Noise Impact of Rail Passenger Service

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ABSTRACT

The California Department of Transportation (Caltrans) petitioned the California Public Utilities Commission (PUC) to allow the National Railroad Passenger Corporation (Amtrak) to increase their train speed limit from 65 to 90 mph between Los Angeles and San Diego. The city of Montebello, which had recently constructed a noise barrier that allegedly reduced the train noise from 95 to 75 dB(A) at the adjacent residences, protested the increase because of the belief that the increase in train speed would negate part of the benefit provided by the barrier. Caltrans performed noise measurements behind and beyond the end of the barrier in Montebello. Measurements were also made in an open area near Galivan in Orange County, where the Amtrak train could travel at 90 mph. Conclusions from this study indicated that the noise barrier in Montebello provided about 13 dB(A) attenuation. An increase in train speed from 65 to 90 mph would increase the noise from 74 to 78 dB(A) behind the barrier. However, the exposure time would decrease from 6 to 3 sec at the higher speed. Twelve Amtrak passenger trains operate between 7:30 a.m. and 9:05 p.m. through Montebello. Other noise from sources such as switching of freight cars on nearby tracks, and operation of freight trains and engines, motorcycles, airplanes, and delivery trucks ranged from 71 to 82 dB(A). The highest train whistle recorded was 99 dB(A). These noise levels were all measured behind the noise barrier. Discussions with residents behind the barrier indicated they were bothered by noises previously mentioned that occurred on a regular basis at night. The noise from the Amtrak train was a small part of the noise environment. The PUC granted Amtrak permission to operate at 90 mph between Los Angeles and San Diego based on the information presented in this study.

The work described in this paper was initiated by the Division of Mass Transportation, California Department of Transportation (Caltrans), which was responding to a request of the California Public Utilities Commission (PUC). The Caltrans Office of Transportation Laboratory (TransLab), in turn, was requested to measure passenger train noise and determine any impact when passenger train speeds are increased.

Information concerning noise impacts created by increasing train speeds from 65 to 90 mph was requested by the city of Montebello. The city had recently constructed a noise wall next to the railroad tracks along Sycamore Street, and there was concern that the efforts might be negated if the noise increased significantly because of the increased speed.

Noise measurements were made of the rail passenger service operating between Los Angeles and San Diego. Test sites were located in Montebello along Sycamore Street to evaluate the noise wall and near Galivan in Orange County to evaluate the effects of speed (Figure 1).

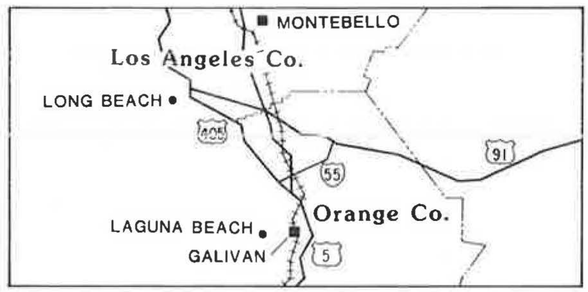

FIGURE 1 Location map of Montebello and Gavilan sites.

All noise measurements were made on the A scale and denoted as dB(A). This means that the measured noise level is comparable to that perceived by the normal human ear. Noise is expressed in terms of peak levels.

INSTRUMENTATION

The following types and quantities of equipment were used in conducting the measurements used in this study:

1. Two B&K 2206 type 1 sound level meters (SLMs),
2. Two B&K 2203 graphic level recorders (GLRs),
3. One B&K 4230 calibrator,
4. Two foam windscreens,
5. Two radar speedometers (Decatur Electronics), and
6. One wind measuring set (Belfort Instrument Company).

The calibrator, SLMs, and GLRs were checked at TransLab before they were taken to the field. Calibration checks on the SLM and GLR systems were made periodically during the measurement periods. (Records of calibration for all sound instruments are on file at TransLab.) The radar speedometers were also calibrated periodically in the field by using tuning forks.

Noise measurements are affected by wind speeds greater than 12 mph. A wind measuring set was used to periodically ensure that speeds were less than this level.

GALIVAN LOCATION

An open area near Galivan, in the vicinity of Mission Viejo in Orange County, was selected to determine changes in noise levels caused by increasing the passenger train speeds from 65 to 90 mph. The site was an area without vegetation and included an old two-lane concrete highway. There is one main track of jointed-rail construction for through traffic in this area and one track that serves as a siding for meeting and passing trains. Current regulations permit passenger trains to travel 90 mph at this location.

SLMs were located 50 and 100 ft from the centerline of the tracks at an elevation of 4 ft above the top of rails. The purpose of the two meters was to determine the decrease in noise due to an increase in distance. These data were used to analyze noise levels at varying distances from the noise source at speeds between 65 to 90 mph, where the terrain is comparable to that in Montebello.

Measurements were made on February 14, 1979. The weather was clear, except for some scattered clouds. The temperature was estimated at 60° to 70°F. Wind speeds were measured at 2 to 5 mph.

All peak noise levels were taken from the graphic level recordings and reported to the closest 0.5 dB(A). Figure 2 shows example graphic level recordings from the Galivan location.

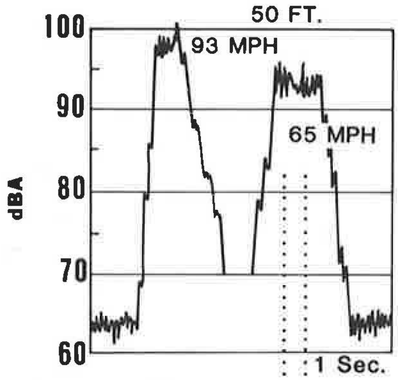

FIGURE 2 Noise level variation with speed.

Train speeds were determined by using two radar speedometers for reliability. The data are given in Table 1 and are plotted in Figure 3.

A regression line was drawn to approximate the estimated increase in noise caused by changes in speed at 50 and 100 ft from the tracks. The data indicate a noise decrease of 4.5 dB(A) as the distance is doubled from 50 to 100 ft. Also, the noise increases 4.5 dB(A) from 65 to 90 mph.

The ambient noise level in this area ranged from 60 to 73 dB(A). This noise was produced by the I-5 freeway traffic that was located near, and due east of, the measurement site. Occasional noise was produced by vehicles using the old highway.

An examination and analysis of the graphic level recordings indicated the peak noise reached a maximum and continued for approximately 6 sec. This

TABLE 1 Decreases in Noise Levels with Distance

Time of Day	Train Speed (mph)	Train Length (cars)	Noise Level [dB(A)] at 50 ft	100 ft
8:30 a.m.	72	6	98	92
9:43 a.m.	93	4	101	96
10:00 a.m.	84	4	100	96
11:40 a.m.	65	4	95	92
2:28 p.m.	63	4	96	90
2:44 p.m.	90	5	99	93
Avg	78		98	93

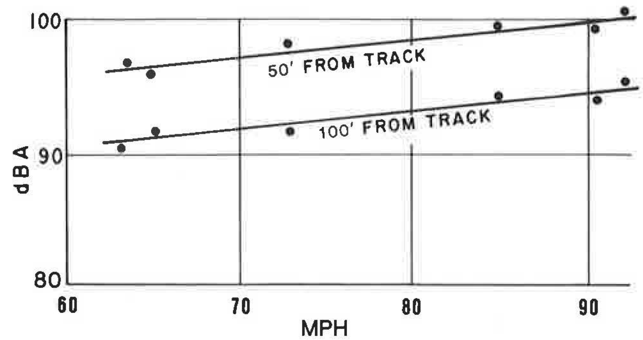

FIGURE 3 Level versus train speed.

occurred when the train speed was 65 mph and the distance from the SLM to the train was 100 ft. The maximum levels were reached and remained for approximately 3 sec at a speed of 90 mph.

MONTEBELLO LOCATIONS

Locations were selected behind the noise wall in Montebello. Two of the locations are shown on the map in Figure 4. Figure 5 shows a typical cross section of the sites behind the noise wall. These sites were far enough from the end of the wall to minimize the noise coming from beyond the end of the wall. There are two main tracks (northbound and southbound) in this area that are of continuously welded rail construction.

Measurements were made at Sycamore and Spruce streets on February 13, 1979. The weather was clear, except for scattered clouds. The temperature was

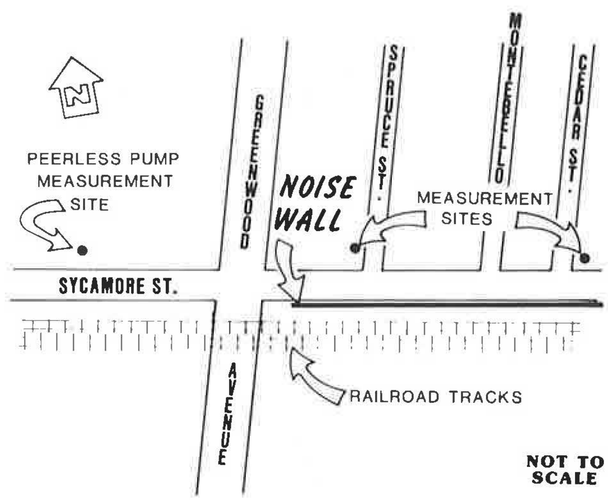

FIGURE 4 Plan of measurement sites in Montebello.

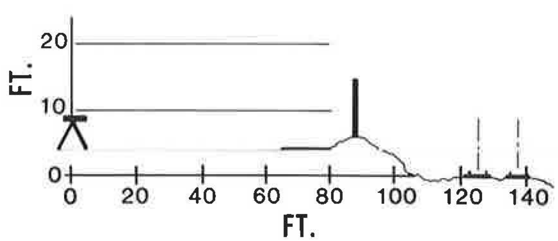

FIGURE 5 Cross section of Montebello site.

estimated at 60° to 70°F. Wind speeds were measured at 2 to 5 mph.

Supplementary measurements were made at Sycamore and Cedar streets on February 15, 1979. Weather conditions were approximately the same as February 13.

A third location was selected in an open area in front of the Peerless Pump Company facility on Sycamore Street north of Greenwood Avenue (Figure 4). There are four sets of tracks in this area, and the main tracks are of continuously welded rail construction. Two other tracks serve as sidings. The measurements at this location also were made on February 13, 1979.

The purpose of the measurements at the three locations was to assess the ambient noise level, passenger train noise, other train noise, noise attenuation because of the sound wall, and any increase in noise from trains traveling at 90 mph. The test data for the various Montebello sites are given in Table 2.

TABLE 2 Montebello Noise Wall Attenuation of Passenger Train Noise

Time of Day	Train Speed (mph)	Train Length (cars)	Noise Level [dB(A)] Behind Wall	Open Area	Attenuation
8:50 a.m.	66	4	74	88	14
9:15 a.m.	67	6	95[a]	–	–
			74	86	12
10:50 a.m.	63	4	74	87	13
11:50 a.m.	66	4	92[a]	–	–
			76	85	9
3:15 p.m.	63	4	73	88	15
4:05 p.m.	64	4	74	89	15
Avg	65		74	87	13

Note: Distance from sound level meter to train averaged 127 ft.
[a]Whistle.

The following table gives data that compare the noise levels at the Orange County site and the open area site in Montebello:

	Train Speed (mph)	100-ft Noise Level [dB(A)]
Open area in Orange County (Galivan)	64	91
Open area in Montebello	65	87

Adjustments to the noise level in Montebello were made based on a 4.5 dB(A) drop-off for a doubling of distance.

The slightly lower levels in Montebello were caused by the continuously welded rail construction of the track. These data reinforced the assumption that the noise level without the wall along Sycamore Street would be about the same as the noise level at the adjacent open area [87 dB(A)]. Because the measured noise levels behind the wall were about 74 dB(A), the attenuation provided by the wall is approximately 13 dB(A).

OTHER MEASUREMENTS BEHIND THE NOISE WALL

Noise measurements were also taken at Sycamore and Spruce streets on February 13 to assess the neighborhood environmental noise. The data are given in the following table:

Noise	Noise Level [dB(A)]
Automobile	70
Jet aircraft	73
Delivery Truck	77
Freight train	82
Train whistle	99

The noise levels represent the maximum levels recorded between the passing of passenger trains. These and other noise sources intermittently disturbed the quiet of the neighborhood, but they were usually lower than the maximum values shown.

DISCUSSION OF RESULTS

There are currently 12 National Railroad Passenger Corporation (Amtrak) passenger trains operating Monday through Friday between Los Angeles and San Diego (6 in each direction). The first leaves San Diego at 11:05 p.m. All 12 Amtrak trains pass through Montebello between 7:30 a.m. and 9:05 p.m. On weekends, one less train per day is operated.

Passenger train noise measurements at the Galivan site in Orange County indicated an increase of 4.5 dB(A) as the speed increased from 65 to 90 mph. The increase in noise in Montebello behind the wall should be less than 4.5 dB(A) because the trackage is of continuously welded rail construction. This increase, however, will generally occur during the nonsleeping hours and will be about equal to and a part of the neighborhood environmental noise (as shown in the preceding table).

An increase of 2 to 3 dB(A) would hardly be noticeable to most people when the change occurs from one day to the next. An increase of 10 dB(A) doubles the noise level as perceived by the human ear. An increase of 4.5 dB(A) would probably be noticeable.

The engine and rail noise are the primary noise sources from a passenger train. Usually the engine is noisier, but this was not confirmed because the Amtrak passenger train was traveling at high speeds and was pulling only four to six cars. The two noise sources could not be separated or detected on the graphic recordings.

Subjectively, the measurement team could not clearly ascertain if the noise level at 90 mph was significantly louder than at 65 mph. This probably was due to the train whistle, which was the dominant noise source that affected the perception of the lower level engine and rail noise. The engineer blew the whistle whenever he saw anyone near the tracks or when he approached a grade crossing of a street or highway.

The train whistle is not affected by speed. Based on the previous discussion, it appears that the whistle will continue to dominate neighborhood noise in Montebello behind the noise wall.

One resident living near Sycamore and Spruce streets indicated that the noise wall helped keep the noise level down. He noted, however, that the most annoying and loud noise occurred at night during the sleeping hours when the freight cars were being coupled, uncoupled, and switched.

CONCLUSIONS

The following conclusions are reached as a result of this study.

1. The passenger train noise increased approximately 4.5 dB(A) when train speeds increased from 65 to 90 mph over jointed rails.
2. At a train speed of 65 mph, the noise level

at 100 ft reached a maximum level and remained constant for approximately 6 sec.

3. At a train speed of 90 mph the noise level at 100 ft reached a maximum level and remained constant for approximately 3 sec.

4. The noise level behind the noise wall in Montebello was 74 dB(A) when the passenger train speed was 65 mph.

5. Because of continuously welded rail construction of the trackage in Montebello, the noise level is expected to increase less than 4.5 dB(A) if the speed is increased to 90 mph.

6. The noise wall in Montebello along Sycamore Street provides approximately 13 dB(A) attenuation.

7. Other noise from sources (such as switching of freight cars, freight trains, and engines; passing cars; motorcycles; delivery trucks; and airplanes) ranged from 71 to 82 dB(A). The highest train whistle noise recorded was 99 dB(A). These levels were measured behind the wall at the intersection of Spruce and Sycamore streets in Montebello.

Publication of this paper sponsored by Committee on Transportation-Related Noise and Vibration.

Synthesis of Disc Brake Squeal Quieting Experience

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ABSTRACT

Disc brake squeal produced by Washington Metropolitan Area Transit Authority transit cars precipitated a number of on-car and laboratory tests. The results of these tests are summarized along with the experience of other investigators in both the transit and automotive fields. Experience indicates that some brake systems are prone to squeal while others are not, and that the benefit of system modifications varies dramatically for different disc brake systems. Modifications that hold the most promise for reducing the propensity of a brake system to squeal are sufficiently damping the brake pad backplate, disc rotor, or caliper; altering disc rotor stiffness, caliper mass, or caliper stiffness; reducing (if possible) the brake pad friction coefficient; and, possibly, eliminating brake pad grooves.

The existence of brake squeal has been recognized as a problem for some time primarily because of its occurrence in highway vehicle drum and disc brake systems. Rail transit cars have also exhibited brake squeal from their tread and disc brakes. In the United States three transit systems use disc brakes: the San Francisco Bay Area Rapid Transit District (BART), the Chicago Transit Authority (CTA), and the Washington Metropolitan Area Transit Authority (WMATA). Of these, only WMATA has experienced problems due to brake squeal. The squeal propensity of the WMATA brake system has limited the options available for replacement friction pad materials, and at one point squeal sound levels became so severe that a considerable public outcry ensued. The purpose of this paper is to document the experience gained in attempting to reduce the brake squeal on WMATA cars and to place this experience in the context of other work.

WASHINGTON METRORAIL EXPERIENCE

The disc brake assembly used by the WMATA Metro cars is similar in configuration to automotive caliper disc brakes with ventilated rotors (Figure 1). The disc is 20 in. in diameter and 3.6 in. thick and weighs 137 lb (1). The kidney-shaped brake pads are actuated by two side-by-side pistons. The brake system was designed by the Abex Corporation with two assemblies fitted per axle for a total of eight assemblies per car. (Author's note: Equipment sup-

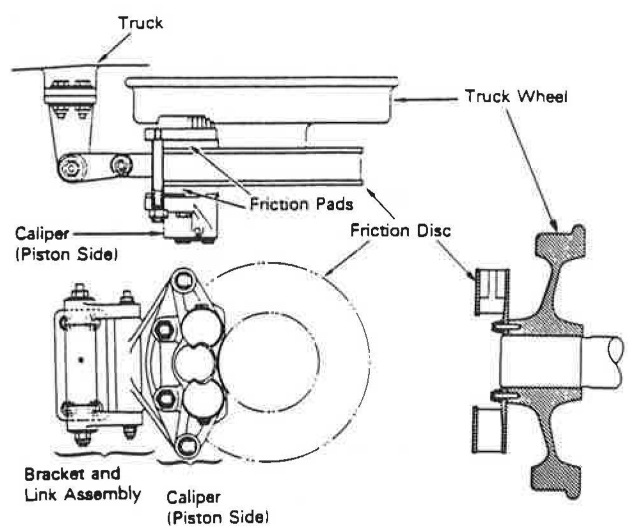

FIGURE 1 WMATA/Abex disc brake system.