MEASUREMENTS AND ANALYSIS OF THE NOISE TO WHICH PASSENGERS ARE EXPOSED IN ISTANBUL METRO

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Recently, noise problems are gaining increasing importance in railway vehicles for passengers. The noise are controlled inside railway vehicles for one or more of four reasons, comfort, ease of voice communication, freedom from hearing damage risk, and ability to hear warning signals that originate outside. The internal noise levels in railway vehicles have been decreased step by step during recent years due to the fact that stiff requirements on passenger comfort. This paper presents the results of measurements and analysis of the noise to which passengers are exposed in Istanbul metro. These measurements demonstrate the role of wheel and rail maintenance in minimizing noise in the metro.

INTRODUCTION

Disturbance caused by noise is one of the most important environmental health consequences of the transport vehicles. Over a number of years, investigations in different countries have shown that noise affects different activities and causes a poorer life quality. There is thus a great need to control noise caused by transport. Investigations of the relationship between exposure to originating from different noise sources in the transport vehicles and effects among the exposed population form an important basis for technical measures to limit noise generation and to regulate noise levels. Such investigations have studied the extent of annoyance among persons exposed to different types and levels environmental noise.

Interior noise is often a problem in the railway passenger car during transportation. This noise may damage hearing if consistently of a high level or an impulsive nature, impair safety by making warnings difficult to hear, hinder communication between passengers, cause fatigue and loss of concentration and be annoying. At the same time, acoustic comfort in railway vehicles for passengers is becoming more and more important parameter. Engineering criteria for specifying acceptable noise levels and for rating them in those locations have been developed over the past half century.

Although, railway lines ensure high quality guidance, the track still has irregularities which cause noise and vibration, such as: defects in truck level, alignment or gauge, welding or rolling defects, rail joints, variable vertical stiffness of the truck (e.g., bridges), level crossings, acceleration and breaking.

Attaining better acoustic characteristics in future railway vehicles requires a better understanding of the sound phenomena taking place in those cars. The major problem is to prevent the noise generated by exterior sources, as the wheel-rail contact and traction system, from penetrating into the passenger compartments. This study reports interior sound measurements and analysis performed in operating conditions on the Istanbul Metro car.

MEASUREMENTS AND ANALYSIS IN THE RAILWAY PASSENGER CAR

Different types of measurements and ratings are used in the control and evaluation of noise depending on purpose. In this study manual measurements of noise levels were performed with a sound level meter in the metro car circulating with passengers on its usual route. One person made A-weighted sound level measurements directly from one station to the next during the time between 08:00 and 20:00, for a period of two hours, using a calibrated microphone on a stand at a level of 1.5 m above the ground.

The statistical analysis of the internal noise of the railway passenger car is shown in Figure 1. The results from the measurements show that, of 1470 measurements, the A-weighted noise level is concentrated around 65 dBA, the level of continuous noise. Corresponding internal noise levels for the railway passenger car are in the range 65-70 dBA, which represent a good compromise between low noise levels, good privacy and speech comprehensibility, but there are tonal and higher frequency components in the noise spectrum. Furthermore, there are interior noise level fluctuations during the transportation that are not desired.

Table 1 shows the equivalent continuous A-weighted noise levels L_{eq}, measured according to time intervals in the metro car circulating with passengers on its usual route from one station to the next. L_{eq} is the

A-weighted energy mean of the noise level averaged over the measurement period. The continuous steady noise levels L_{eq} are dissipating between 70.5 dBA and 80.7 dBA.

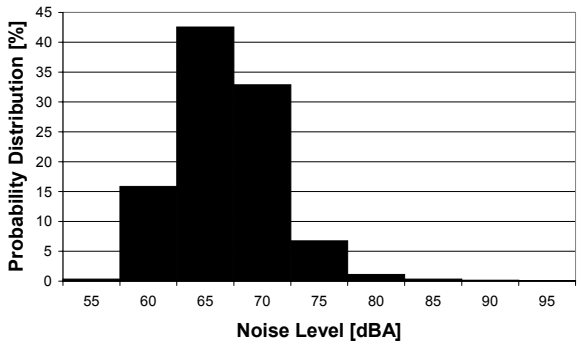

FIGURE 1. Statistical analysis of the railway vehicle interior noise.

Table 2 summarises the maximum A-weighted noise levels L_{Max}, measured according to time intervals in the metro car circulating with passengers on its usual route from one station to the next. The maximum A-weighted noise levels L_{Max} are changing between 78.9 dBA and 92.1 dBA.

Table 1. Equivalent continuous A-weighted noise levels L_{eq}, measured according to time intervals in the metro car circulating with passengers on its usual route from one station to the next.

Stations	Time Intervals					
	08 - 10	10 - 12	12 - 14	14 - 16	16 - 18	18 - 20
Ataköy	73,8	72,7	73,5	75,0	73,4	73,1
Bahçelievler	72,9	73,0	73,1	75,2	74,6	77,3
Bakırköy	71,6	72,4	71,9	72,7	72,7	72,7
Zeytinburnu	74,7	73,2	72,3	73,4	72,4	73,9
Merter	70,4	71,4	70,8	71,4	70,5	72,5
Davutpaşa	71,0	70,7	71,4	72,2	71,6	71,9
Terazidere	70,5	71,4	71,1	71,8	70,6	71,1
Otogar	72,2	73,6	71,0	72,1	71,7	71,4
Kartaltepe	72,4	72,9	71,5	73,5	72,8	73,0
Sağmalcılar	73,8	73,3	72,9	73,5	74,9	74,9
Bayrampaşa	74,5	75,4	74,3	75,5	76,8	77,6
Topkapı	76,6	76,3	75,6	78,1	78,7	79,8
Emniyet	78,2	77,0	76,2	77,5	79,0	80,7
Aksaray	76,8	76,7	75,0	75,6	77,5	78,6

CONCLUSIONS

The internal noise levels of railway vehicles have been gradually decreased during recent years due to tougher requirements on passenger comfort, on external noise and an improved infrastructure. To modify and improve acoustical conditions in the metro car, the relationship between sound sources and the characteristics of the car must be understand. The reduction required in the railway passenger car depends primarily on the function of the inner part of the vehicle and the existing noise level within it. The overriding criteria, which must always be met, is that relating to hearing damage. In less noisy circumstances the allowable noise level may be defined by the requirements for adequate communication, passenger comfort, or avoidance of complaints from the passengers at large.

Table 2. Maximum A-weighted noise levels, L_{Max}, measured according to time intervals in the metro car circulating with passengers on its usual route from one station to the next.

Stations	Time Intervals					
	08 - 10	10 - 12	12 - 14	14 - 16	16 - 18	18 - 20
Ataköy	89,7	85,8	82,8	88,3	84,3	81,9
Bahçelievler	80,3	81,1	82,2	85,1	82,4	83,7
Bakırköy	80,2	80,1	79,6	86,0	81,0	78,9
Zeytinburnu	84,3	88,3	83,0	94,3	82,5	82,1
Merter	79,1	80,0	79,7	82,7	81,3	79,2
Davutpaşa	80,3	78,9	82,1	82,2	80,4	78,7
Terazidere	83,8	81,7	85,8	84,5	81,3	82,2
Otogar	87,6	85,5	80,3	85,9	92,1	80,1
Kartaltepe	81,4	86,5	81,3	88,5	81,1	81,4
Sağmalcılar	84,3	82,9	83,0	84,2	90,4	86,0
Bayrampaşa	82,3	83,4	85,6	85,4	90,7	87,6
Topkapı	82,9	84,1	85,4	87,4	86,4	89,2
Emniyet	85,4	86,5	86,5	87,9	86,5	90,8
Aksaray	85,8	85,3	88,2	88,4	84,2	85,9

The most important noise sources in the vehicles during operation are the track/wheel/suspension and drive systems. Significant noise sources in stationary vehicles are various types of auxiliary systems, but mainly compressors and fans. The noise produced by railway vehicles is highly dependent on the track/wheel/suspension system and these factors should be prime considerations in the selection of the type to be used in a particular situation. Any noise control strategy must take some assumptions regarding rail/wheel maintenance. There can be no doubt that the willingness to maintain a smooth contact surface is an important technical factor in reducing noise. Good maintenance ensures a noise reduction of at least 3 dBA, and potentially 5-10 dBA. This noise control measure will also improve wear and passenger comfort, two factors closely connected to the economics of rail traffic.

REFERENCES

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