

EVALUATION OF EXPOSURE TO EMFs IN DIFFERENT LAYOUTS OF TRANSFORMER ROOMS

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ABSTRACT

Indoor Distribution Transformer Rooms (IDTRs) contain the following sources of EMFs: busbars, isolating switches, cables, fuses, distribution transformer and capacitor bank. These sources can be significant contributors to the magnetic field in areas both inside and outside the location fence. In the IDTRs environment, the electrical workers are exposed to the EMFs during about one working hours. For this study, the category "electrical workers" include electrical engineering technicians, electrical engineers and electricians for operation and inspection. Detailed site surveys identify EMF sources and evaluate their impact on the building, as well as, the equipment and workers in it. The technical inspection in IDTRs focuses on the connection of cables, the adequate protective devices used, the measurement of electrical parameters, the earthing, and the configuration of electrical components.

Measurements of EMFs in work environment were first conducted in about 250 IDTRs of Alexandria Electricity Distribution Company (AEDC) as work environment, which could be considered to be work site with relatively high exposure to EMFs.

EMFs survey inside house located above one IDTR was carried out. EMFs measurements were taken at 20 measured points in different locations. EMFs survey inside house located above one IDTR was carried out. EMFs measurements were taken at 20 measured points in different locations. EMFs produced inside a house can widely vary depending upon the wiring system and appliances usage. These variables could be used to determine the relative importance of local IDTR as opposed to the use of appliances or to internal house wiring.

INTRODUCTION

Since the wavelength of the extremely low frequency (ELF) electric and magnetic fields is sufficiently greater than the dimensions of the biological object, so the electric and magnetic fields can be independently treated.

Recently there has been concern expressed about possible biological effects [1]. For that, this paper mainly concerns about magnetic field measurements inside and outside of IDTRs.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines and the European Council recommended for the general public exposure to power frequency magnetic field the limit of 100 μT . For worker exposure the limits is 500 μT .

CASE STUDY 1

Measurements of EMFs in work environment were taken in about 250 IDTRs of AEDC. The magnetic fields emission were very difficult to predict because the wiring and room layout was so different from case to case. This paper tried to classify IDTRs according to the layouts and wiring system are (cable, bus way or busbar) and find their impact on magnetic fields emission values. The measurements were taken at height 1m from ground level for three positions in each room; at 1m, 2 m from the secondary of the transformer and 1 m from the low voltage panel. Figure 1 presents an open structure LV-IDTR layout. The relation between spot magnetic field measurements; which had been taken at position 1 and the measured loads was presented in Figure 2. The measured magnetic fields range was between 0.129 μT -77.875 μT and the measured current range was between 8amps -600 amps. Figure 3 presents the 2nd IDTRs layout which contains MV panel; the relation between spot magnetic field measurements, which had been taken at position 1 and loads was presented in Figure 4. The measured magnetic field range was between 3 μT -45.2 μT and the measured current range was between 27amps-500amps. In Figure 5, displays the 3rd IDTRs layout which contains busbar LV side. The relation between spot magnetic field measurements. These measurements had been taken at position 1 and load; was presented in Figure 6. The measured magnetic field range was 4.78 μT -30.1 μT and the measured current was between 27amps-400amps. Table (1) summarizes the range of measured loads, and magnetic fields for 3 case studies at three positions.

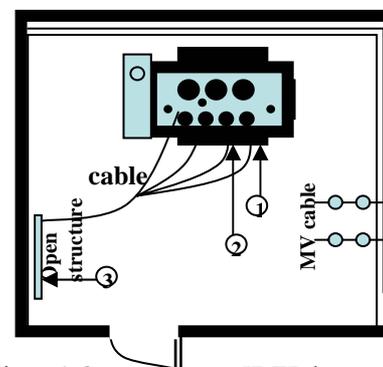


Figure 1. Open structure IDTR layout

*AEDC: Alexandria Electricity Distribution Company

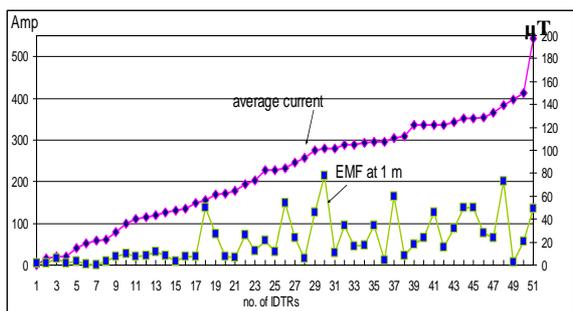


Figure 2. The measured magnetic field values and the load current for 1st IDTR layout

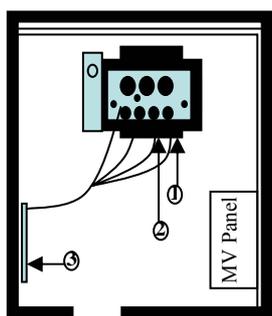


Figure 3. 2nd IDTR Layout

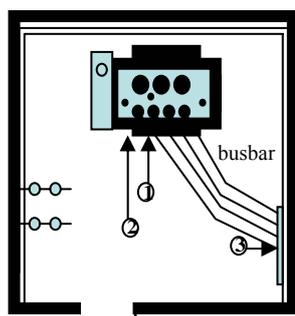


Figure 5. 3rd IDTR Layout

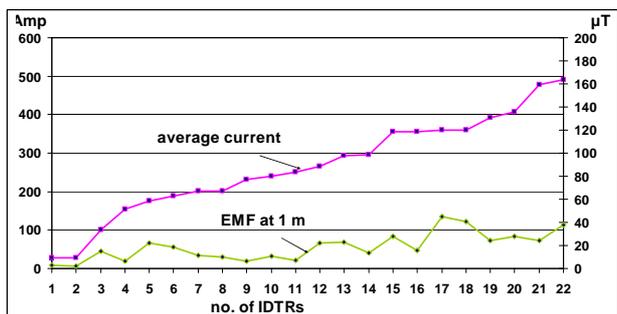


Figure 4. The measured magnetic field values and the load current for 2nd IDTR layout

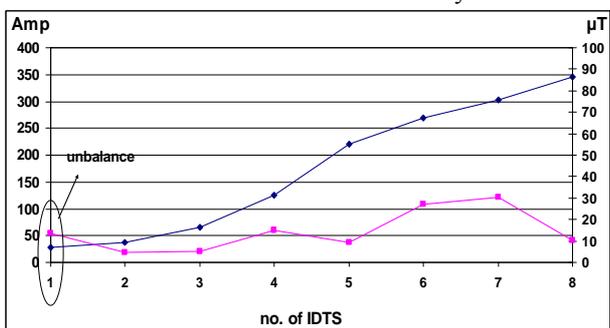


Figure 6. The measured magnetic field values and the load current for 3rd IDTR layout

In case of the IDTRs containing MV and LV panels, the emitted magnetic field had been decreased. The IDTRs with busbar secondary connection had the lowest emitted

magnetic field values.

Table (1) Measurement results for case study 1

Measured parameter Layouts	Current loads (Amps)	Position1 (μT)	Position2 (μT)	Position3 (μT)
1 st layout	8-600	0.129 -77.875	0.378-28.6	0.26-57.93
2 nd layout	27-500	3 -45.2	0.483-43.7	1.44 -67.2
3 rd layout	27-400	4.78 -30.1	1.48-20	3-32.3

CASE STUDY 2

Spot magnetic field measurements and loads measurements had been taken in A. Library which contains 11 enclosure dry transformers (two of them are standby) located at 4th floor under the ground. Figure 7 shows the installed enclosure dry transformer, while Figure 8 depicts the magnetic field measurements positions. Figure 9 displays the measured current at different position and measured magnetic field at different positions. The measured magnetic field values in this case are less than the measured magnetic field in case 1 although the load currents are higher. The measured magnetic field range was between 1.1μT-15.7μT, the current was between 400 amp-875 amp.

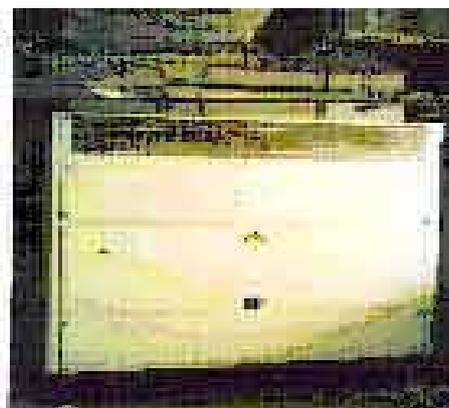


Figure 7. Enclosed dry transformer installed at A. Library

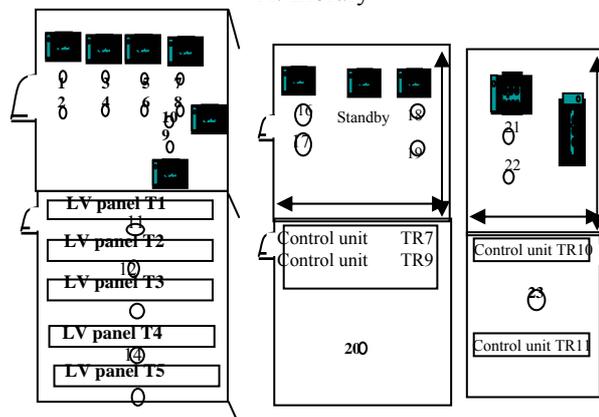


Figure 8. IDTRs plan in A. Library

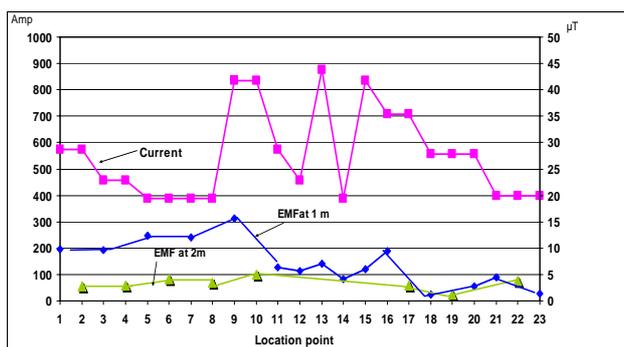


Figure 9. The measured magnetic field values and the current at different positions



Figure 10. busway LV. IDTR layout

CASE STUDY 3

The measurements had been taken in busway LV IDTR layout. The two IDTRs are loaded with high current and located under residential buildings. Table (2) summarizes the measured loads and the measured magnetic field values. The magnetic field measured values in the IDTRs were very small comparable with the results of case study 1. The maximum measured magnetic field value was 8.4 µT at 1m far from the transformer, with load current about 400Amp. Figure 10 shows the IDTR configurations.

Table (2) Measurement results for case study 3

Load Amp	n	R	S	T	EMF At diff. Point (µT)	1	2	3
room 1	25	439	461	448		8.4	2.4	5.32
room 2	30	290	285	300		7.0	2.18	4.15

CASE STUDY 4

The power supply of the residential building in this case study is feeding from IDTR in ground floor. That flat at 1st floor complained from heating and feeling ill and tired. The engineers of the research department in AEDC measured the electrical parameters and the magnetic field levels in IDTR. Also the magnetic field was measured in different locations, and in the flat as shown in Figure 11, especially the bed room which is mainly located above the IDTR. This room was divided into a grid layout with 0.5m side, at height of 1m and at ground level. The following observations have been noticed during carrying out measurements:

1. Unbalanced three phase currents.
2. High neutral current value.

Figure 12 shows the measured magnetic field values, in the flat, above the ground and the max. value was 16.4µT. Figure 13 displays the measured magnetic field values at 1 m above the ground with max. value of 3.45µT. The suggested solutions were:

1. Replacing the old transformer with low losses transformer.
2. Balancing the loads in IDTR and reducing the neutral current. The best mitigation measure for magnetic fields caused by a net-current condition is to correct

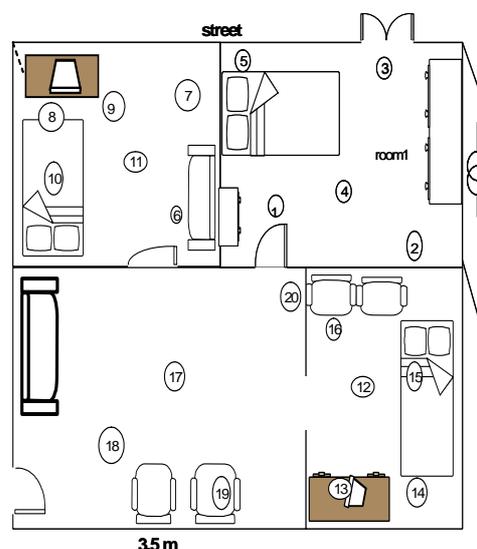


Figure 11. Plan for the flat which contain room1 above the IDTR

3. Rearranging the low voltage cable in the low voltage panel.
4. Shielding the transformer low voltage side.

When the first solution was applied; no complaint of heating is noticed. After that, 2nd solution was applied, rearrangement of the loads on cables decrease the neutral current. This procedure tried to achieve optimal field measurements. In Figure 14-a displays LV cable old arrangements, while Figure 14-b displays the rearrangement applied to reduce the magnetic field by reducing the current in the busbar and flowing the current in opposite direction. The measurements were repeated in the flat and the maximum measured magnetic field value above the ground was 8.91µT. The magnetic field profile for the room above the IDTR is shown in Figure 15. with max. magnetic field value is of 1.2µT, at height 1m.

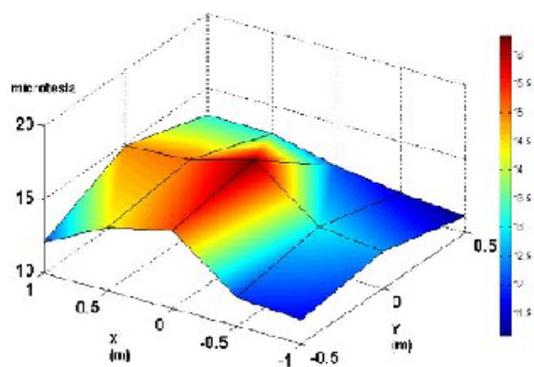


Figure12.Magnetic field profile above the ground

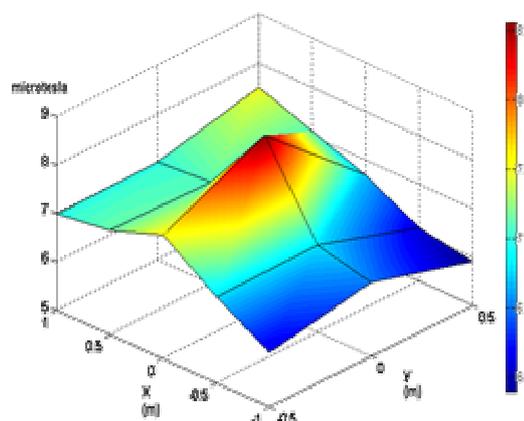


Figure15.Magnetic field profile above the ground after the applied solutions

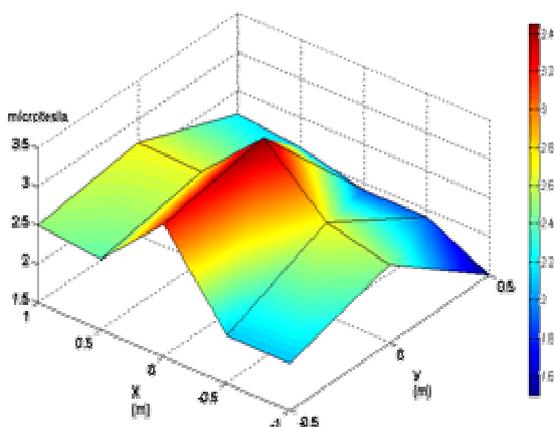


Figure 13.Magnetic field profile at height 1m above the ground

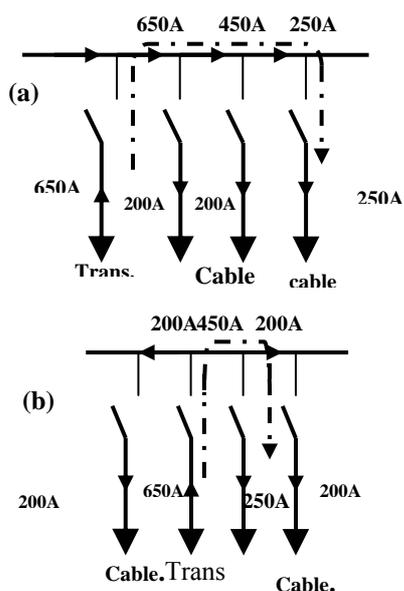


Figure14. LV Cable arrangement to reduce magnetic field

CONCLUSION

The results for the previous cases showed low magnetic field emission for the LV busbar connection. The enclosed dry transformer leads to good values for the magnetic field emission. The buswayLV layout has the lowest values for magnetic field emission, and it was recommended for use in residential building.

The application of practical suggested techniques results in a reduction of the magnetic field about 50% without using high cost solutions in case of residential building. All measurements of EMFs in work environment are within the ICNIRP guidelines.

The data collected provides the preliminary core of documentation for future reference follow-up of trends in EMF emission levels in different layouts of transformer rooms.

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