Measurement of the magnetic fields in cars running at constant speeds

Japan EMF Information Center

Hiroomi Kato[1], Chiyoji Ohkubo[1], and Katsuo Isaka[2] [1] *Japan EMF Information Center,* [2] *The University of Tokushima.*

Introduction

With the recent introduction of electric vehicles and hybrid vehicles, exposure to electric and magnetic fields in those vehicles is becoming an important issue to drivers and passengers. The driver and passengers may have concerns about the possible health effects of magnetic fields in the same manner as they have for power lines and home electric appliances. In response to such concerns, the results of magnetic fields measurements in typical automobile vehicles (cars) are presented and compared with the ICNIRP guidelines. The magnetic field intensities are given in μT in this paper.

Methods

➢ Measurement instrument

····In order to measure the generated magnetic field level and its frequency

【Sensor】
- 3-D fluxgate magnetometer
- Bartington, UK, model Mag-03
- Frequency range ; 0Hz ~ 3kHz
- Measurement range ; -1mT ~ +1mT

【Spectrum analyzer】
- Bartington, UK, model Spectramag-6
- Sampling interval ; 100μs ~ 10s
- Battery life ; 8 hours

The confirmation of the use propriety of sensor ; Mag-03.

→ It confirms that the frequency of the magnetic field which generated from cars is less than 3 kHz

【Sensor】
- 3-D coil magnetometer
- NARDA, Germany, model EFA-300
- Frequency range ; 5Hz ~ 32kHz
- Measurement range ; 100nT ~ 31.6mT

Measurement result

We confirmed that there were no major magnetic fields sources of cars in the frequency range of 3kHz to 32kHz.

➢ Measurement object

The three types of cars were subjected to the measurement.
- ● an electric vehicle (EV)
- ● a hybrid vehicle (HV)
- ● an internal-combustion engine vehicle (ICEV)

➢ Measurement condition

◆ Speeds

Driving speed was kept constant.

0km/h (idling state) / 10km/h / 40km/h / 80km/h

◆ Onboard equipment

The following (radio, car navigation, headlight and Air-conditioner) onboard equipment was measured in power supply OFF.

➢ Measurement seat position

The three types of seat position were subjected to the measurement.
- ●driver's seat
- ●co-driver's seat
- ●rear seat (behind the driver's seat)

➢ Measurement position

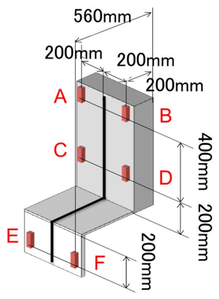


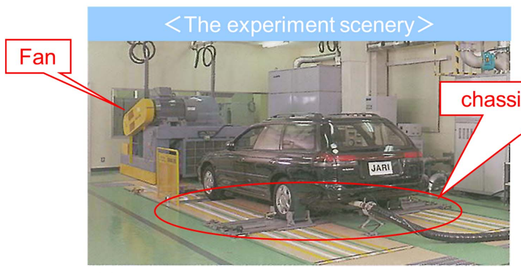
Fig.1. Test arrangement

There are six measurement positions (right and left positions of the head, abdomen, and legs, respectively) on a simple, wooden human model.

The dedicated jig was used to precisely set the 3-D magnetic fields sensor each measurement position.

➢ Test facility

<The experiment scenery>



Measurement cooperation
: Japan Automobile Research Institute

With the use of an indoor test facility (chassis dynamometer), we could perform reproducible measurements under the same conditions.

We needed to eliminate the effect of the magnetic fields generated by the testing equipment from the measurement results to obtain the actual magnetic fields generated by the cars.

Results

ex. driver's seat _ F _ 40km/h

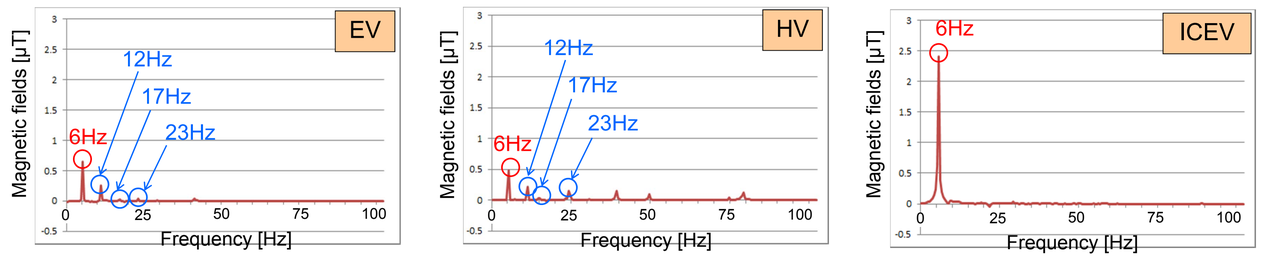


Fig.2. Spectrum of the magnetic fields in the cars as a function of frequency

The EV and HV have several frequencies of peak besides 6Hz of the highest magnetic fields.

The ICEV has frequency of peak only around 6Hz.

Table1 shows a number of frequencies of peaks generated from various vehicle types at given various car speed.

Table.1. Frequencies of peak

Vehicle type	Speed [km/h]	Frequencies of peaks proportional to car speed [Hz]	Other frequency components [Hz]
EV	0	(No peak)	
	10	1.45 / 12.91 / 15.33	
	40	5.81 / 11.63 / 23.25	16.95 / 29.06 / 34.39 / 43.11
	80	11.63 / 23.25 / 48.93	24.22 / / 73.14
HV	0		7.75 / / 24.22 / / 73.14 / 97.75
	10	1.45 / 12.91 / 15.81	7.75 / / 24.22 / 48.93 / 73.14 / 97.85
	40	5.81 / 11.63 / 22.77	7.75 / 17.44 / 24.22 / 48.93 / 73.14 / 97.85
	80	11.63 / 23.25 / 48.93	7.75 / / 24.22 / 48.93 / 73.14
ICEV	0	(No peak)	
	10	1.45 /	
	40	6.29 /	
	80	12.59 /	

(Correction) There were clerical errors at the table of the submitted paper. This table is exact.

The frequencies can be classified into the two groups.
- The frequencies proportional to the car speed
- Other frequencies unrelated to the car speed

The frequencies of peak in red character exist for all the cars.
- approximately 1Hz at 10km/h, 6Hz at 40km/h, and 12Hz at 80km/h

The frequencies of peak in blue character in HV exist regardless of speed.
- Those frequency components in blue character also exist in part of the measurement result of EV

ex. EV_driver's seat_40km/h

Vertical axis; Magnetic fields [μT]
Horizontal axis; Frequency [Hz]

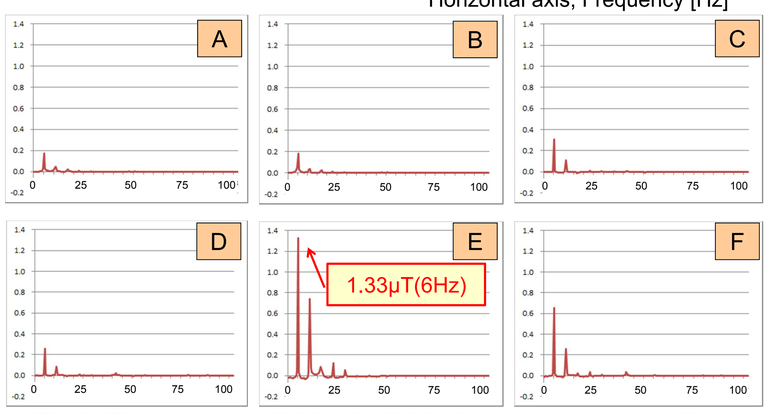


Fig.3. The magnetic field at individual measurement position

The highest level of the magnetic fields was observed at the legs for all seats (in red envelope).

The levels of the magnetic fields are lower at the rear seat.
- disagrees with previous report (1)
  In the previous report, the magnetic field levels of the rear seat were higher than those of driver's and co-driver's seat.

(1) Schmid G, Überbacher R and Göth P: ELF and LF magnetic field exposure in hybrid- and electric cars. BioEM2009 (9-3), 15-19 June 2009.)

Table.2. Maximal magnetic fields of individual measurement positions in EV

Speed [km/h]	Frequency [Hz]	Seat	Measurement position [μT]					
			A	B	C	D	E	F
10	1.45	Driver's seat	0.15	0.12	0.29	0.22	1.38	0.68
		Co-driver's seat	0.15	0.16	0.25	0.27	0.59	1.08
		Rear seat	0.08	0.08	0.10	0.10	0.17	0.15
40	5.81	Driver's seat	0.17	0.18	0.31	0.26	1.33	0.65
		Co-driver's seat	0.18	0.20	0.22	0.26	0.56	1.09
		Rear seat	0.05	0.04	0.14	0.14	0.19	0.17
80	11.6	Driver's seat	0.25	0.23	0.39	0.35	1.32	0.69
		Co-driver's seat	0.20	0.19	0.33	0.35	0.61	1.09
		Rear seat	0.09	0.08	0.15	0.14	0.24	0.23

There is no significant difference in the maximal magnetic field levels depending on the car speed.

The magnetic fields in an idling condition (0km/h) were excluded as they were significantly smaller than those other speeds.

Comparison with the ICNIRP Guideline

The level of the magnetic fields around 6Hz (at 40km/h; 1.33μT) was lower than the general public reference level in the ICNIRP Guidelines.
- ex) The guideline value at the time of 6Hz ; 1111μT

These tendencies of the magnetic field levels in EV were almost the same with HV and ICEV.
- HV was 1.38μT at the position F of the co-driver's seat at 10km/h
- ICEV was 4.20μT at the position E of the driver's seat at 40km/h

While EV and HV have multiple frequencies of peak, the value which added all the rates ($H_j / H_{R,j}$) in each frequency was well below " 1" in eq.(1).

$$\sum_{j=1Hz}^{10MHz} \frac{H_j}{H_{R,j}} \le 1 \qquad \text{Eq.(1)}$$

- H_j : measured value of magnetic fields
- $H_{R,j}$: reference level

Highest value calculated by the Eq(1) is 0.00927.

$$\frac{H_j}{H_{R,j}}$$

Table.3. Comparison with the ICNIRP Guideline

Speed [km/h]	Seat	$H_j / H_{R,j}$ [%]			
		EV position E	EV position F	HV position E	HV position F
10	Driver's seat	0.028	0.010	0.087	0.138
	Co-driver's seat	0.010	0.022	0.059	0.047
	Rear seat	0.002	0.001	0.151	0.139
40	Driver's seat	0.411	0.166	0.440	0.350
	Co-driver's seat	0.134	0.218	0.162	0.242
	Rear seat	0.047	0.067	0.165	0.155
80	Driver's seat	0.927	0.380	0.565	0.482
	Co-driver's seat	0.290	0.560	0.290	0.478
	Rear seat	0.108	0.127	0.283	0.264

Conclusion

The magnetic fields in EV and HV contain multiple frequencies of peak. The ICNIRP Guidelines evaluation method for multiple frequencies was applied. As a result, it is concluded that the magnetic fields in the three types of cars examined are well below the ICNIRP Guidelines.