Evaluation of Magnetic Field Generated by Power Facilities in Accordance with IEC 62110

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Abstract—This paper reports results of magnetic flux density (denoted as magnetic field hereafter) measurements under power transmission lines and around power distribution equipment. Measurements were carried out in accordance with IEC 62110 established in 2009, which prescribes measurement and evaluation procedures of uniform and non-uniform magnetic field generated by ac power systems with regard to human exposure. The average and the maximum exposure levels of magnetic field generated such power facilities were evaluated and found much lower than the reference level from the ICNIRP Guidelines.

Keywords—magnetic field; power transmission lines; pad-mounted transformer; switchgear; vertical cable; average and maximum exposure levels; IEC 62110

I. INTRODUCTION

Calculation results of power frequency magnetic field have been reported, which are generated by power facilities such as transmission lines [1-3], substations [4-6] and so on [7-8]. Reports of measurement results of magnetic field have also been published [9-13]. However, there seem little papers dealing with magnetic field near power distribution equipment such as pad-mounted transformers, switchgears and vertical cables, which are installed on sidewalks in urban areas. Evaluation of magnetic field generated by such equipment is important from the standpoint of public exposure to magnetic fields, because people passed by them closely in some cases.

To evaluate magnetic field generated by ac power systems with regard to human exposure, an international standard IEC 62110 [14] was established in 2009. The standard prescribes measurement and evaluation procedures of uniform and non-uniform magnetic field.

In this paper, magnetic field generated by power facilities was evaluated based on measurement results in accordance with IEC 62110. Magnetic field generated by transmission lines is considered almost uniform near the ground. On the other hand, non-uniform magnetic field is generated by power distribution equipment such as pad-mounted transformers, switchgears and vertical cables.

Evaluation results are also discussed by comparing the average and the maximum exposure levels with the reference levels from the ICNIRP Guidelines [15].
3) **Five-point measurement**: Where there are sources of field below the ground or the floor and there is a reasonable possibility that a person is likely to lie down above it, five-point measurement should be performed as follows.

The field level should be scanned at a height of 0.2 m above the ground or the floor to find the value and the position of the maximum field. The value and the position of the second maximum field should be scanned on a circle with a radius of 0.5 m centered on the maximum position. Another measurement should be made at the point that is symmetric to the second maximum. A further two measurements should be made, along the line perpendicular to the line passing the former three measurement points, at distances of 0.5 m on either side of the position of the maximum.

In cases where a person is not likely to lie on the ground or the floor, the three-point measurement shall be used.

C. **Average and Maximum Exposure Levels**

The average exposure level corresponds to a spatial average of field over the entire human body to which the individual is exposed to. It is defined as shown in Table 1 depending on measurement procedures described above.

<table>
<thead>
<tr>
<th>Measurement Procedure</th>
<th>Definition of Average Exposure Level</th>
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</thead>
<tbody>
<tr>
<td>single-point field</td>
<td>measured field value</td>
</tr>
<tr>
<td>three-point arithmetic</td>
<td>arithmetic mean of the three field values</td>
</tr>
<tr>
<td>five-point arithmetic</td>
<td>arithmetic mean of the largest three field values</td>
</tr>
</tbody>
</table>

The maximum exposure level is defined as the maximum of the average exposure levels over the area of interest.

Beside power equipment, the maximum exposure level is obtained as follows: The magnetic field should be measured at a height of 1.0 m above the ground, around equipment at a horizontal distance of 0.2 m from its surface, at appropriate intervals as shown in Fig. 2. In situations where the equipment has a height less than 1.5 m, the field level should be scanned at the top height of the equipment instead of 1.0 m. At the position where the maximum field level is found, a three-point measurement should be performed. When the position of the maximum field within the area of interest is already known, the three-point measurement should be performed at that position.

III. **EXPERIMENTAL**

A. **Measurement under Transmission Lines**

A magnetic flux density meter with three coils (EMDEX II, Entech Consultants) was used. Resultant magnetic field in root mean square was obtained.

Magnetic field was measured at 1 meter above the ground following the single-point measurement procedure in seven countries. Nominal voltages of transmission lines were 500-, 400-, 275-, 220- and 115-kV. Measurement was carried out at every 1 meter along a path perpendicular to transmission lines at the lowest clearance to draw magnetic field profile, from which the maximum exposure level was obtained.

B. **Measurement around Distribution Facilities**

A magnetic flux density meter (Model 3470, HIOKI E. E. Corporation) was used. The sensor consists of three concentric coils and resultant magnetic flux density in root mean square can be obtained.

Magnetic field measurements were carried out five times in different month of a year around six pad mounted transformers (6,600V/105-210V), six switchgears (6,600V) and five vertical cables (6,600V), which are installed on sidewalks in urban areas and accessible by the public.

Since the height of any equipment was less than 1.5 m, magnetic field was scanned at its top height and at a horizontal distance of 0.2 m from its surface facing to pedestrian passage. After finding the position of the maximum magnetic field, the average exposure level was obtained by following the three-point measurement procedure.

Then, magnetic field was scanned at its top height around equipment at a horizontal distance of 0.2 m from its surface at appropriate intervals. After finding the position of the maximum field, the maximum exposure level was obtained by performing the three-point measurement at the position.
IV. RESULTS AND DISCUSSION

A. Under Transmission Lines

Fig. 3 shows an example of magnetic field profile measured at 1 m above the ground along a path perpendicular to 500 kV transmission lines at the lowest clearance. From this figure, the maximum exposure level of 2.02 μT can be obtained.

The maximum exposure levels of magnetic field under nine transmission lines are summarized in Fig. 4, where filled and unfilled bars indicate 60 Hz and 50 Hz in grid frequency, respectively. The maximum exposure level is less than 11 μT, which is much lower than the reference level of 200 μT from the ICNIRP Guidelines.

B. Around Distribution Facilities

The average and the maximum exposure levels of magnetic field generated by six pad-mounted transformers are shown Fig. 5 (a) and (b), respectively. Fig. 6 (a) and (b) shows the average and the maximum exposure levels of magnetic field generated by six switchgears, respectively. Vertical cables generate the maximum exposure level of magnetic fields shown in Fig. 7.

The average and the maximum exposure levels of magnetic field are much lower than the ICNIRP reference level of 200 μT for any distribution equipment.
Fig. 6. Average and maximum exposure levels of magnetic field generated by switchgeras.

Fig. 7. Maximum exposure levels of magnetic field generated by vertical cables.

V. CONCLUSIONS

The average and the maximum exposure levels of magnetic field generated by transmission lines and power distribution equipment installed on sidewalks were evaluated in accordance with IEC 62110. They are much smaller than the reference levels from the ICNIRP Guidelines.

Further measurements is planned to collect much data. A method will be discussed to estimate the average and the maximum exposure levels in the basis of current flowing into power distribution equipment.

REFERENCES


[16] IEEE Std C95.6, “IEEE standard for safety levels with respect to human exposure to electromagnetic fields, 0-3 kHz”, 2002.