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MBTA RAPID TRANSIT SYSTEM (RED LINE) WAYSIDE AND IN-CAR NOISE AND VIBRATION LEVEL MEASUREMENTS

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FINAL REPORT

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16. Abstract

Wayside and in-car noise and vibration characteristics of a late-model mass transit car making up 2-car and 4-car trains are tabulated and analyzed in this report. The MBTA Type 1 South Shore Rapid Transit Car, designed and built by Pullman Standard, Chicago, Illinois and currently in operation on the Red Line of the Massachusetts Bay Transportation Authority (MBTA) was measured.

Wayside measurements had been made by the tracks of the South Shore Extension of the Red Line 58 days after the official September 1, 1971 opening of this extension. These wayside measurements were repeated six months later.

In-car noise and vibration measurements are made in a selected 2-car train on a typical run over various sections of the Red Line.

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PREFACE

Wayside and in-car noise and vibration characteristics of a late-model mass-transit car, making up four-car and two-car trains, are tabulated and analyzed in this report. The MBTA Type 1, So.Shore Rapid Transit Car designed and built by Pullman Standard, Chicago, Illinois and currently in operation on the Red line of the Massachusetts Bay Transportation Authority (MBTA) was measured.

Wayside measurements were made by the tracks of the So. Shore Extension of the Red line 58 days after the official September 1, 1971 opening of this extension. These noise and vibration measurements were repeated six months later. The average peak value of the wayside noise and vibration levels measured for 2-car and 4-car trains are as follows:

		Avg Peak Noise Level dBA re $20 \mu N/m^2$ *			Avg Peak Vibration Level dB re 10^{-6} g					
Date Trains Measured	Avg Speed mph	at 25 ft	at 50 ft	at 100 ft	at 25 ft z-axis	x-axis	y-axis	at 38 ft z-axis	x-axis	y-axis
Oct 28, 1971 4-Car Trains	50.4	95.1	90.4	85.7	-	-	93.8	-	-	85.9
April 29, 1972 4-Car Trains	50.1	95.2	88.4	83.6	79.4	87.4	91.0	73.1	80.5	83.7
April 29, 1972 2-Car Trains	49.9	89.5	86.5	79.8	79.3	85.0	90.3	72.2	79.4	80.5

*dBA - "A" weighted sound pressure levels
– no data

In-car noise measurements were made at three locations in a selected 2-car train on a typical run over various sections of the Red Line. In addition three-axis vibration measurements were made at a point on the floor tiles over the rear wheel truck on the lead car. Typical coincident noise and vibration levels are tabulated in this report for the many varied conditions of the Red Line.

Note: Three-axis vibration measurements: z-axis vertical, x-axis longitudinal, y-axis lateral, respectively.

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The following individuals of the Noise Abatement Group, Transportation Systems Center, contributed to the preparation of this report: Stanley C. Skeiber, Norman Sussan, and John E. Wesler.

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1. INTRODUCTION

The U.S. Department of Transportation, Transportation Systems Center (TSC), Cambridge, MA undertook a project to measure and document the noise and vibration levels produced by rapid-transit cars operating on the Red Line of the Massachusetts Bay Transportation Authority (MBTA) Rapid Transit System.

The Red Line proper and the Ashmont Extension of the Red Line which run between Harvard Square in Cambridge, MA to Ashmont Station in Dorchester, MA is a relatively old line with wooden ties and a non-welded rail system. The So. Shore Extension of the Red Line which runs between Quincy Center in Quincy, MA and joins the Red Line at a point between Columbia and Andrew Stations in Dorchester, MA is a new line and was put into operation on September 1, 1971. This extension was constructed with a high-quality road bed with concrete ties and a welded rail system. New transit cars, designed and built by Pullman Standard, Chicago, Illinois, to MBTA developed specifications, were purchased by the MBTA for use on this new extension and on the Red Line from Harvard to Andrew Station. These cars have been designated No. 1 So. Shore Rapid Transit Cars by the MBTA.

Wayside noise and vibration measurements were made next to the So. Shore Extension tracks in Dorchester, MA on October 28, 1971 and repeated again on April 27, 1972 to obtain a comparison of measurement levels after the first six-months operational period.

In addition on April 29, 1972, the lead car of a two-car train was instrumented for the measurement of noise at two locations inside the car and at one location on the outside platform between cars. It was also instrumented for the measurement of floor vibrations in three axes at a point inside the car centered over the rear wheel trucks.

The above in-car measurements were made during typical runs over the Red Line proper, and on the Asmont, and So. Shore Extensions of the Red Line.

2. DISCUSSION

Noise-and-vibration level measurements were made on the Red Line and on the Ashmont and So. Shore Extensions of the Red Line of the Massachusetts Bay Transportation Authority (MBTA) Rapid Transit System.

Wayside measurements were made on October 28, 1971 next to the tracks of the So. Shore Extension. This was 58 days after the official September 1, 1971 opening of this extension. These same measurements were repeated six months later on April 27, 1971 to obtain a measure of the condition of the track and/or equipment during the first six months of operation. In addition in-car noise and vibration measurements were made in the lead car of a two-car train on a typical run on April 29, 1972.

This report documents the noise and vibration measurements made. Appendixes A through D contain the analyses of the wayside noise and ground vibration data. Appendixes E and F contain the analyses of the in-car noise and floor vibration data.

Microphone and vibration transducer locations and procedures used in obtaining and reducing measurement data are detailed. (See appendixes G and H.)

Appendixes I through L contain: the description of the transit car in use on the So. Shore Extension; the tunnel configuration at various points on the Red Line; definition of terms and calculation; and environmental data, respectively.

As an aid in reducing and analyzing the recorded data, time-history chart recordings were prepared for each microphone output (Noise level in dBA re $20\mu N/m^2$ vs Time) and for the three vibration axes (root mean square Acceleration dB re $10^{-6}g$ vs Time).

Specific occurrences identified from the time histories were selected for one-third-octave frequency spectral analyses for both noise at the three microphone locations and vibration in three axes.

Statistical analysis of noise data obtained have been prepared showing noise levels (dBA) vs. frequency of occurrence together with calculated noise indexes to form a basis for comparison.

Note that during the in-car measurements, the air conditioning equipment in the test train was turned off.

3. WAYSIDE NOISE MEASUREMENTS-MBTA RED LINE (SO. SHORE EXTENSION) OCTOBER 28, 1971 (1500 TO 1650 HOURS)

Appendix A contains time-histories, statistical analyses, and 1/3-octave frequency spectra of wayside noise-level measurements made at the three wayside locations in an MBTA storage yard on Tenean Street, Dorchester, MA, next to the tracks of the MBTA South Shore Extension of the Red Line.

These measurements were made on October 28, 1971, 58 days after the official opening of the So. Shore Extension of the Red Line.

Figure A-1 contains a short representative coincident time history of wayside noise level measurements. Microphones were set up at perpendicular distances of 25, 50, and 100 ft. respectively from the centerline of the northbound track. The centerline of the southbound track was effectively 38, 63, and 113 ft., from these microphones. Noise levels are plotted in dBA re $20\mu N/m^2$ vs Time with the events of interest identified.

Table 3-1 shows the coincident wayside noise and ground vibration levels measured. The peak RMS noise level measured at the three microphones is tabulated for both north and southbound trains. As shown, measurements were made on individual 4-car trains each time they passed the measurement location in both the north-and southbound directions. Noise data obtained from trains traveling southbound were converted to equivalent levels at 25, 50 and 100 ft. for this tabulation by simple addition of 3.0, 1.8, and 0.9 dB, respectivly. (See appendix K for conversion calculation.)

A comparison of the data on individual trains indicates that northbound trains generated noise approximately 3 dBA greater than southbound trains. The reason was not apparent at this point, but the larger noise levels measured on the northbound track are

TABLE 3-1
COINCIDENT WAYSIDE NOISE AND GROUND VIBRATION LEVELS
MBTA RED LINE (SOUTH SHORE EXTENSION)
PULLMAN STANDARD, MBTA TYPE 1 SOUTH SHORE RAPID TRANSIT CARS

4-Car Trains - October 28, 1971

Car Serial Nos.	Time of Day hours	Speed mph	Direction	Peak RMS Noise Level * dBA re 20µN/m²			Peak RMS Acceleration Level dB re 10^{-6}g	
				at 25 ft	at 50 ft	at 100 ft	y-axis at 25 ft	y-axis at 38 ft
1639,1638,1651,1650	15 03	51.5	N	91	87	81	90	
1639,1638,1651,1650	15 47	51.8	S	89	84	80		83
1639,1638,1651,1650	16 03	51.0	N	92	87	82	91	
1522,1515,1645,1644	15 08	44.5	S	85	81	-		-
1522,1515,1645,1644	15 23	50.0	N	88	84	-	86	
1502,1509,1607,1606	15 11	49.0	N	100	95	-	92	
1502,1509,1607,1606	15 54	50.5	S	97	92	86		87
1502,1509,1607,1606	16 12	50.2	N	100	95	89	95	
1633,1632,1648,1649	15 14	51.0	S	98	93	-		88
1633,1632,1648,1649	15 29	51.0	N	101	96	-	99	
1633,1632,1648,1649	16 13	51.0	S	98	94	88		87
1633,1632,1648,1649	16 28	51.0	N	102	97	93	98	
1505,1510,1618,1619	15 18	50.5	S	92	87	-		85
1505,1510,1618,1619	15 37	49.6	N	95	90	87	93	
1505,1510,1618,1619	16 24	50.5	S	92	87	81		85
1505,1510,1618,1619	16 43	49.5	N	96	91	85	93	
1623,1622,1513,1523	15 29	50.5	S	92	88	-		84
1623,1622,1513,1523	15 43	50.5	N	96	91	86	93	
1623,1622,1513,1523	16 30	50.5	S	92	87	82		84
1626,1627,1613,1612	15 33	51.0	S	91	87	-		86
1626,1627,1613,1612	15 47	49.5	N	94	89	84	91	
1626,1627,1613,1612	16 39	51.0	S	92	88	82		83
1503,1508,1641,1640	15.40	50.4	S	99	94	87		89
1503,1508,1641,1640	15 56	51.0	N	102	97	92	99	
1504,1506,1507,1514	16 08	49.7	S	99	95	88		90
1504,1506,1507,1514	16 22	51.0	N	102	96	91	99	
1637,1636,1517,1518	16 18	51.0	S	93	88	83		86
1637,1636,1517,1518	16 36	51.0	N	96	91	86	94	
Average (All Trains)		50.4	N-S	95.1	90.4	85.7		
Average (Northbound)		50.4	N	96.8	91.9	86.9	93.8	
Average (Southbound)		50.3	S	93.5	89.0	84.1		85.9

* Noise data from southbound trains converted to equivalent levels at 25, 50 and 100 ft from 38, 63 and 113 ft.

\- No data measured

consistent with the larger vibration levels also measured on the northbound track. Ground vibration data from section 4 is also included in table 3-1.

To describe the overall temporal characteristic of the wayside noise at the measurement site, statistical analyses (see appendix K) were performed for the data from the three wayside microphones for a consecutive one-hour period between 1546 and 1646. During this one-hour period, 12 (4-car) trains passed the measurement site, six northbound and six southbound. These analyses are shown in figures A-10, A-11, and A-12.

At the three locations, the dynamic range of the noise measured was 39, 35, 31 dBA; the median noise levels were 69.4, 68.1, 68.3, dBA; and the noise-pollution levels were 89.8, 87.0 and 85.3 dBA for the 25, 50, and 100 ft. microphone locations, respectively. Other pertinent noise indexes are also included.

Figures A-2 and A-9 contain expanded coincident time histories and the associated 1/3-octave noise spectra of a representative selective few of the events measured at the three wayside locations. The integration period chosen for the spectral analysis is located on the time history at the proper point in time.

4. WAYSIDE GROUND VIBRATION MEASUREMENTS-MBTA RED LINE (SO. SHORE EXTENSION) - OCTOBER 28, 1971 (15 00 TO 16 51 HOURS)

Appendix B contains time histories and 1/3-octave frequency spectra of wayside ground vibration level measurements made on October 28, 1971, simultaneously with the noise measurements discussed in section 3.

A brass rod 2 ft. long and 7/8 inch in diameter was driven into the ground and located as shown in figure G-1 in an MBTA storage yard on Tenean Street, Dorchester, MA next to the tracks of the MBTA So. Shore Extension of the Red Line.

An insulated vibration transducer was mounted on the rod and the y-axis acceleration levels (lateral motion relative to track) measured and recorded on an F-M magnetic-tape recorder.

Figure B-1 contains a short representative time history of the wayside ground-vibration levels in the y-axis (lateral) at a point 25 ft. from the centerline of the northbound track. The centerline of the southbound track was effectively 38 ft. from the measurement point. The graphic history, plotted in dB re 10^{-6} g vs. Time, is in time coincidence with the wayside noise-level time history plotted in figure A-1.

Table 3-1 is a tabulation of the coincident wayside noise and ground vibration levels. The peak RMS acceleration levels measured in the y-axis (lateral) are tabulated for both north-and southbound trains. As shown, measurements were made on individual 4-car trains each time they passed the measurement location.

It is noted that the y-axis vibration levels measured for northbound trains were on the average 8 dB greater than those measured for southbound trains. Approximately 4 dB can be attributed to the relative distance that the two tracks are from the measurement point (by the inverse distance law, converting from 38 to 25 ft.). The remaining 4 dB could have been caused by the configuration of the northbound track and/or rail bed at the measurement location. It was noted in discussion (section 3) that northbound trains also generated excess noise when compared with converted equivalent levels measured from southbound trains.

Figures B-2 through B-5 contain expanded time histories of the ground-vibration levels and the associated 1/3-octave vibration spectra of a representative selected few of the events measured. For the purpose of comparison, the same events selected in section 3 are presented. The integration periods chosen for the spectral analyses are located on the time histories at the proper point in time and are in time coincidence with the integration periods chosen for the noise spectral analyses of section 3.

5. WAYSIDE NOISE MEASUREMENTS-MBTA RED LINE (SO. SHORE EXTENSION) APRIL 27, 1972 (13 15 TO 16 05 HOURS)

Appendix C contains time-histories, statistical analysis, and 1/3-octave frequency spectra of wayside noise level measurements made at the same three locations (figure G-1). Measurements were made on April 27, 1972, six months after similar measurements were made at this location. These measurements, made on October 28,1971, are discussed in section 3. The wayside microphones were set up in the exact location for both tests. The April measurements were begun earlier in the afternoon than the October measurements to include measurements on 2-car trains as well as 4-car trains.

Figure C-1 contains a short representative coincident time history of the wayside noise-level measurements. Microphones were set up at a perpendicular distance of 25, 50 and 100 ft. from the centerline of the northbound track. The centerline of the southbound track was effectively 38, 63, and 113 ft. from the three microphones. Noise levels are plotted in dBA re 20μN/m^2 vs Time with events of interest identified.

Tables 5-1 and 5-2 are tabulations of the coincident wayside noise and ground vibration levels measured for 2-car and 4-car trains, respectively. The peak RMS noise level measured at the three microphone locations is tabulated for both north-and southbound trains. As shown, measurements were made on individual trains each time they passed the measurement location in both the north and southbound directions. Noise data obtained for southbound trains were converted to equivalent levels at 25, 50 and 100 ft. for the purpose of these tabulations.

Note from tables 5-1 and 5-2 that the eight individual 2-car trains measured and tabulated were later paired into four different 4-car trains and each of these trains was also measured as the car passed by the measurement location.

TABLE 5-1. COINCIDENT WAYSIDE NOISE AND GROUND VIBRATION LEVELS MBTA RED LINE (SO. SHORE EXTENSION) PULLMAN STANDARD, MBTA TYPE 1 SO. SHORE RAPID TRANSIT CARS

2-Car Trains - April 27, 1972

Serial Nos	Time of Day hour	Speed mph	Direction	Peak RMS Noise Level* dBA re $20\mu N/m^2$ at 25 ft	at 50 ft	at 100 ft	Peak RMS Acceleration Level dB re 10^{-6} g at 25 ft z-axis	at 25 ft x-axis	at 25 ft y-axis	at 38 ft z-axis	at 38 ft x-axis	at 38 ft y-axis
1628,1629	1318	51.3	N	97	91	85	80	-	90			
1628,1629	1400	50.3	S	83	87	80				73	81	83
1514,1515	1323	51.3	S	74	79	73				71	72	75
1611,1610	1327	50.6	N	100	96	90	82	-	95			
1611,1610	1413	50.3	S	99	94	88				75	84	88
1519,1502	1329	47.4	S	90	85	78				72	78	81
1503,1506	1334	49.5	N	90	86	80	76	85	86			
1503,1506	1419	47.9	S	89	84	77				72	79	80
1618,1619	1341	49.9	S	87	83	78				71	78	80
1637,1636	1354	50.5	S	90	85	78				72	79	81
1604,1605	1407	50.4	S	86	81	76				72	74	76
Average(All Trains)		49.9		89.5	86.5	79.8	79.3	85.0	90.3	72.2	79.4	80.5

*Noise data from southbound trains converted to equivalent levels at 25, 50, and 100 ft. from 38, 63 and 113 ft, respectively.

- No data measured

TABLE 5-2. COINCIDENT WAYSIDE-NOISE AND GROUND-VIBRATION LEVELS MBTA RED LINE (SOUTH SHORE LINE) PULLMAN STANDARD, MBTA TYPE 1 SOU H SHORE RAPID TRANSIT CARS

4-Car Trains - April 27, 1972

Car Serial Nos.	Time of Day hours	Speed mph	Direction	Peak RMS Noise Level* dBA re 20μN/m² at 25 ft	at 50 ft	at 100 ft	Peak RMS Acceleration Level dB re 10^{-6}g at 25 ft z-axis	at 25 ft x-axis	at 25 ft y-axis	at 38 ft z-axis	at 38 ft x-axis	at 38 ft y-axis
1616,1617,1634,1635	1342	49.3	N	98	94	88	81	-	93			
1616,1617,1634,1635	1429	50.7	S	95	90	82				74	83	85
1616,1617,1634,1635	1447	49.5	N	100	95	88	81	92	95			
1616,1617,1634,1635	1529	50.7	S	94	90	-				75	83	86
1616,1617,1634,1635	1551	50.0	N	99	94	-	82	91	95			
1502,1519,1515,1514	1349	49.5	N	94	88	83	77	85	88			
1502,1519,1515,1514	1435	50.2	S	91	86	80				72	79	80
1502,1519,1515,1514	1456	50.2	N	94	88	83	78	86	88			
1502,1519,1515,1514	1537	48.8	S	90	85	-				71	78	80
1502,1519,1515,1514	1556	50.8	N	93	88	-	78	85	89			
1513,1523,1500,1518	1359	48.8	N	98	93	86	78	-	90			
1513,1523,1500,1518	1442	49.8	S	95	90	83				73	80	82
1513,1523,1500,1518	1504	36.5†	N	94	88	81	78	88	90			
1513,1523,1500,1518	1544	50.2	S	94	89	-				73	79	82
1604,1605,1619,1618	1406	49.9	N	93	87	80	78	85	87			
1604,1605,1619,1618	1449	48.9	S	87	82	77				72	76	79
1604,1605,1619,1618	1506	50.7	N	93	88	81	78	85	87			
1604,1605,1619,1618	1553	48.6	S	88	83	-				72	77	80
1629,1628,1636,1637	1417	51.0	N	100	94	88	81	90	95			
1629,1628,1636,1637	1505	49.5	S	93	88	81				74	79	83
1629,1628,1636,1637	1527	50.5	N	97	91	-	79	88	90			
1623,1622,1505,1507	1422	49.9	N	97	91	84	80	88	90			
1623,1622,1505,1507	1458	50.5	S	97	92	85				74	83	86
1623,1622,1505,1507	1517	49.4	N	99	95	-	81	89	94			
1623,1622,1505,1507	1600	49.8	S	96	91	-				73	83	86
1612,1613,1602,1603	1431	50.7	N	98	92	85	80	91	93			
1612,1613,1602,1603	1514	49.5	S	93	89	-				73	84	84
1612,1613,1602,1603	1532	51.1	N	97	91	-	80	90	93			
1503,1506,1611,1610	1441	49.7	N	101	96	90	82	90	93			
1516,1520,1509,1508	1527	56.4	S	102	97	-				74	83	86
1643,1642,1505,1507	1557	48.0	N	92	86	-	78	85	88			
Average (All Trains)		50.1	N-S	95.2	88.4	83.6						
Average (Northbound)		50.0	N	96.5	91.1	84.8	79.4	87.4	91.0			
Average (Southbound)		50.3	S	93.5	88.6	81.3				73.1	80.5	83.7

*Noise data from southbound trains converted to equivalent levels at 25, 50 and 100 ft from 38, 63 and 113 ft.

†Not included in average speed calculation

A comparison of the noise levels for north- and southbound trains indicates (as in section 3 of this report) that northbound trains generate noise, approximately 3 dbA greater than southbound trains, which again suggests a configuration condition of the northbound track and/or rail bed. Ground vibration data from section 6 are included in tables 5-1 and 5-2.

To describe the overall temporal characteristics of the noise at the measurement site, statistical analyses (see appendix K) were performed for data from the three wayside microphones for a one hour period from 13 46 to 14 46. During the one hour period seventeen trains passed the measurement site; 5(2-car) trains southbound; 8(4-car) trains northbound; and 4(4-car) trains southbound. These analyses are shown in figures C-20, C-21 and C-22.

Table 5-3 is a summary of the statistical noise indexes calculated for both the October 28, 1971 and the April 27, 1972 measurements at the 50 ft. microphone station. A comparison shows decreases in each of the calculated noise indexes from October 1971 to April 1972 measurements even though more trains passed the measurement location during the April period (17 vs. 12 trains). These decreases noted cannot be accounted for by proximity of the measurement site to the heavily traveled Southeast Expressway and by the fact that the October analysis period was closer in time to the rush hour traffic period. It is noted that the southbound lane which would be the more heavily traveled at this period in time was acoustically shielded from the microphones because of the raised highway.

As will be shown in section 6 similar decreases were noted in the y-axis wayside vibration data. As theorized in section 6 the decrease in noise and vibration is probably due to the settling of the new rail bed during first six-month operation.

Figures C-2 through C-19 contain expanded coincident time histories at the three wayside microphone locations together with the associated 1/3-octave noise spectra of a representative few of the events measured for comparison with the October 28, 1971

TABLE 5-3. STATISTICAL SUMMARY OF WAYSIDE NOISE LEVELS, MBTA RED LINE (SO. SHORE EXTENSION)

Noise data 50 ft from centerline of near northbound track

	October 28, 1971[1] 1546 to 1646 hours	April 27, 1972[2] 1346 to 1446 hours
Max Noise Level	97.0 dBA	96.0 dBA
1% Percentile	87.4 dBA	84.8 dBA
10% Decile	75.1 dBA	70.0 dBA
Median	68.1 dBA	64.6 dBA
90% Decile	65.5 dBA	61.3 dBA
99% Percentile	64.1 dBA	59.4 dBA
Noise Pollution Level	87.0	82.7

[1]Twelve, 4-car trains passed measurement site, 6-northbound, 6-southbound

[2]Seventeen trains passed measurement site; five, 2-car trains, southbound; eight, 4-car trains northbound; and four, 4-car trains southbound

data (figures A-2 through A-9). The integration period chosen for the spectral analysis is located on the time history at the proper point in time.

Figures C-2 through C-5 contain the data and analysis of two (2-car) trains northbound Serial Nos 1611,1610 and Serial Nos 1503,1506. Figures C-6 and C-7 contain the analysis of those 2-car trains paired up as a four car train northbound, with car Serial Nos 1503,1506 as the lead pair. (Note: 2-car train serial nos 1503 and 1506 was selected for in-car measurements during a typical run on April 29, 1972, see sections 7 and 8.) It is interesting to note that the noise generated by the 4-car train was dominated by the more noisy 2-car train Serial Nos 1611 and 1610. The expanded time histories (Figure C-2, C-4, and C-6) of data at the 25-ft. microphone location exemplified this since the double peak in the noise-level history figure C-6a is caused by the passing of 2-car trains (Serial Nos 1503 and 1506 followed by the noisy pair Serial Nos 1611 and 1610. This is less obvious at the other two microphone locations but nevertheless also true.

Figures C-8 through C-11 contain the data and analysis of two 2-car trains southbound Serial Nos 1618 and 1619 and Serial Nos 1604 and 1605. Figures C-12 through C-15 contain the analysis of these 2-car trains paired up as a 4-car train traveling both north-and southbound. In this case, the noise generated by the individual 2-car trains was essentially at the same level and lower than the average, table 5-20. When paired as a 4-car train, the overall maximum level changed little if any; however, the noise level was extended over a longer period of time. The double peak in the noise-level history of the passing of each 2-car pair is again obvious in figures C-12a and C-14a where 2-car Serial Nos 1618 and 1619 were the lead pair southbound and the trailing pair northbound.

Figures C-16 through C-19 contain data and analysis of a 4-car train (Serial Nos 1616,1617,1634, and 1635). Although no measurements were made on the individual 2-car pairs, it is obvious, from the double peak in the noise-level history, (figures C-18a and C-19a), that both pair were essentially at the same level and higher than the average level for 2-car trains (table 5-2).

6. WAYSIDE GROUND VIBRATION MEASUREMENTS - MBTA RED LINE(SO. SHORE EXTENSION) APRIL 27, 1972 (13 15 TO 16 05 HOURS).

Appendix D contains time-histories and 1/3-octave frequency spectra of wayside ground-vibration level measurements made simultaneously with the noise measurements discussed in section 5.

Measurements were made on April 27, 1972, six months after similar measurements were made at this location. These measurements were made on October 28, 1971 and are discussed in section 4. For the October 1971 ground-vibration measurements, a brass rod 2 ft. long and 7/8 inch in diameter was driven into the ground and located as shown in figure G-1. The brass rod was purposely left in the ground at the conclusion of the October 1971 tests for the purpose of repeat measurements at a later time. This rod was used in the measurements to be discussed in this section.

Unlike the October 1971 measurements when only the y-axis (lateral) accelerations were measured, an insulated triaxial arrangement of vibration transducers were mounted on the above driven rod and three axes of acceleration measured and recorded on an F-M magnetic-tape recorder. Because the measurements were started earlier in the day, both 2-car and 4-car trains were available for measurement.

Figure D-1 contains a short representative history of the wayside ground vibration levels in three axes (x-axis - longitudinal motion; y-axis - lateral motion; z-axis - vertical motion; motion relative to all tracks) at 25 ft. from the centerline of the northbound track. The centerline of the southbound track was effectively 38 ft. from the measurement point. This graphic history, plotted in dB re 10^{-6} g vs. Time, is in time coincidence with the wayside noise levels plotted in figure C-1.

Tables 5-1 and 5-2 in section 5 are tabulations of the coincident wayside noise and ground vibration levels measured for 2-car and 4-car trains, respectively. The peak rms acceleration levels measured in three axes are tabulated for both north-and southbound trains. As shown, measurements were made on individual trains each time they passed the measurement location in both the north-and southbound directions.

As in the October 1971 measurements, the y-axis accelerations measured for northbound trains was approximately 8 db greater than for those measured for southbound trains. Considering the relative distance the two tracks are from the measurement point, by the inverse distance law, as in section 4, approximately 4 db difference in level is not accounted for and suggests, together with noise measurement of sections 3 and 5, that a configuration condition exists in the northbound track and/or rail bed. It is also noted that the vibration levels for the x-and z-axes were also greater for northbound trains in excess of that which could be accounted for by the relative distance from the measurement point of the two tracks.

A comparison of the average maximum rms acceleration level in the y-axis measured for both north and southbound trains on April 27, 1971. (91.4 and 83.3 dB re 10^{-6} g in table 5-2) with the y-axis levels measured on October 19, 1971 (93.7 and 85.9 dB re 10^{-6} g in Table 3-1) shows a decrease of 2.5 dB in the vibration level for both north-and southbound trains. As shown in table 5-3, the statistical-noise indexes tabulated also decreased between the October 1971 and April 1972 measurements. It is theorized that these decreases are due to the initial settling of the rail bed during the first six-month's operational period.

Figures D-2 through D-19 contain expanded coincident time histories of the ground-vibration levels in three axes and the associated 1/3-octave vibration spectra of a representative few of the events measured. For the purpose of comparison, the same events selected in section 5 are presented (figures C-2 through C-19). The integration periods chosen for the spectral analyses are located on the time histories at the proper point in time and are in time coincidence with the integration periods chosen for the noise spectral analysis of section 5.

Figures D-2 through D-5 contain data and analysis of two, 2-car trains northbound Serial Nos 1611 and 1610 and Serial Nos 1503 and 1506. Figures D-6 and D-7 contain the analyses of these two-car trains paired up as a four-car train northbound with Serial Nos 1503 and 1506 as the lead pair (Note: 2-car train Serial Nos 1503, 1506 was selected for in-car measurements during a typical run on April 29, 1972 (sections 7 and 8). A close analysis of the expanded time histories of the vibration data, figures D-2, D-4, and D-6 reveals 3 and 5 peaks on the time history during the passing of a 2-car and a 4-car train, respectively. These peaks are a result of the "point source" vibrations from the sets of wheel trucks as they pass the measurement point. Because of the close proximity of the trucks of adjacent cars, a single broader peak is obtained from this pairing. The y-axis data in figure D-2 for Serial Nos 1611 and 1610 show three peaks of varying amplitudes, with the first peak resulting from the passby of the front truck on the lead car. This caused the lowest vibration level. The second broader peak is the combination of the rear truck of the lead car with the front truck of the second car. Finally, the third peak is the rear wheel truck of the second car passing the measurement point. The same thing is true of the peaks shown in the y-axis data in figure D-6 showing the 4-car train made up of the 2-car trains. The five peaks can be easily seen. The first two peaks are identical with the first two shown in figure D-4; the last two peaks are identical with the last two shown in figure D-2; the middle of third peak is a combination of the last peak shown in figure D-4 and the first peak of figure D-2 since the train was joined at this point. Figure D-6 shows a definite difference exists in the vibration levels from the sets of wheel trucks as they passed the measurement point. It appears the condition of the wheels is the main factor causing the differences. It is noted that car Serial Nos 1611 and 1610 generated more noise than car Serial Nos 1503, 1506 (figures C-2 and C-4). Figures D-2 and D-4 show Serial Nos 1611 and 1610 also generated a higher ground-vibration level than Serial Nos 1503 and 1506.

It is more difficult to distinguish the peaks on the vibration time history for the two 2-car trains shown in figures D-8 and D-10 (Serial Nos 1618 and 1619 and Serial Nos 1604 and 1605, respectively) since the levels are lower and the train is farther from the measurement point when traveling on the southbound track; However, when these trains are combined into a 4-car train traveling on the northbound track, the levels are higher and the peaks more distinguishable (figure D-14). It is obvious that the vibration level of the peaks are lower and more uniform in figure D-14 than those in figure D-6 suggesting all wheels on these 4-car trains were more uniform and in good condition. The noise level measured for these 2-car trains and their combination as a four-car train, (figures C-8, C-10, C-12 and C-14) confirms the uniformity between trains and the less-than-average noise generated.

Figures D-16 through D-19 contain data and analysis of a 4-car train with car Serial Nos 1616, 1617, 1634 and 1635 traveling north-and southbound. No measurements were made on these individual 2-car trains: however, the vibration-level peaks suggest a mix of wheels both in good and questionable condition. It appears that the front-wheel trucks on the lead car, and perhaps, the rear wheels on the third car were all in good condition with the remaining trucks containing wheels in questionable condition.

7. IN-CAR NOISE-LEVEL MEASUREMENTS - MBTA RED LINE APRIL 29, 1972 (01 00 TO 04 00 HOURS)

Appendix E contains time-histories, statistical analysis and 1/3-octave frequency spectra of noise-level measurements made on and in, a 2-car train made up of MBTA type 1 So. Shore Rapid Transit Cars designed and built by Pullman Standard, Chicago, Illinois for the MBTA.

A 2-car train with car Serial Nos 1503 and 1506 was selected for this test since wayside noise-and-vibration measurements were made on this pair during revenue service on April 27, 1972 (sections 5 and 6). The lead car of this 2-car train, Serial No. 1503, was instrumented for noise and vibration measurements. Figure G-2 shows microphone and vibration transducer locations; figure G-8 shows the car's interior . Measurements were made in the subways and on the surface lines of the MBTA Red Line proper and the Ashmont and So. Shore Extension of the Red Line during a typical run in the early morning hours of April 29, 1972 when no revenue service was provided on these lines.

Figures E-1, E-15, and E-19 contain coincident time histories of noise measurement levels at three locations on the test car over various sections of the MBTA Red Line. Noise levels are plotted in dBA re $20 \mu N/m^2$ vs. Time with points of interest identified. Coincident values of train speed have been superimposed on the time history charts.

Figure E-1 contains noise data obtained northbound from the Quincy Center Station, Quincy, MA on the So. Shore Extension of the Red Line to the end of the Red Line at Harvard Station, Cambridge, MA. This is the normal route for the Type 1 cars and includes many varied rail-and-road bed conditions including travel on surface lines, in subways of various cross sections, on elevated structures and travel on both welded and non-welded rails. The Tenean St. wayside measurement site is identified on the time history between No. Quincy and Andrew Stations.

Figure E-15 contains noise data obtained from Ashmont to Columbia Stations Dorchester, MA, on the Ashmont Extension of the Red Line. Although the measurements were made on the Type 1 Transit Car; these cars are not normally used on this extension which is relatively old and contains both surface and subway travel on an old rail bed, with non-welded rails and wooden ties. Measurements were made on this extension to compare the effects caused by new and old road beds, and welded and non-welded rails on surfaces lines.

Figure E-19 contains data obtained southbound on the So. Shore Extension of the Red Line, between the Columbia Station Area and Quincy Center Stations. During this run the instrumented car (Serial No. 1503) was the rear car of the 2-car train. The Tenean St. wayside measurement site has been located on the history.

To describe the overall temporal characteristics of the noise levels measured, statistical analyses (Appendix K) were performed for the three microphone locations for the following three sections of the Red Line:

a. So. Shore Extension (figure E-1) - Quincy Center Station to Columbia: New rail bed, welded rail construction, concrete ties with neoprene pads under rails, surface line (figures E-22, E-23 and E-24).

b. Red Line proper (figure E-1) - Columbia to Harvard Stations: Old rail bed, non-welded rails, wood ties on on ballast, 95% subway travel (figures E-25, E-26 and E-27).

c. Ashmont Extension (figure E-15) - Ashmont to Columbia Stations: Old rail bed, non-welded rails, wood ties ballast, 25 percent subway travel (figures E-28, E-29 and E-30).

Table 7-1 is a summary tabulation of several of the calculated statistical noise indexes at the three microphone locations in the 2-car trains for the three sections of the Red Line. The results show in general that operation on the So. Shore extension is

TABLE 7-1 STATISTICAL SUMMARY IN-CAR NOISE-LEVEL MEASUREMENTS - MBTA RED LINE PULLMAN STANDARD, MBTA TYPE 1 SO. SHORE RAPID TRANSIT CARS

2-Car Train Serial Nos 1503, 1506 - April 29, 1972

Line Traversed	Noise Range dBA at Location*			Median Noise Level dBA at Location*			Max Noise Lev dBA at Location*			10% Decile dBA at Location*			Noise Pollution Level at Location*		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
So. Shore Extension-Red Line Quincy Center to Columbia Sta.	20	28	41	70.3	72.2	82.3	82	85	98	73.9	77.4	87.7	78.4	86.1	105.7
Ashmont Extension-Red Line Ashmont to Columbia Sta.	25	36	38	70.2	72.7	79.7	85	90	99	77.9	81.3	92.6	85.4	96.6	118
Red Line (Proper) Columbia to Harvard Sta.	25	31	42	71.9	72.3	82.7	86	88	102	80.9	82.9	95.2	91.0	99.7	121

*Location 1 - Microphone located mid-car inside
Location 2 - Microphone located over rear wheel truck inside
Location 3 - Microphone located on outside platform between cars

quieter than operation on the Red Line proper or the Ashmont Extension. The main reason for this being that operation on the So. Shore Extension included travel on high quality rail bed, welded rail construction and 100% surface line travel. The highest noise levels were measured when the train negotiated the Neponset River Bridge and the Savin Hill Flyover both elevated concrete structures.

Table 7-2 is a tabulation of typical coincident noise and vibration levels recorded on the MBTA Red Line to compare the many varied line conditions. Points selected were chosen where the speed of the train was essentially constant to obtain a representative level unaffected by acceleration and deceleration.

TABLE 7-2 TYPICAL COINCIDENT IN-CAR NOISE AND FLOOR VIBRATION LEVELS-MBTA RED LINE, PULLMAN STANDARD, MBTA TYPE 1 SO. SHORE RAPID TRANSIT CARS

2-Car Train Serial Nos 1503,1506 - April 29, 1972

Operating Situation	Track Condition+	Speed mph	Peak rms Noise Level dBA at Location*			Peak rms Acceleration Level** dB re 10^{-6} g		
			1	2	3	z-axis	x-axis	y-axis
Cruising	A,G	51	69	72	90	83	74	72
Cruising	A,G,F	46	75	78	100	80	70	69
Cruising	B,G,E	44	78	81	105	89	80	79
Cruising	C,G	52	74	80	100	86	76	76
Cruising	C,G,E	36	74	78	100	86	76	74
Cruising	C,D	48	81	86	108	86	78	78
Cruising	C,D,H	30	79	84	108	89	79	77

*Location 1 - Microphone located mid-car inside
Location 2 - Microphone located over rear wheel trucks inside
Location 3 - Microphone located on outside platform between cars
**Triaxial accelerometer mounted on floor tiles over rear wheel trucks.
A) Welded rail, new rail bed, concrete ties
B) Welded rail fastened to concrete bridge deck
C) Non-welded rail, old rail bed, wood ties
D) Subway
E) Elevated Structure
F) Under 8 Lane Highway
G) Surface Line
H) Sharp Curve "Wheel Squeal"

Figures E-2 through E-5 contain the expanded coincident time histories at the three in-car microphone locations along with the associated 1/3-octave frequency spectra of events on the north-bound track of the So. Shore Extension of the Red Line which was selected for analysis. Figures E-16 through E-18 contain analyses of selected events northbound on the Ashmont Extension of the Red Line. Figures E-20 and E-21 contain analyses of selected events southbound on the So. Shore Extension of the Red Line. (See time histories, figures E-1, E-15 and E-19, to locate events on each line with relation to one another.) Where applicable, the integration periods chosen for spectral analysis have been located on the expanded history at the proper point in time.

Figures E-2 and E-3 contain data analysis northbound at the Tenean St. wayside measurement site. Shown on the expanded history also are the increases in noise level due to tunnel effects as the train went under the Redfield St. Bridge and under the 8-lane South-east Expressway. Figures C-4 and C-5 show wayside measurements made on April 27, 1972 as the test train Serial Nos 1503 and 1506 passed this measurement point on a revenue run northbound.

Figures E-4 and E-5 contain analyses and data as the test train negotiated the Neponset River Bridge northbound. The 12 dB increase in noise level is due to the drastic change in the rail bed from high-quality ballast (which tends to absorb sound and vibration) to a highly resonant bridge deck constructed of concrete over rolled steel girders, with rails fastened into the concrete on 1/2-inch neoprene pads. The Savin Hill Flyover (figure E-1) is of a similar construction and shows a similar increase in noise level.

Figures E-6 and E-7 contain data and analysis as the test train entered the subway just before Andrew Station on the Red Line and negotiated a sharp right hand curve. Figure E-7 is the spectral analysis of the "wheel squeal".

No expanded time histories are included for figures E-8 through E-14; figure E-1 shows complete noise history.

Figure E-8 is the spectral analysis at the crest of the Longfellow Bridge. Figure E-9 is the spectral analysis at the Cambridge end of the bridge at a point where the tracks are below grade level, essentially a two-track tunnel with no roof.

The MBTA Red Line subway system is made up of various tunnels with different cross-sections. Figures E-10 through E-14 are the noise spectral analyses at points in the subway system with different tunnel configurations. The cross-sectional data for these locations are included in appendix J; figures J-2 through J-7, respectively. A comparison of the frequency spectra of the noise data recorded at the microphone on the outside platform between cars at each of the six locations shows resonant peaks due to tunnel acoustics associated with the configuration of the tunnel. Note that the analysis of the two-section tunnel (figure E-11) with the smallest dimensions has a peak at 400 Hz, while the larger two-track tunnels peak at higher frequencies.

Figure E-16 is the noise-frequency spectra in the subway tunnel between Ashmont and Shawmut Stations on the Ashmont Extension of the Red Line (figure J-8 shows tunnel cross section).

Figure E-17 is the noise-frequency spectra on a straight section of surface track between Fields Corner and Savin Hill stations. Note that noise levels of 74,80, and 100 dbA were generated by the test train at a speed of 52 mph at the three microphone locations on this section of non-welded track with wood ties.

Figure E-18 is the noise spectra recorded at the Savin Hill Station with the train stopped and the train door open. Levels of 68, 64, and 73 dbA were measured. Each car in the test train was equipped with a motor generator. The major noise source is the operation of the motor generator at a mid-car location under the cars.

Figures E-20 and E-21 contain expanded time histories and noise spectra at the three in-car microphone locations southbound on the straight section of surface track by the Tenean St. wayside measurement site area. A comparison of levels measured at a train speed of 50 mph, 69, 77 and 90 dBA on this track, with levels measured of 71-, 75-, and 92-dBA at 51 mph measured on the northbound track at Tenean St. measurement site (figure E-3) again confirms a configuration condition with the northbound track and/or rail bed. (See discussion in sections 3, 4, 5, and 6.) In addition, a comparison of the above data measured on welded track with the data measured on a non-welded section of track shows the marked effect that track condition has on the noise level generated.

8. IN-CAR FLOOR-VIBRATION LEVEL MEASUREMENT-MBTA RED LINE APRIL 29, 1972 (0100 TO 0400 HOURS)

Appendix F contains time-histories, and 1/3-octave frequency spectra of the in-car floor-vibration level measurements in a 2-car train made up of MBTA Type 1 So. Shore Rapid Transit Cars.

These vibration measurements made on April 29, 1972 were recorded simultaneously with the noise measurements recorded at three locations in the cars and discussed in section 7.

A 2-car train with Serial Nos 1503 and 1506 was selected for this test since wayside noise and ground vibration data were recorded on this pair during revenue service on April 27, 1972 (sections 5 and 6). The lead car of this 2-car train (Serial No. 1503) was instrumented for noise and vibration measurements (figure G-2 shows microphone and vibration transducer locations). A triaxial accelerometer was mounted on the floor tiles centered over the rear wheel trucks with a thin layer of bee's wax. Measurements were made in the subways and on the surface lines of the MBTA Red Line Proper and the Ashmont and So. Shore Extension of the Red Line on a typical run during the early morning hours of April 29, 1972 when no revenue service was being provided on these lines.

Figures F-1, F-15 and F-19 contain coincident time histories of the rms acceleration levels in these three axes (x-axis longitudinal motion; y-axis, lateral motion; z-axis, vertical motion) of floor vibrations at a point centered over the rear wheel trucks of the test car on various sections of the Red Line. These graphic histories plotted in dB re 10^{-6} g vs Time, is in time coincidence with the noise level histories plotted in figures E-1, E-15 and E-19 respectively. Coincident values of speed data have been superimposed only on the noise time-history charts (figures E-1, E-15, and E-19.)

Figure F-1 contains vibration data obtained northbound from the Quincy Center Station, Quincy, MA, on the So. Shore Extension of the Red Line to the end of the Red Line at Harvard Station, Cambridge, MA. This is the normal route for the Type 1 transit cars and includes many varied rail and road bed conditions including travel on surface lines, in subways of various cross sections, on elevated structures, and on both welded and non-welded rails. The Tenean St. wayside measurement site is identified on history between the No. Quincy and Andrew Stations.

Figure F-15 contains vibration data obtained between Ashmont and Columbia Stations, Dorchester, MA on the Ashmont Extension of the Red Line. The Type 1 transit cars are not normally run on this extension of the Red Line which contains both surface and subway travel on an old rail bed, wood ties, and non-welded rails.

Figure F-19 contains vibration data obtained southbound on the So. Shore Extension of the Red Line between Columbia and the Quincy Center Station. Only during this run was the instrumented car (Serial No. 1503) the rear car of the 2-car train. The Tenean St. wayside-measurement site has been located on the time history.

Table 7-1 is a tabulation of typical coincident noise and vibration levels recorded on the Red Line to compare the many varied line conditions. Points selected from figures F-1, F-15, and F-19 were chosen where the speed of the train was essentially constant to obtain a representative level unaffected by acceleration and deceleration. The three sections of the Red Line can be physically described on the whole as follows:

a. So. Shore Extension (figures F-1 and F-19) - Quincy Center Station to Columbia Area, Dorchester, MA (new rail Bed; welded rail construction, concrete ties with neoprene pads under rails, surface line).

b. Red Line (figure E-1) - Columbia Station Dorchester, MA to Harvard Station, Cambridge, MA (old rail bed, non-welded rails, wood ties on ballast, 95 percent subway travel).

c. Ashmont Extension (figure F-15) - Ashmont to Columbia Stations, Dorchester, MA (old rail bed, non-welded rails, wood ties on ballast, 25 percent subway travel).

Figures F-2 through F-5 contain the expanded coincident time histories of the rms acceleration level in three axes along with the associated 1/3-octave vibration spectra of events selected for analysis on the northbound track for the So. Shore Extension of the Red Line. Figures F-6 through F-14 contain analysis of selected events northbound on the Ashmont Extension of the Red Line. Figures F-20 and F-21 contain analysis of selected events southbound on the So. Shore Extension of the Red Line. See time-histories figures F-1, F-15 and F-19 to locate events on each line with relation to one another.

For the purpose of comparison the same events selected for analysis in section 7 are presented (figures F-1, F-15 and F-19).

Where applicable the integration period chosen for vibration spectral analysis has been located on the expanded time history at the proper point in time and are in time coincidence with the integration period chosen for the noise spectral analysis of section 7.

Figures F-2 and F-3 contain data and analyses northbound at the Tenean St. wayside measurement site. Also shown on the expanded time history are points corresponding to where the test train crossed the Walnut and Taylor St. Bridges and where the train went under Redfield St. and the 8 lane Southeast Expressway. Note the absence of a vibration peak (figure F-2) corresponding to the point at which the train went under the SE Expressway and Redfield St.. This confirms the increase in noise levels noted in figure E-2 at these points is a result of tunnel effects. Note also approximately a 2 db increase in the vibration level in the vicinity of the wayside measurement site. This increase is not noted on the data recorded on the southbound track (figure F-20). Figures E-2 and E-3 show the in-car noise level measurements at this point. Figures C-4, C-5 and D-4, D-5 show wayside noise-and-ground-vibration level measurements which were made on April 27, 1972 as the test train (Serial Nos 1503 and 1506) passed the measurement point on a northbound revenue run.

Figures F-4 and F-5 contain vibration data and analyses as the test train negotiated the Neponset River Bridge northbound. Note the increase in vibration level due to the drastic change in rail bed from high-quality concrete ties in ballast to a bridge deck constructed of concrete over rolled steel girders with the rails on 1/2-inch neoprene pads fastened directly into the concrete. The Savin Hill Flyover (figure F-1) is of a similar construction and shows a similar increase in vibration levels. Figures E-4 and E-5 show the coincident noise-level measurements.

Figures F-6 and F-7 contain vibration data and analyses as the train entered the subway and negotiated a sharp right-hand curve just before Andrew Station on the Red Line. Corresponding noise data are included in figures E-6 and E-7.

Figures F-8 through F-14 contain analyses at points at the crest and end of the Longfellow Bridge and at various points of different tunnel configuration. These points are in time coincidence with noise data present in figures E-8 through E-14. It is interesting to note that little difference is seen in the three-axes vibration spectra between points although the noise spectra show differences as a result of tunnel acoustics.

Figure F-16 is the frequency analyses of vibration data in the subway tunnel between Ashmont and Shawmut stations on the Ashmont Extension of the Red Line. As above in the main tunnel of the Red Line, little difference is noted in the vibration spectra.

Figure F-17 is the frequency spectra of vibration levels measured on a straight section of surface track between Fields Corner and Savin Hill stations. Note that 86-, 76-, and 76-dB levels were generated in the z-, x-, and y-axes, respectively, at a speed of 52 mph on this section of non-welded track with wood ties.

Figure F-18 is the vibration spectra recorded at the Savin Hill station with the train stopped and the doors open (55-, 55-, and 53-db re 10^{-6} g levels were measured, respectively). The major contributor to the acceleration levels recorded was the operation of the motor generator at a mid-car location under the cars.

Figures F-20 and F-21 contain expanded time histories and floor-vibration spectra in the z-, x-, and y-axes southbound on the straight section of surface track by the Tenean St. wayside measurement site. A comparison of levels, measured at train speeds of: 50 mph, 82-, 73-, and 72-dB in the z-, x-, and y-axes, respectively, on this section of welded track (concrete ties), with those at 52 mph, 87-, 78-, and 76-dB on non-welded track (wood ties) (Figure F-17), illustrates the effect of track condition on the floor accelerations generated.

9. OBSERVATIONS AND COMMENTS

A review and comparison of in-car noise and vibration measurements made over various sections of the Red Line indicate that the South Shore Extension represents a significant improvement over the older sections of the Red Line with respect to the generation of noise and vibration. This improvement stems from the high-quality track bed with concrete ties and welded rail construction (table 7-2).

Wayside measurements made at six-month intervals indicate an improvement of the noise and vibration characteristics of the South Shore Extension resulting from track bed settling by normal line operations.

In-car measurements were made with no passengers in the cars and all air-conditioning equipment off.

Wayside measurements were made during revenue service. Trains traveling southbound by the Tenean Street measurement site were more heavily laden with passengers than were the northbound trains.

APPENDIX A

WAYSIDE NOISE MEASUREMENTS - MBTA RED LINE (SO. SHORE EXTENSION) - OCTOBER 28, 1971

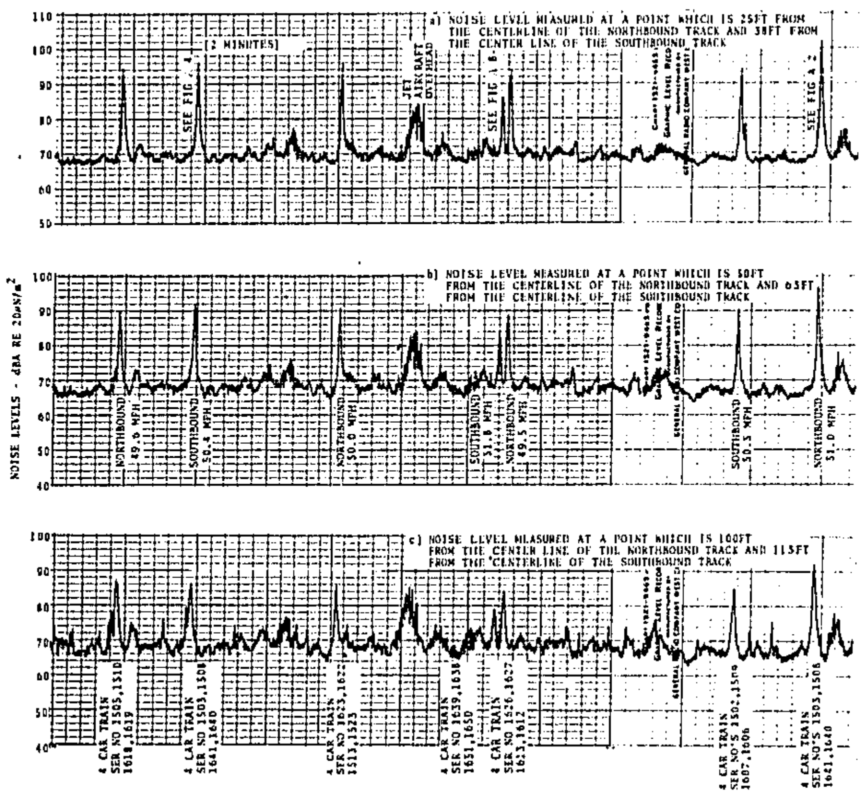


Figure A-1. Coincident Time Histories - Wayside Noise Levels. MBTA Red Line (South Shore Extension) October 28, 1971. Microphones placed 6.1 ft above level grade and 3 ft above rail tops. See figure G-1 for microphone locations.

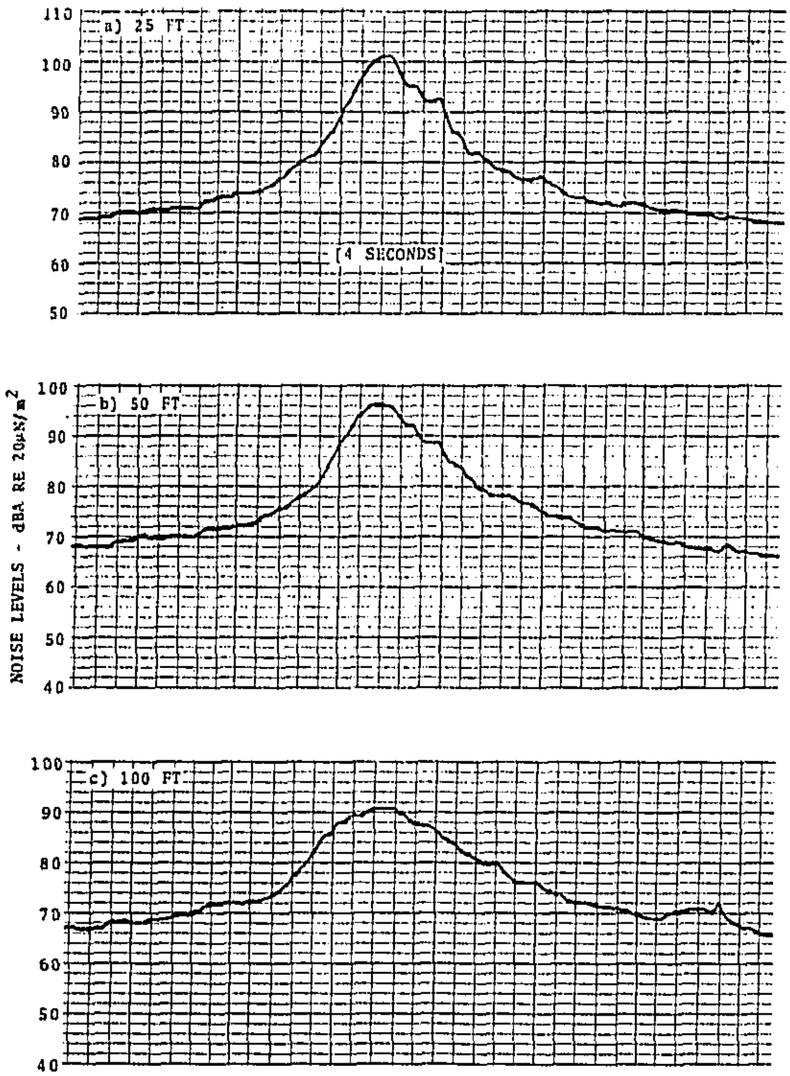


Figure A-2. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 ft from centerline at northbound track. MBTA Redline (So Shore Extension) Oct. 28, 1971. Four-Car Train northbound Ser. Nos 1503, 1508, 1641, 1640 at 51.0 mph. See figure A-1.

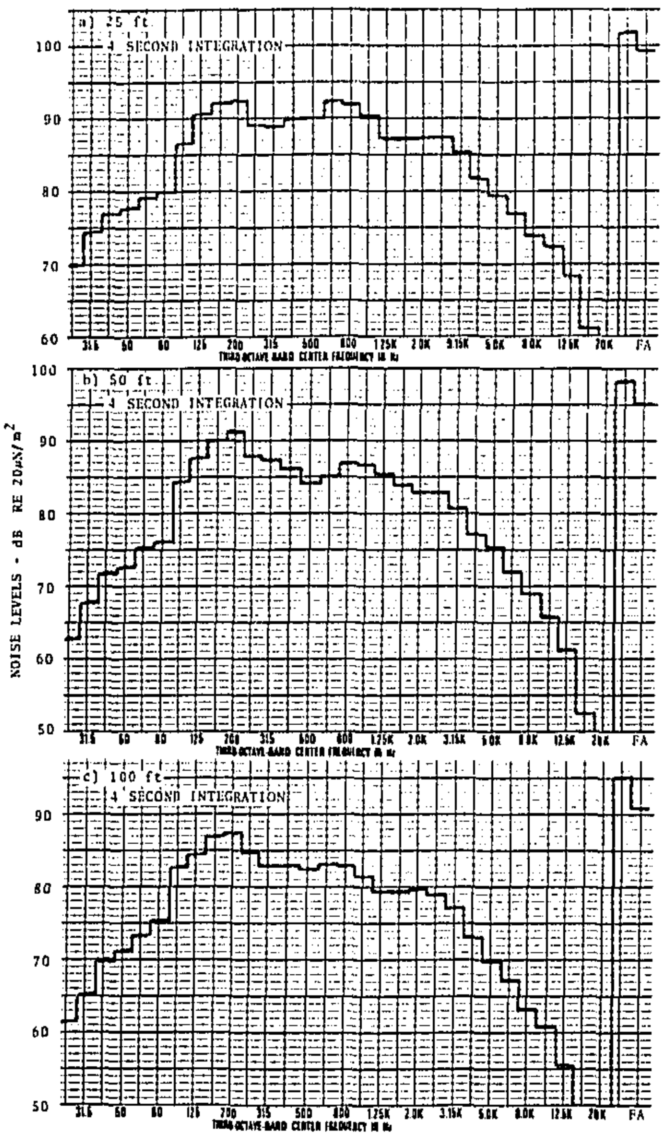


Figure A-3. Wayside Noise Spectra at 25, 50, and 100 ft from center line of northbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four-Car Train northbound Ser. Nos 1503, 1508, 1641, 1640 at 51.0 mph. See figure A-2.

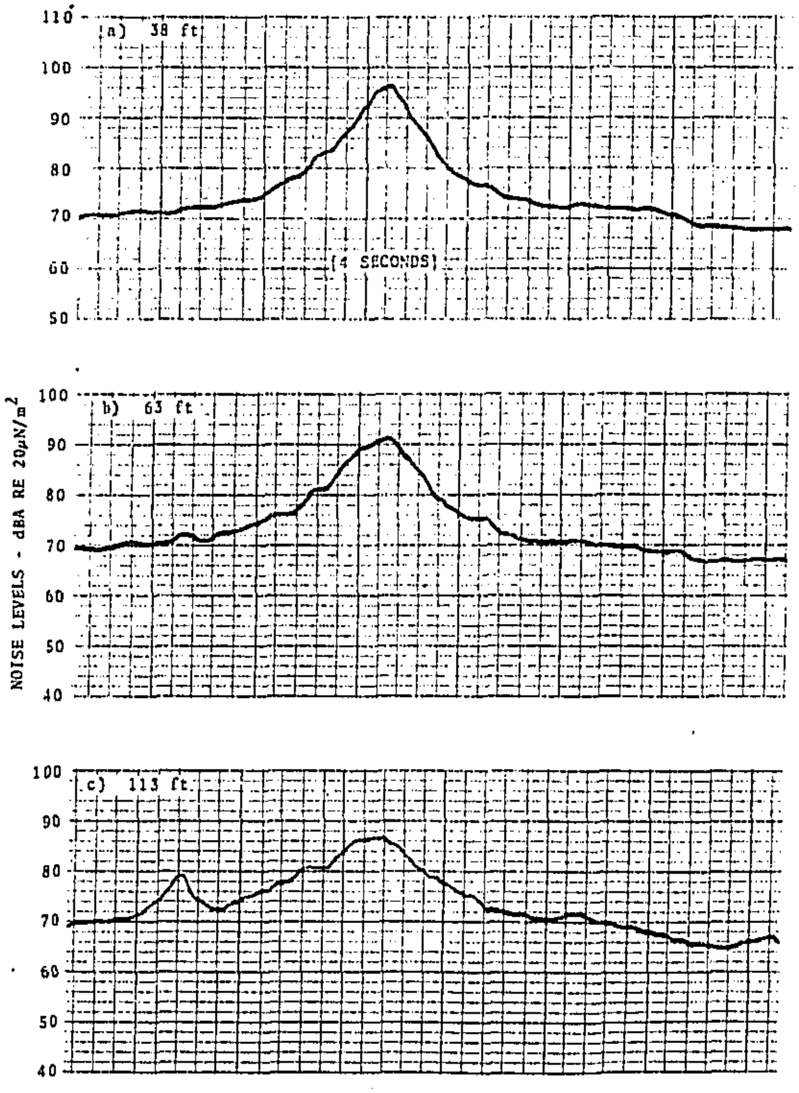


Figure A-4. Coincident Time Histories - Wayside Noise Levels at 38, 63, and 113 ft. from centerline of southbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four-Car Train southbound. Ser. Nos 1503, 1508, 1641, 1640 at 50.4 mph. See figure A-1.

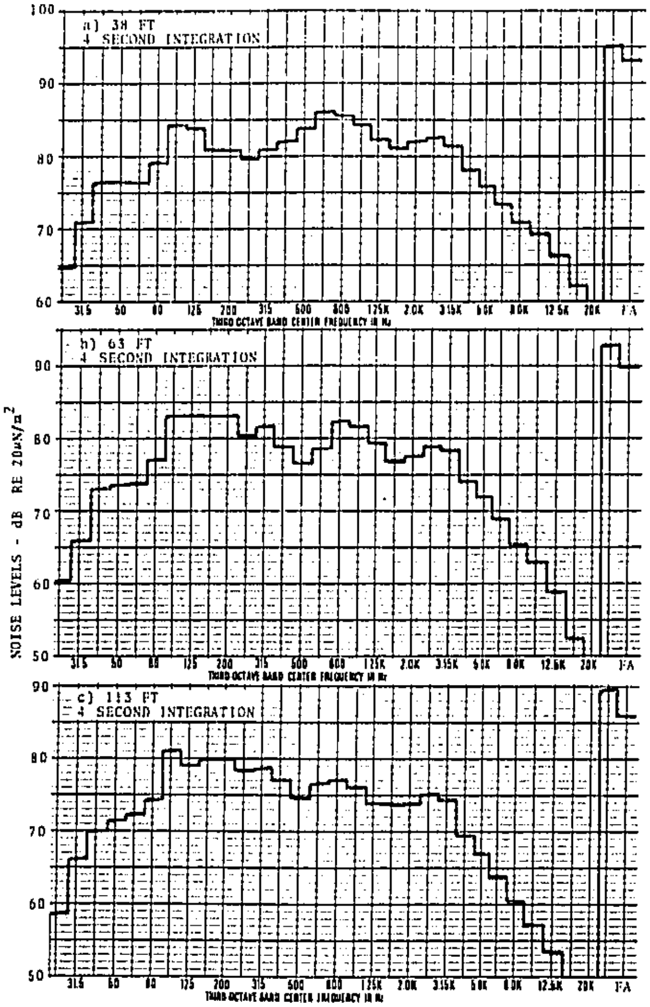


Figure A-5. Wayside Noise Spectra at 38, 63, and 113 ft from centerline of southbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four Car Train southbound, Ser. Nos 1503, 1508, 1641, 1640 at 50.4 mph. See figure A-4.

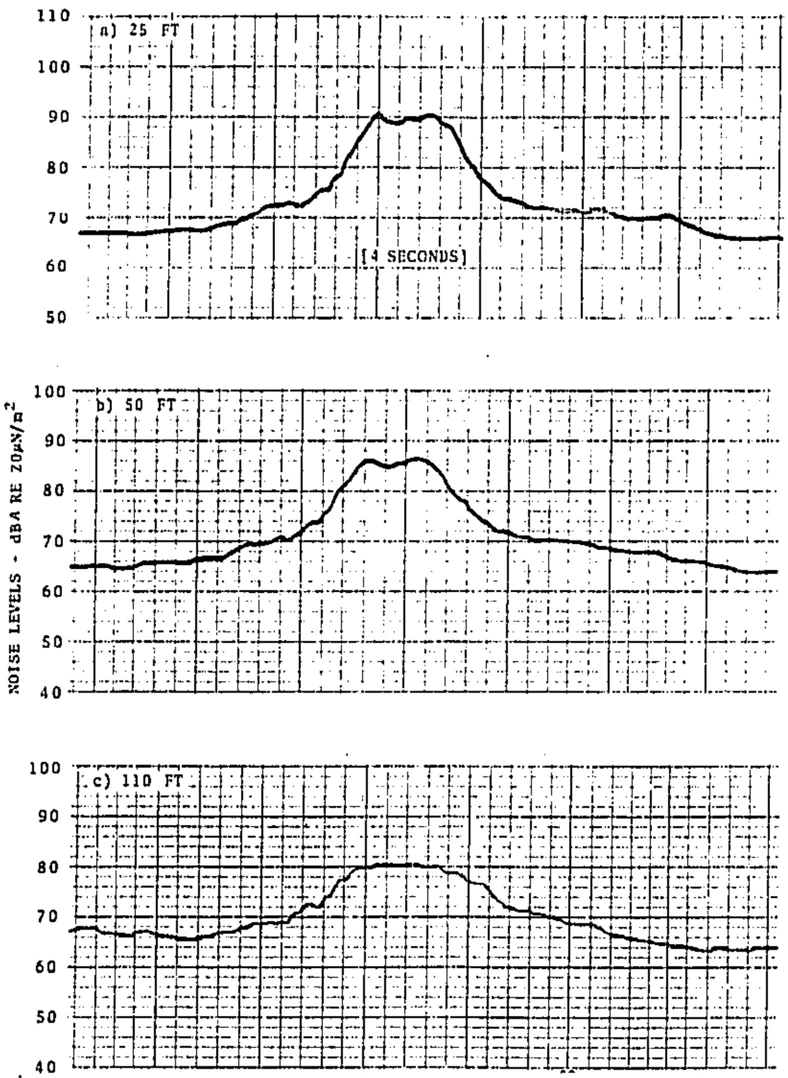


Figure A-6. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 ft from centerline of northbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four Car Train northbound Ser. Nos 1639, 1638, 1650, 1651 at 51.0 mph. See figure A-1.

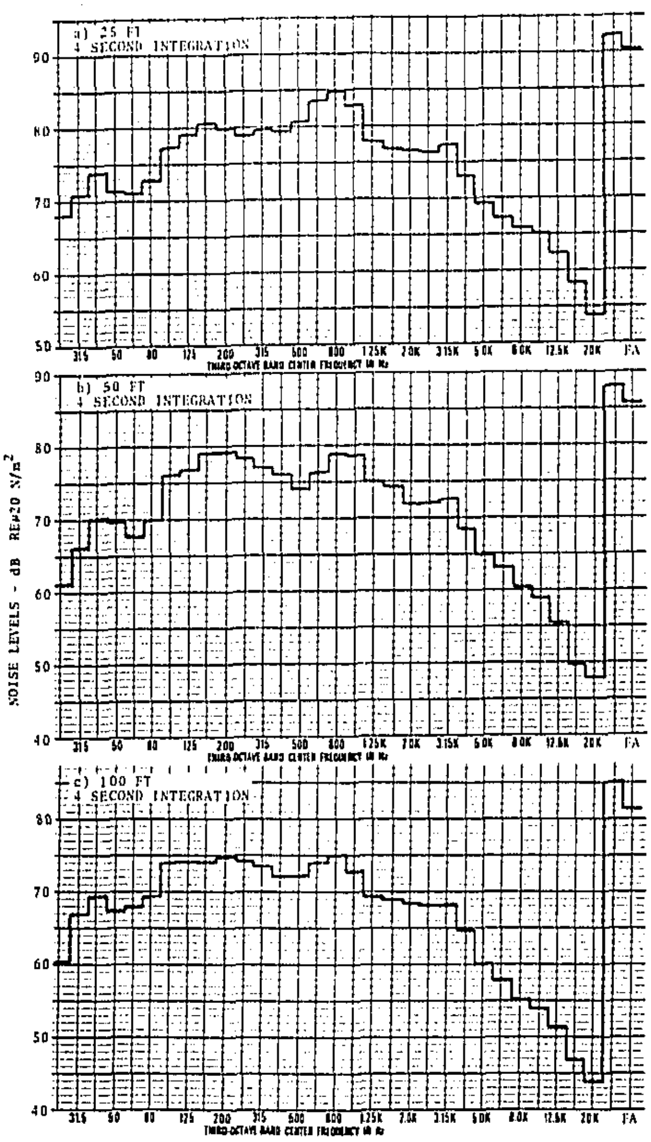


Figure A-7 Wayside Noise Spectra at 25, 50, and 100 ft from centerline of northbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four-Car Train northbound Ser. Nos 1639, 1638, 1650, 1651 at 51.0 mph. See figure A-6.

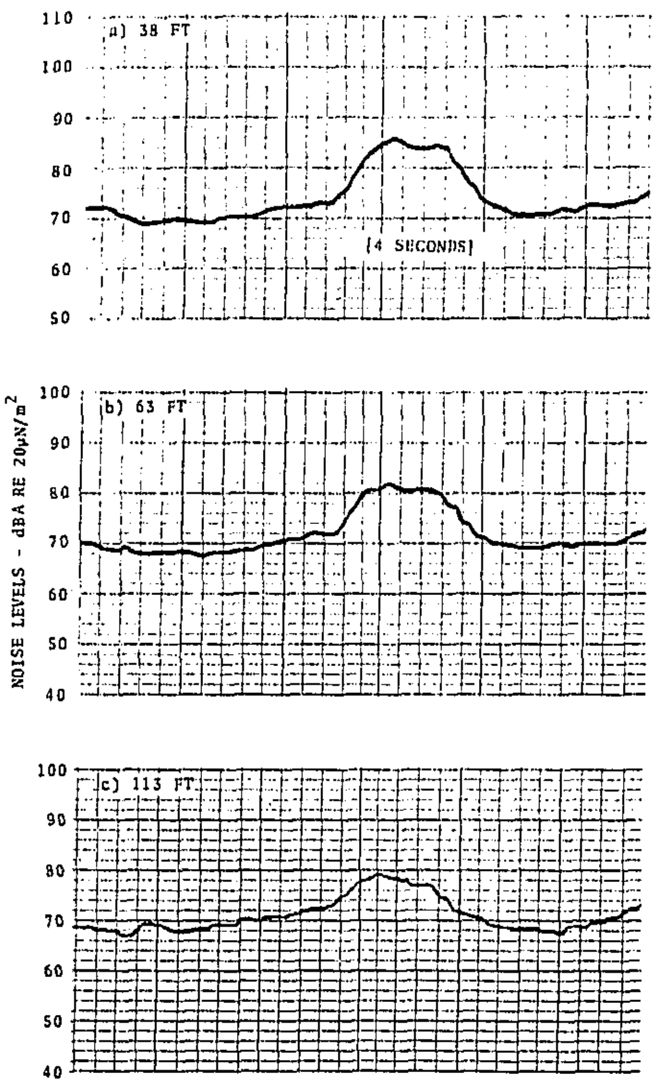


Figure A-8. Coincident Time Histories - Wayside Noise Levels at 38, 63, and 113 ft from centerline of southbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four-Car Train southbound Ser. Nos 1639, 1650, 1651 at 51.8 mph. See figure A-1.

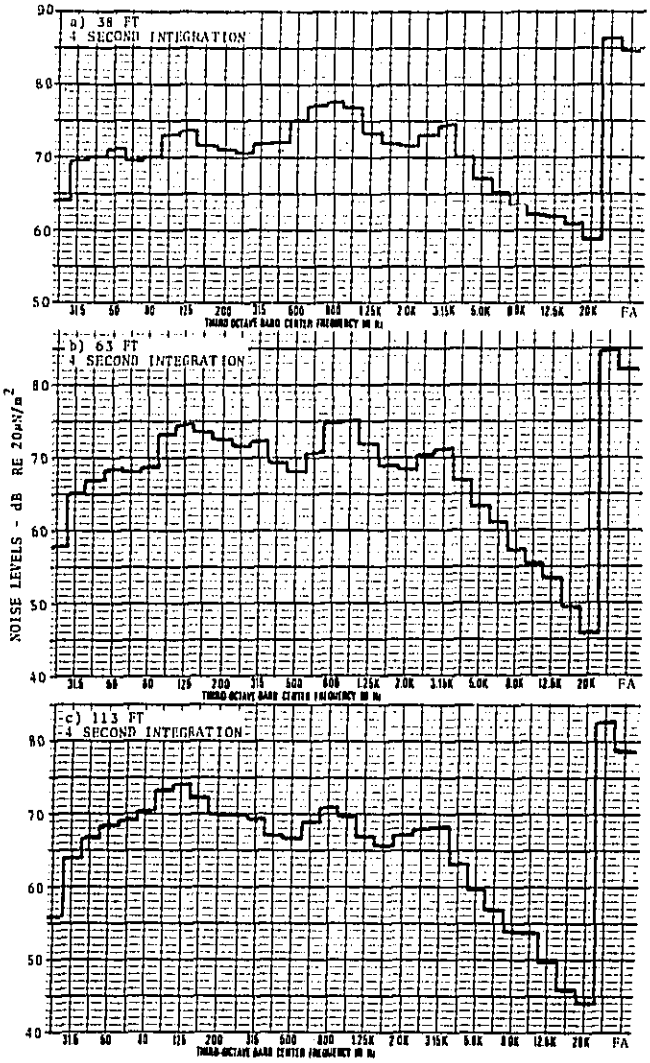


Figure A-9. Wayside Noise Spectra at 38, 63, and 113 ft from the centerline of southbound track. MBTA Red Line (So Shore Extension) Oct 28, 1971. Four-car train southbound, Ser. Nos 1639, 1638, 1650, 1651 at 51.8 mph. See figure A-8.

US DEPARTMENT OF TRANSPORTATION TUE 07/25/72
TRANSPORTATION SYSTEMS CENTER 15:16
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-20-72-3A OF THE MOBILE NOISE LABORATORY ON OCT. 28 1971 FROM 15:46 TO 16:46 ON TENEAN ST. DORCHESTEER, MASS.
(ZONE 19 UNIVERSAL GRID LOCATION 331.61 - 4683.68 .)
MICROPHONE LOCATED 25FT. FROM CENTERLINE NEAR TRACK (NORTHBOUND)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
2	103
13	102
9	101
9	100
14	99
8	98
19	97
25	96
27	95
34	94
33	93
32	92
43	91
39	90
56	89
77	88
70	87
92	86
108	85
130	84
126	83
165	82
172	81
203	80
274	79
295	78
309	77
373	76
518	75
624	74
802	73
1314	72
1911	71
3045	70
5301	69
6163	68
4807	67
1455	66
101	65
2	64
0	63

SAMPLES= 28800
AVERAGE= 70.2 DBA*
STANDARD DEVIATION= 4.6 DBA*
ENERGY MEAN= 78 DB**
NOISE POLLUTION LEVEL= 89.8
1% PERCENTILE= 90.5 DBA*
10% DECILE= 75.8 DBA*
MEDIAN= 69.4 DBA*
90% DECILE= 67.3 DBA*
99% PERCENTILE= 66.1 DBA*
WALSH HEALEY EXP.= 2.9 %
RANGE= 39 DB

0 20 40 60 80 100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure A-10. Statistical Analysis - Wayside Noise Data - MBTA Red Line -25 ft. (So. Shore Extension), October 28, 1971

```
 2       103 0
 13      102 0
 9       101 0
 9       100 0
 14      99  0
 8       98  0
 19      97  0
 25      96  0
 27      95  0
 34      94  0
 33      93  0
 32      92  0
 43      91  0
 39      90  0
 56      89  0
 77      88  00
 70      87  0
 92      86  00
 108     85  00
 130     84  00
 126     83  00
 165     82  00
 172     81  00
 203     80  00
 274     79  000
 295     78  000
 309     77  000
 373     76  000
 518     75  0000
 624     74  0000
 802     73  00000
 1314    72  00000000
 1911    71  00000000000
 3045    70  00000000000000000
 5301    69  00000000000000000000000000000
 6163    68  000000000000000000000000000000000
 4807    67  00000000000000000000000000
 1455    66  000000000
 101     65  00
 2       64  0
DIST. DBA*   0               10              20              30
                LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF
THE SQUARES OF THE SOUND PRESSURES.
```

Figure A-10 (Cont'd). Statistical Analysis - Wayside Noise Data' MBTA Red Line 25 ft. (So. Shore Extension), October 28, 1971

25 ft.

US DEPARTMENT OF TRANSPORTATION　　TUE 07/25/72
TRANSPORTATION SYSTEMS CENTER　　15:02
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-20-72-2A OF THE MOBILE NOISE LABORATORY ON OCT. 28 1971 FROM 15:46 TO 16:46 ON TENEAN ST. DORCHESTEER, MASS.
(ZONE 19 UNIVERSAL GRID LOCATION 331.61 - 4683.68 .)
MICROPHONE LOCATED 50FT. FROM CENTERLINE NEAR TRACK (NORTHBOUND)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

SAMPLES=	28800
AVERAGE=	68.9 DBA*
STANDARD DEVIATION=	4.7 DBA*
ENERGY MEAN=	75 DB**
NOISE POLLUTION LEVEL=	87
1% PERCENTILE=	87.4 DBA*
10% DECILE=	75.1 DBA*
MEDIAN=	68.1 DBA*
90% DECILE=	65.5 DBA*
99% PERCENTILE=	64.1 DBA*
WALSH HEALEY EXP.=	1.2 %
RANGE=	35 DB

DISTRIBUTION	DBA*
12	97
19	96
10	95
12	94
19	93
30	92
28	91
36	90
48	89
41	88
57	87
94	86
129	85
122	84
141	83
165	82
187	81
184	80
271	79
268	78
298	77
344	76
397	75
502	74
718	73
972	72
1305	71
1625	70
2791	69
4167	68
4552	67
4803	66
3203	65
1053	64
186	63
11	62
0	61

0　20　40　60　80　100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure A-11. Statistical Analysis - Wayside Noise Data - MBTA Red Line-50 ft. (So. Shore Extension), October 28, 1971

```
 12      97  0
 19      96  0
 10      95  0
 12      94  0
 19      93  0
 30      92  0
 28      91  0
 36      90  0
 48      89  0
 41      88  0
 57      87  0
 94      86  00
 129     85  00
 122     84  00
 141     83  00
 165     82  00
 187     81  00
 184     80  00
 271     79  000
 268     78  00
 298     77  000
 344     76  000
 397     75  000
 502     74  0000
 718     73  00000
 972     72  000000
 1305    71  00000000
 1625    70  0000000000
 2791    69  0000000000000000
 4167    68  00000000000000000000000
 4552    67  0000000000000000000000000
 4803    66  00000000000000000000000000
 3203    65  000000000000000000
 1053    64  0000000
 186     63  00
 11      62  0
DIST. DBA*   0              10             20             30
                 LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

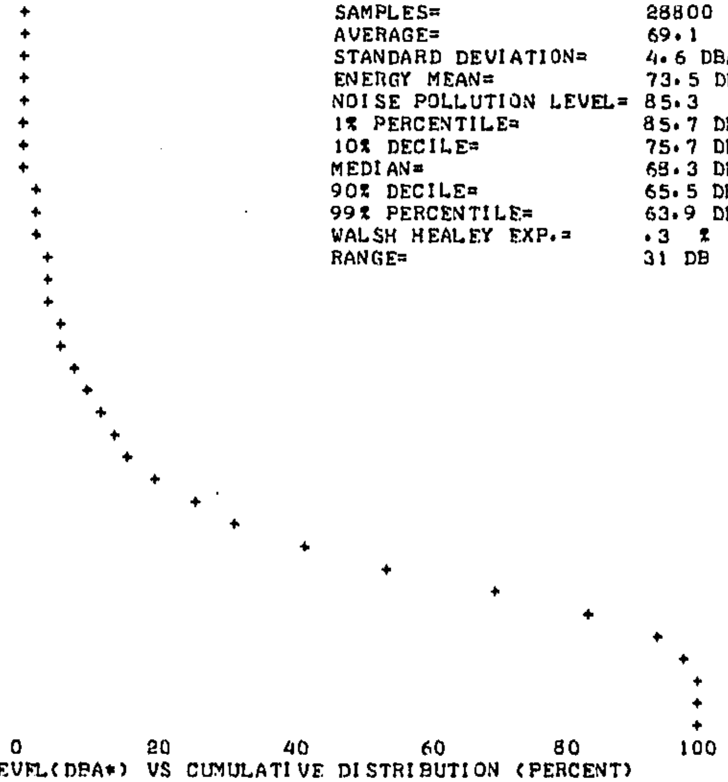
*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure A-11 (Continued). Statistical Analysis - Wayside Noise Data - MBTA Red Line (So. Shore Extension), October 28, 1971
50 ft

US DEPARTMENT OF TRANSPORTATION — TUE 07/25/72
TRANSPORTATION SYSTEMS CENTER — 14:05
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-20-72-1A OF THE MOBILE NOISE LABORATORY ON OCT. 28 1971 FROM 15:46 TO 16:46 ON TENEAN ST. DORCHESTEER, MASS.
(ZONE 19 UNIVERSAL GRID LOCATION 331.61 - 4683.68 .)
MICROPHONE LOCATED 100FT. FROM CENTERLINE NEAR TRACK (NORTHBOUND)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
2	93
12	92
25	91
24	90
25	89
34	88
58	87
79	86
115	85
156	84
163	83
194	82
259	81
248	80
265	79
324	78
340	77
436	76
452	75
608	74
771	73
1076	72
1578	71
1859	70
2732	69
3850	68
4316	67
4291	66
3061	65
1127	64
286	63
34	62
0	61



SAMPLES=	28800
AVERAGE=	69.1 DBA*
STANDARD DEVIATION=	4.6 DBA*
ENERGY MEAN=	73.5 DB**
NOISE POLLUTION LEVEL=	85.3
1% PERCENTILE=	85.7 DBA*
10% DECILE=	75.7 DBA*
MEDIAN=	68.3 DBA*
90% DECILE=	65.5 DBA*
99% PERCENTILE=	63.9 DBA*
WALSH HEALEY EXP.=	.3 %
RANGE=	31 DB

Figure A-12. Statistical Analysis - Wayside Noise Data - MBTA Red Line-100 ft. (So. Shore Extension), October 28, 1971

```
2       93  0
12      92  0
25      91  0
24      90  0
25      89  0
34      88  0
58      87  0
79      86  00
115     85  00
156     84  00
163     83  00
194     82  00
259     81  00
248     80  00
265     79  00
324     78  000
340     77  000
436     76  000
452     75  000
608     74  0000
771     73  00000
1076    72  0000000
1578    71  000000000
1859    70  00000000000
2732    69  000000000000000
3850    68  0000000000000000000000
4316    67  0000000000000000000000000
4291    66  000000000000000000000000
3061    65  00000000000000000
1127    64  0000000
286     63  000
34      62  0
DIST. DBA*  0            10             20             30
             LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure A-12 (Continued). Statistical Analysis - Wayside Noise Data - MBTA Red Line (So. Shore Extension), October 28, 1971
100 ft.

APPENDIX B

WAYSIDE VIBRATION MEASUREMENTS - MBTA RED LINE

(SO. SHORE EXTENSION) - OCTOBER 28, 1971

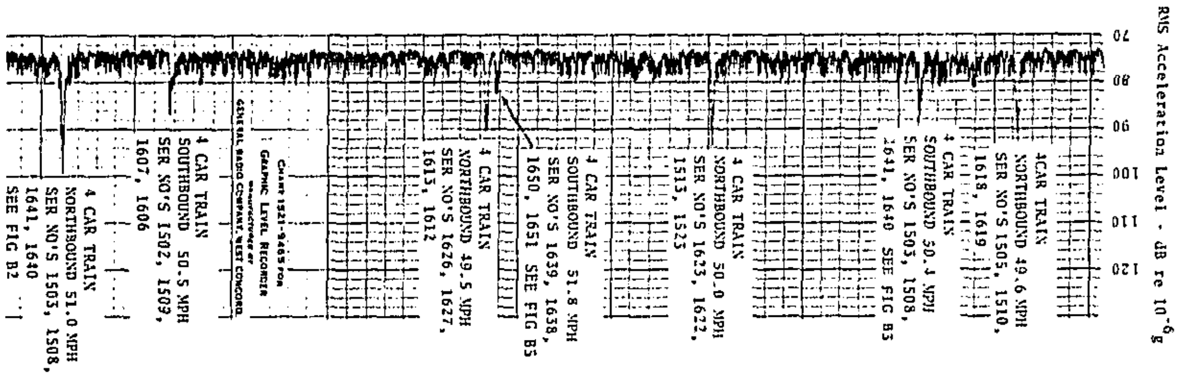


Figure B-1. Time History - Wayside Ground Vibration Levels Lateral (y) Axis at a point which is 25 ft. from the center line of the northbound track and 38 feet from the centerline of the southbound track. MBTA Red Line (So. Shore Extension) Oct. 28, 1971. See Figure G-1 for accelerometer location and mounting.

CORRECTION!

THE PREVIOUS DOCUMENT(S) MAY HAVE BEEN FILMED INCORRECTLY . . .

RESHOOT FOLLOWS!

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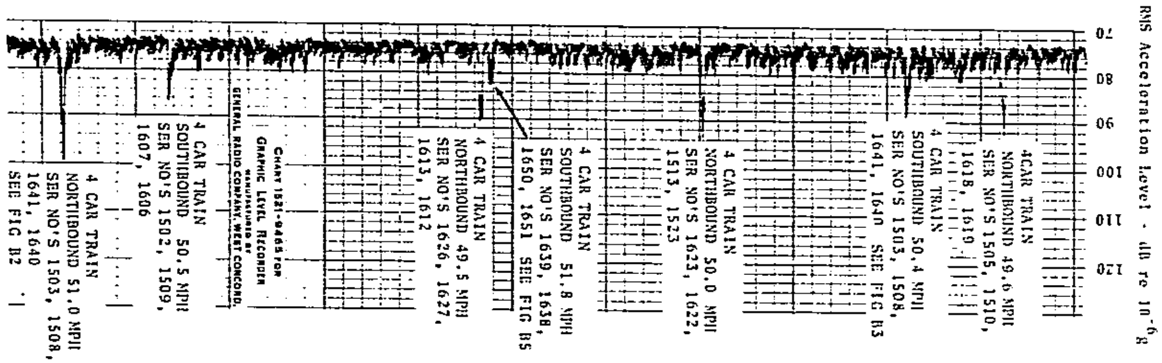


Figure B-1. Time History - Wayside Ground Vibration Levels Lateral (y) Axis at a point which is 25 ft. from the center line of the northbound track and 38 feet from the centerline of the southbound track. MBTA Red Line (So. Shore Extension) Oct. 28, 1971. See Figure G-1 for accelerometer location and mounting.

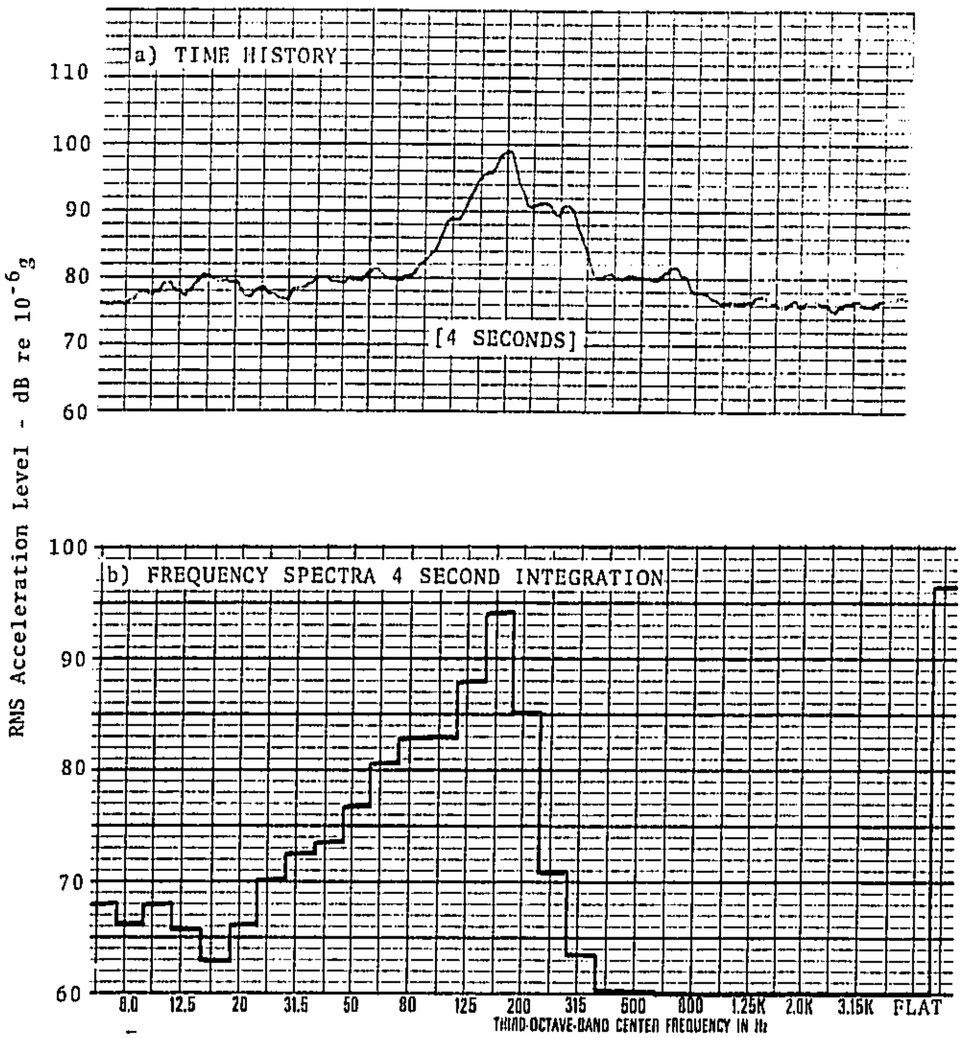


Figure B-2. Ground Vibration - Lateral (y) Axis 25 feet from the centerline of the northbound track. MBTA Red Line (So. Shore Extension) Oct. 28, 1971. Four-Car Train Ser. Nos 1503, 1508, 1641, 1640 at 51.0 mph. See Figure B-1.

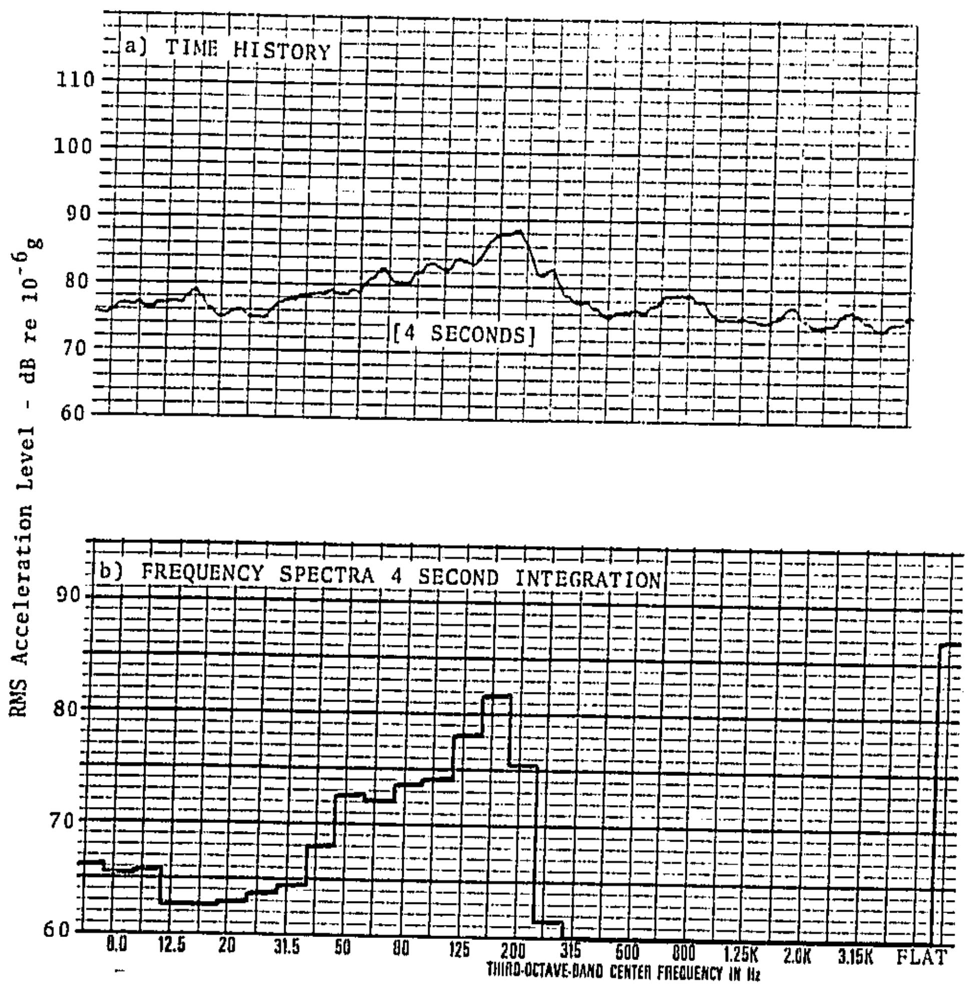


Figure B-3. Ground Vibration-Lateral (y) Axis 38 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension). Four-Car Train Ser. Nos 1503, 1508, 1641, 1640 at 50.4 mph. Oct. 28, 1971. See Figure B1.

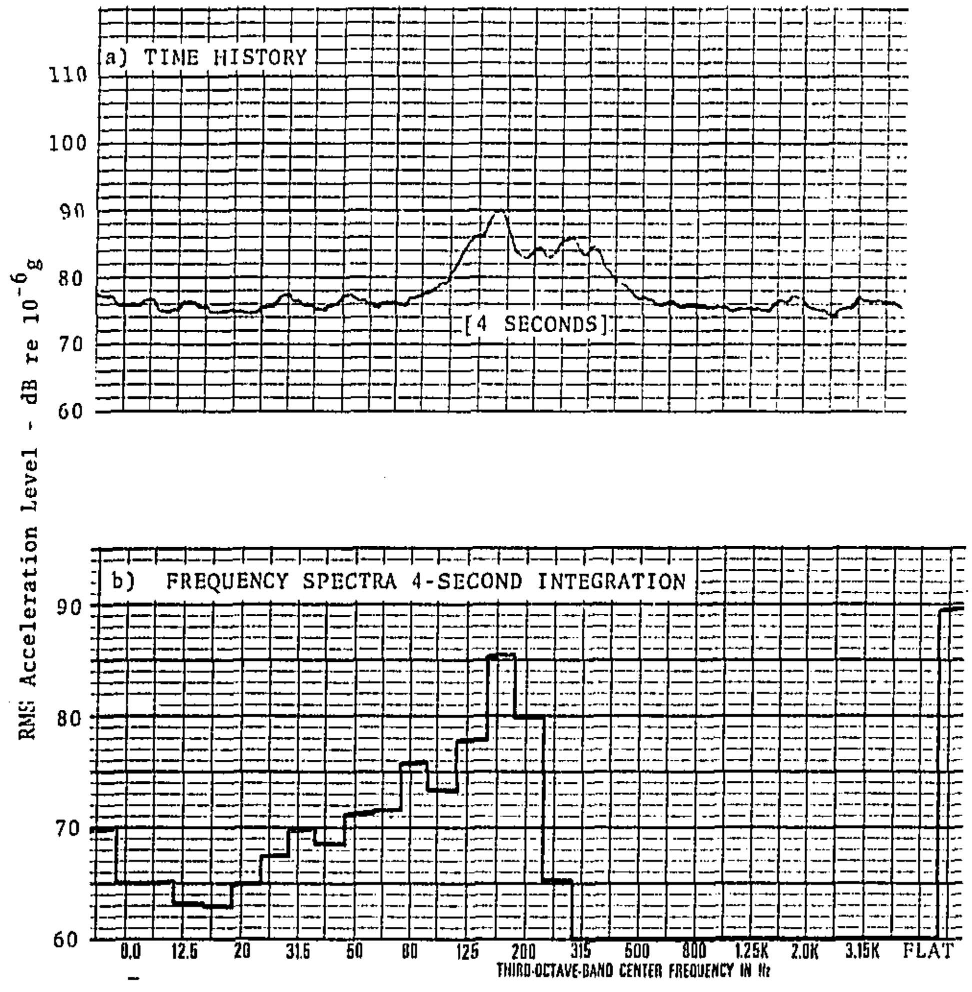


Figure B-4. Ground Vibration - Lateral (y) Axis 25 feet from the center line of the northbound track. MBTA Red Line (So. Shore Extension) Oct. 28, 1971. Four-Car Train Ser. Nos 1639, 1638, 1651, 1650 at 51.0 mph See Figure B-1.

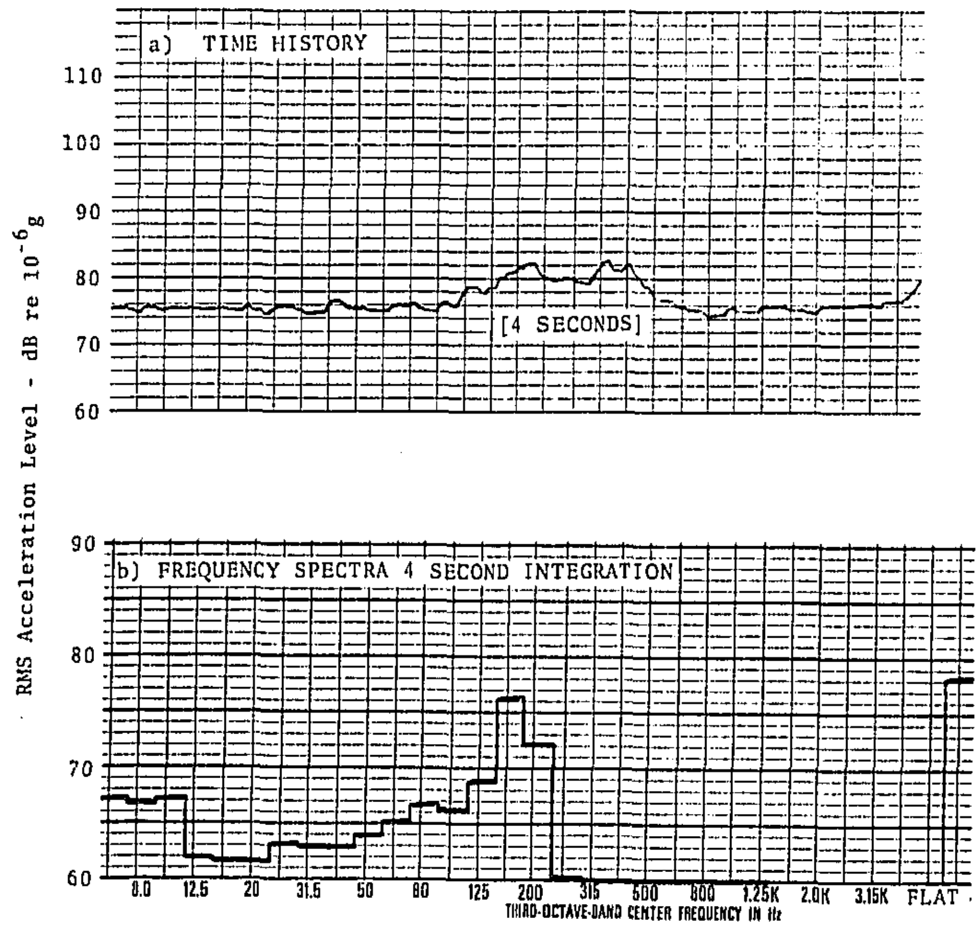


Figure B-5. Ground Vibration - Lateral (y) Axis 38 feet from centerline of southbound track. MBTA Red Line (So. Shore Extension) Oct. 28, 1971. Four-Car Train southbound Ser. Nos 1639, 1638, 1650, 1651 at 51.8 mph. See Figure B-1.

APPENDIX C

WAYSIDE NOISE MEASUREMENTS - MBTA RED LINE (SO. SHORE EXTENSION)-APRIL 27, 1972

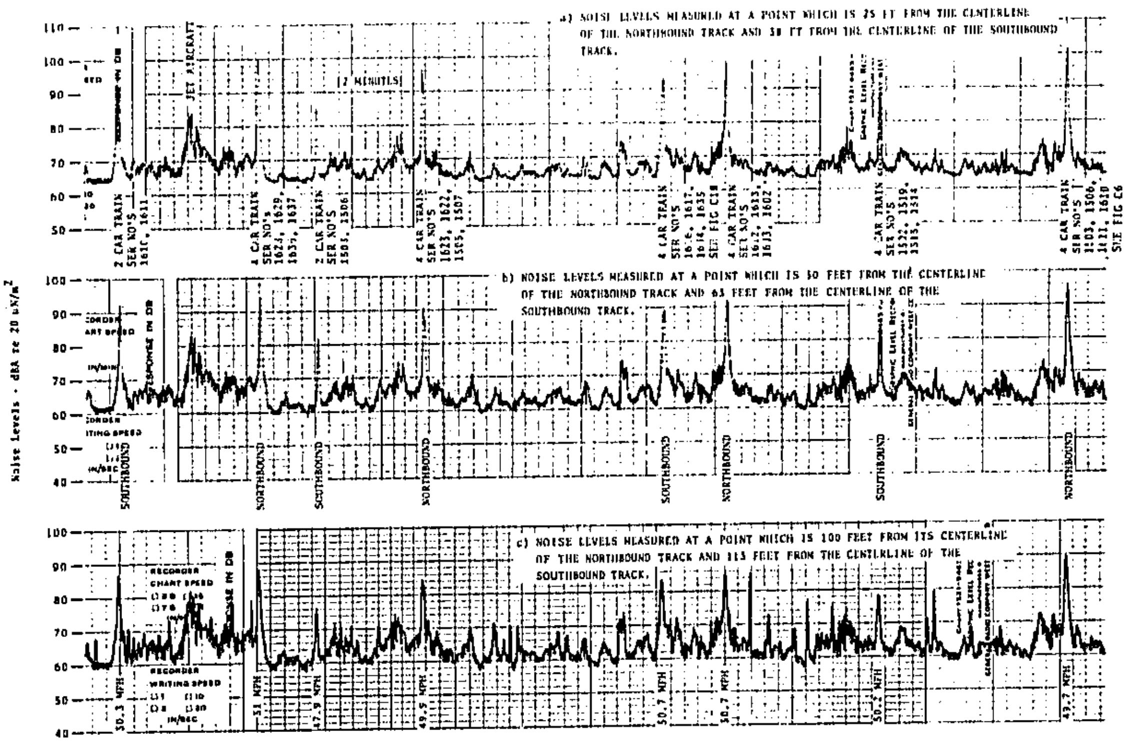


Figure C-1. Coincident Time Histories - Wayside Noise Levels. MBTA Red Line (So. Shore Extention) April 27, 1972. Microphones placed 6.1 ft above level grade and 3 ft above rail tops. See C-1 for microphone locations.

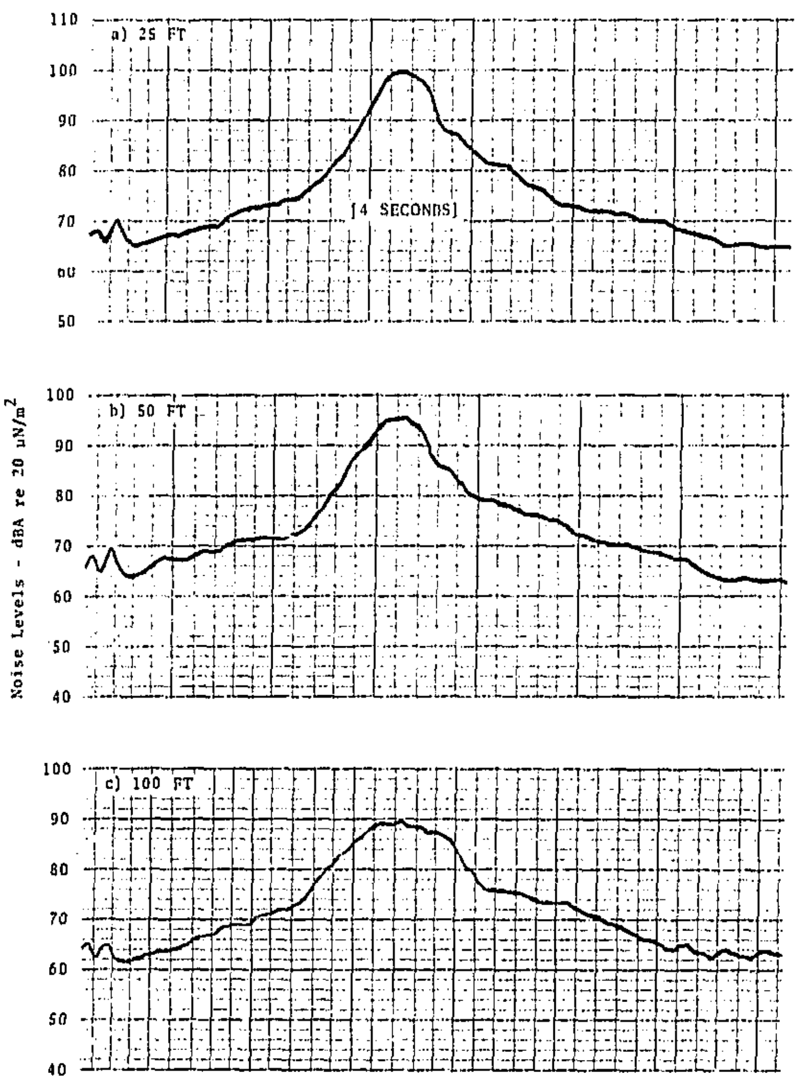


Figure C-2 Coincident Time Histories - Wayside Noise Levels at 25,50 and 100 ft. from the centerline of the northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound Ser. No s 1611, 1610 at 50.6 mph.

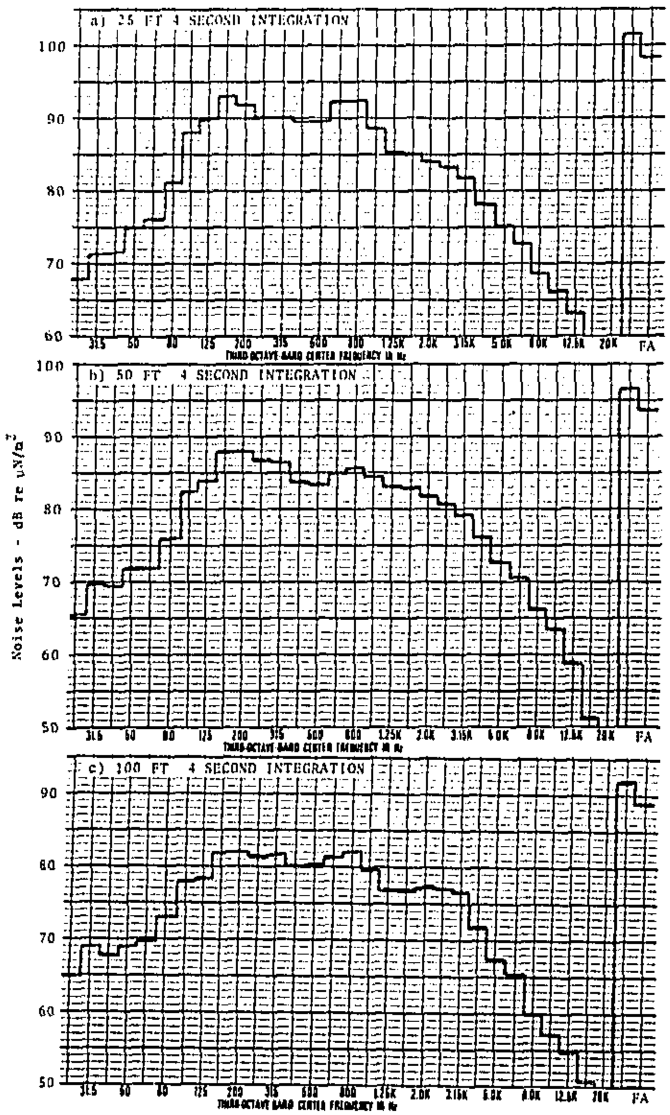


Figure C-3 Wayside Noise Spectra at 25,50 and 100 ft. from the centerline of the northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound Ser. No s 1611, 1610 at 50.0 mph. See Figure C-2.

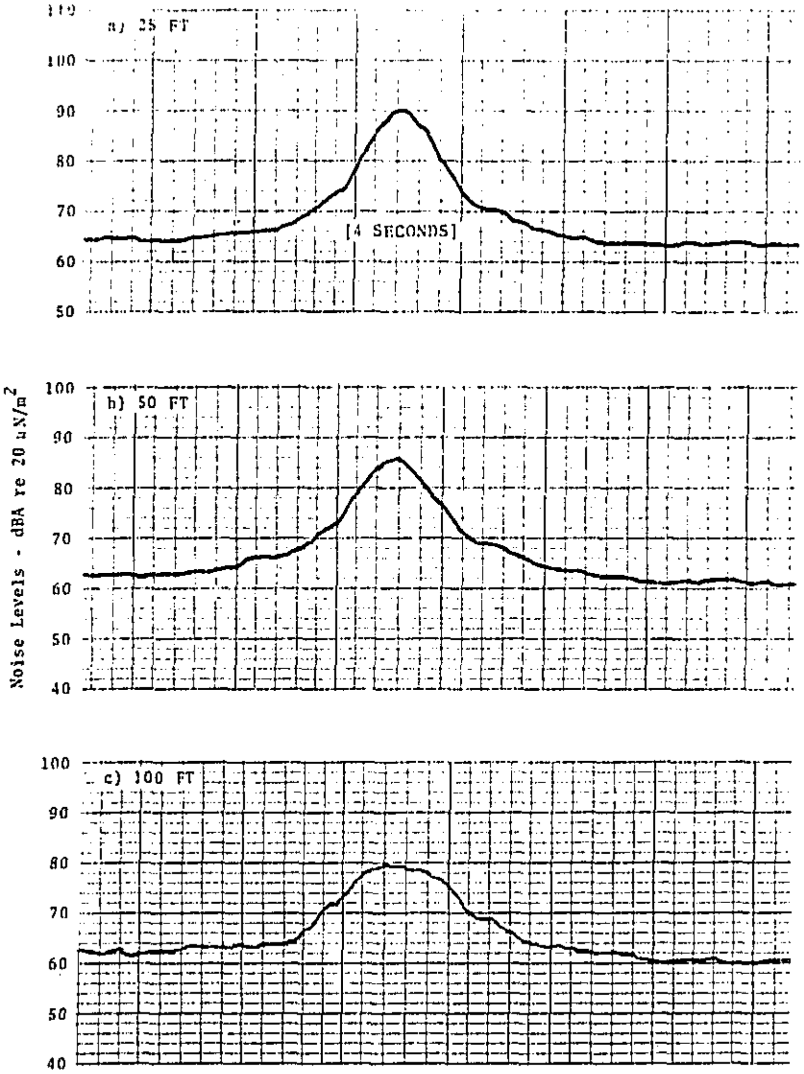


Figure C-4 Coincident Time Histories - Wayside Noise Levels at 25,50 and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound, Ser. Nos 1503, 1506, at 49.5 mph.

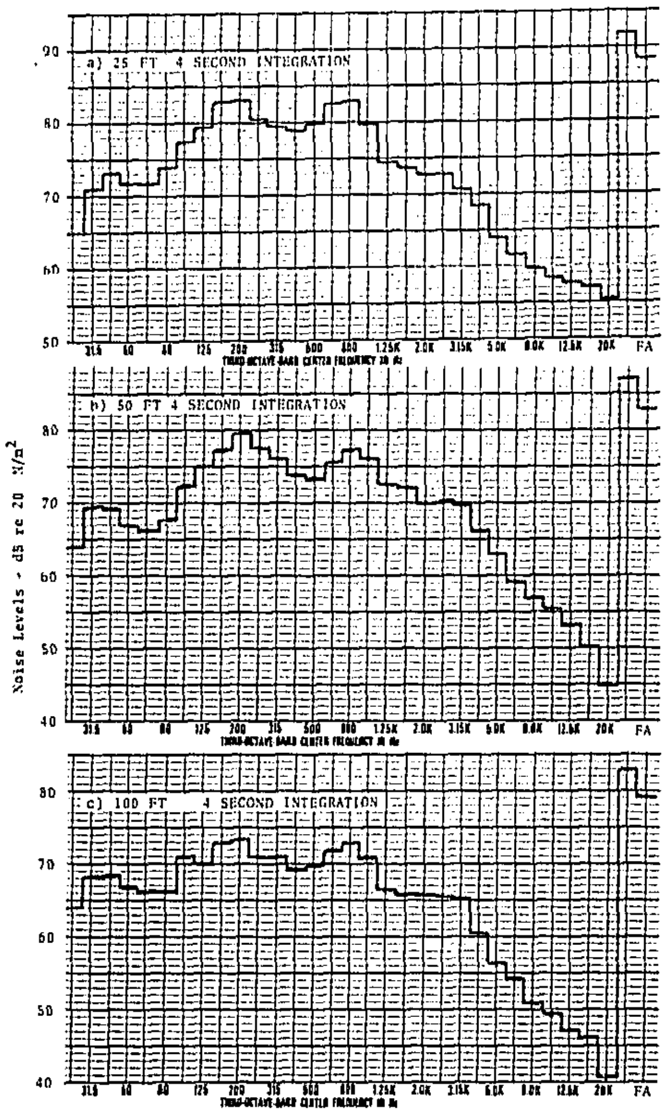


Figure C-5 Wayside Noise Spectra at 25,50, and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound, Ser. Nos 1503, 1506 at 49.5 mph. See Figure C-4.

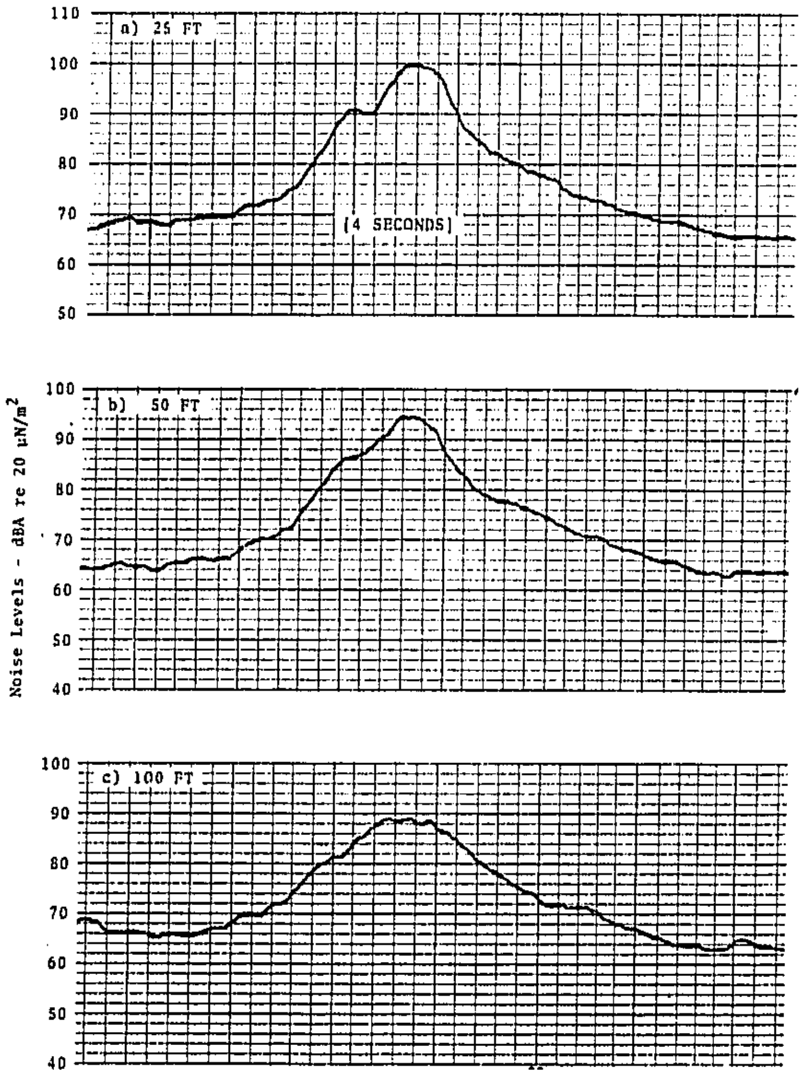


Figure C-6 Coincident Time Histories - Wayside Noise Levels at 25,50 and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension). April 27, 1972. 4-Car Train northbound - Ser. Nos 1503, 1506, 1611, 1610 at 49.7 mph. See Figure G1.

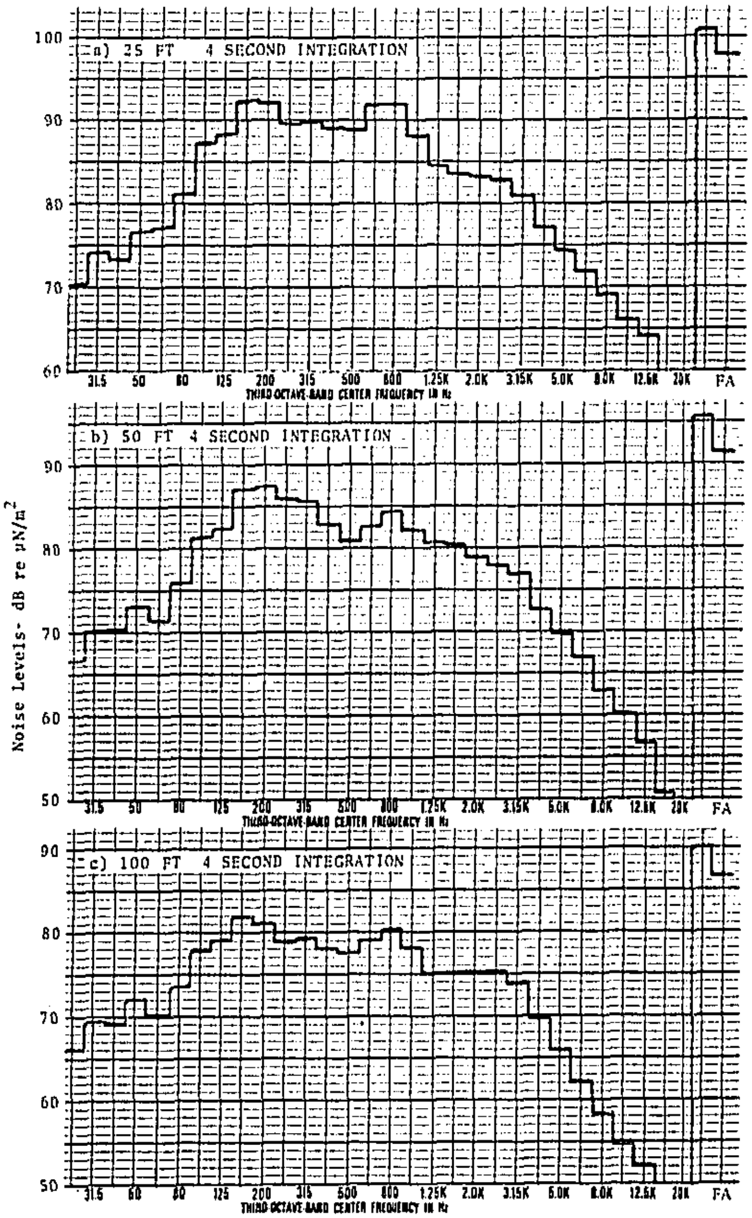


Figure C-7 Wayside Noise Spectra at 25,50, and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound - Ser. Nos 1503, 1506, 1611, 1610 at 49.7 mph. See Figure C-6.

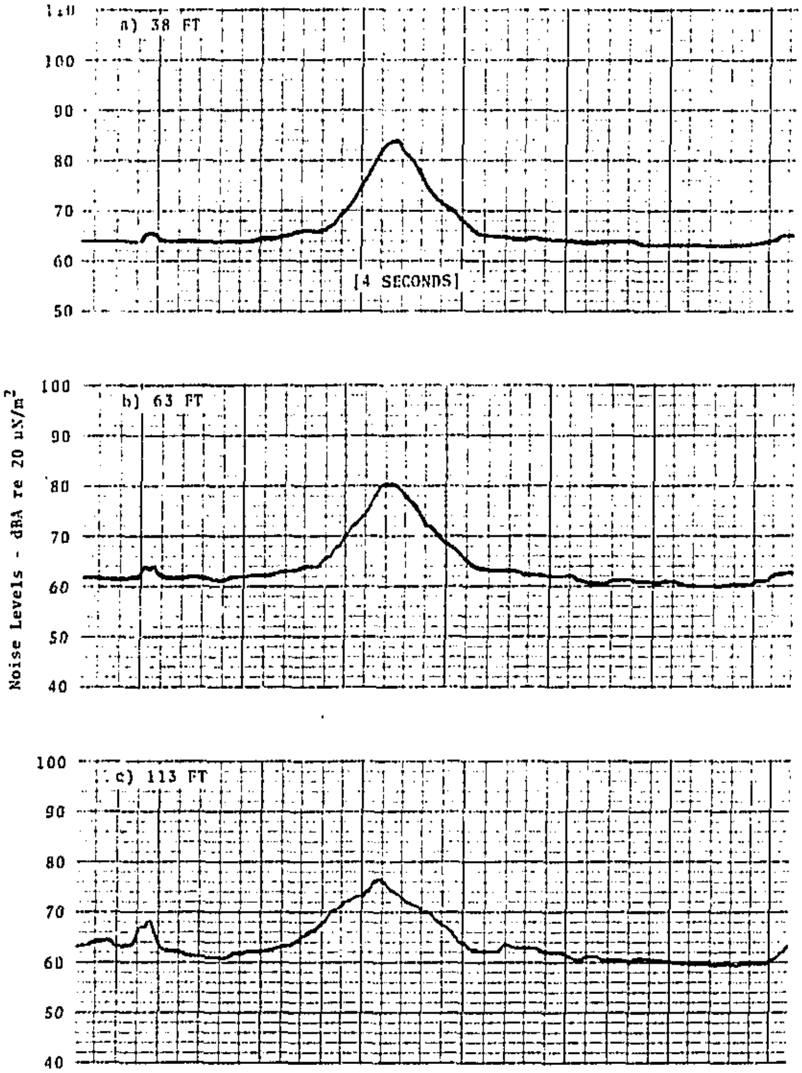


Figure C-8 Coincident Time Histories - Wayside Noise Levels at 38,63, and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound - Ser. Nos 1618, 1619 at 49.9 mph.

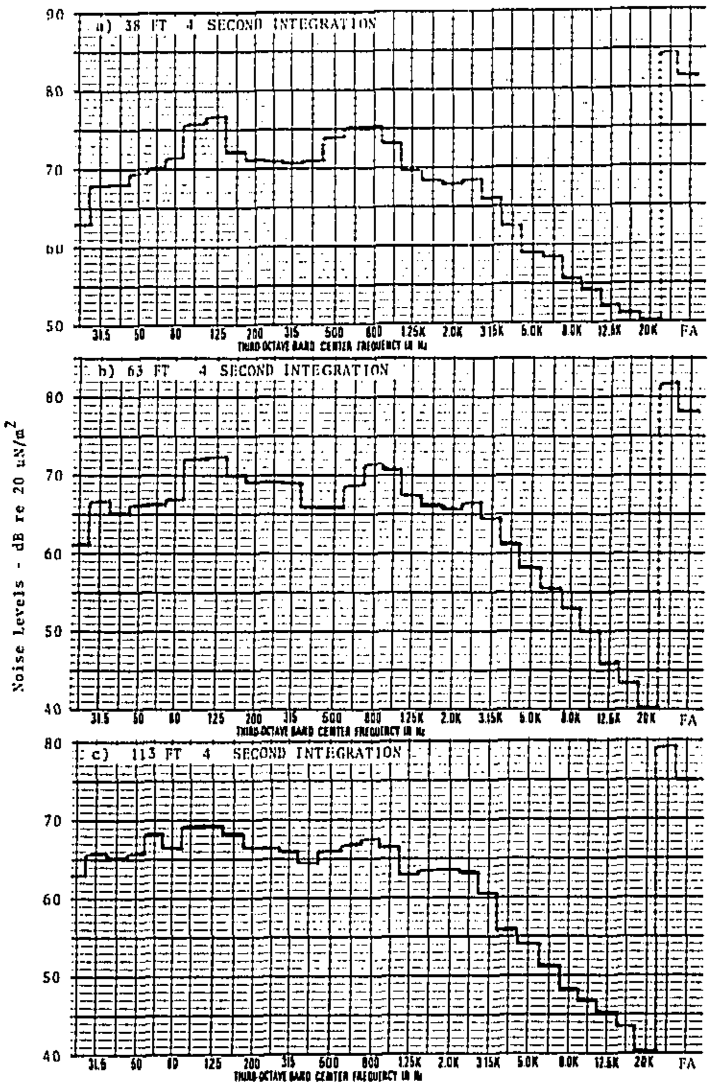


Figure C-9 Wayside Noise Spectra at 38,63, and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound - Ser. Nos 1618, 1619 at 49.9 mph. See Figure C-8.

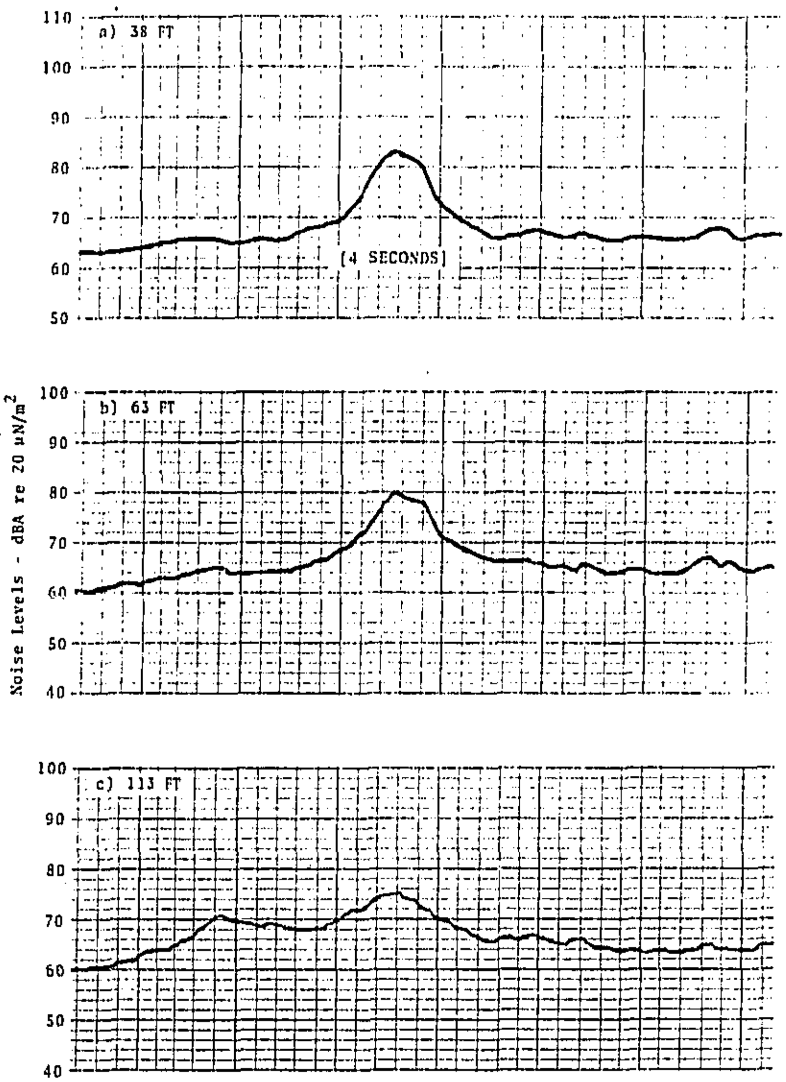


Figure C-10 Coincident Time Histories - Wayside Noise Levels at 38,63 and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound - Ser. Nos 1604, 1605 at 50.4 mph.

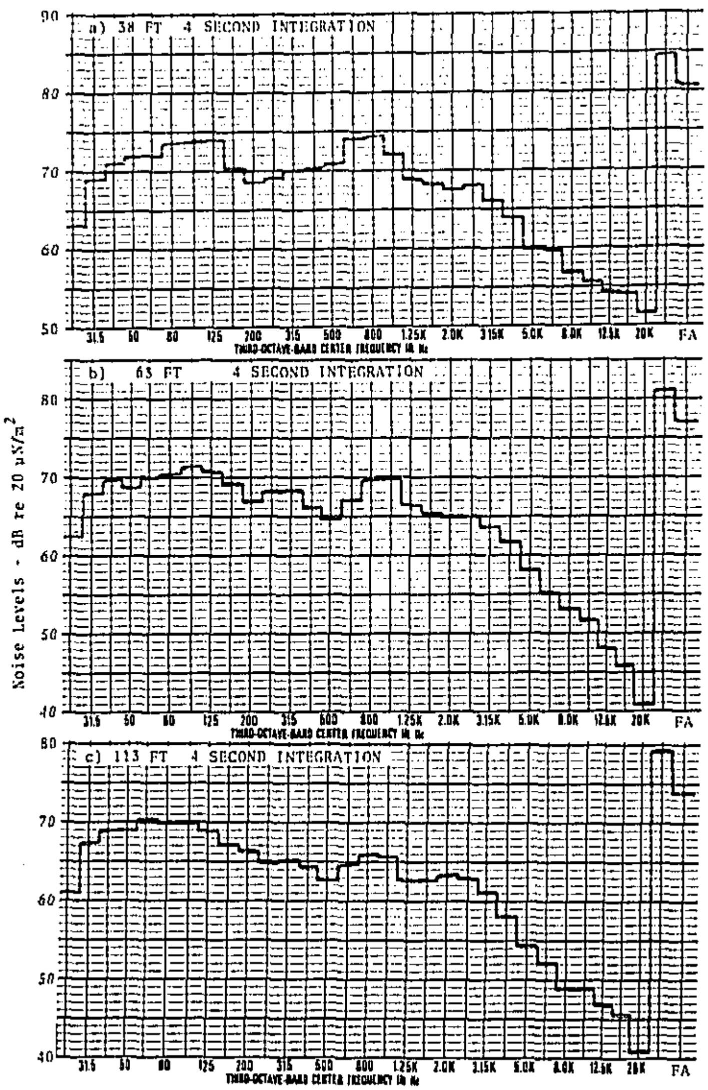


Figure C-11 Wayside Noise Spectra at 38,63 and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound - Ser. Nos 1604, 1605 at 50.4 mph See Figure C-10.

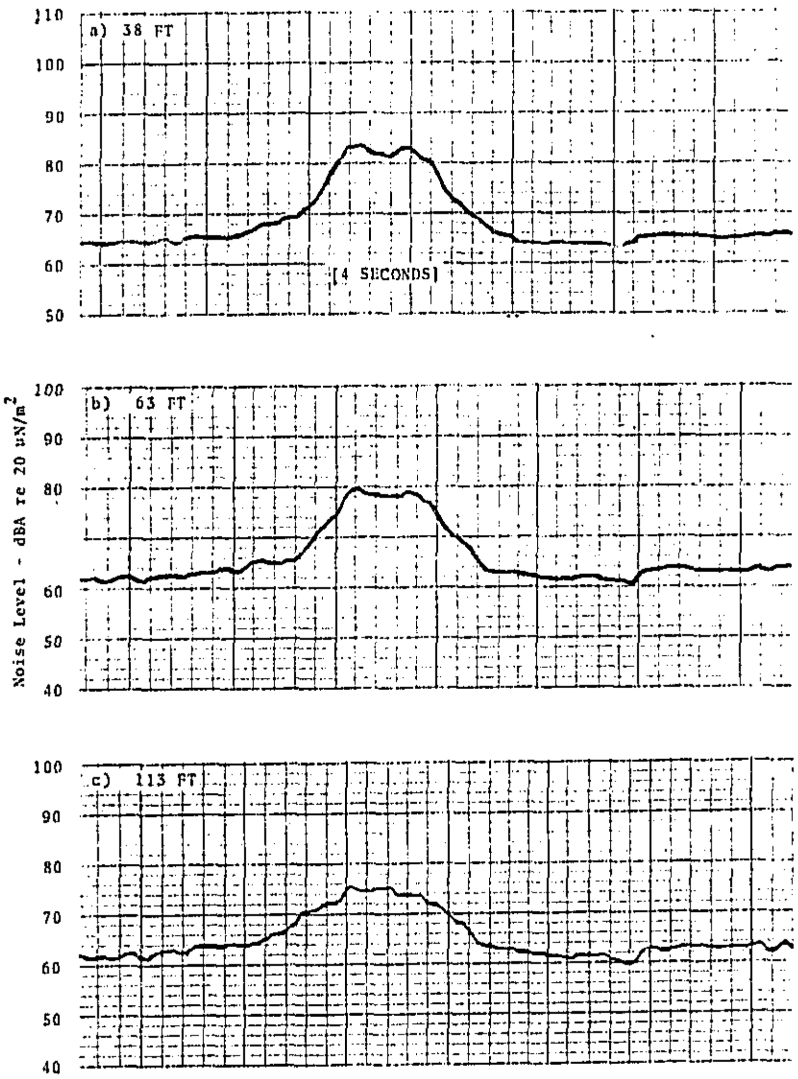


Figure C-12 Coincident Time Histories - Wayside Noise Levels at 38,63, and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension). April 27, 1972. 4-Car Train southbound - Ser. Nos 1604, 1605, 1618, 1619 at 48.9 mph.

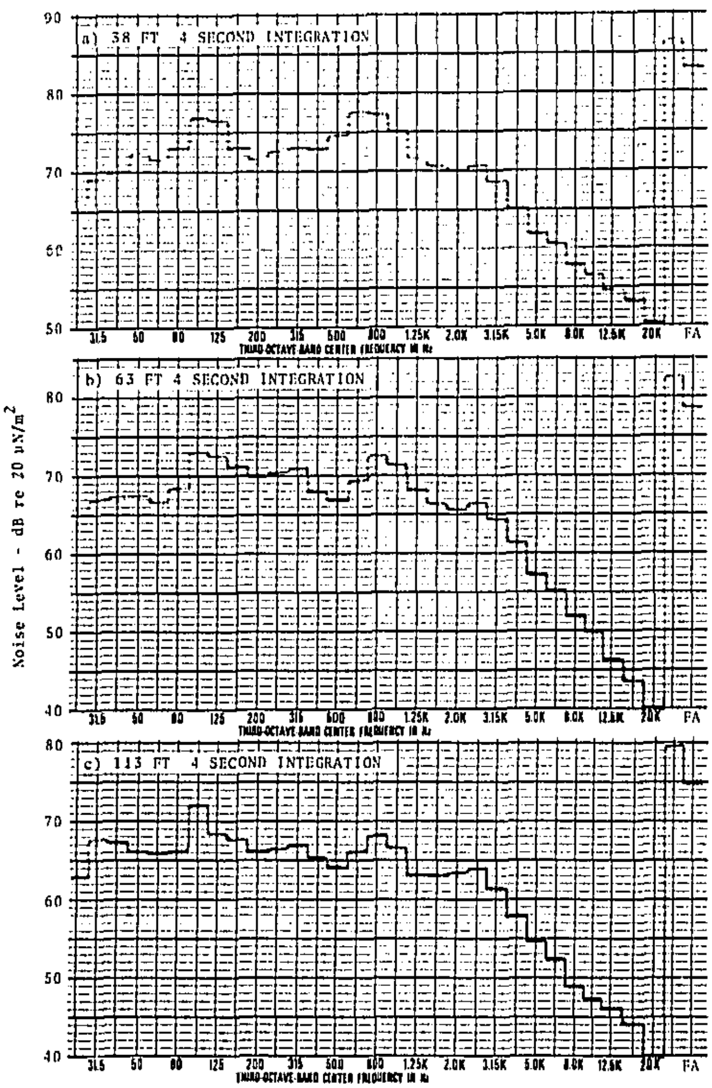


Figure C-13 Wayside Noise Spectra 38,63 and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train southbound - Ser. Nos 1604, 1605, 1619, 1618 at 48.9 mph.

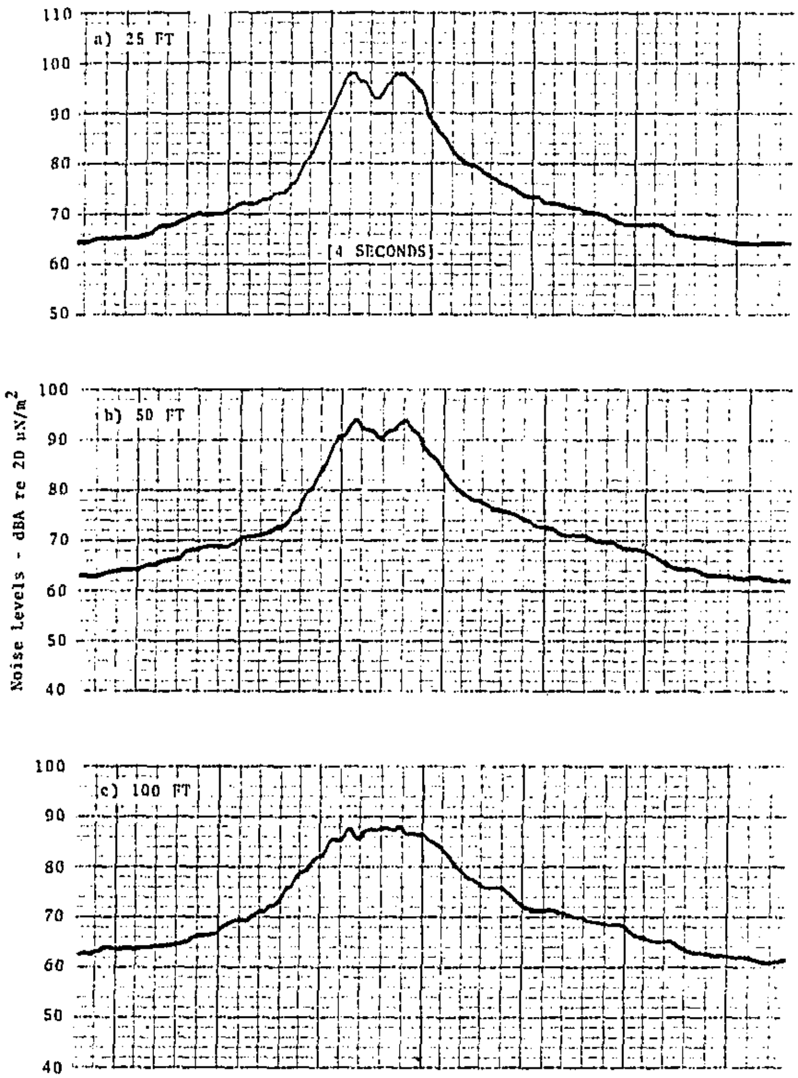


Figure C-14. Coincident Time Histories - Wayside Noise Levels at 25,50, and 100 ft. from center line of northbound track. MBTA Red Line (So. Shore Extension). April 27, 1972. 4-Car Train northbound - Ser. Nos 1604, 1605, 1619, 1618 at 49.9 mph

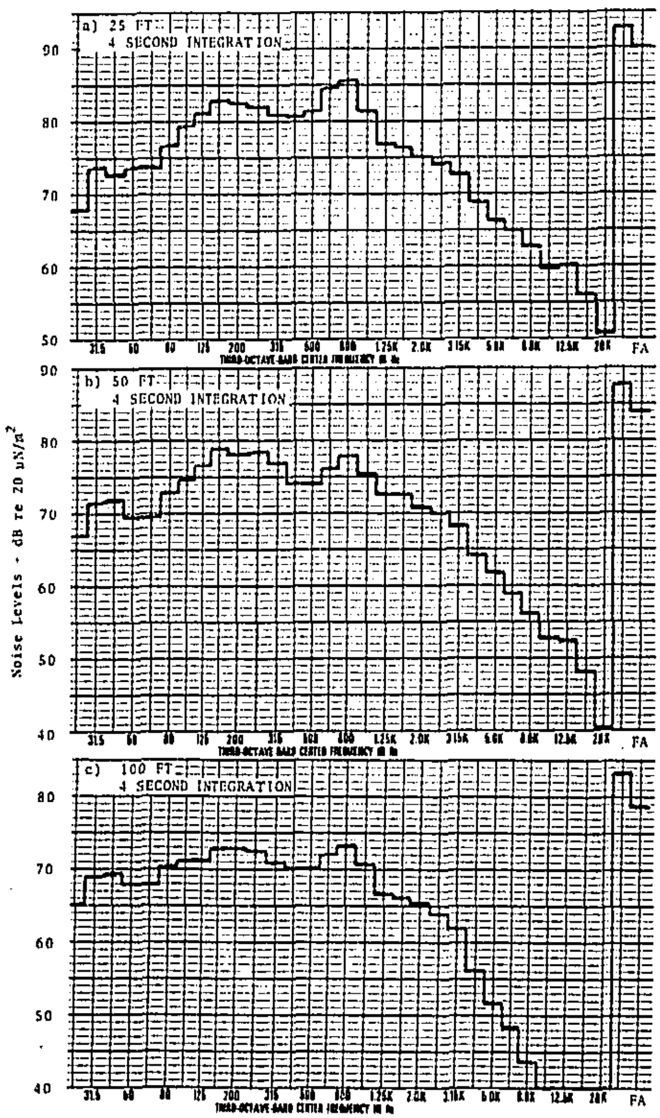


Figure C-15 Wayside Noise Spectra at 25,50, and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound - Ser. Nos 1604, 1605, 1619, 1618 at 49.9 mph. See Figure C-14.

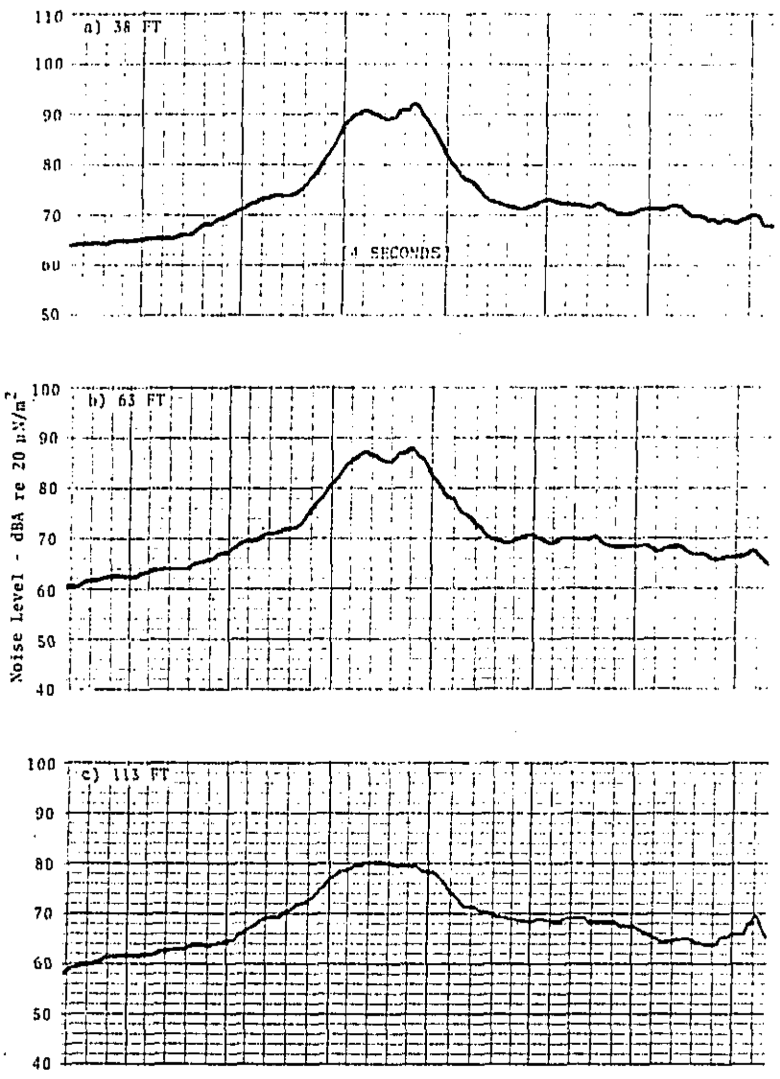


Figure C-16 Coincident Time Histories - Wayside Noise Levels at 38,63, and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension). April 27, 1972. 4-Car Train southbound - Ser. Nos 1616, 1617, 1634, 1635 at 50.7 mph. See Figure C-1.

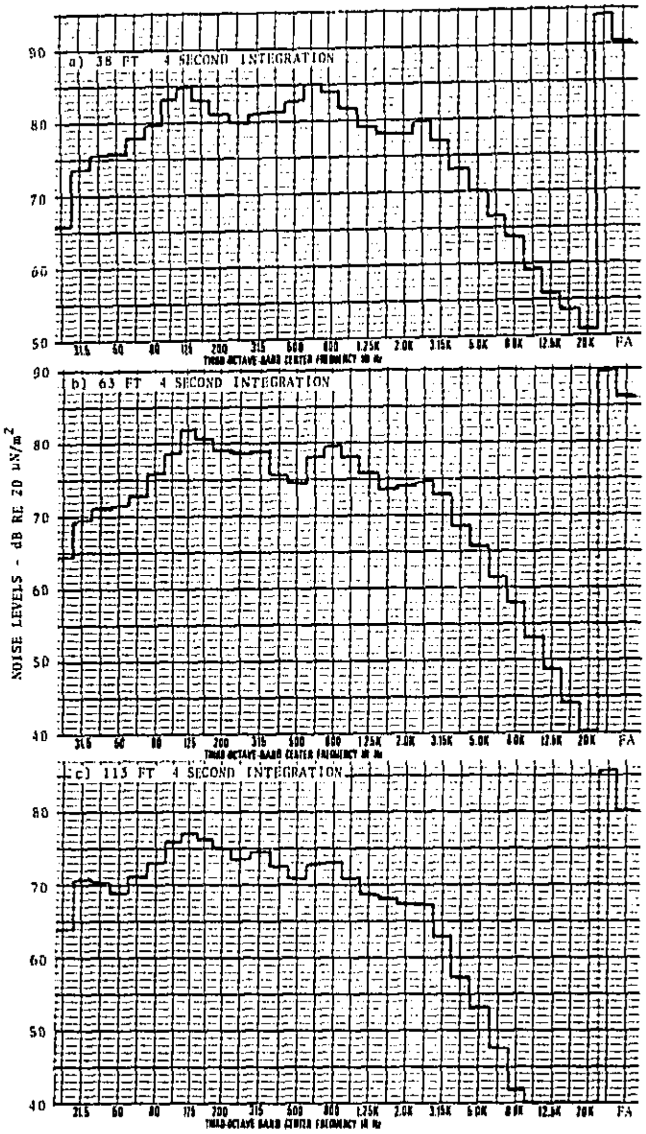


Figure C-17 Wayside Noise Spectra at 38,63, and 113 ft. from centerline of southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train southbound - Ser. Nos 1616, 1617, 1634, 1635 at 50.7 mph. See Figure C-16.

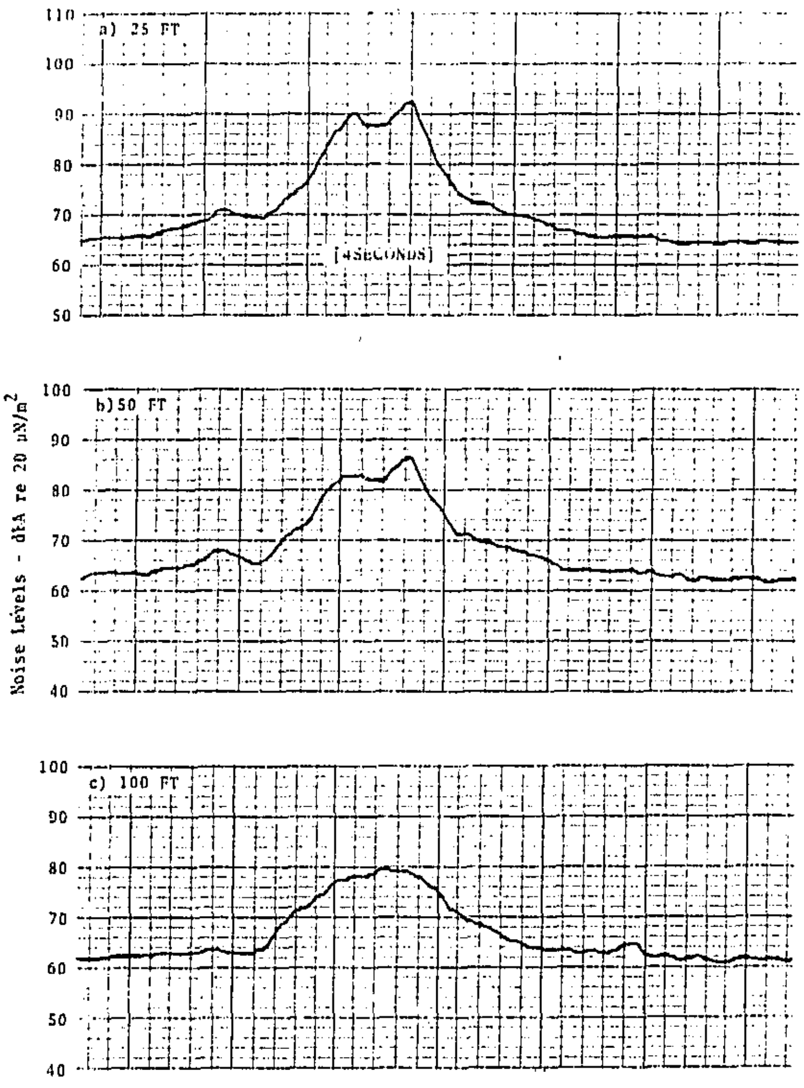


Figure C-18 Coincident Time Histories - Wayside Noise Levels at 25,50 and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension). April 27, 1972. 4-Car Train northbound - Ser. Nos 1616, 1617, 1634, 1635 at 49.3 mph.

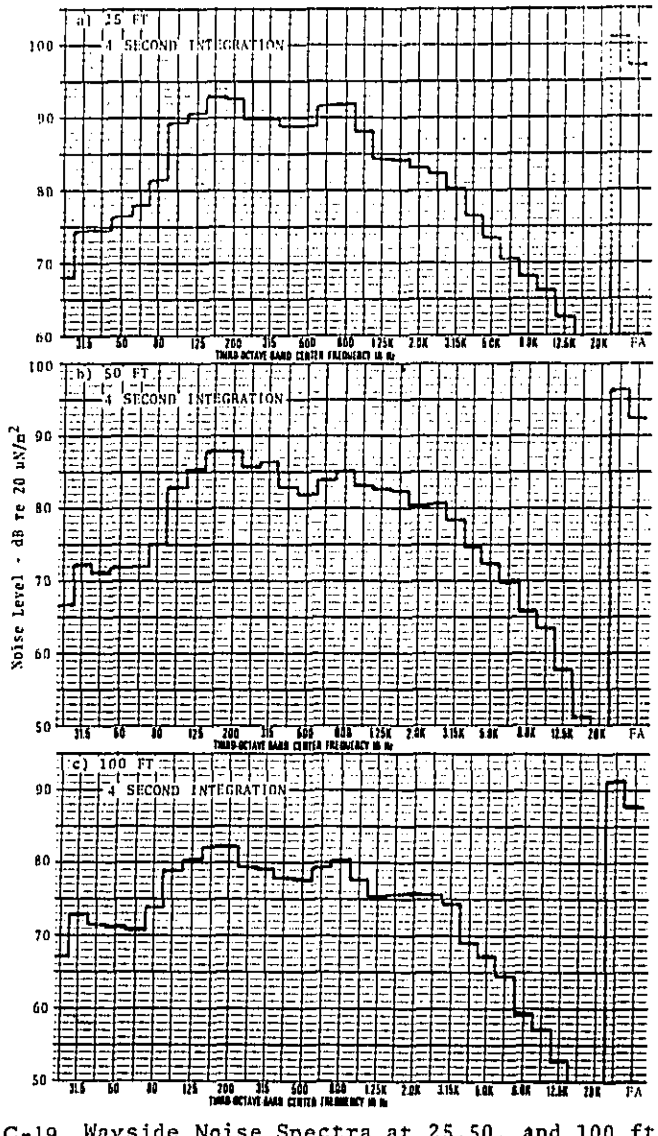


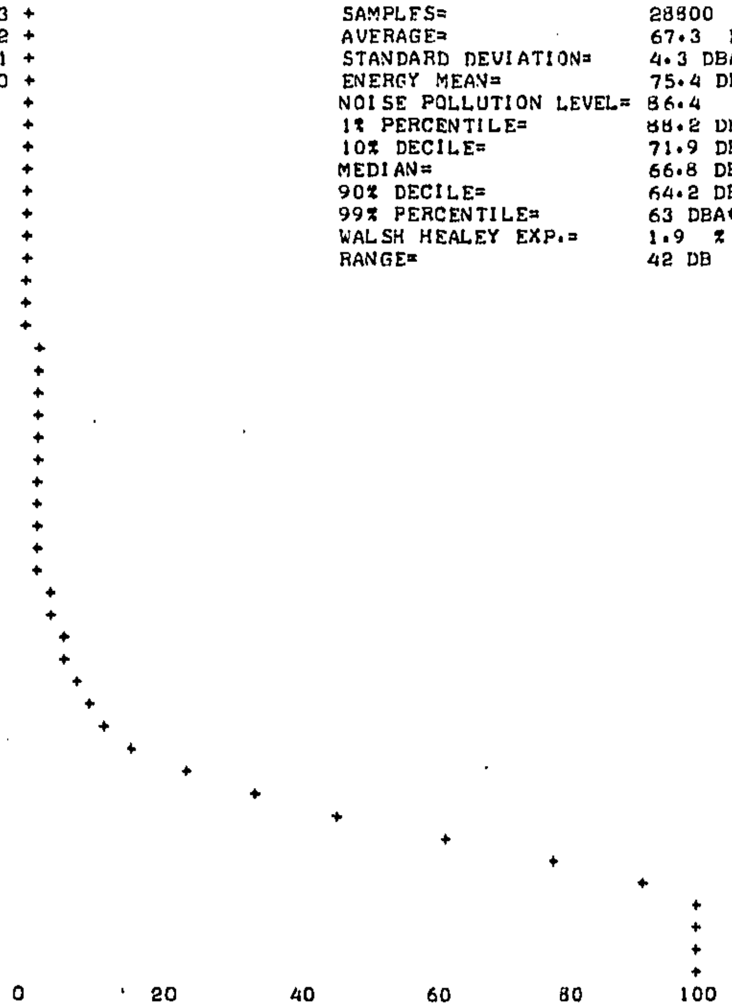
Figure C-19 Wayside Noise Spectra at 25,50, and 100 ft. from centerline of northbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound - Ser. Nos 1616, 1617, 1634, 1635 at 49.3 mph. See figure C-18.

US DEPARTMENT OF TRANSPORTATION WED 07/26/72
TRANSPORTATION SYSTEMS CENTER 13:25
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-46-72-1A OF THE MOBILE NOISE LABORATORY ON
APRIL 27 1972 FROM 13:46 TO 14:46 ON TENEAN ST. DORCHESTER, MASS.
(ZONE 19 UNIVERSAL GRID LOCATION 331.61 - 4683.68 .)
MICROPHONE LOCATED 25FT. FROM CENTERLINE NEAR TRACK(NORTHBOUND)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

SAMPLES=	28800
AVERAGE=	67.3 DBA*
STANDARD DEVIATION=	4.3 DBA*
ENERGY MEAN=	75.4 DB**
NOISE POLLUTION LEVEL=	86.4
1% PERCENTILE=	88.2 DBA*
10% DECILE=	71.9 DBA*
MEDIAN=	66.8 DBA*
90% DECILE=	64.2 DBA*
99% PERCENTILE=	63 DBA*
WALSH HEALEY EXP.=	1.9 %
RANGE=	42 DB

DISTRIBUTION	DBA*
1	103
0	102
5	101
8	100
7	99
10	98
12	97
7	96
16	95
24	94
29	93
43	92
40	91
30	90
29	89
32	88
33	87
35	86
43	85
47	84
43	83
50	82
64	81
49	80
73	79
91	78
156	77
179	76
290	75
360	74
426	73
605	72
821	71
1142	70
2076	69
2708	68
3687	67
4729	66
4621	65
3995	64
1952	63
222	62
10	61
0	60



LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure C-20. Statistical Analysis - Wayside Noise Data - MBTA Red Line-25 ft (So. Shore Extension), April 27, 1972

```
1       103 0
0       102 0
5       101 0
8       100 0
7       99  0
10      98  0
12      97  0
7       96  0
16      95  0
24      94  0
29      93  0
43      92  0
40      91  0
30      90  0
29      89  0
32      88  0
33      87  0
35      86  0
43      85  0
47      84  0
43      83  0
50      82  0
64      81  0
49      80  0
73      79  0
91      78  00
156     77  00
179     76  00
290     75  000
360     74  000
426     73  000
605     72  0000
821     71  00000
1142    70  0000000
2076    69  000000000000
2708    68  000000000000000
3687    67  00000000000000000000
4729    66  00000000000000000000000000
4621    65  0000000000000000000000000
3995    64  0000000000000000000000
1952    63  00000000000
222     62  00
10      61  0
DIST. DBA*  0              10             20             30
                LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF
THE SQUARES OF THE SOUND PRESSURES.
```

Figure C-20 (Continued). Statistical Analysis - Wayside Noise Data - MBTA Red Line (So. Shore Extension), April 27, 1972 25 ft

US DEPARTMENT OF TRANSPORTATION WED 07/26/72
TRANSPORTATION SYSTEMS CENTER 14:04
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-46-72-3A OF THE MOBILE NOISE LABORATORY ON APRIL 27 1972 FROM 13:46 TO 14:46 ON TENEAN ST. DORCHESTER, MASS.
(ZONE 19 UNIVERSAL GRID LOCATION 331.61 - 4683.68 .)
MICROPHONE LOCATED 50FT. FROM CENTERLINE NEAR TRACK(NORTHBOUND)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

SAMPLES=	28800
AVERAGE=	64.9 DBA*
STANDARD DEVIATION=	4.4 DBA*
ENERGY MEAN=	71.4 DB**
NOISE POLLUTION LEVEL=	82.7
1% PERCENTILE=	84.8 DBA*
10% DECILE=	70 DBA*
MEDIAN=	64.6 DBA*
90% DECILE=	61.3 DBA*
99% PERCENTILE=	59.4 DBA*
WALSH HEALEY EXP.=	.5 %
RANGE=	39 DB

DISTRIBUTION	DBA*
5	96
5	95
3	94
13	93
13	92
18	91
21	90
23	89
38	88
55	87
41	86
45	85
34	84
38	83
49	82
48	81
53	80
65	79
87	78
87	77
109	76
128	75
193	74
296	73
403	72
489	71
530	70
846	69
1431	68
1878	67
2618	66
3404	65
3512	64
3895	63
3508	62
2699	61
1504	60
562	59
52	58
2	57
0	56

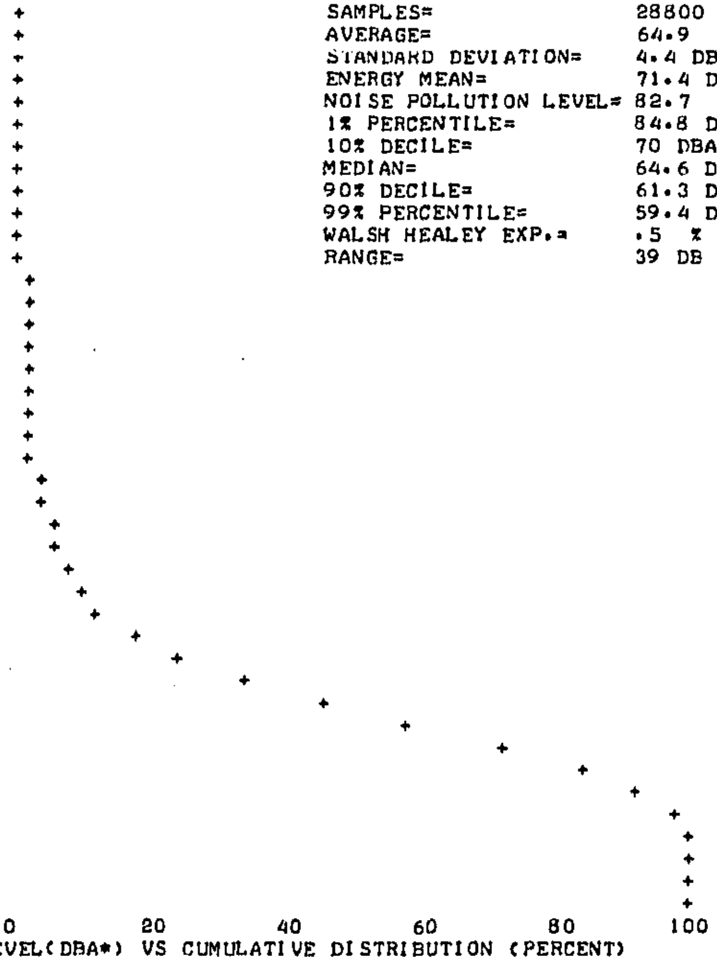


Figure C-21. Statistical Analysis - Wayside Noise Data - MBTA Red Line-50 ft (So. Shore Extension), April 27, 1972

DIST.	DBA*	
5	96	0
5	95	0
3	94	0
13	93	0
13	92	0
18	91	0
21	90	0
23	89	0
38	88	0
55	87	0
41	86	0
45	85	0
34	84	0
38	83	0
49	82	0
48	81	0
53	80	0
65	79	0
87	78	00
87	77	00
109	76	00
128	75	00
193	74	00
296	73	000
403	72	000
489	71	0000
530	70	0000
846	69	000000
1431	68	000000000
1878	67	00000000000
2618	66	000000000000000
3404	65	0000000000000000000
3512	64	0000000000000000000
3895	63	000000000000000000000
3508	62	0000000000000000000
2699	61	000000000000000
1504	60	000000000
562	59	0000
52	58	0
2	57	0
DIST.	DBA*	0 10 20 30

LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure C-21 (Continued). Statistical Analysis - Wayside Noise Data - MBTA Red Line (So. Shore Extension), April 27, 1972 50 ft

US DEPARTMENT OF TRANSPORTATION WED 07/26/72
TRANSPORTATION SYSTEMS CENTER 14:26
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-46-72-4A OF THE MOBILE NOISE LABORATORY ON APRIL 27 1972 FROM 13:46 TO 14:46 ON TENEAN ST. DORCHESTER, MASS.
(ZONE 19 UNIVERSAL GRID LOCATION 331.61 - 4683.68 .)
MICROPHONE LOCATED 100FT. FROM CENTERLINE NEAR TRACK(NORTHBOUND)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
8	90
6	89
11	88
15	87
26	86
22	85
50	84
55	83
62	82
55	81
62	80
68	79
91	78
112	77
128	76
166	75
183	74
313	73
450	72
536	71
567	70
855	69
1446	68
1682	67
2151	66
2688	65
2971	64
3446	63
3494	62
2982	61
2286	60
1336	59
392	58
83	57
2	56
0	55

SAMPLES=	28800
AVERAGE=	64.5 DBA*
STANDARD DEVIATION=	4.3 DBA*
ENERGY MEAN=	68.8 DB**
NOISE POLLUTION LEVEL=	79.8
1% PERCENTILE=	81.4 DBA*
10% DECILE=	70.2 DBA*
MEDIAN=	64.1 DBA*
90% DECILE=	60.5 DBA*
99% PERCENTILE=	58.5 DBA*
WALSH HEALEY EXP.=	0 %
RANGE=	34 DB

0 20 40 60 80 100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure C-22. Statistical Analysis - Wayside Noise Data - MBTA Red Line-100 ft (So. Shore Extension) April 27, 1972

```
 8        90  0
 6        89  0
 11       88  0
 15       87  0
 26       86  0
 22       85  0
 50       84  0
 55       83  0
 62       82  0
 55       81  0
 62       80  0
 68       79  0
 91       78  00
 112      77  00
 128      76  00
 166      75  00
 183      74  00
 313      73  000
 450      72  000
 536      71  0000
 567      70  0000
 855      69  000000
 1446     68  000000000
 1682     67  0000000000
 2151     66  000000000000
 2688     65  000000000000000
 2971     64  00000000000000000
 3446     63  0000000000000000000
 3494     62  0000000000000000000
 2982     61  00000000000000000
 2286     60  0000000000000
 1336     59  00000000
 392      58  000
 83       57  00
 2        56  0
DIST.  DBA*   0             10             20             30
                  LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure C-22 (Continued). Statistical Analysis - Wayside Noise Data - MBTA Red Line (So. Shore Extension) April 27, 1972
100 ft

APPENDIX D

WAYSIDE VIBRATION MEASUREMENTS - MBTA RED LINE

(SOUTH SHORE EXTENSION)-APRIL 27, 1972

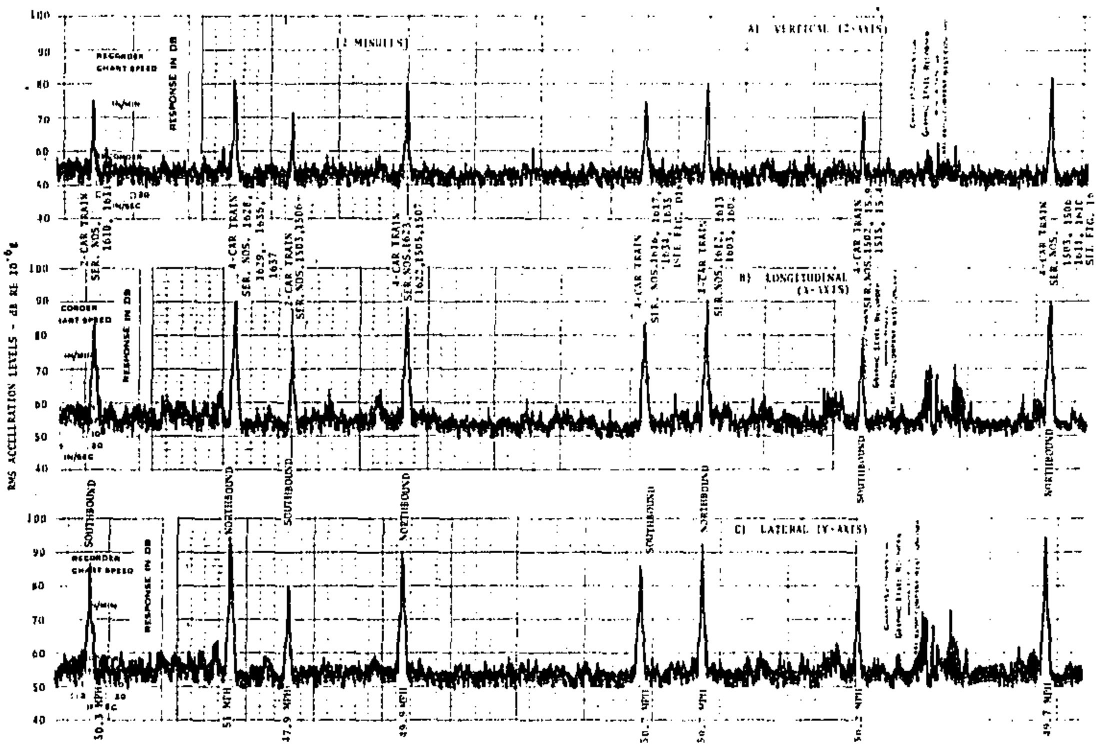


Figure D-1. Coincident Time Histories - Wayside Ground-Vibration Levels in 3 Axes at a point which is 25 ft from the centerline of the northbound track and 38 ft from the centerline of the southbound track. MBTA Red Line (So. Shore Extension) April 27, 1972. See Figure G-1 for accelerometer location and mounting.

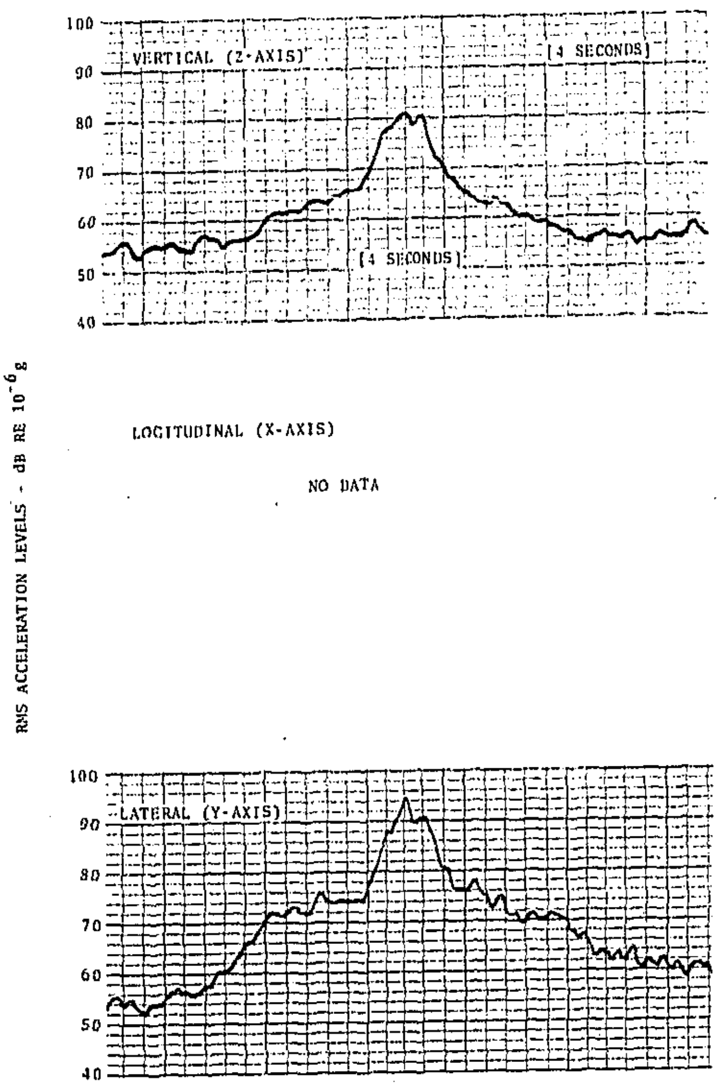


Figure D-2 Coincident Time Histories - Ground Vibration Levels in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound Ser. Nos 1611, 1610 at 50.6 mph.

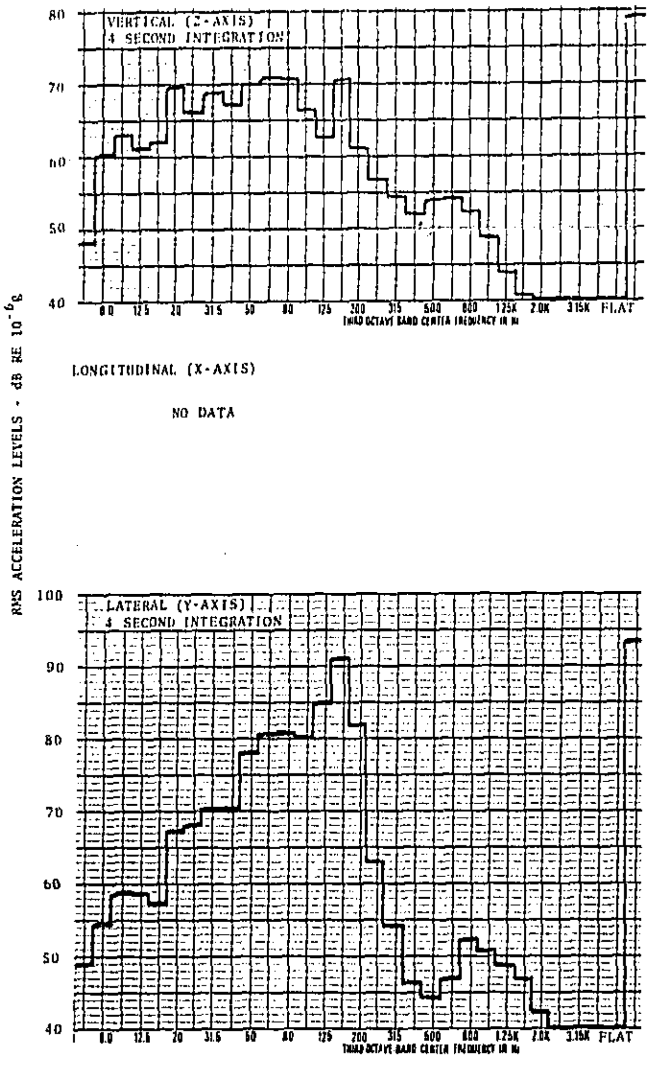


Figure D-3 Coincident Ground Vibration Spectra in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound Ser. Nos 1616, 1610 at 50.6 mph.

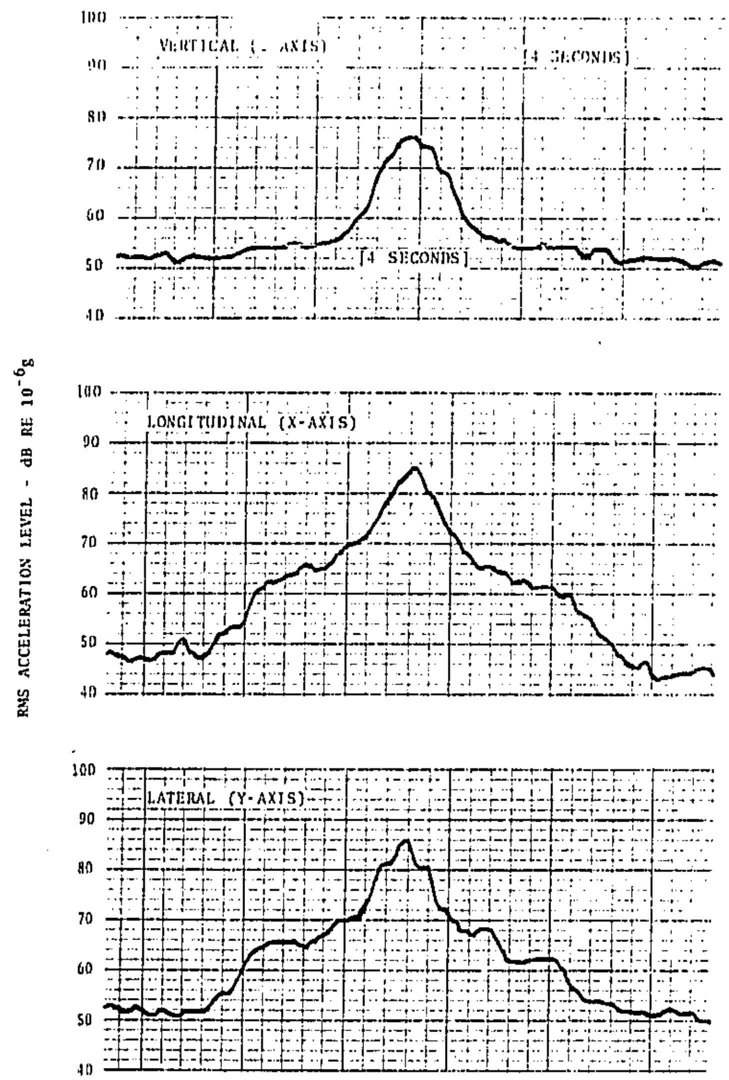


Figure D-4 Coincident Time Histories - Ground Vibration Levels in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound Ser. Nos 1503, 1506 at 49.5 mph.

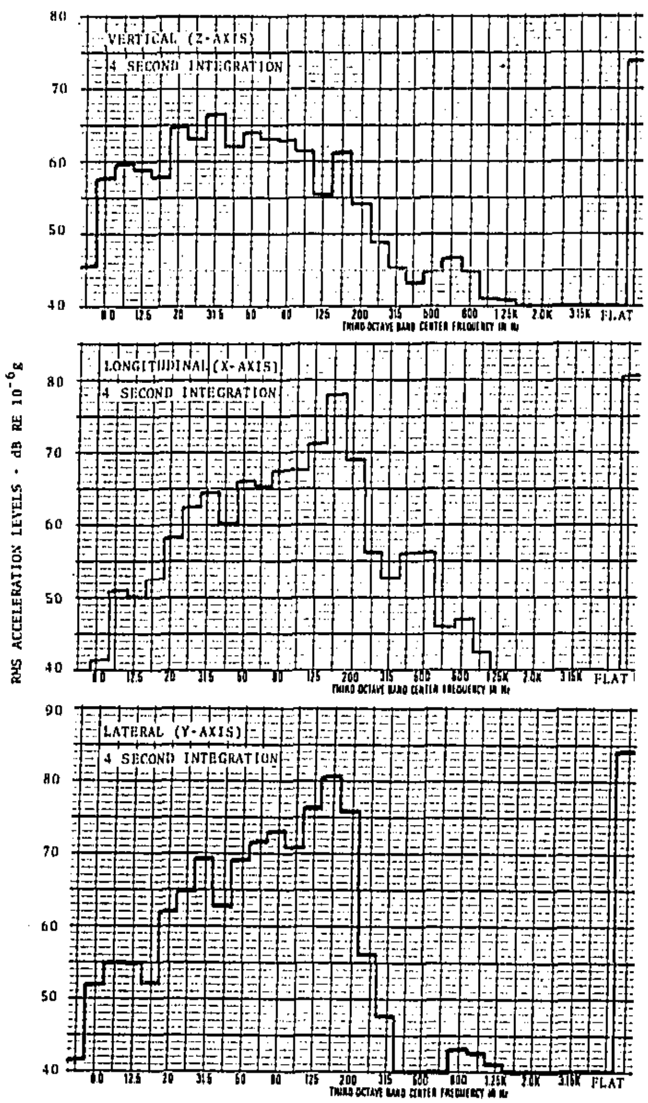


Figure D-5 Coincident Ground Vibration Spectra in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train northbound, Ser. Nos 1503, 1506 at 49.5 mph. See Figure D4.

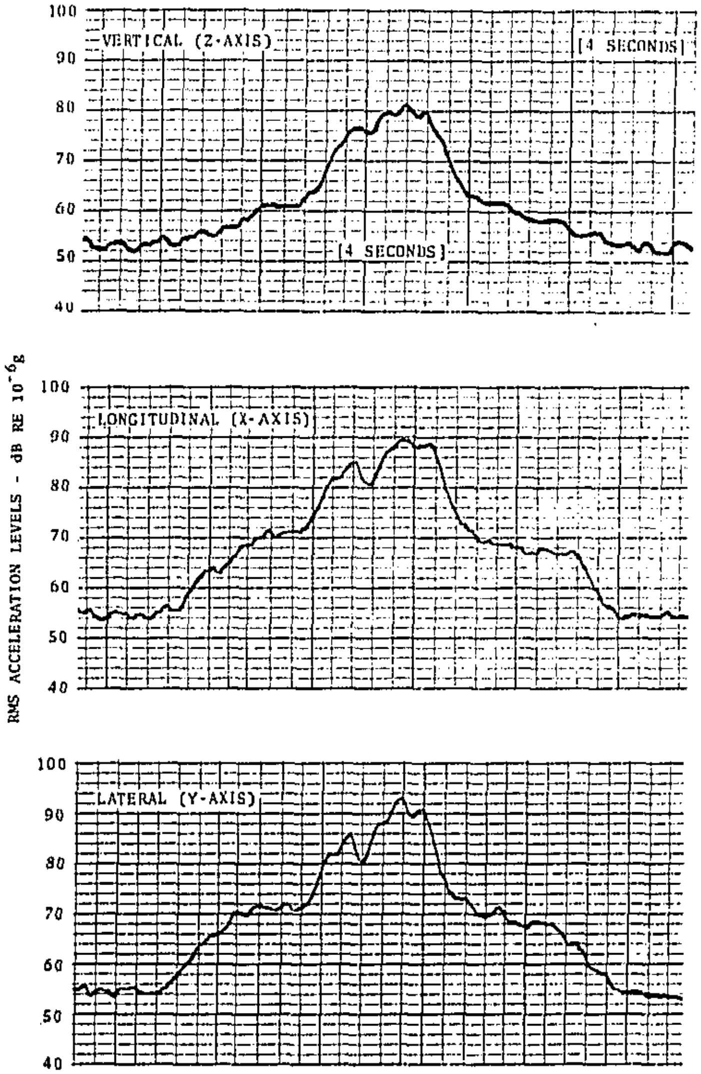


Figure D-6 Coincident Time Histories - Ground Vibration Levels in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car nTrain northbound, Ser. Nos 1503, 1506, 1611, 1610 at 49.7 mph. See Figure D-1.

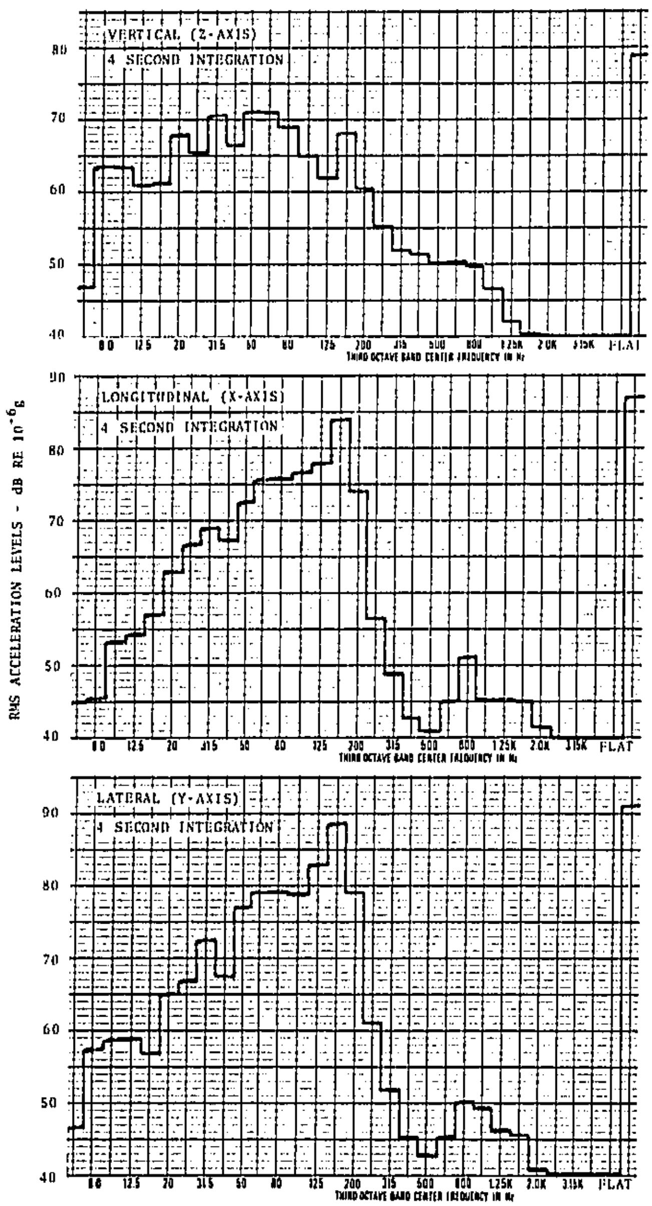


Figure D-7 Coincident Ground Vibration Spectra in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound, Ser. Nos 1503, 1506, 1611, 1610 at 49.7 mph.

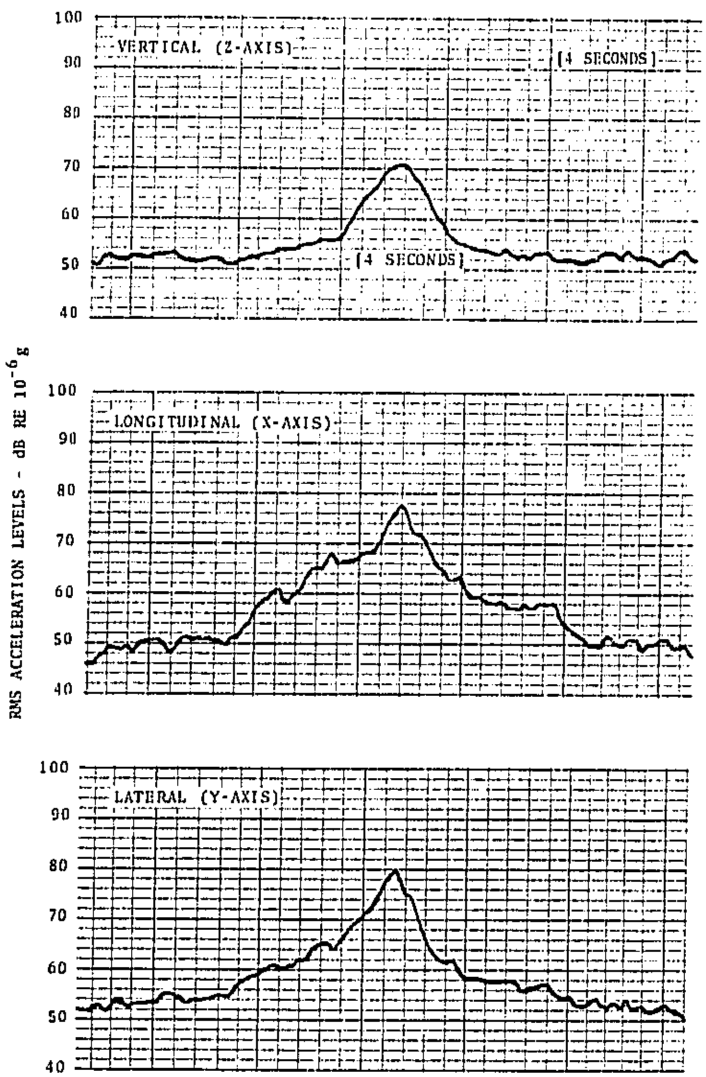


Figure D-8 Coincident Time Histories - Ground Vibration Levels in three axes 38 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound Ser. Nos 1618, 1619, at 49.9 mph.

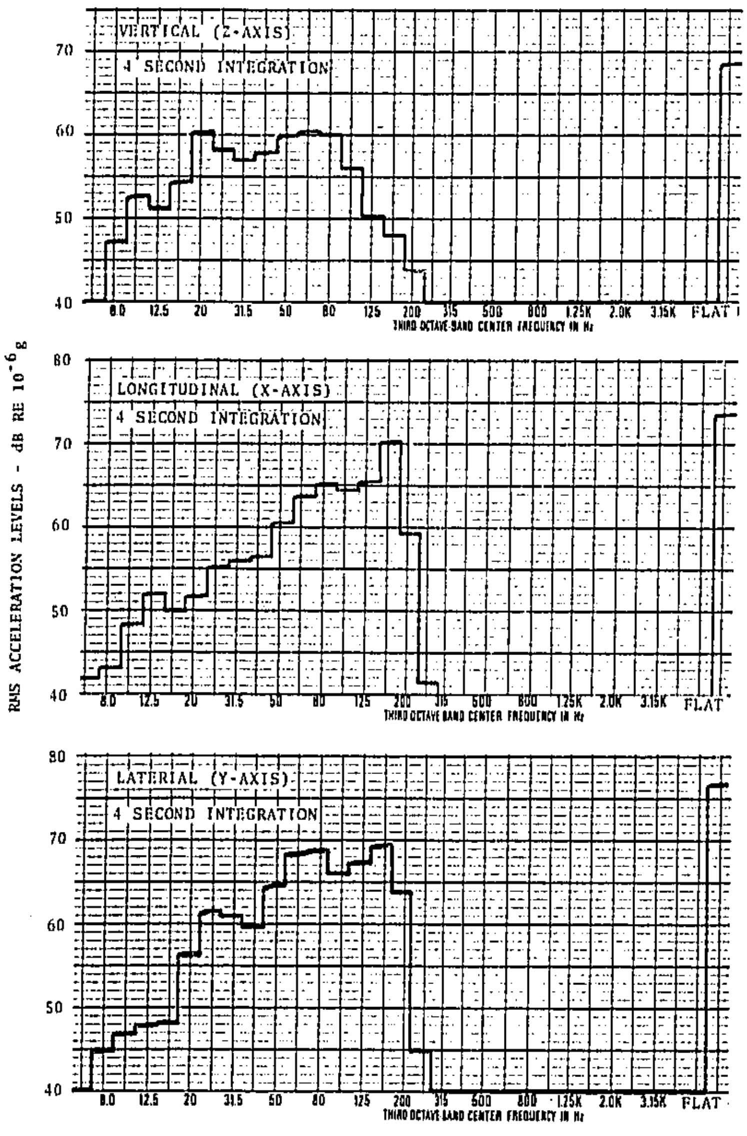


Figure D-9 Coincident Ground Vibration Spectra in three axes 38 feet from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound, Ser. Nos 1618, 1619 at 49.9 mph. See Figure D-8.

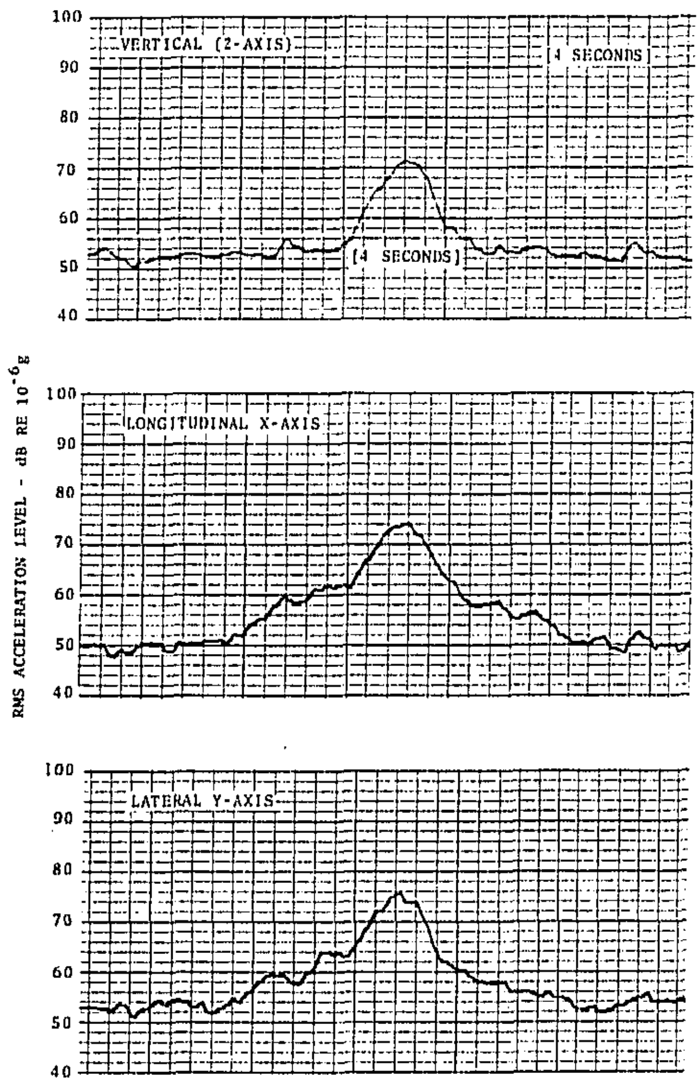


Figure D-10 Coincident Time Histories - Ground Vibration Levels in three axes 38 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound Ser. Nos 1604, 1605 at 50.4 mph.

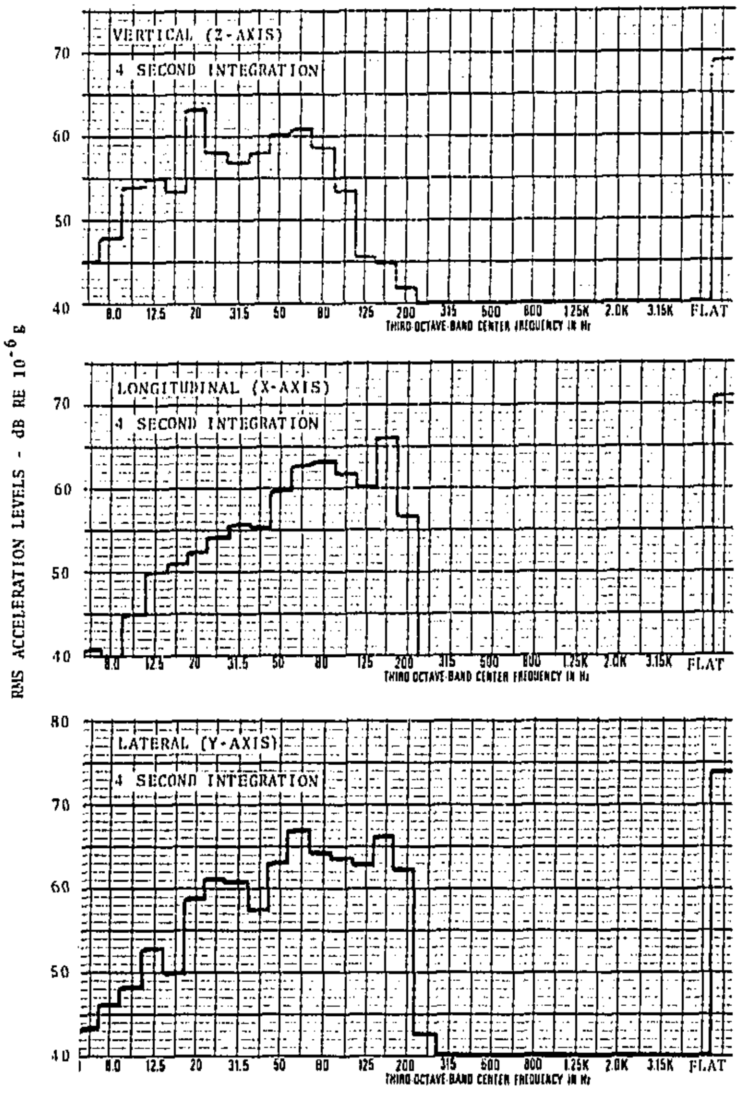


Figure D-11 Coincident Ground Vibration Spectra in three axes 38 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 2-Car Train southbound Ser. Nos 1604, 1605, at 50.4 mph. See figure D-10.

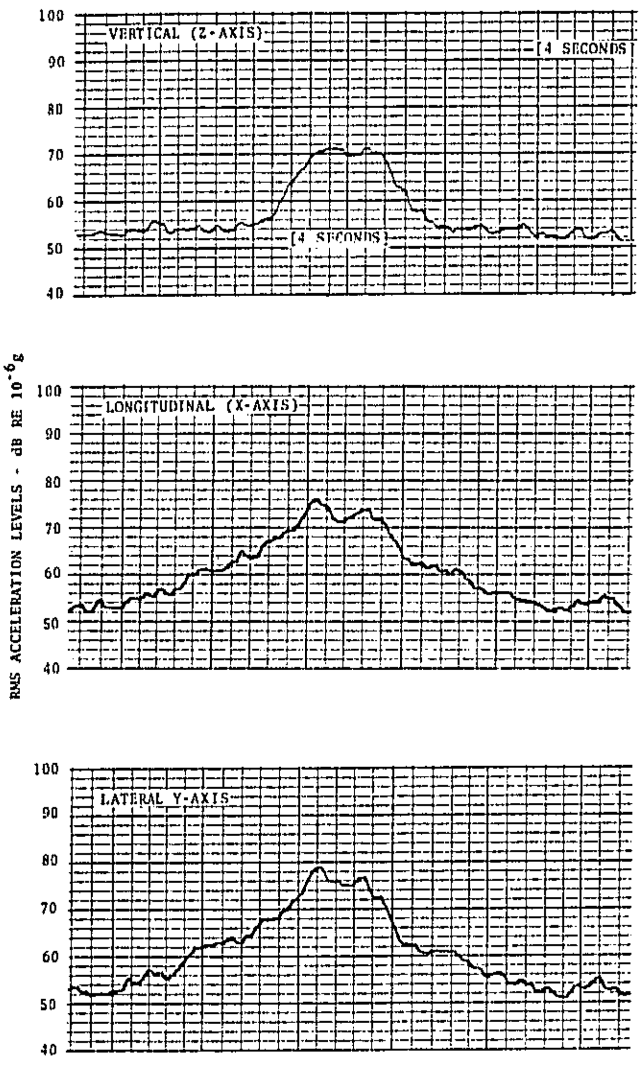


Figure D-12 Coincident Time Histories - Ground Vibration Levels in three axes 38 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train southbound, Ser. Nos 1604, 1605, 1619, 1618 at 48.9 mph.

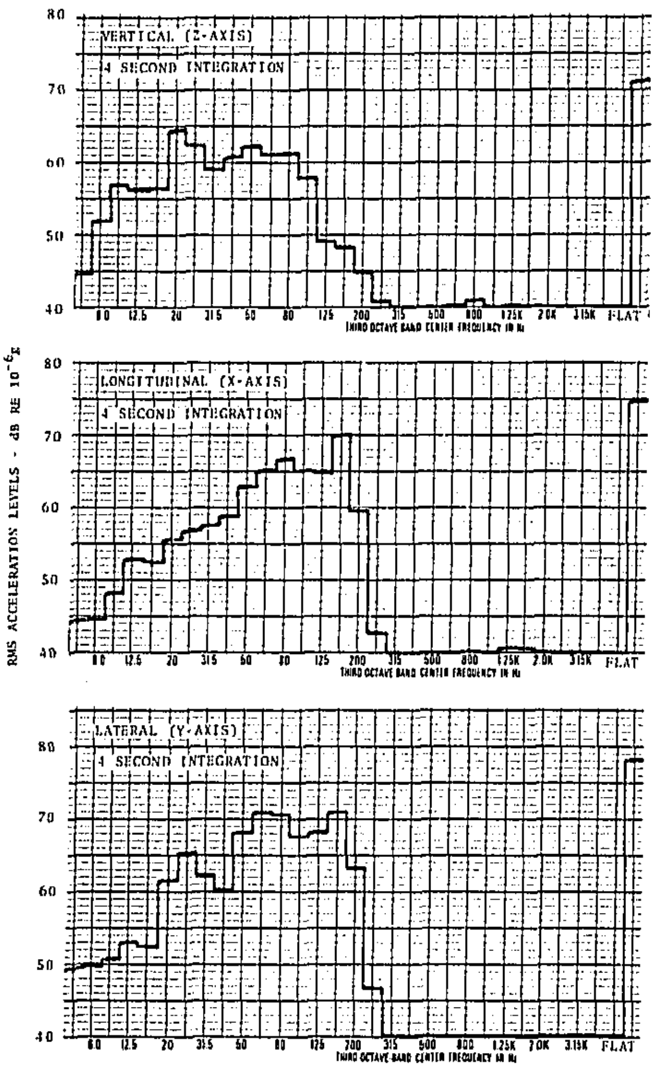


Figure D-13 Coincident Ground Vibration Spectra in three axes 38 feet from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train southbound, Ser. Nos 1604, 1605, 1619, 1618 at 48.9 mph. See Figure D12.

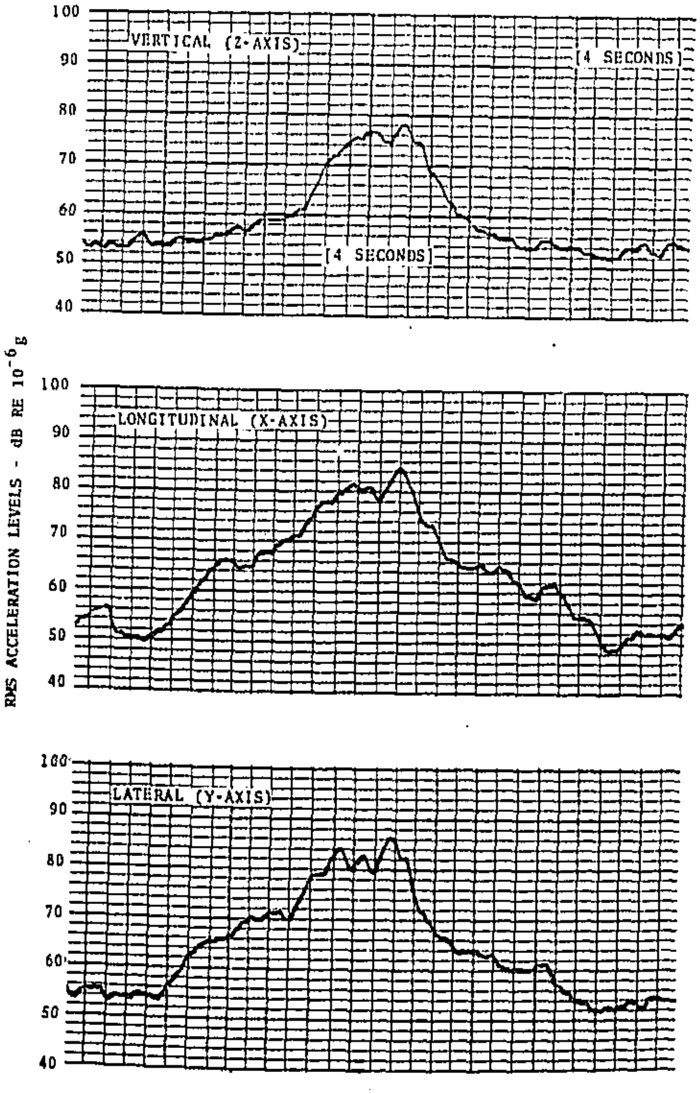


Figure D-14 Coincident Time Histories - Ground Vibration Levels in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound, Ser. Nos 1604, 1605, 1619, 1618 at 49.9 mph.

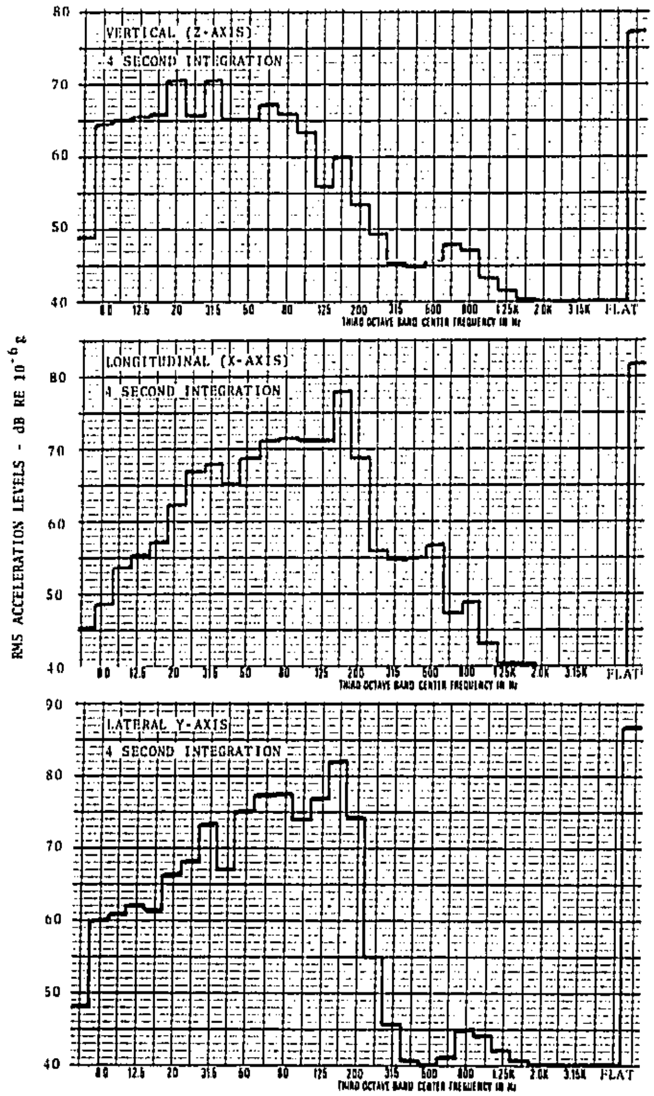


Figure D-15 Coincident Ground Vibration Spectra in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound Ser. Nos 1604, 1605, 1619, 1618 at 49.9 mph. See Figure D-14.

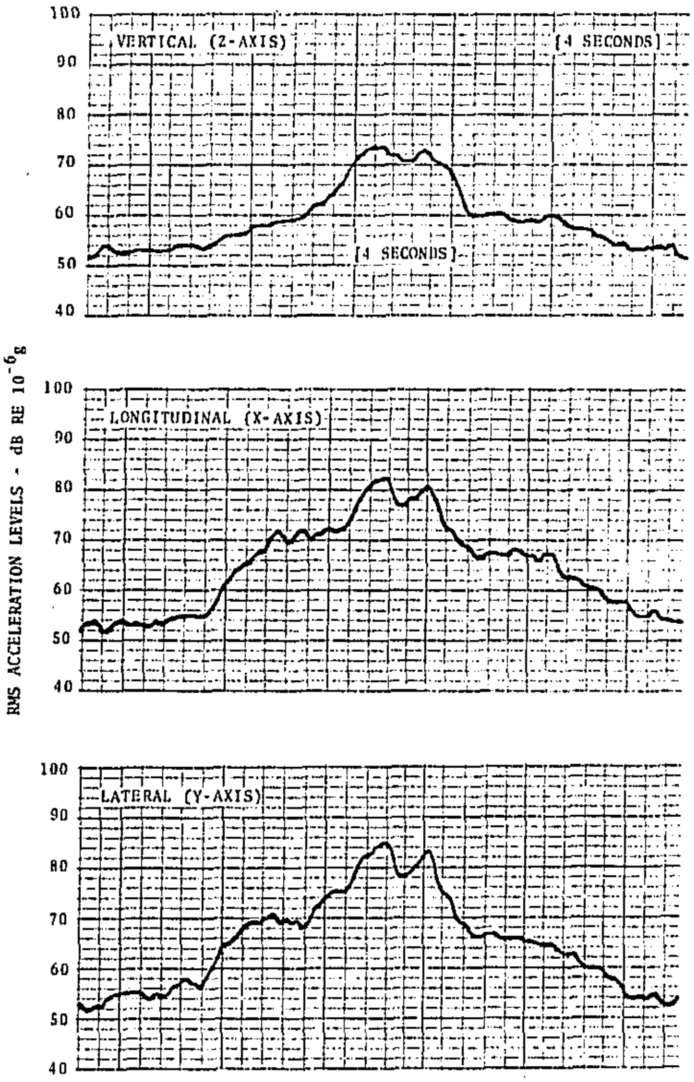


Figure D-16 Coincident Time Histories - Ground Vibration Levels in three axes 38 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train southbound Ser. Nos 1616, 1617, 1634, 1635 at 50.7 mph. See Figure D1.

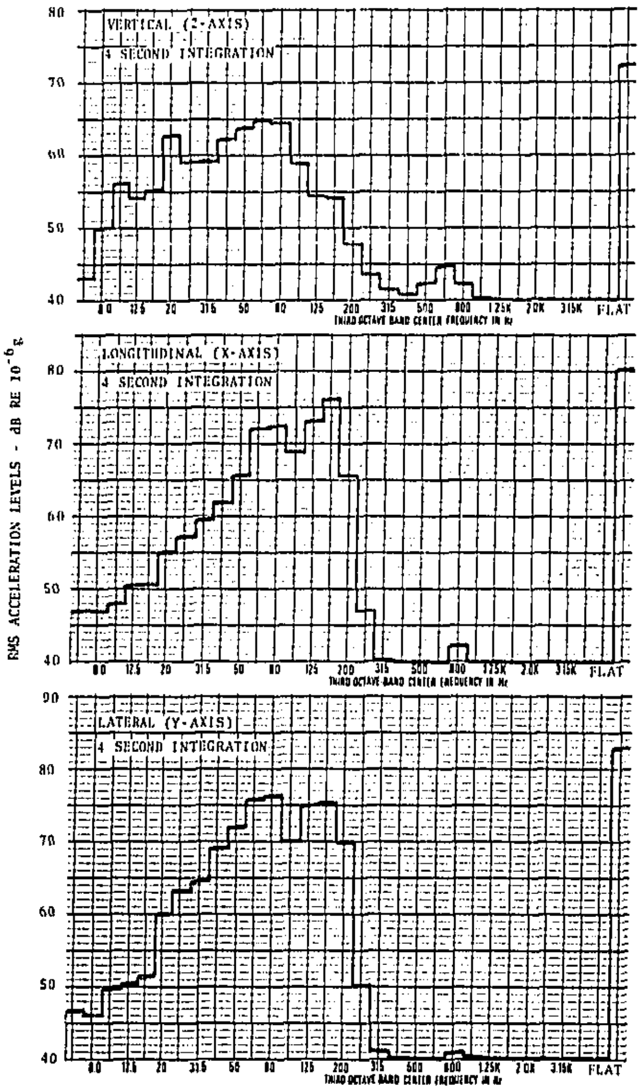


Figure D-17 Coincident Ground Vibration Spectra in three axes 38 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train southbound Ser. Nos 1616, 1617, 1634, 1635 at 50.7 mph. See Figure D16.

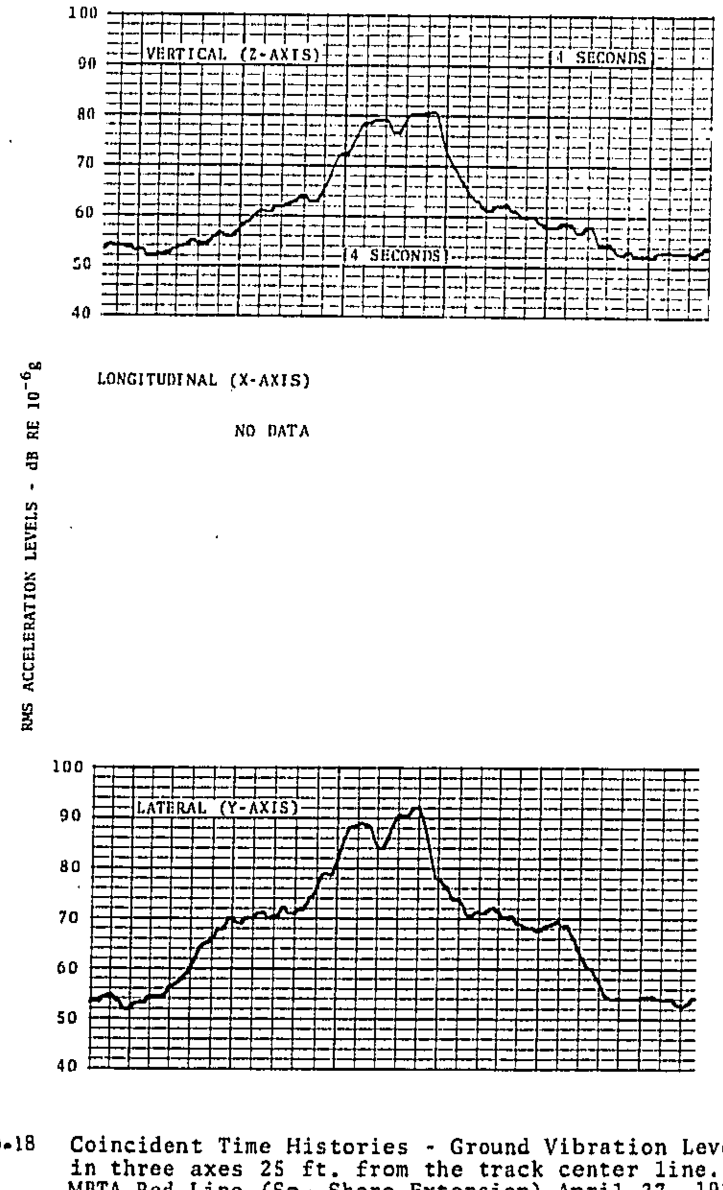


Figure D-18 Coincident Time Histories - Ground Vibration Levels in three axes 25 ft. from the track center line. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound Ser. Nos 1616, 1617, 1634, 1635 at 49.3 mph.

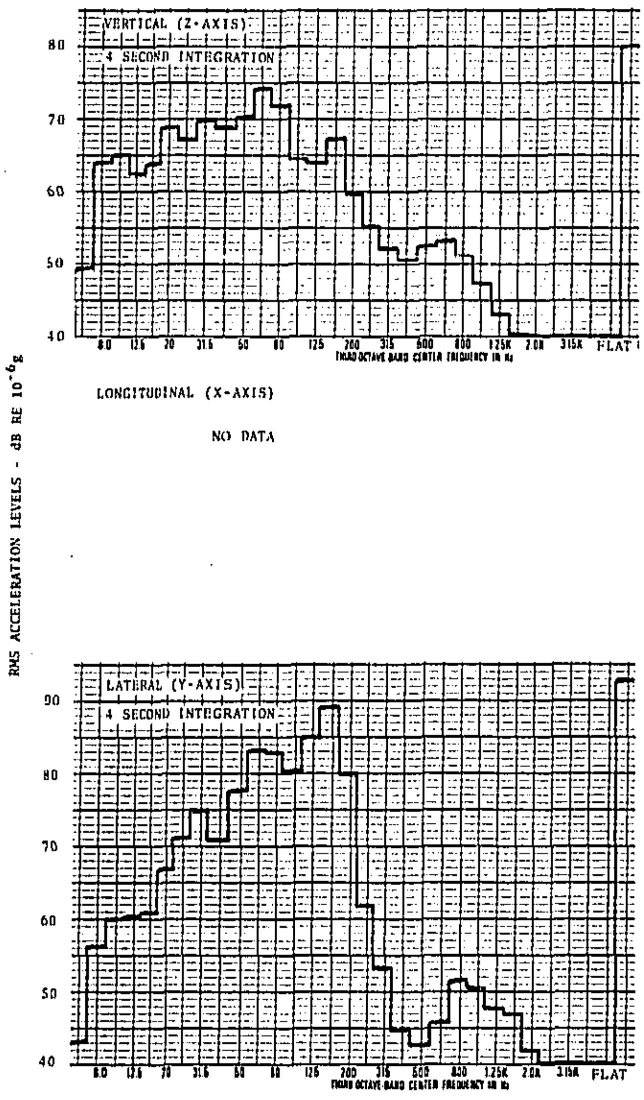


Figure D-19 Coincident Ground Vibration Spectra in three axes 25 ft. from track centerline. MBTA Red Line (So. Shore Extension) April 27, 1972. 4-Car Train northbound Ser. Nos' 1616, 1617, 1634, 1635 at 49.3 mph. See Figure D-18.

APPENDIX E

IN-CAR NOISE LEVEL MEASUREMENTS - MBTA RED LINE

APRIL 29, 1972

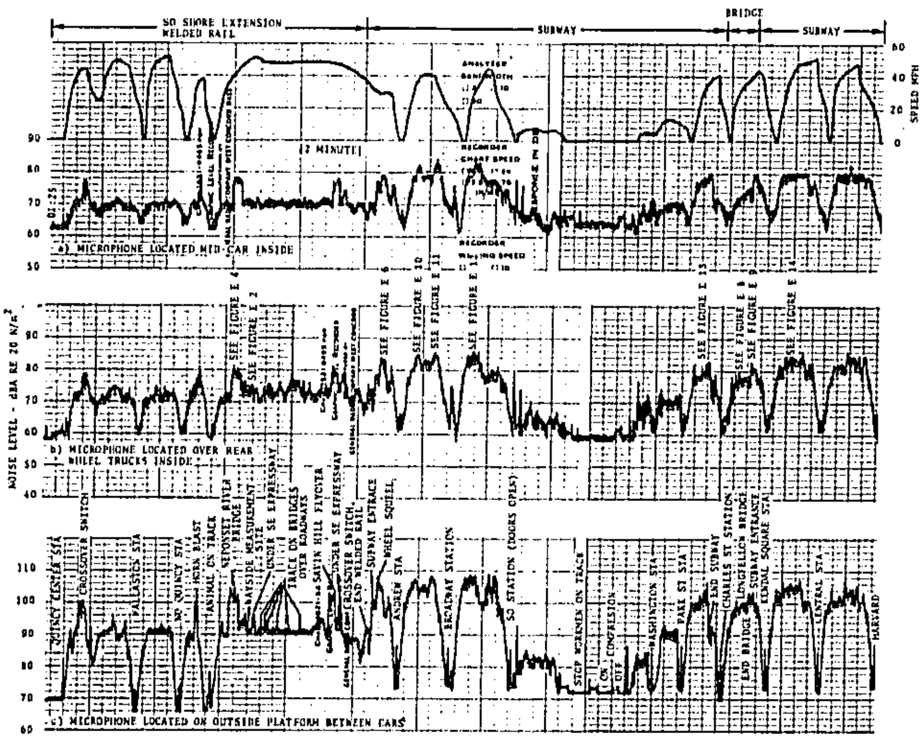


Figure E-1. Coincident Time Histories - Noise Levels Measured at Three Locations on MBTA Type 1 So. Shore Rapid Transit Cars Ser. Nos. 1503, 1506 on the MBTA Red Line (So. Shore Extension) northbound, April 29, 1972. (See Figure G-2 for Microphone Locations).

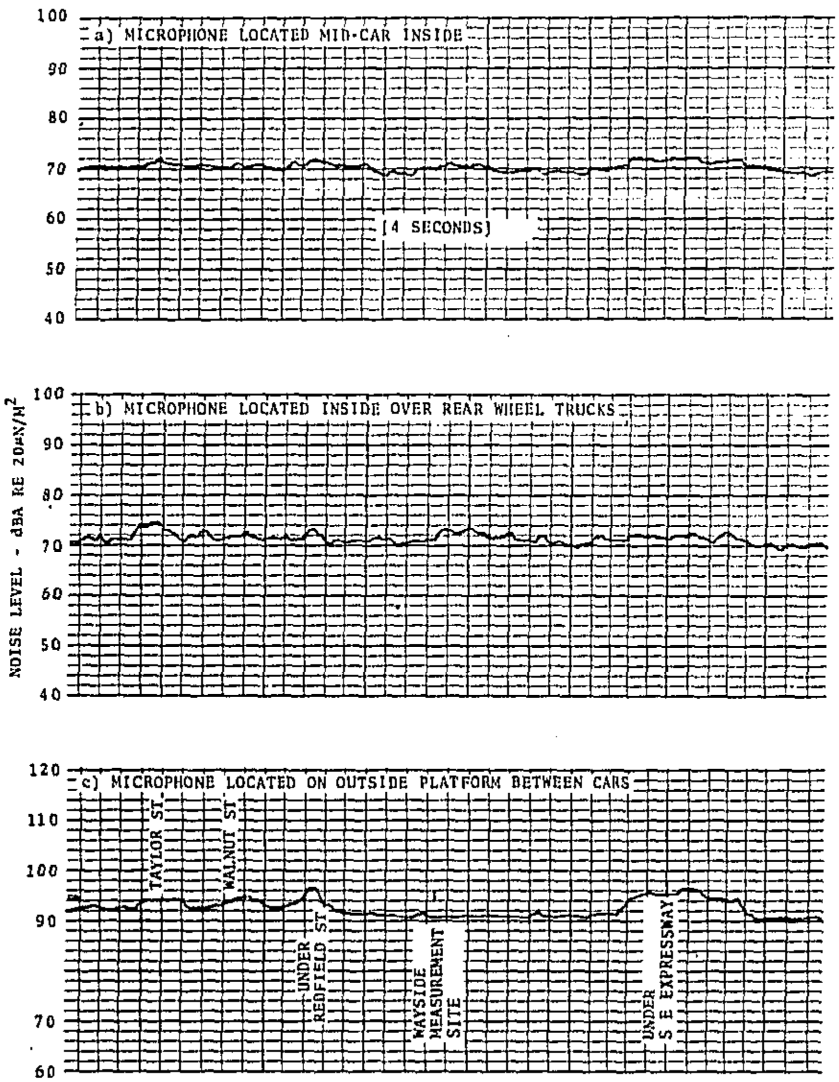


Figure E-2 Coincident Time Histories - Noise Levels at three locations. Tenean St. Wayside Measurements Site Area. MBTA Red Line (So. Shore Extension) April 29, 1972. (See Figure E-1).

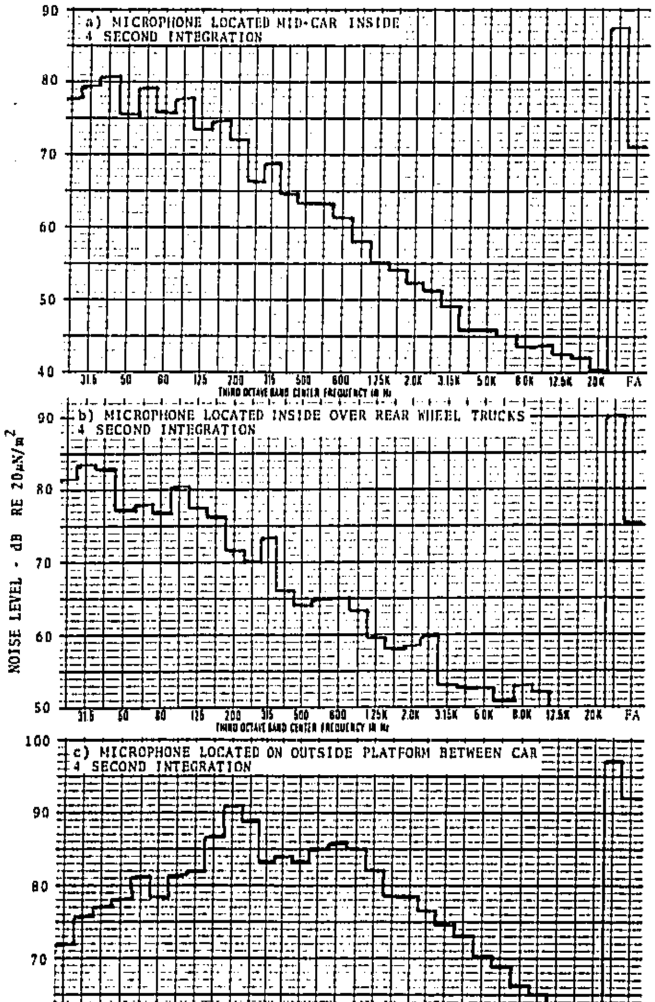


Figure E-3 Coincident Noise Spectra at three in-car locations. Tenean St. Wayside Measurement Site Area. MBTA Red Line (So. Shore Extension) April 29, 1972. (See Figure E-2).

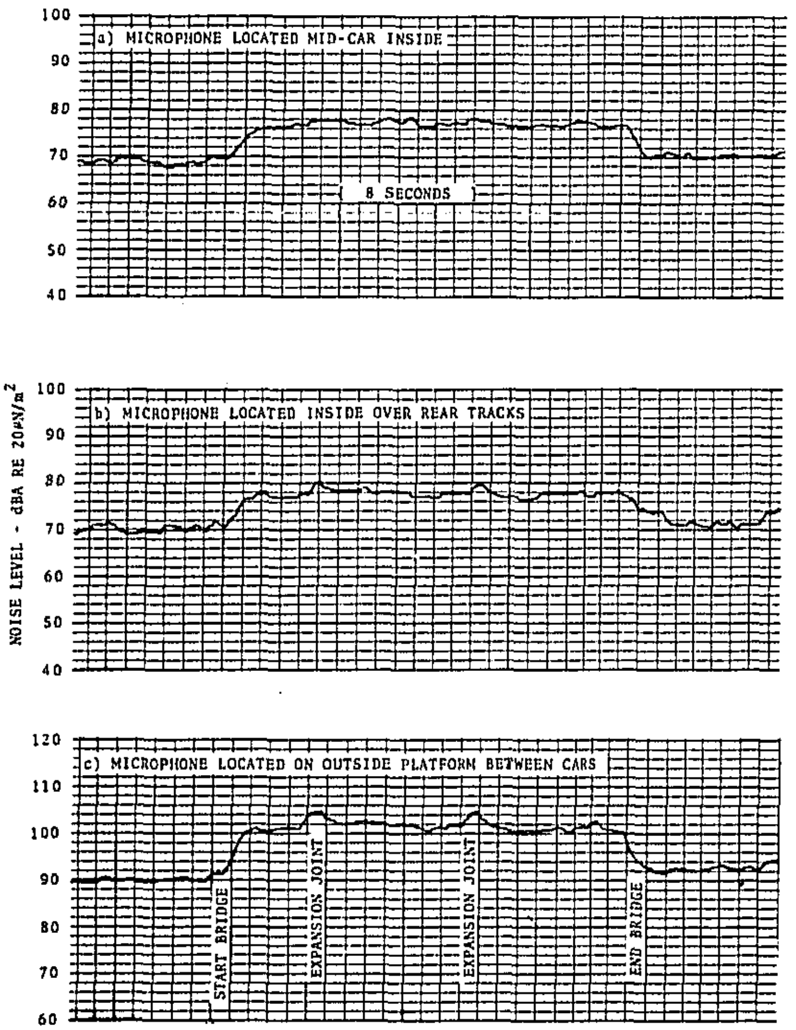


Figure E-4 Coincident Time Histories - Noise Levels at three locations. Neponset River Bridge. MBTA Red Line (So. Shore Extension). (See Figure E-1.)

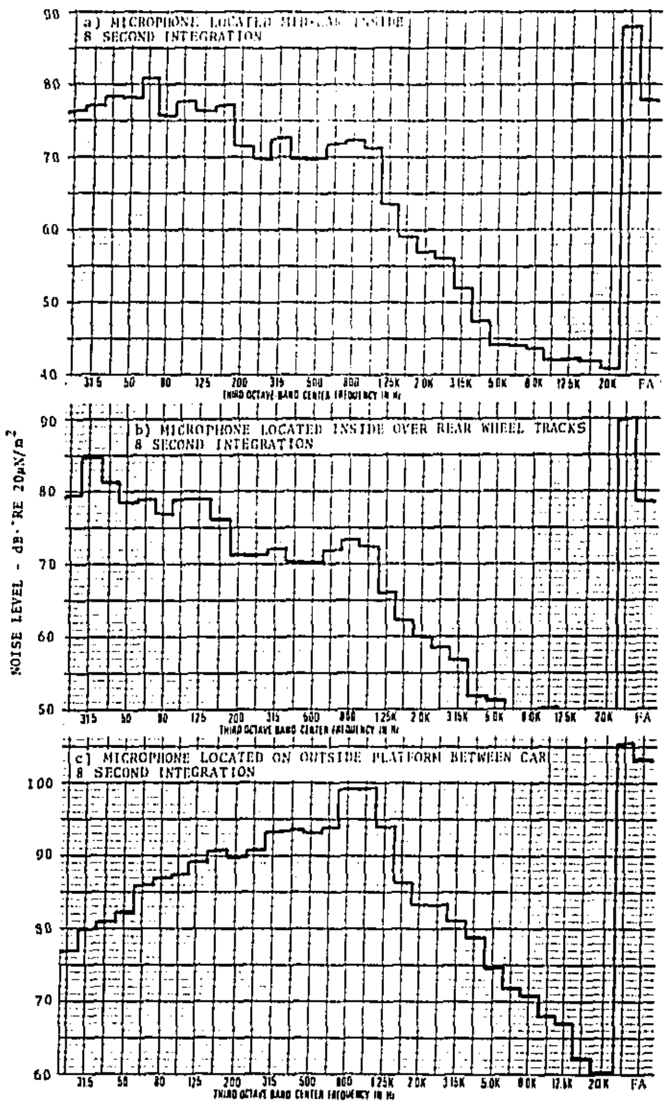


Figure E-5 Coincident Noise Spectra at three locations. Neponset River Bridge. MBTA Red Line (So. Shore Extension). April 29, 1972. (See Figure E-4).

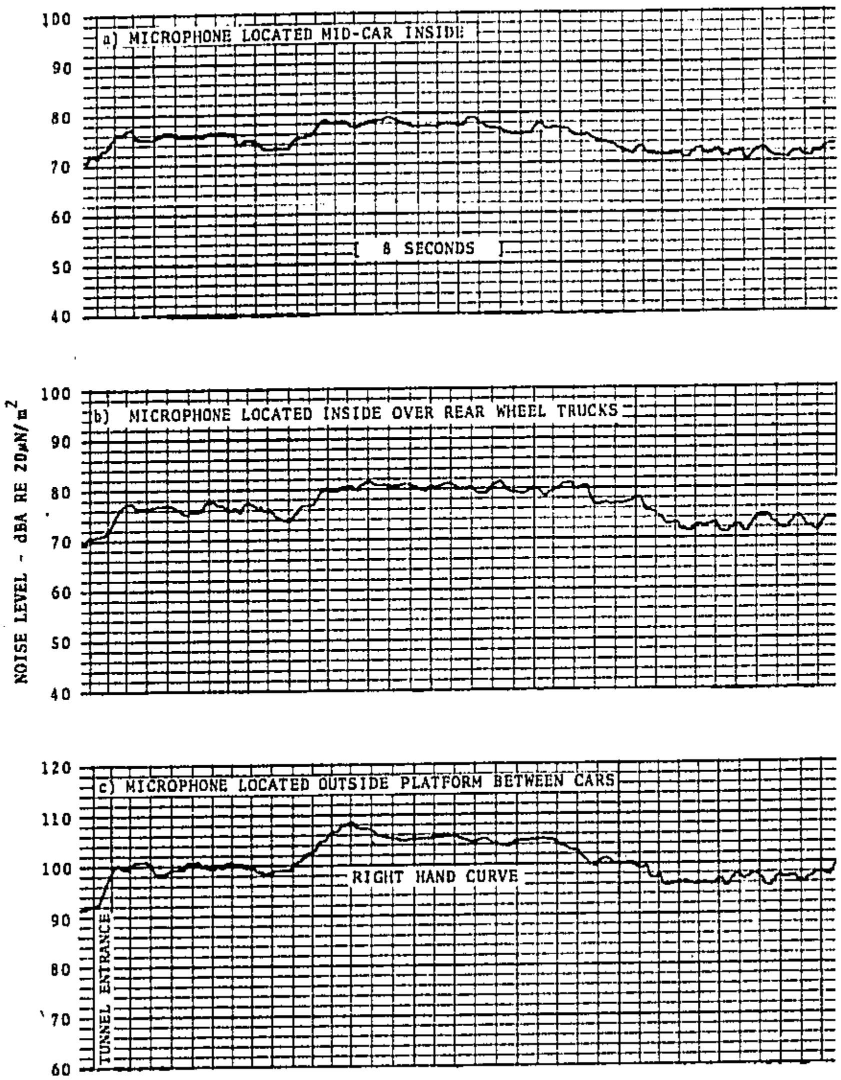


Figure E-6. Coincident Time Histories - Noise Levels at three locations. Sharp right-hand curve after entering tunnel before Andrew Station. MBTA Red Line April 29, 1972. See figure E-1.

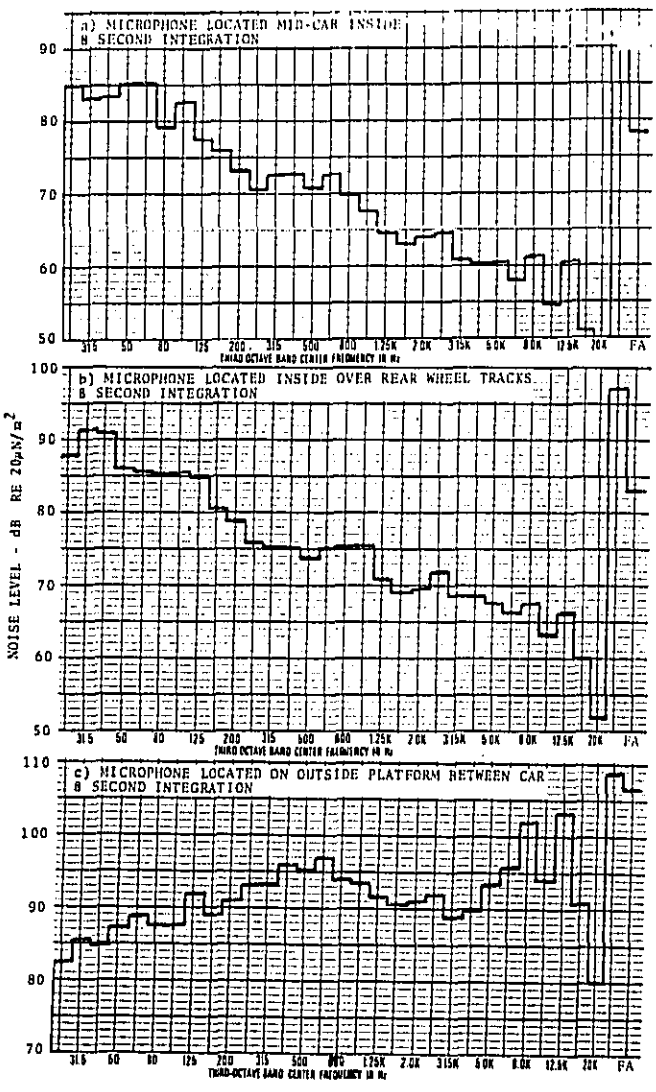


Figure E-7. Coincident Noise Spectra at three locations. Sharp right-hand curve after entering tunnel before Andrew Station. MBTA Red Line. April 29, 1972. See Figure E-6

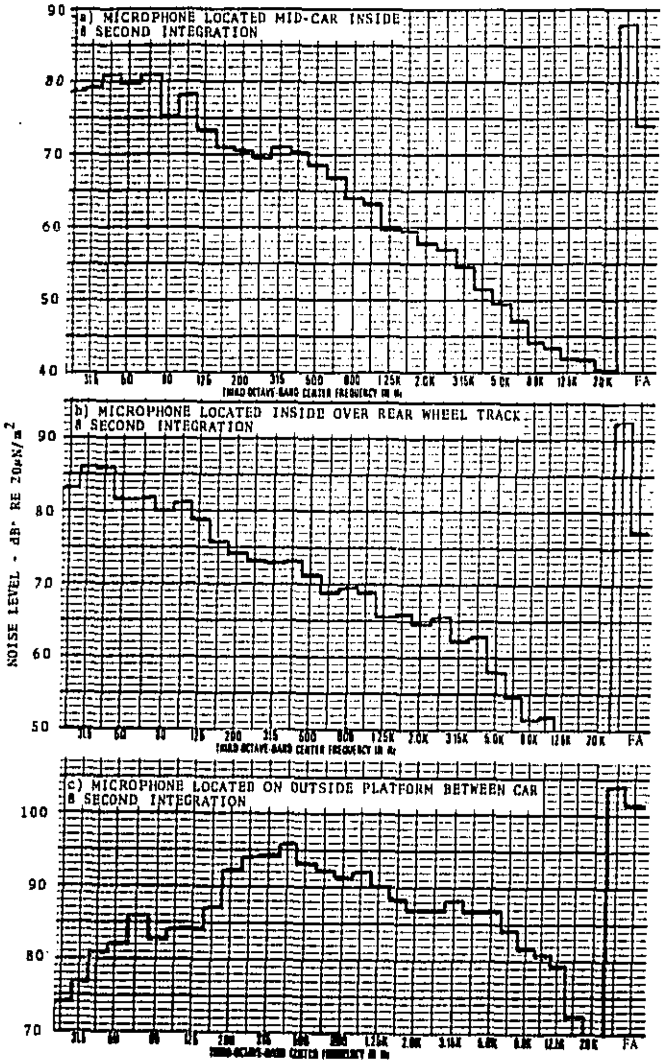


Figure E-8. Coincident Noise Spectra at three locations. At Crest of Longfellow Bridge. MBTA Red Line. April 29, 1972. See Figure E-1.

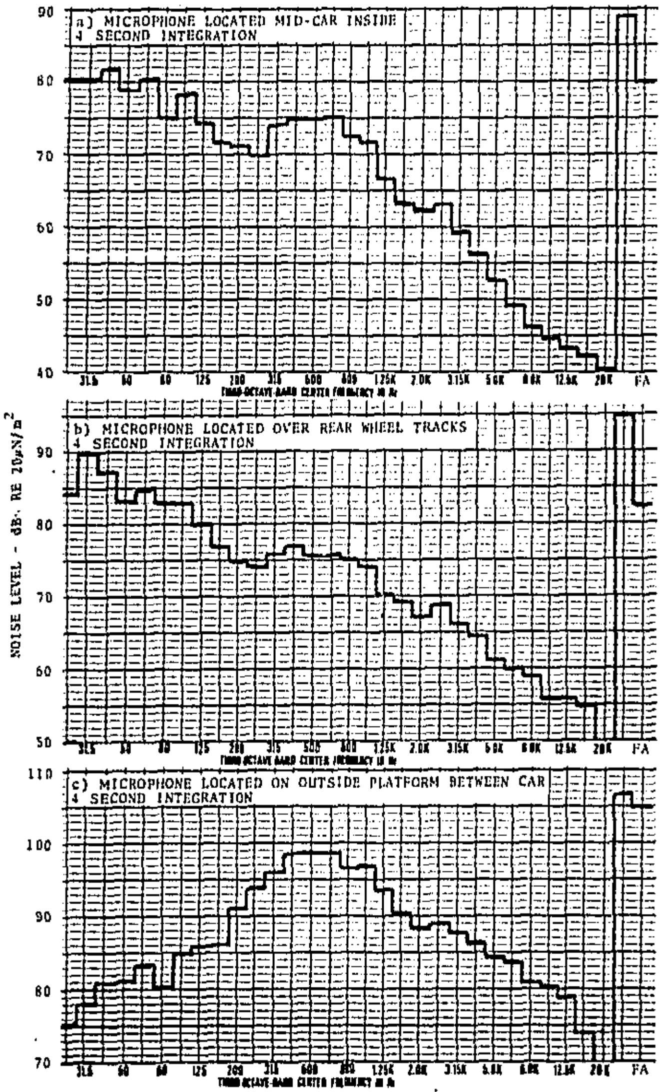


Figure E-9. Coincident Noise Spectra at three locations at Cambridge End of Longfellow Bridge. MBTA Red Line. April 29, 1972. See figure E-1.

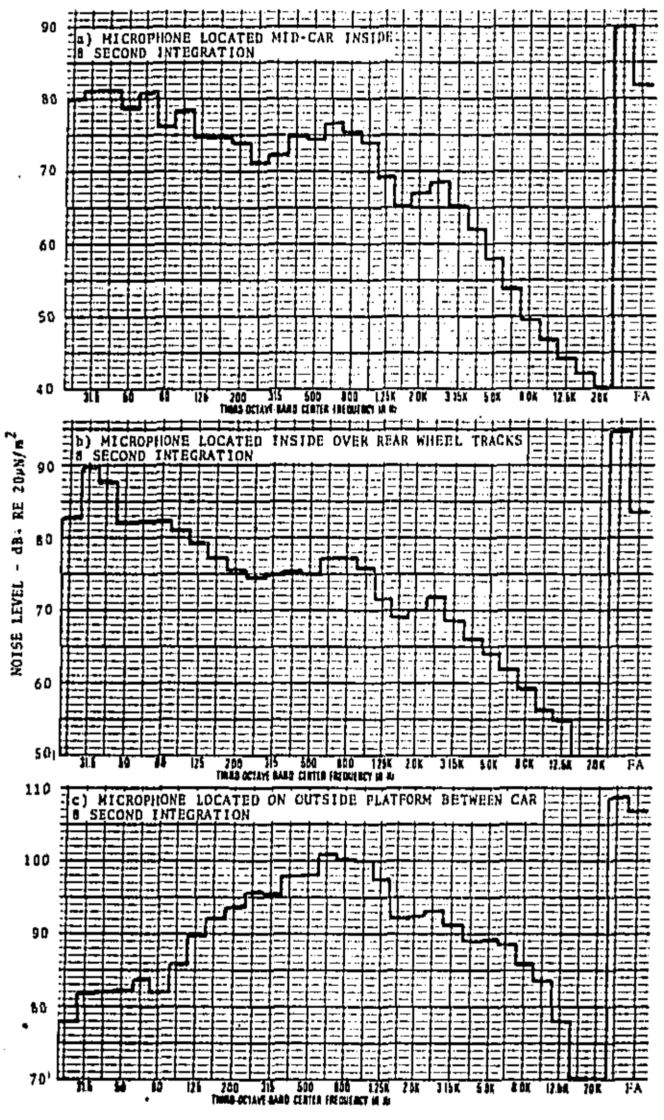


Figure E-10 Coincident Noise Spectra at three locations. Dorchester Tunnel between Andrew and Broadway Stations. MBTA Red Line. April 29, 1972. See Figure E-1. See Figure J-2 for tunnel cross section.

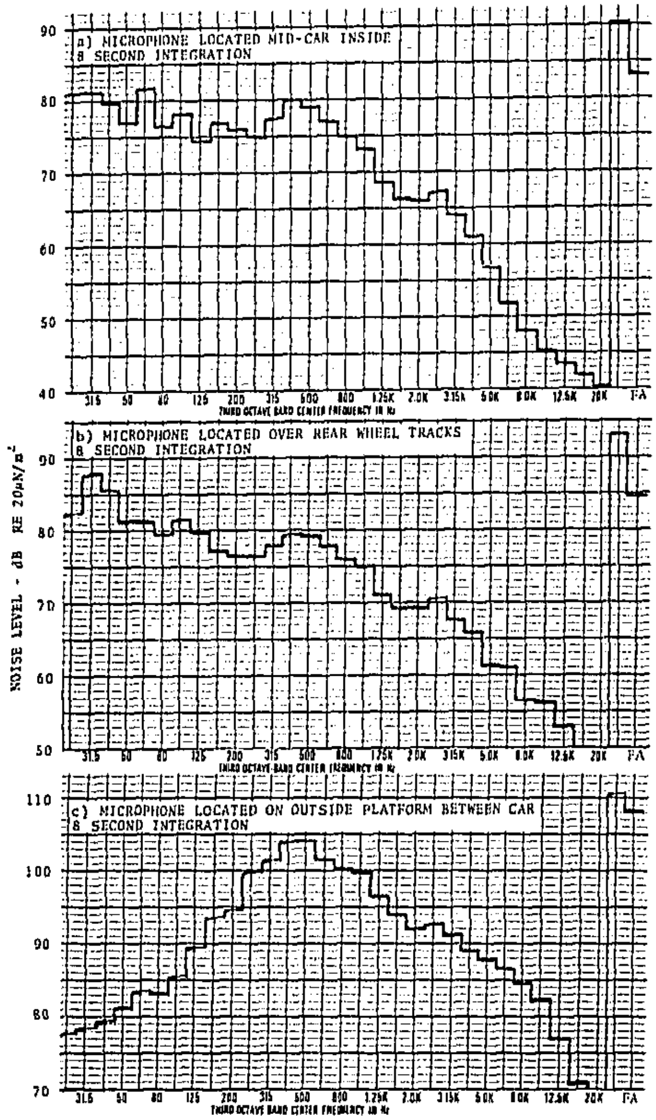


Figure E-11 Coincident Noise Spectra at three locations. Two section tunnel between Andrew and Broadway Stations. MBTA Red Line. April 29, 1972. See Figure E-1. See Figure J-3 for tunnel cross section.

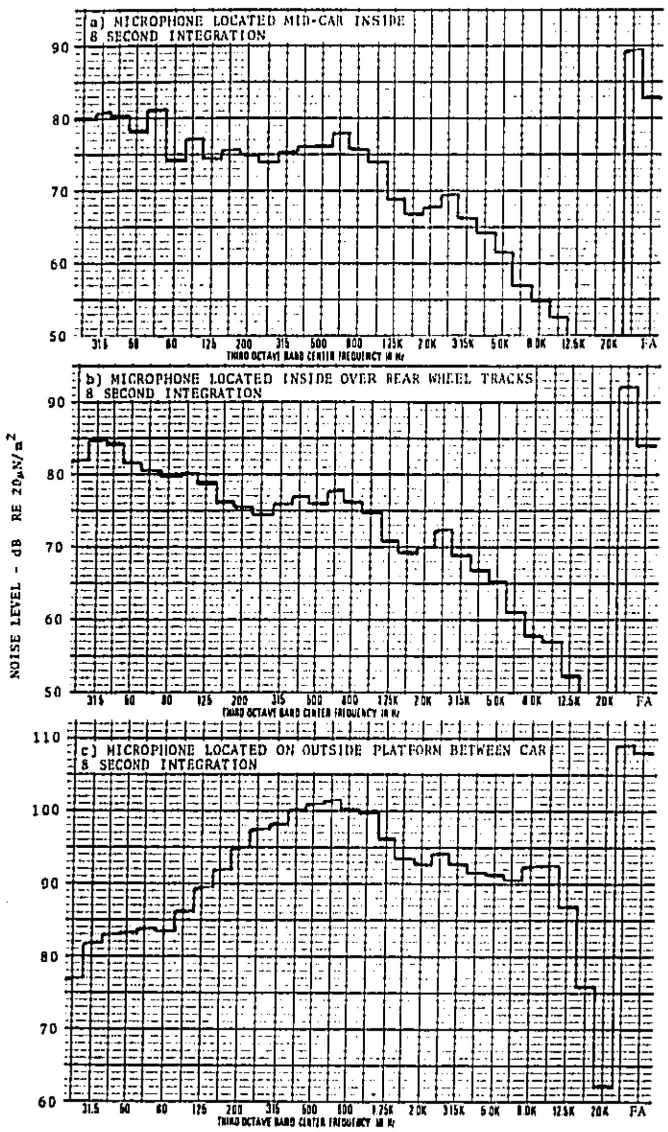


Figure E-12 Coincident Noise Spectra at three locations. Circular Tunnel between Broadway and So. Station. MBTA Red Line. April 29, 1972. See Figure E-1. See Figure J-4 for tunnel cross section.

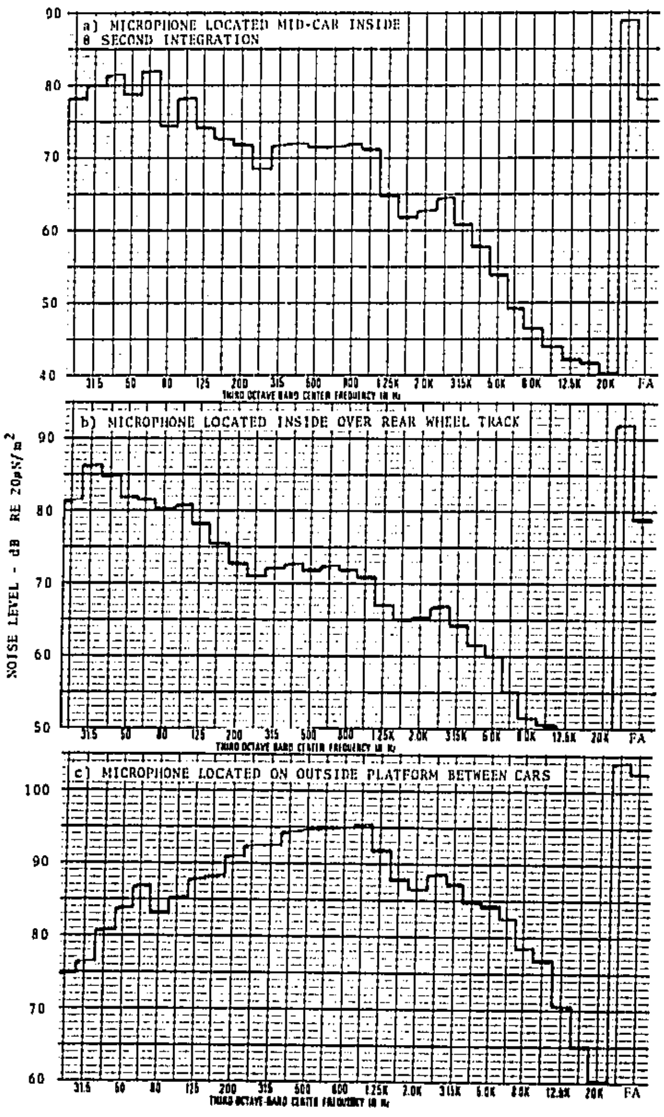


Figure E-13 Coincident Noise Spectra at three locations. Beacon Hill Tunnel between Park St and Charles St. Stations. MBTA Red Line. April 29, 1972. See Figure E-1. See Figure J-5 for tunnel cross section.

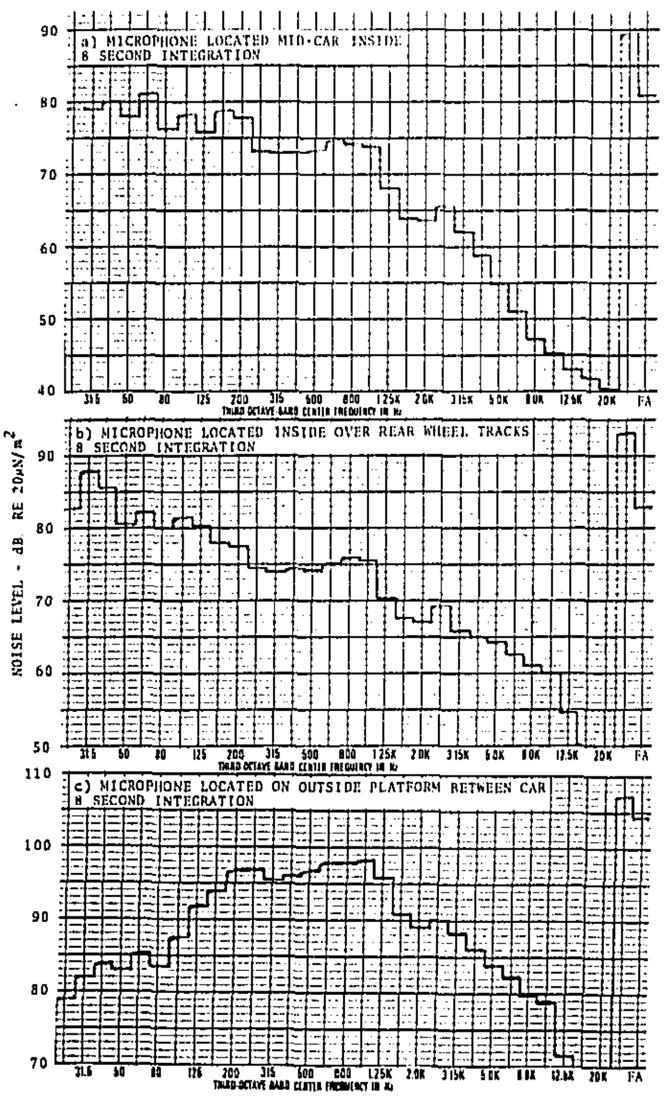


Figure E-14 Coincident Noise Spectra at three locations. Main St. Tunnel between Kendall and Central Stations. MBTA Red Line. April 29, 1972. See Figure E-1. (See Figure J-6 for tunnel cross section)

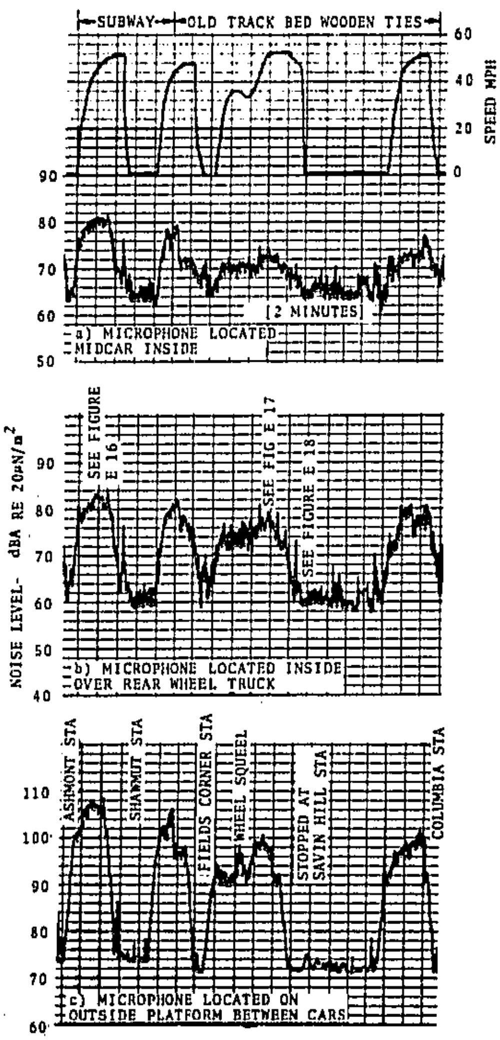


Figure E-15 Coincident Time Histories - Noise Levels measured at three locations on MBTA Type 1 So. Shore Rapid Transit Cars Ser. Nos 1503, 1506 on the MBTA Red Line (Ashmont Extension northbound). April 29, 1972. See Figure G2 for microphone locations.

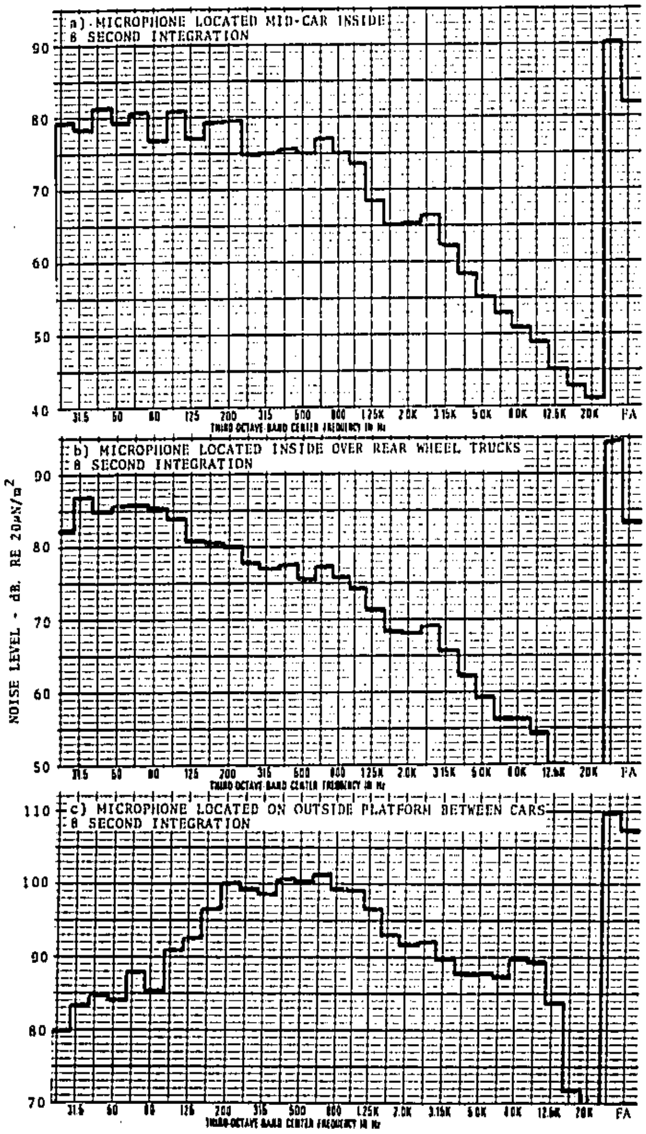


Figure E-16 Coincident Noise Spectra at three locations. Ashmont Tunnel between Ashmont and Shawmut Stations. MBTA Red Line (Ashmont Extension). April 29, 1972. See Figure E-15. See Figure J-7 for tunnel cross section.

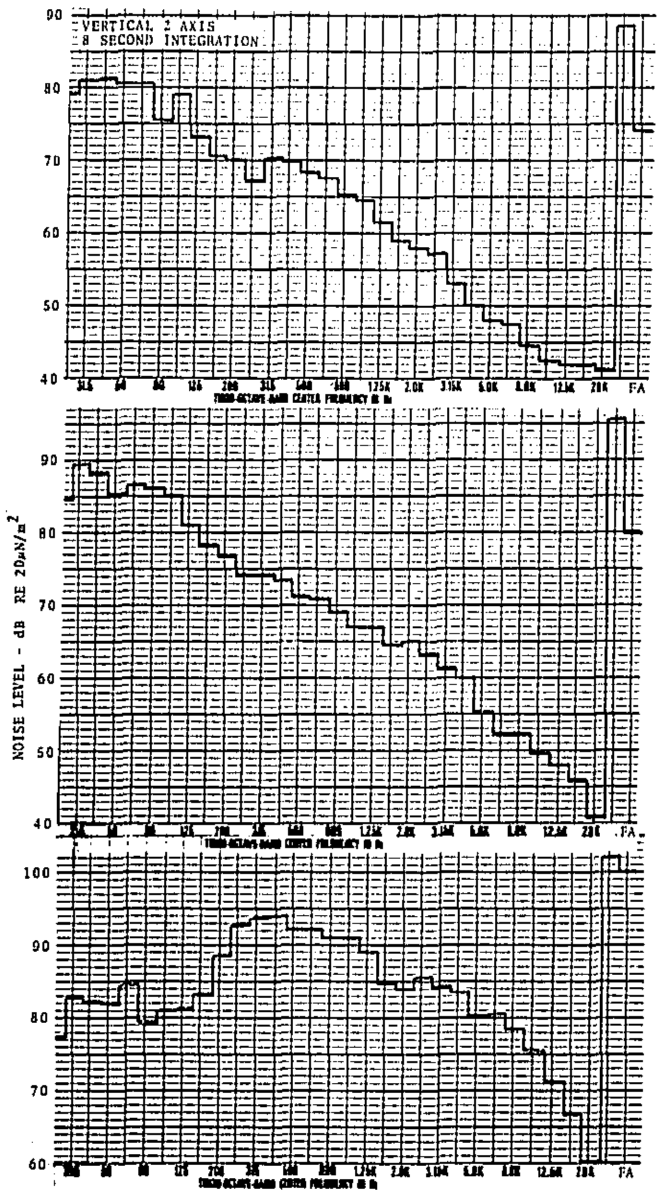


Figure E-17 Coincident Noise Spectra at three locations. Crusing on straight-run surfaceline between Fields Corner and Savin Hill Stations. MBTA Red Line (Ashmont Extension). April 29, 1972 See Figure E-15.

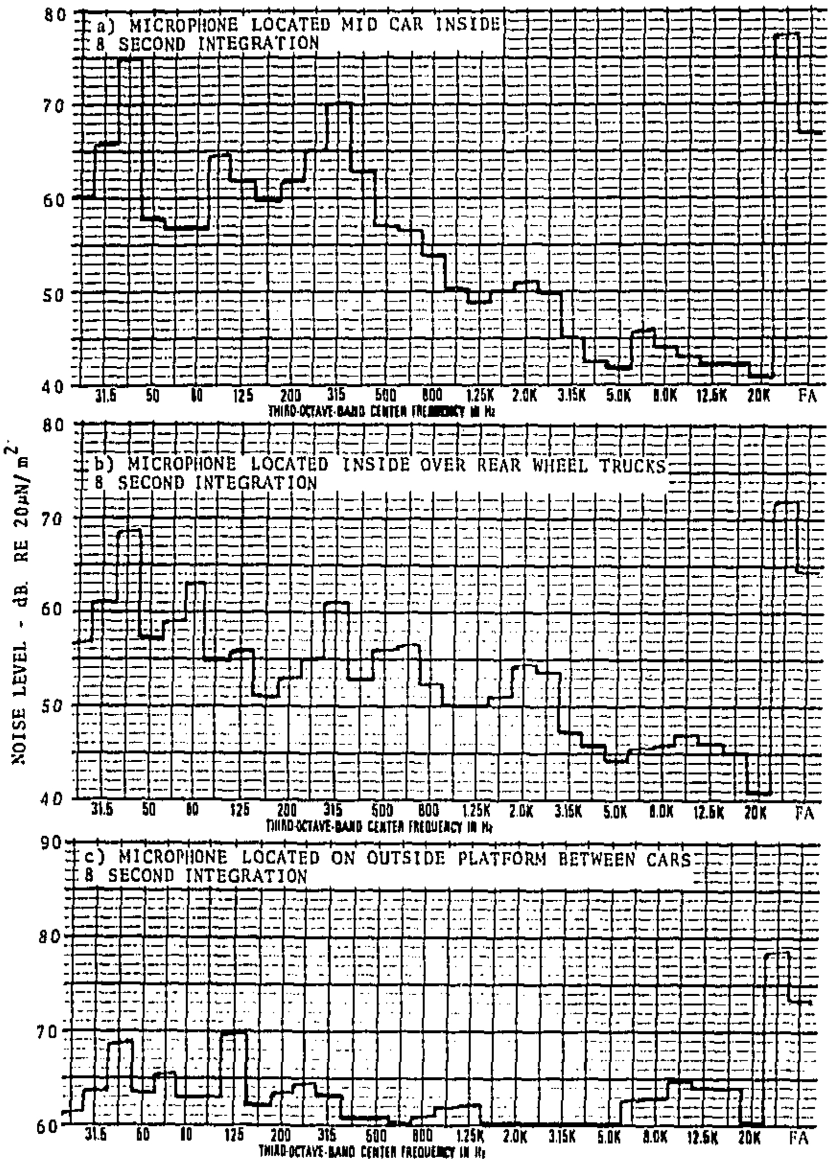


Figure E-18 Coincident Noise Spectra at three locations. Stopped with doors open at Savin Hill Station. MBTA Red Line (Ashmont Extension). April 29, 1972. See Figure E-15.

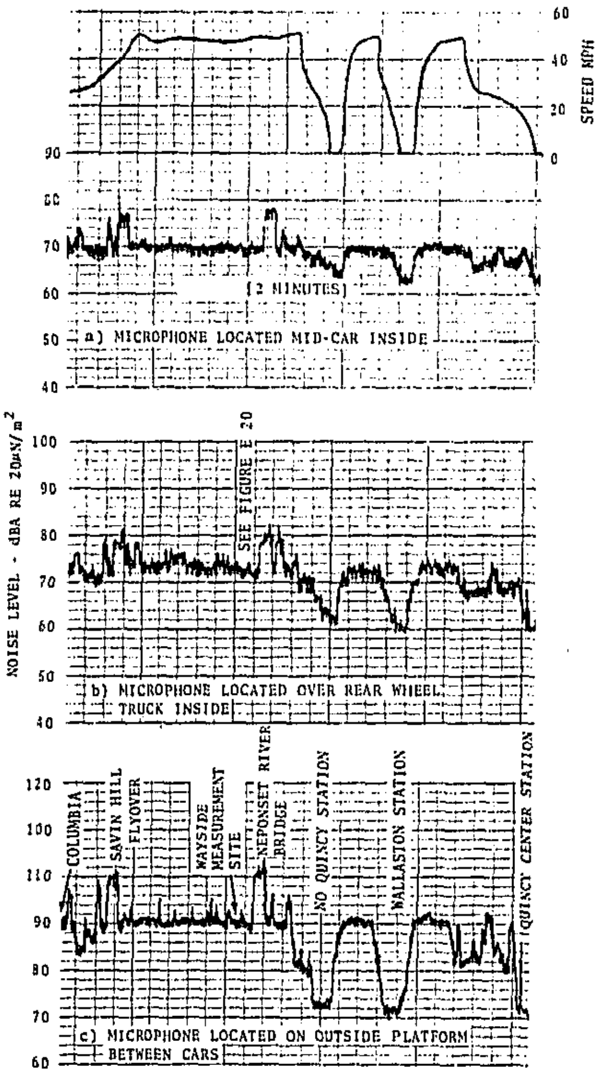


Figure E-19 Coincident Time Histories - Noise Levels measured at three locations on MBTA Type 1 So. Shore Rapid Transit Cars Ser. Nos 1503, 1506 on the MBTA Red Line (So. Shore Extension) southbound. April 29, 1972. See Figure G-2 for microphone locations.

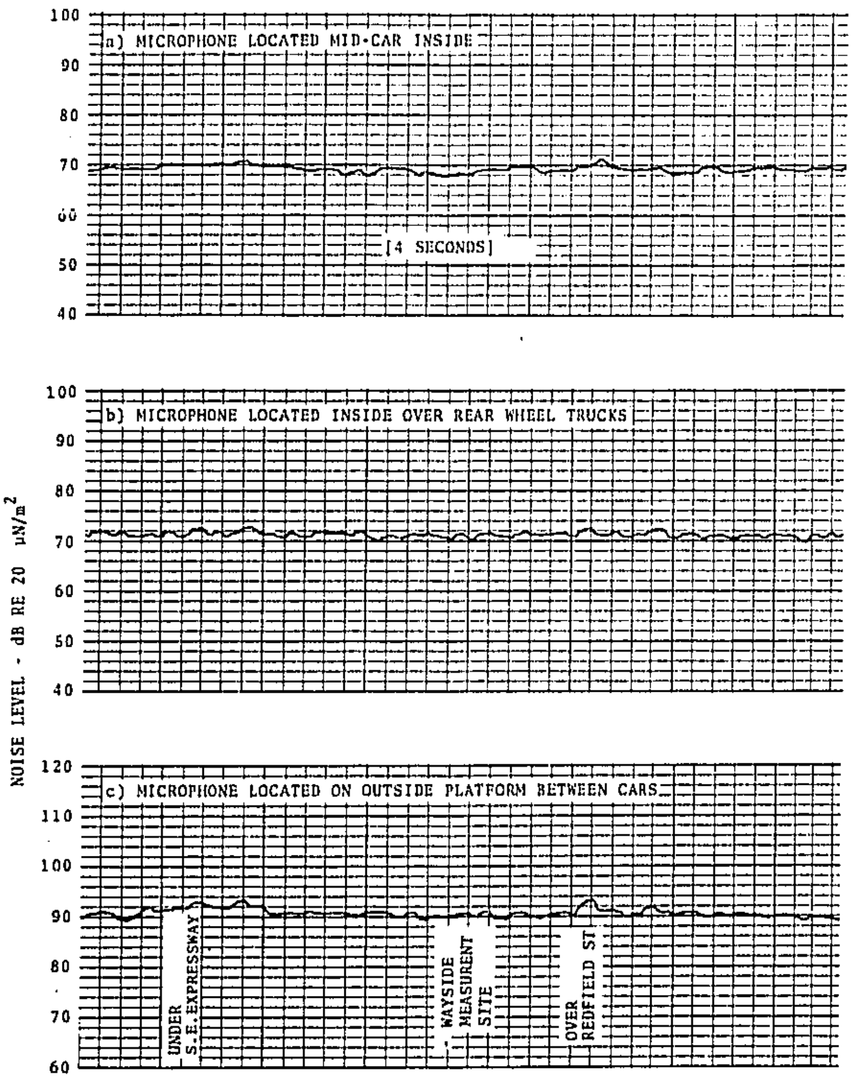


Figure E-20 Coincident Time Histories - Noise Level at three locations. Southbound Tenean St. Wayside Measurement Site. MBTA Red Line (So. Shore Extension) April 29, 1972. See Figure E-19.

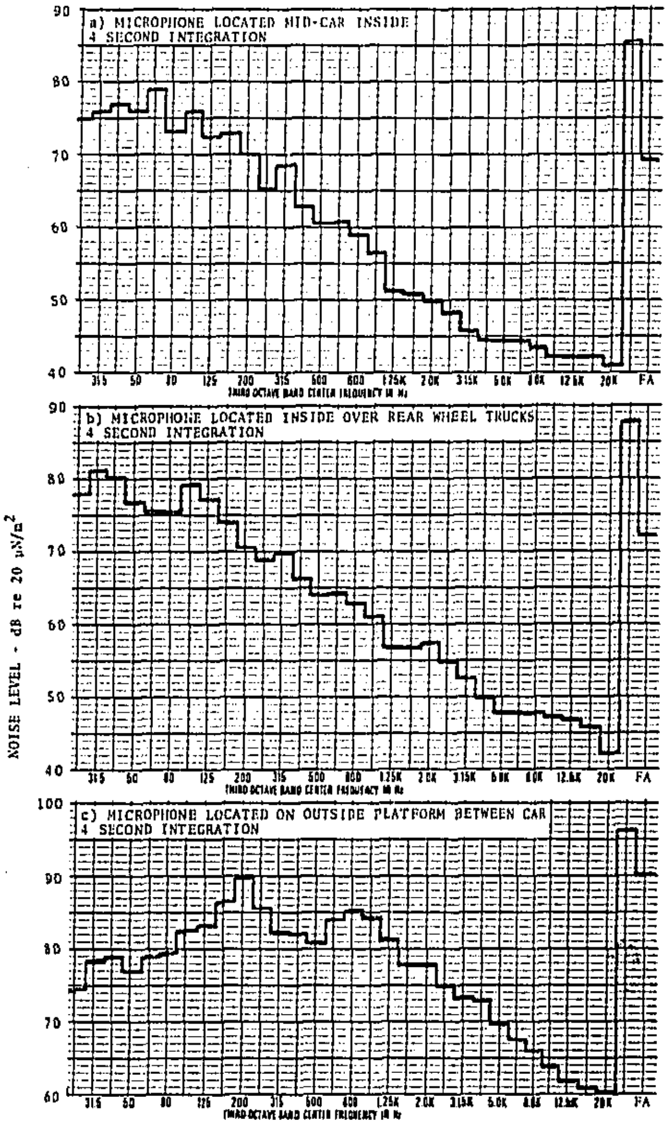


Figure E-21 Coincident Noise Spectra at three locations. Southbound Tenean St. Wayside Measurement Site. MBTA Red Line (So. Shore Extension). April 29, 1972. See Figure E20.

```
              US DEPARTMENT OF TRANSPORTATION                FRI    06/23/72
               TRANSPORTATION SYSTEMS CENTER                        13:58
                  NOISE ABATEMENT GROUP
                          ----
NOISE DATA FROM RUN NO. RT-47-72-1A OF THE PORTABLE NOISE STATION ON
APRIL 29 1972 FROM 01:25 TO 01:34, IN MBTA CAR SER. NO. 1503 & 1506
   (ZONE  99  UNIVERSAL GRID LOCATION  999  -  9999 .)
              (1/8 SECOND INTEGRATIONS,  8  PER SECOND)

DISTRIB
UTION DBA*
 0    82  +                           SAMPLES=                 4200
 1    81  +                           AVERAGE=                 69.9  DBA*
 2    80  +                           STANDARD DEVIATION=      2.9 DBA*
 14   79  +                           ENERGY MEAN=             71 DB**
 42   78   +                          NOISE POLLUTION LEVEL=   78.4
 88   77    +                         1% PERCENTILE=           78.4 DBA*
 102  76     +                        10% DECILE=              73.9 DBA*
 71   75      +                       MEDIAN=                  70.3 DBA*
 83   74       +                      90% DECILE=              66.7 DBA*
 142  73        +                     99% PERCENTILE=          63.4 DBA*
 291  72            +                 WALSH HEALEY EXP.=       0  %
 691  71                    +         RANGE=                   20 DB
 765  70                             +
 827  69                                       +
 428  68                                            +
 190  67                                              +
 149  66                                                +
 148  65                                                  +
 82   64                                                   +
 70   63                                                     +
 13   62                                                     +
 1    61                                                     +
 0    60                                                     +
          0          20         40         60         80         100
      LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)
```

gure E-22. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503, 1506 on the MBTA Red Line (So. Shore Extension) Northbound. Microphone located inside mid-car, April 29, 1972

```
 1       81  0
 2       80  0
 14      79  00
 42      78  000
 88      77  0000
 102     76  00000
 71      75  0000
 83      74  0000
 142     73  000000
 291     72  00000000000
 691     71  000000000000000000000000000
 765     70  00000000000000000000000000000
 827     69  00000000000000000000000000000000
 428     68  0000000000000000
 190     67  00000000
 149     66  000000
 148     65  000000
 82      64  0000
 70      63  0000
 13      62  00
 1       61  0
DIST.  DBA*  0              10              20              30
                LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF
THE SQUARES OF THE SOUND PRESSURES.
```

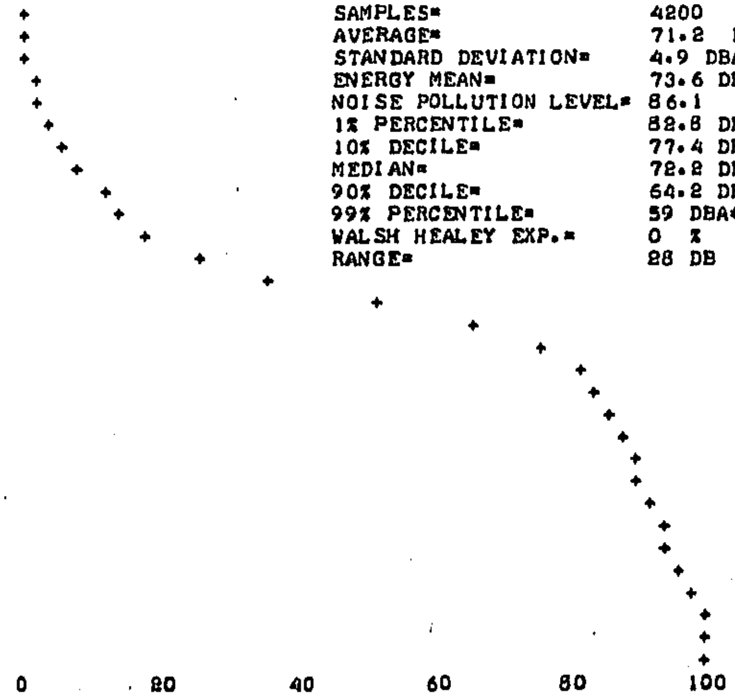
Figure E-22 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line (So. Shore Extension) Northbound. Microphone located inside mid-car, April 29, 1972

US DEPARTMENT OF TRANSPORTATION FRI 06/23/72
TRANSPORTATION SYSTEMS CENTER 14:27
NOISE ABATEMENT GROUP
\----

NOISE DATA FROM RUN NO. RT-47-72-3A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 01:25 TO 01:34, IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS; 8 PER SECOND)

DISTRIBUTION	DBA*
8	85
8	84
18	83
37	82
38	81
36	80
81	79
128	78
112	77
137	76
168	75
282	74
493	73
652	72
606	71
368	70
254	69
122	68
71	67
69	66
54	65
50	64
47	63
69	62
65	61
86	60
98	59
42	58
1	57
0	56

SAMPLES=	4200
AVERAGE=	71.2 DBA*
STANDARD DEVIATION=	4.9 DBA*
ENERGY MEAN=	73.6 DB**
NOISE POLLUTION LEVEL=	86.1
1% PERCENTILE=	82.8 DBA*
10% DECILE=	77.4 DBA*
MEDIAN=	72.2 DBA*
90% DECILE=	64.2 DBA*
99% PERCENTILE=	59 DBA*
WALSH HEALEY EXP.=	0 %
RANGE=	28 DB



LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure E-23. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Car Serial Nos 1503,1506 on the MBTA Red Line (So. Shore Extension) Northbound. Microphone located inside over rear wheel trucks, April 29, 1972

```
8       85  0
8       84  0
18      83  00
37      82  00
38      81  00
36      80  00
81      79  0000
128     78  000000
112     77  00000
137     76  000000
168     75  0000000
282     74  00000000000
493     73  0000000000000000000
652     72  000000000000000000000000
606     71  00000000000000000000000
368     70  00000000000000
254     69  0000000000
122     68  00000
71      67  0000
69      66  0000
54      65  000
50      64  000
47      63  000
69      62  0000
65      61  000
86      60  0000
98      59  00000
42      58  000
1       57  0
DIST. DBA*  0              10             20             30
               LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure B-23 (Continued). Statistical Analysis - In-Car Noise Data. MBTA Type 1 So. Shore Rapid Transit Car Serial Nos 1503,1506 on the MBTA Red Line (So. Shore Extension) Northbound. Microphone located inside over rear wheel trucks, April 29, 1972

US DEPARTMENT OF TRANSPORTATION FRI 06/23/72
TRANSPORTATION SYSTEMS CENTER 14:48
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-4A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 01:25 TO 01:34, IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
2	98
8	97
8	96
20	95
53	94
66	93
69	92
53	91
36	90
35	89
56	88
54	87
101	86
209	85
372	84
541	83
641	82
405	81
205	80
131	79
108	78
97	77
92	76
69	75
51	74
40	73
49	72
34	71
23	70
41	69
29	68
36	67
35	66
38	65
30	64
48	63
37	62
57	61
74	60
97	59
45	58
5	57
0	56

SAMPLES=	4200
AVERAGE=	79.7 DBA*
STANDARD DEVIATION=	8.2 DBA*
ENERGY MEAN=	84.7 DB**
NOISE POLLUTION LEVEL=	105.7
1% PERCENTILE=	94.9 DBA*
10% DECILE=	87.7 DBA*
MEDIAN=	82.3 DBA*
90% DECILE=	65.7 DBA*
99% PERCENTILE=	58.8 DBA*
WALSH HEALEY EXP.=	14.5 %
RANGE=	41 DB

0 20 40 60 80 100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure E-24. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Car Serial Nos 1503,1506 on the MBTA Red Line (So. Shore Extension) Northbound. Microphone located on outside platform between cars, April 29, 1972

```
2       98  0
8       97  0
8       96  0
20      95  00
53      94  000
66      93  000
69      92  0000
53      91  000
36      90  00
35      89  00
56      88  000
54      87  000
101     86  00000
209     85  000000000
372     84  00000000000000
541     83  00000000000000000000
641     82  0000000000000000000000000
405     81  0000000000000000
205     80  00000000
131     79  000000
108     78  00000
97      77  00000
92      76  0000
69      75  0000
51      74  000
40      73  000
49      72  000
34      71  00
23      70  00
41      69  000
29      68  00
36      67  00
35      66  00
38      65  00
30      64  00
48      63  000
37      62  00
57      61  000
74      60  0000
97      59  00000
45      58  000
5       57  0
DIST.   DBA* 0             10             20             30
             LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

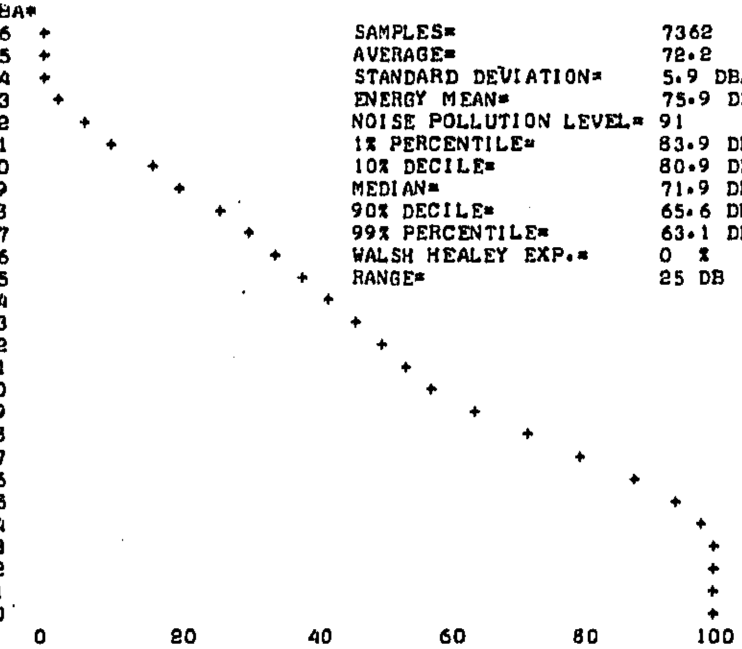
*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure B-24 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Car Serial Nos 1503, 1506 on the MBTA Red Line (So. Shore Extension) Northbound. Microphone located on outside platform between cars, April 29, 1972

US DEPARTMENT OF TRANSPORTATION TUE 07/11/72
TRANSPORTATION SYSTEMS CENTER 13:17
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-1A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 01:34 TO 01:49, IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
4	86
8	85
49	84
133	83
204	82
305	81
421	80
396	79
336	78
370	77
311	76
306	75
282	74
245	73
281	72
277	71
303	70
414	69
637	68
598	67
572	66
453	65
251	64
140	63
52	62
14	61
0	60



LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

SAMPLES=	7362
AVERAGE=	72.2 DBA*
STANDARD DEVIATION=	5.9 DBA*
ENERGY MEAN=	75.9 DB**
NOISE POLLUTION LEVEL=	91
1% PERCENTILE=	83.9 DBA*
10% DECILE=	80.9 DBA*
MEDIAN=	71.9 DBA*
90% DECILE=	65.6 DBA*
99% PERCENTILE=	63.1 DBA*
WALSH HEALEY EXP.=	0 %
RANGE=	25 DB

Figure B-25. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line Northbound. Microphone located mid-car inside car Serial No. 1503, April 29, 1972

```
4       86  0
8       85  0
49      84  00
133     83  0000
204     82  00000
305     81  0000000
421     80  0000000000
396     79  000000000
336     78  00000000
370     77  000000000
311     76  0000000
306     75  0000000
282     74  0000000
245     73  000000
281     72  0000000
277     71  0000000
303     70  0000000
414     69  0000000000
637     68  00000000000000
598     67  0000000000000
572     66  0000000000000
453     65  0000000000
251     64  000000
140     63  0000
52      62  00
14      61  0
DIST. DBA*  0              10              20              30
               LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure E-25 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line Northbound. Microphone located mid-car inside car Serial No. 1503, April 29, 1972

US DEPARTMENT OF TRANSPORTATION TUE 07/11/72
TRANSPORTATION SYSTEMS CENTER 11:41
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-3A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 01:34 TO 01:49, IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
7	88
27	87
83	86
114	85
200	84
270	83
326	82
394	81
409	80
348	79
277	78
286	77
256	76
227	75
199	74
140	73
166	72
156	71
162	70
177	69
192	68
162	67
219	66
240	65
329	64
365	63
419	62
398	61
332	60
321	59
144	58
17	57
0	56

SAMPLES=	7362
AVERAGE=	71.4 DBA*
STANDARD DEVIATION=	8.6 DBA*
ENERGY MEAN=	77.7 DB**
NOISE POLLUTION LEVEL=	99.7
1% PERCENTILE=	86.5 DBA*
10% DECILE=	82.9 DBA*
MEDIAN=	72.3 DBA*
90% DECILE=	60.8 DBA*
99% PERCENTILE=	58.4 DBA*
WALSH HEALEY EXP.=	0 %
RANGE=	31 DB

0 20 40 60 80 100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure B-26. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503, 1506 on the MBTA Red Line Northbound. Microphone located over the rear wheel truck inside car Serial No. 1503, April 27, 1972

```
  7       88   0
 27       87   00
 83       86   000
114       85   000
200       84   00000
270       83   0000000
326       82   00000000
394       81   000000000
409       80   000000000
348       79   00000000
277       78   0000000
286       77   0000000
256       76   000000
227       75   000000
199       74   00000
140       73   0000
166       72   0000
156       71   0000
162       70   0000
177       69   00000
192       68   00000
162       67   0000
219       66   000000
240       65   000000
329       64   00000000
365       63   000000000
419       62   0000000000
398       61   000000000
332       60   00000000
321       59   00000000
144       58   0000
 17       57   0
DIST.  DBA*    0              10             20             30
                 LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

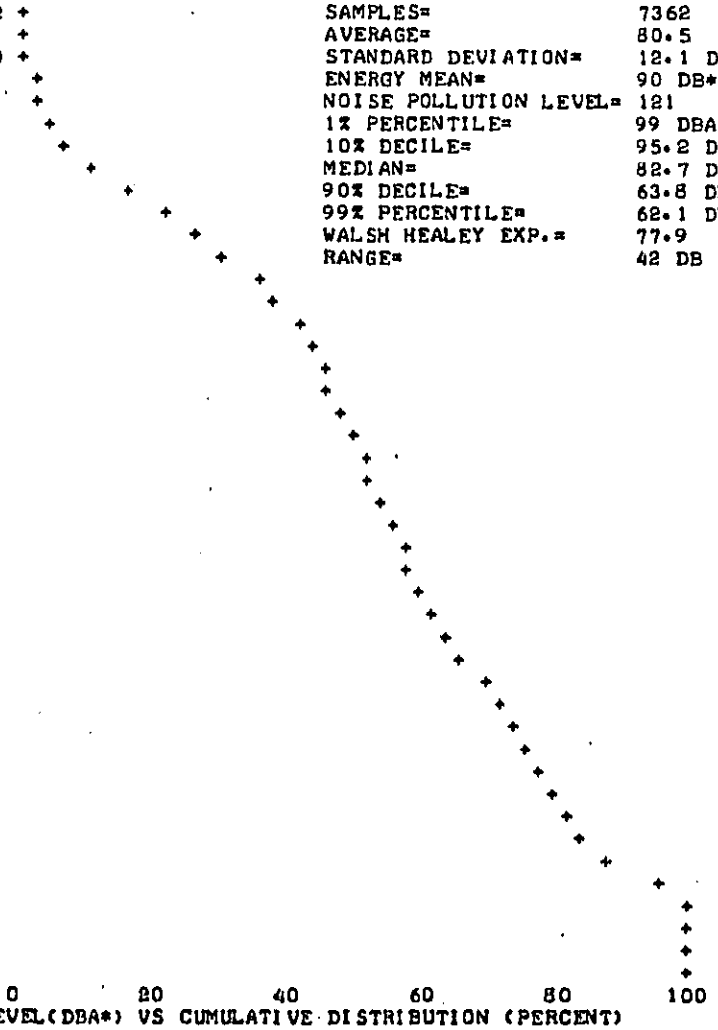
Figure E-26 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line Northbound. Microphone located over the rear wheel truck inside car Serial No. 1503, April 27, 1972

US DEPARTMENT OF TRANSPORTATION TUE 07/11/72
TRANSPORTATION SYSTEMS CENTER 12:03
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-4A OF THE PORTABLE NOISE STATION ON
APRIL 29 1972 FROM 01:34 TO 01:49. IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
2	102
13	101
23	100
36	99
87	98
145	97
209	96
282	95
404	94
373	93
375	92
330	91
301	90
252	89
197	88
168	87
124	86
123	85
104	84
101	83
108	82
121	81
122	80
113	79
126	78
91	77
114	76
124	75
115	74
176	73
230	72
189	71
182	70
154	69
114	68
106	67
173	66
239	65
272	64
477	63
321	62
36	61
10	60
0	59

SAMPLES=	7362
AVERAGE=	80.5 DBA*
STANDARD DEVIATION=	12.1 DBA*
ENERGY MEAN=	90 DB**
NOISE POLLUTION LEVEL=	121
1% PERCENTILE=	99 DBA*
10% DECILE=	95.2 DBA*
MEDIAN=	82.7 DBA*
90% DECILE=	63.8 DBA*
99% PERCENTILE=	62.1 DBA*
WALSH HEALEY EXP.=	77.9 %
RANGE=	42 DB



LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure E-27. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line Northbound. Microphone located on the outside platform cars April 29, 1972

```
2       102 0
13      101 0
23      100 00
36      99  00
87      98  000
145     97  0000
209     96  00000
282     95  0000000
404     94  000000000
373     93  000000000
375     92  000000000
330     91  00000000
301     90  0000000
252     89  000000
197     88  00000
168     87  00000
124     86  0000
123     85  0000
104     84  000
101     83  000
108     82  000
121     81  0000
122     80  0000
113     79  000
126     78  0000
91      77  000
114     76  000
124     75  0000
115     74  000
176     73  00000
230     72  000000
189     71  00000
182     70  00000
154     69  0000
114     68  000
106     67  000
173     66  00000
239     65  000000
272     64  0000000
477     63  00000000000
321     62  00000000
36      61  00
10      60  0
DIST. DBA*  0           10            20            30
              LEVEL(DBA*) VS DISTRIBUTION (PERCENT)
```

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure E-27 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line Northbound. Microphone located on the outside platform cars, April 29, 1972

US DEPARTMENT OF TRANSPORTATION FRI 06/23/72
TRANSPORTATION SYSTEMS CENTER 16:03
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-1A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 03:48 TO 03:56, IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
1	85
6	84
19	83
58	82
69	81
64	80
67	79
89	78
80	77
102	76
163	75
183	74
249	73
243	72
312	71
273	70
335	69
364	68
292	67
317	66
286	65
156	64
69	63
36	62
6	61
1	60
0	59

SAMPLES=	3840
AVERAGE=	70.4 DBA*
STANDARD DEVIATION=	4.7 DBA*
ENERGY MEAN=	73.4 DB**
NOISE POLLUTION LEVEL=	85.4
1% PERCENTILE=	82.8 DBA*
10% DECILE=	77.9 DBA*
MEDIAN=	70.2 DBA*
90% DECILE=	65.4 DBA*
99% PERCENTILE=	62.9 DBA*
WALSH HEALEY EXP.=	0 %
RANGE=	25 DB

0 20 40 60 80 100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure E-28. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line (Ashmont Extension) Northbound. Microphone located inside mid-car, April 29, 1972

DIST.	DBA*	
1	85	0
6	84	0
19	83	00
58	82	000
69	81	0000
64	80	0000
67	79	0000
89	78	00000
80	77	0000
102	76	00000
163	75	0000000
183	74	00000000
249	73	00000000000
243	72	00000000000
312	71	0000000000000
273	70	000000000000
335	69	00000000000000
364	68	000000000000000
292	67	0000000000000
317	66	0000000000000
286	65	000000000000
156	64	0000000
69	63	0000
36	62	000
6	61	0
1	60	0
DIST.	DBA*	0 10 20 30

LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure E-28 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line (Ashmont Extension) Northbound. Microphone located inside mid-car, April 29, 1972

US DEPARTMENT OF TRANSPORTATION FRI 06/23/72
TRANSPORTATION SYSTEMS CENTER 16:20
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-3A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 03:48 TO 03:56. IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
1	90
0	89
1	88
4	87
6	86
29	85
47	84
91	83
116	82
119	81
138	80
145	79
183	78
224	77
225	76
231	75
165	74
163	73
116	72
85	71
63	70
75	69
92	68
98	67
83	66
106	65
97	64
148	63
165	62
251	61
261	60
218	59
84	58
8	57
1	56
0	55
1	54
0	53

SAMPLES=	3840
AVERAGE=	70.5 DBA*
STANDARD DEVIATION=	8 DBA*
ENERGY MEAN=	76.1 DB**
NOISE POLLUTION LEVEL=	96.6
1% PERCENTILE=	85.1 DBA*
10% DECILE=	81.3 DBA*
MEDIAN=	72.7 DBA*
90% DECILE=	60.3 DBA*
99% PERCENTILE=	58.3 DBA*
WALSH HEALEY EXP.=	0 %
RANGE=	36 DB

0 20 40 60 80 100
LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure E-29. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503, 1506 on the MBTA Red Line (Ashmont Extension) Northbound. Microphone located inside over rear wheel truck, April 29, 1972

DIST.	DBA*	
1	90	0
0	89	0
1	88	0
4	87	0
6	86	0
29	85	00
47	84	000
91	83	00000
116	82	000000
119	81	000000
138	80	000000
145	79	0000000
183	78	00000000
224	77	0000000000
225	76	0000000000
231	75	0000000000
165	74	00000000
163	73	0000000
116	72	000000
85	71	0000
63	70	0000
75	69	0000
92	68	00000
98	67	00000
83	66	0000
106	65	00000
97	64	00000
148	63	0000000
165	62	00000000
251	61	00000000000
261	60	00000000000
218	59	0000000000
84	58	0000
8	57	0
1	56	0
0	55	0
1	54	0
DIST.	DBA*	0 10 20 30

LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

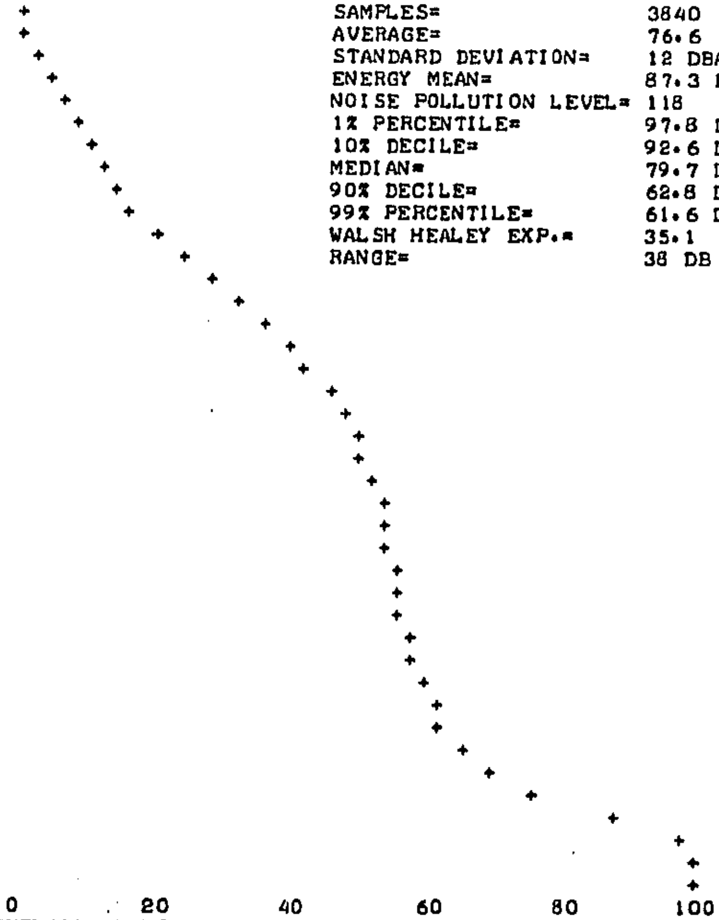
Figure E-29 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503,1506 on the MBTA Red Line (Ashmont Extension) Northbound. Microphone located inside over rear wheel truck April 29, 1972.

US DEPARTMENT OF TRANSPORTATION FRI 06/23/72
TRANSPORTATION SYSTEMS CENTER 16:34
NOISE ABATEMENT GROUP

NOISE DATA FROM RUN NO. RT-47-72-4A OF THE PORTABLE NOISE STATION ON APRIL 29 1972 FROM 03:48 TO 03:53, IN MBTA CAR SER. NO. 1503 & 1506
(ZONE 99 UNIVERSAL GRID LOCATION 999 - 9999 .)
(1/8 SECOND INTEGRATIONS, 8 PER SECOND)

DISTRIBUTION	DBA*
5	99.
23	98
50	97
62	96
63	95
69	94
77	93
80	92
80	91
108	90
133	89
160	88
163	87
177	86
140	85
114	84
125	83
119	82
95	81
59	80
55	79
46	78
35	77
27	76
29	75
33	74
27	73
27	72
44	71
38	70
46	69
42	68
55	67
104	66
165	65
253	64
458	63
391	62
63	61
0	60

SAMPLES= 3840
AVERAGE= 76.6 DBA*
STANDARD DEVIATION= 12 DBA*
ENERGY MEAN= 87.3 DB**
NOISE POLLUTION LEVEL= 118
1% PERCENTILE= 97.8 DBA*
10% DECILE= 92.6 DBA*
MEDIAN= 79.7 DBA*
90% DECILE= 62.8 DBA*
99% PERCENTILE= 61.6 DBA*
WALSH HEALEY EXP.= 35.1 %
RANGE= 38 DB



LEVEL(DBA*) VS CUMULATIVE DISTRIBUTION (PERCENT)

Figure E-30. Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503, 1506 on the MBTA Red Line (Ashmont Extension) Northbound. Microphone located on outside platform between cars, April 29, 1972

DIST.	DBA*	0 10 20 30
5	99	0
23	98	00
50	97	000
62	96	0000
63	95	0000
69	94	0000
77	93	0000
80	92	0000
80	91	0000
108	90	00000
133	89	000000
160	88	0000000
163	87	0000000
177	86	00000000
140	85	0000000
114	84	000000
125	83	000000
119	82	000000
95	81	00000
59	80	000
55	79	000
46	78	000
35	77	00
27	76	00
29	75	00
33	74	00
27	73	00
27	72	00
44	71	000
38	70	000
46	69	000
42	68	000
55	67	000
104	66	00000
165	65	00000000
253	64	00000000000
458	63	0000000000000000000
391	62	0000000000000000
63	61	0000

LEVEL(DBA*) VS DISTRIBUTION (PERCENT)

*-A WEIGHTED DECIBELS-RE. 20 MICRONEWTONS PER SQUARE METER
**-DBA RE. 20 MICRONEWTONS PER SQUARE METER FROM AN AVERAGE OF THE SQUARES OF THE SOUND PRESSURES.

Figure E-30 (Continued). Statistical Analysis - In-Car Noise Data, MBTA Type 1 So. Shore Rapid Transit Cars Serial Nos 1503, 1506 on the MBTA Red Line (Ashmont Extension) Northbound. Microphone located on outside platform between cars, April 29, 1972

APPENDIX F

IN-CAR FLOOR-VIBRATION MEASUREMENTS - MBTA RED LINE

APRIL 29, 1972

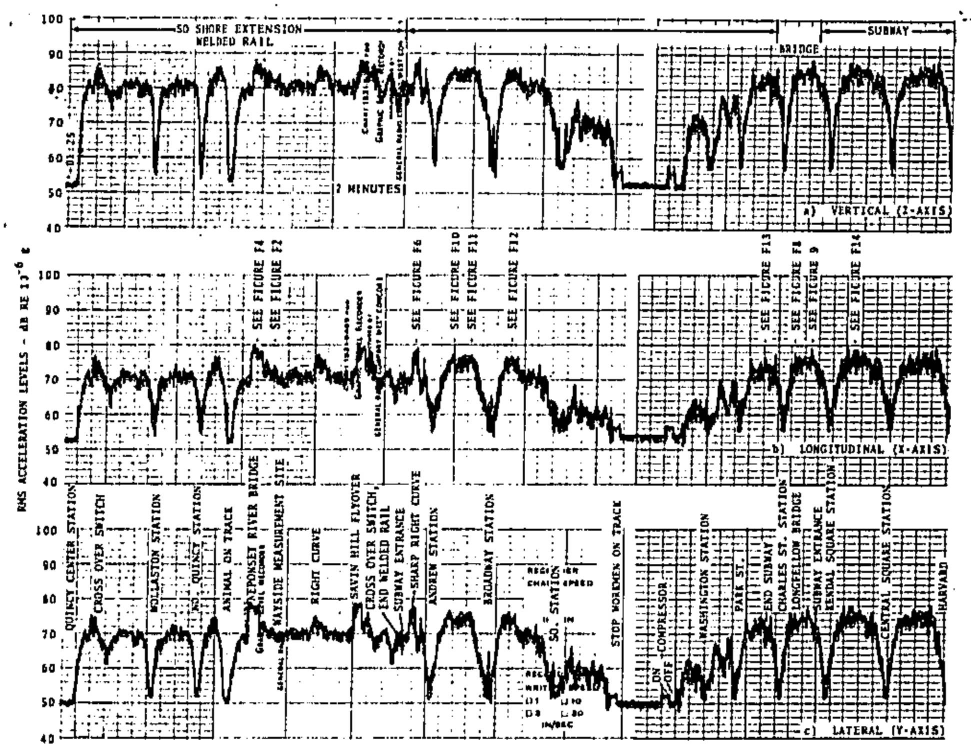


Figure F-1. Coincident Time Histories - Floor-Vibration Levels Measured in Three Axes on MBTA Type 1 So. Shore Rapid Transit Cars S/n 1503, 1506 on the MBTA Red Line and So. Shore Extension, April 27, 1972. Triaxial Accelerometer Mounted on Floor Tiles Inside Car S/n 1503 Centered Over the Rear Wheel Trucks. See figure G-2 for Accelerometer Location. See figure E-1 for Speed Profile.

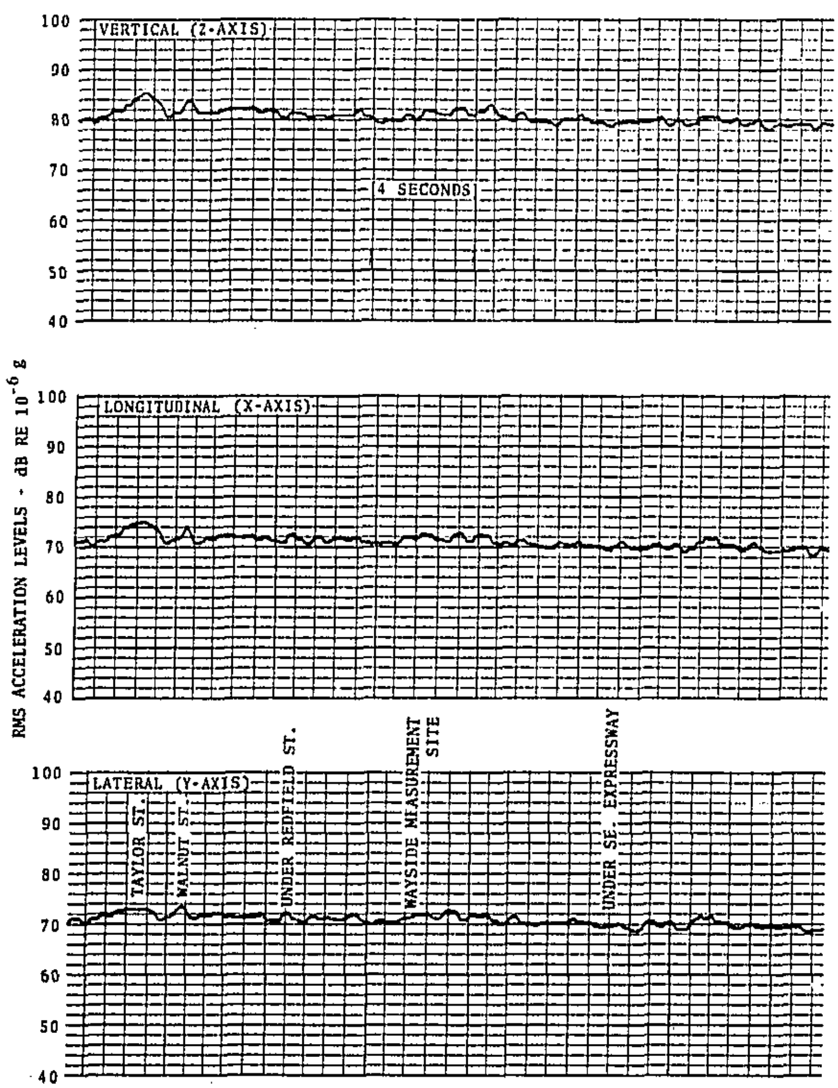


Figure F-2. Coincident Time Histories of Floor Vibration Levels in three axes. Northbound Tenean St Wayside Measurement Site. MBTA Red Line (So. Shore Extension). April 29, 1972. (See Figure F-1).

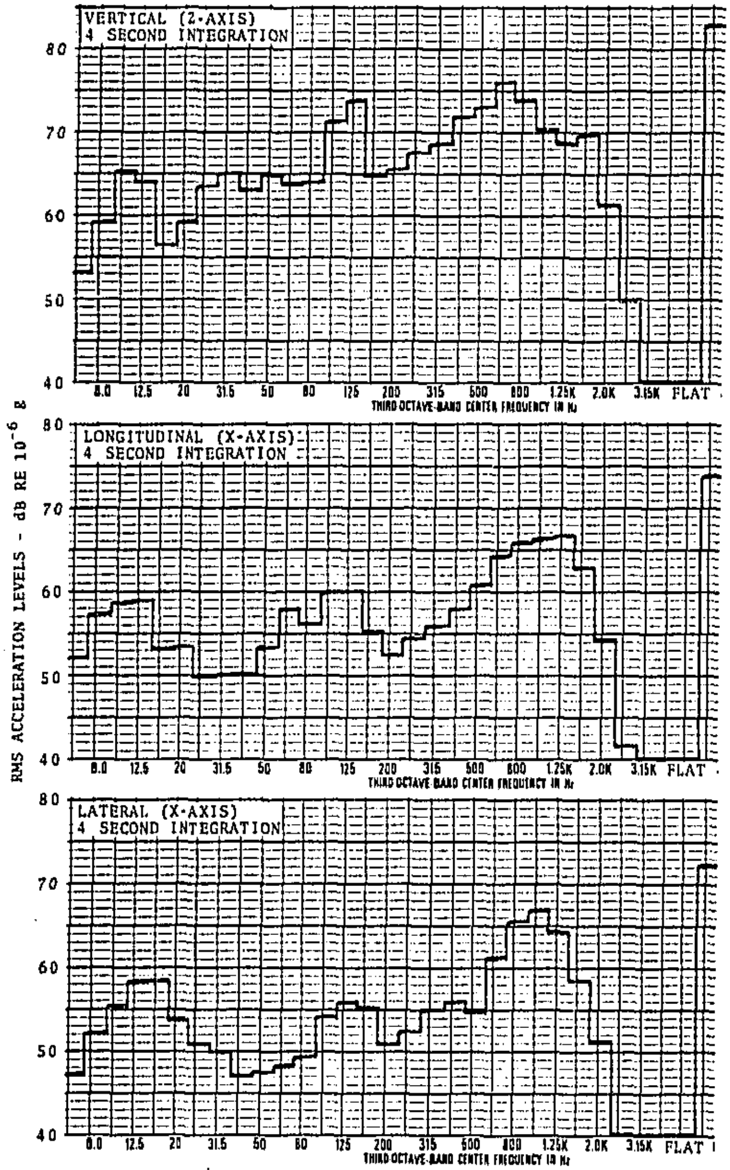


Figure F-3 Coincident Floor Vibration Spectra in three axes. Tenean St. Wayside Measurement Site. MBTA Red Line (So. Shore Extension) April 29, 1972. (See Figure F-2)

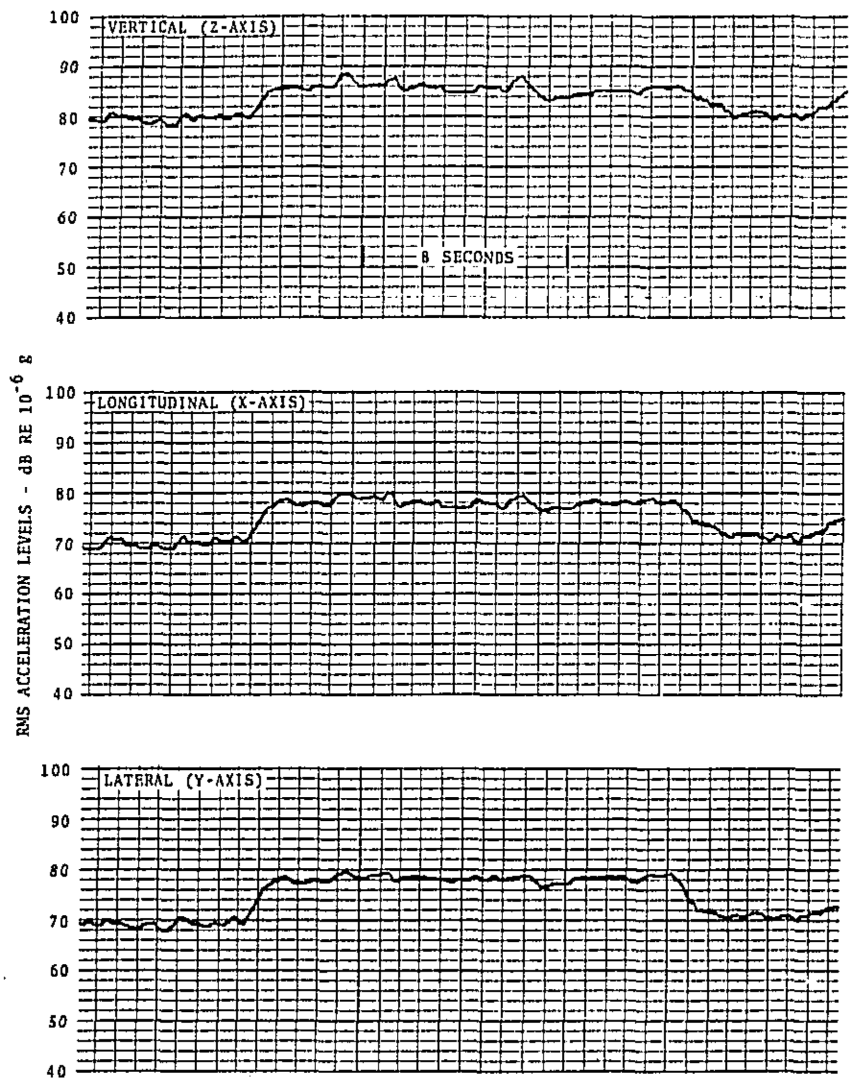


Figure F-4 Coincident Time Histories of Floor Vibration Levels in three axes. Neponset River Bridge. MBTA Red Line (So. Shore Extension) April 29, 1972. (See Figure R-1).

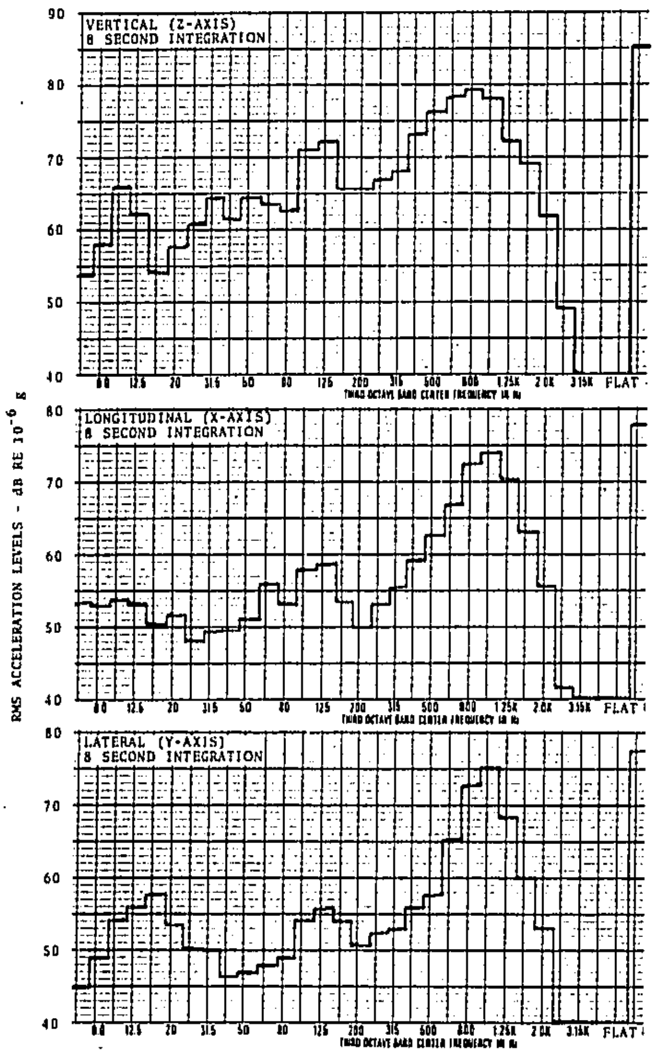


Figure F-5 Coincident Floor Vibration Spectra in three axes. Neponset River Bridge. MBTA Red Line (So. Shore Extension) April 29, 1972. (See Figure F-4)

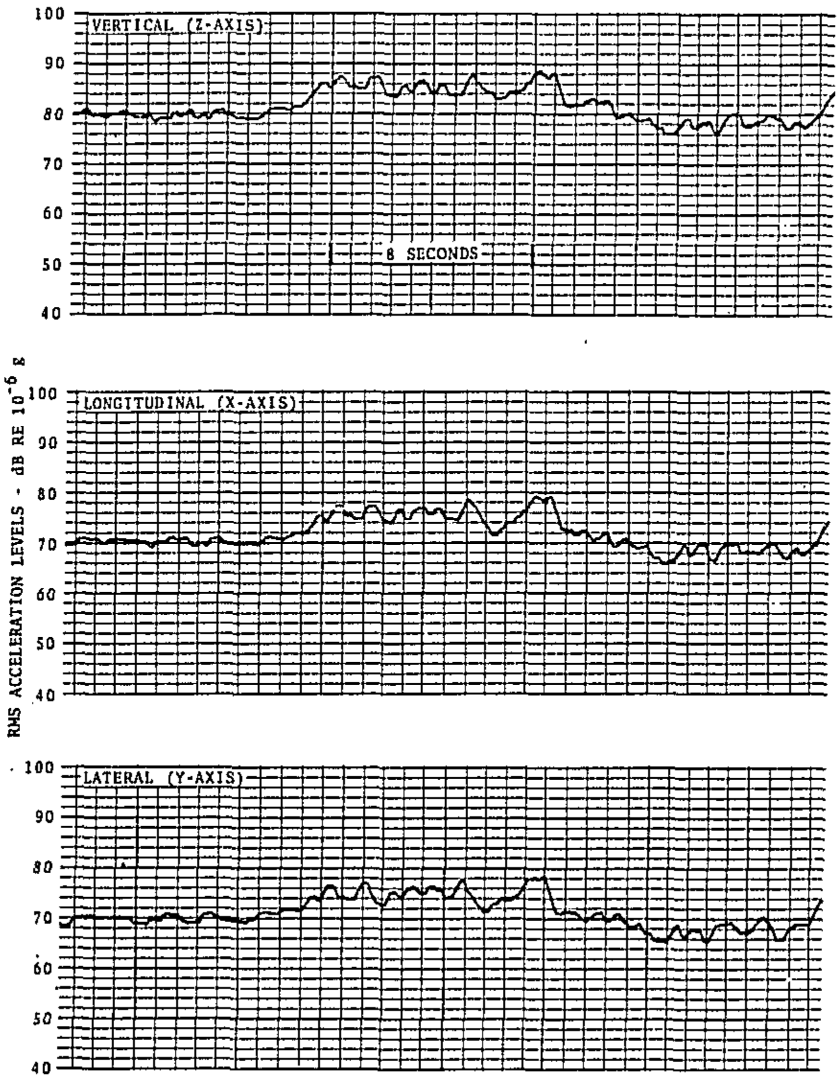


Figure F-6. Coincident Time Histories of Floor-Vibration Levels in three axes. Right-hand curve after entering tunnel before Andrew Station. MBTA Red Line, April 29, 1972. See figure F-1.

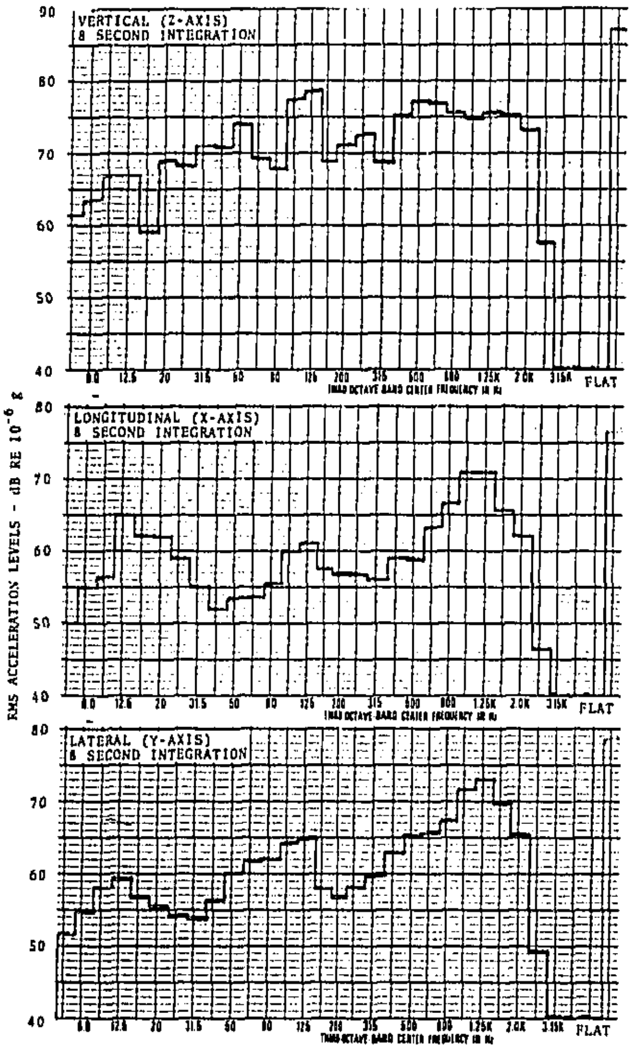


Figure F-7. Coincident Floor-Vibration Spectra in three axes. Sharp right-hand curve after entering tunnel before Andrew Station. MBTA Red Line, April 29, 1972. See figure F-6.

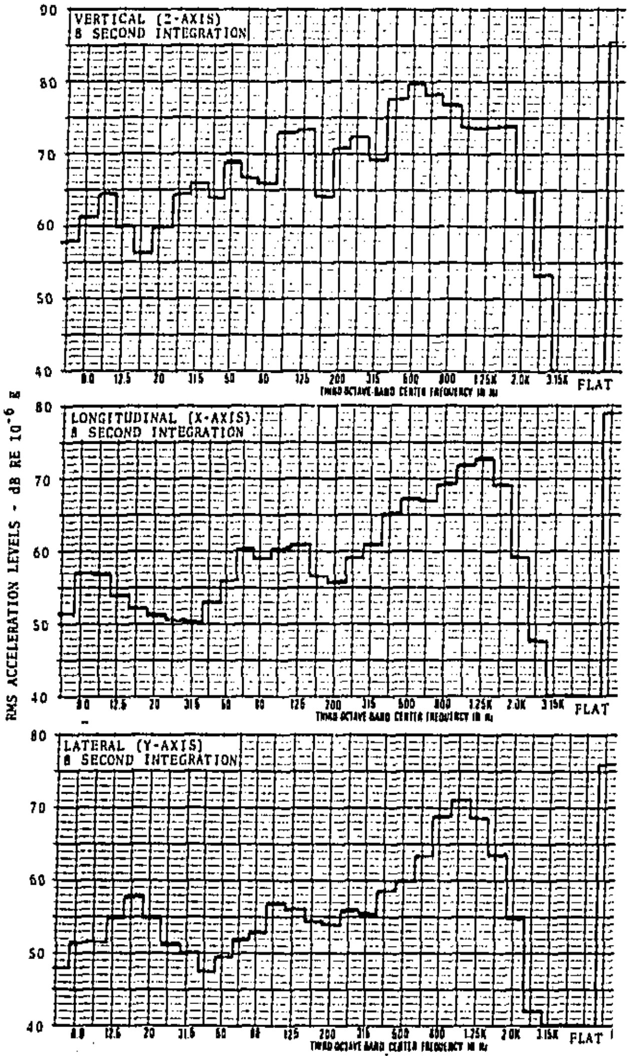


Figure F-8 Coincident Floor Vibration Spectra in three axes at Crest of Longfellow Bridge. MBTA Red Line, April 29, 1972. See Figure F1.

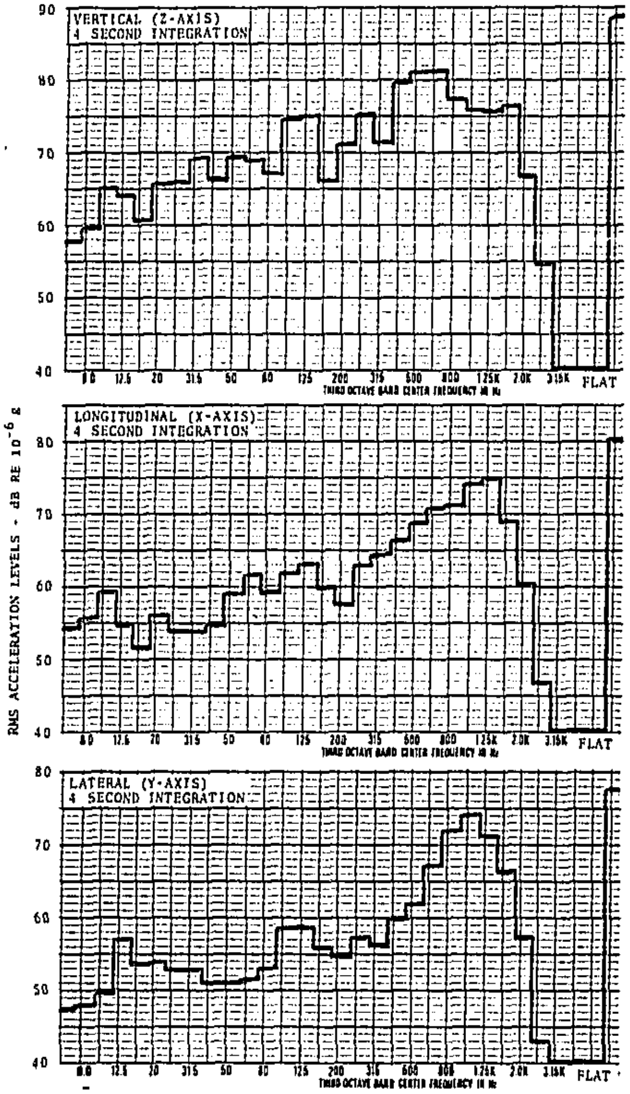


Figure F-9 Coincident Floor-Vibration Spectra in three axes at Cambridge End of Longfellow Bridge. MBTA Red Line, April 29, 1972. See figure F-1.

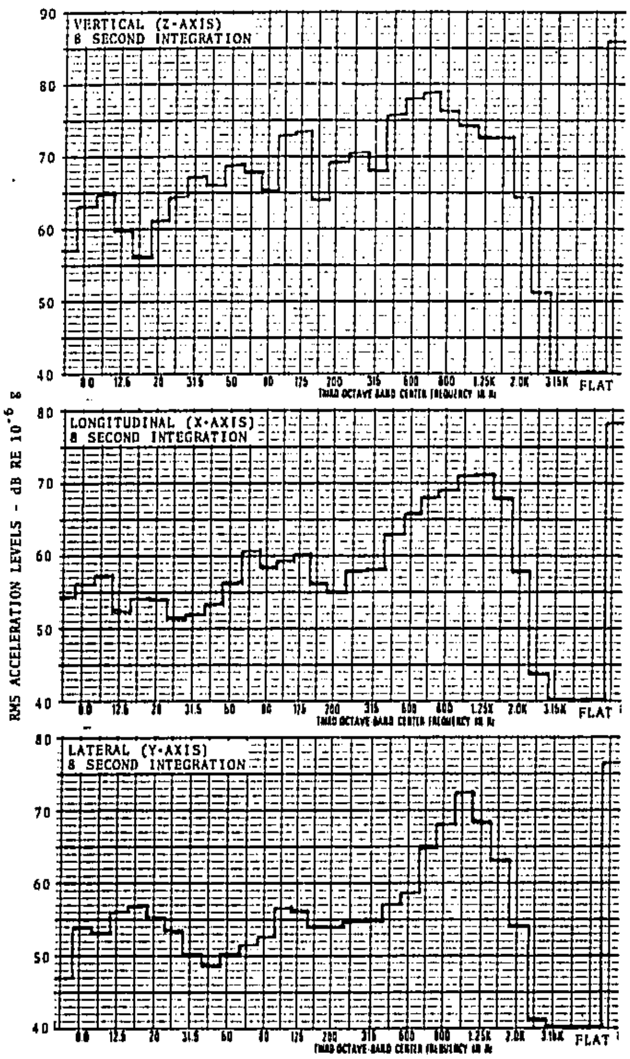


Figure F-10 Coincident Floor Vibration Spectra in three axes. Dorchester Tunnel between Andrew and Broadway Stations. MBTA Red Line, April 29, 1972. See Figure R1. See Figure R2 for tunnel cross section.

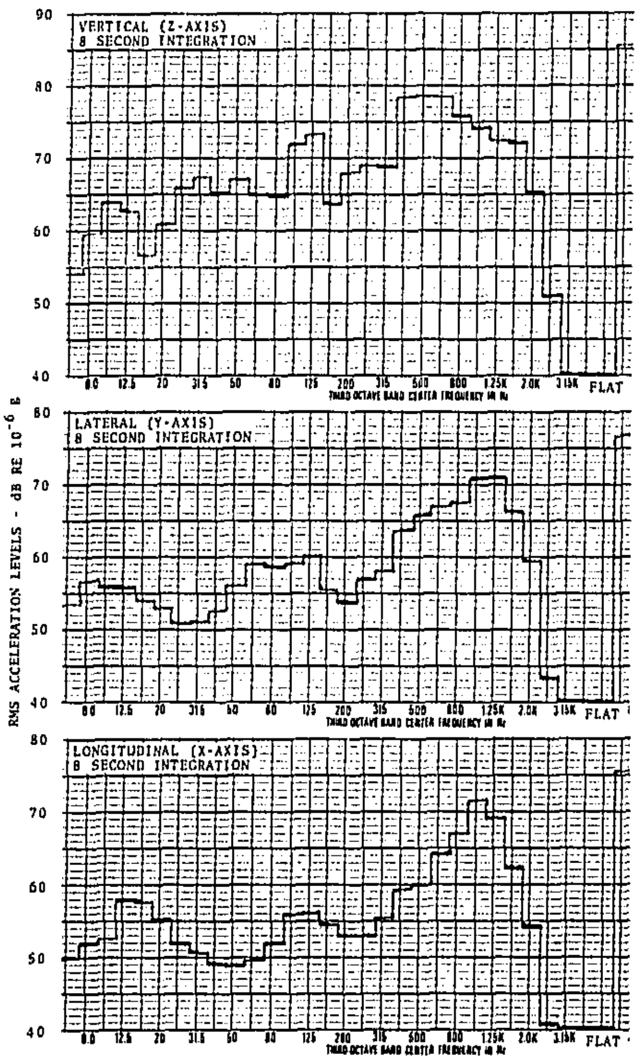


Figure F-11 Coincident Floor Vibration Spectra in three axes. Two Section Tunnel between Andrew and Broadway Stations: MBTA Red Line, April 29, 1972. See Figure E1. See Figure J-3 for tunnel cross section.

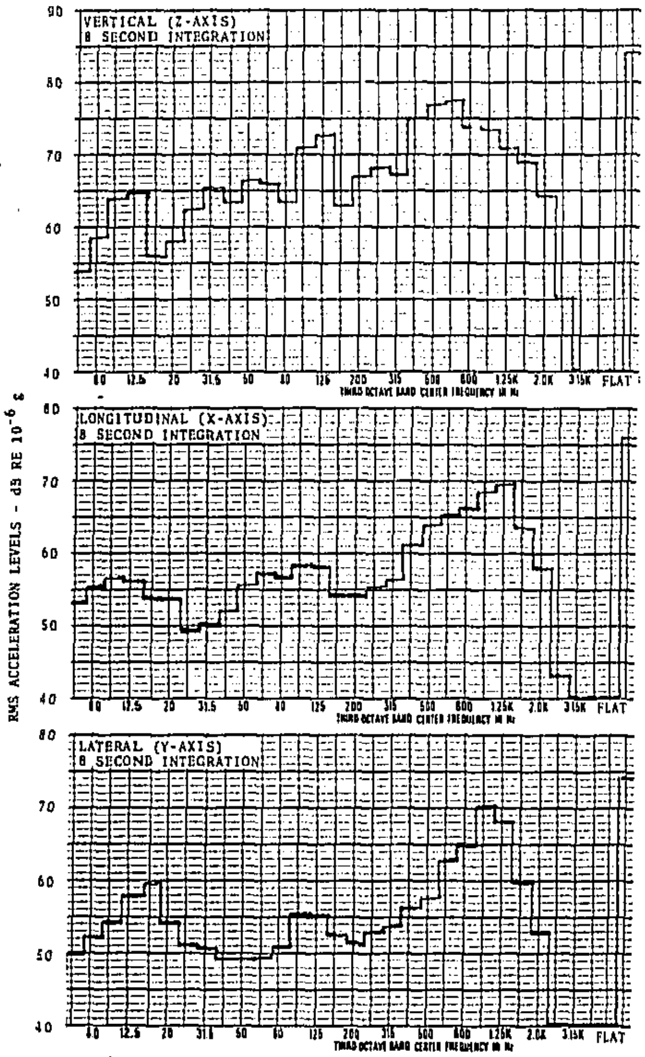


Figure F-12. Coincident Floor-Vibration Spectra in three axes. Circular Tunnel between Broadway and So Stations MBTA Red Line, April 29, 1972. See figure F-1. See figure J-4 for tunnel cross section.

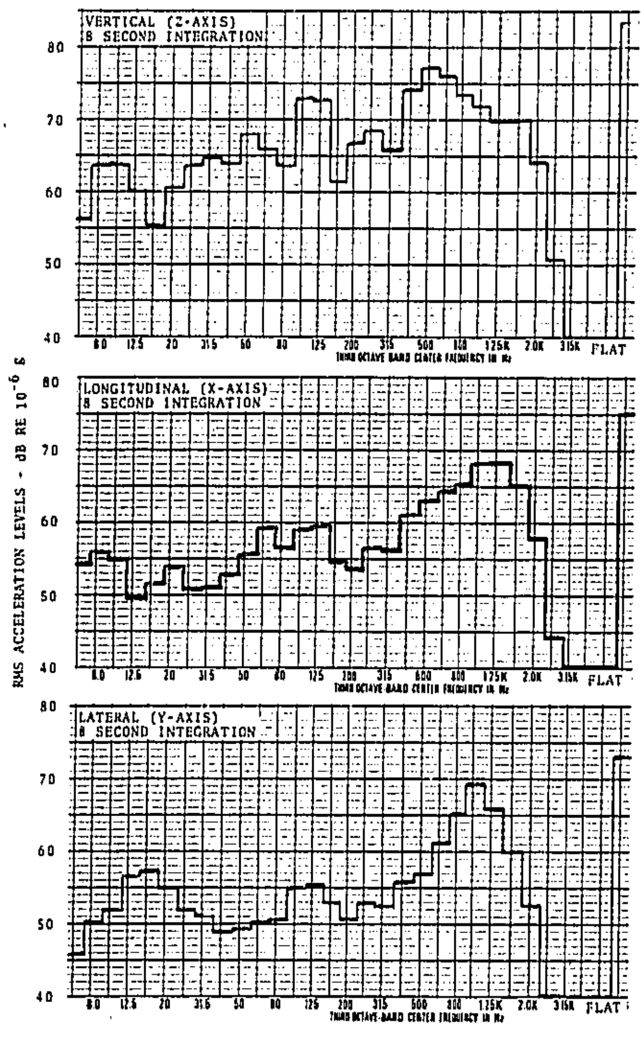


Figure F-13 Coincident Floor Vibration Spectra in three axes. Beacon Hill Tunnel between Park St and Charles St. Stations. MBTA Red Line, April 29, 1972. See Figure F-1. See Figure J-5 for tunnel cross section.

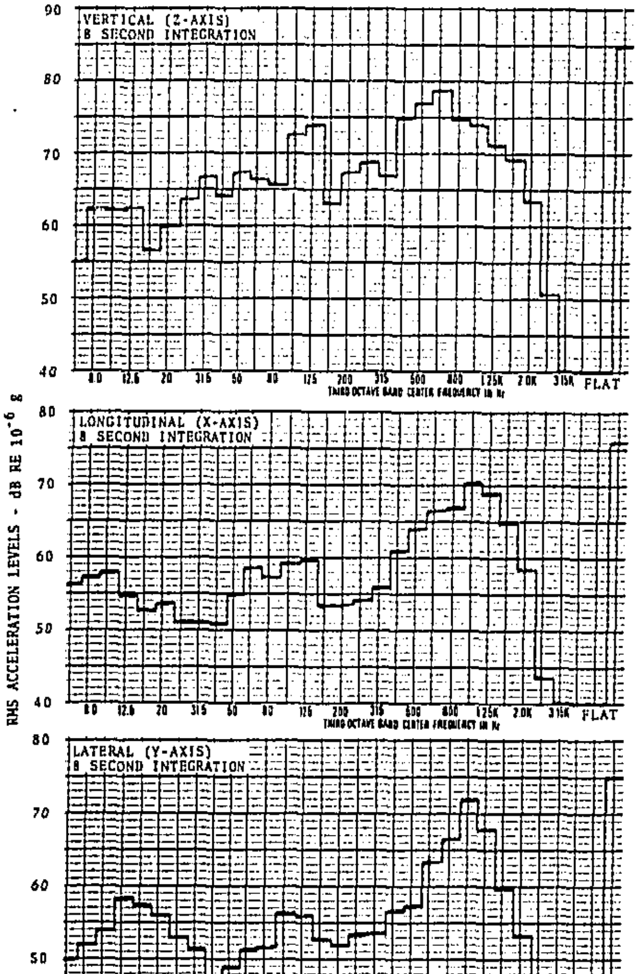


Figure F-14 Coincident Floor Vibration Spectra in three axes in Main St. Tunnel between Kendall and Central Stations. MBTA Red Line, April 29, 1972. See Figure F-1. See Figure J-6 for tunnel cross section.

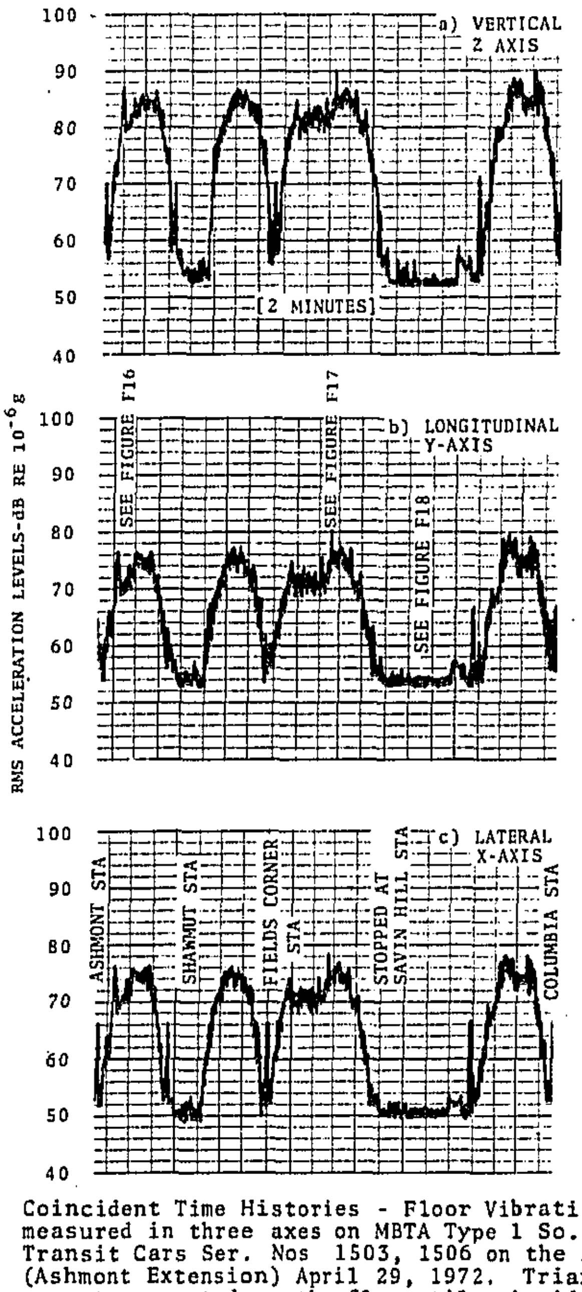


Figure F-15 Coincident Time Histories - Floor Vibration Levels measured in three axes on MBTA Type 1 So. Shore Rapid Transit Cars Ser. Nos 1503, 1506 on the MBTA Red Line (Ashmont Extension) April 29, 1972. Triaxial accelerometer mounted on the floor tiles inside Car No. 1503 centered over the rear wheel trucks. See Figure G-2 for accelerometer locations. See Figure E-15 for speed profile.

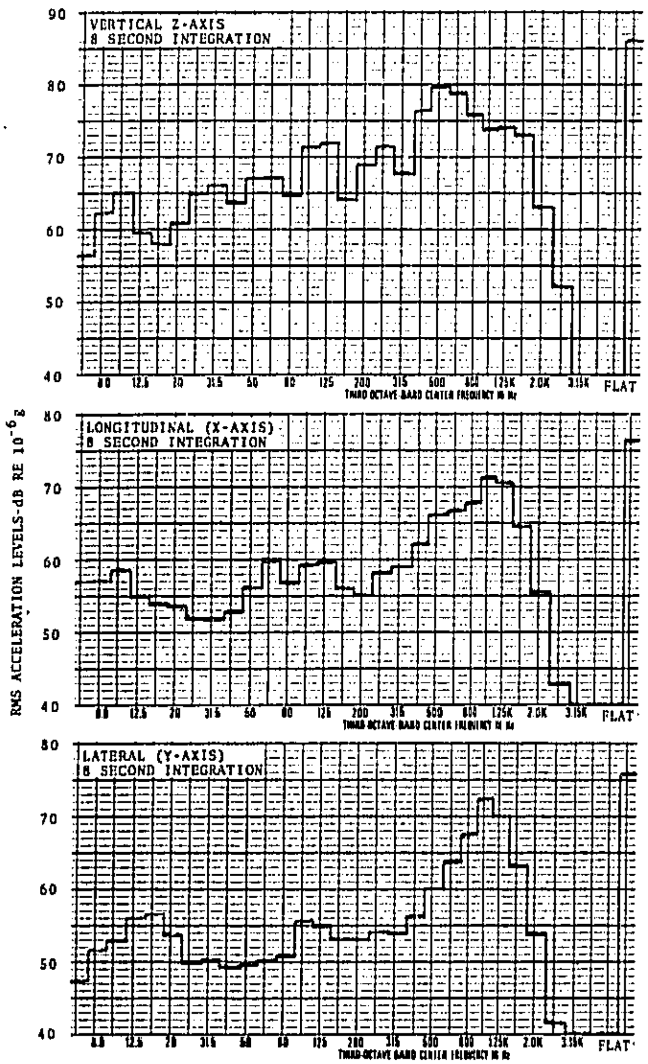


Figure F-16 Coincident Floor Vibration Spectra in three axes. Ashmont Tunnel between Ashmont and Shawmut Stations. MBTA Red Line (Ashmont Extension), April 29, 1972. See Figure F-15.

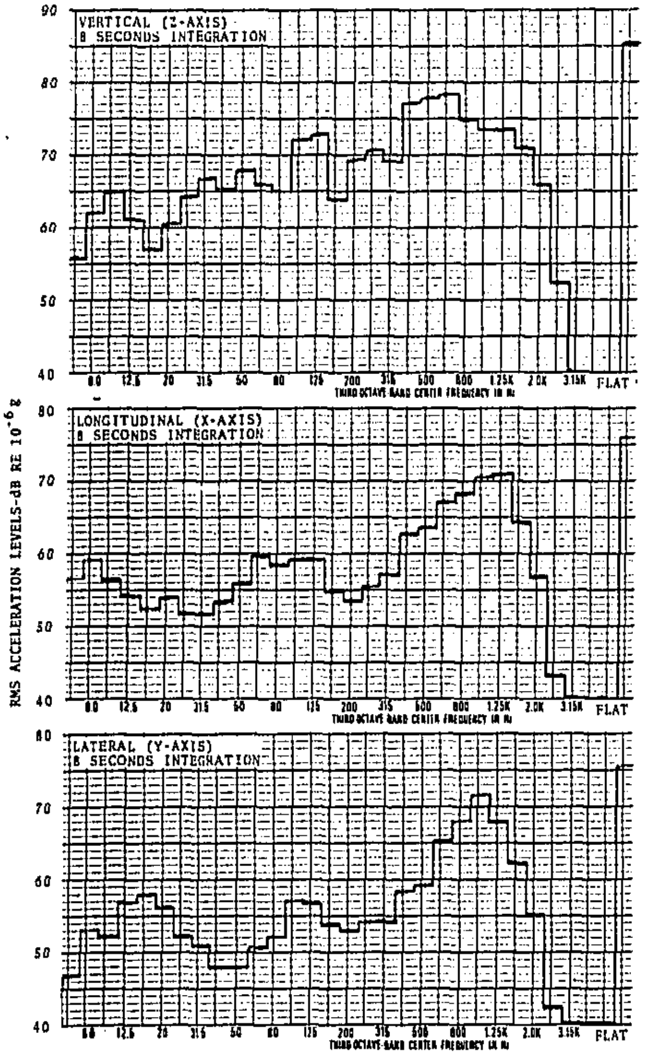


Figure F-17 Coincident Floor Vibration Spectra in three axes. Cruising on straight run, surfaceline between Fields Corner and Savin Hill Stations. MBTA Red Line (Ashmont Extension) April 29, 1972. See Figure F-15.

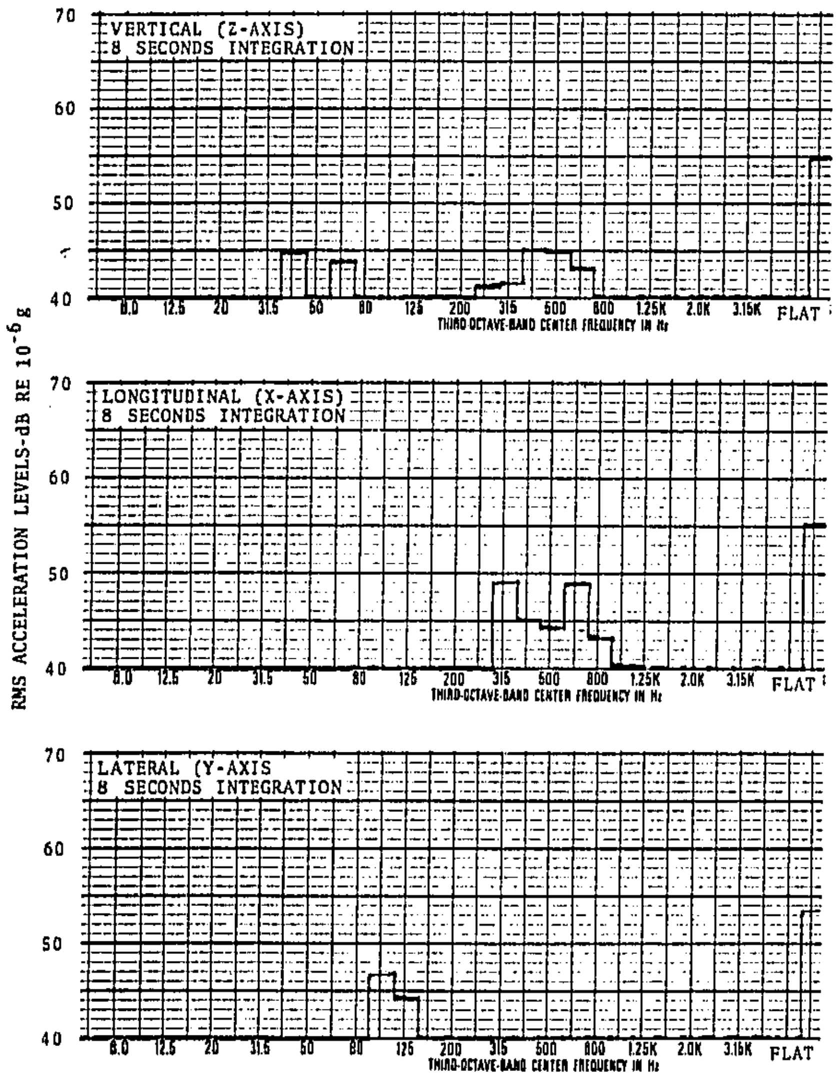


Figure F-18 Coincident Floor Vibration Spectra in three axes. Stopped with doors open at Savin Hilll Station. MBTA Red Line (Ashmont Extension) April 29, 1972. See Figure F-15.

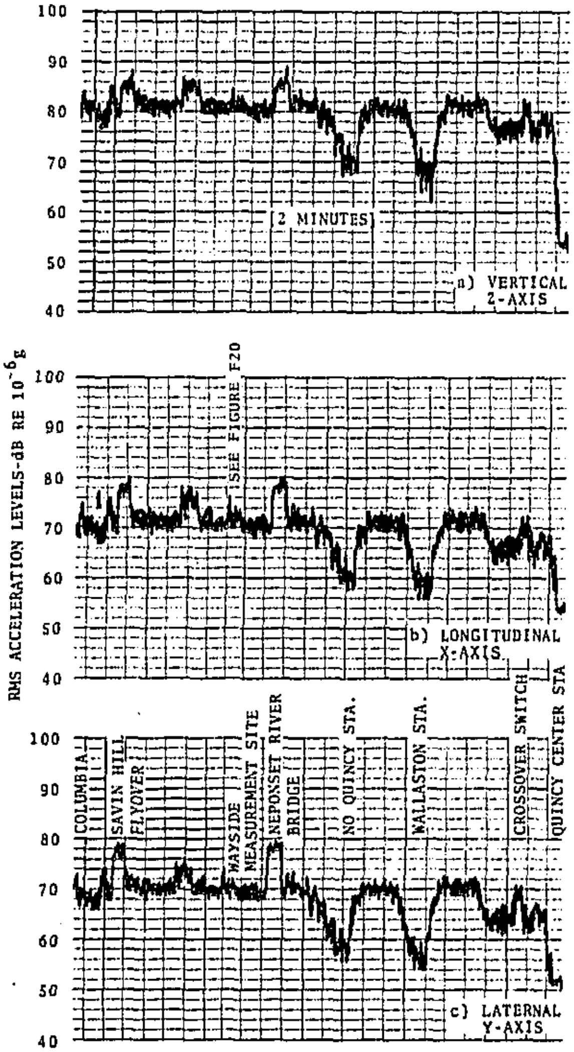


Figure F-19 Coincident Time Histories - Floor Vibration Levels in three axes on MBTA Type 1 So. Shore Rapid Transit Cars. Ser. Nos 1503, 1506 on the MBTA Red Line (So. Shore Extension) southbound. April 29, 1972. Triaxial accelerometer mounted on the floor tiles inside Car No. 1503 centered over the rear wheel trucks. See Figure G2 for accelerometer location. See Figure E19 for speed profile.

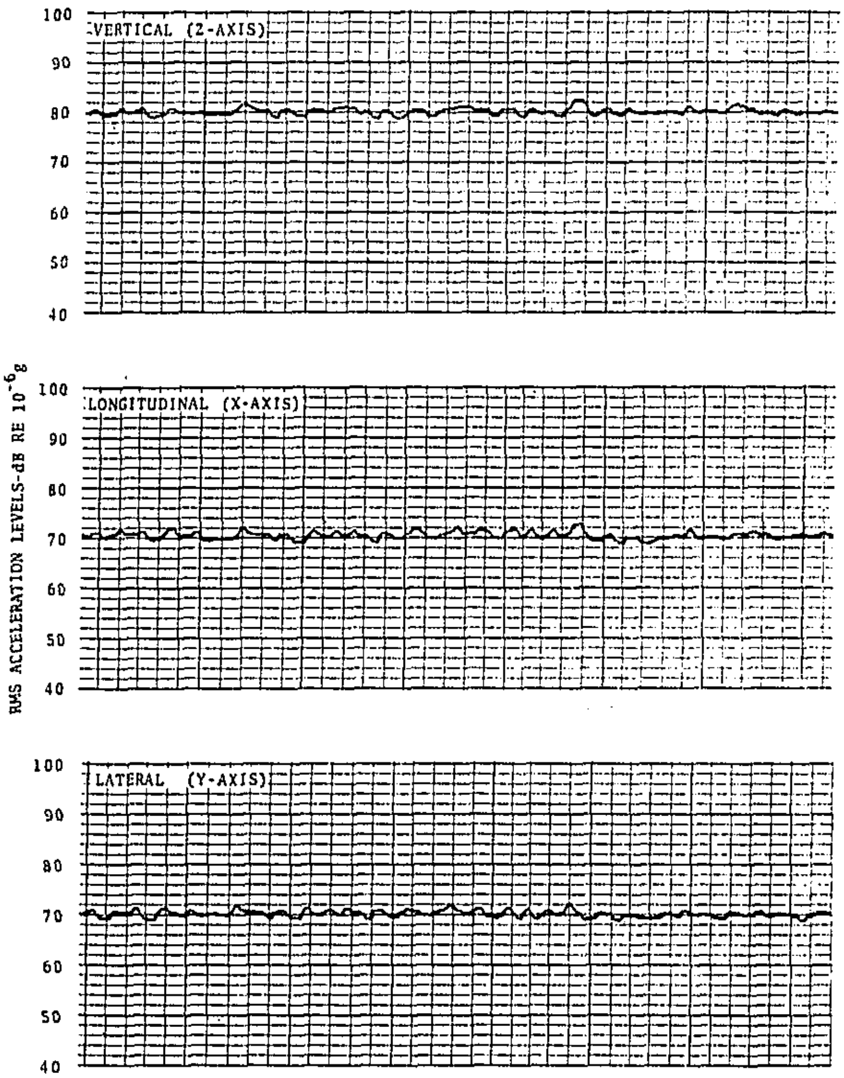


Figure F-20 Coincident Time Histories of Floor Vibration Levels in three axes. Southbound Tenean St. Wayside Measurement Site. MBTA Red Line (So. Shore Extension) April 29, 1972. See Figure F-19.

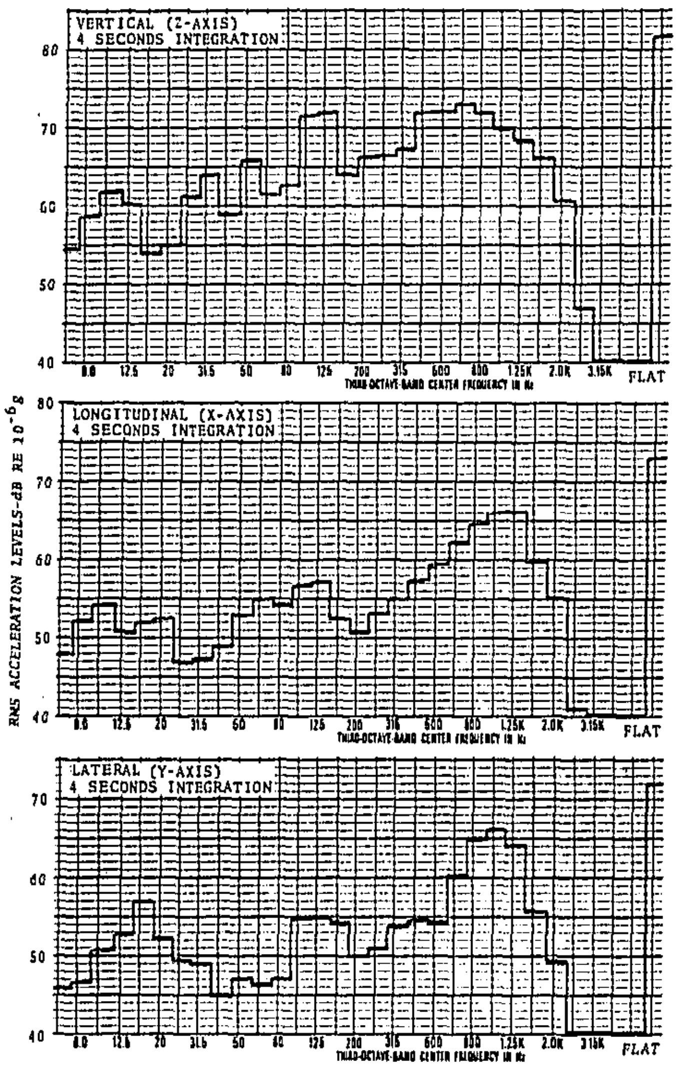


Figure F-21 Coincident Floor Vibration Spectra in three axes. Southbound Tenean St. Wayside Measurement Site. MBTA Red Line (So. Shore Extension) April 29, 1972. See figure F-20.

APPENDIX G

MICROPHONE AND VIBRATION TRANSDUCER LOCATIONS

MEASUREMENT LOCATIONS

Figure G-1 depicts the location of the three wayside microphone systems and triaxial accelerometer systems set in an MBTA storage yard on Tenean St. Dorchester, MA next to the MBTA Rapid Transit tracks of the Red Line's So. Shore Extension. The microphones were placed 25 ft., 50 ft. and 100 ft. from the centerline of the near northbound track and six feet above level grade. The top of the rails in this location was 3 ft. 1 inch above level grade. The triaxial arrangement of accelerometers were mounted on a brass rod (2 ft. long and 7/8 inch in diameter) which was driven into the ground 25 ft. from the centerline of the northbound track at a point 2 ft. away from microphone system No. 1.

For the October 28, 1971 measurements, a robot camera was placed 100 ft. from the northbound track and was programmed to take sequential photographs of the passing trains every 1/4 second. These photographs were used to calculate the speed of the train.

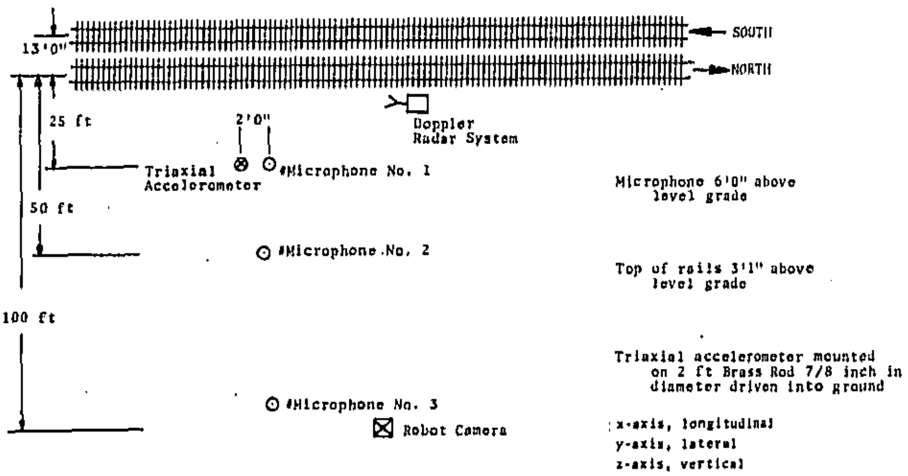
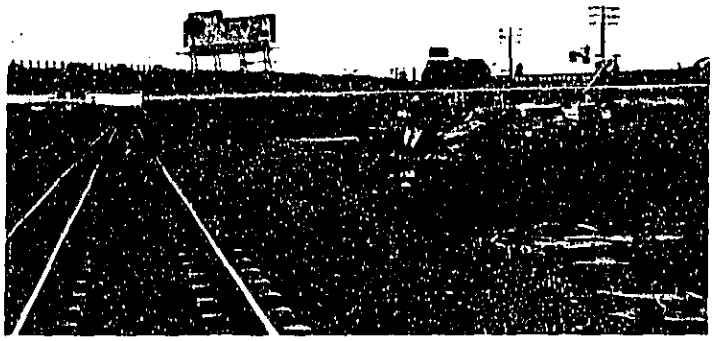


Figure G-1. Wayside Instrument Locations MBTA Red Line - So. Shore Extension, Tenean Street, Dorchester, MA

For the April 27, 1971 measurements an X-band Doppler radar system was set up trackside for speed information.

Figures G-2 through G-5 are photographs of the Tenean Street measurement site.

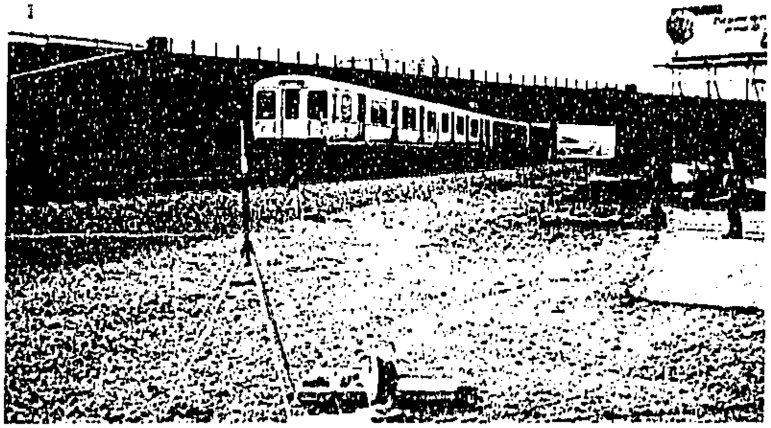
Figure G-6 shows the location of three microphones set up in the lead car of a 2-car train. Microphone system No. 1 was placed at ear level of a seated passenger at a mid-car location (3.5 ft. above the floor); microphone system No. 2 was placed at ear level of a seated passenger and located over the rear wheel trucks (3.5 ft. above floor); microphone system No. 3 was placed on the outside platform between cars at a height of 5.5 ft. (See photograph of car interior figure G-7.) A triaxial accelerometer was attached with a thin layer of bee's wax to the floor tiles inside and was centered over the rear wheel truck (See photograph figure G-8.) Speed of the train over the Red Line was obtained from the in-car digital speedometer in the car operater's compartment. A technician stationed in the compartment read the speed data from the speedometer and position statistics into a synchronized tape recorder.



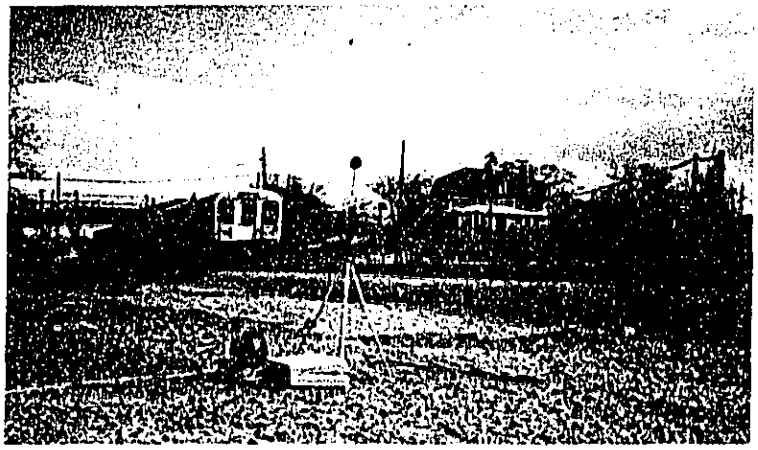
a) North bound - SE Expressway in Background

b) South bound - Redfield Street Bridge in Background

Figure G-2. Two Views at Tenean Street Wayside Measurement Site

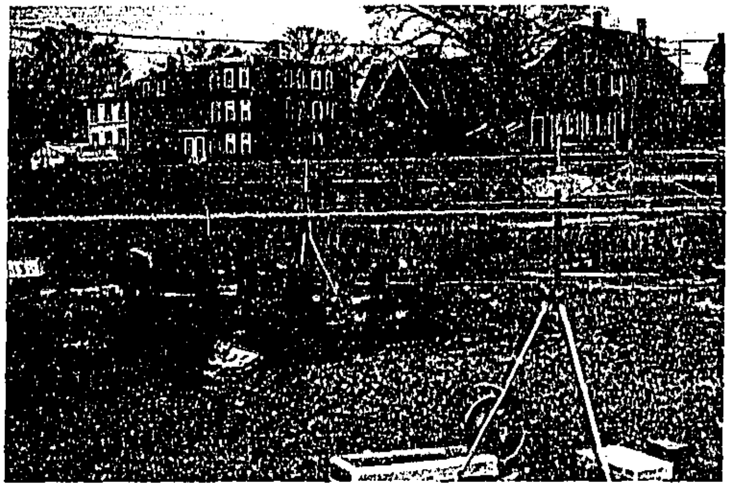


a) Southbound



b) Northbound

Figure G-3. 4-Car Trains Approaching at Tenean St. Wayside Measurement Site. Microphone No. 1 in Foreground



a) From Trackside, Tenean St. in Background

b) From Microphone No. 3

Figure G-4. Two Views of the Microphone at Tenean St. Wayside Measurement Site

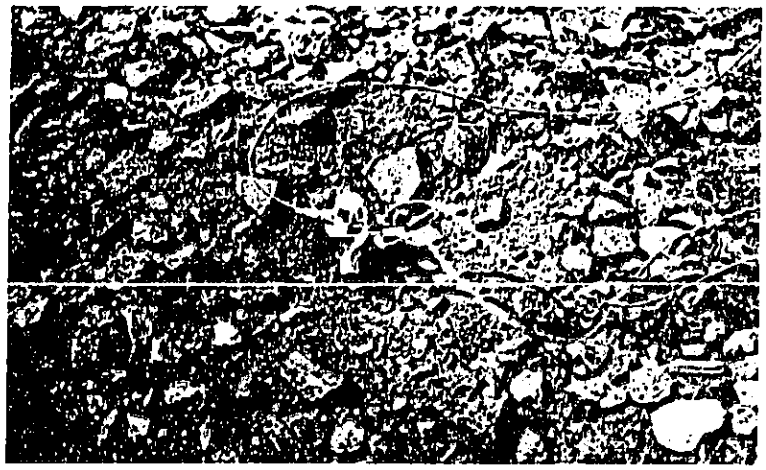
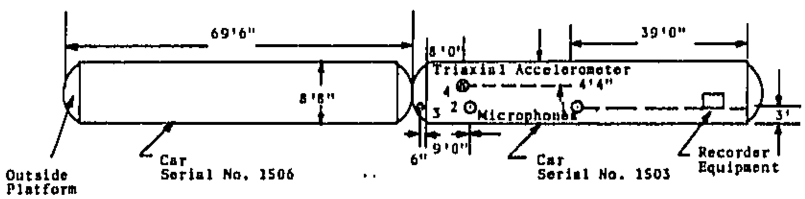


Figure G-5. Triaxial Vibration Transducer Mounted on 7/8" diameter, 2 ft. brass rod driven in ground. Tenean St. Wayside Measurement Site



* Drawing not drawn to scale

1. Microphone located mid-car at ear level to a seated passenger (3.5 feet above floor).
2. Microphone located over rear wheel truck at ear level to a seated passenger (3.5 feet above floor).
3. Microphone located on outside platform between cars at ear level to a standing passenger (5.5 feet above platform).
4. Triaxial Accelerometer mounted on floor tiles with bee's wax.

Figure G-6. Microphone and Vibration Transducer Locations, Pullman Standard, MBTA Type 1 So. Shore Rapid Transit Cars

Figure G-7. Inside View - MBTA Type 1 So. Shore Rapid Transit Car. Microphone mid-car in foreground; microphone over rear wheel truck in background.

Figure G-8. Triaxial Vibration Transducer mounted on floor tiles with thin layer of bee's wax. MBTA Type 1 So. Shore Rapid Transit Car.

APPENDIX H

MEASUREMENT AND DATA REDUCTION SYSTEMS

NOISE-MEASURING SYSTEM

Figure H-1 depicts the noise data gathering equipment used at the three wayside location and at the three in-car measurement locations. Figures G-1 and G-2 show the exact locations for each system at the wayside measurement site and in the transit car.

A magnetic tape recorder, capable of essentially flat recordings from 30 Hz to 15 kHz, was used. The recorder was operated in the direct mode at a tape speed of 3-3/4-inch per second. The dynamic range of the recorder and measuring system was 50 dB.

Prior to each run, a short verbal annotation was recorded on tape giving the following: date, time, location, tape number, tape recorder channels used, and gain setting for each channel.

A calibration signal of 1000 Hz at a level of 114 dB re 20 micronewton per square meter was recorded on tape before and after each run to provide a reference for the data-reduction instrumentation and detect any system instability. The calibrator used was a General Radio Model #1562A. In this calibrator, the signal is generated by a solid-state oscillator driving a small magnetic loudspeaker.

The calibrator is placed on the microphone and the resultant signal at the specified sound pressure level is fed through the system and recorded on tape. The calibration frequency selected, 1000 Hz, eliminated any necessity for "A" weighted frequency response correction during system calibration. In addition, a passive microphone simulator was substituted for the microphone to determine the minimum discernible sound-pressure level (Noise Floor) for the system. This signal is also preserved on tape.

The fourth channel on the recorder is for verbal annotation and to record a time code signal (hours, minutes, and seconds) to synchronize data between channels and between recorders.

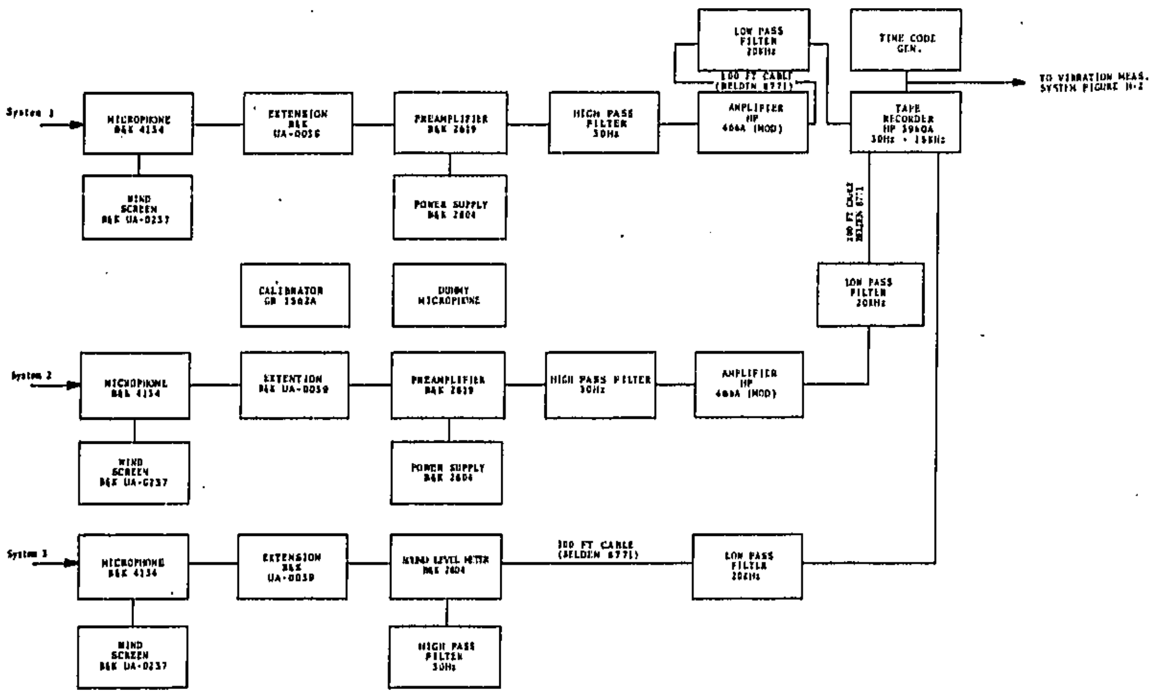


Figure H-1. Three Microphone Noise-Measuring System

Noise Data Reduction

The configuration of the data reduction system is shown in figure H-2. The noise data plus the calibration signal recorded on magnetic tape at the test site were reproduced and fed to a General Radio (GR) 1921 Real Time Analyzing System made up of a GR 1925 Multifilter and a GR 1926 Multichannel RMS Detector. The necessary gain adjustments were made in the multifilter and graphic level recorder with the calibration signals.

The GR 1921 multifilter contains a set of 30 parallel 1/3-octave band filter channels ranging from 25 Hz to 20 kHz, plus additional channels with standard "A," "B," and "C" sound-level meter weighting networks and an unfiltered channel with a flat frequency response. The output of the "A" weighted channel was selected and fed to the Graphic Level Recorder to produce a chart of sound level vs. time (time history) of all recorded data. All 34 outputs from the multifilter are fed into the multichannel detector. The multichannel detector simultaneously computes the rms (root mean square) level for each channel and converts this level to a digital output. Single integration or measurement periods are adjustable from 1/8 to 32 seconds. A statistical analysis of the measured noise was obtained by programming the detector to integrate for 1/8 second, compute the dB value of the "A" weighted filter output, and provide a binary coded decimal signal to the Wang Computing Calculator eight times every second. This computer counted and totaled the number of samples at each sound level for a selected time period and a punched tape was produced. These data were subsequently entered into a time-shared computer to produce statistical analysis printouts contained in appendixes A, C, and E.

These statistical analyses contain a histogram presentation of dBA value versus frequency of occurrence and a cumulative distribution curve of dBA value vs frequency of occurrences. Selected indexes were also calculated and tabulated; e.g., average noise level dba, standard deviation, energy mean, range of values measured, median, selected percentiles and deciles, the noise-pollution

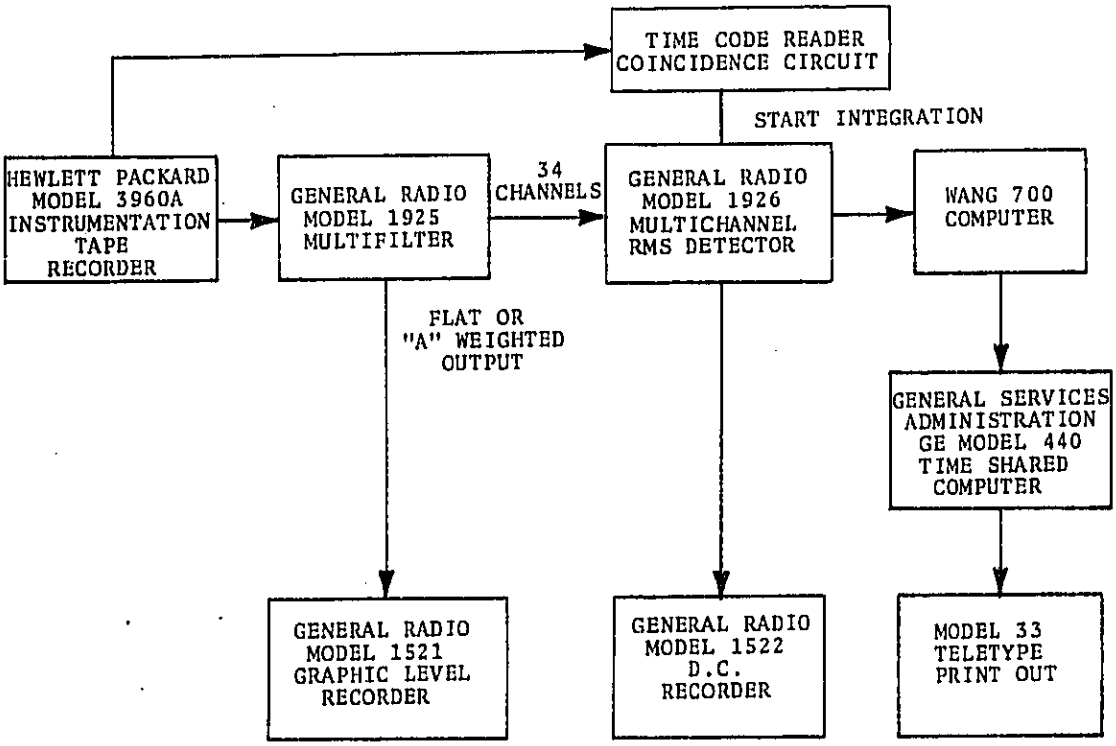


Figure H-2. Noise and Vibration Data Reduction System level and Walsh-Healey Exposure index. A complete description of these indexes is contained in Appendix K.

Special selected events are analyzed in detail for their 1/3 octave band frequency spectra using the same equipment just cited and the GR 1522 dc Recorder which in conjunction with the GR 1926 Multichannel RMS Detector provides a hard copy bar graph of level (dB) vs 1/3 octave frequency bands from 25 Hz to 20 kHz, including the flat (F) and "A" weighted outputs.

The Multichannel detector is programmed to integrate over the time interval of the selected event, compute the level in dB for all 32 channels and provide a dc output to the recorder. The recorder provides a hard copy of the level dB vs 1/3 octave bands for the event. The start of the integration period is controlled by a coincidence circuit in the time code reader; thus insuring the identical start of the integration period for events on multichannel recorders or between recorders which have been synchronized with time code signals. The graphic recorder at a pen writing speed of 3 inches per second simultaneously provides an expanded "A" weighted time history of the special event. Time marks are manually placed on the graphic recording to show the start and end of the integration period.

Vibration Measuring System

Figure H-3 depicts the equipment used for data gathering of ground vibrations in three axes at the wayside measurement location shown in figure G-1 and for in-car measurements in three axes shown in figure G-2. The frequency response of this system is 3 to 1250 Hz.

For wayside ground vibration measurements, a brass rod 2 ft long and 7/8 inch wide was driven into the ground at the measurement location and three accelerometers mounted on the rod with a apecial adapter in a triaxial arrangement, each accelerometer was electrically insulated from one another and from the driven stake.

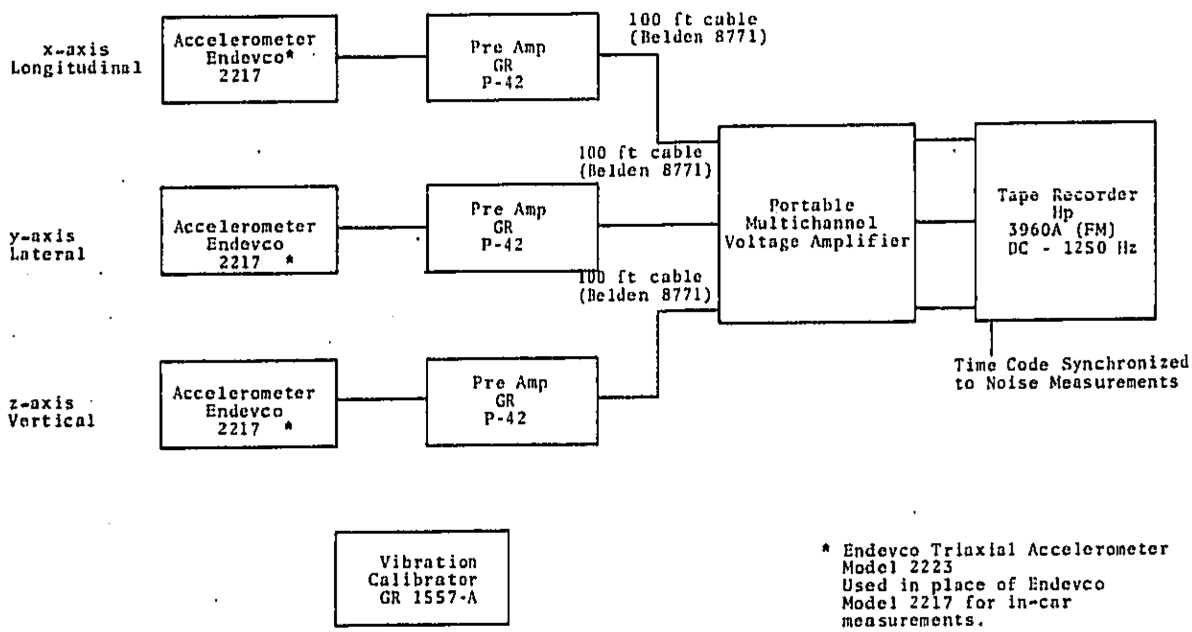


Figure H-3. Three-Axis Vibration-Measuring System

For in-car measurements a triaxial accelerometer was used. It was secured to the floor tiles at a location over the rear wheel truck with a thin layer of bee's wax

A magnetic tape recorder, capable of essentially flat recording from dc to 1250 Hz was used. The recorder was operated in the FM mode at a speed of 3-3/4-inch per second. The dynamic range of the recorder and measuring system was 60 dB.

Prior to each run, a short verbal annotation was recorded on tape giving the following: date, time, location, tape number, tape recorder channels used and gain setting for each channel.

A dynamic calibration signal of 100 Hz at 1 g was recorded on tape before and after each run to provide a reference for the data reduction instrumentation and to detect any system instability. The GR Type 1557A Vibration Calibrator was used to provide this on-the-spot calibration of the vibration measuring system including the accelerometer. The 1557-A is a small battery-operated unit consisting of a transistorized electromechanical oscillator and a cylindrical shaker. The accelerometer of known mass is attached to the shaker and the level control adjusted to the proper mass setting. The accelerometer is then automatically subjected to an acceleration of 1 g at 100 Hz. In addition, the accelerometer is replaced by a short circuit to determine the minimum discernible acceleration level (Noise Floor) for the measuring system. This signal was also preserved on tape.

The fourth channel on the recorder was used for verbal annotation and to record a time code signal (hours, minutes and seconds). This signal was simultaneously recorded on the multichannel recorder used to record noise data. Thus the data between channels and between recorders were synchronized.

Vibration Data Reduction

The configuration of the vibration data reduction system is as shown in figure H-3. It is noted that this is the identical system described above for Noise Data Reduction. To utilize this system, which is equipped with 1/3 octave filters down to 25 Hz, for the analysis of data with frequency components down to 3 Hz, the following frequency transformation procedure was necessary. The vibration data which was originally recorded at a speed of 3-3/4-inch per second was played back at a tape speed of 15 inches per second. The recorded signal is thus scaled up in frequency by a factor of 4, and frequency components of the original signal that were in the 1/3-octave bands of 6.3 Hz, 8 Hz, 10 Hz, 12.5 Hz appear as 25 Hz, 31.5 Hz, 40 Hz, and 50 Hz 1/3 octave bands, respectively. Thus, the data are shifted into the usable frequency range of the 20 Hz to 20 kHz data reduction system shown in figure H-3.

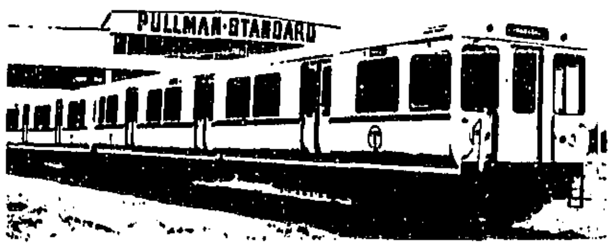
The vibration data plus the 100 Hz, 1 g calibration signal recorded at 3-3/4-inch per second at the test site are reproduced at 15 inches per second and fed into the GR 1921 Real Time Analyzing system. The necessary gain adjustments are made in the Multifilter and recorders with the calibration signal now at a frequency of 400 Hz.

Special events (as in the Noise Data Reduction Section) are analyzed in detail for their 1/3 octave frequency spectra and a hard copy bargraph of level (dB) vs 1/3 octave frequency bands from 6.3 Hz to 5 KHz plus an unfiltered flat (F) output are produced with the 1522 dc recorder in conjunction with the 1926 Multichannel Detector.

The multichannel detector is programmed to integrate over the time interval of the selected event (now occuring in 1/4 the time), compute the level in dB for all 31 channels and provide a dc output to the recorder which provides a hard copy of the level in dB vs the 1/3 octave bands from 6.3 to 1250 Hz plus flat (F) output of the vibration spectra of the event. The start of the integration period is controlled by a coincidence circuit in the time code reader, thus insuring the identical start of the integration periods for events on multichannel recorders or between recorders which have been synchronized with time code signals. The graphic recorder simultaneously provides an expanded time history of the event analyzed and time marks are manually placed on the history to show the start and end of the integration period.

APPENDIX I

DESCRIPTION (PULLMAN STANDARD) MBTA TYPE 1 SO. SHORE RAPID TRANSIT CARS



Massachusetts Bay Transportation Authority Transit Cars

Designed and built by Pullman-Standard for the Massachusetts Bay Transportation Authority (MBTA), these sturdy transit cars are in daily service on the busy South Shore Line. The clean lines of the cars and their brushed aluminum exteriors keep maintenance down and help preserve their appearance. The aluminum bodies are semi-monocoque design with steel bolster-draft sill-end sill weldments to provide a good blend of strength, light weight, and economy.

Each car pair has a cab on each end, and shares a motor-generator set, battery, air compressor, and automatic train control equipment. Each single car unit has the same equipment, plus a cab on each end. When two-car or four-car trains are needed, the car pairs should be the most economical. During off-peak service, however, the single car units should result in substantial savings in crew and operating expenses.

Adding to the MBTA cars' flexibility are their unique safety systems—Automatic Train Operation for maintaining desired speed, and Automatic Train Control to slow the train if the allowable speed limit is exceeded.

Gray and black plastics accented by vinyl and stainless steel moldings create a modern, passenger-attracting interior that is easy to maintain. Ample fluorescent lighting, tinted windows, air conditioning, and soundproofing throughout the cars help assure MBTA passengers quiet and comfort.

BASIC SPECIFICATIONS

Length, over anti-climbers	70'0"
Length, center to center of trucks	51'0"
Truck wheel base	6'10"
Maximum width	10'0"
Interior width, between inside side finish	9'4¾"
Width of side door openings, 3 per car side	4'0"
Height, rail to top of floor	4'1"
Height, rail to top of roof corrugation	12'4-15/16"
Seat arrangement	2 and 2
Number of seated passengers, single car unit	60
Number of seated passengers, car pair	64
Maximum number of standees, single car unit	168
Maximum number of standees, car pair	175
Acceleration rate	2.5 mph per sec.
Braking rate, from 70 mph to 50 mph	1.3 mph per sec. at 70 mph, tapering to 2.75 mph per sec. at 50 mph.
Braking rate, from 50 mph to 0 mph	2.75 mph per sec.
Top speed	70 mph
Construction	All aluminum except HTLA bolster-draft sill-end sill weldments
Braking	Combination dynamic and electro-pneumatic
Brake units	Eight, with composition shoes
Power supply	600v DC, third rail
Signals	Automatic Train Operation and Automatic Train Control
Traction motors	Four, 100 hp each
Trucks	Inboard bearing, air-coil spring suspension, 28" wheels
Approximate weight per car, single car unit	64,190 lbs.
Approximate weight per car, car pair	60,750 lbs.

Figure I-1

The MBTA Type 1 So. Shore Transit Cars were designed and built by Pullman Standards, Chicago, Illinois to MBTA developed specifications, specifically for use on the new MBTA So. Shore Extension of the Red Line which was officially opended on September 1, 1971.

Figure I-1 contains basic specifications of the Type 1 cars as published by Pullman Standard .

The single unit cars, identified (with Serial No.) series "1500" are completely self-contained cars and can be run as single cars on the line. The MBTA currently runs 2-car trains and pairs up two of the 1500 series cars. The test train Serial Nos' 1503 and 1506 were single unit cars.

The 1600 series cars are a mated pair and must be operated in pairs since they share a common motor generator set, battery, air compressor, and automatic train control equipment.

APPENDIX J

MBTA TRANSIT SYSTEM MAP AND TUNNEL CROSS SECTIONS

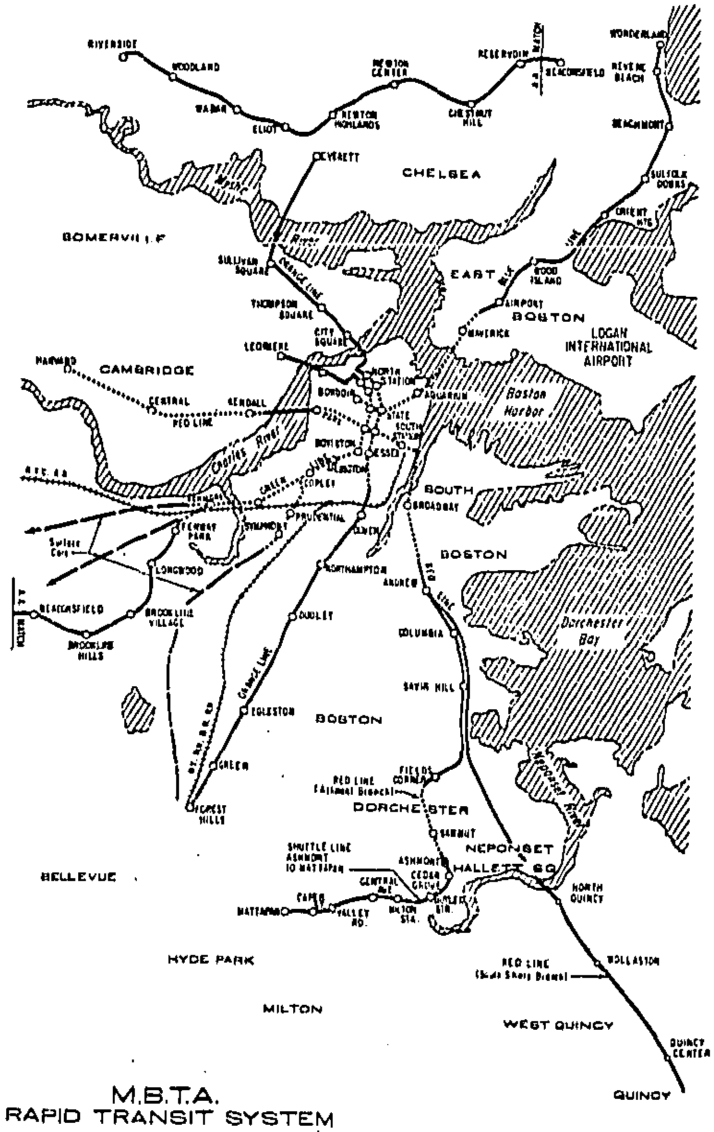


Figure J-1. MBTA Rapid Transit System

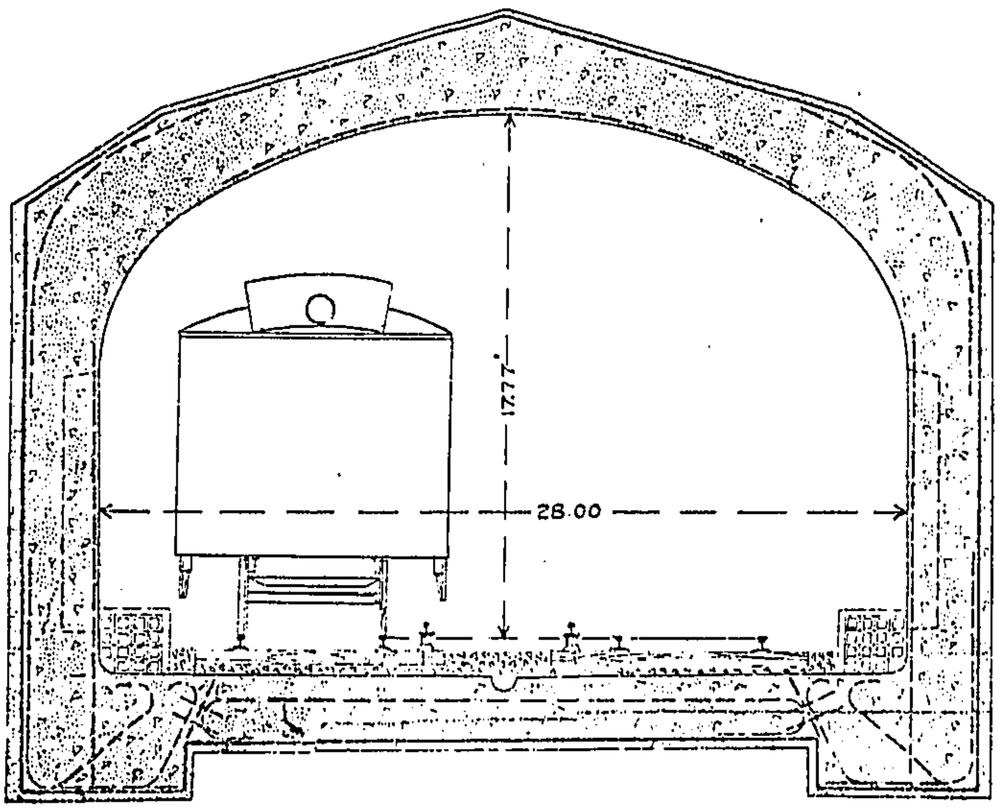


Figure J-2. Red Line-Dorchester Tunnel
(See figure E-10 for Noise Spectra)

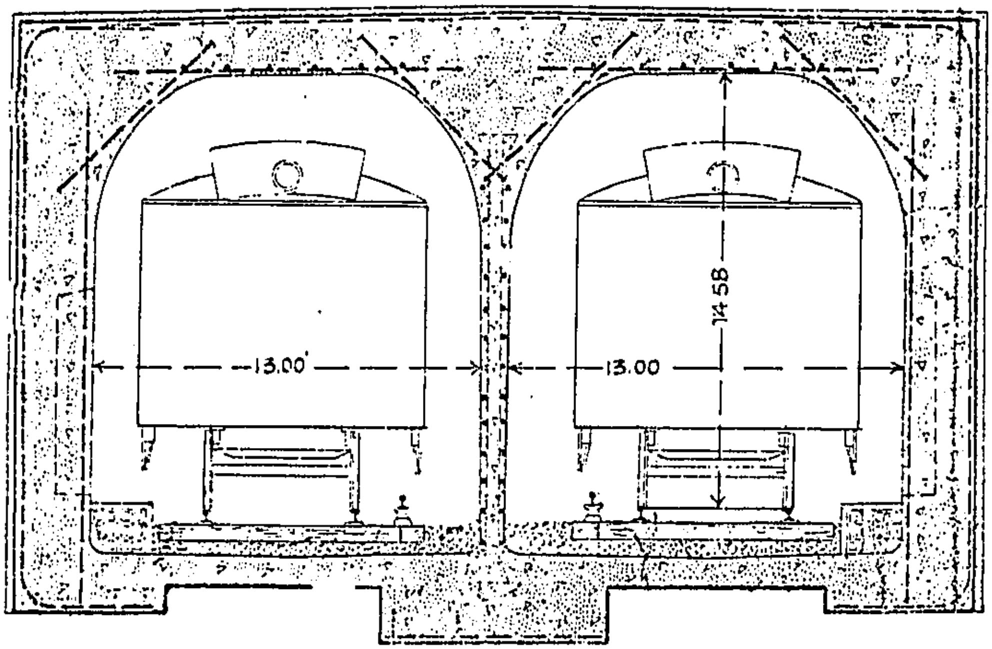
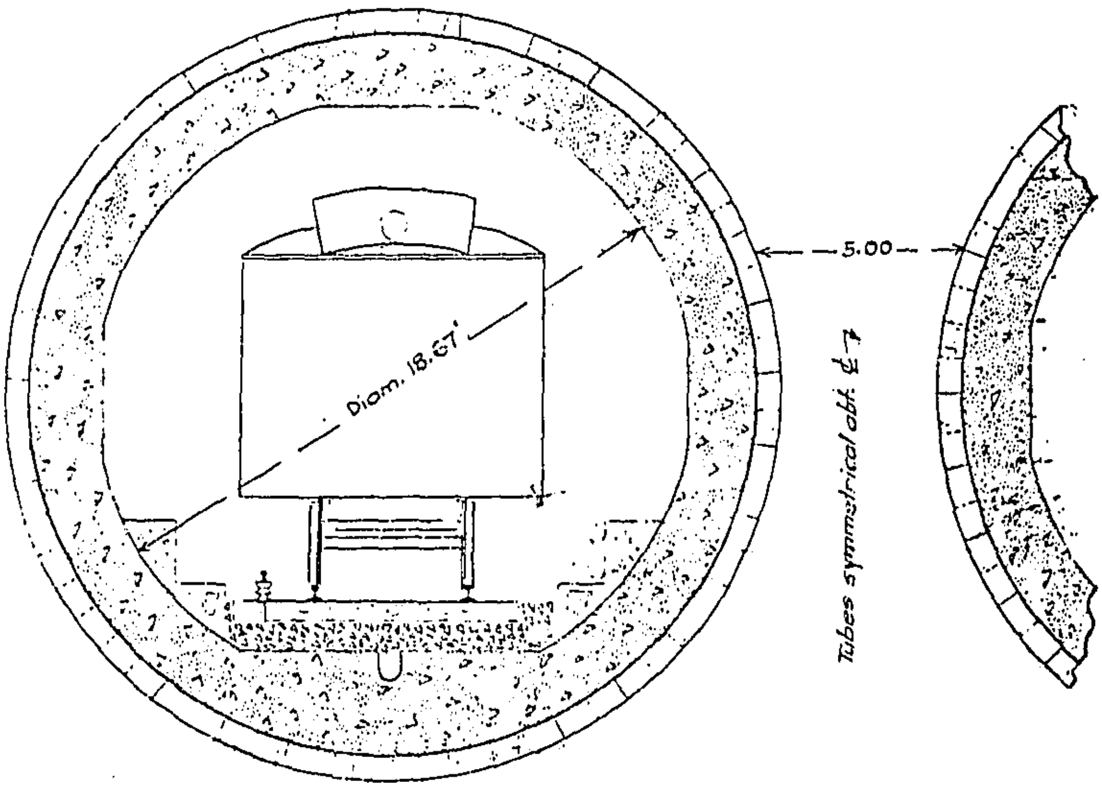


Figure J-3. Red Line-Two-Section Tunnel
(See Figure E-11 for Noise Spectra)



RED LINE
DORCHESTER TUNNEL

Figure J-4. Red Line-Circular Tunnel
(See figure E-12 for Noise Spectra)

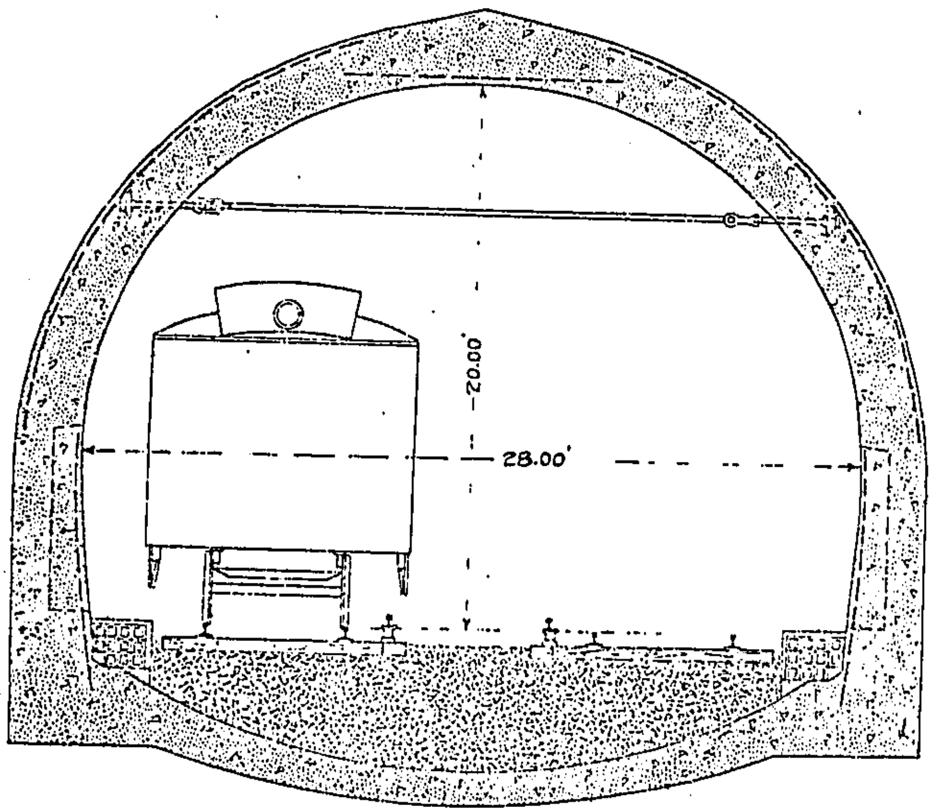


Figure J-5. Red Line - Beacon Hill Tunnel
(See figure E-13 for Noise Spectra)

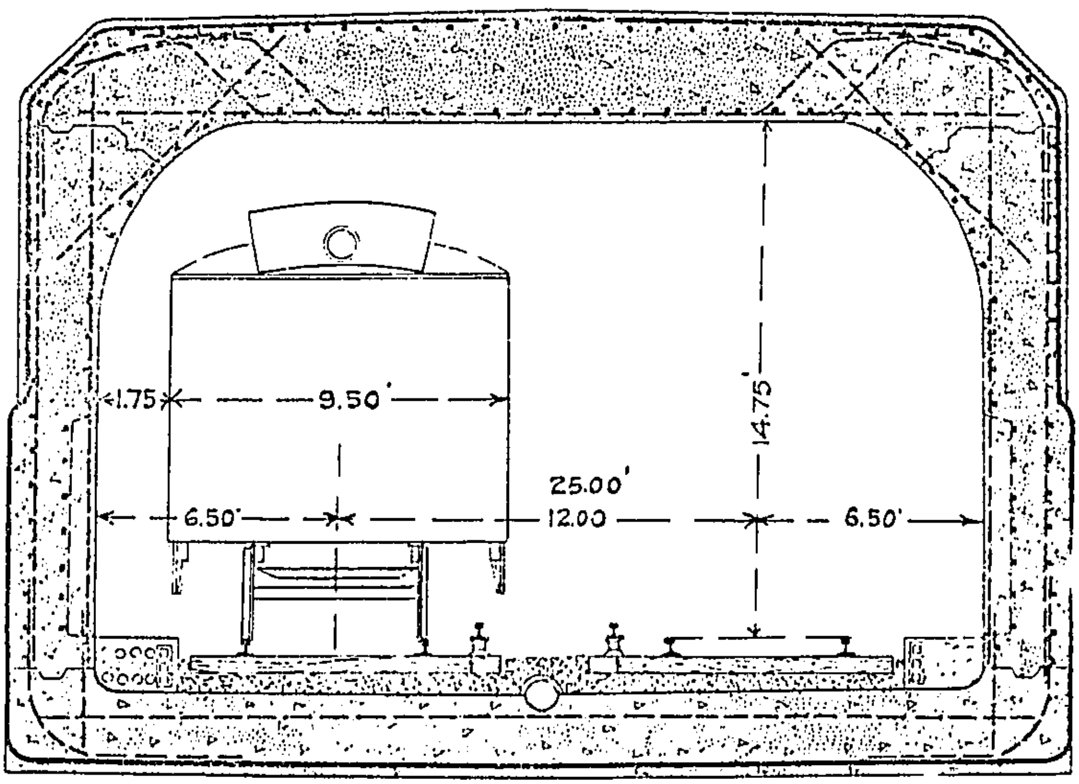


Figure J-6. Red Line - Cambridge Main St. Subway
(See figure E-14 for Noise Spectra)

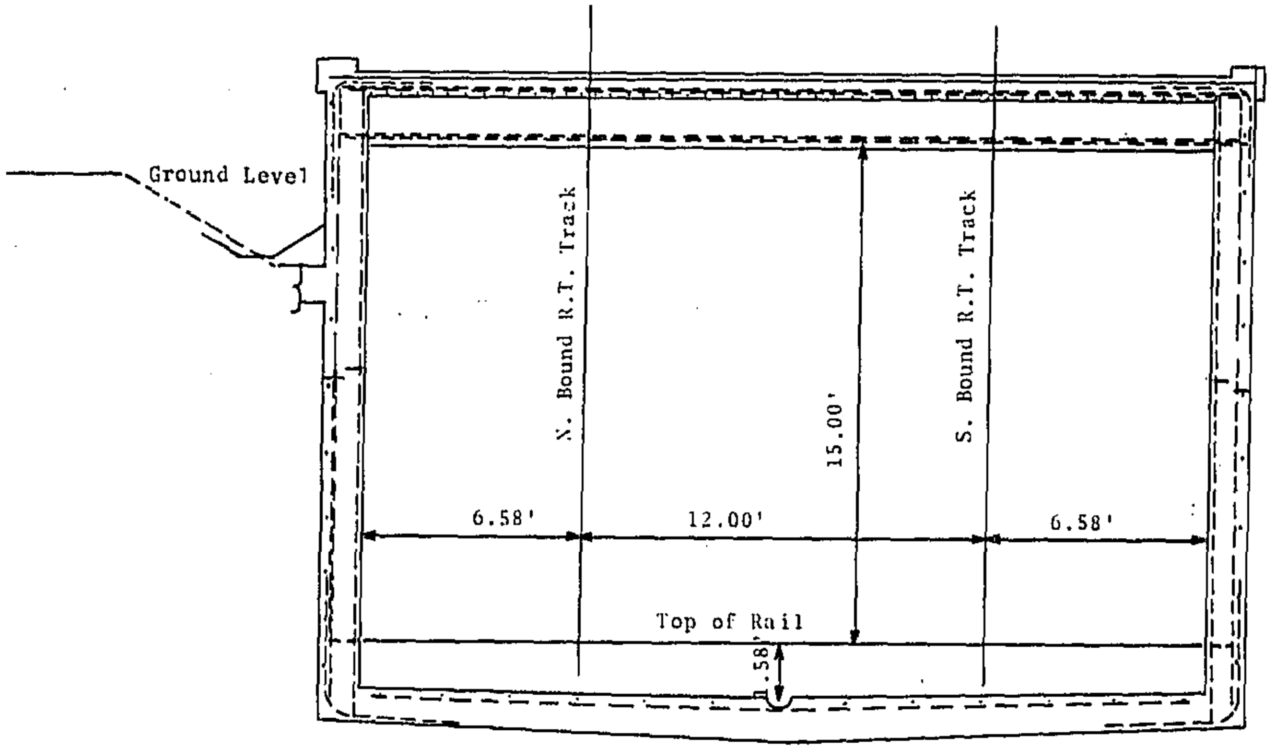


Figure J-7 Red Line - Ashmont Extension
(See Figure E-16 for Noise Spectra)

APPENDIX K

DEFINITION OF TERMS AND CALCULATED VALUES

DEFINITION OF TERMS

TERM	ABBREVIATION	DEFINITION
A-Weighted Sound Level	dBA	Sound level obtained by measuring the sound pressure through a filter network having a frequency response (A-weight) conforming to American National Standards Institute (ANSI, S1.4, 1961).
Median Noise Level	L 50	Sound level (dBA) exceeded by 50% of total measurements.
10% Decile	L 10	Sound level (dBA) exceeded by 10% of total measurements.
90% Decile	L 90	Sound level (dBA) exceeded by 90% of total measurements.
Noise Pollution Level	L NP	A composite index (see Calculation B6).
Walsh Healey Exposure		Measure of noise in terms of a Federal regulation (Walsh-Healey Act) limiting the industrial noise to which a worker can be exposed.

CALCULATIONS

To describe the temporal characteristics of the noise data gathered, a statistical analysis of sound pressure level samples was performed. RMS sound pressure level samples were taken using an integration time of 1/8 second at a sample rate of eight samples per second to obtain the information contained in appendixes A, C, and E. The frequency response characteristics of the samples conformed to ANSI Standard for Type 1 Sound Level Meters, S1.4, 1971 for "A" weighted sound level.

The following terms and equations were used to compute the statistical and single number indexes appearing in this report:

A. BASIC TERMS

1. Total samples obtained: N
2. Total number of Sound Pressure Levels (from lowest level containing samples to highest level containing samples, inclusive): M
3. Sound Pressure Level (lowest to highest) SPL_1, SPL_2, ..., SPL_M
4. Samples at each Sound Pressure Level: C_1, C_2, ..., C_M
5. Relationships

a. $$\sum_{i=1}^{M} C_i = N \, .$$

b. $$SPL_M - SPL_1 + 1 = M \, .$$

6. dB ("A" Weight) - Sound level obtained by measuring through a filter network having a frequency response (A weight) conforming to American National Standards Institute (ANSI), S1.4, 1971. Reference sound level - 20 micronewtons per square meter.

B. STATISTICAL EQUATIONS

1. Cumulative Distribution, Percent (D_c)

$$D_c\ i = \frac{CM + CM\text{-}1 + \ldots + Ci}{N} \quad (100)$$

2. Statistical Distribution, Percent (D_s)

$$D_s\ i = \frac{Ci}{N}\ (100) \qquad i = 1, 2, \ldots, M$$

3. Average (Arithemetic Mean, $\overline{SPL}$)

$$\overline{SPL} = \sum_{i=1}^{M} \frac{C_i \ SPL_i}{N}$$

4. Standard Deviation about Averages σ

$$\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} C_i \ (SPL_i - \overline{SPL})^2} \ .$$

5. Energy Mean (L eq)

$$L\ eq = 10 \log_{10} \left[\frac{\sum_{i=1}^{M} C_i \ 10^{\frac{SPL_i}{10}}}{N} \right] .$$

6. Noise-Pollution Level (L_{NP})

$$L_{NP} = L\ eq + 2.56 \ \sigma \ .$$

7. Percentile Noise Levels, dBA

a. 1% Percentile (L_1) = Level exceeded by 1% of total samples

b. 10% Decile (L_{10}) = Level exceeded by 10% of total samples

c. Median (L_{50}) = Level exceeded by 50% of total samples

d. 90% Decile (L_{90}) = Level exceeded by 90% of total samples

e. 99% Percentile (L_{99}) = Level exceeded by 99% of total samples

These percentile levels are obtained from linear interpolation of the percentage cumulative distribution values.

8. Range: Highest sound level containing samples minus the lowest sound level containing samples.

$$\text{Range} = SPL_M - SPL_1$$

9. Occupational Safety and Health Act of 1970 (O.S.H.A.)

a. The O.S.H.A. is a Federal Regulation setting standards to assure safe and healthful working conditions for working men and women. One of the standards set by O.S.H.A. is concerned with the noise an employee may be exposed to during an eight-hour work day. The noise standards published by the Secretary of Labor in the Federal Register, dated May 29, 1971, are identical to those of the Walsh-Healey Act of 1969.

The O.S.H.A. Exposure Percentage is a measure of the noise levels in terms of Walsh-Healey Exposures normalized to an 8-hour work day. When the percentage reaches or exceeds 100%, it means that exposure of a worker to that same noise climate for 8 hours would be in violation of the Act. Additionally, any one-time exposure over 115 dBA is exceeded during the measurement period, the exposure percentage number will be followed by a "V" indicating a violation even if the number is less than 100%.

b. The equation used to calculate the the O.S.H.A. exposure percentage is as follows:

$$W1 = \left[\frac{W2}{6} + \frac{W3}{4} + \frac{W4}{3} + \frac{W5}{2} + \frac{W6}{1.5} + \frac{W7}{1} + \frac{W8}{0.5} + \frac{W9}{0.25}\right] \times \frac{800}{N}$$

where

W1 = O.S.H.A Exposure in percent.
W2 = Number of samples in the 90 to 92 dBA band.
W3 = Number of samples in the 92 to 95 dBA band.
W4 = Number of samples in the 95 to 97 dBA band.
W5 = Number of samples in the 97 to 100 dBA band.
W6 = Number of samples in the 100 to 102 dBA band.
W7 = Number of samples in the 102 to 105 dBA band.
W8 = Number of samples in the 105 to 110 dBA band.
W9 = Number of samples in the 110 to 115 dBA band.
N = Total number of samples where one sample represents 1/8 second.

C. CONVERTING NOISE DATA TO STANDARD DISTANCES OF 25, 50, AND 100 FT.

Point Source

By the inverse square law the change in sound pressure level with distance is

$$\Delta SPL = 20 \log \frac{r}{r_x}$$ where $(\frac{r}{r_x})$ is the change in distance from the noise source

thus, if $r = r_x$, the sound pressure drops by 6 dB.

Line Source

$$\Delta SPL = 20 \log (\frac{r}{r_x})^{1/2}$$

thus if $r = 2r_x$ the sound pressure drops by 3 dB.

By actual measurement the sound pressure level dropped by approximately 5 dB between the 25 ft. and 50 ft. microphone location and for the 50 and 100 ft. microphone locations. Thus, for the transition region between 25 ft. and 100 ft. at the measurement site the "best fit" for the inverse distance law is:

$$\Delta SPL = 20 \log \left(\frac{r}{r_x}\right)^y = 5 \text{ dB}$$

$\therefore \quad y = \frac{5}{6}$ in the region between 25 and 100 ft.

Thus, the noise data shown in Tables 3-1, 5-1 and 5-2 for southbound trains can be converted to standard distances of 25, 50, and 100 ft. with this relation

$$\Delta SPL = 20 \log (\frac{r}{r_x})^{5/6}$$

Noise correction from 38 ft to 25 ft = +3.0 db,
Noise correction from 63 ft to 50 ft = +1.8db, and
Noise correction from 113 ft to 100 ft = +0.9 db.

APPENDIX L

ENVIRONMENTAL DATA

ENVIRONMENTAL DATA

Date	Time	Temperature	Relative Humidity	Barometric Pressure	Wind Velocity	Wind Direction	Sky
	Hours	°F	Percent	mm Hg	mph		
Oct. 28, 1971	1500-1650	70	70	761	5	SW	Sunny
April 27, 1972	1315-1605	50	50	764	2	E	Partly Cloudy
April 29, 1972	0100-0400	72	63	769	(Inside Measurements)		