MAGNETIC FIELD MEASUREMENT METHOD FOR RAILWAY

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Abstract: International standard relevant to EMC on railways was established as IEC 62236, this year. This paper will describe the present situation of actual magnetic field on Japanese railway systems and the studying measurement method of magnetic field for railway systems.

Key words: Magnetic field, railway, measurement method, hole element and Flux gate measurement

1. Introduction

For railway, EMC standard has just become effective on this year as IEC 62236 and guideline of magnetic field that are radiated by railway systems is described in this standard. Therefore, we must clarify that magnetic fields by Japanese railway systems are accepted within this guideline. Therefore, we measured magnetic fields on Japanese several railway systems by actual measurement method and studied the appropriate measurement method for railway magnetic field.

2. Magnetic field subjects on Japanese railways

2.1 Characteristics on magnetic field of Japanese railways

Electric railway is propelled by motors controlled by control devices by receiving currents through pantograph and trolley lines supplied from substations. At the same time, many currents are used for any other devices on board. Therefore, several types of magnetic fields are radiated within and without railway systems. Especially, Japanese railway systems have many types of propelling and supporting methods, for examples, rotary motors, linear motors or wheel, magnetic levitation, air suspension or etc. These systems radiate different types of magnetic fields and have wide range of frequencies. We must measure magnetic fields on Japanese railway systems taking into account of these characteristics.

2.2 Relationship of IEC 62236

IEC 62236 has established as the guideline of EMC on railway systems. In the present stage, on behalf of Japanese claims through several discussions in the international conference, guideline of magnetic field by railway running is not yet regulated. But, in the European standard of EN50121 that was the base of IEC62236, guideline of magnetic field is regulated like electric field. Therefore, in the near future, guideline of magnetic field will be discussed again in the international conference. Accordingly, we must prepare the documents that are described Japanese actual magnetic field data and the proper measurement method for railway systems.

2.3 Relationship of IEC TC106

On the other hand, measurement methods for human effect against electric magnetic fields are discussed in the technical committee (TC106) of international standard (IEC). In this committee, railway system is only one part of industrial applications. Accordingly, after deciding several standards for other industrial fields for examples, commercial frequency power line, mobile phones and etc, official measurement method for electric magnetic field on railway will be discussed. For this reason, we must study the proper measurement method of magnetic field for railway systems.

3. Present stage of magnetic field subjects on Japanese railways

3.1 Measurement examples of magnetic field by actual measurement method

We measured several magnetic fields by different Japanese railway systems by actual magnetic measurement methods of hole element and magnetic flux gate methods. Figure 1 shows the measurement results of magnetic field outside vehicle.
These values are plotted by the maximum data on the platform at vehicle running (starting or stopping). The maximum magnetic field is recorded as about 400 $\mu$T of DC magnetic flux density in HSST systems (magnetically levitation system). On the contrary, AC magnetic field is lower than DC magnetic one. Their maximum magnetic field of AC is about 40 $\mu$T in OTIS systems (linear motor propelled and air suspension) and this frequency is almost several Hz and we can judge this frequency is almost near static magnetic field. Magnetic field of middle frequency range (approximately under several kHz order) is a little detected as under several $\mu$T order. Moreover, magnetic field of high frequency (more than 30 kHz) that is often discussed the relation of human effects is scarcely detected in these actual measurement devices. These data were acquired by the conventional measurement devices that are partly improved for justification of railway applications.

3.2 Present measurement method

Measurement method of magnetic field for railway systems is not yet established formally. Figure 2 shows the rough applicable range of measurement method with relationship between magnetic field strength and frequency range.

![Fig.2 Applicable measurement method with magnetic field strength and frequency range](image)

You can find that no measurement method can cover all of magnetic field range and strength by railway systems. Therefore, we must consider these situations and choose the appropriate measurement method that can be measured accurately for the purpose of required magnetic frequency and strength range. That is, we must prepare several measurement devices for evaluation of accurate magnetic field on railway systems and this means the complications of measurement and the difficulties of measurement space. Accordingly, for the accurate and saving measurement spaces, one measurement device is required in the near future.

3.3 Development of new measurement device

Under these circumstances, we developed the new magnetic field measurement device for specific railway use. This device is combined with flux gate and search coil method and cover the magnetic field of frequency range from DC to 10kHz and of strength range from 1mT to 0.01 $\mu$T. Table 1 shows the major specifications of this device and figure 3 shows the outlook of this device.

<table>
<thead>
<tr>
<th>Items</th>
<th>Performances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency characteristics</td>
<td>±1.5%(400Hz~10kHz)</td>
</tr>
<tr>
<td>(Search coil)</td>
<td>±3.0%(50Hz~400Hz)</td>
</tr>
<tr>
<td>(Flux gate)</td>
<td>Under 5%(0~120Hz)</td>
</tr>
<tr>
<td>Filter for output</td>
<td></td>
</tr>
<tr>
<td>(Search coil)</td>
<td>200Hz, 10kHz, 20kHz</td>
</tr>
<tr>
<td>(flux gate)</td>
<td>200Hz</td>
</tr>
<tr>
<td>Weight</td>
<td>about 5.5kg</td>
</tr>
</tbody>
</table>

![Fig.3 Outlook of measurement device](image)

In this device, sensing method of magnetic field is changed at 120Hz from flux gate to search coil method automatically by software calculations. By using this device, we can measure magnetic fields that are radiated by railway systems covered with almost frequency and strength range. And this device can execute frequency analysis after data acquisitions.

According to IEC 62236 or any other standards for guideline of magnetic field, all measurement data must be evaluated with frequency range, so it is better to measure and analyze immediately for us. This device can measure magnetic field at once and can analyze these data by computer at our desired time and immediately shows the analysis result.

Figure 4 shows the analysis example outside linear motor. This linear motor is controlled by VVVF inverter and the range of propelling frequency is from 0 to 12Hz. In this experiment, we controlled and drove this motor by frequency range of 0~8Hz.
You can find almost constant big magnetic field from 0 to 8Hz and a little peak of one at nearby 200Hz. This shows that low frequency magnetic field of 0 to 8Hz is control one that is controlled by VVVF inverter and nearby 200Hz is switching one of this inverter.

4. EMC subjects on Japanese railway systems

4.1 Influences to signalling systems

EMC problems between railway vehicles and signalling systems are discussed for a long time and have been solved individually in Japan. However, in Europe, the movements that these relations must be clarified and regulated occurred and European standard was established as EN50238. Accordingly, as these movements will affect international standards in the near future, we must prepare and correspond to these movements. In Japan, many types of vehicles and signalling systems are practical uses and all these EMC problems are settled by the railway operators in corporation with makers. Hereafter, we must arrange quantitatively and adjust these data and experiences.

4.2 Influences to human bodies

As to the effects against human bodies by magnetic field, two phenomena are considered.

(1) Transient effects

These phenomena are appeared to have heats in the cell and representative of induced currents in the body. For this protection, international organization of ICNIRP has decided the guideline for electric magnetic exposure against human bodies. Railway systems must keep these guidelines for the safety on human bodies. Though in the present stage, no measurement methods are decided, IEC TC106 is now discussing these subjects. If international standard for measurement method on railway at this TC, all railway systems must keep this measurement method and be measured and evaluated electric magnetic field on railway in the view points of effects on human bodies. Accordingly, we must study and check the adjustment of these measurement methods that are discussing in this TC. After that, we must construct the proper measurement method for railway and human bodies.

As the references, the guideline of magnetic field strength described in ICNIRP and the measurement data range of our measurements that were put into operation in Japanese railways are shown in figure 5.

Judging from these data, as for the magnetic field on Japanese railway systems measured by actual devices, there are much room for limitations.

(2) Hereditary effects

This problem is now under studying by many scientists and doctors and some reports that are related to railway field are published. However, at the present stage, no clear evidences between magnetic fields on railway and effects on human bodies are shown yet. But, we must check and study these sorts of reports prudently and continuously.

5. Conclusion

We measured magnetic field on Japanese railway systems by actual measurement method and found these values are satisfied with present guideline. However, for clarifying the accurate adaptability on standard, we developed new measurement devices for railway systems. After this, we will accumulate more effective data for this purpose.

References
