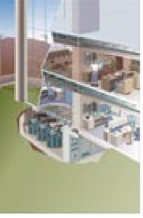


Electromagnetic Fields:

Are You Shielded yet?

Many experts will agree that it is essential for facility managers to stay abreast of new developments in office technology. Current trends towards increased dependence on sophisticated technology in the workplace means a number of inherent changes in how we manage our commercial, industrial and institutional facilities. While much of the focus to date has been on the equipment, furniture or cabling necessary to support future technological demands, there is another dimension of planning that is also essential – planning for potential electromagnetic interference (EMI)

Magnetic fields are an unseen and potentially costly factor that facility managers must consider when organising, renovating or selecting new office space. Nearly every commercial and industrial building has certain areas with elevated magnetic fields, some high enough to render the space unusable for today's technology, particularly for computers. The best way for facility managers to avoid costly and embarrassing mitigation is to be knowledgeable about the sources of magnetic fields and the problems they can cause.

A number of facilities are preparing to incorporate wireless voice and data systems over the next few years and are investigating potential conflicts from high frequency sources. EMI though can occur at much lower frequencies and from much more common sources including the building's own power infrastructure.

Even with increased efficiency, electricity is expected to account for about 75 per cent of energy consumed by the commercial sector in the year 2020. According to a recent forecast released by the U.S Department of Energy, "Energy use for personal computers is projected to grow by 4.5 per cent per year and for other office equipment, such as fax machines and copiers, by about 3.5 per cent per year." And, as the use of electricity increases, so will the potential for EMI from power frequency (50/60 Hz) sources.

"Energy use for personal computers is projected to grow by 4.5 per cent per year and for other office equipment, such as fax machines and copiers, by about 3.5 per cent per year."

Physics of the Problem

Electric and Magnetic Fields (EMF) are the result of the generation, distribution and use of electricity. These fields exist in different frequencies and waveforms, and are not always static. At most frequencies, the electric and magnetic fields operate together, but at the lowest frequencies, including those caused by electrical power, called the Extremely Low Frequency (ELF), they operate independently; it is possible to shield the electric field without affecting the magnetic field.

Magnetic and electric fields are vector quantities, which means that they have both field strength and direction. The electric field is generated by voltage, and, since voltage is relatively stable, the strength of the electric fields produced by power systems are relatively constant over time. Magnetic fields, however, are produced by electric current and will vary proportionately to the amount of current being used. Consequently, industrial and commercial buildings, which have areas of high concentration of high current, particularly at the entrance to the building, will have high magnetic fields in these areas.

The primary difference between electric fields and magnetic fields is that electric fields are blocked by most common building materials, while magnetic fields are extremely difficult to block. Accordingly, most of the issues regarding EMF center on magnetic fields.

In most facilities, the areas adjacent to high current carrying devices such as external transmission lines, transformers, service panels and conduit will have elevated levels of EMF. In commercial buildings, the average level of magnetic fields will vary between a range of 0.5 and 4 milliGauss (mG), depending on location. In areas of high current concentration, values greatly above these are common.

Equipment Interference

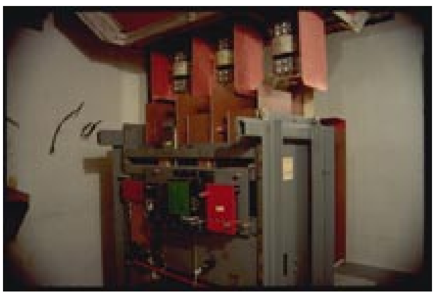
CPUs, peripherals and data networks can all potentially become unstable in elevated magnetic fields. Broadcast and audio equipment will actually emit a noise indicative of interference. It is usually an audible "hum."

Medical equipment is not immune to the effects of magnetic fields either: EEG, EKG, EMG, scanning equipment and electron beam microscopes are all exquisitely sensitive to external fields. Implanted personal medical devices, such as pacemakers and insulin delivery systems, can be affected by elevated magnetic fields.

Computer monitors are the most frequently cited example of equipment that is receptive to interference from magnetic fields. Interference with equipment such as CRT monitors, CPUs, data networks and medical devices can occur anytime the external magnetic fields are stronger than a unit's internal fields. The threshold level for interference will vary depending on the type of equipment being used.

Generally, the more sophisticated and technologically advanced the equipment is, the more susceptible it is to interference. For example, graphics workstations tend to have highly sensitive CRT monitors that can exhibit instability, or "jitter" in fields as low as 3 to 5 mG, but almost all CRT monitors will become unstable above 10 mG.

Most new monitors are designed to be "low radiation emitting". This enhancement is accomplished by slowing down the internal electron beam as it writes to the screen but it has a side effect of making the monitor more susceptible to jitter and other forms of screen interference.



Transformers, especially in large commercial buildings, are one of the most obvious sources of power frequency magnetic field interference

Photo Courtesy of Field Management Services Corp.

Finally, there is a great variation in the sensitivity of the individual user. Two people looking at the same monitor in the same environment may have very differing perceptions of screen distortion. More sensitive users may complain of eye strain or headaches from prolonged exposure to monitor jitter.

The standard **FMS JitterBox** from **Field Management Services Corp.** is a monitor enclosure. Made of an alloy processed for high magnetic permeability, the FMS JitterBox works by attracting and absorbing ELF magnetic fields. It directs the external fields away from the monitor's fields and provides a path for the external fields to follow. When surrounded by the JitterBox, the monitor's own internal magnetic fields are protected from outside interference. The image remains stable and color integrity is assured. It is similar to many Mu-Metal en closures currently on the market but at a competitive price. The JitterBox is available in a range of sizes and capacities to meet the demands of many different environments. The three levels offered, in order of increasing strength, are Standard, Enhanced and Custom.

The FMS JitterBox

Enquiry No: FM114/11/2001

From the view of the real estate industry, the concern about magnetic fields falls into two categories: Equipment interference and health problems. Both of these issues revolve around the field strength of EMF but a host of other metrics can play a part, including frequency of exposure, intermittency, how often and how much the exposure changes over time, and harmonics. The location and strength of elevated fields and how to rectify the problem are critical tools of the real estate professional, since problems arising from equipment interference will often cascade into a series of occupancy problems, leading to diminished utility and value of the building.

Sources of Magnetic Fields

Devices that carry heavy alternating current (AC) are the most obvious sources of magnetic fields: Transmission lines close to the building, transformer and network protection vaults, electric service panels, circuit boxes, and bus ducts. Less obvious sources include conduit running through the walls or floors, wiring errors, fluorescent lights, and other high-current electrical equipment.

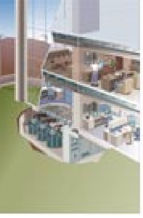
Magnetic fields from direct current (DC) can be generated by passing trains, elevators or standby power supplies. The magnets frequently used in MRI and NMR equipment in commercial or health facilities are also sources of magnetic fields from DC. A source unknown to many property managers is a building's steel structure, which may have become magnetised during construction and now generates its own DC field.

In some situations, a combination of AC and DC sources can cause both types of fields to occur in the same area. For example, trains and elevators, which combine high AC or DC current-flow with a quickly moving object, are responsible for both causing and disturbing a field, and thus, create even more complicated interference scenarios.

Planning is Essential

The best strategy for dealing with a magnetic field problem is to plan for it; the first line of defense is planning the building's space allotment. As magnetic fields generally diminish quickly over distance, sensitive equipment can be kept further away from large sources of EMF.

Be aware of the locations of transformers, service panels and elevators in your facility. If possible, map heavy current-carrying conductor runs in the walls and floors. While areas immediately adjacent to heavy current-carrying devices may not allow optimal use of sensitive equipment, they can be designated as low-



technology areas, such as for storage space or as a conference room.

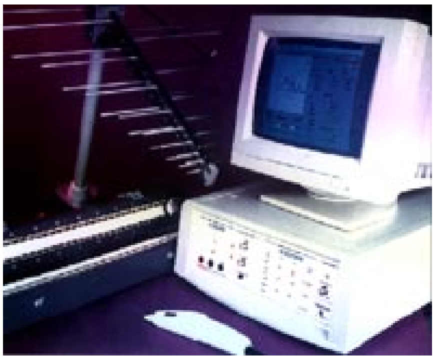
If renovations are planned for the building, especially if they include any alterations to the building's power system, it is advisable to evaluate the potential for increased field levels in the newly constructed or improved space.

Identifying Problems

Often, magnetic field interference problems will emerge after a building has been remodeled or upgraded. This usually occurs if spaces previously not used for computer or medical technology are now designated for such use. If computer monitors and other sensitive equipment begin to display signs of instability, you should suspect EMF problems.

Once you encounter signs of elevated magnetic fields, your first course of action is to determine the source. The source and strength of the fields will determine which mitigation options are available to you. Fields concentrated in a specific area will most likely reveal an obvious source, such as a transformer vault. Moderately elevated fields that are spread out over a large area may suggest, however, a net-current problem from wiring errors.

To evaluate your situation, it is advisable to get a survey taken of the



Seaward Electronics' EMC kits

fields. Your local electric utility may be able to provide a low or no-cost preliminary survey. Another option is to rent or buy a magnetic field meter. There are several inexpensive and reliable AC field meters available, but DC fields require a separate meter that can be quite costly. It may also be worthwhile to get a professional, independent company to conduct a survey that will provide detailed information; the best of them will include an appropriate mitigation plan.

A range of specialist equipment to meet the EMC (electromagnetic compatibility) training requirements of manufacturers, academic institutions and electronic engineering organisations has been developed by **Seaward Electronics Ltd**, a British company. Its range is one of the broadest available and is designed to provide cost-effective solutions to all training needs.

The training kits comprise a range of different test instrumentation, accessories and problem solving software to provide a comprehensive and practical understanding of EMC legislation, enabling users to ensure compliance with European regulations. Cost-effective training kits are customised to meet the EMC emissions and immunity testing needs of particular industry-based or training organisations.

The core component for emissions is the **Spectrum Receiver**, which is capable of analysing both radiated and conducted emissions and has a frequency range of 9kHz to I GHz and includes an in-built LISN (line impedance stabilisation network). Also for emissions testing, the **Orb** is a software-controlled harmonics and flicker meter suitable for testing to EEC610000-3-2 and IEC610000-3-3.

A wide range of accessories and supporting equipment is also available for specialist applications. These include board-level diagnostic **Near Field** probes; a log periodic antenna for the measurement of radiated emissions; and a large loop antenna for luminaire emissions.

For immunity testing, the range includes the **Mace** interference simulator, providing voltage dip, fast transient and electrostatic discharge testing. Accessories for the Mace include a capacitive coupling clamp to test signal and data cables and air and contact discharge probes. Additionally, the **Thor** near-lightening-strike tester provides surge testing to EEC610000-4-5 conformance standards. The kits are complemented by the **Expert Consultant** software package, which offers guidance on the selection of EMC standards, information on test procedures and limits, and provides a professional EMC knowledge base using a Windows environment.

Enquiry No: FM115/ 11/2001

Magnetic Fields' Effects on Human Beings

There is a potential for EMFs to have biological effects because AC fields create weak electric currents in the bodies of people and animals. Currents from electric and magnetic fields are distributed differently within the body. The amount of this current, even if you are directly beneath a large transmission line, is extremely small (millionths of an ampere). The current is too weak to penetrate cell membranes; it is present mostly between the cells.

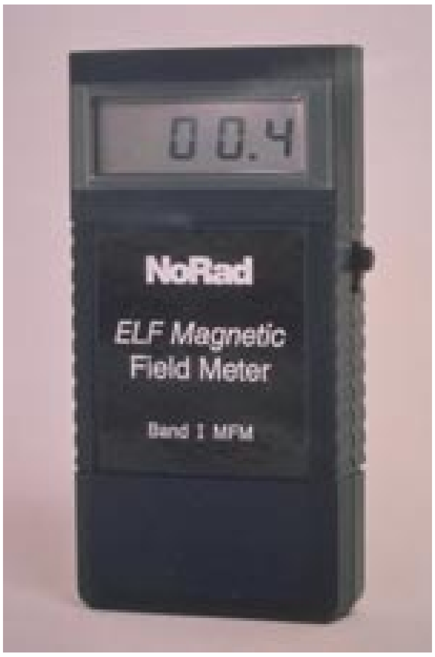
Currents from 50/60-Hz EMF's are weaker than natural currents in the body, such as those from the electrical activity of the brain and heart. Some scientists argue that it is therefore impossible for EMFs to have any important effects. Other scientists argue that, just as a trained ear can pick up a familiar voice or cry in a crowd, a cell may respond to induced current as a signal that is lower in intensity yet detectable even through the background "noise" of the body's natural currents. Numerous laboratory studies have shown that biological effects can be caused by exposure to EMFs. In most cases, however, it is not clear how EMFs actually produce these demonstrated effects.

Strong electric and magnetic fields, such as those found beneath large transmission lines, can cause hair on your exposed head or arms to vibrate slightly at 50 Hz. This is felt by some people as a tingling sensation. EMFs from transmission lines can also in some circumstances cause nuisance shocks from voltages created by EMFs on objects like underground metal fences.

Electric Fields' Effects on Human Beings

There are not yet related records between E-fields and hazard to human beings. However, some preliminary medical research may recommend avoiding overexposure to E-fields.

Main risks identified are associated with equipment and machinery malfunction due to a high frequency EMI/RFI (Radio Frequency Inteference) disturbance that may cause disruption, that ultimately could put into risk, the safety of the operator or people.



The 8260 Magnetic Field Meter, a precise, single-axis meter, detects and analyses AC magnetic fields

The **8260 Magnetic Field Meter** from FMS offers good accuracy in a low-cost, portable, single-axis meter. With 0.1 milliGauss accuracy, the 8260 provides easy and accurate measurement of magnetic fields in a home, office or industrial environment. It is calibrated for 60 Hz fields (the frequency which carries current in the U.S.) and is appropriate for measuring emissions from computer monitors, televisions, power lines, scanners, microwave ovens and other sources of magnetic fields.

The 8260 is designed to operate without the need for frequent adjustment or maintenance by the user. It has been calibrated at the factory in conformance with the recommendations of the United States National Institute of Standardsand Technology.

The 8260 measures the alternating magnetic field strength at the position of the meter. It can be used for both power line and computer display applications since it has the capacity to accurately measure sinusoidal wave forms as well as more complex geometric forms. The 8260 is a single axis device which reveals field direction as well as strength. In addition, its bandwidth (5 Hz - 2,000 Hz) is sharply limited to exclude frequencies which are outside of the MPR II standard.

The meter should measure fields in one direction (or plane) at a time and display the maximum field strength at that location and at that angle. But a person in that location will be exposed to fields coming from all angles simultaneously. To determine the maximum field strength at a particular location, rotate the meter through all possible angles so that the field which is present can intersect with the sensor in such a way as to display the maximum reading. To determine exposure at that location, take a maximum field strength measurement in three planes (x, y and z) and extract the square root of the sum of the squares of the individual readings. The resulting RMS value is part of the MPR II measurement protocol for emissions testing.

Enquiry No: FM116/11/2001

Managing the Problem

If mitigation is in order, in many cases, the first and least expensive option is to increase the distance between the affected device(s) and the source. Magnetic fields generally diminish quickly with distance, so moving a monitor, or even an office, further from a power source may solve the interference problem. Unfortunately, in many situations this option has the downside of diminishing the utility of prime office space.

The next option to consider is lowering the fields that are being created through engineering techniques that can increase the natural cancellation of the fields. It may be possible to decrease the fields by reconfiguring the transformer arrangement or by compacting the cabling. In situations where the source is wiring errors, decreased fields are achieved by isolating and correcting the errors, which will enable the natural cancellation of the fields.

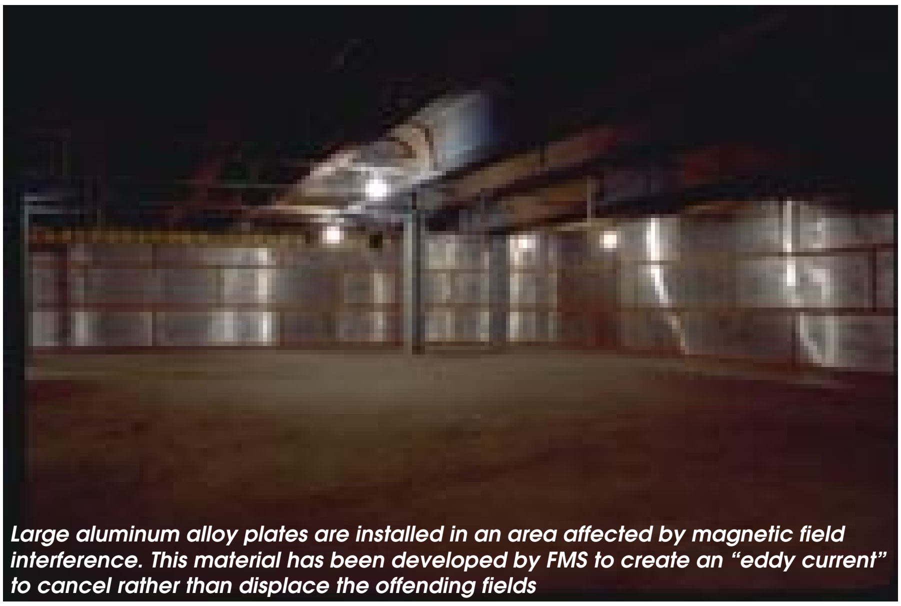
Finally, area, source or device shielding may be considered. Area or source shielding can be expensive but can effectively and permanently restore the utility and value of an affected space. Device shielding may provide an effective solution if just a couple of monitors are affected or if the source is transmission lines running outside the building.

Contact with magnetic fields may be unavoidable, whether it is naturally occurring or artificially generated. In addition, our use of electricity is increasing at the rate of about two per cent a year as our dependence upon technology grows, so our production of EMF is rising. These two factors, plus our increasing workplace density, make magnetic field interference a concern for today's facilities, many of which already have areas of elevated magnetic fields.

Engineers and architects are studying the creation of "low-EMF" buildings, facilities designed to be immune to magnetic field interference problems. Until we are managing those, however, the answers lie in awareness and planning during the layout or renovation of a facility to prevent costly mitigation. If mitigation is necessary, knowledge about the issues can speed diagnosis of the problem and lead to finding the most effective solution.

Avoiding Future EMI Problems

The best strategy to avoid costly



Large aluminum alloy plates are installed in an area affected by magnetic field interference. This material has been developed by FMS to create an "eddy current" to cancel rather than displace the offending fields

Photo Courtesy of Field Management Services Corp.

and sometimes embarrassing, shielding and mitigation projects is good space planning. When laying out new space or rearranging current space, identify all the major sources of AC and DC current, including transformers, electric panels, major conduit paths, elevators, etc. Office space closest to these areas can be designated as "low-technology" areas. Space with elevated magnetic fields can be turned into hallways, storerooms, or lounge areas. Individual devices as well will emit fields and can interfere with other equipment so care should be taken when arranging these items to ensure compatibility.

It is also advisable to get a survey performed with the space under load. If there are any planned changes in the building's power infrastructure, it may be extremely valuable to engage a firm to do modelling of the fields. With this data, designers can visualise where the problem areas will most likely be and effectively plan to avoid or mitigate potential interference. Above all, make certain that all electrical work is done in strict conformance to code, particularly those elements of code which pertain to grounding.

A specialised bonding process is utilised as part of the application of a shielding scheme

Photo Courtesy of Field Management Services Corp.

When doing long term forecasting, be aware that future increases in technology usage will impact the building's energy load. If it is possible to estimate future energy demands, then it will be possible to use these other tools available to forecast the impact on the building's magnetic fields.

This article is based on an article by Mr Michael L. Hiles.

Mr Michael L. Hiles is president of the Los Angeles-based Field Management Services. With a background in electrical engineering, he has served in a number of capacities in the television, telecommunications, videographic, and teleconferencing systems industries. He regularly speaks about topics involving magnetic fields.

Magnetic Field Assessment

Magnetic field assessment involves two distinctly different measurement protocols used for two different purposes. The most common is the measurement of the maximum field strength, used to locate the source of a field, determine its direction and its strength. Typically, power line measurements or general background measurements are of this type. The other is concerned with exposure and is usually associated with the measurement of a particular appliance, like a computer monitor.

It is impossible to avoid exposure to low frequency magnetic fields in modern society - there is always some level of background radiation present. This background radiation could be coming from a number of sources and must be taken into consideration when you are attempting to measure fields from a particular appliance or source. Before any assessment of the emissions from a computer monitor or other appliance is possible, it is necessary to first determine the strength of the background field. In some cases, that field will be greater than that which is coming from the monitor, making measurements of the monitor's emissions impossible.

In order to determine background radiation levels, turn off the computer monitor to be measured and take a set of readings of the area around the unit. If the background radiation is high, (say, several milliGauss), the contribution of the monitor to the environment may not be measurable. (In recognition of this fact, the Swedish specification MPR II requires that the background levels be no greater than 0.4 milliGauss in order for testing to be valid.)

If two sources are close enough for their fields to interact, they could amplify each other or cancel each other, depending on distance and field direction. Thus, it is possible for the field strength measurement to increase after turning off a source.

A useful future A

By **Jon Munderloh**

It is becoming increasingly common to have an expert on EMF interference issues work with the architect and engineering firms at the start of a building project. Such a project is underway in Osaka, Japan, where a major software vendor has included EMF analysis in the design of the company's new corporate headquarters. Although the project is at the very early stages, it will follow, in form, similar projects in other parts of the world where the cooperation between the parties will result in a building that is immune to these problems.

A recently completed building project in Los Angeles illustrates the risks and the value of this pre-construction planning and is a useful model for future projects in the planning stage in Asia.

The management company for an older, 20-storey downtown Los Angeles commercial office building wanted to revitalise the aging property. They developed a unique strategy to attract new tenants by targeting large telecommunications service providers. The building was ideally sited to support what the building management and ownership correctly believed would be an increasing demand for telecommunications services.

Their efforts were successful and they landed an ideal new tenant. As part of the lease negotiations, the management company agreed to some building upgrades. They planned to substantially increase the power quality and capacity of the facility's infrastructure, both to support the new tenants telecommunications switching equipment and to provide for future growth.

It was during this power upgrade that the project's electrical engineer expressed concern that EMF from the new electrical equipment might cause interference with tenant computer equipment in adjacent spaces. The existing utility electric transformer and

case study for sian projects

the building's main electrical distribution equipment were located in the basement parking area of the building, but space and access restrictions precluded installing the upgraded equipment in the existing area.

A 2,500-square-foot, street-level space was selected to house a new utility transformer and distribution equipment, but this site posed some serious complications. The electrical equipment would be within a short distance of computer systems on the same and adjacent floors.

The building owner authorised EMF experts, Field Management Services, Inc. of Los Angeles to perform an analysis of the potential for interference and, if appropriate, to design measures into the construction of the building that would lower the fields to acceptable levels.

Measurements of several similar electrical installations, combined with computer projections confirmed that substantial levels - in the tens of milliGauss (mG) - of magnetic fields would exist in tenant areas adjacent to the new facility. Ambient or background magnetic field levels in commercial buildings typically range from 0.5 to 3 mG, with higher levels close to some office equipment.

Establishing an acceptable field level is a difficult task, since, for liability reasons, equipment manufacturers seldom specify a safe magnetic field operating environment for their products. However, experience and most of the technical literature defines 10 mG as an acceptable level for computer monitors. Several of FMS' major technology and financial services clients have established a caution-based 30 mG threshold for ambient fields near all data processing and communications cabling.

To ensure that elevated magnetic fields would not interfere with equipment in areas adjacent to the electrical equipment, FMS professionals developed and implemented EMF mitigation measures during the design and construction of the new electrical facility. Although the total mitigation plan increased the cost of the utility upgrade slightly, it was a small fraction of the cost - not counting the tenant dislocations - that would have been required to correct the problem after installation was complete.

Much of the EMF mitigation plan was in the form of low-cost engineering modifications. For example:

∑ Substantial field reductions were achieved by moving a high-current bus duct that connects the utility transformer to the building distribution equipment, from the ceiling to the floor.

∑ Special magnetic field shielding scheme was incorporated in the construction sequence.

∑ Magnetic field shielding material was installed beneath the large utility transformer, on the adjacent walls and ceiling and in the electrical distribution room prior to the placement of the electrical cabinets.

∑ Space planners used higher field areas for non-technical use – bathrooms, conference rooms, hallways, etc.

Measurements taken in the adjacent tenant areas and the second-floor law offices after the new electrical facilities were energised confirmed that the mitigation measures had successfully reduced magnetic fields coming from the electrical equipment. Magnetic field levels in the tenant areas and adjacent offices ranged from 0.1 to three mG - a level at or below the comparable levels prior to the upgrade.

The mitigation plan at this stage was comparatively inexpensive. The results were accurately predicted and the project schedule was not impaired.

About the author

Mr Jon Munderloh is a Senior Consultant with Field Management Services Corporation in Los Angeles.

EMF Basics

E.L.F., or Power Frequency, magnetic fields are the natural consequence of the use and distribution of electricity. The strength and area of magnetic fields emitted is proportional to the amount of current being used. Consequently, all commercial buildings have areas with elevated fields. Fields in these areas are caused by high current-carrying devices (transformers, electric panels) common to all buildings. Wiring errors, as well, can lead to elevated magnetic field levels. Fortunately, in most cases, they are avoidable.

Tips To Spot a Potential Problem

It is very common for magnetic field interference problems to emerge following a building remodel or upgrade.

Computer monitors may begin to display jitter, color distortion, or other signs of instability. Other sensitive equipment may be affected as well, including computers, peripherals, data networks and certain medical devices.

A magnetic field survey of the area should be conducted prior to construction in previously unoccupied areas, now designated as prime office space with computers. Pay particular attention to areas near electrical equipment, including transformers, switch gear or electric service panels.

Good planning and awareness can minimise the costs of a magnetic field problem. At the building design stage, avoidance costs are minimal; at the outset of a renovation, the costs are greater; after the building is complete, the remediation costs are often economically infeasible.