Acoustical Properties of Escalator Tunnels in St.-Petersburg Underground

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Knowledge of acoustical properties of escalator tunnels is necessary for assessment of speech intelligibility with a view to insonation of the tunnels which is common for notice and advertising. Underground is known as a danger zone and it is important to provide rather good speech intelligibility for emergency notice.

The particular feature of St.-Petersburg Underground is its depth. The average depth of Underground stations in St.-Petersburg is 60 meters. The length of escalator tunnels at some stations reaches 150 meters. A tunnel presents an inclined concrete tube and moving escalators divide this tube into two equal parts – upper for passengers and lower for mechanisms. The walls of tunnels are usually plastered. Generally there are two types of escalator tunnels. The first one is 3 escalators tunnel with 6 meters diameter. The second type is 4 escalators tunnel with 9 meters diameter.

Particular difficulty specific for tunnels in St.-Petersburg Underground is permanent high noise level from moving escalators and passengers flow.

For definition of speech intelligibility it is necessary to know dependence of reverberation time from the frequency and spectral distribution of the noise. These characteristics were determined in two escalator tunnels of St.-Petersburg Underground. Here the term "reverberation time" is defined as the time required for the sound pressure in a certain point in a tunnel to decay 60 dB taking into account propagation of sound energy along a tunnel.

The sound source was mounted in the upper part of the tunnels at the depth equal to the tunnel diameter. Measurement of reverberation time was made at distances of 12, 30 and 55 m for 3 escalators tunnel and 12 and 30 m for 4 escalators tunnel from the sound source. Radiated channel consisted of white noise generator type 2027 (by Bruel&Kjaer), band-pass filter type 1617 (by Bruel&Kjaer). As a radiating element was used omnidirectional acoustic radiator type 6KZ22 (by JSC "ELAT", Russia).

Reception channel consisted of two sound level meters type 2209 and 2203 (by Bruel&Kjaer), octave filter type 1613 (by Bruel&Kjaer) and measuring sound recorder type 7006 (by Bruel&Kjaer). The signal from sound level meters was recorded in sound recorder, then given to inlet of ADP and saved in hard disk of PC Pentium II-266 for further processing and analysis.

During the daily measurements the passengers moved at two side escalators, number of passengers was 6-8 persons for the 5 meters.

The measurements were made in the central escalator where reverberation time is maximum value because of curved form of tunnel's ceiling.

As a result frequency dependences of reverberation time in the tunnels with and without passengers, dependence of the reverberation time at the different frequencies on the distance along the tunnel axis between a sound source and receiving point and spectrum of the noise in the tunnels produced by a passengers flow on moving escalators were obtained.

Analysis of obtained data lets to make following conclusions:

1. The level of own noise in the tunnels is 45-50 dB at night when escalators are stopped. In the afternoon the noise level in both tunnels is 72-74 dBA. Noise level in the tunnels in the afternoon does not depend on intensity of a passenger flow and numbers of moving escalators. Typical noise spectrum in the tunnel is shown in Fig. 1.

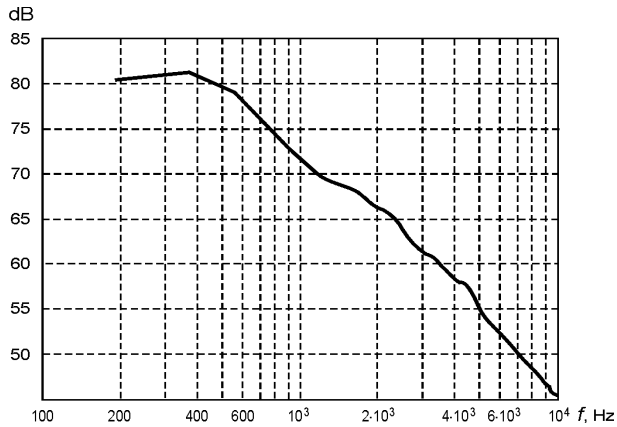

Fig. 1. Typical daytime noise spectrum in escalator tunnel

$L_{max} = 72 \div 74$ dBA

2. Reverberation time in 3 escalators tunnel is 0.9-0.95 sec at low and middle frequencies and 0.6 sec at high frequencies at night (Fig. 2).

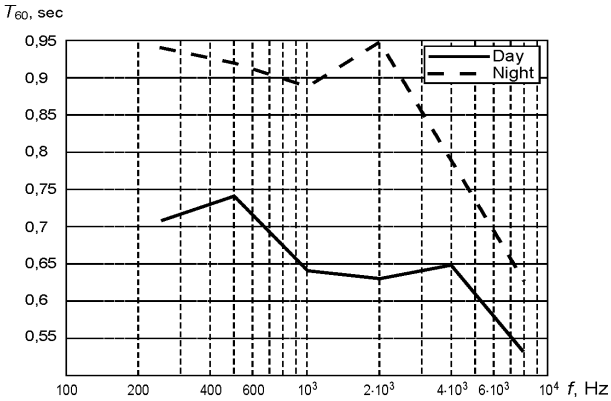

Fig. 2. Frequency dependence of reverberation time in escalator tunnel at the depth 12 m (3 escalators tunnel)

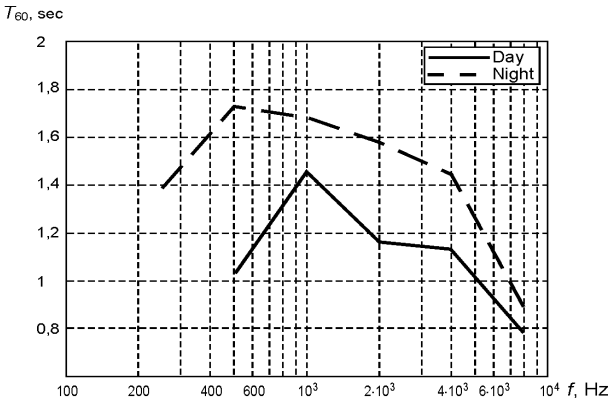

Fig. 3. Frequency dependence of reverberation time in escalator tunnel at the depth 12 m (4 escalators tunnel)

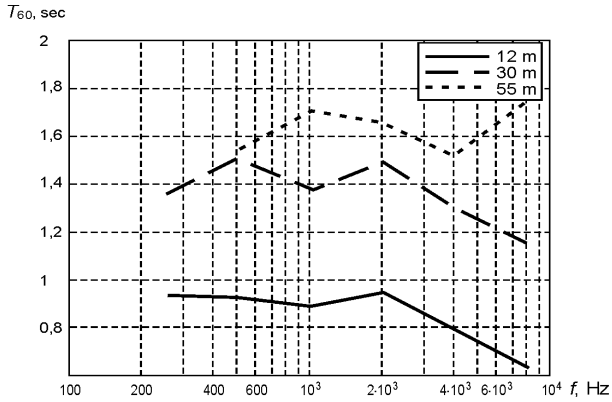

Fig. 4. Frequency dependence of reverberation time in the night time (3 escalators tunnel)

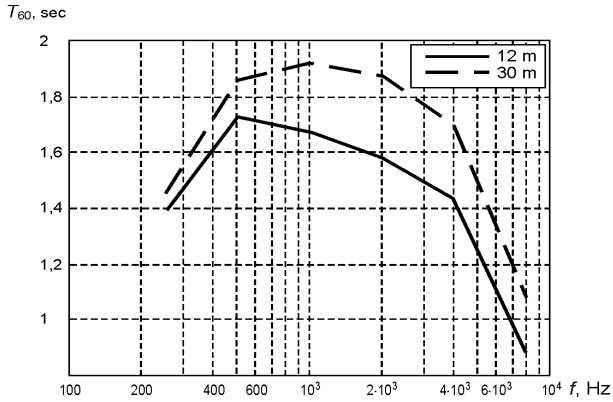

Fig. 5. Frequency dependence of reverberation time in the night time (4 escalators tunnel)

3. Reverberation time in 4 escalators tunnel is 1.4-1.7 sec at low and middle frequencies and 0.9 sec at high frequencies at night. Reverberation time at second tunnel is more than at first one. This fact is explained by the greater diameter of second tunnel.

4. Reverberation time in the afternoon is decreased because of absorption by passengers.

5. Fig. 4 and 5 show dependence of the reverberation time at the different frequencies on the distance along the tunnel axis between a sound source and receiving point. Reverberation time increases with the increasing of distance value because of increasing of sound propagation time.

Obtained results can be used for development of the voice information system for the passengers in Underground tunnels.