UOZ-1 animal deterrent for railway lines with high-speed train traffic

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Abstract. The article demonstrates the principles of functioning, structure and basic technical parameters of a device for deterring animals migrating across express railway lines. The novel device UOZ-1 is a result of cooperation of animal ethologists and designers of sophisticated electrical and electronic equipment. The presented device has been already tested in the field conditions and first conclusions are very encouraging.

Key words: rail way lines, animmals mortality, animal deterrent, acoustic signals

1. Introduction

The problem of wildlife being killed by quickly moving trains has existed since the beginnings of railway transport. This problem has recently escalated along with the improvements in the substructure of the track and the application of advanced solutions in the construction of runway subassemblies of cars and locomotives. All this has led to such a significant reduction of noise and vibrations produced by increasingly fast trains, that on modernised railway line sections, the train is first seen, and when and if it is heard, it already very close. However, it is not the lower noise level that is the source of danger. The problem here is the ever-increasing speed of trains.

Leveraging years of experience in constructing microchip automatic devices for PKP (Polish State Railways) as well as the outcome of discussions, consulting, and direct cooperation with representatives of nature conservation bodies, PKP, and scientists and practicing experts involved with wildlife behaviourism, the Implementation-Production Enterprise (Przedsiębiorstwo Wdrożeniowo-Produkcyjne) 'NEEL' Sp. z o. o. in Warsaw developed the UOZ-1 animal-dispersing apparatus, an innovative solution that is unique on the global scale. Experts from the Forestry Research Institute in Warsaw, the CBPBBK 'Kolprojekt' in Warsaw, and Bombardier Transportation (ZWUS) Polska Sp. z o. o. in Katowice participated in the work.

These devices are designed to prevent the migration of large mammals across railway lines just before the run of a train, minimising losses in the population of these animals caused by collision, while at the same time ensuring that they are not limited in their migrations into their pastures and calving areas. Acoustic signals were used for deterring, prepared by Prof. Dr. hab. Simona Kossak, the Head of the Department of Natural Forests in the Forestry Research Institute, a renowned specialist in zoopsychology.

2. Scope of application

The scope of application of UOZ-1 devices is for the protection of railway lines in permanent wildlife migration places. This can be point type protection, covering a section of several hundred meters long, or continuous (e.g. on the borders of nature reserves), operating in an area determined by the size of the border region.

3. System structure

3.1. Overview

The complete animal deterring system consists of UOZ-1 devices (dispersers) installed by the track-way at the place of fixed migration routes of wildlife, as well as of the communicating EZG-2102 diagnostic modules with modified software, installed in linear self-blocking SHL-12 containers manufactured by Bombardier Transportation (ZWUS) Polska Sp. z o.o. (they are their factory equipment) (Fig. 1).

Fig. 1. Depicts a UOZ-1 device installed by the track-way and the linear self-blocking container next to it

Each UOZ-1 device is an autonomous unit, equipped with an electric terminal strip, an electronics control unit, as well as a head with electro-acoustic transformers. The device is mounted to a solid concrete foundation in the substructure of the track (in line with traction poles) alternately, on both sides of the track-way. It is cylindrical in shape, approx. 110 cm in height, and approx. 30 cm in diameter. There are visible holes in the upper part of the device through which deterring sounds are broadcasted. The casing is grey and is made of weather-resistant, high impact-resistant epoxy-fibreglass composites.

The power to the devices is supplied through a cable from the linear self-blocking container with UPS emergency power for a minimum of 8 hours. All UOZ-1 devices, which are powered from one linear self-blocking container (SBL), are connected with one another and with the SBL container by an information bus based on wire communication. It enables the operation of devices to be synchronised, as well as for full auto-diagnostics with the option to control their work in the Service

Centre of the Local Railway Traffic Control Centre. Moreover, each UOZ-1 device is equipped with a set of sensors that react to theft and vandalism attempts (in such a case, all the UOZ devices from a given region broadcast an alarm sound and transmit information about the theft attempt to LCS).

Up to 32 UOZ-1 devices can work with each SHL-12 type linear self-blocking container (which guarantees full protection of the route along the entire length of the isolated section (length of up to 2300 meters) and can be used for protection of railway lines running through large forest areas or a nature reserve) (Fig. 2).

Fig. 2. UOZ-1 devices installed along the length of an area of more than 2 km bordering the nature reserve

If it is necessary to protect smaller areas, the number of dispersers can be adjusted to their size (e.g. four UOZ-1 devices allow for protection of a railway line section approx. 250-300 m in length). The assumed effective scope of impact of a single UOZ-1 device is more than 70 meters. The same (approx. 70 meters) distance is counted along the track-way axis between the subsequent dispersers. Installing UOZ-1 devices in this way makes it possible to maintain the continuity of the deterrence zone, without any acoustic 'holes', with maximum equalisation of the intensity of the acoustic field transmitted by dispersers.

3.2. Technical parameters

The UOZ-1 device is designed for operation in a moderate climate in open air in an ambient temperature ranging from -35^0C to $+55^0$C. Other technical parameteres are presented by the table 1.

Table 1. Technical parameters of the UOZ-1 device

Characteristic feature	Value
Weight of UOZ-1 device	~29 kg (290N) (composite casing)
Weight of foundation foot	~128 kg (1.28kN)
Protection degree	IP 65 (control electronics unit)
Power supply	230V 50Hz (separated voltage)
Test voltage	4000 V RMS
Maximum power input	80VA, $\cos\varphi>0.9$
Protection	C class overcurrent installation switch
Maximum output power of amplifier	Pmax=50W
Standard transfer of digital data	RS-485
Transfer speed	300 Bd

3.3. Design of UOZ-1 device

The UOZ-1 device is made of the following components: casing, head with acoustic transformers, electronics control unit, temperature control system and anti-overvoltage and anti-disturbance protection elements.

The casing was made in the form of a covering tube, narrowing in the upper part, with an external diameter of approx. 30 cm, fitted to a concrete foundation foot and sticking out of it to the height of approx. 110 cm. Inside the protective tube, there is inner casing, containing a terminal strip to which power and data transmission cables are connected. Over the strip, a complete electronics control unit that controls the operation of the device, enclosed in a hermetic casing, was fastened. The upper part of the body was closed with a round head containing acoustic transformers.

The head with acoustic transformers is an integral part of the inner body. A set of two dynamic transformers has been used, together covering the acoustic range from 300 to 20,000Hz, with an effectiveness above 90dB and characterised by surround-sound transmission.

The electronics control unit is responsible for the logic of operation of the UOZ-1 device and is built based on a single-unit microprocessor of very low power consumption and high processing power.

Samples of deterring signals stored in the specialised memory system are the source of the acoustic signal controlling the power amplifier. The module moreover consists of:

- A feeder operating on 230V 50Hz voltage provides power for digital systems and a power supply to the heater and the acoustic power amplifier.
- The data transmission module was built using specialised RS-485 series transmission systems, providing proper voltage separation.
- The power amplifier module, built using a monolithic integrated circuit, has output power of 30-50 W, whilst maintaining full resistance to thermal stress and surge charge.

The temperature control system has to maintain the temperature of operation of electronic devices in the moisture condensation safe range during the winter exploitation period of the system.

Anti-overvoltage and anti-disturbance protection elements protect the operation of UOZ-1 devices from power energy and radioelectrical disturbances and overvoltage that occur in power supply and data transmission networks.

The terminal strip makes connecting the power supply and data transmission cables possible. Moreover, on the strip there is an installation overcurrent switch, an anti-overvoltage protector, and an anti-disturbance filter for data transmission lines.

3.4. Description of mechanical design

The UOZ-1 device is made of materials fully resistant to corrosion. The appearance of the UOZ-1 device is shown in Fig. 3. The device consists of an inner body (hot galvanised steel or epoxy-fibreglass composite) as well as a cylindrical outer shell (epoxy-fibreglass composite). The inner body and outer casing are tubular in shape. The outer casing is fastened to the body with special (anti-theft) bolts. The lower part of the body has a base plate with assembly holes and staffing boxes, whilst at the top there is a head with electroacoustic transformers. On the side of the inner body there are two rectangular inspection holes, making access to the apparatus installed inside possible. The openings are covered with covers fitted with rubber gaskets.

Fig. 3. The appearance of the UOZ-1 device

On the rim of the outer casing of the UOZ-1, there are a number of holes that make u hindered broadcasting of warning sounds from the electroacoustic transformer possible. The space between the outer casing and inner body creates an area of thermal circulation of air, effectively protecting the electronics unit inside the body from overheating. The material from which the casing was made guarantees its durability for a period of 20 years.

3.5. System autodiagnostics

Each UOZ-1 device was fitted with an autodiagnostics system, enabling remote detection and localisation of all malfunctions (meaning from the level of the Local Control Center and linear self-blocking container). The preciseness of localisation of malfunctions from the level of LCS is limited to determining the localisation of the container and the general type of defect. Detailed information of the place and type of damage is shown on an LCD display of the diagnostics module in the linear self-blocking container.

3.6. Anti-theft protection

The UOZ-1 device is fitted with an anti-theft protection system, reacting to attempts to disassemble or destroy the casing. The protection activates shortly after assembling and closing the outer casing. If a theft or break-in attempt is detected, all the devices belonging to one deterring point emit a very loud acoustic alarm signal (police sirens, etc.) for 90 seconds and a report of the break-in is immediately sent via the communication system to the container and further along to the Local Railway Traffic Control Center.

3.7. UOZ-1 communication system

UOZ-1 devices belonging to one deterring point are linked with a wire communication system with one another and with the cooperating linear self-blocking SHL-12container. A two-channel two-directional system of series transmission was adopted, a ‘master-slaves’ type based on the standard RS-485. An EZG-2102 diagnostics module was selected as the master, being the standard

equipment of the SBL container, equipped with an LCD display unit, RS-485 transmission output, and linking with linear self-blocking automatics. 'Slave' functions are played by controllers of UOZ devices.

Modified software of the diagnostics module enables the execution of all its existing functions as well as functions controlling a UOZ system in a given area. The planned transmission speed in the communication network is relatively low and amounts to 300 Bd. Such a slow transmission made it possible to achieve very high resistance to frequently-occurring electromagnetic and radio-electric disturbance.

4. Principle of operation

UOZ-1 devices are automatically started shortly before the run of a train, based on signals received from linear self-blocking automatics circuits. In practice, the principle is that all the UOZ devices connected to the given container are sent information about trains freeing or occupying the subsequent isolated sections. This enables maps of the area of the railway line where changes in the current movement of trains are tracked to be created in the memory of computers controlling the operation of UOZ-1 devices. For calculation of the time of arrival of a train to the area of the dispersers, an intelligent algorithm that takes the topology of the line section and the analysis of the speed of trains into account was utilised. For each train, the time until the arrival of the train is calculated, and based on this the procedure of deterring is started at the appropriate time in individual UOZ-1 devices. The complete deterring sequence lasts from 50 to 180 seconds and its duration is adjusted to the traffic situation on the railway line (the train slows down, speeds up, or stops at a station).

The initiation of the deterring procedure consists in all of the UOZ-1 device stations belonging to one point emitting acoustic signals. Moreover, it is assumed that during the deterring procedure, which lasts from 1 to 3 minutes, the duration of individual signals making up the complete sequence will change in order to eliminate the effect of animals' insensibilisation to warning signals of one type that are repeated and come from the same area. Moreover, several different sequences are utilised. The decision to start and select a sequence is made by all UOZ-1 devices located in a given group of stations. One of them will do it the fastest and it imposes its decision on the others. The changes are synchronised in real time, using the previously described communication system. The selection of the sequence can also be controlled by a calendar or a timer. The use of certain sequences can be limited to a particular time of day or season of the year.

The deterring procedure ends after playing through completely. There might be cases in which the deterring sequence does not end directly before the arrival of a train and its final part is played during the run of the train through the area of deterrence. In accordance with the assumptions made, this is correct operation.

5. Conclusions

As compared to the limitation of access to railway line track-way of increased or high-train speeds generally used in western Europe, through their fencing with a tall fence as well as the construction of engineering structures in the form of wildlife under- and overpasses, the proposed form of wildlife protection has two crucial advantages. The first one is the complete lack of limitation of the free migration of animals in their pastures and calving areas; the second, the incomparably lower cost of the investment. The cost of building one wildlife overpass corresponds to the cost of protecting a railway line section of from 200 to 500 km in length using UOZ-1 devices. Such a large discrepancy in the length of railway lines results from the varying density of forest and

forest-meadow areas. The proposed solution meets the requirements of the European Union in the scope of environmental effect of transportation investments.

6. Recapitulation

The first lot of UOZ-1 devices was installed on the railway line section E20 between Mińsk Mazowiecki and Siedlce, where in the conditions of real exploitation, the technical solutions as well as method of emission and the arsenal of deterring stimuli were verified. A total of 62 UOZ-1 devices were installed there, of which 32 were located at eight points of wildlife migration and the other 30 limit the access of animals to the railway line at its 2 km long section bordering the "Stawy Broszkowskie" nature reserve near Siedlce. Photo 4 shows UOZ-1 devices installed at the Woźbin deterring point near the Mrozy railway station. Four UOZ-1 devices provide protection there of the railway line along a length of approx. 300 meters.

Fig. 4. UOZ-1 devices installed at the Woźbin deterring point near the Mrozy railway station on the railway line section E20 between Mińsk Mazowiecki and Siedlce bordering the 'Stawy Broszkowskie' nature reserve near Siedlce

More than two years of exploitation of the devices has shown their high reliability and resistance to theft and damage. The composite design of the casing has proven very resistant to attempts to devastate, not yielding to such actions as an attempt to pull it off using a chain tied to a car or a tractor. A key role was undoubtedly played here by the effective anti-theft system, in which a very loud alarm signal emitted at the same time from the whole group of devices was very discouraging to the perpetrators, and the report of the break-in sent to the Local Control Centre made the immediate intervention of the maintenance service staff or officers of the Railway Security Service possible.

The cycle of testing the effectiveness of UOZ-1 devices was realised by the Forestry Research Institute in the winter of 2004/2005, when based on observations of traces of animals on snow, we could reliably determine their reaction to the stimuli applied. The final report showed that both wild herbivores(red deer, roe deer, wild boar, and hare), as well as carnivores (foxes) and birds (jays) correctly read the meaning of the applied deterring signals and while not giving up staying near the railway line section with UOZ-1 devices installed.