



## Measurement of the acoustic pressure distribution occurring around an aerial substation adjacent to apartment buildings

Sebastian Borucki, Tomasz Boczar and Andrzej Cichon

Technical University of Opole, ul. Miko<sup>3</sup>ajczyka 5, 45-271 Opole, Poland  
s.borucki@po.opole.pl

The subject matter of the research work presented in this paper refers to the measurements of the value of the acoustic pressure level (noise) occurring around an aerial electric power station (Main Feed Point) of the voltage of 110/30/15 kV, adjacent to apartment buildings. The paper presents noise values obtained which accompanies electrical appliances installed in the station diagnosed, first of all transformers, during their regular operation. The main aim of the research work conducted was to compare and assess the acoustic pressure values measured with permissible values defined in environmental standards being in force in Poland. The measurement results obtained during the experiment made it possible to determine area zones of the station, in which the acoustic pressure parameters obtained assume permissible values.

## 1 Introduction

The work of an electric power station is connected with the emission of noise into the environment, the main source of which are power transformers (the work of the fans of the coolers, magnetostriction vibrations of the core, the work of the pumps). A transformer to be installed in an electric power station should meet environmental standards [5, 6], i.e. the noise generated by its regular operation may not exceed permissible values. These standards define permissible levels of the acoustic pressure that may occur in the vicinity of a station and electric power lines depending on their location (Table 1).

No.	Area designation	Permissible equivalent sound level A [dB]	
		Day time, reference time range equal to 16 hours	Night time, reference time range equal to 8 hours
1	a) Areas protected as spas, b) Areas of hospitals, nursing houses, buildings connected with permanent or many-hour stay of children and youth.	45	40
2	c) Areas with apartment buildings (including detached houses and farms), d) Recreational areas outside cities.	50	45

Table 1 Permissible in Poland noise levels in environment produced by electric power lines and stations [5]

Meeting environmental standards related to the permissible acoustic pressure levels occurring around power stations is a problem to technical service responsible for their operation and to people responsible for observing environmental standards in power enterprises. Due to the wear processes of electrical appliances installed at the stations, mainly transformer units, the level of the acoustic pressure may increase in time. Therefore during periodical inspections of the technical condition of power transformers it is advisable to measure the acoustic pressure level. Such measurements are required not only due to environmental considerations but they may constitute an additional criterion for the assessment of the technical condition, e.g. of the cooling system elements [1, 2, 3].

## 2 Measurement taking methodology

The measurements of the corrected acoustic pressure level were taken in the night ( $22^{00} - 6^{00}$ ) with SVAN 945A meter by the firm Svanetek. This appliance is designated for taking measurements of the sound level with accuracy corresponding to class 1 and for a frequency analysis of the acoustic signals in the band 1 Hz – 20 kHz.

An acoustic calibrator KA-50 by the firm Sonopan was applied for calibration of the measuring appliance used. Fig. 1 shows a measuring procedure for one measurement position (measurement point) around transformer TR1 installed at the station under study. The other photograph shows an overall view of the measuring appliance used.



Fig. 1 Measuring appliance (SVAN 945A) used for measurements at the electric power station

The power station had:

- aerial switching station 110 kV – system H5,
- aerial switching station 30 kV – two systems of cumulative buses,
- interior switching station 15 kV – two systems of cumulative buses,
- two distributing transformers of the power of 25 MV·A each.

The transformer units under test were equipped with two coolers, which were permanently turned on during the procedure of measurement taking. Due to a short distance of the transformer units from apartment buildings (distance of about 25 m), an L-shaped acoustic screen of the sides of 8 m x 30 m and height 7 m was used, the aim of which was to limit the noise level to permissible values. The diagram of the spacing of electrical appliances and elements in the discussed power station 110/30/15 kV, with selected positions of the measurement points, is shown in Fig. 2.

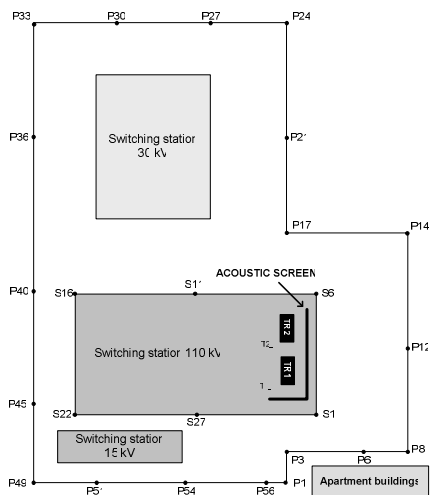


Fig. 2 General outline of the station under study with selected measurement points

Distances between measurement points marked with acronym P were 12 m, with S – 6 m, and T1 and T2 3 m, respectively. The acoustic pressure level, with the transformer ventilation on, was measured in measurement points 2 m away from the transformer tub, which was assumed as the main surface of sound radiation [4]. A detailed distribution of the measurement points around one of the transformer units is shown in Fig. 3.

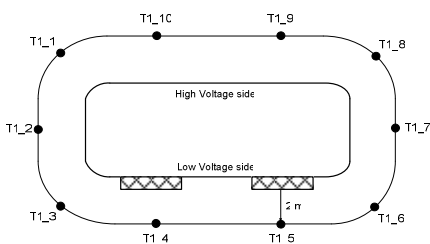


Fig. 3 Distribution of the measurement points around transformer TR1

### 3 Discussion on the measurement results

In the result of the measurements taken at the power station 100 / 30 / 15 kV the values of the corrected acoustic pressure levels were determined around the following zones: the envelope of the whole station, the envelope of the switching station 110 kV and each of the power transformers installed. According to the standard recommendations and the minister of environment order [5], a correcting filtration complying with the characteristic of filter A was used during measurement taking. The values of noise levels obtained for the area of the whole station are shown in the form of column diagrams in Fig. 4. Fig. 5 shows the values of the acoustic pressure measured, occurring around the aerial high-voltage 110 kV switching station.

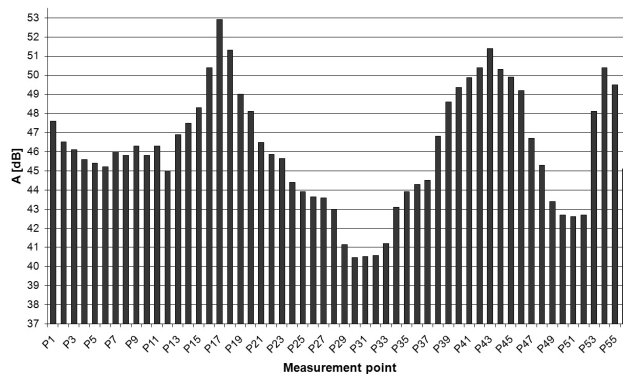


Fig. 4 The value of the A-corrected acoustic pressure level around the 110 / 30 / 15 kV station under study

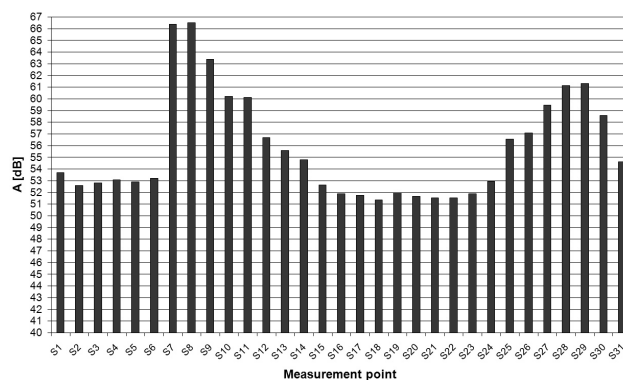


Fig. 5 The value of the A-corrected acoustic pressure level around the 110 kV switching station

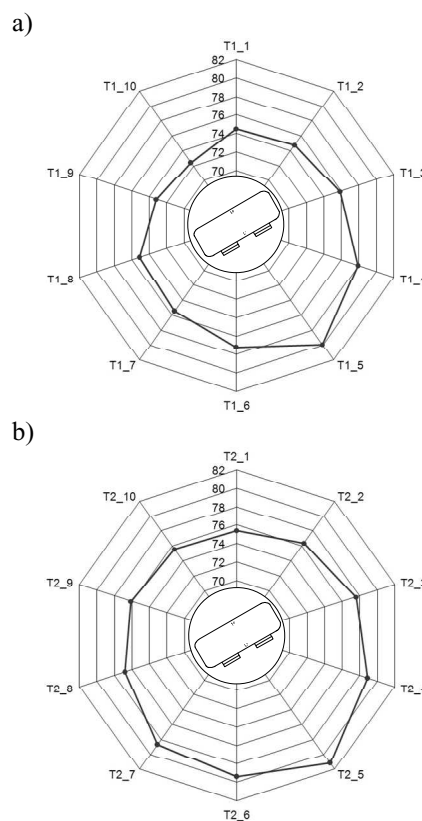


Fig. 6 Circle diagrams showing the acoustic pressure distribution around transformers: a) TR1, b) TR2

In order to visualize the acoustic pressure level emitted by working power transformers and the areas of the highest

noise levels, Fig. 6 shows circle diagrams with marked measurement points.

Additionally, an average corrected level A of the acoustic pressure taking into account an environmental correction was determined during the analysis the noise values registered around the power transformers. The results obtained are shown in Table 2.

Transformer unit under study	Average corrected level of the acoustic pressure [dB]
<b>TR1</b>	<b>75,6</b>
<b>TR2</b>	<b>77,5</b>

Table 2 Collective listing of average values of the corrected level A of the acoustic pressure

It results from the values of the level of the acoustic pressure accompanying the work of the power station that transformers are the main electrical appliances responsible for the noise emission into environment. The values of the corrected acoustic pressure, shown in Figs 4 and 5, peremptorily confirm and the measurements taken along the whole station indicate that the highest noise level zone occurs around transformers TR1 and TR2. Based on the analysis of circle diagram runs presented in this paper (Fig. 6) it can be observed that the highest values of the acoustic pressure were registered on the low voltage side (LV), where two coolers were working with turned on fans. Maximum average value of the corrected level A of the acoustic pressure, taking into account an environmental correction, was 77.5 dB, which according to recommendations included in IEEE C57.12.90 standards is a permissible value during a regular work of power transformers equipped with appliances of forced cooling. Due to a considerable adjacency of the building apartments to the power station, such a high noise level (77.5 dB) emitted by any appliance installed on it is too high, because at such a high value of the acoustic pressure level it is not possible to obtain a permissible environmental level, equal to 45 dB at night time. A significant limitation of the noise emitted by the transformers is an acoustic screen, which made it possible, to a large extent, to reduce the acoustic pressure level registered for the nearest apartment building. In practice, thanks to the acoustic screen absorbing sound, the noise level measurement of the building apartments was reduced from 53 to about 46 dB. Nevertheless, from the point of view of the Environment Protection Office, the noise level obtained with the application of the acoustic screen still exceeds the maximum permissible value, defined in Table 1. Based on the analysis of the values measured, it also results that there are only two areas on the whole station site, which meet the requirements of environmental standards. One area is determined by a triangle built on the vertices of measurement points P24, P33, P37 and the other behind the control room building.

## 4 Summing-up

It results from the investigations carried out and periodical measurements of the noise level that the acoustic pressure level emitted by electrical appliances installed at power

stations is not constant but is subject to changes during their many-year operation. This can be caused by a significant wear of the particular components of these appliances, especially of cooling systems or the changes taking place in the transformer core. Therefore the increase of the noise level above permissible values can be the cause of failing to meet the environmental standards. Due to a considerable increase of social consciousness and the will to claim one's rights we can witness a growing number of claims addressed to power enterprises. Therefore it is important that the level of the acoustic pressure be monitored constantly during periodical inspections, especially around high-power transformers. Detection of an increased acoustic pressure level will enable a company operating of given unit to prepare itself logistically and financially for necessary repairs.

*This research work is financed with the means devoted to science development as a research – development project No. R01 006 01 and a research project No. N511 019 31/3638*

## References

- [1] ABB - Testing of Power Transformers, Zürich, October (2003)
- [2] T. Boczar, S. Borucki, A. Cichoń, M. Lorenc: „Measurement results of the acoustic pressure level during unit transformer operation”, *36th International Conference and Exhibition, Defektoskopie 2006*, 7 - 9 November 2006, pp. 25 – 31 (2006)
- [3] IEEE STANDARDS TEST CORE FOR LIQUID – Immersed Distribution, Power and Regulating Transformers (*IEEE Std. C57.12.90-1999*)
- [4] PN-EN 60076-10 – Transformatory, Część 10: Wyznaczanie poziomów dźwięku, Warszawa listopad (2003)
- [5] Rozporządzenie Ministra Środowiska z dnia 29 lipca 2004r. w sprawie dopuszczalnych poziomów hałasu w środowisku (Dz. U. Nr 178, poz.1841) (2004)
- [6] Prawo ochrony środowiska - Ustawa z dnia 27 kwietnia 2001r. (Dz.U. Nr 62 poz. 627 z późn. zm.) (2001)