

Electromagnetic Interference (EMI) and Structural Vibration Effects on MRI Site Construction and Installation Requirements

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Site Environment Concerns:

Electromagnetic interference (EMI) and structural vibrations can impact the diagnostic performance of imaging equipment. MRIs, for example, are susceptible to EMI and structural vibrations and these disturbances can impact the quality of clinical images or data collected for spectroscopy, functional MR, and other MR diagnostics.

Electromagnetic Interference (EMI):

There are two major types of disturbances. The first type is often referred to as DC or Quasi-DC sources. These types of disturbances require DC voltage sources for operation or generate DC disturbances through physical movement of the source. Common sources of Quasi-DC EMI include cars, trucks, and other sources of moving metal that is in close proximity to the proposed MRI location. Other common Quasi-DC sources include subways, electric trains, trams, and similar equipment that require strong electrical currents for operation. Subways are often mistakenly referred to as a moving metal source and may be overlooked when considering a site because the subway is a good distance away. However, sources like subways can generate magnetic fields that will impact MRIs that are several hundred yards (meters) from the source due to the large amount of electrical current that such items require for operation.

The second type of disturbance is created by electrical equipment like transformers, electrical lines, switch gear, and other electrical items. Typically, these sources can create large 50/60Hz magnetic fields that may impact imaging.

Note that there are two primary sources of EMI disturbances, but in some parts of the world there may

be other common sources. For example, many of the trains in Europe run on 16-2/3 Hz power, which is noted as a potential disturbance source for MRIs installed in Europe.

The specifications for these disturbances vary from manufacturer to manufacturer and from MRI to MRI. For example, the specifications for one OEM's 3T MRI will differ from another OEM's 3T specifications. Similarly, and OEM's 3T specifications may differ from the same OEM's 1.5T specifications. OEMs detail their specifications in their site planning guides and due to the potential problems that EMI can cause, OEMs recommend a survey for all sites under consideration.



An electric train is just of example of a DC EMI source. Electric trains draw large amounts of current, which create a DC magnetic field, which can be a source of electromagnetic interference (EMI).

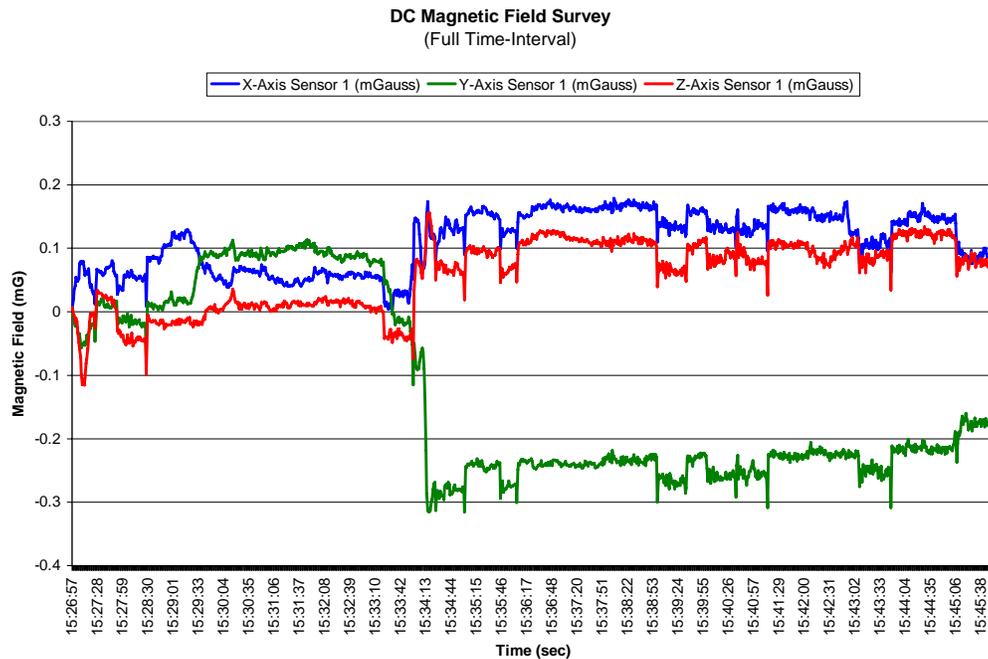


Figure 1
 Example of DC magnetic field survey data. DC magnetic field surveys are used to measure the potential influence of sources, which include automobiles, subways, and trams, on an MRI.

Structural Vibrations:

Structural vibrations are another potential issue for MRIs. Structural vibrations can be produced by a number of sources. Electrical motors, vehicles passing near a building, or traffic created by activities in a building can all be potential sources of structural vibrations. These sources will generate vibrations that can be transmitted through the structure. It is also possible that a poorly designed structure or slab could amplify the vibration responses created by these sources.

Similar to EMI specifications, the structural vibration specifications vary from MRI vendor to MRI vendor and from the MRI model to MRI model.



In order to verify that a site is acceptable for the installation an EMI and vibration survey should be conducted. The data collected can be used to verify that a site meets the required specification.

Electric motors are one example of a potential vibration source

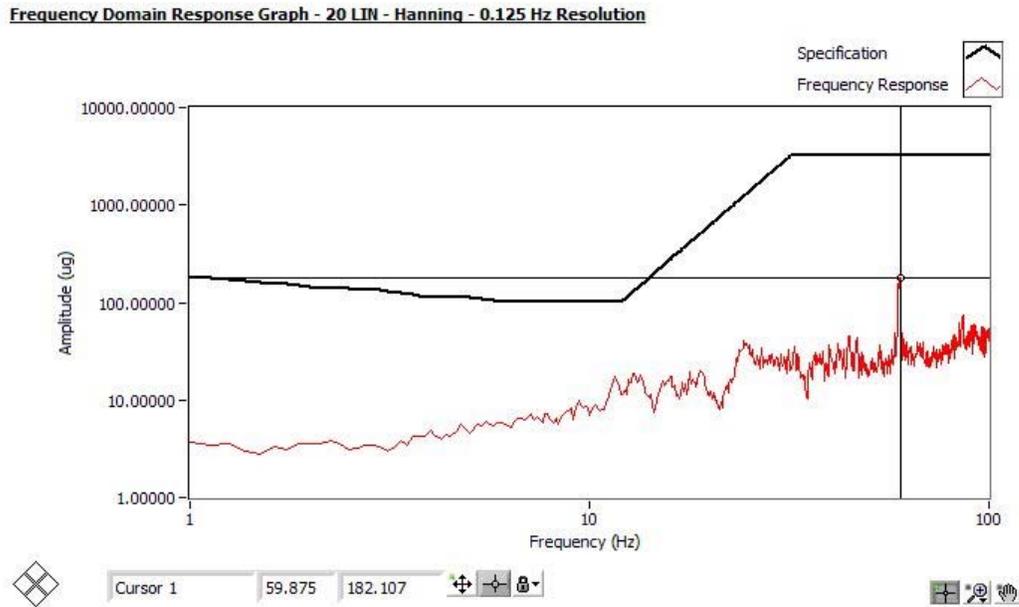


Figure 2
Example of vibration data from a site survey conducted for a potential MRI site

When designing new building that will incorporate MRI equipment; a review of the proposed layout can be performed to prevent the possibility of EMI and vibration issues.

Solutions:

Solutions can often be proposed for sites that do not meet EMI and vibration specifications. In many cases, the end user may have limited space available for the placement of an MRI. If the site does not meet EMI and vibration specifications, users are left with a few options. One option is to not install an MRI in the space. The second option is to identify a solution.

EMI Solutions:

EMI issues can, typically, be resolved with passive shielding or active shielding. Passive shielding utilizes materials with magnetic shielding properties such as silicon steel, carbon steel, mu-metal, or other magnetic shielding materials. The shielding properties of such materials can vary significantly and shielding solutions are usually prepared on a site by site basis based upon the source and magnitude of the EMI present. Passive shielding can often be quite effective in resolving 50/60 Hz related EMI issue, but the shielding properties of most materials do not lend themselves to resolving EMI issues created by Quasi-DC sources. While it is possible to resolve Quasi-DC EMI issues with passive shielding, it is difficult to guarantee the performance of a proposed solution and these solutions can become cost prohibitive. Another limitation with the use of passive shielding for EMI issues is that if the environment changes over time, the passive shielding may not provide ample protection unless the shield is designed to account for a potential increase of the EMI disturbance.

An alternative solution for EMI issues is active shielding. Active shielding uses coils that are mounted in the finished wall. The coils are connected to an electronic system that monitors the environment and drives a current through the coils to create a magnetic field, which cancels the EMI. Active shielding is, typically, a more cost effective solution than passive shielding and can easily be incorporated into an existing site.

Additionally, an active system can adjust to a changing environment. Therefore, the system will adjust the level of the cancelling field to properly null the EMI disturbance.



Structural Vibration Solutions:

Again, if a site does not meet the specification requirements for structural vibrations, solutions can often be designed. These solutions can vary from eliminating the source to spring isolators for the MRI to an isolated structural slab. If the source can be identified, it may be possible to eliminate the source or limit the structural vibrations from the source. For example, if an air conditioner is identified as the source, it may be possible to move the AC unit or place the unit on isolators to limit the vibrations transmitted through the structure. Some MRI systems can also be placed on spring isolators to limit the level of structural vibrations that are transmitted to the MRI. Finally, an isolated slab may be used to limit the structural vibrations that are transmitted to the MRI. Usually, this is the most expensive solution as it will involve major construction. Typically, these solutions are designed by consultants and engineers that specialize in vibration solutions.

A Magnetic Active Cancellation System (MACS) is one potential solution for AC and DC EMI issues

Diagnosis:

It is important to review site layout carefully during the design phase. Avoiding areas that are near electrical and mechanical equipment will reduce the probability of EMI or structural vibration issues. However, the only way to verify that a site meets specification for an MRI is to perform an EMI and vibration survey. The results will determine if the site is in specification or whether other measures are necessary to bring the site into specification.

About the Author



Mr. Kellogg has eight years of experience with ETS-Lindgren. After joining Lindgren R.F. Enclosures in 1998, Mr. Kellogg began new product development projects that included the MACS (Magnetic Active Cancellation System) and design of new data acquisition hardware and software for magnetic surveys and diagnostic applications. Eventually, Mr. Kellogg developed and implemented the manufacturing process for the MACS product, managed production projects, and new product development projects associated with the MACS and low frequency products.

Mr. Kellogg is currently responsible for the Low Frequency Product Line, associated production projects, and training. The products and services include surveys and engineered solution for vibration, acoustic, EMI (electro-magnetic interference), and RF (radio frequency). Additional products include active or electronic solutions for EMI and ferromagnetic detection systems for MR safety applications. In addition to managing the product line, Mr. Kellogg provides consulting services to aid in the siting of equipment that is sensitive to or creates RF, EMI, vibration, and/or acoustic environmental issues, including magnetic resonance equipment.