

SAFETY FOR TUNNEL

– ADVANCED VOICE EVACUATION SYSTEM FOR TUNNELS



Road tunnels are specific facilities, where the top priority is to maintain traffic and ensure the safety of travellers. Voice evacuation systems used in tunnels must ensure effective evacuation of people staying there to safe locations.

Voice evacuation system installed in a facility allows conveying messages to travellers. In a fire hazard or other emergency, it allows to carry out the evacuation and direct travellers to safe locations immediately. The most effective and most efficient system is the voice evacuation system, which provides clear and understandable transmission of voice messages from the beginning of their broadcasting. As a result, in an emergency, passengers can quickly and efficiently respond to commands of evacuation services. Transmission of voice should be as clear as possible. In tunnels, due to the long reverberation time and the high level of prevailing noise, it is very difficult to meet this condition.

Obtaining the highest degree of speech intelligibility, which is a critical parameter of evaluation of each voice evacuation system, becomes the most

important task posed a voice evacuation system inside acoustically difficult spaces.

Acoustic Conditions Prevailing in Tunnels

Road tunnels are very difficult acoustic environments. Conventional loudspeaker solutions used in voice evacuation systems do not provide clear and understandable messages in such an environment. In the process of the voice evacuation system design in a tunnel, you should consider some important factors that have a very large impact on obtaining the required speech intelligibility.

Severe acoustic conditions prevailing inside the tunnel are associated with **long reverberation time** and the **reflections of sound waves** from the hard concrete surfaces. This leads to the fact that it is very difficult to get the right ratio of direct sound energy to the reflected sound

energy, which is necessary to achieve a high level of speech intelligibility. The use of acoustic treatment consisting in covering the tunnel internal surfaces with materials of high sound absorption is very costly and not used in practice. Reducing the reflections is possible with highly directional speakers. Another factor having a negative impact on the intelligibility of speech is the **noise generated by cars and ventilation and smoke exhaust systems**. The required values of signal to noise ratio, expressing the speech signal level to the prevailing noise level, can be achieved using a highly efficient loudspeakers. Such a solution can give the appropriate level and intelligibility of the broadcasted messages. Conventional loudspeakers for voice evacuation systems are not sufficiently directional, and their low efficiency and power do not allow to obtain a high level of SPL (Sound Pressure Level) without distorting the audio signal.

Considering the above problems, the use of effective and at the same time highly directional tunnel loudspeakers is a complete sound solution in difficult acoustic conditions prevailing in tunnels. By reducing the amount of sound reflections from the walls to the minimum, ratio of the direct sound energy to the reflected sound energy value is increased. It is then possible to achieve even higher values of speech intelligibility.



S4T – Safety for Tunnel

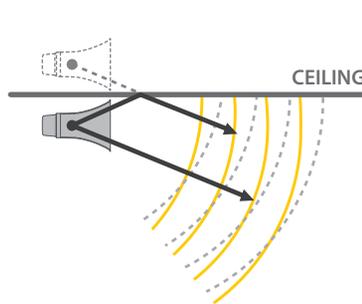
Ambient System Sp. o.o., as the only Polish manufacturer of sound evacuation systems, introduced a solution dedicated to the public address systems for tunnels. **S4T – Safety for Tunnel** is a system based on central units managed by the ABT-CU11LCD digital control unit with built-in DSP and specially designed ABT-TNL100 loudspeakers for tunnel applications.

The aim of the project was to design and implement for sale a loudspeaker allowing obtaining the highest achievable speech intelligibility in the previously described harsh sound environment in the tunnel.

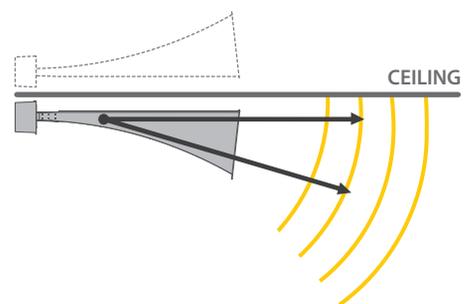
ABT-TNL100 Loudspeaker

The first produced series of ABT-TNL100 loudspeakers has been fully tested under the measurement conditions of anechoic chamber and in a facility, i.e. in the newly built tunnel in Istanbul, Turkey. Measuring more than 5 km long transcontinental tunnel linking Europe with Asia has been dug under the Bosphorus (Eurasia Tunnel). Tests conducted by Ambient System confirmed

Conventional Loudspeaker



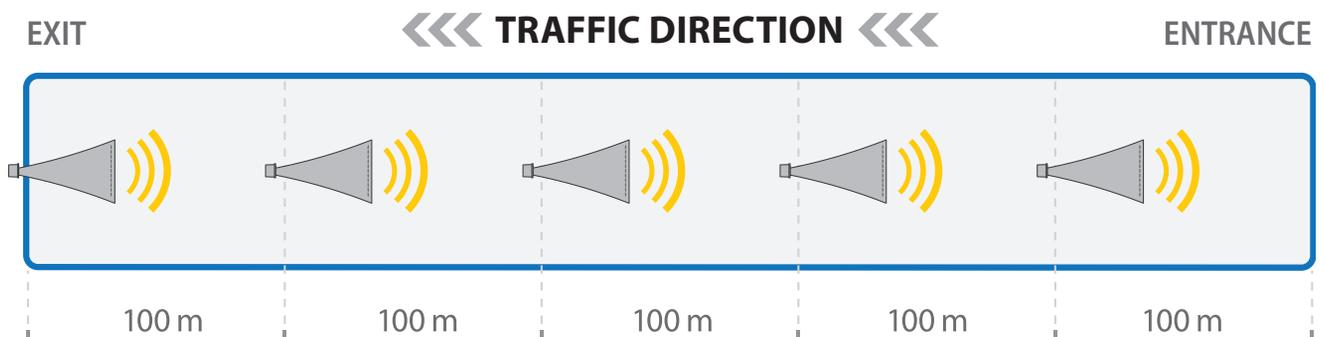
ABT-TNL100 Tunnel Loudspeaker

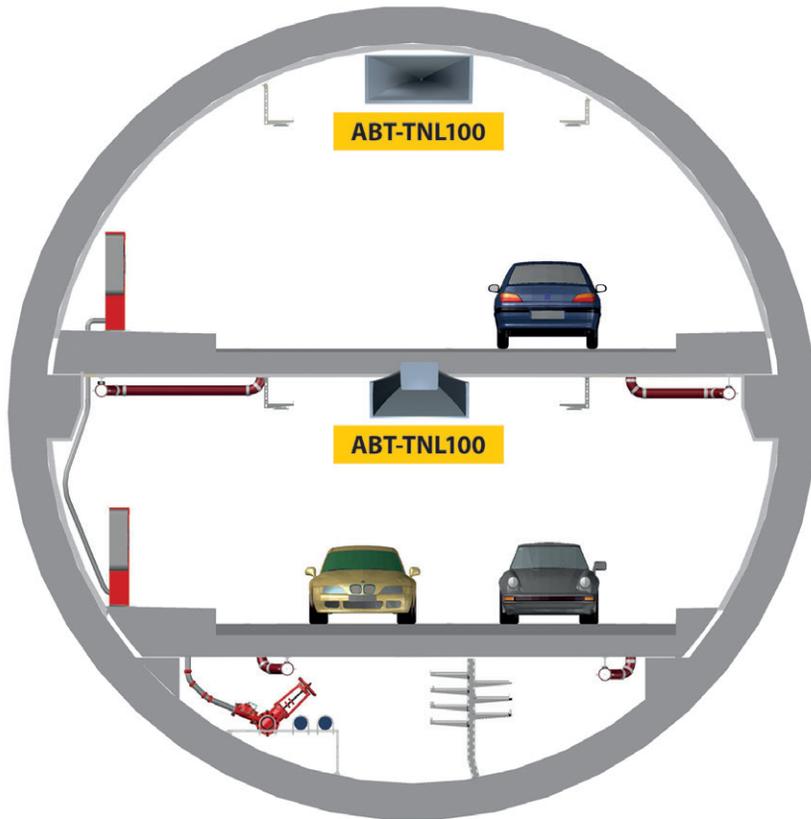


that the introduced S4T solution allowed clean transmission of clear and understandable messages to the tunnel users. Narrow angles of radiation and the ability to produce high sound pressure levels without distorting the audio signal makes ABT-TNL100 an ideal solution designed for noisy environments of road tunnels.

Asymmetric construction of the loudspeaker has been designed using the method of virtual sources in order to

produce the flat face of the acoustic wave. Through the simple installation of ABT-TNL100 on the roof, the roof of the tunnel becomes a boundary surface and waveguide of coherent acoustic wave. By reducing the impact of additional reflections, it is possible to obtain a coherent wave front. In contrast to the conventional horn loudspeakers, which have to be mounted at a distance from the wall or roof, the use of ABT-TNL100 prevents





the occurrence of undesirable acoustic effects. This eliminates to the minimum the adverse impact of wave interference and comb filter caused by phase shift between the direct and reflected sounds in a wide frequency band.

ABT-TNL100 has been designed not only to allow the transmission of clear and intelligible voice messages, but also to meet the conditions prevailing during firefighting, and maintenance and cleaning tunnels. When designing, special attention was paid to the resistance of the loudspeaker to the water extinguishing and sprinkler systems as well as water under high pressure. The interior of the loudspeaker is protected by a thick mesh of stainless steel especially designed so that it had no effect on the primary function of the loudspeaker, that is to produce the acoustic wave. The outer casing is also fully made of stainless steel, making the loudspeaker fire and water resistant in case of fire and providing the safe, long-term and reliable operation throughout the product life.

ABT-TNL100 is designed for installation on the round and flat roofs. The best location for the loudspeaker is the centre of the tunnel, above the line dividing the lanes. The Eurasia tunnel tests have shown that the achievement of the required acoustic parameters, such as SPL (105 dB) and STI (0.45) (Speech Transmission Index – speech intelligibility index), was possible even with the loudspeakers spaced of 100 m. However, depending on the architecture of the tunnel, selection of the number and location of ABT-TNL100 loudspeakers should be preceded by acoustic simulations, in order to verify obtaining the required parameters.

Dedicated Amplifier System

When designing voice evacuation systems in road tunnels, it is necessary to use dedicated tunnel loudspeakers, but also a dedicated system for amplifying the electroacoustic signal. **S4T – Safety for Tunnel** is a comprehensive solution for tunnels, which includes voice evacuation

system control units also manufactured in Poland by Ambient System. The heart of the system is the ABT-CU11LCD control unit with built-in DSP. It is the manager of the system and audio matrix at the same time that allows monitoring of key functions and all system components, such as memory cards, power amplifiers (e.g. switching to standby amplifiers), emergency power supply, loudspeaker lines, the connection between other systems, e.g. fire detection systems and many others. The unit allows you to control the loudspeaker line impedances with built-in adaptive measuring algorithm and to adjust tolerance for each loudspeaker. It provides redundant connections between next control units and firefighter microphones through digital fibre optic connection implemented in the ring topology, allowing the transmission of 28 audio channels at 32-bit resolution. With built-in network card with SFP ports, there is no need to use any external network switches. Matrix provides the ability to use audio limiter on each loudspeaker line, to prevent damage to the loudspeakers. Built-in DSP allows for higher values of speech intelligibility through the use of the 3-band parametric equalizer EQ on every audio input and 8-band parametric EQ on each audio output. It has a built-in feedback eliminator and the ability to define the delay for each tunnel loudspeaker (30 sec). The system also has a built-in intercom between the alarm and the zone microphones. Class D multi-channel power amplifiers allow you to provide an adequate amplification of the acoustic signal and the use of a single channel for a standby amplifier.

Delays of Loudspeaker Lines

In order to minimize unwanted echo effects that adversely affect speech intelligibility, each loudspeaker needs to be powered individually by a signal from a separate amplifier channel. The use of DSP is necessary, which enables the processing of each signal with EQ and defining the delay line. You should take into account the propagation time of the acoustic wave that takes it to go long

distances between the loudspeakers. Time synchronization of sound coming from each previous loudspeaker with the currently considered loudspeaker is of great importance. The conducted tests have proven that with the right tuning and using the built-in EQ and precise setting of the delay, it is possible to increase the speech intelligibility index, STI, of 0.1.

Ambient System – manufacturer of MULTIVES digital voice evacuation system, fully compliant with current

standards, PN-EN 54-16 and EN 54-4, has extensive experience in providing comprehensive solutions for public address and voice evacuation systems for acoustically challenging facilities, where the very high quality of sound reproduction and obtaining the highest degree of speech intelligibility are the most important. We successfully deliver sound systems for sports facilities, airports, train stations, museums, multi-storey shopping malls and road tunnels, etc.

S4T – Safety for Tunnel offers the most effective solution that combines a dedicated Voice Evacuation System and specially designed ABT-TNL100 tunnel loudspeakers. **“**

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