ELECTROMAGNETIC ENVIRONMENT ASSESSMENT FOR THE TOBU-KYURYO-LINE (HSST SYSTEM) IN JAPAN

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Keywords

Maglev train, electromagnetic field, health risk, safety evaluation.

Abstract

Electromagnetic field environment around Tobu-Kyuryo-Line for maglev trains, which employ normal conductive magnets for levitation and linear induction motor for propelling, was assessed from the viewpoint of possible human health risk. The transient magnetic fields around an experimental line were measured as a function of distance by using a magnetic field measuring system, and maximum exposure levels at direct-current (DC) and alternating-current (AC) were extracted in various situations for safety evaluation. The results show that the electromagnetic fields from Tobu- Kyuryo-Line are fully under the international safety guidelines.

1 Introduction

Tobu-Kyuryo-Line is an urban transportation system in which the trains are levitated about 8 mm height by the attractive power of magnets and propelled by linear motors. It initiates the maglev application in the world, while its leaked electromagnetic fields also attract a concern about possible health risk to the inhabitants along the line. For wiping out the inhabitants' uneasiness toward the electromagnetic fields due to the Tobu-Kyuryo-Line, it is necessary to quantify the filed level and evaluate its safety with respect to international safety guidelines. Since the electromagnetic field evaluation have to be conducted before the completion and beginning of service of the Tobu-Kyuryo-Line, the measurement is conducted for an experimental line with the same magnetic levitation system. By using a three-axis magnetic field probe, the magnetic fields along the experimental line are measured for both the direct-current (DC) and alternating-current (AC) components as a function of distance from the rails. The measured field levels are compared with the well-known guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields issued by International Commission on Non-Ionizing Radiation Protection (ICNIRP) [1].

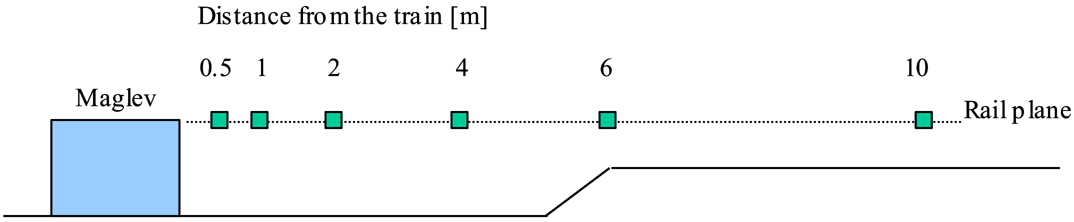
In this paper, beginning with a detailed description of the measurement method, we show the measurement results for both DC and AC magnetic fields along the experimental line, which are compared with the ICNIRP guidelines for evaluating the safety of the Tobu-Kyuryo-Line.

2 Measurement Method

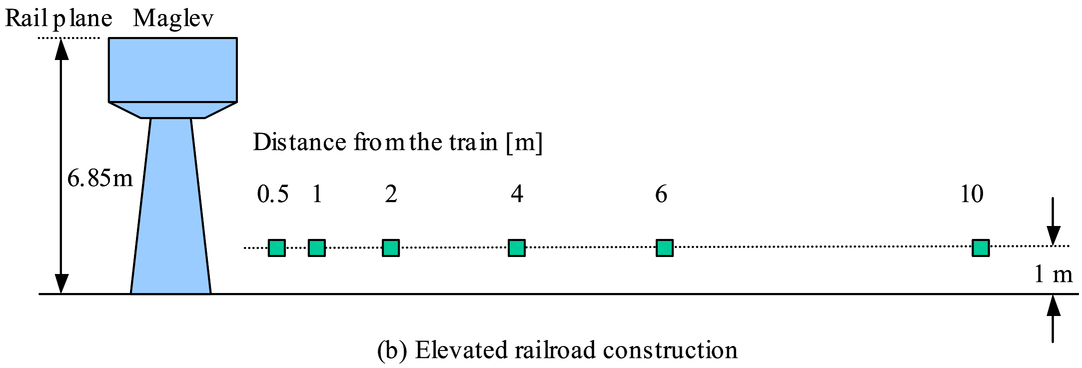
The measurement was conducted along the 1.5 km long experimental line. The maglev train included two carriages with a total length of 30 m, and the DC power reached 1500 V. Fig. 1 shows measurement points. Since the rails were either just above the ground or elevated, the situations as indicated in Fig. 1 were considered in the measurement. In Fig. 1(a) the measurement was conducted at the same height as the rails, and in Fig. 1(b) the measurement was conducted at a height of 1 m from the ground due to the elevated railroad construction. With the fixed heights, the magnetic fields were measured as a function of the distance from the maglev train at designed measurement points.

The magnetic filed probe (Tokin TRM-20DA) was a three-axis type one which employed flux gate detection and indicated the magnetic flux density. The frequency range of the probe was between DC and 300 Hz, and the magnetic flux density up to ±2000 μT was measurable with a resolution of 1 μT. Table I gives its specifications. At each measurement point, the measurement started 5 seconds before the maglev train arrived and ended 5 seconds after the maglev train departed. During this period the magnetic flux density data were sampled at an interval of 1/500 second and were sent to a personal computer for post-process. On the personal computer, the DC components and AC components of measured magnetic flux density were extracted. For the DC components the maximum value during the measurement period was used as the exposure level at each measurement point, and for the AC component the amplitude was used as the exposure level. For reference the frequency of AC component was also determined from the time interval between two maximum field values.

The measurement condition of magnetic fields was as follows: (1) the environmental field level, (2) the field level when the maglev train was turned on the electricity (1500 V), (3) the field level when the maglev train started to move, and (4) the field level when the maglev train accelerated to the maximum speed.



(a) Above the ground construction



(b) Elevated railroad construction

Fig. 1 Measurement situations

Table I Specifications of Magnetic Probe

Detecting method	Flux gate
Frequency	DC ~ 300 Hz
Field strength	0 ~ ± 2000 μT
Resolution	1.0 μT
Directivity	3-axises

3 Results and Discussion

Fig. 2 shows the measured DC components of magnetic flux density in the situations that (a) the rails were above the ground and (b) the situation of elevated railroad. The three curves represent the measured results on the conditions where the maglev train started to move, the maglev train accelerated to the maximum speed, and the environmental level. The DC components were mainly due to the overhead wires and electromagnets of the maglev train. As can be seen from Fig. 2(a), the maximum magnetic field was observed when the maglev train started to move, and a similar field level also occurred when the maglev train accelerated. When the distance from the train was smaller than 2 m the field level was significantly larger than the environmental field level, while after that distance the maglev-induced magnetic field was at the same level as the environmental field. On the other hand, in the situation of elevated railroad as shown in Fig. 2(b), the maglev-induced magnetic field at the measurement points was low enough so that it was nearly the environmental field level. In addition, for the measurement condition when the maglev train was turned on the electricity, the magnetic field level was also almost equal to the environmental level, although the data were not given in the figure.

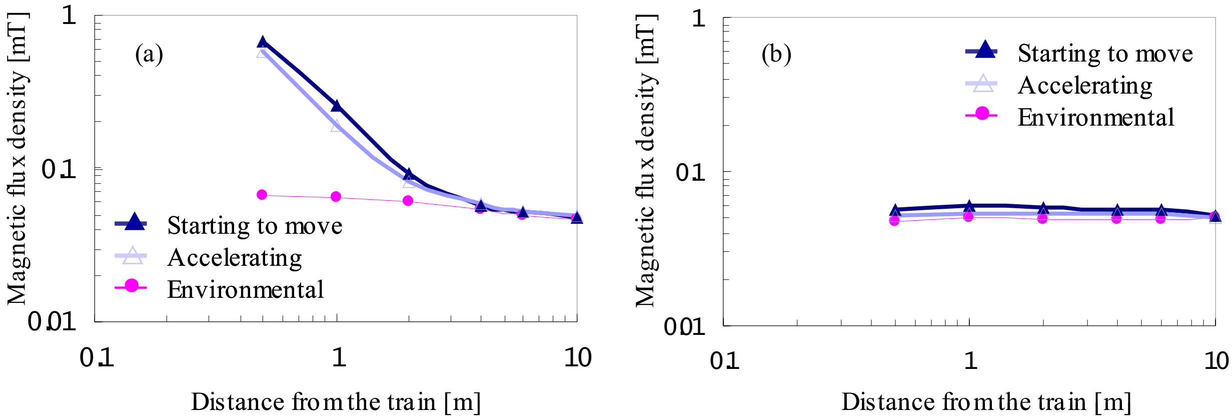


Fig. 2 Measured DC components of magnetic flux density. (a) Above the ground construction, (b) Elevated railroad construction.

Fig. 3 shows the measured AC components of magnetic flux density when the maglev started to move. The maglev-induced magnetic filed was also largest at this measurement condition just as the DC components. The AC components of magnetic field were mainly due to the linear motors and inverters of the maglev train. The frequency was found around 13 – 23 Hz when the maglev started to move. Compared to the DC level, the AC level of magnetic field was lower in an order of about 1/10 or smaller.

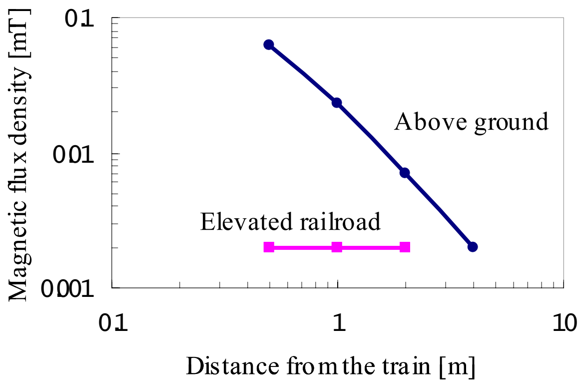


Fig. 3 Measured AC components of the magnetic flux density when the maglev train started to move.

From the above results, the maximum magnetic field was dependent on the distance from the maglev train and became the maximum when the measurement point was closest to the train. The maximum DC magnetic flux density was found to be 0.682 mT at a distance of 0.5 m from the maglev train when it started to move. The distance of 0.5 m could be considered as the possible minimum distance from the Tobu-Kyuryo-Line for the inhabitants. According to the ICNIRP guidelines in which the reference level for public exposure to magnetic fields up to 1 Hz should be smaller than 40 mT, the maglev-induced DC magnetic fields were fully under this safety guideline and exhibited a safety factor of 58.

On the other hand, the maglev-induced AC magnetic flux density was 0.063 mT at maximum with a frequency of 23 Hz. This level was also found at a distance of 0.5 m from the maglev train when it started to move. The ICNIRP has defined a reference level of 0.217 mT at this frequency, and the maglev-induced AC magnetic flux density was about 3/10 compared to this reference level. From the viewpoint of safety evaluation with respect to the ICNIRP guidelines, the worst case was found when the maglev train accelerated to 70 km/h. The AC magnetic flux density was found to be 0.042 mT at 63 Hz in this worst case, while the level was still half of the ICNIRP guideline at this frequency (0.079 mT).

4 Conclusion

Electromagnetic field environment around Tobu-Kyuryo-Line has been evaluated based on measured magnetic fields for an experimental line. The maximum exposure level has been extracted at DC and AC leakage components in various situations for health risk assessment. The results have shown that the maglev-induced electromagnetic fields from Tobu- Kyuryo-Line are fully under the ICNIRP safety guidelines. Even in the worst case when the maglev train accelerates to the maximum speed, the AC magnetic field level is still half of the ICNIRP reference level.

References

[1] International Commission on Non-Ionizing Radiation Protection, *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*, Health Physics, vol.74, no.4, pp.494-522, 1998.4