

EVALUATION OF NOISE AROUND MILITARY INSTALLATIONS

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Abstract. Noise is one of the most common adverse environmental factors. Military bases and airports and the areas surrounding them are affected by acoustic impact. The problem of military noise is researched in this article. Since 2004 Šiauliai Airport has been the site of NATO forces' base in the Baltic States for the protection of the region's airspace. Military aircraft are used for the mission. The Kairiai military grounds on the Curonian Lagoon is the only site in Lithuania where all kinds of military forces may arrange their training. Measurement of the level of noise caused by Šiauliai Airport in residential and public areas of the surrounding areas and by the Kairiai military grounds was carried out using a Nor121 digital sound analyser. It was found that the maximum noise level (L_{max}) in the surroundings of Šiauliai Airport sometimes exceeds the permissible maximum noise level specified in HN 33:2007. Exceeding of L_{max} on aircraft flights was short (up to 5 minutes). The calculated level of noise L_{den} and L_{night} at all points of measurement within the territories surrounding Šiauliai Airport does not exceed the limit values and causes no damage to the health of the population in Šiauliai. The noise generated by shooting at Kairiai military grounds causes no damage to the health of residents.

Keywords: noise level, field training, military territories, environmental impact.

1. Introduction

In the course of town growth, development of industry and increase in the number of vehicles, zones of acoustic discomfort extend and the quality of life worsens (Grubliauskas *et al.* 2006). The problem of spreading noise and its reduction in manufacture has been discussed earlier in Lithuania as well (Nainys 1972). People are permanently affected by noise caused by machines, mechanisms, etc. Its level is particularly high in locations where industrial and transport centers are concentrated (Baltrėnas *et al.* 2007). The principal sources of noise in

urban factories are transport flows in streets (Baltrėnas and Nainys 2000). Like other countries, Lithuania pays considerable attention to reducing the level of noise in working environments (Nainys and Šukys 2001). Scientists of Vilnius Gediminas Technical University (VGTU) successfully and intensively settle problems related to noise and its reduction using modern methods of environmental noise simulation (Grubliauskas 2009). In addition, scientists at VGTU explore environmental protection issues related to military bases, examine valuable

territories and those under protection, analyse cases of anthropogenic damage caused to landscape, and carry out experiments to establish the impact of explosions on the reduction of the content of organic substances in soil (Baltrėnas *et al.* 2005).

Striving to implement the provisions of Directive 2002/49/EC 'On assessment and management of environmental noise' (D1 2002) in Lithuania, the National Action Programme for Noise Prevention for the years 2007–2013 (LĮ2 2007) is being implemented, and tasks related to noise strategic cartography, noise measurement in towns (Report on Šiauliai Municipal Environmental Monitoring 2008), environmental pollution and assessment of possible impact on human health (Report of the State Environmental Health Center 2008) are being carried out.

The problem bound with the most negative environmental impact of military activities is the acoustic impact of military training on the areas surrounding military bases and military airports.

Warfare is a sphere of human activities that requires the mobilisation of various resources. Ensuring national security, national defense, and settlement of strategic problems requires rapid improvement of military forces. This circumstance forces the use of updated and improved weaponry for military needs. Introduction of new types of weaponry in the national military forces requires regular professional training of military personnel on their usage. It is impossible to ensure the required level of skills of military personnel by theoretical training or computer simulators only. For this purpose, field training in conditions imitating military conditions to the maximum possible extent is required. Usually, military bases and military training territories are used for this purpose.

Research on noise on territories used by the military is important for implementing Lithuanian environmental protection standards and ensuring conformity of the living conditions of the population to the set requirements. The research on noise in the military territories of Zokniai Airport and Kairiai military grounds was an attempt to determine the risk caused by military activities and, in particular, by the noise caused by military aircraft and weaponry for public health and the environment. The results of the work will enable the choice of required safety and prevention measures; in addition, they will be helpful in appeasing the disputes on these topical problems that arise from time to time in the community.

2. Legal norms for regulation of noise emission

Before 2002, European noise-related policy was based on passing directives for regulating noise caused by various products with fixed limits of noise for products in the European market (Stankūnas *et al.* 2002). The member

states were required to implement the directives on the national level.

On 25 June 2002, the European Parliament and the Council passed Directive 2002/49/EC 'On assessment and management of environmental noise' (D1 2002). It was the first European document for regulating environmental noise.

Directive 2002/49/EC 'On assessment and management of environmental noise' was implemented in Lithuanian legislation by key legal norms: the Law of Republic of Lithuania on Noise Management (LĮ1 2004) and Lithuanian Hygiene norm HN 33:2007 'Acoustic noise. The limit values of noise in residential and public buildings as well as their environment' (LS1 2007).

In the Law on Noise Management, the key noise management principles and measures, including strategic noise cartography and establishing noise limiting zones, are described.

Plans to establish sanitary protection zones according to the noise level for in order to prevent noise caused by aircraft were undertaken as well.

The National Action Programme for Noise Prevention for the years 2007–2013 (LĮ2 2007) was approved. Its implementation is being pursued.

3. Research on noise

3.1. Methodology of noise level measurement

Measurement of the level of noise caused by Šiauliai Airport in residential and public areas of the surrounding territories and by Kairiai military grounds was carried out using a Nor121 digital sound analyser with an RMS digital level detector. Technical data for the RMS digital level detector are as follows: disassembling 0.1 dB; accuracy 0.2 dB; measurement range 15–140 dBA; time constants: fast, slow and impulse. The disassembling profile time is from 0.5 ms to hundreds of hours, with a 0.5 ms or 1 s step. Noise measurements were carried out upon operation of the analyser in the environmental mode.

The measurements were carried out following the methodological guidelines provided in the standards LST ISO 1996–1:2005 and LST ISO 1996–2:2008.

3.2. Research on noise level caused by Šiauliai Airport

There are two 3500-m-long runways (14L/32R and 14R/32L) at Šiauliai Airport.

The direction of the principal runway is 14L/32R. The width of the runway is 45 m. The pavement of the runway is asphalt; it includes rolling ways and one platform.

Aircraft take off and landing are the key sources of noise in aviation (aerodynamic noise). Noise is generated by aircraft engines in certain periods of their operation: the noise of switching-on and preheating of the engine; the noise of running along the runway before take

off; the noise of acceleration; the noise of take off; the noise of flying; the noise of landing (deceleration) and the noise of running along the runway after the landing.

For research on noise spreading, the southern residential area of Šiauliai, the area of Zokniai, the settlement of Šilėnai, the central part of the city, and the area surrounding Zokniai Airport were chosen (Fig. 1).

Nine sites were chosen for measuring noise caused by Šiauliai Airport (Table 1). The noise level was measured from July to October 2008.

In the paper, the maximum noise levels L_{\max} of the flight of aircraft and the equivalent noise levels L_{ekv} are compared with the permissible norms of L_{\max} and L_{ekv} according to HN 33:2007 for daytime (06.00 am –

06.00 pm), evening (06.00 pm – 10.00 pm) and night-time (10.00 pm – 06.00 am) (Table 2), and the excess of the noise levels L_{\max} and L_{ekv} (dBA) was calculated according to the data on the take off and landing of the aircraft in respect of the types of the climbing and landing aircraft specified in the noise level variation pictures.

Measurements of noise level **in the surroundings of point 1.1** were carried out on 15 July 2008 between 00.00 and 24.00. Noise level variation is provided in Fig. 2.

1.1 conclusions:

1. On 15 July 2008 between 00.00 and 24.00, aircraft climbed and landed twelve times in Zokniai Airdrome; L_{\max} was exceeded by 7–37 dBA six times; L_{ekv} was not exceeded.

2. Excess L_{\max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level **in the surroundings of point 2.1** (Fig. 3) were carried out on 26 June 2008 between 13.10 and 23.50.

2.1 conclusions:

1. On 26 June 2008 between 13.10 and 23.50, aircraft in Zokniai Airdrome climbed and landed six times; L_{\max} was exceeded by 18–20 dBA twice; L_{ekv} was not exceeded.

2. Other fixed cases of excess L_{\max} are not related to flights of aircraft, because data on aircraft climbing and landing are absent.

3. Excess L_{\max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level **in the surroundings of point 2.2** (Fig. 4) were carried out on 4 July 2008 between 9.20 and 24.00.

2.2 conclusions:

1. On 4 July 2008 between 9.20 and 24.00, aircraft flew into Zokniai Airport three times; L_{\max} was exceeded by 28–29 dBA twice; L_{ekv} was exceeded by 17–20 dBA.



Fig. 1. The sites for measuring noise caused by Šiauliai Airport

Table 1. Sites for noise measurement

Sites for noise measurement	Distance from the Airport runway, km
1. Southern residential area:	
1.1. Multi-unit residential buildings, Gegužių g. 94	8.0
2. Zokniai area:	
2.1. Auksinis Raktelis Pre-School, Radviliškio g. 86	1.5
2.2. Zokniai Basic School, Radviliškio g. 66	1.7
2.3. Multi-unit residential building, Radviliškio g. 78	1.6
2.4. Multi-unit residential building, Margių g. 10 A	1.2
2.5. The end of Zokniai Airport runway out of the territory of the airport	0.5
3. Settlement of Šilėnai:	
3.1. Šilėnai Basic School, Saulės g. 38	1.6
3.2. Multi-unit residential building, Ateities g. 5	1.7
4. Central part of the city:	
4.1. Kregždutė Pre-School, P.Cvirkos g. 60	5.0

Table 2. Permissible limits of noise

Description of the object	Acoustic level, equivalent acoustic level, dBA	Maximum acoustic level, dBA	Time of day, h	Limits of noise usable for assessing the results of environmental noise cartography			
				L _{den}	L _{day}	L _{evening}	L _{night}
007 Surroundings of residential and public buildings	65	70	6–18	65	66	61	55
	60	65	18–22				
	55	60	22–6				

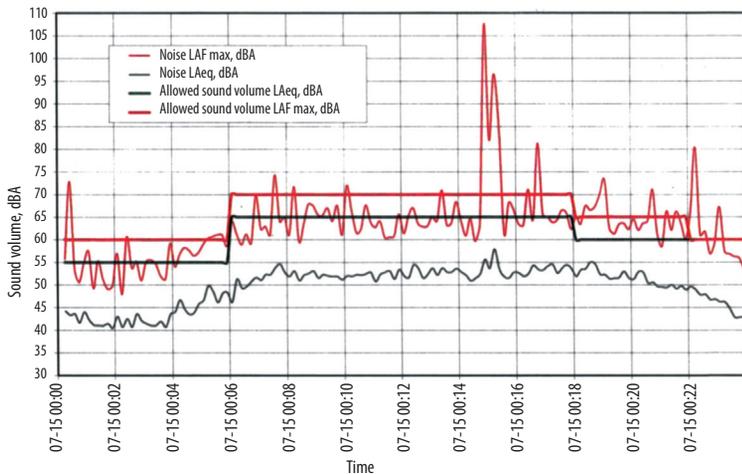


Fig. 2. Noise level variation in the surroundings of point 1.1

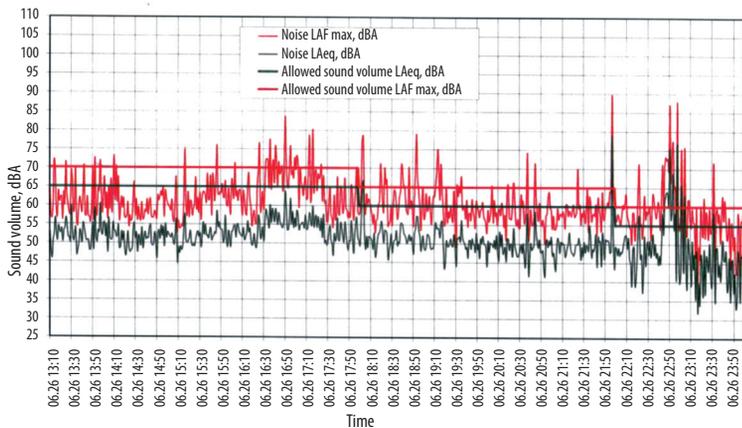


Fig. 3. Noise level variation in the surroundings of point 2.1

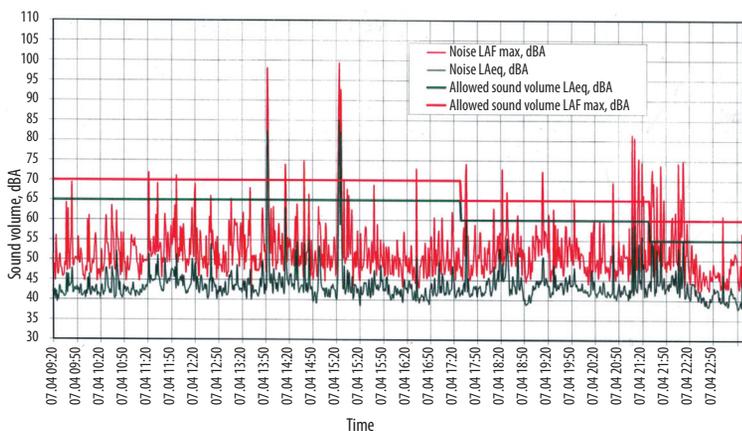


Fig. 4. Noise level variation in the surroundings of point 2.2

2. Other fixed cases of excess L_{max} are not related to flights of aircraft, because data on aircraft climbing and landing are absent.

3. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level in the surroundings of point 2.3 (Fig. 5) were carried out from 30 June to 3 July 2008.

2.3 conclusions:

1. In the period from 30 June to 3 July 2008, the maximum noise level L_{max} exceeded the permissible maximum noise level in the daytime from 15 to 37 dBA.

2. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level in the surroundings of point 2.4 were carried out from 22 to 24 April 2008. The noise level variation is provided in Fig. 6.

2.4 The conclusions from the research:

1. On 22–24 April 2008, the maximum noise level L_{max} exceeded the permissible maximum noise level in the daytime by 29–33 dBA, in the evening by 24 dBA, and at nighttime by 29 dBA.

2. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level in the surroundings of the point 2.5 at the end of the runway out of the territory of the airport (Fig. 7) were carried out on 7 October 2008 between 16.49 and 17.10.

2.5 conclusions:

1. On 7 October 2008 between 16.49 and 17.10, in the surroundings of Zokniai Airport one flight of an aircraft took place. The maximum noise level L_{max} was exceeded by 37 dBA; L_{ekv} was exceeded by 30 dBA.

2. Two other cases of L_{max} excess by 10 dBA and dBA can be attributed to the preheating of two F-15 aircraft.

3. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level **in the surroundings of point 3.1** (Fig. 8) were carried out on 10 July 2008 between 00.00 and 24.00.

3.1 conclusions:

1. On 10 July 2008 between 00.00 and 24.00, eight flights took place at Zokniai Airport. L_{max} was exceeded by 15–34 dBA five times; L_{ekv} was exceeded by 10–22 dBA.

2. Other fixed cases of excess L_{max} are not related to flights of aircraft, because data on aircraft climbing and landing are absent.

3. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level **in the surroundings of point 3.2** (Fig. 9) were carried out on 11 July 2008 between 00.00 and 24.00.

3.2 conclusions:

1. On 11 July 2008 between 00.00 and 24.00, aircraft climbed and landed eight times at Zokniai Airport: L_{max} was exceeded by 6–33 dBA 6 times; L_{ekv} was exceeded by 5–20 dBA.

2. Other fixed cases of excess L_{max} are not related to flights of aircraft, because data on aircraft climbing and landing are absent.

3. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Measurements of noise level **in the surroundings of point 4.1** (Fig. 10) were carried out from 22 to 25 July 2008.

4.1 conclusions:

1. On 22–25 July 2008, the maximum noise level L_{max} exceeded the permissible maximum noise level by 8–14 dBA in the daytime, by 19–22 dBA in the evening, and by 18–24 dBA at nighttime.

2. Excess L_{max} on aircraft flights was short (up to 5 minutes).

Fixed excess of noise level can be described as noise lasting for less than 5 minutes. Such noise may be generated by a passing train or a flying aircraft. The source of noise at Šiauliai Airport operated for a short time only. In the paper, the level of day, evening, and night noise L_{den} and the level of night noise L_{night} were assessed and presented in all points of measurement (Table 3).

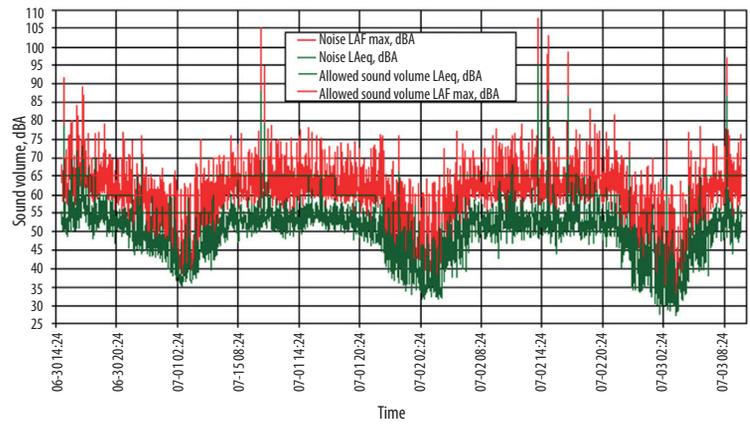


Fig. 5. Noise level variation in the surroundings of point 2.3

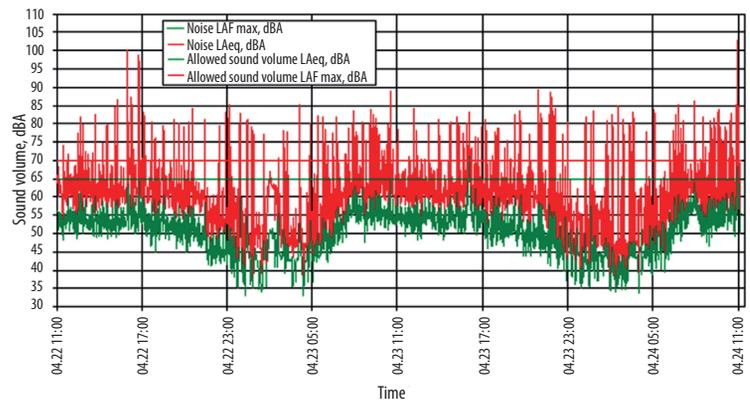


Fig. 6. Noise level variation in the surroundings of point 2.4

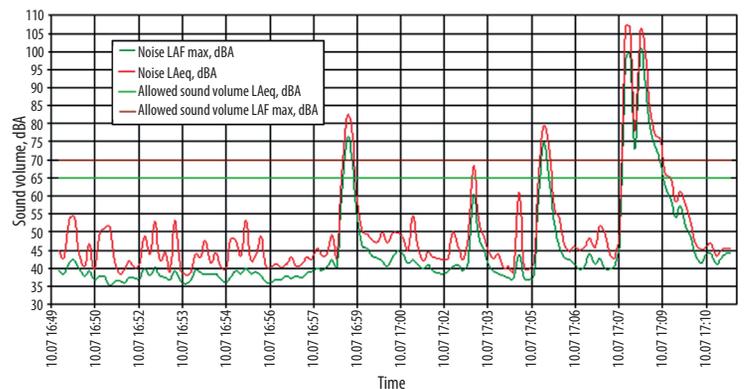


Fig. 7. Noise level variation in the surroundings of point 2.5

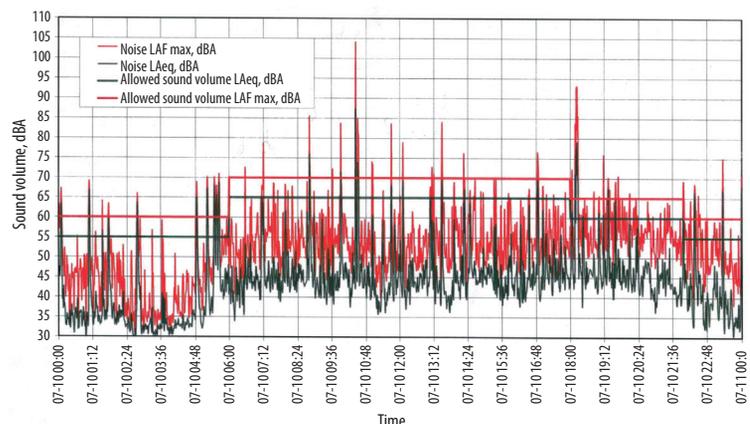
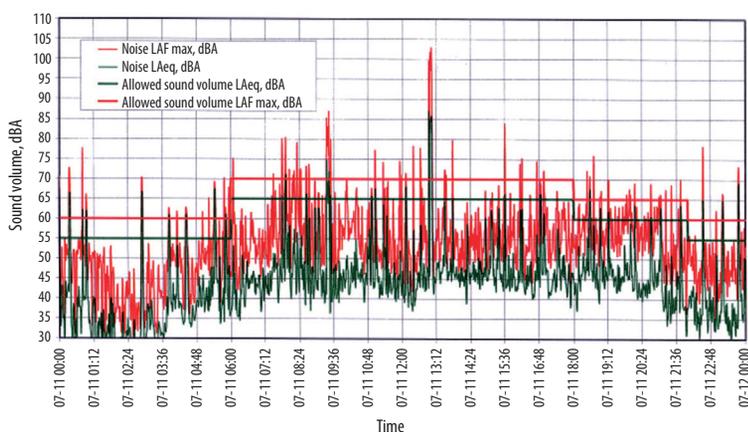
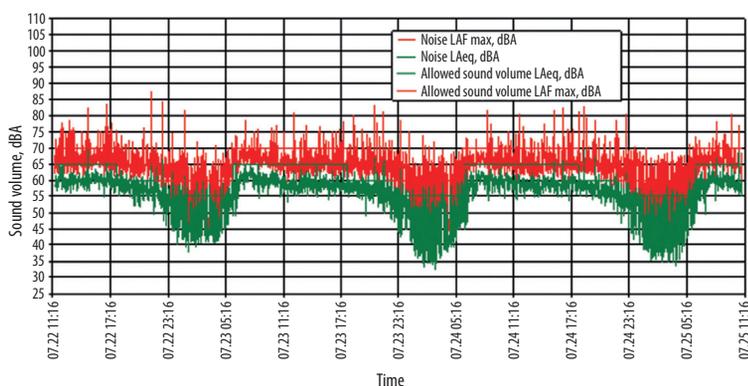


Fig. 8. Noise level variation in the surroundings of point 3.1

Table 3. Noise levels L_{den} and L_{night} in the surroundings of Šiauliai Airport

Measuring point	L_{den} (permissible level 65 dB)	L_{night} (permissible level 55 dB)
1. Southern residential area		
1.1.	57.2	48.5
2. Zokniai area		
2.1	55.2	43.1
2.2	49.4	40.3
2.3	52.9	42.8
2.4	56.4	46.7
2.5	One measurement	
3. Settlement of Šilėnai		
3.1	56.3	41.8
3.2	57.1	42.1
4. Central part of the city		
4.1	57.4	49.2

**Fig. 9.** Noise level variation in the surroundings of point 3.2**Fig. 10.** Noise level variation in the surroundings of point 4.1

The level of day, evening, and night noise L_{den} and night noise L_{night} were assessed and presented in accordance with the indicators and assessment methods agreed upon by the European Parliament and Council Directive 2002/49 EC (D1 2002).

The calculated level of noise L_{den} and L_{night} at all points of measurement within the territories surrounding Šiauliai Airport does not exceed the limits according to HN 33:2007 and Directive 2002/49 EC.

3.3. Research on noise caused by shooting at Kairiai military grounds

Measurements of noise level during training on military grounds were carried out on 22 August 2008. In the training, AK-4MT automatic rifles with 7.62 mm × 51M80 cartridges were used; shooting took place in the second rifle range (measuring point 1) and there were fourteen places where shots were fired.

During the shooting the noise-level meter was situated 10 m eastward (measuring point 1^a) and 10 m westward (measuring point 1^b) from the places where shots were fired. On the training, no shooting was done in the southeastern direction.

The closest settlements from the military unit are the settlement of Kairiai at a distance of 2.75 km from the second rifle range (measuring point 2) and Dituva Gardens at a distance of 3 km from the firing line (measuring point 3) (Fig. 11).

During shooting, five single shots were fired from an AK-4MT automatic rifle, and they were followed by fourteen serial shots. At each measurement point, the sound caused by the five single shots and one serial shot was measured. The average values of the results of the measurement of the noise level caused by the single shots and the absolute values of the results of the measurement of the noise level caused by the serial shots are provided in Table 4.

After the results of the measurements were assessed, it was found that during shooting from AK-4MT automatic rifles with 7.62 mm × 51M80 cartridges at

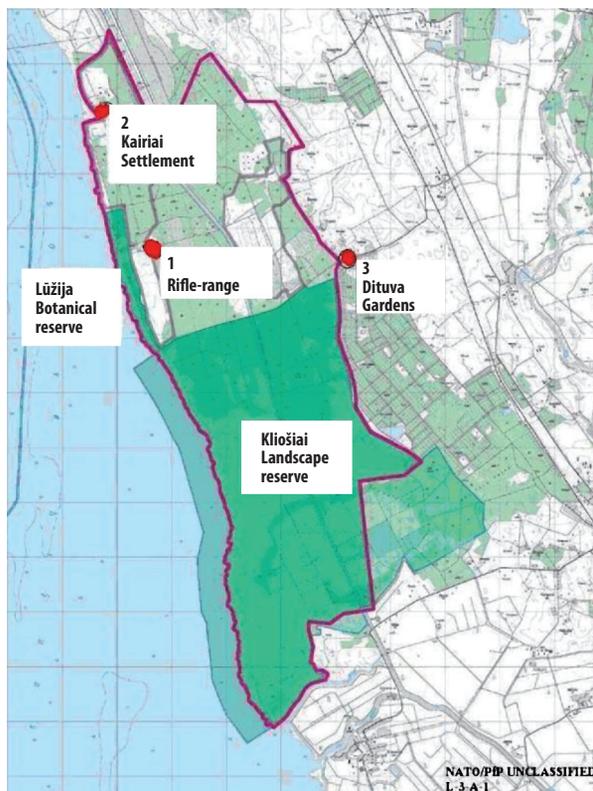
Table 4. Noise level measured during shooting at the rifle range 2 of Kairiai military grounds

Measuring point	Time	The measured noise level, dBA	
		Single shots	Serial shots
1 ^a	12.00	105.2 ± 5.3	105
1 ^b	12.45	102.3 ± 5.0	102
2	13.30	60.2 ± 3.1	60
3	14.15	56.8 ± 2.8	57

measuring points 1^a and 1^b located 10 m from the place where the shots were fired the measured noise level during the shots reached 110.5 dBA and 107.3 dBA, respectively, thus exceeding the permissible daytime norm by 40.5 dBA and 37.3 dBA, respectively.

At the second measurement point, i.e. at Kairiai settlement, located 2.75 km from the place where the shots were fired, the measured noise level during the shots reached 63.3 dBA; in consideration of its impulse character and the circumstance that such shooting takes place for only several hours a day, it was concluded that it should not cause damage to human health.

At the third measurement point, i.e. at Dituva Gardens, located 3 km from place where shots were fired, the measured noise level during the shots was up 59.6 dBA, so it does not exceed the permissible daytime norm of noise level and causes no damage to human health.

**Fig. 11.** Noise measurement points on experimental shooting at second rifle range of Kairiai military grounds

4. Conclusions

1. During measurement of the noise level in residential and public buildings in the surroundings of Šiauliai Airport, i.e. in the southern residential area of Šiauliai, the Zokniai area, the settlement of Šilėnai, the central part of the city, and the territory surrounding Zokniai Airport, it was found that:

1.1. The calculated level of noise L_{den} and L_{night} at all points of measurement within the territories surrounding Šiauliai Airport does not exceed the limits according to HN 33:2007 and EU Directive 2002/49 EC and cause no damage to the health of the population in Šiauliai.

1.2. The maximum noise level (L_{max}) in the places studied sometimes exceeds the permissible maximum noise level specified in HN 33:2007.

1.3. A part of the cases in which the maximum noise level (L_{max}) was exceeded can be attributed to flights of aircraft, taking into account the time of their climbing and landing; however, the equivalent noise level (L_{ekv}) due to flights of aircraft is not exceeded in any cases.

1.4. The cases of exceeding the maximum noise level (L_{max}) were short (up to 5 minutes).

1.5. Other fixed cases of exceeding the maximum noise level (L_{max}) that are not due to flights of aircraft are attributed to noise generated by other means of transport (road transport and railways).

2. The noise generated by shooting at Kairiai military grounds causes no damage to the health of the population and holiday-makers in the closest residential areas: the settlement of Kairiai and Dituva Gardens.

5. Proposals

In consideration of the research completed on the noise level in the residential and public areas of the territories surrounding Šiauliai Airport (at a distance of 0.5–8 km), it is proposed to reduce the noise level as follows:

- To recommend relevant protective measures, such as using sound damping materials for windows, balcony doors, etc. in residential buildings and noise-sensitive institutions;
- To alter the land zoning in the vicinity of the airport: to identify the zones being impacted by noise and to change the terms for land use by

reducing the population of noisy territories in the future;

- If the load of the airport increases considerably, it is recommended to introduce a computerised noise control system to establish stationary noise level control centres in the city and to acquire software for simulating noise spreading from the airport;
- To take measures to reduce the total noise level in the city of Šiauliai;
- To carry out sociological interviews of the population about general acoustic discomfort suffered in the city of Šiauliai and to make a decision on future actions.

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TRIUKŠMO KARINĖSE TERITORIJOSE ĮVERTINIMAS

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Santrauka. Vienas iš plačiausiai paplitusių kenksmingų aplinkos veiksnių yra triukšmas. Akustinį poveikį patiria karinių poligonų ir aerodromų aplinka. Šiame straipsnyje nagrinėjama karinio triukšmo problema. Nuo 2004 m. Šiaulių oro uostas tapo Baltijos šalių NATO pajėgų dislokacijos vieta, iš kurios vykdoma Baltijos šalių oro apsauga. Šiai apsaugai atlikti naudojami kariniai lėktuvai. Prie Kuršių marių išikūręs Kairių poligonas yra vienintelis Lietuvoje, kuriame gali treniruotis visų rūšių karinės pajėgos. Šiaulių oro uosto triukšmo matavimai aplinkinių teritorijų gyvenamojoje ir viešosios paskirties aplinkoje bei Kairių poligone atlikti skaitmeniniu garso analizatoriumi Nr. 121. Nustatyta, kad maksimalus triukšmo lygis (L_{max}) Šiaulių oro uosto aplinkoje kartais viršija leistinąjį maksimalų triukšmo lygį pagal HN 33:2007. L_{max} viršijimai, siejami su orlaivių skrydžiais, buvo trumpalaikiai (iki 5 min.). Apskaičiuoti dienos, vakaro, nakties triukšmo lygis L_{dvn} ir nakties triukšmo rodiklis $L_{nakties}$ neviršija ribinių triukšmo dydžių, Šiaulių miesto gyventojų sveikatai grėsmės nekelti. Kairių poligone šaudymo pratybų keliamas triukšmas gyventojų sveikatai grėsmės nekelti.

Reikšminiai žodžiai: triukšmo lygis, lauko pratybos, karinės teritorijos, poveikis aplinkai.