FROM THE FIELD

Letter to the Editor

ELF Magnetic Fields from Spinning Steel-Belted Radial Tires: Implications for Epidemiological Studies

February 6, 1998

To the Editor:

A few months ago, one of us (SM) measured extremely low frequency (ELF) magnetic fields in his car, a 1993 Eagle Vision, using an F.W. Bell triaxial gaussmeter (model 4080). The fields were 3.0-4.0 mG (0.3-0.4 μT) at the driver's seat level and 6.0-20.0 mG on the rear seat, with higher fields measured laterally near the doors. Mysteriously, the fields were present only when the car was moving, and persisted when the car was coasting at 60 mph with the engine turned off.

Kjetil Vedholm and Dr. Yngve Hamnerius[1] recently explained that, "The metal cord in the tires is often permanently magnetized, which gives rise to an alternating magnetic field when the car is rolling." These Swedish researchers reported fields on the back seats of passenger vehicles as high as 50 mG (in the 5 Hz-2 kHz frequency range) when the car was traveling at 60 mph.

A visit to the two largest tire retailers in the Seattle area revealed that virtually all new radial tires contain steel belts and attract a compass needle. At the annual Department of Energy EMF review in San Diego last November, a number of colleagues suggested that SM's gaussmeter readings might have been motion-induced artifacts due to interaction with the Earth's static magnetic field. Hamnerius dismissed this idea, noting that an isolated tire spinning in his lab generated fields similar to those he had measured in moving cars.

A spinning wheel without a tire did not change the 0.2 mG field measured near the safety cover of the tire balancer, but a spinning steel-belted radial tire mounted on a wheel generated fields of about 6.8-7.0 mG in the same place.

Why had these fields not been discovered sooner, given the many hours of personal monitoring done with sophisticated recording gaussmeters in epidemiological studies of utility workers? Dr. William Kaune of EM Factors in Richland, WA, suggested that the fields were of such low frequency that they were filtered out by the meters.

Using the circumference of passenger car tires, Kaune and SM estimated that, at legal speeds, the tires would always spin at less than 20 revolutions/second (20 Hz). Nearly all the EMF epidemiologic studies published to date, both occupational and residential, have used versions of one of three meters to measure magnetic fields: the EMDEX and the AMEX, both made by Enertech Consultants in Campbell, CA, and the Positron, made by Positron Industries in Montreal, Canada. All of these units filter out frequencies below 35-40 Hz in order not to register effects of movement in Earth's static magnetic field.

Using the Bell 4080 meter and an EMDEX II meter, side-by-side measurements were made around appliances and under high-voltage transmission lines. The meters gave nearly identical readings. But in a moving car, the EMDEX usually gave substantially lower readings. At 60 mph, the EMDEX read 1.9 mG on the floor of the front seat, while the Bell meter read 7.9 mG in the same location. Similarly, on the back seat close to the doors, the EMDEX read 2.9-5.0 mG, while the Bell read 15.0-20.0 mG. More importantly, at a commercial tire-balancing machine, the EMDEX read 1.0 mG one foot from a spinning steel-belted radial tire, while the Bell read 6.0 mG and 6.4 mG in two trials with one tire, and 7.6 mG with another tire. Clearly, fields below 40 Hz are more effectively rejected by the EMDEX meter than by the Bell meter. (The Bell meter is designed to measure 60 Hz fields but filters the low frequencies somewhat less effectively than the EMDEX.)

Next, the static magnetic field associated with the tires in the store was corroborated with a fluxgate magnetometer (Walker FGM-301). We routinely detected static fields above the meter's maximum measurable level of 2.0 G at the tread surface of radial tires. In fact, we found some tires above the 5.0 G maximum measurable level of another magnetometer (R.B Annis Co.). The fields varied dramatically in both strength and polarity across the tread of the tire within very short distances (less than an inch), with many "hot spots." Some new tires had stronger fields than others, but all steel-belted radial tires—whether new, on cars or in a tire dump—showed similar fields. The fields dropped off quickly with distance from the tread surface, from over 2.0 G at the tread to about 100 mG at 3 inches from the tread.

The alternating magnetic fields generated by spinning tires were studied at a tire-balancing machine and in a moving car using the magnetometer connected to a portable oscilloscope (Tektronix 222 Digital Storage Oscilloscope) and a Toshiba portable computer (loaded with Metratek Waveform Manager, version 2, for Microsoft Windows 3.1). Magnetic flux density time-series data were acquired at different tire rotation rates and transformed into the frequency domain using a fast Fourier transform (FFT) algorithm in the computer.

We found that the frequency of the magnetic field was directly proportional to the speed of the automobile, 6 Hz at 30 mph and 12 Hz at 60 mph, while the intensity (rms) of the magnetic field remained fairly constant at 19 mG. (Note that care must be taken in interpreting magnetic field readings using common loop-type magnetic field probes, because field sensors will give the appearance of increasing magnetic flux density with increasing tire-rotation rate since the meters are more responsive to higher frequencies.) The waveform was roughly sinusoidal, but was distorted by high harmonic content. The magnitudes of the fundamental and harmonic components of the 30 mph magnetic waveform were 16 mG rms at 6 Hz, 10 mG at 12 Hz and 3 mG at 18 Hz.

Tires were easily degaussed using a hand-held magnetic tape degausser (Geneva Audio/Video Tape Eraser, Model PF211). With the car jacked up, the degausser was held near the tread of a tire—as it was spun by hand—and was gradually moved away over a 15-second period. Magnetic field measurements were taken after each tire was degaussed, and it became clear that each tire has its own sphere of magnetic influence inside the car. For instance, degaussing the right rear tire dropped the fields on the rear seat near the right door from 20 mG to 2.0 mG but had no effect on the fields on the rear seat near the left door.

Once the tires were degaussed, their magnetic fields stayed very low over a period of a few months.

Steel belts are made of very fine high-carbon wire (diameter = 0.0092 in). Each tire contains nearly one mile of wire. All iron wire products tested (nails, springs and paper clips) were magnetic, and the static field of a single strand of wire varied along its length in both polarity and intensity, suggesting that the wire manufacturing process may be the source of magnetism in tires. However, some specialty stainless steel wires are weakly magnetic, or not magnetic at all, and are difficult to magnetize.

Our observations suggest the need to reevaluate how exposures were assessed in previous residential and occupational epidemiological studies. If magnetic fields below 35 Hz are included, a child riding to and from school in the back seat of a car for one hour could receive as much magnetic field exposure on a time-weighted average basis as he could from spending 24 hours at home.

Similarly, electric utility line crews may spend as much time driving between jobs as they do climbing poles or towers—most of them

no doubt commute to work in cars. A rural area meter reader driving around in a car all day will have a significant magnetic field exposure below 35 Hz but relatively little exposure at power frequencies.

If magnetic field exposures below 35-40 Hz are biologically important, the use of meters that reject this part of the EMF spectrum could give a very distorted picture of ELF magnetic field exposure, thereby compromising epidemiological study results.

The focus on power frequency (50 and 60 Hz) magnetic fields was logical, since they are a pervasive concomitant of electricity use. However, the human nervous system operates at frequencies below 20 Hz as measured by brain waves, and magnetic fields sinusoidally modulated at 0.2 Hz were long ago shown to affect reaction time performance in humans.[2]

In view of our observations, we must wonder whether the outcomes of various EMF epidemiological studies would have been the same if the exposures had been assessed with meters that could measure magnetic fields below 35 Hz. Indeed, if cars are a major source of ELF fields, inclusion of exposures away from home should be considered in designing field measurement strategies for residential EMF studies.

It should not be technically difficult to build meters that can detect these ELF fields and isolate them from the effect of Earth's magnetic field. Also, it should not be very difficult to build field-free radial tires or to degauss existing tires.

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1. K. Vedholm and Y.K. Hamnerius, "Personal Exposure from Low Frequency Electromagnetic Fields in Automobiles," *2nd World Congress for Electricity and Magnetism in Biology and Medicine,* Abstract No.F-9, Bologna, Italy, 1997.

2. H. Friedman, R.O. Becker and C.H. Bachman, "Effect of Magnetic Fields on Reaction Time Performance," *Nature, 213,* pp.949-950, 1967.

Clippings from All Over

"I have no intention of turning the FCC into a national zoning board."

—William Kennard, chairman, Federal Communications Commission, in a speech at CTIA's *Wireless '98,* Atlanta, GA, February 23, 1998

"I had thought it was voodoo."

—Dr. Fatih M. Uckun, pediatric oncologist, Wayne Hughes Institute, St. Paul, MN, on his earlier skepticism regarding a possible EMF–cancer link, quoted by Janet Raloff in "Electromagnetic Fields May Trigger Enzymes," *Science News,* p.119, February 21, 1998 (see p.7)

EMF Research Program Ending; Health Hazard Not Yet Found

—Headline of article on the impending conclusion of the EMF RAPID program, in *Electroindustry,* published by the National Electrical Manufacturers Association, Washington, DC, p.3, February 15, 1998

"...lowering per-minute costs will dramatically enlarge the market. The name of the game is to get people to talk more."

—Mario Gabelli, mutual fund manager, quoted by Susan Pulliam in "Bell Atlantic's Move May Spark a Price War in Cell Phone Service, Hurting Some Players," *Wall Street Journal,* p.C4, March 5, 1998

Home values can still be affected. Although the National Association of Realtors receives fewer inquiries on EMFs, real estate agents continue to contend with buyer anxieties, a problem also inextricably entangled with a dislike of the aesthetics of utility towers. Susan Coveny, president of RE/MAX Prestige, a realty agency in Long Grove, IL, says a home near a power line can sell for 20% less than a comparable house at some distance away. Coveny says she has commissioned tests of field strength in homes near power lines and has shown buyers literature about studies that have cast doubt on health effects. "It doesn't matter," she states. "Their reaction is, 'I know somebody near a power line who has brain cancer'."

—Gary Stix, "Closing the Book: Are Power Line Fields a Dead Issue?" *Scientific American,* p.33, March 1998