Electromagnetic Fields: Kicking Out an Uninvited Guest

EMF's can effect equipment and possibly the health of building occupants. A comprehensive EMF survey is the first step in identifying and solving problems.

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Electromagnetic fields (EMF's) are an aggravating by product of the electrical power and radio-frequency (RF) communications necessary in the operation of commercial, industrial and institutional buildings. They cannot be seen, heard or felt even though they penetrate virtually all objects, including buildings and people.

Building occupants become aware of electromagnetic interference (EMI) from alternating-current (ac) power sources when the emanating magnetic fields generate screen jitter in computer monitors, noise in audio-visual equipment and data errors in magnetic media. And although the results are disputed, research also has linked ac power EMFs to health problems, most notably leukemia, cancer and recently Alzheimer's Disease.

The key to dealing with EMFs is identifying sources within or outside a building keeping in mind that EMFs are present in every building. An EMF survey is often the first step in solving a problem.

EMF Sources

Magnetic fields within a building emanate from transformers, network protectors, secondary feeders, switchgear, busway risers and electrical panels. National Electric Code (NEC)®* wiring violations

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Solving One Facility's EMF Problems

Recently VitaTech Engineering, LLC accepted a challenge from a New York City community college, where peak readings in a fitness center were 111 milligauss (mG) 1 meter above the floor (720 mG on floor). The center was directly over four transformers, network protectors, feeders and switch gear. The college asked for and received magnetic shielding that would reduce the average room levels to 3mG.

A three-dimensional contour survey determined milligauss levels of AC magnetic field penetration throughout the room as shown in Figure 1. The survey path followed to measure levels is superimposed in Figure 2 over the EMF sources.

Clearly it would have been impractical to shield each source.

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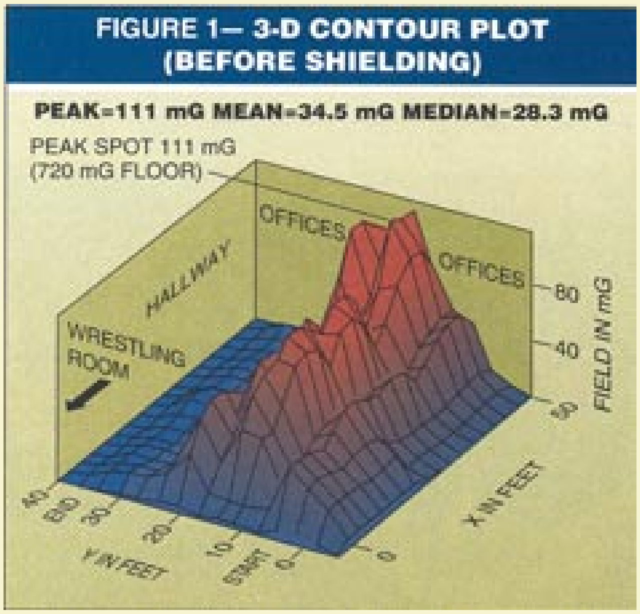
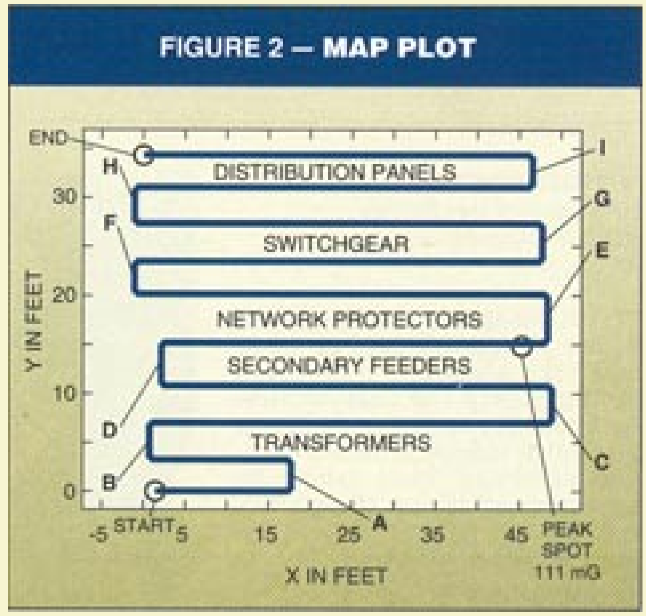


A 3-D contour plot of the fitness center at New York City Community College showed a peak reading of 111 mG at a level of 1 meter above the floor.



Superimposing the path taken by surveyors over a map showing equipment in the space below helps identify key areas contributing to high magnetic field readings.

can inject ground currents onto metal conduits, water pipes, building steel and heating, ventilation and air-conditioning (HVAC) ducts, generating EMI problems throughout the building. Thus, while ac magnetic fields generally are located and mitigated near an electrical source, magnetic fields can be a challenge throughout a building.

While electrical systems within a building itself are the major sources of EMFs affecting the building, outside sources also can produce problems. Buildings near transmission lines, subways and electrified- rail systems can experience high magnetic fields, especially when trains pass by.

On many roofs and upper floors, radiated EMF energy from nearby antennas and microwave dishes can exceed minimum acceptable human exposure standards as outlined in IEEE/ANSI (Institute of Electrical and Electronics Engineers/American National Standards Institute) Standard C95.1 and by the Federal Communications Commission. As wireless local-area networks, cellular telephones, micro-wave and other forms of RF communications grow, so will the associated EMI problems and potential health risks in commercial buildings.

Taking these factors into account, one international bank conducted a full-spectrum EMF site survey prior to constructing its new headquarters building. Microwave and RF levels were recorded around the site at various elevations as well as magnetic field levels from a nearby electrified rail system plus all overhead and underground power lines. By including EMF considerations in its planning, the bank knew what potential EMF challenges existed at the site before construction began, thereby reducing mitigation costs by a factor of 2-to-4.

Selecting an EMF survey

Often, an EMF source is obvious: The computer screen jitters near an electrical switchgear room or the screen changes color as a subway passes. However, complex problems can be generated by plumbing currents on water pipes, magnetic resonance imaging (MRI) equipment, *Three types of commercial AC power EMF surveys are used today: spot, contour and dosimetric*

uninterruptible power supply (UPS)units and shorted electrical equip- ment. Problems also may arise from RF sources such as nearby UHF, VHF and FM antennas, airport radar and landing systems, rooftop antenna farms, police/ambulance vehicles and hand-held transceivers (cellular, CB, mobile).

A detailed site survey can identify EMF sources and evaluate their impact on the building, as well as the equipment and people in it. Three types of commercial ac-power EMF surveys are used today: spot, contour and dosimetric. In each, a three-axis gaussmeter measures magnetic-flux density, in milligauss (mG), emanating from electric power sources.

Spot surveys record EMF levels in spots such as the center of each office, work area or electrical-equipment room and around the property. With a contour survey, levels are recorded at one-foot intervals along selected paths (i.e., back-and-forth pattern within a large room, outside perimeter of a building or property line or perpendicular from an overhead transmission line or electrified train). Recorded data is processed and plotted in two or three-dimensional graphical presentations.

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Dosimetric surveys place a gaussmeter at a fixed location or on a test subject. Exposure levels are recorded in timed increments over a defined period (typically 8, 12 or 24 hours), which shows accumulated exposure and level changes over time.

For commercial buildings, spot or contour methods generally are used, with contour surveys favored because each room or area can be measured

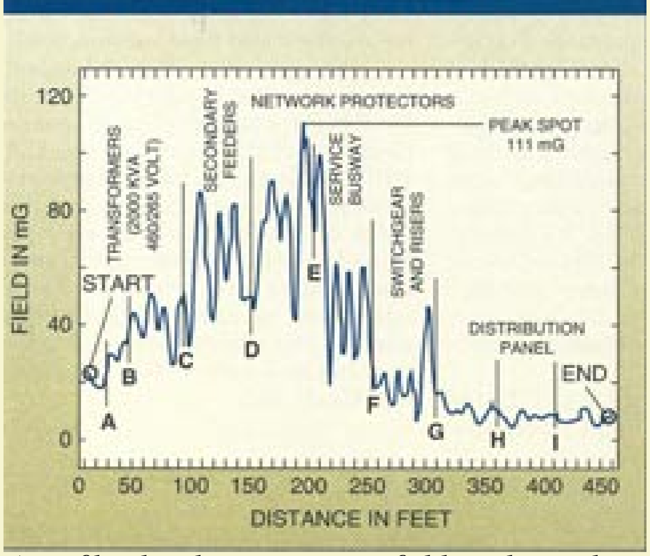
Solving Problems (cont.)

Instead, the entire room was shielded from the multiple sources below. The survey plot in Fig. 3 shows the levels emanating from each electrical source. Comparing the capital letters in Fig. 2 and 3 allowed correlation of the readings with the exact location of each electrical source.

With this information, the shielding engineer determined the area to be shielded and the shield design necessary to achieve the 3 mG average levels. The engineering team created a multi layer, three-substrate shield consisting of welded aluminum plates and multiple layers of silicon-iron and metal sheets. The shield covered the floor and all four walls in the fitness center.

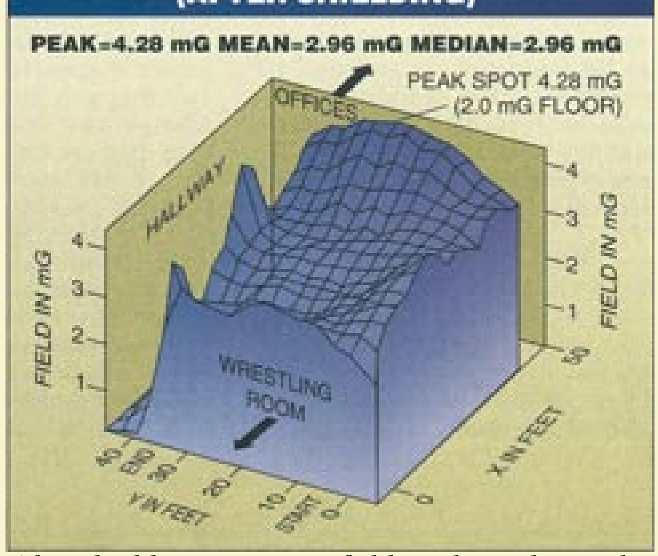
After the magnetic shield was installed, a survey engineer conducted a final contour survey to verify results. In Fig. 4, the final milligauss readings show that the average 3 mG target was achieved throughout the center, with a level of 2mG on the floor.

FIGURE 3 — PROFILE PLOT



A profile plot shows magnetic field readings along the path taken by surveyors, shown in Fig. 2. Letters correlate to turn markers in Fig. 2.

FIGURE 4 — 3-D CONTOUR PLOT (AFTER SHIELDING)



After shielding, magnetic field readings dropped to a mean level 2.96 mG from 34.5 mG before shielding. Peak levls dropped to 4.28 mG from 111 mG.

across a variety of points, providing a clear picture of magnetic- field penetration and levels. Generally, levels below 10 mG do not interfere with computer monitors, electronic cabling, magnetic media or audio-visual equipment. As for the health consequences of short and long-term exposure to EMFs, no industry agreement or federal standard exists.

After the ac power EMF survey is completed, an experienced engineer should prepare a comprehensive report that includes:

•Recorded contour measurements (with plots) of the surveyed areas, including selected equipment mea- surements and noted NEC wiring violations, grounding and plumbing current problems.

•Detailed drawings of the property, buildings and nearest electrical sources.

•Risk-assessment information the latest news in EMF research.

•Recommended mitigation activities (magnetic shielding, active or passive cancellation) plus estimated design and installation costs.

When RF levels exceed minimum recommended human exposure standards, immediate action is required to protect occupants. Also, RF interference equipment susceptibility must be evaluated. In elevated RF environments, RF radiated sources should be located and logged by frequency and field strength. The owner of the equipment also should be identified.

Mitigation solutions

Depending on the EMF survey results, building management may implement one or more mitigation solutions, depending on the levels and type of EMF source. Five basic strategies are used:

•If excessive ac power magnetic fields emanate from water-service lines (plumbing currents caused by electrical current attaching itself to metal water pipes), a dielectric coupler generally will eliminate the problem.

•If excessive ac power magnetic fields emanate from building steel, HV AC ducts, metal pipes and conduits, then locating and correcting the ground-current sources (NEC violations or shorts) should reduce or eliminate the problem.

•If people or the ac power magnetic source can be moved (EMF exposure diminishes quickly over distance), a strategy of prudent avoidance may be possible. However, in commercial buildings, it is highly unlikely that rentable space will be vacated permanently to solve an EMF expo- sure challenge.

•If unacceptable EMF levels emanate from outside the building Area shielding protects against EMF problems from sources outside the

Area shielding protects against EMI problems from sources outside the building, such as subways

building, such as subways (power lines or RF/microwave signals from nearby antennas), then ac power magnetic-field cancellation technology or RF shielding likely will have to be implemented. For ac power magnetic field mitigation, a building can be protected using a passive wire or active loop cancellation system between the building and EMF source. Building size severely limits the use of this mitigation solution. Radiated RF/microwave signals can be mitigated using special conductive window coatings electrically grounded to foils (aluminum/copper) or conductive paints on walls and floors.

•When ac-power magnetic fields exceed 10 mG and empty rentable space cannot be used as a barrier between people, computers and the EMF source, magnetic shielding is the only viable solution. Two approaches can be used: shielding the EMF source or shielding the room and people.

Shielding the source is the most effective and often least expensive alternative. However, if multiple magnetic field sources are present (parallel transformers, network protectors, secondary feeders, switchgear, busways, risers, UPS units) or the sources are not readily accessible (buried underground, spread out behind walls), it may not be economically feasible to individually shield each source. The solution then becomes to shield the room or area in which people work and EMF sensitive equipment is used. This solution is selected most often.

Area shielding also protects against EMI problems from sources outside the building, in particular subway and electrified rail systems. These transportation modes, using either third-rail or overhead catenary wires, can generate huge direct current (dc) or ac power emissions, which makes shielding an extremely challenging design effort. .

Conclusion

Obtaining success with hard to manage ac power magnetic fields requires proper use of state-of-the-art instruments, experienced survey techniques and expert EMF engineering services (shield design, installation and final verification).

With growing dependence on computers and equipment sensitive to EMFs and increased concern about health-related issues, EMFs will continue to be an important issue for engineers to address. While much of the focus will be on mitigation of existing problems, it is important to note that when the issue is addressed as part of the building's design, the effectiveness of mitigation can be increased significantly at a reduced cost.