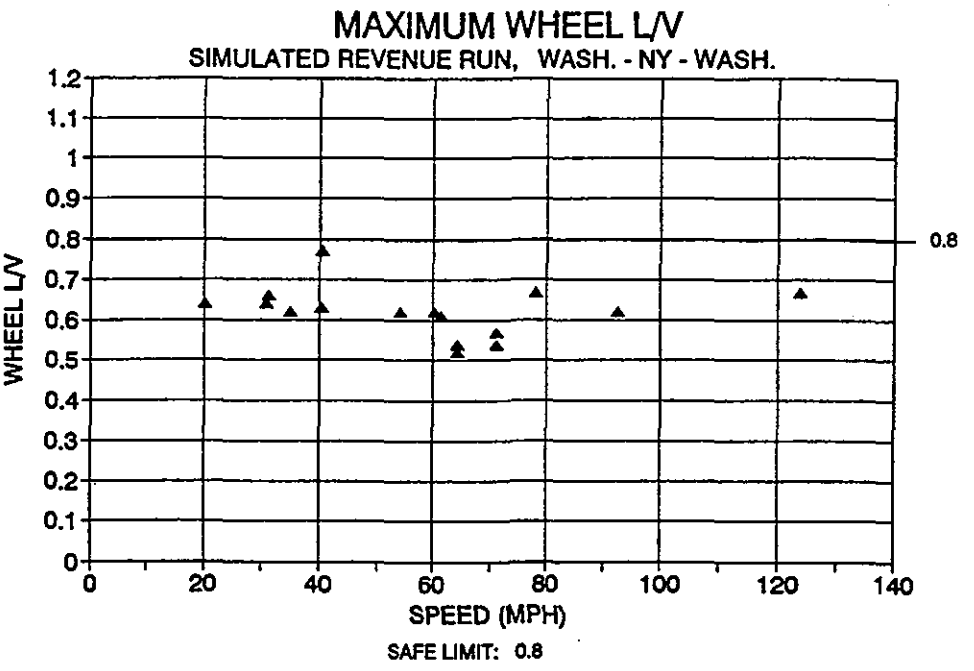


Figure 4.11: Maximum Wheel L/V Ratios, Simulated Revenue Service Run

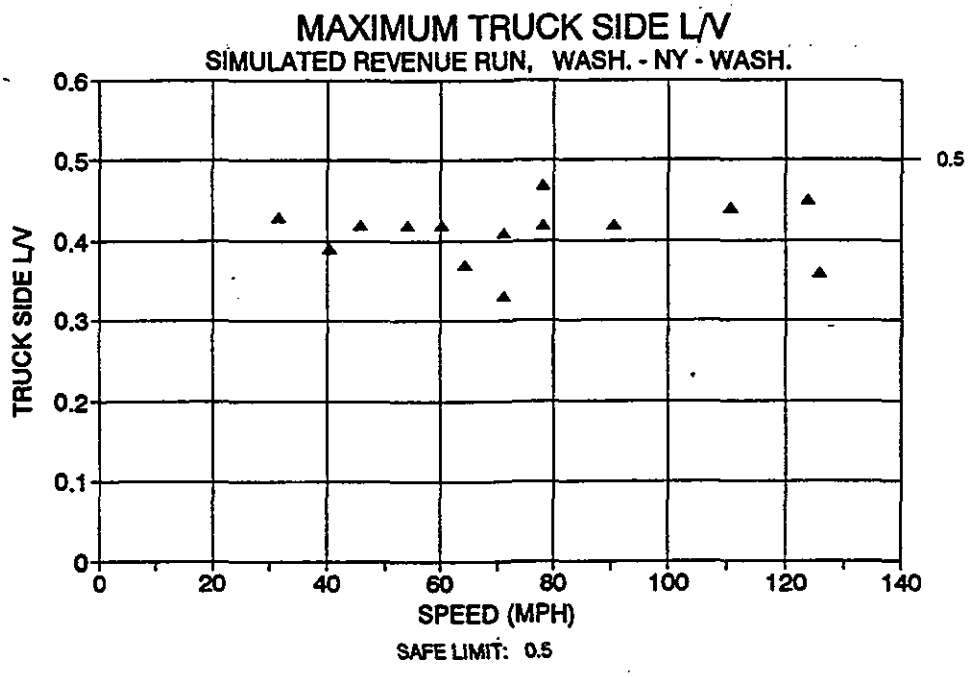


Figure 4.12: Maximum Truck Side L/V Ratios, Simulated Revenue Service Run

TABLE 4.2 PEAK VALUES, SIMULATED REVENUE RUN, NEC, WASHINGTON - NEW YORK R/t

A) MINIMUM VERTICAL WHEEL FORCE, Vmin

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
30 kN	74%	Right Wheel Axle 1 (Loco)	400 Wa-Ph	North Track 2	76 - 75	Dry		125 mph	Axle 24 (Cab)	Tangent track
31 kN	73%	Left Wheel Axle 1 (Loco)	400 Wa-Ph	North Track 1	63 - 62	Dry		126 mph	Axle 24 (Cab)	
27 kN	72%	Left Wheel Axle 23 (Cab)	400 Wa-Ph	North Track 2	59 - 58	Dry		105 mph	Axle 24 (Cab)	
31 kN	73%	Left Wheel Axle 1 (Loco)	400 Wa-Ph	North Track 2	39 - 38	Dry		126 mph	Axle 24 (Cab)	
37 kN	66%	Right Wheel Axle 1 (Loco)	402 Ph-NYP	East Track 2	66 - 65	Dry		125 mph	Axle 24 (Cab)	
36 kN	66%	Left Wheel Axle 2 (Loco)	402 Ph-NYP	East Track 2	66 - 65	Dry		125 mph	Axle 24 (Cab)	
28 kN	76%	Left Wheel Axle 1 (Loco)	401 NYP-Ph	West Track 3	22 - 23	Dry		44 mph	Axle 1 (Loco)	
32 kN	72%	Left Wheel Axle 2 (Loco)	401 NYP-Ph	West Track 3	22 - 23	Dry		44 mph	Axle 1 (Loco)	
26 kN	74%	Left Wheel Axle 24 (Cab)	401' NYP-Ph	West Track 3	57 - 58	Dry		103 mph	Axle 1 (Loco)	
24 kN	77%	Right Wheel Axle 24 (Cab)	403 Ph-Wa	South Track 3	35 - 36	Dry		124 mph	Axle 1 (Loco)	
25 kN	80%	Right Wheel Axle 1 (Loco)	403 Ph-Wa	South Track 3	55 - 56	Dry		121 mph	Axle 1 (Loco)	
25 kN	80%	Right Wheel Axle 2 (Loco)	403 Ph-Wa	South Track 3	55 - 56	Dry		121 mph	Axle 1 (Loco)	
28 kN	76%	Left Wheel Axle 23 (Cab)	403 Ph-Wa	South Track 4	62 - 63	Dry		114 mph	Axle 1 (Loco)	

TABLE 4.2 PEAK VALUES, SIMULATED REVENUE RUN, NEC, WASHINGTON - NEW YORK R/t

B) MAXIMUM NET AXLE LATERAL FORCE, NAL

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
63 kN	70%	Axle 1 (Loco)	400 Wa-Ph	North Track 2	99 - 98	Dry		55 mph	Axle 1 (Loco)	
48 kN	62%	Axle 24 (Cab)	400 Wa-Ph	North Track 2	98 - 97	Dry		33 mph	Axle 1 (Loco)	
50 kN	64%	Axle 24 (Cab)	400 Wa-Ph	North Track 2	27 - 26	Dry		35 mph	Axle 24 (Cab)	
44 kN	49%	Axle 1 (Loco)	402 Ph-NYP	East Track 2	75 - 74	Dry		120 mph	Axle 24 (Cab)	
39 kN	50%	Axle 23 (Cab)	402 Ph-NYP	East Track 2	75 - 74	Dry		120 mph	Axle 24 (Cab)	
45 kN	49%	Axle 1 (Loco)	401 NYP-Ph	West Track 3	7 - 8	Dry		45 mph	Axle 1 (Loco)	
47 kN	52%	Axle 2 (Loco)	401 NYP-Ph	West Track 3	74 - 75	Dry		118 mph	Axle 1 (Loco)	
46 kN	59%	Axle 24 (Cab)	401 NYP-Ph	West Track 3	74 - 75	Dry		118 mph	Axle 1 (Loco)	
54 kN	60%	Axle 1 (Loco)	401 NYP-Ph	West Track 4	87 - 88	Dry		40 mph	Axle 1 (Loco)	
47 kN	60%	Axle 24 (Cab)	403 Ph-Wa	South Track 3	50 - 51	Dry		120 mph	Axle 1 (Loco)	
43 kN	48%	Axle 1 (Loco)	403 Ph-Wa	South Track 3	94 - 95	Dry		45 mph	Axle 1 (Loco)	
41 kN	46%	Axle 1 (Loco)	403 Ph-Wa	South Track 3	95 - 96	Dry		20 mph	Axle 1 (Loco)	
49 kN	54%	Axle 1 (Loco)	403 Ph-Wa	South Track 3	96 - 97	Dry		31 mph	Axle 1 (Loco)	

TABLE 4.2 PEAK VALUES, SIMULATED REVENUE RUN, NEC, WASHINGTON - NEW YORK R/t

C) MAXIMUM WHEEL L/V RATIO, L/V

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
0.66	83%	Right Wheel Axle 24 (Cab)	400 Wa-Ph	North Track 2	97 - 96	Dry		31 mph	Axle 24 (Cab)	
0.62	78%	Left Wheel Axle 24 (Cab)	400 Wa-Ph	North Track 2	94 - 93	Dry		60 mph	Axle 24 (Cab)	
0.62	78%	Right Wheel Axle 2 (Loco)	400 Wa-Ph	North Track 1	27 - 26	Dry		35 mph	Axle 24 (Cab)	
0.57	71%	Left Wheel Axle 24 (Cab)	402 Ph-NYP	East Track 2	82 - 81	Dry		71 mph	Axle 24 (Cab)	
0.67	84%	Right Wheel Axle 1 (Loco)	401 NYP-Ph	West Track 3	10 -11	Dry		78 mph	Axle 1 (Loco)	
0.61	76%	Left Wheel Axle 1 (Loco)	401 NYP-Ph	West Track 3	81 - 82	Dry		62 mph	Axle 1 (Loco)	
0.77	96%	Right Wheel Axle 1 (Loco)	401 NYP-Ph	West Track 4	87 - 88	Dry		40 mph	Axle 1 (Loco)	In "Zoo" interlocking, approaching 30th St. Station, Phil.
0.63	79%	Right Wheel Axle 23 (Cab)	401 NYP-Ph	West Track 4	87 - 88	Dry		40 mph	Axle 1 (Loco)	In "Zoo" interlocking, approaching 30th St. Station, Phil.
0.67	84%	Right Wheel Axle 1 (Loco)	403 Ph-Wa	South Track 3	35 - 36	Dry		124 mph	Axle 1 (Loco)	
0.62	78%	Right Wheel Axle 1 (Loco)	403 Ph-Wa	South Track 4	60 - 61	Dry		93 mph	Axle 1 (Loco)	
0.64	80%	Right Wheel Axle 1 (Loco)	403 Ph-Wa	South Track 3	95 - 96	Dry		20 mph	Axle 1 (Loco)	
0.64	80%	Right Wheel Axle 1 (Loco)	403 Ph-Wa	South Track 3	96 - 97	Dry		31 mph	Axle 1 (Loco)	
0.62	78%	Right Wheel Axle 1 (Loco)	403 Ph-Wa	South Track 3	98 - 99	Dry		54 mph	Axle 1 (Loco)	

TABLE 4.2 PEAK VALUES, SIMULATED REVENUE RUN, NEC, WASHINGTON - NEW YORK R/t

D) MAXIMUM TRUCK SIDE L/V RATIO, T-L/V

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
0.42	84%	Left Side Truck 12 (Cab)	400 Wa-Ph	North Track 2	95 - 94	Dry		46 mph	Axle 24 (Cab)	
0.42	84%	Left Side Truck 12 (Cab)	400 Wa-Ph	North Track 2	94 - 93	Dry		60 mph	Axle 24 (Cab)	
0.42	84%	Left Side Truck 12 (Cab)	400 Wa-Ph	North Track 1	13 - 12	Dry		91 mph	Axle 24 (Cab)	
0.37	74%	Left Side Truck 12 (Cab)	402 Ph-NYP	East Track 2	86 - 85	Dry		64 mph	Axle 24 (Cab)	
0.41	82%	Left Side Truck 12 (Cab)	402 Ph-NYP	East Track 2	82 - 81	Dry		71 mph	Axle 24 (Cab)	
0.42	84%	Left Side Truck 1 (Loco)	401 NYP-Ph	West Track 3	10 - 11	Dry		78 mph	Axle 1 (Loco)	
0.47	94%	Right Side Truck 1 (Loco)	401 NYP-Ph	West Track 3	10 - 11	Dry		78 mph	Axle 1 (Loco)	
0.39	78%	Left Side Truck 1 (Loco)	401 NYP-Ph	West Track 4	87 - 88	Dry		40 mph	Axle 1 (Loco)	
0.39	78%	Right Side Truck 1 (Loco)	401 NYP-Ph	West Track 4	87 - 88	Dry		40 mph	Axle 1 (Loco)	
0.45	90%	Right Side Truck 1 (Loco)	403 Ph-Wa	South Track 3	35 - 36	Dry		124 mph	Axle 1 (Loco)	
0.43	86%	Right Side Truck 1 (Loco)	403 Ph-Wa	South Track 3	97 - 98	Dry		32 mph	Axle 1 (Loco)	
0.42	84%	Right Side Truck 1 (Loco)	403 Ph-Wa	South Track 3	98 - 99	Dry		54 mph	Axle 1 (Loco)	
0.44	88%	Left Side Truck 1 (Loco)	403 Ph-Wa	South Track 3	128 - 129	Dry		111 mph	Axle 1 (Loco)	

A maximum top speed of 125 mph was attained during the simulated revenue service round trip, and no transgressions of any safety limits were observed.

A second simulated revenue service round trip was made between Washington and New York Penn Station. In this case, the trip was made at speeds 5 mph above the 9 inch cant deficiency baseline speeds, except where other restrictions were applied. A composite plot of the four highest recorded values of each safety parameter in each test zone is shown in **Figures 4.13 - 4.16** as a function of vehicle speed. More detailed information on the location and conditions for these peak values is given in **Table 4.3.**

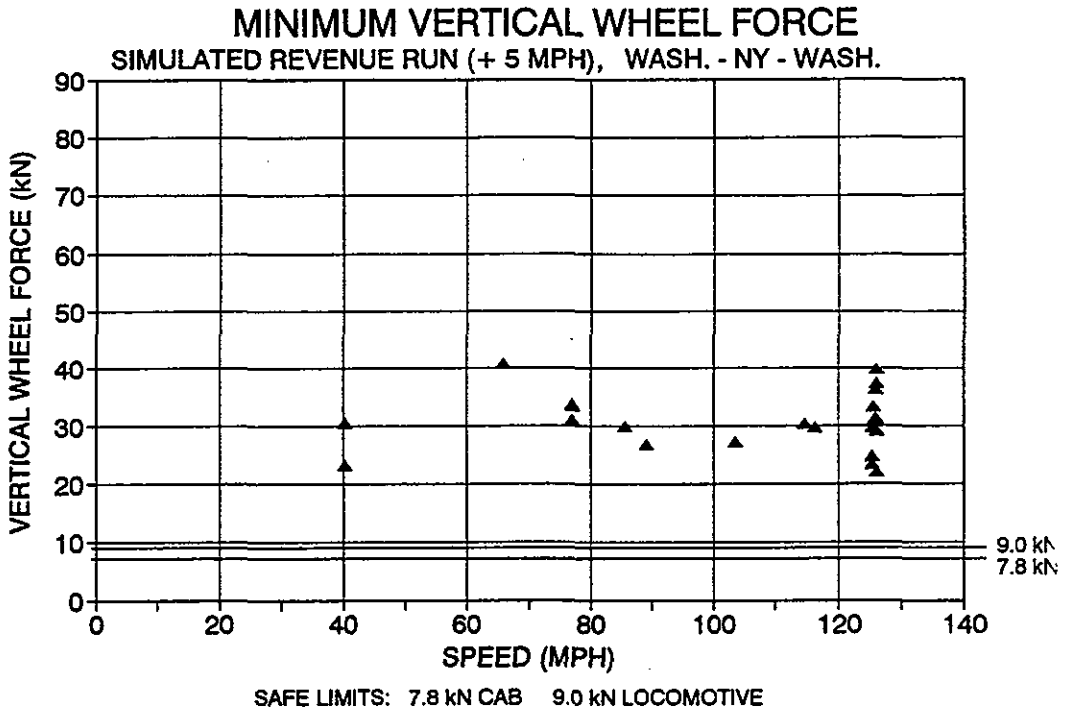


Figure 4.13: Minimum Vertical Wheel Forces, Simulated Revenue Run + 5mph

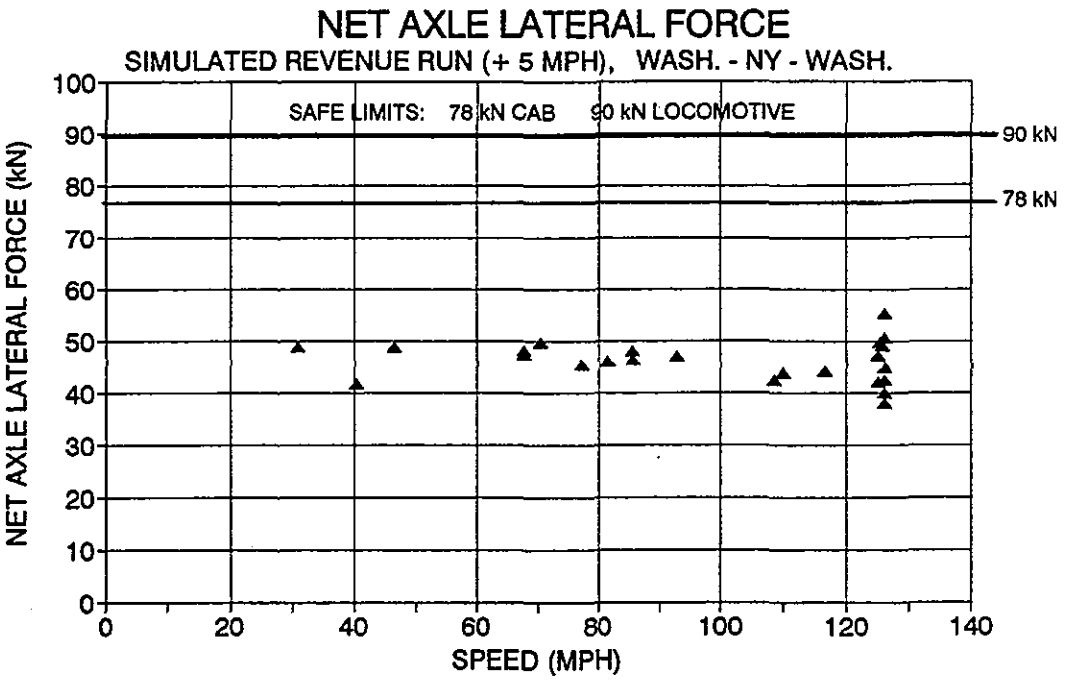


Figure 4.14: Peak Net Axle Lateral Forces, Simulated Revenue Run + 5mph

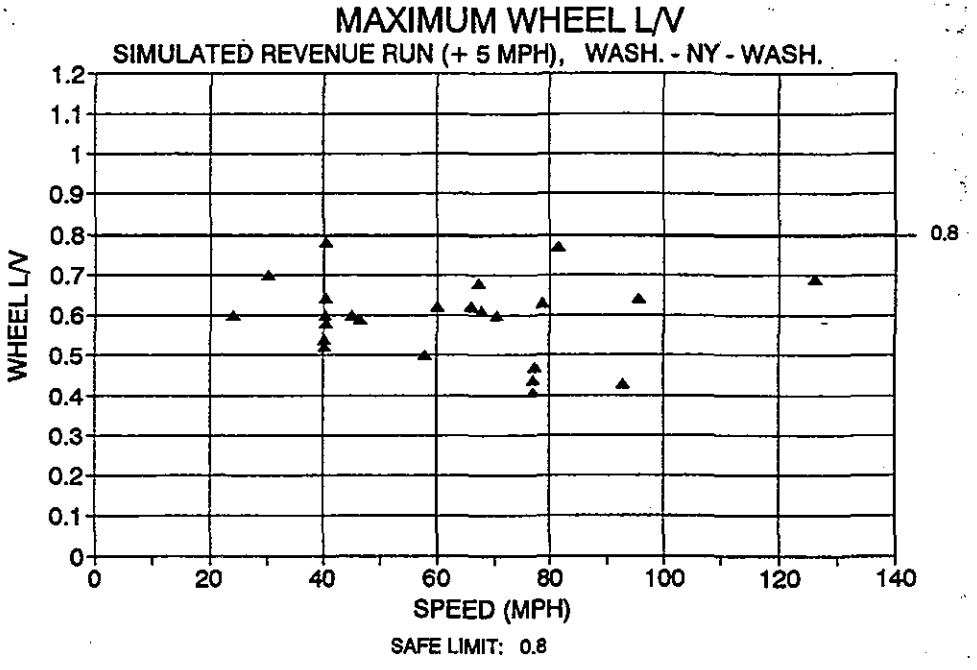


Figure 4.15: Maximum Wheel L/V Ratios, Simulated Revenue Run + 5mph

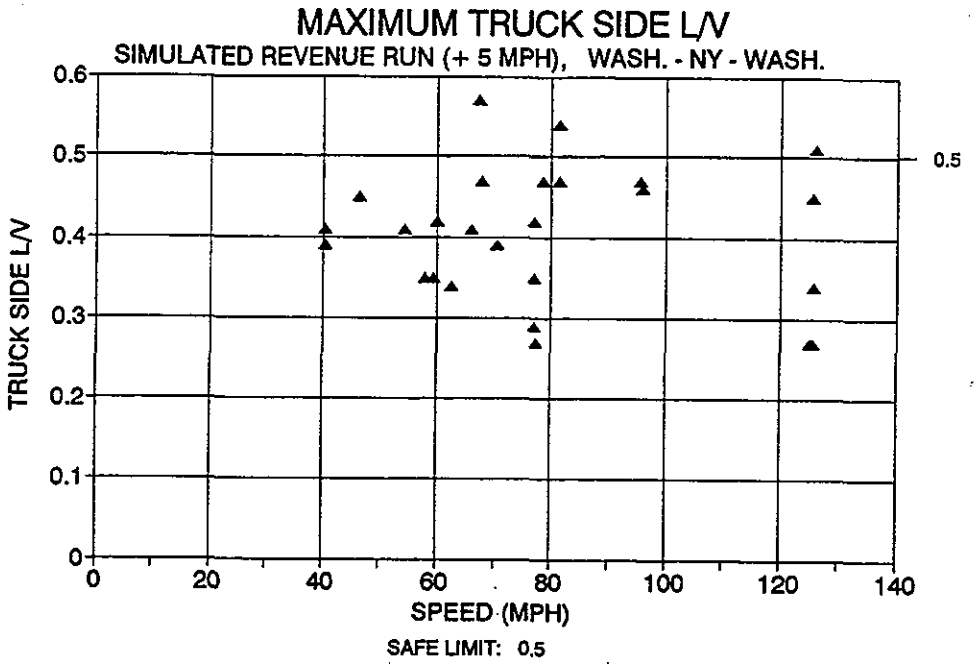


Figure 4.16: Maximum Truck Side L/V Ratios, Simulated Revenue Run + 5 mph

For this second higher speed round trip, no transgressions of any safety limits were observed during any of the transits of approximately 400 different curves at or below the intended +5 mph speed profile. Of the total of 448 miles of track tested, only three transgressions of the locomotive truck-side L/V limit of 0.5 were registered:

0.57 at 60 mph, 1 mile south of 30th Street Station in Philadelphia, past a turnout at the end of a curved section (curve 305) adjacent to a bridge

0.54 at 81.5 mph, done deliberately at 6.5 mph above the simulated engineer 5 mph excess-speed profile for a section of 1° (1746m radius) curve with four switches in the curve at Hunter interlocking

0.51 at 126 mph, on tangent track while transiting a switch for the Harmony Industrial Track, south of Stanton

No transgression of any other safety limit was recorded.

It should be noted that the force ratio required to roll over a rail on tangent track, even if worn, is likely to be closer to 0.6 (new rail limit) than the 0.5 limit used in trials for worn curve rail. Any rail bolted to a nearby switch crossing will probably tolerate force ratios in excess of 0.6 without rolling over.

TABLE 4.3 PEAK VALUES, SIMULATED REVENUE RUN (+5 mph), NEC, WASHINGTON - NEW YORK R/t

A) MINIMUM VERTICAL WHEEL FORCE, Vmin

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
31 kN	73%	Right Wheel Axle 1 (Loco)	404 Wa-Ph	North Track 2	75 - 74	Dry	0.0"	126 mph	Axle 24 (Cab)	
31 kN	73%	Left Wheel Axle 1 (Loco)	404 Wa-Ph	North Track 1	62 - 61	Dry	6.0"	126 mph	Axle 24 (Cab)	
30 kN	75%	Left Wheel Axle 1 (Loco)	404 Wa-Ph	North Track 2	50 - 49	Dry	9.0"	125 mph	Axle 24 (Cab)	
27 kN	78%	Left Wheel Axle 1 (Loco)	404 Wa-Ph	North Track 2	29 - 28	Dry	4.8"	89 mph	Axle 24 (Cab)	
23 kN	82%	Left Wheel Axle 2 (Loco)	406 Ph-NYP	East Track 1	88 - 87	Dry	1.2"	40 mph	Axle 24 (Cab)	
31 kN	68%	Left Wheel Axle 24 (Cab)	406 Ph-NYP	East Track 1	88 - 87	Dry	1.2"	40 mph	Axle 24 (Cab)	
27 kN	77%	Left Wheel Axle 1 (Cab)	406 Ph-NYP	East Track 1	71 - 70	Dry	3.0"	104 mph	Axle 24 (Cab)	
30 kN	74%	Left Wheel Axle 2 (Loco)	406 Ph-NYP	East Track 2	11 - 10	Dry	0.0"	86 mph	Axle 24 (Cab)	
30 kN	68%	Right Wheel Axle 24 (Cab)	405 NYP-Ph	West Track 3	24 - 25	Dry	10.8"	115 mph	Axle 1 (Loco)	
30 kN	69%	Left Wheel Axle 24 (Cab)	405 NYP-Ph	West Track 3	25 - 26	Dry	6.0"	116 mph	Axle 1 (Loco)	
31 kN	66%	Left Wheel Axle 23 (Cab)	405 NYP-Ph	West Track 3	32 - 33	Dry	0.0"	126 mph	Axle 1 (Loco)	
31 kN	73%	Right Wheel Axle 2 (Loco)	405 NYP-Ph	West Track 3	74 - 75	Dry	10.8"	126 mph	Axle 1 (Loco)	

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
29 kN	70%	Left Wheel Axle 24 (Cab)	407 Ph-Wa	South Track 3	35 - 36	Dry	0.0"	126 mph	Axle 1 (Loco)	
22 kN	80%	Right Wheel Axle 24 (Cab)	407 Ph-Wa	South Track 3	35 - 36	Dry	0.0"	126 mph	Axle 1 (Loco)	
23 kN	82%	Right Wheel Axle 2 (Loco)	407 Ph-Wa	South Track 3	55 - 56	Dry	0.0"	126 mph	Axle 1 (Loco)	
25 kN	76%	Right Wheel Axle 24 (Cab)	407 Ph-Wa	South Track 3	55 - 56	Dry	0.0"	126 mph	Axle 1 (Loco)	
33 kN	70%	Right Wheel Axle 1 (Loco)	410 Ph-Tre	East Track 2	82 - 81	Dry	6.0"	77 mph	Axle 24 (Cab)	
31 kN	73%	Right Wheel Axle 2 (Loco)	410 Ph-Tre	East Track 2	82 - 81	Dry	6.0"	77 mph	Axle 24 (Cab)	
34 kN	63%	Right Wheel Axle 24 (Cab)	410 Ph-Tre	East Track 2	82 - 81	Dry	6.0"	77 mph	Axle 24 (Cab)	
33 kN	70%	Left Wheel Axle 2 (Loco)	410 Ph-Tre	East Track 2	66 - 65	Dry	4.8"	126 mph	Axle 24 (Cab)	
36 kN	59%	Left Wheel Axle 24 (Cab)	411 Tre-Ph	West Track 3	65 - 66	Dry	3.6"	126 mph	Axle 1 (Loco)	
40 kN	62%	Left Wheel Axle 2 (Loco)	411 Tre-Ph	West Track 3	70 - 71	Dry	9.0"	126 mph	Axle 1 (Loco)	
37 kN	58%	Left Wheel Axle 24 (Cab)	411 Tre-Ph	West Track 3	70 - 71	Dry	9.0"	126 mph	Axle 1 (Loco)	
41 kN	61%	Right Wheel Axle 1 (Loco)	411 Tre-Ph	West Track 3	85 - 86	Dry	0.0"	66 mph	Axle 1 (Loco)	

TABLE 4.3 PEAK VALUES, SIMULATED REVENUE RUN (+5 mph), NEC, WASHINGTON - NEW YORK R/t

B) MAXIMUM NET AXLE LATERAL FORCE, NAL

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
49 kN	63%	Left Wheel Net Axle 24 (Cab)	404 Wa-Ph	North Track 2	94 -93	Dry	0.0"	46 mph	Axle 24 (Cab)	
48 kN	53%	Left Wheel Net Axle 1 (Loco)	404 Wa-Ph	North Track 2	93 - 92	Dry	4.2"	68 mph	Axle 24 (Cab)	
48 kN	62%	Left Wheel Net Axle 24 (Cab)	404 Wa-Ph	North Track 2	93 - 92	Dry	4.2"	68 mph	Axle 24 (Cab)	
50 kN	64%	Left Wheel Net Axle 24 (Cab)	404 Wa-Ph	North Track 2	50 - 49	Dry	9.0"	125 mph	Axle 24 (Cab)	
43 kN	48%	Left Wheel Net Axle 1 (Loco)	406 Ph-NYP	East Track 2	27 - 26	Dry	9.0"	109 mph	Axle 24 (Cab)	
44 kN	49%	Left Wheel Net Axle 1 (Loco)	406 Ph-NYP	East Track 2	25 - 24	Dry	10.8"	117 mph	Axle 24 (Cab)	
48 kN	53%	Left Wheel Net Axle 1 (Loco)	406 Ph-NYP	East Track 2	11 - 10	Dry	0.0"	86 mph	Axle 24 (Cab)	
46 kN	59%	Left Wheel Net Axle 24 (Cab)	406 Ph-NYP	East Track 2	11 - 10	Dry	0.0"	86 mph	Axle 24 (Cab)	
46 kN	51%	Left Wheel Net Axle 1 (Loco)	405 NYP-Ph	West Track 3	10 - 11	Dry	3.0"	82 mph	Axle 1 (Loco)	
55 kN	61%	Left Wheel Net Axle 2 (Loco)	405 NYP-Ph	West Track 3	74 - 75	Dry	10.8"	126 mph	Axle 1 (Loco)	
51 kN	65%	Left Wheel Net Axle 24 (Cab)	405 NYP-Ph	West Track 3	74 - 75	Dry	10.8"	126 mph	Axle 1 (Loco)	
50 kN	64%	Left Wheel Net Axle 24 (Cab)	405 NYP-Ph	West Track 3	81 - 82	Dry	9.0"	70 mph	Axle 1 (Loco)	

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
44 kN	49%	Left Wheel Net Axle 2 (Loco)	407 Ph-Wa	South Track 3	23 - 24	Dry	8.4"	110 mph	Axle 1 (Loco)	
49 kN	63%	Left Wheel Net Axle 24 (Cab)	407 Ph-Wa	South Track 3	50 - 51	Dry	11.4"	126 mph	Axle 1 (Loco)	
43 kN	48%	Left Wheel Net Axle 1 (Loco)	407 Ph-Wa	South Track 3	75 - 76	Dry	0.0"	126 mph	Axle 1 (Loco)	
49 kN	54%	Left Wheel Net Axle 1 (Loco)	407 Ph-Wa	South Track 3	97 - 96	Dry		31 mph	Axle 1 (Loco)	
46 kN	59%	Left Wheel Net Axle 24 (Cab)	410 Ph-Tre	East Track 2	82 - 81	Dry	6.0"	77 mph	Axle 24 (Cab)	
47 kN	52%	Left Wheel Net Axle 1 (Loco)	410 Ph-Tre	East Track 2	81 - 80	Dry	6.0"	93 mph	Axle 24 (Cab)	
47 kN	52%	Left Wheel Net Axle 1 (Loco)	410 Ph-Tre	East Track 2	75 - 74	Dry	11.4"	125 mph	Axle 24 (Cab)	
42 kN	54%	Left Wheel Net Axle 23 (Cab)	410 Ph-Tre	East Track 2	75 - 74	Dry	11.4"	125 mph	Axle 24 (Cab)	
38 kN	42%	Left Wheel Net Axle 1 (Loco)	411 Tre-Ph	West Track 3	70 - 71	Dry	9.0"	126 mph	Axle 1 (Loco)	
45 kN	50%	Left Wheel Net Axle 2 (Loco)	411 Tre-Ph	West Track 3	70 - 71	Dry	9.0"	126 mph	Axle 1 (Loco)	
40 kN	51%	Left Wheel Net Axle 24 (Cab)	411 Tre-Ph	West Track 3	70 - 71	Dry	9.0"	126 mph	Axle 1 (Loco)	
42 kN	47%	Left Wheel Net Axle 1 (Loco)	411 Tre-Ph	West Trck 3,4	87 - 88	Dry	0.0"	40 mph	Axle 1 (Loco)	

TABLE 4.3 PEAK VALUES, SIMULATED REVENUE RUN (+5 mph), NEC, WASHINGTON - NEW YORK R/t

C) MAXIMUM WHEEL L/V RATIO, L/V

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
0.70	88%	Right Wheel Axle 24 (Cab)	404 Wa-Ph	North Track 2	96 - 95	Dry	0.0"	30 mph	Axle 24 (Cab)	
0.60	75%	Right Wheel Axle 2 (Loco)	404 Wa-Ph	North Track 2	95 - 94	Dry	4.8"	24 mph	Axle 24 (Cab)	
0.59	74%	Left Wheel Axle 24 (Cab)	404 Wa-Ph	North Track 2	94 - 93	Dry	0.0"	46 mph	Axle 24 (Cab)	
0.61	76%	Left Wheel Axle 24 (Cab)	404 Wa-Ph	North Track 2	93 - 92	Dry	4.2"	68 mph	Axle 24 (Cab)	
0.60	75%	Left Wheel Axle 2 (Loco)	406 Ph-NYP	East Track 1	88 - 87	Dry	1.2"	40 mph	Axle 24 (Cab)	
0.52	65%	Left Wheel Axle 24 (Cab)	406 Ph-NYP	East Track 1	88 - 87	Dry	1.2"	40 mph	Axle 24 (Cab)	
0.54	68%	Right Wheel Axle 24 (Cab)	406 Ph-NYP	East Track 1	88 - 87	Dry	1.2"	40 mph	Axle 24 (Cab)	
0.50	63%	Left Wheel Axle 24 (Cab)	406 Ph-NYP	East Track 1	86 - 85	Dry	0.0"	58 mph	Axle 24 (Cab)	
0.62	78%	Right Wheel Axle 1 (Loco)	405 NYP-Ph	West Track 2	1-2	Dry	4.8"	60 mph	Axle 1 (Loco)	
0.60	75%	Right Wheel Axle 1 (Loco)	405 NYP-Ph	West Track 3	7-8	Dry	3.0"	45 mph	Axle 1 (Loco)	
0.77	96%	Right Wheel Axle 1 (Loco)	405 NYP-Ph	West Track 3	10-11	Dry	3.0"	82 mph	Axle 1 (Loco)	
0.60	75%	Left Wheel Axle 1 (Loco)	405 NYP-Ph	West Track 3	81-82	Dry	9.0"	70 mph	Axle 1 (Loco)	

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
0.68	85%	Right Wheel Axle 1 (Loco)	407 Ph-Wa	South Track 3	2-3	Dry	3.0"	67 mph	Axle 1 (Loco)	
0.63	79%	Right Wheel Axle 1 (Loco)	407 Ph-Wa	South Track 3	3-4	Dry	3.0"	79 mph	Axle 1 (Loco)	
0.64	80%	Right Wheel Axle 1 (Loco)	407 Ph-Wa	South Track 3	13-14	Dry	0.0"	96 mph	Axle 1 (Loco)	
0.69	86%	Right Wheel Axle 1 (Loco)	407 Ph-Wa	South Track 3	35-36	Dry	0.0"	126 mph	Axle 1 (Loco)	
0.47	59%	Left Wheel Axle 24 (Cab)	410 Ph-Tre	East Track 2	83-82	Dry	0.0"	77 mph	Axle 24 (Cab)	
0.41	51%	Left Wheel Axle 2 (Loco)	410 Ph-Tre	East Track 2	82-81	Dry	6.0"	77 mph	Axle 24 (Cab)	
0.44	55%	Right Wheel Axle 24 (Cab)	410 Ph-Tre	East Track 2	82-81	Dry	6.0"	77 mph	Axle 24 (Cab)	
0.43	54%	Right Wheel Axle 24 (Cab)	410 Ph-Tre	East Track 2	81-80	Dry	6.0"	93 mph	Axle 24 (Cab)	
0.62	78%	Right Wheel Axle 1 (Loco)	411 Tre-Ph	West Track 3	85-86	Dry	0.0"	66 mph	Axle 1 (Loco)	
0.58	73%	Left Wheel Axle 1 (Loco)	411 Tre-Ph	West Trck 3,4	87-88	Dry	0.0"	40 mph	Axle 1 (Loco)	
0.78	98%	Right Wheel Axle 1 (Loco)	411 Tre-Ph	West Trck 3,4	87-88	Dry	0.0"	40 mph	Axle 1 (Loco)	
0.64	80%	Right Wheel Axle 23 (Cab)	411 Tre-Ph	West Trck 3,4	87-88	Dry	0.0"	40 mph	Axle 1 (Loco)	

TABLE 4.3 PEAK VALUES, SIMULATED REVENUE RUN (+5 mph), NEC, WASHINGTON - NEW YORK R/t

D) MAXIMUM TRUCK SIDE L/V RATIO, T-L/V

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
0.45	90%	Left Side Truck 12 (Cab)	404 Wa-Ph	North Track 2	94-93	Dry	4.8"	46 mph	Axle 24 (Cab)	
0.47	94%	Left Side Truck 12 (Cab)	404 Wa-Ph	North Track 2	93-92	Dry	4.2"	68 mph	Axle 24 (Cab)	
0.45	90%	Left Side Truck 12 (Cab)	404 Wa-Ph	North Track 2	62-61	Dry	6.0"	126 mph	Axle 24 (Cab)	
0.46	92%	Left Side Truck 12 (Cab)	404 Wa-Ph	North Track 2	12-11	Dry	2.4"	96 mph	Axle 24 (Cab)	
0.35	70%	Left Side Truck 12 (Cab)	406 Ph-NYP	East Track 1	86-85	Dry	0.0"	58 mph	Axle 24 (Cab)	
0.35	70%	Left Side Truck 12 (Cab)	406 Ph-NYP	East Track 1	85-84	Dry	0.0"	59 mph	Axle 24 (Cab)	
0.41	82%	Left Side Truck 12 (Cab)	406 Ph-NYP	East Track 1	82-81	Dry	1.2"	54 mph	Axle 24 (Cab)	
0.34	68%	Left Side Truck 12 (Cab)	406 Ph-NYP	East Track 2	42-41	Dry	0.0"	126 mph	Axle 24 (Cab)	
0.42	84%	Right Side Truck 1 (Loco)	405 NYP-Ph	West Track 2	1-2	Dry	4.8"	60 mph	Axle 1 (Loco)	
0.47	94%	Left Side Truck 1 (Loco)	405 NYP-Ph	West Track 3	10-11	Dry	3.0"	82 mph	Axle 1 (Loco)	70 mph posted speed, Class 4 Track, interlocking in middle of 1° curve, Hunter
0.54	108%	Right Side Truck 1 (Loco)	405 NYP-Ph	West Track 3	10-11	Dry	3.0"	82 mph	Axle 1 (Loco)	70 mph posted speed, Class 4 Track, interlocking in middle of 1° curve, Hunter
0.39	78%	Left Side Truck 1 (Loco)	405 NYP-Ph	West Track 3	81-82	Dry	9.0"	70 mph	Axle 1 (Loco)	

Measured Value	% of Limit	Vehicle Element	Run No/ Line	Direct/ Track	Track Milepost	Track Condit	Measured Cant Def	Measured Speed	Leading Axle	Comments
0.57	114%	Right Side Truck 1 (Loco)	407 Ph-Wa	South Track 3	2-3	Dry	0.6"	60 mph	Axle 1 (Loco)	Switch, in a spiral adjacent to bridge. Posted Class 3
0.47	94%	Right Side Truck 1 (Loco)	407 Ph-Wa	South Track 3	3-4	Dry	3.0"	79 mph	Axle 1 (Loco)	
0.47	94%	Right Side Truck 1 (Loco)	407 Ph-Wa	South Track 3	13-14	Dry	0.0"	96 mph	Axle 1 (Loco)	
0.51	102%	Right Side Truck 1 (Loco)	407 Ph-Wa	South Track 3	35-36	Dry	0.0"	126 mph	Axle 1 (Loco)	Switch, tangent track, Class 5 profile exception
0.27	54%	Left Side Truck 12 (Cab)	410 Ph-Tre	East Track 2	83-82	Dry	0.0"	77 mph	Axle 24 (Cab)	
0.35	70%	Left Side Truck 12 (Cab)	410 Ph-Tre	East Track 2	82-81	Dry	6.0"	77 mph	Axle 24 (Cab)	
0.42	84%	Left Side Truck 12 (Cab)	410 Ph-Tre	East Track 2	82-81	Dry	6.0"	77 mph	Axle 24 (Cab)	
0.29	58%	Right Side Truck 12 (Cab)	410 Ph-Tre	East Track 2	82-81	Dry	6.0"	77 mph	Axle 24 (Cab)	
0.27	54%	Left Side Truck 12 (Cab)	410 Ph-Tre	East Track 2	75-74	Dry	11.4"	125 mph	Axle 24 (Cab)	
0.27	54%	Left Side Truck 12 (Cab)	410 Ph-Tre	East Track 2	66-65	Dry	4.8"	126 mph	Axle 24 (Cab)	
0.34	68%	Right Side Truck 1 (Loco)	411 Tre-Ph	West Track 3	84-85	Dry	0.0"	63 mph	Axle 1 (Loco)	
0.41	82%	Right Side Truck 1 (Loco)	411 Tre-Ph	West Track 3	85-86	Dry	0.0"	66 mph	Axle 1 (Loco)	
0.41	82%	Left Side Truck 1 (Loco)	411 Tre-Ph	West Track 3	87-88	Dry	0.0"	40 mph	Axle 1 (Loco)	
0.39	78%	Right Side Truck 1 (Loco)	411 Tre-Ph	West Track 3	87-88	Dry	0.0"	40 mph	Axle 1 (Loco)	

5. DISCUSSION OF RESULTS

5.1 TEST HIGHLIGHTS AND SIGNIFICANT EVENTS

- 12.5" maximum average cant deficiency achieved in a test curve.
- 154 mph maximum speed attained; no instability observed.
- No safety criteria exceeded during cant deficiency test runs on the Harrisburg line and the NEC test zone between Trenton and Newark.
- The main circuit breaker, left open for an extended time, resulted in loss of tilting at one occasion during a test; no safety criteria were exceeded.

5.2 MAXIMUM THEORETICAL CANT DEFICIENCY

Based on the trends exhibited for the safety related criteria, it could be expected that the X2000 would not exceed any of the safety criteria in the test curves for cant deficiencies of up to 15 inches. While extrapolation of the test data to this extent assumes linearity and is not truly valid, it is useful in assessing the relative margin of safety which is likely to exist for the proposed revenue service.

5.3 EFFECTS OF TILT

During two test runs on the Philadelphia - Harrisburg line, the tilt system was deactivated on the cab car and on the 2 adjacent cars (#2810 & 2609). These test runs (129,130) were carried out at 9 inches of cant deficiency, with the locomotive leading westbound and the cab car leading eastbound. A preliminary comparison of results for the cab car with those obtained from similar 9 inch cant deficiency test runs (125,126) with normal tilting shows little difference in the derailment related safety parameters.

The maximum steady state carbody lateral acceleration recorded with the tilt system deactivated was 0.19g on the cab car above truck #12 while traversing curve 662 (4°). The maximum peak lateral acceleration observed with no tilting was 0.33g while traversing curve 672 (2°).

A more detailed comparison will be carried out in the final analysis.

5.4 EFFECTS OF WET RAIL

During the test it was observed that the amount of lateral load sharing by the wheel on the low rail, due to radial steering, was reduced when the rail was wet. As a result the lateral force applied to the high rail increased. This was felt to have little or no impact regarding wheel climb due to the reduction in the coefficient of friction on the

high rail. While no hazards are anticipated in any way, further analysis to determine the effect on truck side L/V ratio is recommended to fully describe the effect of wet rail conditions on performance.

5.5 EFFECTS OF SIDE WIND ON ATTAINABLE CANT DEFICIENCY

The effect of side winds on vehicle overturning can be expressed in terms of vertical wheel force unloading. An estimate of the unloading experienced by the cab car, the worst case vehicle for the X2000 in the leading position, predicts the vertical wheel force will unload by 5.7 kN (1280 pounds) with a 40 mph side wind applied. This is roughly equivalent to the unloading experienced by the X2000 when operating at 1.5" of cant deficiency around a curve.

The effect of sidewinds on the attainable cant deficiency can also be expressed by the weight vector intercept (WVI) value. Since the wind conditions during the tests have been negligible, the measured WVI values have been low. In order to draw conclusions as to the influence of higher sidewinds on the WVI, simulations using wind tunnel test results have been made by ABB. In principle, the calculated effect of a sidewind (in an ideal curve) is added to the actual measured values.

At this preliminary stage, no calculations from a specific curve including track irregularities (e.g. from the NEC) have been done. Nevertheless there is a high degree of confidence in the method used. One uncertainty is the assumption that the dynamic variation of the WVI with sidewind is not higher than without sidewind (as in tests). Since the dynamics that are essential with respect to vehicle overturning are of rather low frequency (a very short duration wheel unloading will not result in overturning), it is likely that the low frequency variations of the WVI will not be higher than without sidewind. However, this has still to be proven through calculations.

Investigations have shown that for the X2000, the most exposed car during sidewinds is the cab car in the leading position. Preliminary results of this case were derived by adding the effect of a 45 mph sidewind on the WVI to the measured values for the curves 662, 663, 671, and 672 on the Harrisburg line, as well as for the curves 265, 266, and 268 on the Trenton-Newark line. With the above assumptions, the maximum expected dynamic value of the WVI for a 45 mph sidewind and at 10" cant deficiency is about 24.5" for curve 663 and about 23" for the other curves on the Harrisburg line. On the Trenton-Newark curves, the maximum expected WVI is about 22".

The limit of 26.5" assumes a 10% margin remaining on the inner wheels before total unloading occurs. This and the fact that the WVI values are derived with a filter frequency of 25 Hz (in Sweden 1.5 Hz is used in these cases) and most likely contains high frequency components, gives an additional safety margin against vehicle overturning at 10" unbalance and 45 mph sidewind.

5.6 EFFECT OF TRACK GEOMETRY VARIANCE ON ATTAINABLE CANT DEFICIENCY

To describe the full effect of various track geometry variations on the performance relative to the safety criteria is a major task well beyond the scope of this effort. Realistic, performance based limits for track geometry for high speed passenger train operations in the United States have yet to be developed and will be addressed in the final test report. An anomaly which reduces the crosslevel by one inch in the body of a curve will be used as a convenient estimate of the likely contribution of the 'realistic worst case' track geometry. Although it is unlikely such an anomaly would exist on Amtrak's high speed track, it is considered a reasonable indicator of the maximum track geometry related effect. The net effect of such an anomaly would be to increase the actual cant deficiency by 1 inch. Deviations in curvature or crosslevel could realistically be expected to increase the cant deficiency by this amount.

5.7 EFFECT OF SPEED VARIANCE ON ATTAINABLE CANT DEFICIENCY

Operating at speeds greater than intended due to speedometer or operator error is a likely occurance. The effect of overspeed operation is a function of both curve geometry and the planned operating speed. In general, the higher the degree of curvature and the greater the operating speed, the greater the effect overspeed operation will have on safety. The change in cant deficiency for an overspeed of 5 mph is shown as a function of operating speed for various curvatures in **Figure 5.1.**

5.8 EFFECT OF VEHICLE CONDITION ON ATTAINABLE CANT DEFICIENCY

Obviously the range of possible effects of vehicle maintenance condition on performance is unlimited. As a realistic worst case condition, it is conceivable that the radial steering ability of the truck would be lost.

Much experience gained from a wide variety of radial steering trucks in service (in particular, the X2000) has indicated that the components most likely to suffer from sub-standard maintenance are the dampers. Extensive trials were carried out during 1989 in Sweden to verify the effects of removing up to half of any one group of dampers, often in combinations of several groups together. It was found that under such conditions of only 50% damping, safety criteria at high cant deficiencies in curves were little affected. Stability at high speed on tangent was affected negatively, but even with truck hunting, all safety criteria were still fulfilled. However, ride comfort did degenerate more significantly with 50% damper unavailability. This supports the conclusion that damper failure is primarily a comfort and wear problem rather than a safety risk. A 1 inch cant deficiency margin should be ample to account for damper degradation.

Another area requiring maintenance is that of wheel profiles. Careful follow-up programs in Sweden during X2000 revenue service have shown that the wheel profiles maintain a fairly stable worn shape after an initial period of wear-in.

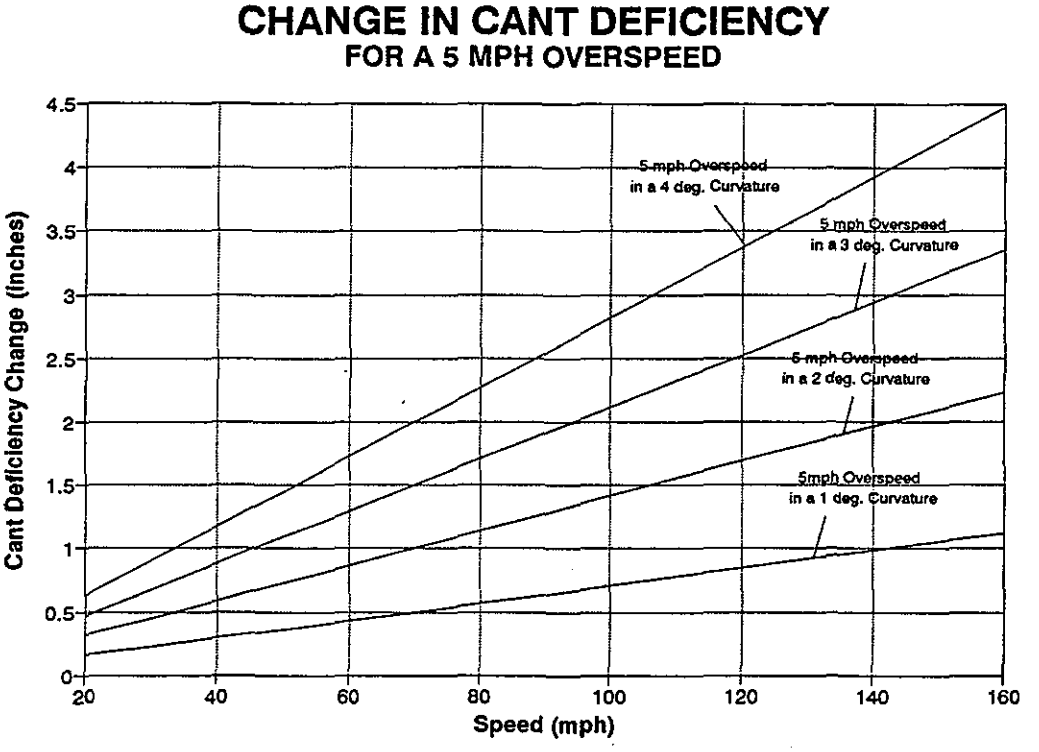


Figure 5.1: Effect of 5 mph Overspeed on Cant Deficiency

Inspection of the profiles chosen for running in the U.S. after some 5000 miles suggests this pattern would be repeated for Amtrak track conditions. Again, a 1 inch cant deficiency margin on safety should provide adequate margin for the eventuality of turning different wheel diameters and other such errors, and for a likely worst case worn wheel profile shape.

5.9 SUMMARY OF EFFECTS ON SUSTAINABLE OPERATIONAL CANT DEFICIENCY

The sum total of the above effects would be to increase the effective cant deficiency by 5.9 inches. A discussion of these effects is presented in **Section 6.**

6. PRELIMINARY RECOMMENDATIONS AND CONCLUSIONS

As previously stated, the purpose of this report is to provide a basis for establishing procedures and limits for the safe operation of the X2000 by Amtrak in the NEC. In developing the conclusions and recommendations presented here the authors have attempted to strike a balance between performance and safety. Where either the available data or time for analysis was limited, conservative judgement has been applied in the interest of safety.

The X2000 has been thoroughly analyzed and tested in Europe and has compiled a successful operating and safety record in service in Sweden. The fundamental question addressed by the tests and analysis supporting operations in the United States is how the X2000 would respond to the track conditions here.

The tests here were conducted by Amtrak over specific test zones on Amtrak's Harrisburg line and on the NEC between Trenton and Newark. Specific test curves chosen for detailed analysis ranged from 4° 16' (409m radius) to 1° 26' (1221m radius) giving a theoretical cant deficiency of 12" at speeds ranging from 77 mph to 134 mph respectively. Trials were carried out in each of these selected curves at up to 12" of cant deficiency or at a maximum of 125 mph, whichever limit was reached first. During the 42 test runs, from which 156 curve transits were analyzed in detail, not one safety limit was exceeded. The highest average cant deficiency recorded by the axle mounted accelerometer through an entire curve during trials was 12.5". The test runs were made in conditions varying from dry to wet and with the tilt activated and deactivited on separate runs.

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.

6.1 RECOMMENDATION FOR OPERATION AT 9" OF CANT DEFICIENCY

Test results show the X2000 radial truck to be effective in transferring lateral loads from the high rail to the low rail at elevated cant deficiency. Vertical load transfer and vehicle overturning are effectively controlled by the truck design which incorporates a roll stabilizer. These design features allow the X2000 to operate in regular service at 9.6 inches of cant deficiency in Sweden (1.6 m/s^2 lateral acceleration), based on the design curve geometry.

The test results from both the Harrisburg line and the NEC test zones indicate the peak dynamic responses for the safety relevant parameters never reached more than 92% of the stop test criteria at up to 12" of cant deficiency.

The Harrisburg test zone was believed by the Amtrak test planners to be representative of the 'realistic worst case' Amtrak track conditions. A linear projection of the trends established from the test data suggest that, for the conditions

tested, somewhere around 15 inches of cant deficiency could be attained before the safety criteria would have been exceeded.

Several factors which were not evaluated during the test, will 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 below.

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

Factor	*Calculated/Estimated* Equivalent Cant Deficiency
-40 mph Side Wind	1.5"
-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)	2.0"

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 9 inches of cant deficiency based on average geometry would produce a total equivalent cant deficiency of just below 15 inches.

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 X2000 at 9 inches of cant deficiency over Amtrak track can be considered safe with the following conditions.

6.2 RECOMMENDED CONDITIONS FOR 9 INCH CANT DEFICIENCY OPERATION

Condition (1) Track Geometry/Structure for 9" C.D. - The track geometry in the curves over which 9" C.D. operation is allowed should meet all applicable FRA Track Safety Standards. The limiting speed for each curve will be calculated based on a 9 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 an automated Track Geometry measurement car.

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

Condition (2) Wind - Should wind speeds be predicted in excess of 40 mph, X2000 speeds should be restricted to those for Metroliner operations under the same conditions.

Condition (3) Vehicle Conditions - While wheel wear has been reported from service experience in Sweden 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 assure that accelerated tread and flange wear do not occur.

Dampers are used more extensively on the X2000 than on existing Amtrak equipment to limit undesired vehicle response. Evaluating the effects 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 assure they are functioning properly by measuring vehicle carbody accelerations on a regular basis .

Condition (4) Speed Control - Amtrak should take steps to assure 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.

6.3 RECOMMENDATIONS FOR OPERATION AT 10" OF CANT DEFICIENCY IN SELECTED CURVES

From observations of both the measured track geometry and vehicle response, it is clear that some curves on the NEC could safely support operation at even higher cant deficiency. Curves which meet the following conditions should apply to safely support 10" C.D. operation:

Condition (5) 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 trackwork or structures within 200 feet of the curve along the track (i.e.- switches, crossings, undergrade bridges, etc.)
- Limited dynamic response during simulated revenue test runs.

Condition (6) Strict speed control - Steps will be taken to ensure that the 10" unbalance speed, based on the limiting track geometry conditions, is never exceeded. Thus overspeed operation is prevented from impacting the margin of safety.

6.4 RECOMMENDATION FOR 135 MPH MAXIMUM OPERATION SPEED

The X2000 demonstrated stable operation at 150 mph over the NEC high speed stability test zone. Analysis performed by the equipment manufacturer has predicted stable performance, under normal conditions, for speeds up to 165 mph.

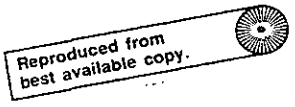
Both the data and the analysis support the operation at elevated speeds. Operation at speeds up to 135 mph would be considered conservatively safe under conditions 2, 3 and 4 above and the following:

Condition (7) Track Geometry/Structure for 125 mph - The track meets the conditions currently approved for 125 mph Metroliner operations.

Condition (8) Instability in Service - Any indications of instability during operation would be reported to the FRA and speeds for the X2000 would be restricted to 125 mph until the cause(s) of instability were identified and corrected.

APPENDIX A

TEST EVENT LOG, X2000 U.S. DEMONSTRATION



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TEST EVENT LOG
X2000 US Demo

LR 9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry Wet	N2 2013 direction	Remarks
30/11	12^{30}	11	101	W	3"	3	D	E	Old cal. in computer
		11							Lateral forces OK
		20				4			Accelerometer signals OK
									Problem with magnets, cab car
									No filter on Truck acc.
	13^{30}								Stop Lancaster
	15^{25}		102	E	5"	1	D	E	Problem with magnets
	15^{50}								Stop Park
	16^{20}		103	W	6"	4	D	E	
	16^{35}								Stop Lancaster
	16^{50}		104	E	6"	1	D	E	
	17^{10}								Stop Thorndale
	18^{10}		105	W	7"	4	D	R	Y612 Lad, tilt problems
	18^{20}								Stop Lancaster
	18^{50}		106	E	7"	1	D	E	
	19^{10}								Stop Parksburg.

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TEST EVENT LOG
X2000 US Demo

LR.9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry/Wet	X2 2013 direction	Remarks
1/12	11:50		107	W	7"	4	D ½W	E	False magnets calcar.
	12:05								
	13:05		108	E	7"	1	½W	E	
	13:20								
	13:40		109	W	8"	4	W	E	
	13:55								
	14:20		110	E	8"	1	W	E	
	14:35								
	14:50		111	W	9"	4	W	E	
	15:05								
	15:20		112	E	9"	1	W	E	
	15:40								
	16:11		113	W	10"	4	W	E	
	16:25								
	17:10		114	E	10"	1	W	E	
	17:25								

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TEST EVENT LOG
X2000 US Demo

LR 9223-12n

Date	Time	MP	Run #	Direction	1% Balance	Track #	Rail Dry Wet	X2 2013 direction	Remarks
2/12	10:45		115	W	10"	4	D	E	
	11:00								
	11:20		116	E	10"	1	D	E	
	11:35								
	12:40		117	W	11"	4	D	E	
	12:55								
	14:05		118	E	11"	1	D	E	
	14:20								
	15:40		119	W	12"	4	D	E	
	15:55								
	16:05		120	E	12"	1	D	E	
	16:15								

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TEST EVENT LOG
X2000 US Demo

LR 9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry/Wet	X2 2013 direction	Remarks
3/12	10^{55}		121	W	9"	4	D	W	Train turned.
	11^{05}								SNo Y-kompensation bolster MP54
									on axle 23 and 24
	11^{25}		122	E	10"	1	D	W	
	11^{40}								
	12^{40}		123	W	10"	4	D	W	
	12^{55}								
	14^{25}		124	E	11"	1	D	W	
	14^{40}								
4/12	11^{15}		125	W	9"	4	D	W	Ripple on V24 before 4K
	11^{30}								
	12^{25}		126	E	9"	1	D	W	
		57							Stem stop
		52-51							False MP
	13^{45}								
	14^{50}		127	W	12"	4	D	W	
	19^{05}								
	15^{10}		128	E	12"	1	D	W	
		58							L23r, L23l adjusted
	15^{45}								
	16^{20}		129	W	9"	4	D	W	No 1:11 car 4, 5 and 6
		53							L23r, L23l adjusted
	16^{35}								
			130	E	9"	1	D	W	
	17^{10}	56							L24r, L24v adjusted.
	17^{20}								

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TEST EVENT LOG
X2000 US Demo

LR.9223-12n

Date	Time	MP	Run #	Direction	Un Balance (speed)	Track #	Rail Dry/Wet	X2 2013 direction	Remarks
7/12	0⁴⁵	56	200	E	130	3	D	rear	
	0⁵⁵	41	"						
7/12	2⁰⁹	39/32	200	E	5"	3	D	rear	1 false magnet M4 (loco
	2¹⁶								
7/12	2²⁵	33/32	201	W	7"	3	D	front	1 double magnet M1 (loco
	2³⁵								1 false " M4 "
7/12	2⁵²	32/31	202	E	9"	3	D	rear	
	3⁰¹								
7/12	3¹²	27/31	203	W	10"	3	D	front	1 missing magnet
	3²⁰								1 false " M4 loco
									Waiting for freight tra
7/12	3⁴⁵	31/21	204	E	11"	3	D	rear	
	3⁵⁵								
7/12	4²⁸	21/3	205	W	12"	3	D	front	
	4²⁷								
7/12	4²⁸		206	W	140	3	D	"	changed during run
	4⁴⁰								

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TEST EVENT LOG
X2000 US Demo

LR 9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry/Wet	X2 2013 direction	Remarks
									speed
8/12	0825		202	E	150	3	D	rear	
	0839								
8/12	0859		206	E	9"	3	D	rear	Changed during run
	050								1 false magnet M4 after 5. (loco)
									No data on computer
									Chart recorders OK
8/12	105		-	W	-	2	-	front	Clearance run
8/12	112		207	W	9"	2	D	Front	V=113 instead of 117
	125								restricted signal
8/12	217		208	E	10"	2	D	rear	One vertical hit
	229								
8/12	235		209	W	11"	2	D	Front	v=115 mph instead
	245								
8/12	255		210	E	12"	2	D	rear	
	305								
8/12	318		211	W	linespeed	2	D	front	v=95 mph
8/12	333		303	W	150	3	D	"	Changed during run
	355								at mp 31
10/12	1000		131	W	9"	4	D	rear	Plessrun
	1015		131	W	9"	4	Snow	"	Dep from Downingtown
	1108								
10/12	1200		132	E	9"	1	Snow	Front	Dep from Lancaster
	1315								2nd last non tilted
									First curve in linespeed
									due to low adhesion

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TEST EVENT LOG
X2000 US Demo

LR 9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry Wet	N2 2013 direction	Remarks
12/12	905	54	304	E	140	3	W	rear	
	915	34							End of run 304
12/12	955	24	305	W	150	3	W	front	Extra for Thomas Edwa
	1001	34							153 mph
	1007	54							End of run 305

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TEST EVENT LOG
X2000 US Demo

LR 9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry/Wet	X2 2013 direction	Remarks
14/12	8[14]	132	400	N	9"	2	D	rear	Washington-Philadelphia
									channel 17-32 are
									recorded with lower sample
									freq. (100Hz) due to long runs
									(Run number 400 – 411)
		121							Penalty for overspeed
	835	113							– " –
									First time ever this
									driver is driving!!
		70/69							High L/V1L on "TRAS", not on Brush
	916	63				1			L1L false from 945-985 sek.
	912	60				2			
	923	42							MP synchronized
	950	0				1 in i		Phy	
14/12	10[13]	88	402	E	9"	1	D	rear	The train starts be-
									fore the measurement
									car is ready AGAIN!
		87				2			without intervention
		8				1			Same track, new number
	1101	900				5			after Newark
									Staff at Penn Cen
									MP lost numbers
									906 → 900. 906
									resynchronized
	The start 8[14] was nearly one minute								
	early & without any notice.								

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TEST EVENT LOG
X2000 US Demo

LR:9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry Wet	X2 2013 direction	Remarks
14/12	12[10]	920	401	W	9"	5	D	front	V23L false from 901 – 903
		905				2			
12[12]	1220	6				3			
my notes	1223	23							Stop Newark
Thorg Elevate									" Metro Park
	1317	87				4			
	1322					5			" Philadelphia
									Check V22L + V24L
									Pantograph down for
									ID's. No change in
									signals.
									Grounding problems
									to the Q-shaper.
									Fixed
14/12	1428	0	403	S	9"	3	D	front	Track 5 : Philadelphia
		60				4			
		72				3			
	1526					7			Stop Baltimore
									Slipringdevice 4 (axle 23)
									changed to 5. Train moved to #
	1607					1			
	1608					3			
	1627								Red signal. Caught up train 905
	1646					16			Stopp at Washington
									Slipringdevice 10 (axle 24)
									changed to 6.

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TEST EVENT LOG
X2000 US Demo

LR 9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry: Wet	X2 2013 direction	Remarks	
15/12	8:15	135	404	N	9"5mph	2	D	rear	Recorded from start	
									L23 L24 L2r not OK from sta	
		133							All signals OK	
		128							Temporary stop	
		122							Penalty overspeed	129 mp
	9:47	96							Stop at Baltimore track #6.	2 min
		67	and north		→ mph	25			Frost	
		64				1				
		60				2				
		18				1			Arrival Willmington	
	9:29					1			Stop at Willmington	1 min
	9:31	26				1				
	9:49	0				4			Stop at Philadelphia	
	10:0		406			1			Dep "	
						1			We are on wrong	Tk
									and miss the high UB.	
	10:35	58				2			Back to #2	
									Channel 17-32 lost	
									mph 60-57 on TRA5	
									but not on Brush	
									Changed 15V supply	
									False signal me57→906	
									for channel 17-32. Un-	
									filtered signals are (1-16) OK	
		49				2			Reached 125 m/h	
									Slow acceleration due to	
									low line voltage 10kV	
	10:58	9				2			Stop at Newark	Open Bridge
	10:59								Dep "	
Dep	11:02								Stop on bridge "	
	11:25					6			Stop in New York	
	11:29								Channel 17-32 OK	

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TEST EVENT LOG
X2000 US Demo

LR.9223-12m

Date	Time	MP	Run #	Direction	Un Balance	Track #	Rail Dry Wet	X2 2013 direction	Remarks
15/12	12.12	988	405	W	9"+5mph	6	D	front	Leave NYP
	12.14					2			
		6.				3			
		26							One false magnet before
	1255	~58				3			Stop for restrictive signal
	1317	85				3			Just before Philadelphia
15/12	1328	85	410	E	9"+5mph	2	D	rear	Repetition of the morning test run but on the right Tr
	1341	60				2			Finish
15/12	1354	58	411	W	9"5mph	3	D	front	Cross over to # 3
	1417	87				4			Stop at Philadelphia Tra
15/12	1421	1	407	S	9"5mph	3	D	front	Dep Phy track #6
									One false mp before nr
	1434	25				3			Stop at Wilmington 2 min
		60				4			
		73				3			
	1509	95							Stop Baltimore Tk #7 1
		111/114							Power off twice to the strip chart recorders.
									TRAS OK
	1543	195							Stop 2 min outside Washingt
	1552					16			Stop in Washington

APPENDIX B

TRACK CURVE INFORMATION

Eastbound

X2000 TEST PROGRAM
HARRISBURG LINE SPEEDS

Track No. 1

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			PROPOSED CURVING SPEED FOR X-2000 TEST										PROPOSED MAXIMUM TESTING SPEED
		West	East	DEGREE [decimal]	RADIUS [feet]	S.E. [inches]	3"UB [mph]	4"UB [mph]	5"UB [mph]	6"UB [mph]	7"UB [mph]	8"UB [mph]	9"UB [mph]	10"UB [mph]	11"UB [mph]	12"UB [mph]	[mph]
677		66.58	66.26	0.60	9,549	1.875	108	110	110	110	110	110	110	110	110	110	110
676.1		66.22	66.17	0.37	15,626	0.750	110	110	110	110	110	110	110	110	110	110	"
676		65.52	64.79	0.32	18,094	0.750	110	110	110	110	110	110	110	110	110	110	"
675		63.87	63.51	1.00	5,730	3.375	95	103	109	110	110	110	110	110	110	110	"
674		63.21	62.97	0.45	12,733	0.500	105	110	110	110	110	110	110	110	110	110	"
673		62.10	61.64	1.02	5,636	3.250	94	101	108	110	110	110	110	110	110	110	"
672	Curve west of MP 61	61.48	60.97	2.03	2,818	5.250	76	81	85	89	93	97	100	104	107	110	"
671	Curve west of MP 60	60.62	59.97	2.00	2,865	5.500	78	82	87	91	95	98	102	105	109	110	"
670	Curve west of MP 59	59.69	59.53	1.10	5,209	3.000	88	95	102	108	110	110	110	110	110	110	"
669		58.99	58.42	1.52	3,778	5.500	90	95	99	104	109	110	110	110	110	110	"
668		57.84	57.36	0.65	8,815	1.250	97	107	110	110	110	110	110	110	110	110	"
667		56.64	55.79	0.98	5,827	2.250	87	95	103	110	110	110	110	110	110	110	"
666		54.58	54.38	0.45	12,733	0.875	110	110	110	110	110	110	110	110	110	110	"
665		53.99	53.66	0.47	12,278	0.875	109	110	110	110	110	110	110	110	110	110	"
664		53.25	52.74	2.05	2,795	5.625	78	82	86	90	94	97	101	104	108	110	"
663	Curve west of Gap	52.44	52.00	4.03	1,421	5.750	56	59	62	65	67	70	72	75	77	79	"
662	Curve at Gap	51.63	50.77	4.20	1,364	5.625	54	57	60	63	66	68	71	73	75	77	"
661		50.61	50.19	2.00	2,865	5.875	80	84	88	92	96	100	103	107	110	110	"
660		50.06	49.81	1.00	5,730	3.375	95	103	109	110	110	110	110	110	110	110	"
659		49.16	48.84	1.00	5,730	3.375	95	103	109	110	110	110	110	110	110	110	"
658		48.72	48.36	1.00	5,730	3.125	94	101	108	110	110	110	110	110	110	110	"
657	Curve west of Algien	48.29	47.50	2.00	2,865	5.750	79	84	88	92	95	99	103	106	109	110	"
656		46.86	46.77	0.33	17,189	0.375	110	110	110	110	110	110	110	110	110	110	"
655		45.34	45.24	0.40	14,324	0.750	110	110	110	110	110	110	110	110	110	110	"
654.1		44.81	44.61	0.45	12,733	0.875	110	110	110	110	110	110	110	110	110	110	"
654		43.79	43.65	0.32	18,094	0.750	110	110	110	110	110	110	110	110	110	110	"
653.1		43.97	43.96	0.37	15,626	0.750	110	110	110	110	110	110	110	110	110	110	"
653		41.63	41.32	0.65	8,815	2.250	107	110	110	110	110	110	110	110	110	110	"
652		41.03	40.84	0.75	7,640	1.875	96	106	110	110	110	110	110	110	110	110	"
651		39.90	39.42	0.67	8,594	2.250	106	110	110	110	110	110	110	110	110	110	"
650		39.09	38.39	0.50	11,459	1.625	110	110	110	110	110	110	110	110	110	110	"
649		37.92	37.33	1.02	5,636	3.375	95	102	109	110	110	110	110	110	110	110	"

X2000HBE.XLS

Eastbound

X2000 TEST PROGRAM
HARRISBURG LINE SPEEDS

Track No. 1

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			PROPOSED CURVING SPEED FOR X-2000 TEST										PROPOSED MAXIMUM TESTING SPEED
		West	East	DEGREE (decimal)	RADIUS (feet)	S.E. (inches)	3"UB (mph)	4"UB (mph)	5"UB (mph)	6"UB (mph)	7"UB (mph)	8"UB (mph)	9"UB (mph)	10"UB (mph)	11"UB (mph)	12"UB (mph)	(mph)
648		37.30	36.77	0.98	5,827	3.500	97	104	110	110	110	110	110	110	110	110	110
647		35.87	35.70	0.37	15,626	1.250	110	110	110	110	110	110	110	110	110	110	"
646		35.55	35.43	0.32	18,094	1.125	110	110	110	110	110	110	110	110	110	110	"
645		35.13	34.84	0.32	18,094	1.500	110	110	110	110	110	110	110	110	110	110	"
644		34.58	34.10	0.92	6,251	3.000	97	104	110	110	110	110	110	110	110	110	"
643		34.04	33.55	0.72	7,995	2.250	102	110	110	110	110	110	110	110	110	110	"
642		33.16	32.88	0.82	7,016	2.500	98	107	110	110	110	110	110	110	110	110	"
641		32.56	32.19	0.97	5,927	3.375	97	104	110	110	110	110	110	110	110	110	"
640		31.58	31.27	1.70	3,370	6.000	87	92	96	100	105	109	110	110	110	110	"
639	1st & 2nd curve 1200' west of Signal 295	30.84	30.34	2.37	2,421	5.625	72	76	80	84	87	91	94	97	100	103	"
638	1st & 2nd curve 1200' west of Signal 295	30.28	29.81	3.00	1,910	5.500	64	67	71	74	77	80	83	86	89	91	"
637		29.20	28.20	0.20	28,648	1.250	110	110	110	110	110	110	110	110	110	110	"
636		25.71	25.50	0.45	12,733	1.500	110	110	110	110	110	110	110	110	110	110	"
635		24.50	24.15	0.50	11,459	1.750	110	110	110	110	110	110	110	110	110	110	"
634		23.60	23.30	0.20	28,648	0.750	110	110	110	110	110	110	110	110	110	110	"
630	First 3 curves west of MP 21	22.74	22.35	2.05	2,795	5.500	77	81	86	90	93	97	101	104	107	110	"
629	First 3 curves west of MP 21	22.31	21.97	2.05	2,795	5.750	78	82	87	91	94	98	101	105	108	110	"
628	First 3 curves west of MP 21	21.85	21.60	2.12	2,707	5.625	76	81	85	89	92	96	99	103	106	109	"

Westbound

X-2000 TEST PROGRAM
HARRISBURG LINE SPEEDS

Track No. 4/2

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			CALCULATED CURVING SPEEDS										PROPOSED MAXIMUM TESTING SPEED
		East	West	DEGREE (decimal)	RADIUS (feet)	S.E. (inches)	3"UB (mph)	4"UB (mph)	5"UB (mph)	6"UB (mph)	7"UB (mph)	8"UB (mph)	9"UB (mph)	10"UB (mph)	11"UB (mph)	12"UB (mph)	[mph]
628	First 3 curves west of MP 21	21.64	21.88	2.13	2,686	5.750	77	81	85	89	92	96	99	103	106	109	110
629	First 3 curves west of MP 21	22.01	22.32	2.10	2,728	5.750	77	81	86	89	93	97	100	104	107	110	"
630	First 3 curves west of MP 21	22.37	22.76	2.03	2,818	5.750	78	83	87	91	95	98	102	105	109	110	"
631		23.30	23.60	0.20	28,648	1.000	110	110	110	110	110	110	110	110	110	110	"
632		24.63	24.85	1.17	4,911	4.125	93	100	106	110	110	110	110	110	110	110	"
633		25.25	25.40	0.43	13,222	0.750	110	110	110	110	110	110	110	110	110	110	"
634		25.53	25.75	0.42	13,751	1.625	110	110	110	110	110	110	110	110	110	110	"
635		26.30	26.39	0.22	26,445	0.875	110	110	110	110	110	110	110	110	110	110	"
636		26.47	26.53	0.27	21,486	1.000	110	110	110	110	110	110	110	110	110	110	"
637		28.20	29.20	0.20	28,648	1.250	110	110	110	110	110	110	110	110	110	110	"
638	1st & 2nd curve 1200' west of Signal 295	29.81	30.25	3.07	1,868	5.625	63	67	70	74	77	80	83	85	88	91	"
639	1st & 2nd curve 1200' west of Signal 295	30.32	30.81	2.35	2,438	5.625	72	77	80	84	88	91	94	98	101	104	"
640		31.22	31.56	1.55	3,697	5.875	90	95	100	105	109	110	110	110	110	110	"
641		32.16	32.55	0.93	6,139	3.500	100	107	110	110	110	110	110	110	110	110	"
642		32.87	33.15	0.82	7,016	3.500	107	110	110	110	110	110	110	110	110	110	"
643		33.57	33.87	0.27	21,486	1.250	110	110	110	110	110	110	110	110	110	110	"
644		34.23	34.61	0.32	18,094	1.125	110	110	110	110	110	110	110	110	110	110	"
645		35.06	35.19	0.55	10,418	1.375	107	110	110	110	110	110	110	110	110	110	"
646		35.88	36.04	0.38	14,947	1.250	110	110	110	110	110	110	110	110	110	110	"
647		36.11	36.25	0.37	15,626	1.500	110	110	110	110	110	110	110	110	110	110	"
648		36.79	37.31	1.00	5,730	3.250	95	102	109	110	110	110	110	110	110	110	"
649		37.34	37.93	0.98	5,827	3.375	96	104	110	110	110	110	110	110	110	110	"
650		38.43	39.12	0.47	12,278	1.375	110	110	110	110	110	110	110	110	110	110	"
651		39.45	39.90	0.75	7,640	2.500	102	110	110	110	110	110	110	110	110	110	"
652		40.85	41.05	0.73	7,813	2.500	104	110	110	110	110	110	110	110	110	110	"
653		41.33	41.65	0.73	7,813	2.375	102	110	110	110	110	110	110	110	110	110	"
654		43.60	43.71	0.42	13,751	0.500	110	110	110	110	110	110	110	110	110	110	"
655		45.13	45.34	0.45	12,733	0.750	109	110	110	110	110	110	110	110	110	110	"
656		46.76	46.87	0.37	15,626	0.000	108	110	110	110	110	110	110	110	110	110	"
657	Curve west of Elgin	47.41	48.21	2.02	2,841	5.500	78	82	86	90	94	98	101	105	108	110	"
658		48.26	48.65	0.97	5,927	3.000	94	102	109	110	110	110	110	110	110	110	"
659		48.76	49.08	1.02	5,636	3.375	95	102	109	110	110	110	110	110	110	110	"
660		49.73	50.10	0.88	6,486	2.750	96	105	110	110	110	110	110	110	110	110	"

Westbound

X-2000 TEST PROGRAM
HARRISBURG LINE SPEEDS

Track No. 4/2

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			CALCULATED CURVING SPEEDS										PROPOSED MAXIMUM TESTING SPEED
		East	West	DEGREE [decimal]	RADIUS [feet]	S.E. [inches]	3"UB [mph]	4"UB [mph]	5"UB [mph]	6"UB [mph]	7"UB [mph]	8"UB [mph]	9"UB [mph]	10"UB [mph]	11"UB [mph]	12"UB [mph]	[mph]
661	Curve east of Gap	50.22	50.64	2.05	2,795	5.750	78	82	87	91	94	98	101	105	108	110	110
662	Curve at Gap	50.79	51.70	4.05	1,415	5.250	54	57	60	63	66	68	71	73	76	78	"
663	Curve west of Gap	52.02	52.46	4.13	1,386	5.875	55	58	61	64	67	69	72	74	76	79	"
664	Curve at MP 53	52.77	53.27	2.02	2,841	5.500	78	82	86	90	94	98	101	105	108	110	"
665		53.69	54.02	0.45	12,733	0.750	109	110	110	110	110	110	110	110	110	110	"
666		54.41	54.60	0.45	12,733	0.750	109	110	110	110	110	110	110	110	110	110	"
667		55.82	56.65	1.00	5,730	3.000	93	100	107	110	110	110	110	110	110	110	"
668		57.39	57.65	0.65	8,815	1.500	99	110	110	110	110	110	110	110	110	110	"
669		58.43	58.99	1.50	3,820	5.500	90	95	100	105	109	110	110	110	110	110	"
670		59.54	59.69	0.97	5,927	3.125	95	103	110	110	110	110	110	110	110	110	"
671	Curve west of MP 60	59.97	60.61	2.03	2,818	5.625	78	82	86	90	94	98	101	105	108	110	"
672	Curve west of MP 61	60.96	61.48	2.00	2,865	5.625	79	83	87	91	95	99	102	106	109	110	"
673		61.63	62.11	1.00	5,730	3.250	95	102	109	110	110	110	110	110	110	110	"
674		62.98	63.22	0.43	13,222	0.500	80	90	90	90	90	90	90	90	90	90	90
675		63.53	63.87	1.00	5,730	2.625	90	90	90	90	90	90	90	90	90	90	"
676		64.85	65.51	0.33	17,189	0.750	90	90	90	90	90	90	90	90	90	90	"
677		66.36	66.59	0.85	6,741	2.875	90	90	90	90	90	90	90	90	90	90	"

X2000HBW.XLS

Eastbound

X-2000 TEST PROGRAM
NEC MAINLINE SPEEDS

Track No.2

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			CALCULATED CURVING SPEEDS										PROPOSED MAXIMUM TESTING SPEED
		West	East	DEGREE (decimal)	RADIUS (feet)	S.E. (inches)	3"UB (mph)	4"UB (mph)	5"UB (mph)	6"UB (mph)	7"UB (mph)	8"UB (mph)	9"UB (mph)	10"UB (mph)	11"UB (mph)	12"UB (mph)	(mph)
302		85.40	85.30	1.98	2,889	2.00	60	66	71	76	81	85	89	90	90	90	90
301		85.06	85.00	1.47	3,907	1.75	68	75	81	87	90	90	90	90	90	90	*
300	Curves at east & west ends of N. Phila. sta. pltfrm.	84.93	84.84	0.83	6,876	2.00	90	90	90	90	90	90	90	90	90	90	*
299	Curves at east & west ends of N. Phila. sta. pltfrm.	84.78	84.70	1.03	5,545	1.25	77	85	90	90	90	90	90	90	90	90	*
299	Curve MP 84.0 to 2nd Street overhead bridge	83.82	83.08	2.52	2,277	5.00	67	71	75	79	83	86	89	90	90	90	*
298	Curve between Shore and Ford	81.75	81.38	4.02	1,426	5.50	55	58	61	64	67	69	72	74	77	79	100
297	Curve eastward from Ford	81.30	80.89	1.80	3,183	2.00	63	69	75	80	85	89	93	98	100	100	*
296		79.68	79.18	0.60	9,549	2.25	100	100	100	100	100	100	100	100	100	100	*
295		78.51	78.20	0.32	18,094	1.50	100	100	100	100	100	100	100	100	100	100	*
294		77.04	76.68	1.00	5,730	4.75	105	112	118	124	125	125	125	125	125	125	125
293		76.47	76.11	0.68	8,385	3.25	114	123	125	125	125	125	125	125	125	125	*
292	First curve west of MP 75.0	75.40	75.09	0.75	7,640	4.00	115	123	125	125	125	125	125	125	125	125	*
291	Reverse curves between MP 74.0 and MP 75.0	75.08	74.62	1.55	3,697	5.75	90	95	100	104	108	113	117	120	124	125	*
290	Reverse curves between MP 74.0 and MP 75.0	74.47	74.07	1.47	3,907	5.25	90	95	100	105	109	114	118	122	125	125	*
289		72.57	72.17	0.33	17,189	1.75	125	125	125	125	125	125	125	125	125	125	*
288	Curve west of Croydon	70.61	70.08	1.18	4,842	5.75	103	108	114	119	124	125	125	125	125	125	*
287		68.70	68.60	0.17	34,378	0.50	150	150	150	150	150	150	150	150	150	150	150
286		67.89	66.72	0.47	12,278	2.25	127	136	149	150	150	150	150	150	150	150	*
285	Curve west of Grundy	66.33	65.62	0.72	7,995	4.75	124	132	139	146	150	150	150	150	150	150	*
284	Curve east of Grundy	64.94	64.60	0.65	8,815	3.75	122	131	139	146	150	150	150	150	150	150	*
283	Curve between MP 61.0 and MP 62.0	61.93	61.39	0.72	7,995	4.25	120	128	136	143	150	150	150	150	150	150	*
282		60.54	60.22	0.35	16,370	1.25	132	146	150	150	150	150	150	150	150	150	*
280	First curve west of Morris	57.13	57.00	0.57	10,111	2.00	112	123	133	142	150	150	150	150	150	150	*
279	First curve west of Trenton	56.33	56.05	0.67	8,594	2.25	106	116	125	133	141	148	150	150	150	150	*
278		50.46	50.36	0.30	19,099	1.00	138	150	150	150	150	150	150	150	150	150	*
277		40.24	39.48	0.30	19,099	1.50	146	150	150	150	150	150	150	150	150	150	*
276		39.36	41.94	0.52	11,090	3.25	131	142	150	150	150	150	150	150	150	150	*

Eastbound

X-2000 TEST PROGRAM
NEC MAINLINE SPEEDS

Track No.2

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			CALCULATED CURVING SPEEDS										PROPOSED MAXIMUM TESTING SPEED
		West	East	DEGREE [decimal]	RADIUS [feet]	S.E. [inches]	3"UB [mph]	4"UB [mph]	5"UB [mph]	6"UB [mph]	7"UB [mph]	8"UB [mph]	9"UB [mph]	10"UB [mph]	11"UB [mph]	12"UB [mph]	[mph]
275		34.21	33.75	0.30	19,099	1.25	142	150	150	150	150	150	150	150	150	150	150
274		31.34	31.12	0.45	12,733	2.75	135	146	150	150	150	150	150	150	150	150	"
273		30.65	30.25	0.43	13,222	2.75	138	149	150	150	150	150	150	150	150	150	"
272		28.97	28.85	0.47	12,278	2.25	127	138	149	150	150	150	150	150	150	150	"
271		27.65	27.43	0.28	20,222	1.75	150	150	150	150	150	150	150	150	150	150	"
270	Third curve west of Lincoln	27.17	26.74	0.77	7,473	3.75	112	120	128	135	142	148	150	150	150	150	"
269	Second curve west of Lincoln	26.65	26.38	1.45	3,951	5.75	93	98	103	108	112	116	121	125	125	125	125
268	First curve west of Lincoln	25.54	24.68	1.87	3,069	6.25	84	89	93	97	101	104	108	112	115	118	"
267	Curve at MP 25.0	24.53	24.11	1.18	4,842	4.75	97	103	108	114	119	124	125	125	125	125	"
266	First curve west of MP 24.0	23.88	23.61	1.55	3,697	5.75	90	95	100	104	108	113	117	120	124	125	"
265	First curve east of MP 24.0	23.51	22.86	1.45	3,951	5.25	90	95	100	105	110	114	118	123	125	125	"
264		22.81	22.45	0.77	7,473	4.50	118	125	125	125	125	125	125	125	125	125	"
263		22.04	21.88	0.72	7,995	4.25	120	125	125	125	125	125	125	125	125	125	"
262		21.84	21.68	0.72	7,995	3.25	112	120	125	125	125	125	125	125	125	125	"
261		20.80	20.71	0.67	8,594	3.25	116	125	125	125	125	125	125	125	125	125	"
260		20.69	20.39	0.25	22,919	0.50	125	125	125	125	125	125	125	125	125	125	"
259		19.74	19.64	0.42	13,751	1.75	125	125	125	125	125	125	125	125	125	125	"
258		19.41	19.28	0.28	20,222	1.75	125	125	125	125	125	125	125	125	125	125	"
256		18.94	18.84	0.42	13,751	3.00	125	125	125	125	125	125	125	125	125	125	"
255		18.50	18.20	0.20	28,648	0.50	125	125	125	125	125	125	125	125	125	125	"
254		15.10	14.70	0.20	28,648	0.50	125	125	125	125	125	125	125	125	125	125	"
253	Curves between Elizabeth & Elmora Block Station	14.26	14.03	2.37	2,421	2.50	58	63	67	72	76	80	83	87	90	94	110
252	Curves between Elizabeth & Elmora Block Station	13.10	13.05	1.97	2,913	4.25	73	77	82	86	90	94	98	102	105	109	"
251		12.54	12.29	0.20	28,648	0.50	110	110	110	110	110	110	110	110	110	110	"
250		10.49	10.21	0.32	18,094	2.00	110	110	110	110	110	110	110	110	110	110	"
249	Curve at Hunter	9.24	9.18	1.02	5,636	2.75	90	90	90	90	90	90	90	90	90	90	90
248		9.20	9.30	1.47	3,907	2.00	70	76	83	88	90	90	90	90	90	90	"

X2000NEE.XLS

Westbound

X-2000 TEST PROGRAM
NEC MAINLINE SPEEDS

Track No.3

CV.#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			CALCULATED CURVING SPEEDS										PROPOSED MAXIMUM TESTING SPEED
		East	West	DEGREE (decimal)	RADIUS (feet)	S.E. (inches)	3"UB (mph)	4"UB (mph)	5"UB (mph)	6"UB (mph)	7"UB (mph)	8"UB (mph)	9"UB (mph)	10"UB (mph)	11"UB (mph)	12"UB (mph)	(mph)
248		9.20	9.30	0.95	6,031	1.000	78	87	90	90	90	90	90	90	90	90	90
249	Curve at Hunter	10.24	10.56	0.97	5,927	2.750	90	90	90	90	90	90	90	90	90	90	"
250		12.28	12.56	0.32	18,094	1.250	110	110	110	110	110	110	110	110	110	110	110
251		13.05	13.10	0.20	28,648	0.500	110	110	110	110	110	110	110	110	110	110	"
252	Curves between Elizabeth & Elmora Block Station	14.05	14.29	1.95	2,938	4.250	73	78	82	87	91	95	99	102	106	109	"
253	Curves between Elizabeth & Elmora Block Station	14.29	14.70	2.40	2,387	4.500	67	71	75	79	83	86	90	93	96	99	"
254		18.20	18.48	0.20	28,648	0.500	125	125	125	125	125	125	125	125	125	125	125
255		18.85	18.95	0.20	28,648	0.250	125	125	125	125	125	125	125	125	125	125	"
256		19.25	19.45	0.20	28,648	0.500	125	125	125	125	125	125	125	125	125	125	"
258		19.75	19.85	0.20	28,648	0.500	125	125	125	125	125	125	125	125	125	125	"
259		20.39	20.71	0.48	11,854	1.500	115	125	125	125	125	125	125	125	125	125	"
260		20.74	20.80	0.28	20,222	1.000	125	125	125	125	125	125	125	125	125	125	"
261		21.67	21.85	0.70	8,185	4.000	120	125	125	125	125	125	125	125	125	125	"
262		21.89	22.08	0.70	8,185	3.000	111	120	125	125	125	125	125	125	125	125	"
263		22.47	22.84	0.65	8,815	3.500	120	125	125	125	125	125	125	125	125	125	"
264		22.87	23.57	0.82	7,016	4.500	115	122	125	125	125	125	125	125	125	125	"
265	First curve east of MP 24.0	23.66	23.92	1.42	4,044	6.000	95	100	105	110	115	119	123	125	125	125	"
266	First curve west of MP 24.0	24.15	24.59	1.50	3,820	5.500	90	95	100	105	109	113	118	122	125	125	"
267	Curve at MP 25.0	24.73	25.52	1.20	4,775	4.750	98	102	108	113	118	123	125	125	125	125	"
268	First curve west of Lincoln	26.39	26.66	1.93	2,964	6.000	82	86	90	94	98	102	105	109	112	115	"
269	Second curve west of Lincoln	26.76	27.18	1.43	3,997	6.000	95	100	105	109	114	118	122	125	125	125	"
270	Third curve west of Lincoln	27.46	27.68	0.77	7,473	3.750	112	120	128	135	142	148	150	150	150	150	150
271		28.86	29.07	0.20	28,648	1.500	150	150	150	150	150	150	150	150	150	150	"
272		30.27	30.66	0.43	13,222	2.750	138	149	150	150	150	150	150	150	150	150	"
273		31.13	31.33	0.45	12,733	3.000	138	149	150	150	150	150	150	150	150	150	"
274		33.77	34.22	0.45	12,733	3.000	138	149	150	150	150	150	150	150	150	150	"
275		39.08	39.37	0.30	19,099	1.500	146	150	150	150	150	150	150	150	150	150	"

Westbound

X-2000 TEST PROGRAM
NEC MAINLINE SPEEDS

Track No.3

CV#	TIMETABLE DESCRIPTION	MILEPOST LOCATION		CURVE GEOMETRY			CALCULATED CURVING SPEEDS										PROPOSED MAXIMUM TESTING SPEED
		East	West	DEGREE (decimal)	RADIUS (feet)	S.E. (inches)	3"UB (mph)	4"UB (mph)	6"UB (mph)	6"UB (mph)	7"UB (mph)	8"UB (mph)	9"UB (mph)	10"UB (mph)	11"UB (mph)	12"UB (mph)	(mph)
276		39.49	40.26	0.52	11,090	3.250	131	142	150	150	150	150	150	150	150	150	150
277		50.38	50.50	0.30	19,099	1.000	138	150	150	150	150	150	150	150	150	150	*
278		56.13	56.35	0.27	21,486	1.000	146	150	150	150	150	150	150	150	150	150	*
279	First curve west of Trenton	56.99	57.12	0.67	8,594	2.500	109	118	127	135	143	150	150	150	150	150	*
280	First curve west of Morris	58.42	59.09	0.82	7,016	4.000	111	118	125	132	139	145	150	150	150	150	*
281		59.50	59.70	0.17	34,378	0.750	150	150	150	150	150	150	150	150	150	150	*
282		60.24	60.57	0.37	15,626	2.250	143	150	150	150	150	150	150	150	150	150	*
283	Curve between MP 61.0 and MP 62.0	61.40	61.94	0.73	7,813	4.500	121	129	136	143	150	150	150	150	150	150	*
284	Curve east of Grundy	64.62	64.95	0.65	8,815	4.000	124	133	141	148	150	150	150	150	150	150	*
285	Curve west of Grundy	65.63	66.33	0.73	7,813	4.500	121	129	136	143	150	150	150	150	150	150	*
286		66.72	67.68	0.47	12,278	2.250	127	138	149	150	150	150	150	150	150	150	*
287		68.60	68.70	0.17	34,378	0.500	150	150	150	150	150	150	150	150	150	150	*
288	Curve west of Croydon	70.03	70.59	1.17	4,911	6.000	105	111	116	121	125	125	125	125	125	125	125
289		72.21	72.60	0.35	16,370	1.500	125	125	125	125	125	125	125	125	125	125	*
290	Reverse curves between MP 74.0 and MP 75.0	74.08	74.49	1.45	3,951	5.750	93	98	103	108	112	116	121	125	125	125	*
291	Reverse curves between MP 74.0 and MP 75.0	74.64	75.11	1.42	4,044	5.000	90	95	100	105	110	115	119	123	125	125	*
292	First curve west of MP 75.0	75.14	75.41	0.75	7,640	3.500	111	120	125	125	125	125	125	125	125	125	*
293		76.14	76.46	0.70	8,185	3.250	113	122	125	125	125	125	125	125	125	125	*
294		76.70	77.04	1.00	5,730	4.000	100	107	113	120	125	125	125	125	125	125	*
295		78.21	78.50	0.33	17,189	1.250	100	100	100	100	100	100	100	100	100	100	100
296		79.23	79.73	0.62	9,291	1.500	100	100	100	100	100	100	100	100	100	100	*
298	Curve between Shore and Ford	81.39	81.75	4.07	1,409	5.000	53	56	59	62	65	68	70	73	75	77	*
299	Curve MP 84.0 to 2nd Street overhead bridge	83.14	83.83	2.47	2,323	5.000	68	72	76	80	83	87	90	90	90	90	90
299	Curves at east and west ends of N. Phila. station pl	84.74	84.81	1.08	5,289	1.000	73	81	89	90	90	90	90	90	90	90	*
300	Curves at east and west ends of N. Phila. station pl	84.88	85.01	0.80	7,162	2.250	90	90	90	90	90	90	90	90	90	90	*
301		85.07	85.14	1.37	4,192	1.500	69	76	82	89	90	90	90	90	90	90	*
302		85.38	85.49	1.90	3,016	2.250	63	69	74	79	83	88	90	90	90	90	*

X2000NEW.XLS

EASTBOUND - TRACK NO.2

Washington DC to New York, NY

REVISED : 1/20/93

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

Eastbound

NATIONAL RAILROAD PASSENGER CORPORATION

WAS to NYP

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE	SUPER-ELEV.	AVERAGE	LIMITING	CURRENT	PROPOSED	INCREASE	
					[dec.degree]	*[inches]*	*[inches]*	*[inches]*	*[mph]*	*[mph]*	*[mph]*	*[mph]*
ALL TRACKS		136.00	134.50	WASHINGTON TERMINAL to AVENUE								TIMETABLE SPEED
415	2	135.19	134.82		2.80	1.75	2.2	2.2	45	45	0	
TRACK # 2		134.50	133.00	AVENUE to MILEPOST 133.0								85
414	2	133.91	133.34		0.97	4.45	0.5	0.5	85	85	0	
TRACK # 2		133.00	99.80	MILEPOST 133.0 to FREDERICK ROAD								125
413	2	130.68	129.28		0.68	4.54	2.9	5.3	125	125	0	
412	2	128.90	128.79	Curve at Landover	0.35	0.99	2.8	5.3	100	125	25	
411	2	128.79	128.54	Curve at Landover	0.97	3.65	7.0	7.7	100	125	25	
410	2	127.74	127.42		0.37	2.40	1.6	1.6	110	125	15	
409 M	2	127.25	127.18		0.18	0.12	1.8	2.8	110	125	15	
409	2	126.95	126.67		1.10	6.40	5.6	6.3	110	125	15	
406	2	126.29	125.95		1.02	5.83	5.3	5.8	110	125	15	
407	2	125.55	125.21		1.03	5.85	5.4	6.2	110	125	15	
406	2	122.05	121.96		0.28	2.31	0.8	0.8	110	125	15	
405	2	120.25	119.96	Curve south of MP 120.0	0.82	6.18	2.8	3.9	115	125	10	
404	2	119.67	119.07		0.47	2.83	2.3	3.5	125	125	0	
403	2	118.37	118.11	First curve south of MP 118.0	0.62	4.14	2.6	3.9	120	125	5	
402	2	117.78	117.61	All curves MP 110.0 to MP 118.0	0.58	3.07	3.3	4.3	120	125	5	
401	2	117.49	116.72	All curves MP 110.0 to MP 118.0	0.85	5.97	3.3	4.2	120	125	5	
400	2	116.67	116.27	All curves MP 110.0 to MP 118.0	0.87	5.31	4.2	5.3	120	125	5	
399	2	115.62	115.16	All curves MP 110.0 to MP 118.0	0.87	5.40	4.1	5.2	120	125	5	
398	2	114.39	113.79	All curves MP 110.0 to MP 118.0	0.87	6.06	3.5	4.6	120	125	5	
397	2	113.61	113.17	All curves MP 110.0 to MP 118.0	0.80	5.61	2.9	4.0	120	125	5	
396	2	111.25	110.71	All curves MP 110.0 to MP 118.0	0.67	6.43	3.1	4.9	120	125	5	
395	2	110.46	110.16	All curves MP 110.0 to MP 118.0	0.65	4.52	2.6	4.6	120	125	5	
392	2	108.50	108.10		0.47	2.62	2.3	3.3	125	125	0	
391	2	106.93	106.48	Curve south of MP 106.0	1.53	6.59	8.8	9.3	90	120	30	
390	2	106.01	105.39		1.00	5.81	5.1	6.4	110	125	15	
389	2	104.74	104.43		0.42	2.54	2.1	3.0	110	125	15	
388	2	104.17	103.86		0.97	5.89	4.7	5.9	110	125	15	
387	2	103.71	103.45	Curve at Whans	1.06	5.01	6.8	6.9	100	125	25	
386	2	103.03	102.88		0.23	2.03	0.5	2.9	110	125	15	

Eastbound

NATIONAL RAILROAD PASSENGER CORPORATION

WAS to NYP

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(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE	SUPER-ELEV.	AVERAGE	LIMITING	CURRENT	PROPOSED	INCREASE	
					(dec.degree)	*(inches)*	*(inches)*	*(inches)*	*(mph)*	*(mph)*	*(mph)*	*(mph)*
TRACK # 2		**133.00**	**99.80**	**MILEPOST 133.0 to FREDERICK ROAD (continued)**								**125**
385	2	102.13	101.45	First curve south of MP 101.0	1.02	4.80	6.4	7.3	105	125	20	
384	2	100.30	100.20		0.20	0.75	1.4	1.4	125	125	0	
383	2	99.97	99.81	First curve south of MP 100.0	1.12	3.91	7.4	9.0	100	120	20	
TRACK # 2		**99.80**	**98.10**	**FREDERICK ROAD to FULTON**								**80**
382	2	99.78	99.38	First curve north of Frederick Road Station	1.75	4.36	3.5	4.2	75	80	5	
381	2	98.59	98.18	First curve south of Bridge	3.75	4.77	4.7	5.3	50	60	10	
ALL TRACKS		**98.10**	**94.60**	**FULTON to NORTH PORTALS OF UNION TUNNEL**								**TIMETABLE SPEED**
380	2	98.10	97.63	Curve at Fulton	4.22	1.65	3.1	3.8	40	40	0	
379	2	97.43	97.38		0.80	0.10	0.4	0.5	30	30	0	
378	2	97.20	96.94		7.52	1.95	2.8	3.2	30	30	0	
377	2	96.94	95.71		7.67	1.88	3.1	3.6	30	30	0	
376	2	95.53	95.20		4.42	0.36	2.4	0.7	30	30	0	
TRACK # 2		**94.60**	**91.70**	**NORTH PORTALS OF UNION TUNNEL to BAY**								**60**
375	2	94.52	94.24	First curve north of Union Tunnels	5.00	2.58	6.2	7.1	45	50	5	
374	2	94.18	93.82	Curve at MP 94.0	4.20	4.53	6.1	6.7	50	60	10	
373	2	93.22	92.85		2.05	2.89	2.3	2.7	60	60	0	
372	2	92.41	91.96	Reverse curves at Bay Interlocking	1.90	3.04	1.7	2.7	60	60	0	
371	2	91.92	91.82	Reverse curves at Bay Interlocking	1.02	0.95	1.6	1.9	60	60	0	
TRACK # 2		**91.70**	**85.00**	**BAY to MILEPOST 85.0**								**110**
369	2	91.13	90.36		0.35	2.40	0.6	1.3	100	110	10	
365	2	89.90	89.76		0.52	3.68	0.7	1.5	110	110	0	
364	2	89.68	86.40		0.63	4.80	0.5	2.3	110	110	0	
362	2	86.15	86.59		0.90	5.47	2.2	3.1	110	110	0	
360	2	86.36	85.73		0.92	6.39	1.4	2.4	110	110	0	
TRACK # 2		**85.00**	**71.50**	**MILEPOST 85.0 to BUSH**								**125**
358	2	82.76	80.51		0.28	2.19	0.9	0.9	125	125	0	
357 N	2	79.79	79.73		0.25	1.25	1.5	2.8	125	125	0	
357 M	2	79.64	79.57		0.30	1.36	1.9	2.9	125	125	0	
357	2	78.40	77.88	First curve north of Gunpow	1.22	6.22	7.1	8.1	100	125	25	
356	2	77.67	77.57	First curve south of Magnolia	0.28	1.96	1.1	1.1	125	125	0	
355	2	73.80	73.65		0.20	0.75	1.4	1.4	125	125	0	

NATIONAL RAILROAD PASSENGER CORPORATION

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(125 mph Maximum Speed)

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**								**125**
354	2	71.30	69.74	Curve north of Bush	0.27	2.85	0.1	3.5	125	125	0	
352	2	68.71	68.21		0.50	3.14	2.3	3.1	125	125	0	
351	2	65.36	64.80		1.00	5.67	5.1	6.0	110	125	15	
350	1	62.81	62.07		0.65	4.33	2.8	4.0	125	125	0	
349	1	61.35	60.45	First curve south of Grace	0.72	1.17	3.9	5.1	95	100	5	
TRACK # 2		**60.70**	**59.70**	**GRACE to SOUTHWARD LIMITS OF PERRY**								**90**
TRACK # 2		**59.70**	**28.30**	**SOUTHWARD LIMITS OF PERRY to YARD**								**125**
348	2	57.90	57.59		0.45	1.75	3.2	4.2	110	125	15	
347	2	57.17	56.71	Curve at MP 57.0, north of Prince	1.40	6.07	8.0	8.7	95	120	25	
345	2	54.14	53.81	Curves MP 53.0 and 1,000 feet south of MP 54.0	0.50	2.91	2.6	3.4	110	125	15	
344	2	53.74	53.26	Curves MP 53.0 and 1,000 feet south of MP 54.0	1.12	6.02	6.2	7.3	110	125	15	
343	2	51.82	51.14		0.75	5.34	2.9	4.3	125	125	0	
342	2	50.66	49.90	Curve at MP 50.0	1.36	5.83	7.9	9.1	90	120	30	
341	2	49.12	48.62	Curve at MP 49.0	0.95	5.82	4.6	5.5	110	125	15	
340	2	47.26	46.71	Curve at MP 47.0	0.92	5.90	4.2	4.9	115	125	10	
339	2	45.85	45.26		0.53	3.69	2.1	3.1	125	125	0	
338	2	44.01	43.82		0.25	1.18	1.6	1.6	125	125	0	
337	2	41.94	41.78		0.36	2.36	1.8	3.7	125	125	0	
336	2	40.50	39.39	First curve south of Davis	0.52	2.62	3.1	4.2	110	125	15	
335	2	36.90	36.60		0.20	0.75	1.4	1.4	125	125	0	
334	2	34.85	34.53		0.40	2.58	1.8	2.8	125	125	0	
333	2	33.74	33.29		0.50	2.82	2.6	3.2	125	125	0	
332	2	33.05	32.59	Curve north of MP 33.0	1.05	5.73	5.6	7.0	110	125	15	
331	2	30.99	30.81		0.48	2.84	2.4	3.9	125	125	0	
330	2	30.39	30.03	Curve at MP 30.0	1.05	6.16	5.3	6.3	110	125	15	
329 N	2	29.80	29.55		0.27	0.39	2.6	3.2	125	125	0	
329 M	2	29.45	29.36		0.17	0.39	1.5	1.5	125	125	0	
329	2	29.29	28.80	Curve at MP 29.0	0.82	4.58	4.4	5.8	110	125	15	

Eastbound

NATIONAL RAILROAD PASSENGER CORPORATION

WAS to NYP

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(125 mph Maximum Speed)

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	2	27.53	26.98	Curve at MP 27.0	3.48	0.01	4.9	4.9	40	45	5	
TRACK # 2		**27.00**	**26.80**	**BRANDY to WINE**								**30**
TRACK # 2		**26.80**	**25.50**	**WINE to LANDLITH**								**80**
327	2	26.79	26.17	Curve north of Wilmington Station	4.77	1.76	5.0	5.4	40	45	5	
TRACK # 2		**25.50**	**16.50**	**LANDLITH to HOOK**								**110**
326	2	25.12	24.14		0.43	1.91	1.7	3.7	105	110	5	
325	2	23.76	22.92	First curve south of Bell	1.36	5.36	6.3	7.4	90	110	20	
323	2	22.27	21.92		0.80	4.18	2.6	4.0	110	110	0	
322	2	21.26	21.20		0.27	0.34	1.9	2.5	110	110	0	
321	2	21.03	20.69		0.72	3.47	2.6	3.8	110	110	0	
320 N	2	20.26	20.21		0.30	0.58	2.0	2.7	110	110	0	
320 M	2	20.20	20.10		0.30	0.58	2.0	2.7	110	110	0	
320	2	19.87	19.51		1.02	5.84	2.8	3.5	110	110	0	
319	2	18.48	17.97		1.02	5.54	3.1	3.7	110	110	0	
TRACK # 2		**16.50**	**11.50**	**HOOK to BALDWIN**								**90**
318	2	16.50	16.40		0.20	0.75	0.4	0.4	90	90	0	
317	2	15.95	15.80		0.20	0.76	0.4	0.4	90	90	0	
316	2	14.97	14.61		0.45	2.17	0.4	1.7	90	90	0	
315	2	13.92	13.69		0.60	2.62	1.9	3.3	90	90	0	
314	2	12.31	11.79		0.62	2.60	2.0	3.6	90	90	0	
TRACK # 2		**11.50**	**3.00**	**BALDWIN to MILEPOST 3.0**								**100**
313	2	11.02	10.45		1.00	5.23	1.8	2.3	100	100	0	
312	2	9.83	9.41		1.02	5.24	1.9	3.3	100	100	0	
311	2	7.21	6.78	Reverse curves between Brill and Sharon Hill	1.00	3.25	3.6	4.7	80	100	20	
310	2	6.78	6.00	Reverse curves between Brill and Sharon Hill	1.02	2.94	4.2	5.3	80	100	20	
308	2	6.00	5.39	Reverse curves between Brill and Sharon Hill	1.05	3.00	4.4	4.9	80	100	20	
307 N	2	3.31	3.20		0.20	0.44	1.0	1.9	100	100	0	
307 M	2	3.20	3.10		0.20	0.44	1.0	1.9	100	100	0	

Eastbound

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(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [deg.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
ALL TRACKS		3.00	86.75	MILEPOST 3.0 to EASTWARDLIMITS OF ZOO								TIMETABLE SPEED
307	2	2.98	2.85		1.42	2.78	2.1	2.7	70	70	0	
306	2	2.84	2.34		2.50	5.20	3.4	3.8	70	70	0	
305	2	2.31	1.98		2.05	3.00	2.2	2.6	60	60	0	
304	2	1.56	1.31		4.70	3.23	8.6	9.7	60	60	0	
303 H	2	1.23	1.14	All curves between 34th St. OH Bridge & Penn I/L Signal loc	4.78	0.21	5.1	4.3	40	40	0	
303 G	2	0.88	0.67	All curves between 34th St. OH Bridge & Penn I/L Signal loc	6.07	1.70	5.1	5.9	40	40	0	
303 F	1	88.99	88.79	All curves between Zoo and 34th St. OH Bridge	0.97	1.66	-1.0	-0.6	30	30	0	
303 E	1	88.73	88.44	All curves between Zoo and 34th St. OH Bridge	2.80	2.59	-0.6	-0.1	30	30	0	
303 C	1	88.30	87.71		6.50	1.94	2.2	2.4	30	30	0	
303 B	1	87.32	87.26		0.98	0.79	2.6	3.3	70	70	0	
303 A	1	87.26	87.17		0.65	0.96	1.2	2.2	70	70	0	
TRACK # 2		86.75	85.50	EASTWARD LIMITS OF ZOO to NORTH PHILADELPHIA								70
303	2	86.45	86.31	Curve at Bridge 86.11 (Ridge Ave.)	1.78	3.74	2.4	2.9	70	70	0	
TRACK # 2		85.50	84.50	THROUGH NORTH PHILADELPHIA INTERLOCKING								60
302	2	85.39	85.27		2.00	2.02	3.0	3.6	60	60	0	
301	2	85.05	84.99	Curve at west end North Philadelphia Sta. platform	1.42	1.82	1.8	2.2	60	60	0	
300	2	84.92	84.84		0.87	1.93	0.3	0.7	60	60	0	
299 W	2	84.77	84.70	Curve at east end North Philadelphia Sta. platform	1.00	1.36	1.2	1.9	60	60	0	
TRACK # 2		84.50	82.00	NORTH PHILADELPHIA to SHORE								70
299	2	83.62	83.08	Curve MP 84 to 2nd Street OH Bridge	2.55	5.06	3.7	4.9	65	70	5	
TRACK # 2		82.00	76.00	SHORE to MILEPOST 76.0								110
298	2	81.75	81.37	Curve between Shore and Ford	4.05	5.30	8.6	8.9	50	70	20	
297	2	81.30	80.89	Curve eastwrd from Ford	1.60	1.98	8.2	9.8	60	90	30	
296	2	79.69	79.19		0.60	2.31	2.8	4.3	100	110	10	
295	2	78.51	78.20		0.30	1.41	1.1	2.2	100	110	10	
294	2	77.04	76.68		0.62	4.54	2.4	3.7	100	110	10	
293	2	76.46	76.12		0.62	3.01	2.2	3.3	100	110	10	

Eastbound

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(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [deg.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 2		**76.00**	**58.40**	**MILEPOST 76.0 to MORRIS**								**125**
292	2	75.40	74.95	First curve west of MP 75.0	0.75	4.63	3.6	4.3	120	125	5	
291	2	74.95	74.82	Reverse curves between MP 74.0 and MP 75.0	1.55	6.00	8.3	8.9	90	115	25	
290	2	74.47	74.05	Reverse curves between MP 74.0 and MP 75.0	1.48	5.49	8.2	8.7	90	115	25	
289	2	72.57	72.18		0.35	2.04	1.8	1.8	125	125	0	
288	2	70.61	70.08	Curve west of Croydon	1.20	5.93	7.2	7.6	105	125	20	
287	2	68.75	68.60		0.18	0.75	1.3	1.3	125	125	0	
286	2	67.89	66.72		0.47	2.57	2.6	3.3	125	125	0	
285	2	66.32	66.52	Curve west of Grundy	0.73	3.85	4.1	5.2	115	125	10	
284	2	64.94	64.50	Curve east of Grundy	0.65	3.71	3.4	4.1	120	125	5	
283	2	61.93	61.39	Curve between MP 61.0 and MP 62.0	0.72	5.21	2.7	3.8	110	125	15	
282	2	60.53	60.22		0.36	1.59	2.2	3.1	110	125	15	
280	2	59.24	58.05	First curve west of Morris	0.58	1.72	4.6	6.5	110	125	15	
TRACK # 2		**58.40**	**54.00**	**MORRIS to MILEPOST 54.0**								**110**
	2	58.40	58.00	Morris Interlocking					100	100	0	
279	2	57.10	56.74	First curve west of Trenton	0.92	2.61	5.2	6.0	110	110	0	
278	2	56.25	56.07		0.32	1.37	1.3	2.3	110	110	0	
TRACK # 2		**54.00**	**28.00**	**MILEPOST 54.0 to MILEPOST 28.0**								**125**
277	2	50.46	50.35		0.32	1.83	1.7	1.7	125	125	0	
276	2	40.23	39.45		0.50	3.82	1.8	2.5	125	125	0	
275	2	39.34	39.04		0.32	1.52	2.0	3.1	125	125	0	
274	2	34.20	33.74		0.47	3.09	2.1	2.8	125	125	0	
273	2	31.33	31.11		0.45	2.73	2.2	3.3	125	125	0	
272	2	30.65	30.25		0.47	2.34	2.6	3.6	125	125	0	
271	2	28.97	28.85		0.28	1.67	1.2	1.2	125	125	0	
TRACK # 2		**28.00**	**20.00**	**MILEPOST 28.0 to MILEPOST 20.0**								**110**
270	2	27.65	27.43	Third curve west of Lincoln	0.77	3.83	2.7	3.1	110	110	0	
269	2	27.17	26.75	Second curve west of Lincoln	1.47	5.89	6.6	7.2	90	110	20	
268	2	26.65	26.38	First curve west of Lincoln	1.67	6.38	8.1	8.5	80	105	25	
267	2	25.54	24.68	Curve at MP 25.0	1.20	4.90	5.3	5.8	95	110	15	
266	2	24.53	24.11	First curve west of MP 24.0	1.55	5.73	7.4	8.7	90	110	20	
265	2	23.92	23.65	First curve east of MP 24.0	1.45	5.22	7.1	8.0	90	110	20	

Eastbound

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X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE *[deg degree]*	SUPER-ELEV. *[inches]*	AVERAGE *[inches]*	LIMITING *[inches]*	CURRENT *[mph]*	PROPOSED *[mph]*	INCREASE *[mph]*	*[mph]*
TRACK # 2		**28.00**	**20.00**	**MILEPOST 28.0 to MILEPOST 20.0 (continued)**								**110**
264	2	23.55	22.85		0.78	4.72	1.9	3.3	110	110	0	
263	2	22.81	22.45		0.68	4.33	1.4	3.0	110	110	0	
262	2	22.03	21.89		0.53	2.24	2.2	3.9	110	110	0	
261	2	21.84	21.68		0.67	3.35	2.3	3.1	110	110	0	
260	2	20.80	20.71		0.27	0.53	1.6	2.2	110	110	0	
259	2	20.68	20.38		0.45	2.03	1.8	2.9	110	110	0	
TRACK # 2		**20.00**	**15.10**	**MILEPOST 20.0 to ELMORA**								**125**
258	2	19.74	19.67		0.32	1.85	1.7	2.7	125	125	0	
256	2	19.41	19.27		0.42	3.25	1.3	3.0	125	125	0	
255	2	18.94	18.84		0.20	0.44	1.7	3.0	125	125	0	
254	2	18.35	18.10		0.30	0.75	2.5	6.0	125	125	0	
TRACK # 2		**15.10**	**10.50**	**ELMORA to HUNTER**								**110**
	2	15.10	14.70	Elmora Interlocking					55	55	0	
253	2	14.65	14.25	Curve east of Elmora	2.37	2.68	3.3	3.5	55	60	5	
252	2	14.25	14.03	First curve west of MP 14.0	1.98	4.09	2.7	3.1	65	70	5	
251	2	13.05	13.20		0.25	0.75	1.4	1.4	110	110	0	
250	2	12.53	12.28		0.32	2.06	0.6	0.6	110	110	0	
249	2	10.49	10.21	Curve at Hunter	1.02	2.74	0.8	1.8	70	70	0	
ALL TRACKS		**10.50**	**0.00**	**HUNTER to PENNSYLVANIA STATION, NEW YORK**								**TIMETABLE SPEED**
248	2	9.24	9.18		1.00	0.50	2.9	5.5	70	70	0	
247 M	2	8.98	8.84		0.42	0.21	0.2	-0.4	35	35	0	
247	2	8.82	8.70		1.50	0.10	1.2	0.9	35	35	0	
246	2	8.63	8.51		1.57	0.29	1.1	0.5	35	35	0	
245	2	8.44	8.30		0.62	0.00	0.5	0.7	35	35	0	
244	2	8.30	8.11		0.67	0.81	0.1	1.0	45	45	0	
243	2	8.03	7.76		3.20	4.00	4.1	5.2	60	60	0	
242	1	6.71	6.33		0.45	2.25	0.3	1.0	90	90	0	
	1	W 6.10	W 6.10	Portal Movable Bridge					70	70	0	
241	1	W 5.75	W 5.50		0.47	1.81	0.9	1.3	90	90	0	
240	1	W 3.61	W 2.96	Curve west of the west portal North River Tunnels	2.02	4.12	3.8	5.8	75	75	0	
239	1	W 1.14	W 1.10		0.40	0.32	0.7	1.1	60	60	0	

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WESTBOUND - TRACK NO.3

New York, NY to Washington DC

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

REVISED : 1/20/93

Westbound

NATIONAL RAILROAD PASSENGER CORPORATION

NYP to WAS

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

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	0.8	0.8	60	60	0	
240	2	W 3.03	W 3.65	Curve west of the west portal North River Tunnels	2.22	4.110	1.5	2.3	60	60	0	
241	2	W 6.61	W 6.79		0.43	1.710	0.7	1.9	90	90	0	
		W 6.10	W 6.10	Portal Movable Bridge					70	70	0	
242	2	W 7.38	W 8.11		0.47	1.850	0.8	1.3	90	90	0	
243	3	7.78	8.02		3.27	3.370	4.9	5.5	60	60	0	
244	3	8.11	8.44		0.67	0.180	0.8	0.5	45	45	0	
245	3	8.51	8.53		1.45	0.290	1.0	0.6	35	35	0	
246	3	8.69	8.82		1.47	0.300	1.0	1.4	35	35	0	
247	3	8.93	9.00		0.85	0.470	0.3	0.8	35	35	0	
248	3	9.20	9.30		0.97	0.820	2.5	3.1	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	0.3	1.9	70	70	0	
250	3	12.28	12.67		0.32	1.390	1.3	2.0	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	2.6	3.2	65	70	5	
253	3	14.29	14.70	Curve east of Elmora Interlocking	2.42	4.580	1.5	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								110
259	3	20.39	20.72		0.48	1.360	2.7	3.4	110	110	0	
260	3	20.74	20.81		0.30	1.100	1.4	2.2	110	110	0	
261	3	21.68	21.85		0.70	4.090	1.8	2.2	110	110	0	
262	3	21.90	22.05		0.68	2.920	2.8	3.9	110	110	0	
263	3	22.46	22.65		0.65	3.520	2.0	3.0	110	110	0	
264	3	22.86	23.55		0.77	4.540	2.0	3.0	110	110	0	
265	3	23.67	23.93	First curve east of MP 24.0	1.43	5.970	6.1	6.8	95	110	15	
266	3	24.15	24.59	First curve west of MP 24.0	1.50	5.130	7.6	7.9	90	110	20	
267	3	24.73	26.55	Curve at MP 25.0	1.18	4.260	5.7	6.8	95	110	15	

X2RV125W.XLS

Westbound

NATIONAL RAILROAD PASSENGER CORPORATION

NYP to WAS

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE	SUPER-ELEV.	AVERAGE	LIMITING	CURRENT	PROPOSED	INCREASE	
					[deg degree]	[inches]	[inches]	[inches]	[mph]	[mph]	[mph]	[mph]
TRACK # 3		**20.00**	**28.00**	**MILEPOST 20.0 to MILEPOST 28.0 (continued)**								**110**
268	3	26.40	26.67	First curve west of Lincoln	1.93	6.190	8.7	9.4	80	105	25	
269	3	26.77	27.18	Second curve west of Lincoln	1.43	6.030	6.1	7.3	90	110	20	
270	3	27.46	27.67	Third curve west of Lincoln	0.77	3.900	2.6	3.3	110	110	0	
TRACK # 3		**28.00**	**54.00**	**MILEPOST 28.0 to MILEPOST 54.0**								**125**
271	3	28.87	29.07		0.20	1.680	0.5	0.5	125	125	0	
272	3	30.25	30.65		0.43	2.850	1.9	2.7	125	125	0	
273	3	31.13	31.34		0.45	3.000	1.9	2.8	125	125	0	
274	3	33.77	34.23		0.43	3.230	1.5	2.9	125	125	0	
275	3	39.08	39.36		0.30	1.630	1.7	2.8	125	125	0	
276	3	39.47	40.28		0.53	3.440	2.4	3.3	125	125	0	
277	3	50.38	50.52		0.26	1.060	2.0	3.0	125	125	0	
TRACK # 3		**54.00**	**58.40**	**MILEPOST 54.0 to MORRIS**								**110**
278	3	56.10	56.33		0.28	1.200	1.2	2.1	110	110	0	
279	3	56.99	57.12	First curve west of Trenton	0.68	2.510	3.2	3.9	95	110	15	
	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	3.690	4.7	6.2	110	125	15	
281	3	59.44	59.60		0.17	0.530	1.3	1.3	110	125	15	
282	3	60.24	60.58		0.38	2.490	1.7	1.7	110	125	15	
283	3	61.40	61.94	Curve between MP 61.0 and MP 62.0	0.75	4.920	3.3	3.9	110	125	15	
284	3	64.62	64.96	Curve east of Grundy	0.63	4.180	2.7	3.7	120	125	5	
285	3	65.63	66.33	Curve west of Grundy	0.75	4.990	3.2	4.1	115	125	10	
286	3	66.72	67.66		0.50	1.940	3.5	4.3	125	125	0	
288	3	70.03	70.60	Curve west of Croydon	1.05	5.330	6.2	6.2	105	125	20	
289	3	72.19	72.60		0.37	1.680	2.4	3.1	125	125	0	
290	3	74.06	74.50	Reverse curves between MP 74.0 and MP 75.0	1.45	5.820	7.6	7.9	90	115	25	
291	3	74.65	75.09	Reverse curves between MP 74.0 and MP 75.0	1.43	5.330	7.9	9.6	90	115	25	
292	3	75.13	75.42	First curve west of MP 75.0	0.73	4.030	4.0	4.9	110	125	15	

Westbound

NATIONAL RAILROAD PASSENGER CORPORATION

NYP to WAS

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE	SUPER-ELEV.	AVERAGE	LIMITING	CURRENT	PROPOSED	INCREASE	
					[deg.degree]	[inches]	[inches]	[inches]	[mph]	[mph]	[mph]	[mph]
TRACK # 3		**76.00**	**82.00**	**MILEPOST 76.0 to SHORE**								**110**
293	3	76.13	76.47		0.70	3.480	2.4	3.4	100	110	10	
294	3	76.70	77.04		0.67	2.730	2.9	4.1	100	110	10	
295	3	78.21	78.50		0.35	1.490	1.5	2.6	100	110	10	
296	3	79.23	79.72		0.60	1.690	3.4	4.8	100	110	10	
297	3	80.90	81.32	Curve eastwrd from Ford	1.75	2.470	8.6	9.7	60	95	35	
298	3	81.39	81.79	Curve between Shore and Ford	4.10	5.320	8.7	9.5	50	70	20	
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**								**60**
299 M	3	84.74	84.81	Curve at east end North Philadelphia Station platform	1.27	0.880	2.3	2.8	60	60	0	
300	3	84.89	85.01		0.60	2.370	-0.4	0.1	60	60	0	
301	3	85.07	85.14	Curve at west end North Philadelphia Station platform	1.37	1.520	1.9	2.5	60	60	0	
302	3	85.38	85.49		1.90	2.300	2.5	3.1	60	60	0	
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	1.8	2.4	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	2.7	1.4	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	3.5	4.2	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	0.6	0.9	50	50	0	
306	3	2.31	2.84		2.47	6.130	2.3	2.8	70	70	0	
307	3	2.84	3.05		1.40	3.160	1.6	1.8	70	70	0	
TRACK # 3		**3.00**	**11.50**	**MILEPOST 3.0 to BALDWIN**								**100**
307 M	3	3.15	3.24		0.25	0.430	1.3	1.7	100	100	0	
308	3	5.38	6.02	Reverse curves between Brill and Sharon Hill	1.07	3.080	4.4	5.0	90	100	10	
309	3	6.02	6.81	Reverse curves between Brill and Sharon Hill	1.00	3.110	3.9	5.0	90	100	10	
311	3	6.81	7.22	Reverse curves between Brill and Sharon Hill	1.02	2.940	4.2	5.3	90	100	10	
312	3	9.41	9.66		1.02	5.660	1.5	2.4	100	100	0	
313	3	10.48	11.04		0.93	4.360	2.2	3.5	100	100	0	

Westbound

NATIONAL RAILROAD PASSENGER CORPORATION

NYP to WAS

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [deg.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	2.6	3.3	90	90	0	
315	3	13.69	13.94		0.75	2.630	1.6	3.3	90	90	0	
316	3	14.79	14.98		0.47	0.860	1.8	3.1	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**								**110**
319	3	17.98	18.51		1.00	5.600	2.7	4.1	110	110	0	
320	3	19.43	19.79		1.02	5.280	3.4	4.0	110	110	0	
320 M	3	20.07	20.15		0.20	0.840	0.9	0.9	110	110	0	
320 N	3	20.22	20.28		0.20	1.030	0.7	2.1	110	110	0	
321	3	20.80	21.03		0.70	3.410	2.5	3.4	110	110	0	
323	3	21.86	22.18		0.97	4.880	3.3	5.0	110	110	0	
324	3	22.94	23.77	First curve south of Bell	1.40	4.820	7.0	8.5	90	110	20	
326	3	24.20	25.16		0.42	2.030	1.5	2.6	105	110	5	
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	0.3	0.6	30	30	0	
327 N	3	26.93	26.97		1.10	0.320	0.4	0.1	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	2.6	2.9	45	45	0	
TRACK # 3		**28.30**	**59.70**	**YARD to SOUTHWARD LIMITS OF PERRY**								**125**
329	3	28.63	29.30	Curve at MP 29.0	0.85	4.850	4.4	6.3	110	125	15	
330	3	30.07	30.41	Curve at MP 30.0	1.05	5.930	5.6	6.5	110	125	15	
331	3	30.84	30.99		0.47	3.530	1.6	2.6	125	125	0	
332	3	32.61	33.09	Curve north of MP 33.0	1.02	5.790	5.4	6.4	110	125	15	
333	3	33.33	33.75		0.50	2.950	2.5	3.3	125	125	0	
334	3	34.53	34.85		0.40	2.090	2.3	3.3	125	125	0	
335	3	35.80	35.90		0.20	0.750	1.4	1.4	125	125	0	
336	3	39.42	40.62	First curve south of Davis	0.50	3.110	2.4	3.5	125	125	0	
337	3	41.79	41.93		0.47	3.100	2.0	3.4	125	125	0	

NATIONAL RAILROAD PASSENGER CORPORATION

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(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE (deg. degree)	SUPER-ELEV. (inches)	AVERAGE (inches)	LIMITING (inches)	CURRENT (mph)	PROPOSED (mph)	INCREASE (mph)	(mph)
TRACK # 3		**28.30**	**59.70**	**YARD to SOUTHWARD LIMITS OF PERRY (continued)**								**125**
338	3	44.01	44.21		0.22	1.760	0.6	0.6	125	125	0	
339	3	45.27	45.83		0.57	3.520	2.7	3.7	125	125	0	
340	3	46.72	47.29	Curve at MP 47.0	0.95	6.040	4.4	5.1	115	125	10	
341	3	48.62	49.07	Curve at MP 49.0	0.63	4.600	4.3	6.6	110	125	15	
342	3	49.65	50.67	Curve at MP 50.0	1.40	5.170	8.9	9.6	90	120	30	
343	3	51.18	51.65		0.60	6.150	2.6	3.8	125	125	0	
344	3	53.26	53.76	Curves between MP 53.0 and 1,000 feet south of MP 54.0	1.12	5.780	6.5	7.9	105	125	20	
345	3	53.83	54.17	Curves between MP 53.0 and 1,000 feet south of MP 54.0	0.50	2.390	3.1	4.7	105	125	20	
346	3	55.62	55.84		0.30	0.500	2.6	4.4	125	125	0	
347	3	56.74	57.20	Curve at MP 57.0, north of Prince	1.37	6.130	8.9	9.3	95	125	30	
348	3	57.61	57.93		0.47	1.590	3.6	4.4	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**								**125**
349	4	60.53	61.35	First curve south of Grace	0.77	2.110	3.6	6.2	95	105	10	
350	4	62.05	62.78		0.65	3.760	3.3	5.2	125	125	0	
351	4	64.63	65.40		0.97	5.980	4.6	5.4	110	125	15	
352	4	66.21	66.72		0.52	3.350	2.3	3.7	125	125	0	
353	4	69.83	71.30	Curve north of Bush	0.28	1.440	1.6	4.0	120	125	5	
TRACK # 3		**71.50**	**85.00**	**BUSH to MILEPOST 85.0**								**125**
355	3	73.65	73.80		0.20	0.500	1.7	1.7	125	125	0	
356	3	77.61	77.67	First curve south of Magnolia	0.25	1.940	0.6	0.8	125	125	0	
357	3	77.90	78.42	First curve north of Gunpow Interlocking	1.17	6.460	6.3	7.8	100	125	25	
357.M	3	79.46	79.52		0.25	0.940	1.8	2.7	125	125	0	
358	3	80.57	82.62		0.32	1.290	2.2	3.5	125	125	0	
TRACK # 3		**85.00**	**91.70**	**MILEPOST 85.0 to BAY**								**110**
359	3	85.78	86.37		0.95	5.360	2.7	3.8	110	110	0	
361	3	86.62	88.16		0.67	5.390	2.0	3.2	110	110	0	
363	3	88.41	89.71		0.65	3.840	1.7	4.5	110	110	0	
366	3	89.77	89.93		0.47	3.480	0.5	2.0	110	110	0	
369	3	90.18	91.03		0.37	0.790	2.3	4.9	100	110	10	
370	3	91.16	91.27		0.37	0.900	2.2	3.3	100	110	10	

Westbound

NATIONAL RAILROAD PASSENGER CORPORATION

NYP to WAS

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE	SUPER-ELEV.	AVERAGE	LIMITING	CURRENT	PROPOSED	INCREASE	
					[dec.degree]	[inches]	[inches]	[inches]	[mph]	[mph]	[mph]	[mph]
TRACK # 3		**91.70**	**94.60**	**BAY to NORTH PORTALS OF UNION TUNNEL**								**60**
371	3	91.87	92.00	Reverse curves at Bay Interlocking	1.00	1.850	0.7	1.1	60	60	0	
372	3	92.00	92.42	Reverse curves at Bay Interlocking	2.02	3.040	2.1	2.9	60	60	0	
373	3	92.88	93.27		2.02	4.440	0.7	1.6	60	60	0	
374	3	93.85	94.12	Curve at MP 94.0	4.10	4.300	6.0	6.5	50	60	10	
375	3	94.22	94.53	First curve north of Union Tunnels	4.43	3.350	4.4	5.0	45	50	5	
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	2.7	2.6	30	30	0	
377	3	95.69	96.34		7.20	1.990	2.5	2.9	30	30	0	
378	3	96.96	97.12		7.65	1.510	3.3	3.7	30	30	0	
379	3	97.31	97.36		0.82	0.230	0.3	0.2	30	30	0	
380	3	97.59	98.10	Curve at Fulton	4.15	1.940	2.7	3.5	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	7.0	7.5	50	60	10	
382	3	99.36	99.79	First curve north of Frederick Road Station	1.72	4.650	3.1	4.0	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	1.16	3.360	8.5	8.8	100	120	20	
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	6.6	7.6	105	125	20	
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	6.6	7.9	100	125	25	
388	3	103.90	104.15		0.97	6.550	4.1	4.6	110	125	15	
389	3	104.43	104.74		0.47	2.620	2.5	3.3	110	125	15	
390	3	105.40	106.03		0.40	2.040	2.3	3.9	110	125	15	
391	3	106.49	106.95	Curve south of MP 106.0	1.55	6.000	8.3	8.3	90	115	25	
392	3	108.11	108.48		0.47	2.980	2.2	4.4	125	125	0	
395	3	110.17	110.46	All curves MP 110.0 to MP 116.0	0.80	5.570	3.2	4.4	120	125	5	
396	3	110.72	111.24	All curves MP 110.0 to MP 116.0	0.87	6.070	3.4	4.9	120	125	5	
397	3	113.16	113.54	All curves MP 110.0 to MP 116.0	0.83	5.820	3.3	4.1	120	125	5	
398	3	113.82	114.39	All curves MP 110.0 to MP 116.0	0.83	5.740	3.3	4.9	120	125	5	
399	3	115.15	115.63	All curves MP 110.0 to MP 116.0	0.80	5.550	3.2	3.9	120	125	5	
400	3	116.26	116.67	All curves MP 110.0 to MP 116.0	0.83	6.030	3.0	4.9	120	125	5	

X-2000 Proposed Revenue Service Speed Profiles

(125 mph Maximum Speed)

CV#	TRK	MILEPOST LOCATION		TIMETABLE DESCRIPTION	CURVE GEOMETRY		UNBALANCE		CURVING SPEEDS			MAXIMUM LINE SPEED
					DEGREE [deg.degree]	SUPER-ELEV. [inches]	AVERAGE [inches]	LIMITING [inches]	CURRENT [mph]	PROPOSED [mph]	INCREASE [mph]	[mph]
TRACK # 3		**99.80**	**133.00**	**FREDERICK ROAD to MILEPOST 133.0 (continued)**								**125**
401	3	116.76	117.48	All curves MP 110.0 to MP 118.0	0.83	6.050	3.0	4.4	120	125	5	
402	3	117.58	117.74	All curves MP 110.0 to MP 118.0	0.55	3.910	2.1	3.4	120	125	5	
403	3	118.10	118.34	First curve south of MP 118.0	0.70	5.190	2.5	3.6	120	125	5	
404	3	119.10	119.69		0.46	1.620	3.6	4.7	125	125	0	
405	3	120.01	120.24	Curve south of MP 120.0	0.82	6.250	2.7	4.2	115	125	10	
406	3	121.96	122.06		0.28	1.930	1.1	1.1	110	125	15	
407	3	125.26	125.59		1.02	6.160	5.0	5.9	110	125	15	
408	3	126.01	126.69		0.96	6.200	4.5	5.2	110	125	15	
409	3	126.64	126.92		1.12	6.050	6.2	6.9	110	125	15	
410	3	127.44	127.82		0.42	2.110	2.5	3.0	110	125	15	
411	3	128.57	128.94	Curve at Landover	0.60	2.720	3.8	6.2	100	125	25	
413	3	129.28	130.68		0.68	4.540	2.9	4.0	125	125	0	
TRACK # 3		**133.00**	**134.50**	**MILEPOST 133.0 to AVENUE**								**85**
414	3	133.34	133.91		0.97	4.450	0.5	1.5	85	85	0	
ALL TRACKS		**134.50**	**136.00**	**AVENUE to WASHINGTON TERMINAL**								**CURRENT TIMETABLE**
415	3	134.82	136.19		2.80	1.750	2.2	3.0	45	45	0	