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NOISE AND VIBRATION SURVEY FOR THE METRO RAIL PROJECT CORE STUDY

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43

Prepared for:

Metro Rail Transit Consultants

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1. INTRODUCTION AND SUMMARY OF FINDINGS

This report presents a study of the ambient noise and ground-borne vibration existing at the present time (1987) along portions of the five alternative alignments which comprise the Metro Rail System "CORE" Study. The five candidate alignments are designated 1 through 5 and are described in the memorandum of December 23, 1986, "CORE Study Final Candidate Alignments" (Ref. 1). The data presented in this report is designed to be a supplement to the extensive data obtained in 1981 and 1982 and presented in the report, "Noise and Vibration Study for the Metro Rail Project" of August 1983 (Ref. 2).

Noise and vibration measurements were made outside representative buildings and in representative areas along the five candidate alignments which were not previously characterized by the earlier sets of ambient measurements. The measurements were made to provide information and documentation on the existing ambient levels and to provide assistance in determining the acceptable or allowable Metro Rail System noise and vibration levels at nearby buildings and community areas. These ambient noise and vibration data used in conjunction with the noise and vibration design criteria provide a basis for determining those areas where special design features are needed to reduce the noise and vibration from transit train operations to acceptable levels.

This noise and vibration survey report discusses the survey locations and procedures, presents background information on noise and vibration measurements and descriptors, and presents the results of the measurements. Background on the noise and vibration characteristics of transit train operations and related facilities, impact of each candidate alignment and a general assessment of construction noise is contained in the report, "Noise and Vibration Analysis for the Metro Rail Project CORE Study" of March 1987 (Ref. 3).

The results of the noise and vibration survey indicate that the existing noise and vibration levels are relatively high, but are consistent with the activities and uses of the area. The measurements confirm the previous selected criteria for the evaluation of potential impact at the buildings in the CORE Study area, which are indicated in Reference 3. Thus, the selection of appropriate noise and vibration CRITERIA for transit train operations is based on the type of building occupancy and measured existing noise and vibration levels.

2. SURVEY PROCEDURE AND BACKGROUND INFORMATION

Establishing the existing noise levels or noise environment in a community requires measuring the noise at a number of locations at several different times of day and, preferably, on several different days. Community noise is a continually fluctuating entity dependent on many factors. Because the noise level does fluctuate over a relatively wide range, it is necessary to perform measurements which are statistically significant and which can be analyzed on a statistical basis. Ground-borne vibration exhibits much the same statistical variation as airborne noise, and though reference is made throughout this section to ambient or community noise, this discussion is for the most part, equally applicable to vibration.

For commercial areas, with primarily daytime occupancy, the possibility of intrusion from transit train operations is primarily a daytime consideration. In residential areas, the community ambient or background noise level is generally the lowest during the evening and nighttime hours and the possibility of intrusion from transit train operations is greatest during this time period. Thus, in commercial areas, design criteria are based primarily on daytime operations and noise levels. In residential areas, environmental measurements are performed at several different characteristic times of the day and design criteria are based primarily on evening and nighttime operations and noise levels.

Although community noise data for the daytime in commercial areas and noise data for the evening and nighttime in residential areas are sufficient to establish the design criteria and evaluate the potential impact of the transit system, such measurements are not sufficient for a complete assessment of the community area environment. Therefore, measurements are generally made to provide data on the existing noise levels for several different times of day. Complete 24-hour surveys of the noise level can be performed in order to obtain a complete statistical representation of the daily noise exposure in a community area. It has been found, however, that the noise in communities can be characterized adequately by making spot-check measurements during at least four characteristic times of day. Because of the purpose of the noise measurements reported herein, the spot-check type of survey with a measurement duration of 10 minutes was performed at all of the measurement locations during appropriate characteristic times of day and, in almost all cases, on two different days. These data are supplemented by complete 24-hour noise surveys at two selected measurement locations.

For the purpose of this study the day was divided into four characteristic measurement periods representing:

Daytime:	10:00 a.m. to 2:00 p.m.
Rush Hour:	4:00 p.m. to 6:00 p.m.
Evening:	7:00 p.m. to 10:00 p.m.
Nighttime:	11:00 p.m. to 2:00 a.m.

Additional measurements in the peak morning commute period are generally unnecessary because the results in this period are essentially the same as for the evening rush hour.

Each measurement location was chosen to obtain the noise levels characteristic of the area or near a potentially noise sensitive building or group of buildings. Wherever possible, the measuring microphone was located at the setback line of the nearby buildings.

The locations of the measurement sites are indicated on Figure 2-1. A brief description of each measurement location is given in Table 2-1. The survey data were obtained between August 4 and 7, 1987. The short-term noise and vibration data were subsequently laboratory analyzed using the instrumentation shown in Figure 2-2.

The results of environmental noise measurements are presented in terms of a statistical analysis of the observed noise levels in decibels. The factors derived from the analysis are the levels exceeded 99% of the time, 90% of the time, 50% of the time, 10% of the time, and 1% of the time designated L_{99}, L_{90}, L_{50}, L_{10}, and L_1, respectively.

L_{99} and L_{90} are descriptors of typical minimum or "residual" background noise level observed during a measurement period, normally made up of the summation of a large number of sound sources distant from the measurement position and not usually recognizable as individual sound sources. The most prevalent source of this residual noise is distant street and highway traffic, and L_{99} and L_{90} are not strongly influenced by occasional local motor vehicle passbys. However, they can be influenced by nearby stationary sources such as air conditioning equipment.

L_{50} represents a long-term statistical average or median sound level over the measurement period and does reveal the long-term influence of local traffic. If the instantaneous sound level is sampled over a measurement period, the sound level will be above L_{50} for 50% of the time.

L_{10} describes the average peak or maximum sound level occurring, for example, during nearby passbys of trucks, buses, automobiles, trains, or airplanes. Thus, while L_{10} does not describe the long-term noise prevailing it does describe the typical maximum noise levels observed at a point and is strongly influenced by the momentary maximum sound level occurring during vehicle passbys.

L_1, the sound level exceeded 1% of the time, is representative of the occasional maximum or peak sound level which occurs in an area.

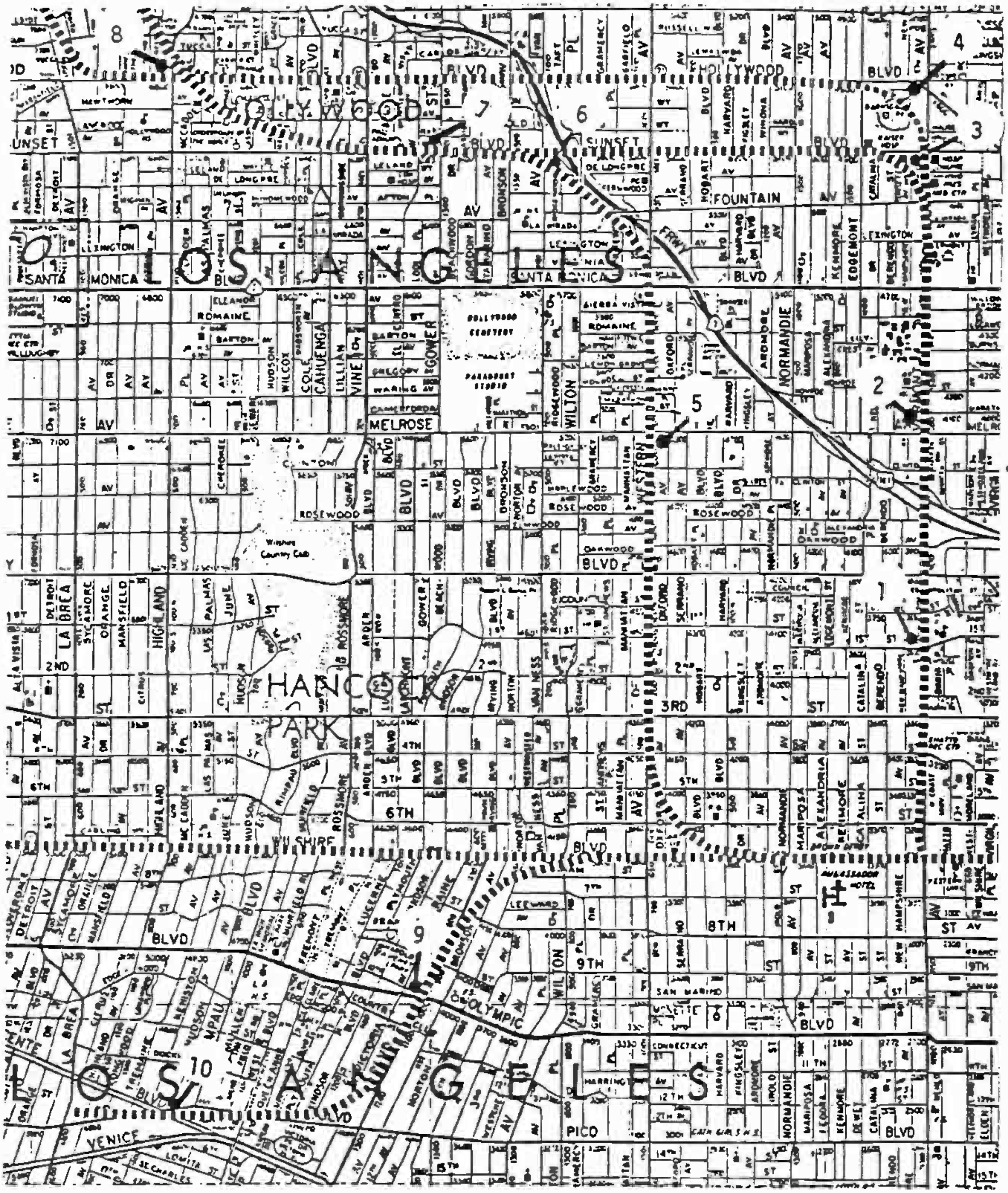
Because of some inherent deficiencies of the simple percentile measures described above in evaluating the noise exposure effects of short duration, high level sounds (such as heavy vehicle or train passbys), the Energy Equivalent Level, L_{eq}, has been developed and is widely used as a valid single-number descriptor of environmental noise. Since it is an energy integral over time, L_{eq} represents the constant or steady sound level which would give the same energy level as the fluctuating value integrated over the total time period. Because sound energy is proportional to the square of the sound pressure, L_{eq} places more emphasis on high noise level periods than does L_{50} or a straight arithmetic average of noise level over time. Some consider L_{eq} a more useful measure than L_{50} for the average or typical noise exposure in an area and most recent evaluation systems such as CNEL (Community Noise Equivalent Level) or L_{dn} (Day/Night Average Sound Level) use the energy equivalent concept.

Additional definitions and discussion of acoustical terms are contained in Appendix VI of Reference 3.

TABLE 2-1 LOCATIONS USED FOR EVALUATION OF THE EXISTING NOISE AND VIBRATION ENVIRONMENT ALONG THE CORE STUDY ALIGNMENT ALTERNATIVES

Location Number	Site Description
1	On sidewalk at northeast corner of intersection of 1st Street and Vermont Avenue, approximately 80 ft north of 1st Street in front of Full Gospel Church.
2	On sidewalk on west side of Vermont Avenue opposite Marathon Street, approximately 20 ft from normal curb of Vermont Avenue, in front of Braille Institute at 741 Vermont Avenue.
3	On sidewalk at northwest corner of intersection of Vermont Avenue and Sunset Boulevard, approximately 160 ft south of Sunset Boulevard in front of new hospital building.
4	At perimeter of parking lot east of Barnsdall Park, near intersection of Hollywood Boulevard and Vermont Avenue, in front of H. Salt Fish and Chips.
5	On sidewalk at southeast corner of intersection of Western and Melrose Avenues, approximately 55 ft south of Melrose Avenue, in front of Walter Allen Plant Rentals.
6	On sidewalk at southeast corner of intersection of Van Ness Avenue and Sunset Boulevard, approximately 20 ft south of Sunset Boulevard, near the Fox Building at 5752 Sunset Boulevard and across Van Ness Avenue from the KTLA Channel 5 antenna.
6 (24-Hour Noise Survey)	Noise monitoring unit fixed to "Tow-Away Zone" sign at southeast corner of intersection of Van Ness Avenue and Sunset Boulevard, approximately 40 ft east of Van Ness Avenue in front of Fox Building at 5752 Sunset Boulevard.
7	On sidewalk at northeast corner of Gower Street and Sunset Boulevard, approximately 25 ft west of Gower Street and 6 ft north of Sunset Boulevard, outside CBS Studios.

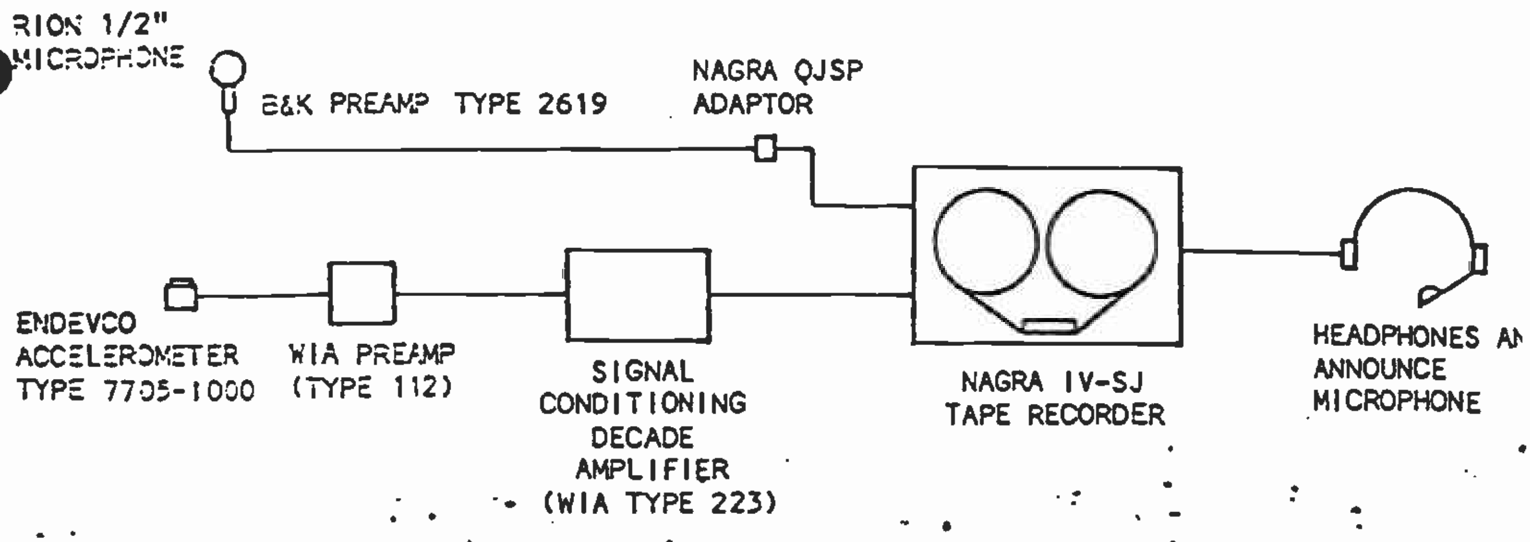
7 (24-Hour Noise Survey)	Noise monitoring unit fixed to light pole at northeast corner of Gower Street and Sunset Boulevard, approximately 25 ft west of Gower Street, outside CBS Studios.
8	On sidewalk at northeast corner of intersection of Highland Avenue and Hollywood Boulevard, approximately 100 ft east of Highland Avenue.
9	On sidewalk at northwest corner of intersection of Olympic Boulevard and Crenshaw Avenue at setback line of restaurant at 4201 Olympic Boulevard, approximately 15 ft west of Crenshaw Avenue.
10	On sidewalk at northeast corner of San Vicente Boulevard and Keniston Avenue, one block west of Pico Boulevard, near apartment building at 4279 Pico Boulevard.



(SCALE: 1 INCH = 2800 FT)

FIGURE 2-1 LOCATION OF NOISE AND VIBRATION MEASUREMENT SITES ALONG THE CORE STUDY ALIGNMENT ALTERNATIVES

FIELD INSTRUMENTATION



LABORATORY INSTRUMENTATION

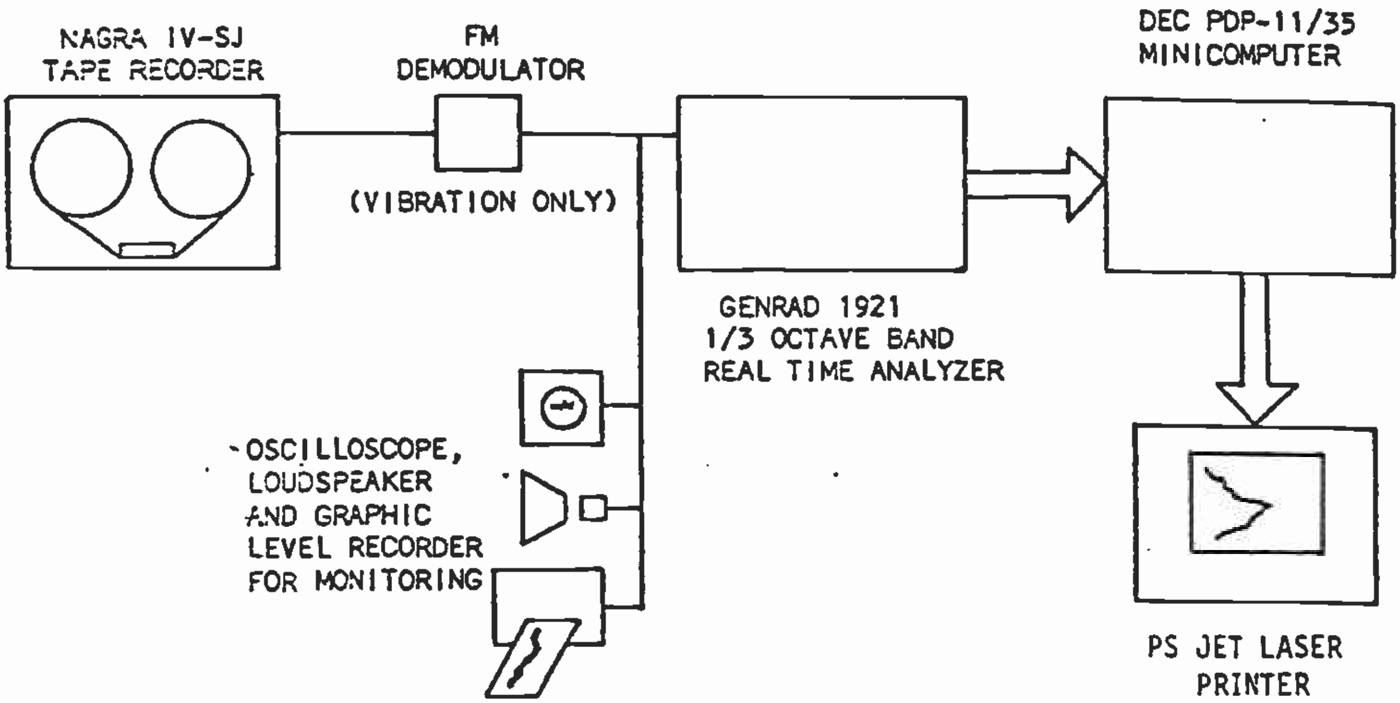


FIGURE 2-2 NOISE AND VIBRATION MEASUREMENT AND ANALYSIS INSTRUMENTATION

3. EXISTING NOISE LEVELS

Table 3.1 presents the results of the statistical analysis of the noise observed at each of the 10 noise measurement locations. All of the noise levels are presented in terms of A-weighted sound level in decibels, abbreviated dBA. This measurement scale is used because it has become accepted as the best compromise scale, using frequency weighting which approximates the hearing characteristics of the average human ear. The A-weighted sound level shows good correlation between the subjective response of people and communities with measured noise levels. Also, most noise ordinances, standards and specifications are written in terms of A-weighted sound level.

As noted earlier, the measurements to determine the noise data in Table 3.1 consisted of ten minute long continuous samples of noise at the site, recorded by means of a calibrated multi-channel precision magnetic tape recorder equipped with a sound level meter microphone. The recordings obtained were later analyzed to obtain the statistical distribution and other descriptors of the noise levels. The tape recordings can be used in the future to obtain spectral analysis of the noise at the sites (such as octave band or 1/3 octave band analyses) and are permanently retained as a record of the noise environment existing at the time of the measurements. Most measurement sites were visited at least twice to ensure that the measured levels were characteristic. The data obtained on each day were averaged to obtain the results shown on Table 3.1.

Review of the sound level data obtained during the spot-check or 10-minute measurements indicates that the residual background noise levels, L_{99} and L_{90} range from 59 to 71 dBA during the rush hours and day, and 53 to 70 dBA during the evening and nighttime hours. These levels are relatively high for residual background noise levels, but are typical of areas with considerable street and freeway traffic at all times of day. At most locations the noise levels do show a significant decrease during the evening and nighttime hours when compared with those measured during the daytime and rush hour.

The median or L_{50} noise level for the different sites ranges from 64 to 75 dBA during the rush hour, 65 to 74 dBA during the day, 62 to 73 dBA during the evening and 60 to 72 dBA during the night.

For all of the locations, the data for L_{10} and L_1 show typical levels for a high volume of vehicular traffic on city streets. This results in L_{10} and L_1 noise levels greater than 70 dBA, and at most locations, greater than 80 dBA. An L_1 noise level of 80 dBA or greater is generally considered a high noise level for commercial and residential developed areas. At several of the measurement locations there was only a slight decrease in the L_1 and L_{10} noise levels during the evening and nighttime hours which indicates that there is a significant volume of nearby vehicular traffic at night.

The Energy Equivalent Level, L_{eq}, ranges from 66 to 80 dBA during the rush hour, 67 to 76 dBA during the daytime, 66 to 76 dBA during the evening and 64 to 75 dBA during the nighttime. As with the noise levels characterized by the other statistical descriptors, the noise levels represented by the upper bound of the range for each time period are quite high and are due primarily to vehicular traffic on the nearby street.

As stated previously, 24-hour or long-term noise measurements were made at 2 measurement locations. These long-term measurements were made in order to obtain a complete statistical representation of the daily noise exposure in a community area and to show that the short-term or spot-check sample data correlate well with the variation of noise levels characteristic of the four time periods used. As with the spot-check measurements, the 24-hour or long-term noise measurements are reported in terms of A-weighted sound level in decibels, abbreviated dBA.

The equipment used for the long-term noise evaluation at Location 6 consisted of a calibrated, precision, digital acoustical data acquisition system with a sampling rate of 60 measurements per minute. This digital data acquisition system digitizes the A-weighted noise level each second, and then stores these digitized data on a tape cassette for subsequent laboratory statistical analysis of the noise levels observed. The equipment used for the long-term noise evaluation at Location 7 is similar, but samples at the rate of 480 measurements per minute and stores the digitized data for later statistical printout. This unit was programmed to begin sampling at midnight on August 5. Although the digital data acquisition systems can provide information on the noise levels over a long period of time, since these units digitize the A-weighted noise level, they cannot provide information on the spectrum of noise, i.e., octave band or 1/3 octave band analyses are not possible.

Since these digital acquisition systems operate unattended, they were secured to a sign post or street lightpole which usually located the measuring microphone closer to nearby vehicular traffic but higher above the ground than the microphone of the spot-check measuring system. Thus, the peak noise levels measured by the digital data acquisition system can be greater than that observed by the spot-check measurement system. However, these data do show good correlation with that obtained with the spot-check measuring system.

With the long-term measurement system, single number descriptors of the noise environment over a 24-hour time period can be obtained. The descriptors, CNEL and L_{dn} are by definition, based on a 24-hour time period and are minor variations of L_{eq}. These descriptors take into consideration the fact that people are generally more annoyed by a given sound level at night than during the day. They are determined in the same manner as L_{eq}, except that both have a 10 dB adjustment factor added to the noise levels between 10 p.m. and 7 a.m. In addition, CNEL has a 5 dB penalty applied to the noise levels between 7 p.m. and 10 p.m. Thus, depending on the noise levels occurring in a community during the evening and nighttime, CNEL and L_{dn} are often several decibels greater than $L_{eq}(24)$, the energy equivalent level over a 24-hour period.

CNEL is the noise descriptor specified in the California State Aeronautic Code for evaluation of noise impact of aircraft operations. CNEL is also specified in the California State Noise Insulation Standards for new multi-family residential dwellings. Hence, local compliance with these standards often necessitates that community noise be specified in terms of CNEL. L_{dn} represents a slight simplification of CNEL and is the noise descriptor preferred by the U.S. EPA. For most environmental noise, L_{dn} and CNEL seldom differ by more than 1 dB. Although no long-term noise descriptor levels are specified by any legislative body for operation or construction of the Metro Rail System, CNEL, L_{dn} and $L_{eq}(24)$ are reported for each long-term measurement location. The CNEL was 79 dBA at Location 6 and 76 dBA at Location 7, while the $L_{eq}(24)$ was 74 dBA at Location 6 and 72 dBA at Location 7.

Figures 3-1 through 3-3 are plots of the time history of the noise levels at the long-term measurement locations. These figures also show the date and time each survey began, as well as the values for CNEL, L_{dn} and $L_{eq}(24)$. These surveys are representative of weekday activities and generally show the decrease in noise levels during the nighttime and early morning hours which is characteristics of urban noise dominated by transportation activities.

As previously stated, at each of the long-term measurement locations, the time history of the noise levels shows the characteristic pattern of urban noise dominated by transportation activities. Thus, the noise levels are the greatest during the rush hour period, the same or somewhat lower during the daytime, still somewhat lower during the evening and considerably lower during the nighttime. This characteristic pattern of the variation of noise level over a full day was shown at each of the locations where a long-term measurement was made, thus the correlation between the short and long term measurements can be drawn at those locations where both types of measurements were made. This noise level variation over a full day has been shown to be characteristic of noise environments in a large number of urban areas in the U.S.A. and Canada. This correlation of noise measurements during different times of the day can be logically extended to the short term noise measurements, thus validating them as characteristic for the appropriate time of day and accurately characterizing the noise environment at a particular location without the need for a complete 24-hour survey.

TABLE 3.1 ENVIRONMENTAL NOISE LEVELS MEASURED AT TEN LOCATIONS IN THE CORE STUDY AREA

AUGUST 4 THROUGH 7, 1987

Location Number	Time of Day	Date (August 1987)	Noise Levels - dBA					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
1	Rush Hour	4 & 6	65	67	72	76	86	74
	Day	5 & 7	64	66	72	77	85	74
	Evening	5 & 6	62	64	70	74	80	71
	Night	5 & 7	53	58	64	71	76	68
2	Rush Hour	4 & 5	62	65	69	73	79	71
	Day	5 & 7	61	65	69	74	81	71
	Evening	5 & 6	58	63	69	73	77	70
	Night	4 & 7	56	58	66	72	77	69
3	Rush Hour	4 & 5	65	67	72	76	85	74
	Day	5 & 7	65	67	71	76	85	74
	Evening	5 & 6	60	62	67	71	79	69
	Night	4 & 6	57	60	65	72	77	69
4	Rush Hour	4 & 5	60	61	64	68	73	66
	Day	5	63	64	65	69	74	67
	Evening	4 & 5	54	58	62	66	77	66
	Night	4	54	58	62	66	74	64
5	Rush Hour	5 & 6	67	69	73	78	86	75
	Day	5	68	70	74	78	85	75
	Evening	5	67	69	73	77	86	76
	Night	5	65	67	71	77	85	74
6	Rush Hour	5 & 6	66	69	72	77	85	75
	Day	5 & 7	67	69	72	77	84	75
	Evening	4 & 5	64	67	71	76	84	73
	Night	4 & 5	59	62	68	74	80	71
7	Rush Hour	4 & 6	66	68	73	77	84	75
	Day	5 & 7	67	70	73	78	83	75
	Evening	4 & 5	63	66	71	75	82	72
	Night	4 & 5	59	62	68	75	84	72

(Table 3.1 Continued)

Location Number	Time of Day	Date (August 1987)	Noise Levels - dBA					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
8	Rush Hour	4 & 6	69	70	74	82	90	80
	Day	5 & 7	69	70	73	77	87	76
	Evening	4	68	70	72	76	83	74
	Night	6	67	70	72	80	85	75
9	Rush Hour	5	69	71	75	78	82	76
	Day	5 & 7	65	67	72	76	82	74
	Evening	4 & 6	63	67	72	76	82	73
	Night	5 & 7	56	58	65	71	77	68
10	Rush Hour	5 & 6	60	63	69	74	80	71
	Day	5 & 7	59	63	69	74	80	71
	Evening	4 & 6	59	62	68	73	80	70
	Night	5 & 7	53	55	60	68	74	65

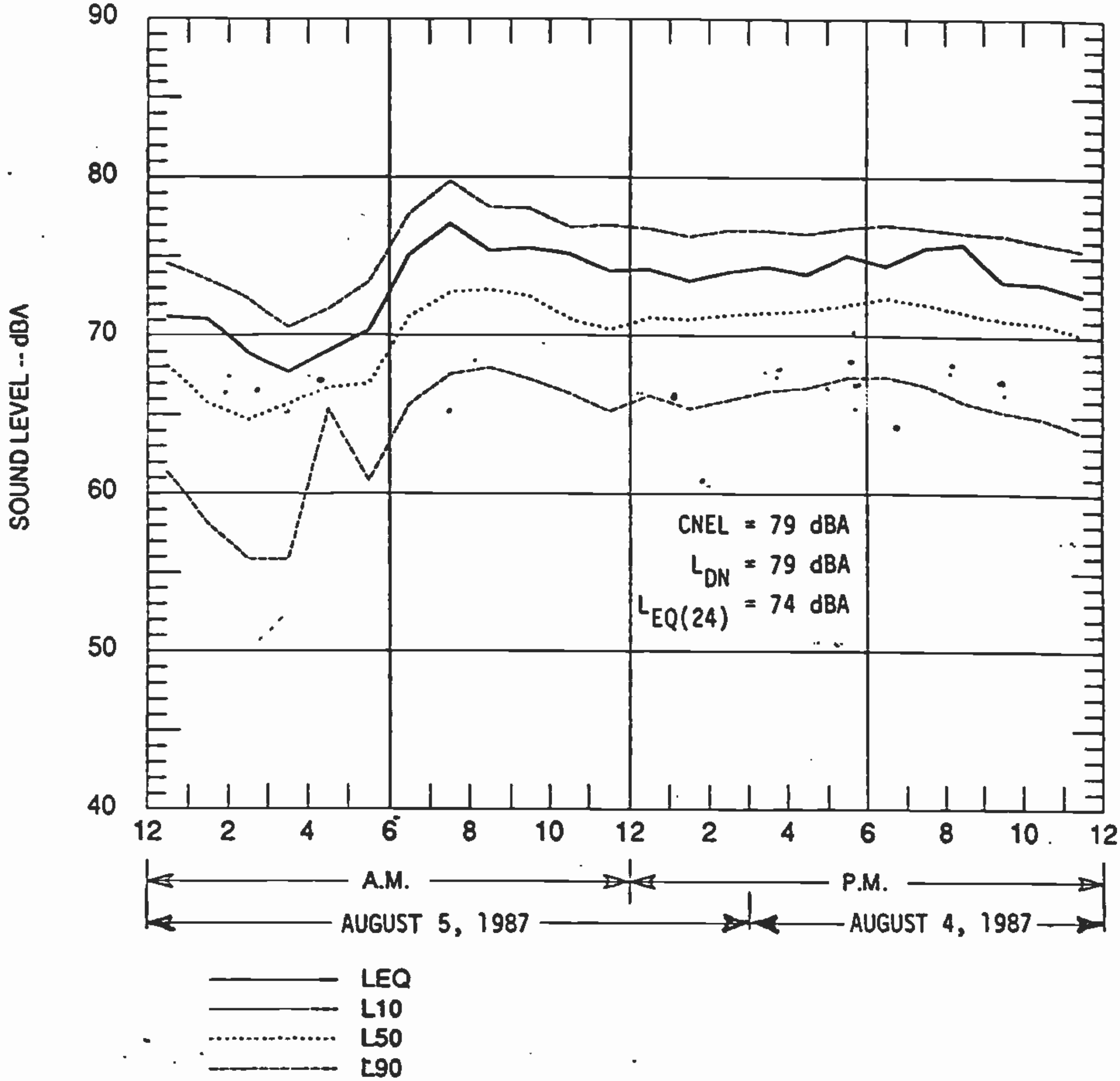


FIGURE 3-1 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 6, BEGINNING 3 PM, TUESDAY, AUGUST 4, 1987

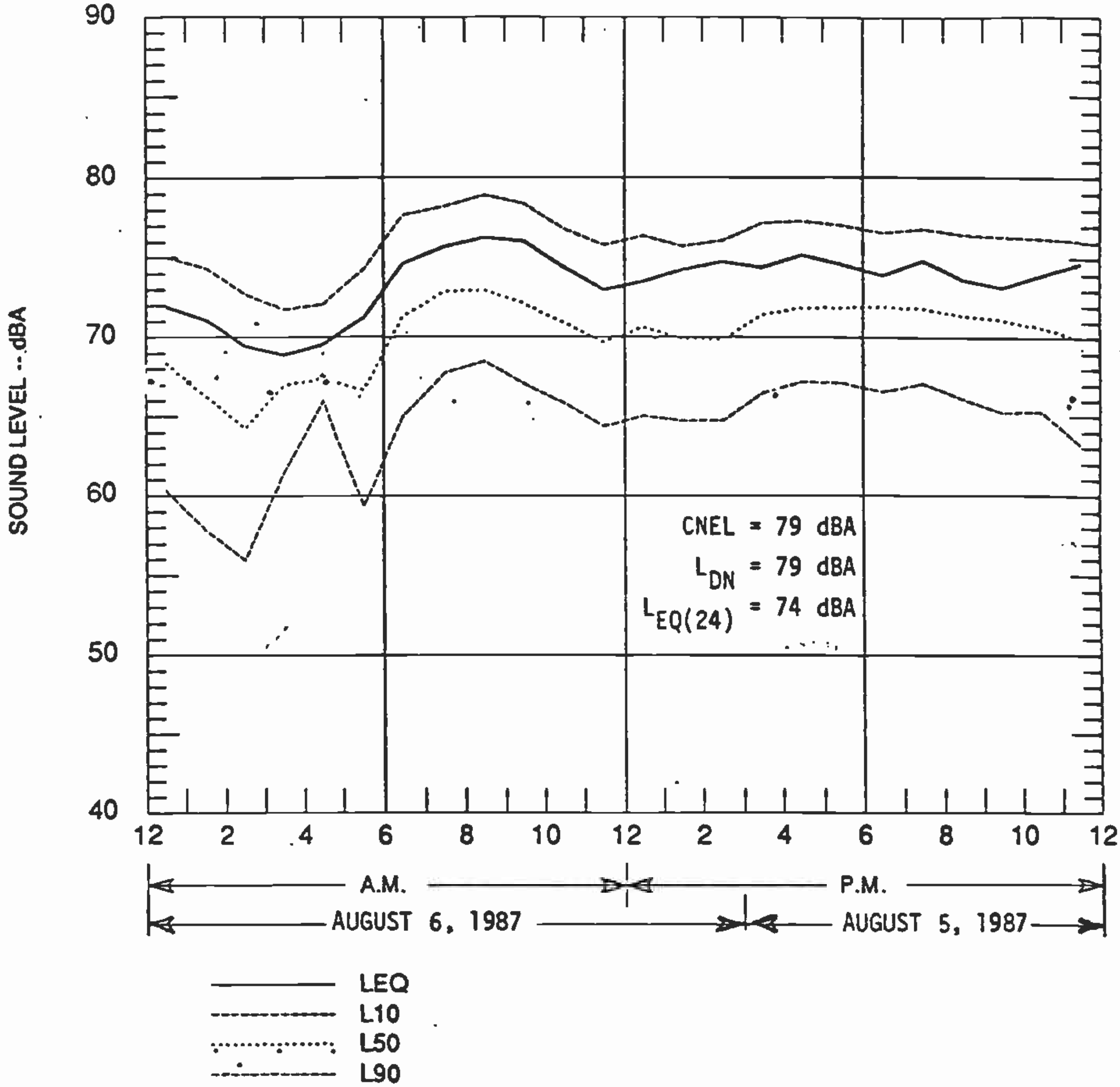


FIGURE 3-2 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 6, BEGINNING 3 PM, WEDNESDAY, AUGUST 5, 1987

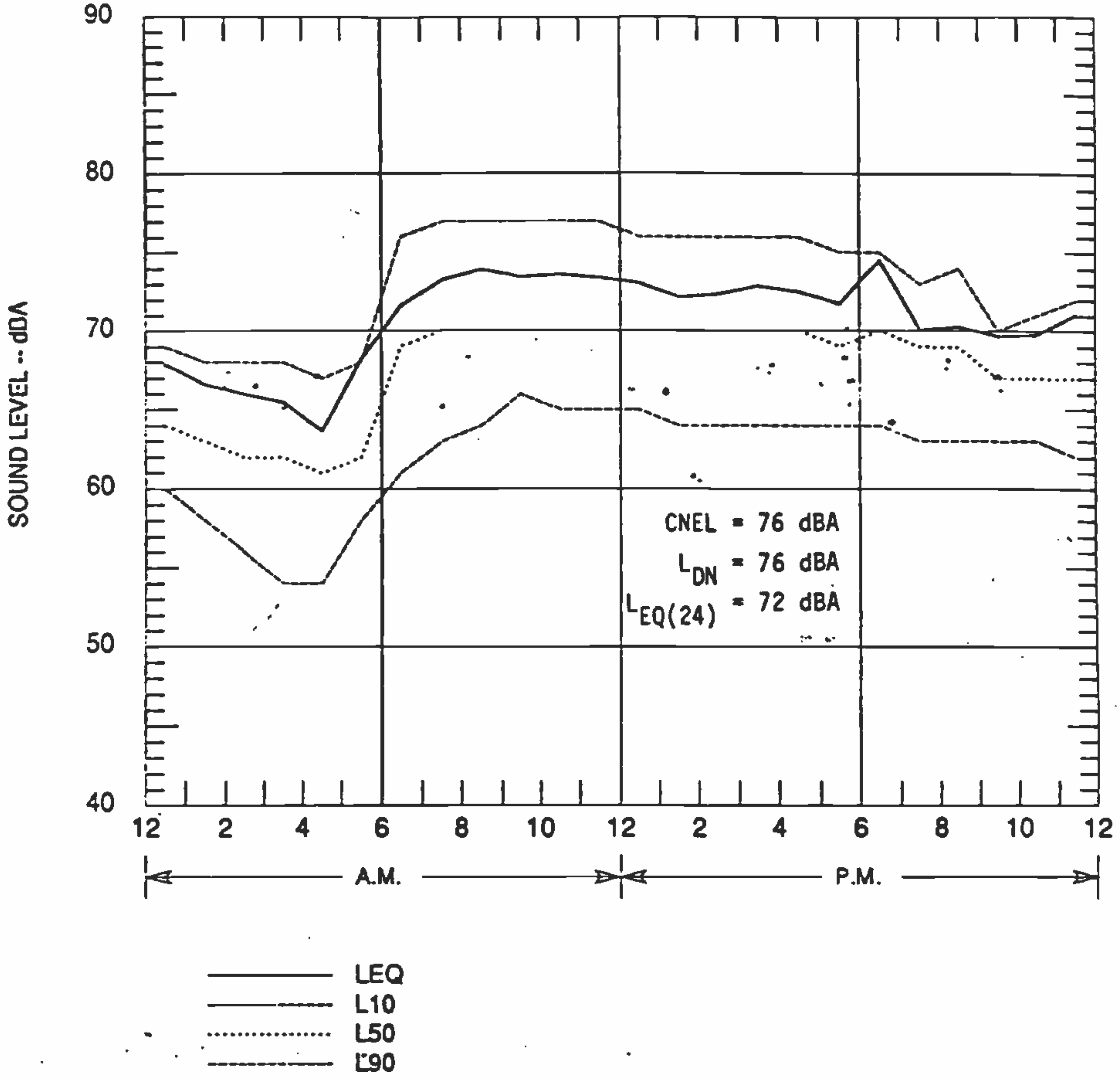


FIGURE 3-3 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 7, WEDNESDAY, AUGUST 5, 1987

4. EXISTING VIBRATION LEVELS

Although the perception of vibration by people has been discussed extensively in the literature, most of the criteria are based on results obtained from steady-state sinusoidal vibration excitation in laboratory environments. Relatively little information is available on the response of humans to low level random vibration or to transient vibration levels. Recently, more information on this type of vibration has been obtained from the results of measurements and subjective evaluations of transit train vibration in Toronto, Washington, D.C., Chicago, San Francisco, Atlanta and Pueblo, Colorado (The Transportation Test Center).

A number of scales for evaluating the effect of vibration on man have been devised. Units such as Pal and Trem have been presented for establishing scales of response to vibration similar to the A-weighted sound level or the various loudness scales which have been used for the determination of subjective response to noise levels. None of the scales have been widely accepted in evaluating human response to vibration levels and, in general, the criteria for response are presented as charts with ranges of response as a function of vibration frequency. As for the subjective response to noise, the human sensitivity to vibration varies with frequency. Therefore, the frequency must be taken into consideration in assessing annoyance due to vibration. A number of studies have indicated that at frequencies above approximately 12 to 16 Hz, sensitivity to vibration is primarily determined by the amplitude of velocity and is relatively independent of frequency. Since the frequency range over which human sensitivity is approximately proportional to velocity amplitude covers the range of principal vibration components from transit trains and since the noise level generated by the vibration of building surfaces is approximately proportional to vibration velocity level, it is appropriate to present vibration criteria and data in terms of velocity level.

A curve of human response to vibration has evolved from the studies which have been done and has been documented in the International Standards Organization document 2631 and ANSI Standard S3.29-1983. Additional information on human sensitivity to vibration is contained in the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) Publication, "Guidelines for Preparing Environmental Impact Statements on Noise", which has utilized much of the information contained in the ISO Standard. These standards and publications do indicate that, below about 12 to 16 Hz, the sensitivity to vibration velocity is somewhat lower. This is characterized in Figure 2-4.1 of Reference 2 which indicates human response to building vibration. The curve shape is based on information in the CHABA publication and in this report will be known as CHABA weighting. These curves show the vibration perception level ranges in decibels, dB, re 1.0 micro in/sec, as a function of frequency in Hertz, Hz.

Existing exterior vibration sources include automobiles, trucks, buses, underground mechanical equipment, and on a local scale, pedestrians. Most of the vibration sources, except stationary mechanical equipment operating continuously, create transient vibration levels. The observed level of vibration at a particular location is the summation of the vibrations created by all the various sources, near and far. This is analogous to ambient community noise which represents the summation of many noise sources.

For this survey, the vibration level data were taken simultaneously with, and at the same locations as, the sound level data. Vibration acceleration was measured using a piezoelectric accelerometer, with a signal recorded on one channel of the data tape recorder.

The data were analyzed to obtain a single-number velocity level, weighted in such a way to approximate the CHABA weighting previously discussed. To obtain the weighted velocity level from the acceleration data, an electronic integrator and filter approximating the inverse of the CHABA weighting were used.

Although the CHABA weighting is not a standardized measurement, the resultant weighted velocity level is a good single-number indication of the human response to vibration. Weighted vibration velocity levels below about 69 dB overall level are generally imperceptible or just perceptible as vibration to the average person under normal conditions.

The weighted vibration velocity levels obtained in this manner were statistically analyzed to obtain the same statistical parameters used to describe the existing noise levels: L_{99}, L_{90}, L_{50}, L_{10}, L_1, and L_{eq}.

Table 4.1 presents a complete tabulation of the statistical analysis of the weighted vibration velocity levels observed at each measurement site. In general those locations with the highest noise levels also have the highest vibration levels and vice versa, since in most cases trucks and buses which produce high noise levels also produce high vibration levels. However, this correlation is not always true since airplanes, motorcycles, and some cars can produce high noise levels but not necessarily high vibration levels.

Review of the data obtained shows that the vibration velocity L_{eq} ranges from 36 to 57 dB. The higher levels are typical of areas near moderately to heavily traveled streets and highways in commercial and residential areas. Comparing these data with that obtained during other environmental vibration studies performed by WIA indicates that the vibration levels are typical of those in other large cities (such as Baltimore, Chicago, Dallas).

Although not reflected in Table 4.1, since the data presented generally reflect an average of two measurements, the L_1 weighted vibration velocity level did exceed 69 dB for one measurement period at Locations 7 and 8. At Location 7 during the daytime period of August 5 and at Location 8 during the rush hour period of August 4, the weighted vibration velocity level exceeded 69 dB for 1% of the time. This means that for approximately 6 seconds in 10 minutes, the vibration from passing vehicles or other transient sources was at least barely perceptible at the measurement location. Vibration at other locations where the L_1 weighted velocity level is less than 69 dB should generally not be perceptible as mechanical motion.

TABLE 4.1 WEIGHTED OVERALL VIBRATION VELOCITY LEVELS MEASURED AT TEN LOCATIONS IN THE CORE STUDY AREA

AUGUST 4 THROUGH 7, 1987

Location Number	Time of Day	Date (August 1987)	Weighted Vibration Velocity Levels - dB re 1 micro in/sec					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
1	Rush Hour	4 & 6	38	43	49	56	65	54
	Day	5 & 7	33	39	46	55	62	51
	Evening	5 & 6	32	38	47	55	63	52
	Night	5 & 7	24	28	40	50	60	47
2	Rush Hour	4 & 5	32	34	38	46	59	46
	Day	5 & 7	31	34	38	46	55	44
	Evening	5 & 6	26	29	34	40	52	40
	Night	4 & 7	24	26	32	38	48	36
3	Rush Hour	4 & 5	35	38	42	48	60	47
	Day	5 & 7	36	38	42	50	60	48
	Evening	5 & 6	32	34	38	44	52	42
	Night	4 & 6	29	31	36	42	52	40
4	Rush Hour	4 & 5	33	36	38	45	54	42
	Day	5	42	43	45	48	55	46
	Evening	4 & 5	26	29	34	42	52	40
	Night	4	24	27	33	41	53	40
5	Rush Hour	5 & 6	38	42	48	54	64	52
	Day	5	39	42	48	55	65	53
	Evening	5	35	40	46	52	59	49
	Night	5	30	34	43	51	58	48
6	Rush Hour	5 & 6	40	44	50	56	62	54
	Day	5 & 7	40	44	50	57	64	54
	Evening	4 & 5	38	42	48	54	60	51
	Night	4 & 5	34	37	45	53	59	49
7	Rush Hour	4 & 6	42	46	50	56	62	53
	Day	5 & 7	44	46	51	58	66	55
	Evening	4 & 5	41	44	50	56	62	53
	Night	4 & 5	39	40	45	53	62	50

(Table 4.1 Continued)

Location Number	Time of Day	Date (August 1987)	Weighted Vibration Velocity Levels - dB re 1 micro in/sec					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
8	Rush Hour	4 & 6	47	50	54	60	67	57
	Day	5 & 7	43	46	50	58	64	56
	Evening	4	47	48	52	58	65	55
	Night	6	49	50	52	56	65	55
9	Rush Hour	5	32	37	45	51	58	48
	Day	5 & 7	32	38	45	52	59	50
	Evening	4 & 6	32	36	44	50	58	47
	Night	5 & 7	28	30	36	46	55	43
10	Rush Hour	5 & 6	35	39	46	52	59	49
	Day	5 & 7	38	41	48	54	60	50
	Evening	4 & 6	36	40	46	52	60	50
	Night	5 & 7	36	37	40	46	56	45

REFERENCES

1. "Core Study Final Candidate Alignments," Memorandum to Distribution from Nadeem Tahir of SCRTD, December 23, 1986.

2. S. L. Wolfe, Wilson, Ihrig & Associates, Inc., "Noise and Vibration Study for the Metro Rail Project," Report prepared for the Southern California Rapid Transit District, August 1983.

3. S. L. Wolfe, Wilson, Ihrig & Associates, Inc., "Noise and Vibration Analysis for the Metro Rail Project CORE Study," Submitted to Metro Rail Transit Consultants, March 1987.