MEASUREMENT OF THE EXPOSURE OF THE SWISS POPULATION TO MAGNETIC FIELDS OF 50 Hz POWER FREQUENCY AND 16⅔ Hz IN RAILWAYS

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INTRODUCTION

All installations that generate, transmit, or use electric power cause electric and magnetic fields. Common to all types of sources is a strong dependence of the magnetic flux density on the distance to the source. However, this information is not sufficient to know to what degree various parts of the population are exposed to magnetic fields during the different periods of the day. For this reason a study was carried out to assess the typical exposure of the Swiss population to the magnetic fields of 50 Hz power frequency and to 16⅔ Hz magnetic fields in railways. A method of data reduction that allows for the determination of frequency distribution and percentiles for any selection of measurements was applied.

50 Hz MEASUREMENTS

These measurements were made with EMDEX-II instruments which register the resultant of the magnetic flux density up to about 300 μT. In the broadband mode the frequency response is flat from 40 to 800 Hz. Thus, for 50 Hz fields the magnetic flux density is measured correctly, while fields from railways (16 2/3 Hz) are underestimated.

Data from 464 employees were collected on weekdays (24 h, sampling interval (sa) = 10 s). To complete the time range and the demographic spectrum, 45 of the employees collaborated also for weekend measurements (48 h, sa = 30 s). In addition, data from 43 house keepers were included as well (24 h, sa = 10 s). The collected data were transferred to a notebook and the time series were evaluated with the EMCALC V2.12 software. The information of a simple protocol served to split the time series into 5 environmental categories: at work, commuting, at home, at rest and miscellaneous. For each environmental category of every person the frequency distribution was calculated with the EMCALC software. For further analysis the numerical output data were transferred to a large EXCEL table.

16⅔ Hz MEASUREMENTS

Measurements in railways were made with HFR-1200 instruments. The instruments register the resultant of the magnetic flux density in the frequency range from 16 to 500 Hz with a sampling interval of 2 seconds, 1 minute or 1 hour.

Magnetic field measurements were made in fast trains from Zurich to Geneva and also from Zurich to Chur. More data were collected in double-decker S-trains around Zurich. In all cases the magnetic flux density was measured at floor-level, at waist-height and in the luggage rack. Most of the time the sampling interval was 1 minute, only short measurements were made with a sampling interval of 2 seconds. The collected data were transferred to a notebook and the time series were evaluated with the HFR-1200 software and the graphic program EXCEL V5.0.

RESULTS

50 Hz fields

The evaluation of the complete data set gives the following results: Median 0.05 μT, geometric mean 0.06 μT, geometric standard deviation 3.8, arithmetic mean 0.21 μT. 69% of the recorded values are below 0.1 μT, 3% are above 1 μT, and only 0.17% are above 10 μT. The results for "commuting" are intermediate, but these values may represent only a lower limit. 162/3 Hz fields from railways, which are likely to be an important source for this category, are not included in these results.

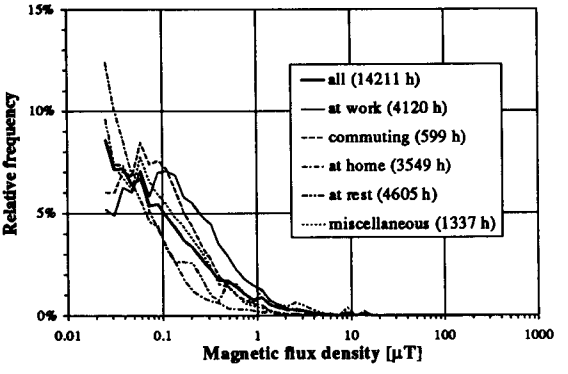

Figure 1:

50 Hz magnetic fields: Relative frequency distribution curves for the complete data set and the main categories. Total measurement times were put in parenthesis.

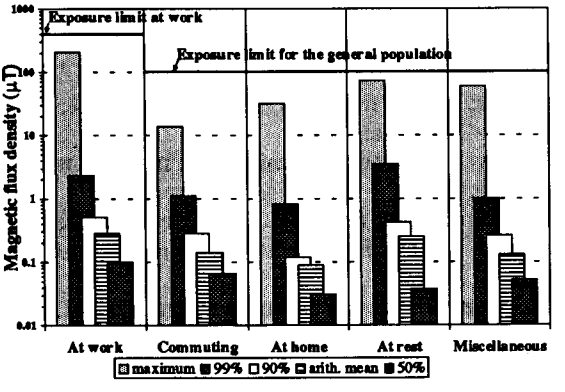

Figure 2:

50 Hz magnetic fields: Maximum, arithmetic mean, 99%, 90%, and 50% percentiles. The exposure limits for the general population (100 μT [3]) and at work (400 μT [4]) which are based on acute biological effects, were never exceeded.

As in similar studies [1, 2], the data of the 50 Hz measurements for all 5 main categories show an approximately log-normal distribution. As expected, the highest exposures were found in the category "at work" and the lowest magnetic flux densities were recorded "at home". Quite surprisingly for the category "at rest" the measured magnetic flux densities are partially higher than those "at home" (see Figure 1) and the arithmetic mean is almost as high as "at work" ($mean_{at\ work}$ = 0.28 μT; $mean_{at\ rest}$ = 0.25 μT; see Figure 2). This is mainly due to a small number of cases with fields in the range from 1 to 15 μT. The main reason for these high readings was, that some people put the EMDEX meter during the night very close to a clock radio or a similar electric appliance. For this reason the measured magnetic flux densities during the night may not be representative for the exposure of the person. Therefore, detailed measurements were made in bedrooms. With the exception of two cases the arithmetic mean within the area of the bed had been close to the arithmetic mean in the category „at home" of earlier

measurements (< 0.1 μT). In one of the exceptional cases an electrical mattress caused arithmetic means between 0.08 μT and 0.45 μT. In the other case higher values (arithmetic means between 0.18 μT and 1.95 μT) had been measured around the pillow only because of a nearby clock radio.

162/3 Hz fields

In trains the arithmetic means of the magnetic flux density varied in most cases between 3 μT and 6 μT with a maximum of 20 μT. A maximum single value of 75 μT was measured in a double-decker train on the lower floor at ground-level. In contrast to the 50 Hz magnetic fields the readings for 162/3 Hz in trains show almost symmetric distributions. The exposure limit for the general population for 162/3 Hz magnetic fields of 300 μT [3] has never been exceeded.

CONCLUSIONS

In residences a range from 0.02 to 0.04 μT can be considered as background level for 50 Hz power frequency magnetic fields. A significant enhancement of magnetic field exposure may be generated by electrical appliances. This is the case in particular if the distance to appliances containing transformers or motors is less than 1 m for an extended period of time. In trains (162/3 Hz) mean magnetic flux densities of 3 μT to 6 μT can be considered as typical. The recommended exposure limits of 100 μT for 50 Hz and 300 μT for 162/3 Hz have never been exceeded.

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