Acoustic Treatment for MRI Shielded rooms

European EMC Products

Technical Datasheet

The Magnet Room (MR)

While noise generated by the MRI is inherent to the operation of the system, the introduction of sound absorbing materials can lessen the effects of sound reverberation in the Magnet Room. The measured sound levels within the space via a sound level meter will not change. However, the measured sound levels can only be reduced when the sound level generated by the MR system is reduced.

Sound quality (reverberation) improvements can be achieved through the following methods:

- Using ceiling tiles with fibreglass panels having a 51mm thickness set into the standard T-bar grid system.
- Adding mineral fibre panels to the sidewalls covering approximately 20% or more of the sidewall surface area. The panels should cover the top half of the sidewalls.
- Panels can take many decorative shapes to improve the sterile look of the rooms. Typical panels are 1200mm x 1800mm with a thickness of 100mm or equivalent. Panel shapes may be varied to produce mosaic effects to meet the customers preference.

Any decorative materials used to cover the wall panels must be porous, allowing sound waves to pass through freely. A person should be able to breathe through the decorative cover material with ease. A fire-retardant cloth should be used. The NRC (Noise Reduction Coefficient) of the panels should be 0.95 or better when mounted against a hard surface such as drywall or concrete.

Interspatial Areas

Controlling noise from being transmitted to surrounding spaces often amounts to paying attention to small details while working with ordinary construction materials. Sound that exits the room through cracks, gaps or poorly constructed joints is called “flanking” noise.

The key objectives in controlling such noise are to:

- Eliminate all cracks and gaps in the wall construction.
- Ensure that doors, floors, walls, and ceilings have adequate transmission loss via mass or special double wall.
- Ensure that all doors and windows are well-designed to fit well.
- Surround the entire magnet with walls having substantial mass and/or double wall construction.
- Seal wall junctions with acoustical sealant. In principle, the MRI room should be rendered airtight to prevent sound waves from escaping into adjacent areas of the building.

Wall Construction

Wall construction should involve ordinary building materials in a carefully designed configuration.

To achieve the preferred acoustic wall construction having an ASTM STC 50 or better rating, the following parameters are advised:

- Use a standard wall construction of 2 layers of plasterboard typically 15mm, with steel studs and fibreglass in the stud cavity. This construction should result in a total of four layers.
- Both the inner and outer layers of drywall should have their seams offset from one another by a minimum of 150mm. Beads of acoustical caulking (non-hardening) is recommended around the entire perimeter of the drywall.

- Any form of wall penetration should be avoided or sealed. The sealant should be a combination of acoustical caulking and fiberglass batting material.
- The wall structure must join the ceiling and floor structures so that no cracks or gaps occur. If a structural, metal pan ceiling is used, then flute seals will be necessary to seal the gaps between the drywall and the pan. Alternatively, drywall can be cut out to fit into the flutes. Acoustical caulking should be used to seal the remaining cracks and gaps. The cavity wall constructed inside the RF shield should employ acoustic treatments. The cavity wall should employ acoustic. The cavity wall should be filled with fibreglass insulation. Two layers of 15mm plasterboard should be applied as the interior surface finish. Follow the above recommendations for the application of acoustical caulking.

Air Ducts

Ventilation ductwork can carry unwanted noise from the MRI room to surrounding rooms. Two solutions are recommended:

- Line the air duct walls with a thick, absorbent material.
- Place intermittent baffles within supply and return ducts.

Plumbing, Penetration Panels, RF Windows and RF Doors

The following construction details are equally important to mitigate noise transmission:

- Pipes (gas or water) and electrical conduit or Magnet Room signal cables must be sealed where they penetrate the walls or ceiling.
- Penetration panel areas should be enclosed in an acoustically dampened closet or small room with acoustically rated access door(s).
- RF windows should be purchased as window/frame units with an STC rating obtained from laboratory testing per ASTM standards. STC 40-50 windows are recommended. The installation must include proper sealing to avoid sound leaks.
- RF doors should be purchased from an RF shielded room supplier and proved an STC 30 or higher rating to quell the noise. Contact an RF shielded room supplier for selection of RF doors that meet the local acoustic codes and site acoustic requirements. RF door seals must be selected to prevent small gaps around the door perimeter and at the door threshold. RF door seals may require periodic replacement due to normal wear and tear. Acoustic gaskets should also be adjusted periodically.

Lead shielding can be a very effective means of providing sound abatement. Although more expensive than plasterboard, lead sheets afford a thinner wall section and are easily formed. Lead sheet is heavy, with a surface density of 11.4 kg/m2 per mm thickness. Because it has an inherent limpness or softness, lead cannot be easily set in vibration.

Isolation for Structure Borne Noise

When possible, the magnet should be set up on the ground floor and designed with either an isolated room slab or magnet pad. This minimises the transmission of vibration from the scanning equipment to the floor or walls, thereby hindering mechanical coupling. When mounting the MRI equipment onto a magnet pad, the MRI should be loaded to bear its weight with elasticity. Position the elastomeric pads underneath the magnet's support points to alleviate some of the noise radiating from the magnet. If the magnet cannot reside on the ground level, consult an acoustic engineer.

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Acoustically Rated RF Doors

Acoustically rated RF doors have been developed and fully tested to deliver improved STC ratings for sound abatement. These acoustically enhanced versions of standard MRI RF doors feature door leaf and perimeter jamb area seals. Without acoustically rated designs, it would require an expensive, massive and difficult-to-use door to achieve a favourable sound rating in an RF door. By contrast, the specially developed acoustical seal, design, core material and overall weight of EEP's acoustically rated RF doors help to minimise opening and closing forces to provide ease of use.

Acoustically Rated RF Windows

Acoustically enhanced window assemblies are completely sealed and offer provides an STC rating of 40. The window construction consists of two layers of high visibility screen material to optimize visibility and to minimise noise distortion. The aluminium flame-sprayed, precision extrusion is fitted with 6mm laminated safety glass on both sides, and each glass layer is sandwiched between a neoprene rubber base gasket on the inside extrusion surface and a plastic snap-in glazing bead on the exterior side. This combination of production features provides excellent sound abatement while protecting the screen material and sealing out dust. Standard RF shielded view window has an ASTM STC 40 rating.
Further improvements to the window area can be achieved by adding a third layer of laminated glass to the exterior finished wall assembly. This addition will provide an STC rating of 44 or higher.

RF Shield Decoupling

For enhanced sound abatement in MRI rooms, it is imperative that the type of RF shield used be completely independent of the parent room walls. EEP RF shields are self-supporting and do not rely on the parent room walls for structural support. With this type of construction, the air space between the RF shield and the acoustically designed parent walls acts to further reduce sound transmission.

Acoustically Enhanced RF Shields

Depending on the acoustic contribution needed, we can provide "rock wool" inserts (for minimum acoustic contribution), "mineral wool" inserts (for moderate acoustic contribution), or high-density fibreglass inserts (for maximum acoustic contribution). A variety of acoustic panel inserts for your site-specific needs are available. High-density fibreglass acoustic inserts may be placed in all wall and ceiling surfaces. When used with STC 50+ rated parent wall assemblies, without penetrations, the RF shield wall and ceiling assemblies are capable of contributing additional STC rating points between 10 and 30, depending on the type of interior wall preparations provided by the customer and the type of shielding material. This contribution would be made to the entire acoustic assembly, consisting of parent walls/ceiling, RF shield acoustic modification and finished interior walls.

Acoustic Floor Systems

While the thickness and construction of MRI suite floors vary considerably, the mass of reinforced concrete floor slabs work as an effective shield to airborne noise. The estimated STC ratings for such floors is STC 48 for 90mm slabs and STC 52 for 130mm floor slabs. The floor is, however, the point at which structure-borne noise and vibration are transferred from the MRI equipment (magnet) to the surrounding building. A variety of acoustic floor systems can be provided depending on the parent floor construction and the amount of sound and vibration dampening required.

Acoustic floor solutions can include:

- Floating slabs: entire room or magnet only.
- Elastomeric pads: entire floor or magnet footprint only.
- Elastomeric isolators: magnet and patient table anchors.

These floor construction configurations will provide both acoustic barriers to noise and vibration dampening to decouple the magnet from the structure, thus minimizing structure-borne noise and optimizing structure-related noise insulation. When using elastomers to dampen vibration, consideration must be given to selection, loading, and tuning of the dampening material to ensure optimum performance. This may mean that different materials must be used to accommodate the various loadings that will exist at wall, general floor and magnet mounting locations.

For New Construction

The customer should follow the recommendations for construction of the parent room walls and ceiling areas at the direction of their architect or acoustic consultant. The use of the recommended parent room structures will provide the least expensive yet highly effective acoustic shield if desired.
The new cavity wall constructed inside of the RF shield should employ acoustic treatments. The cavity wall should be filled with fibreglass insulation. Two layers of 15mm plasterboard should be applied as the interior finish surface. Follow the above recommendations for the application of acoustical caulking (non-hardening).

For Existing Sites

At locations where the RF shield will be placed within existing parent wall structures, the addition of acoustic damping may be appropriate. The customer may still find that it will be less expensive to replace the existing parent walls with acoustically constructed wall assemblies. If the existing walls were to remain unaltered, then the addition of extra acoustically rated walls within the interior of the RF shield would prove beneficial. Again, the overall contribution of this to a wall assembly consisting of existing parent room partitions and new interior acoustic partitions, would be marginally beneficial. The new cavity wall constructed inside of the RF shield should employ acoustic treatments. The cavity wall should be filled with fibreglass insulation. Two layers of 15mm plasterboard should be applied as the interior finish surface. Follow the above recommendations for the application of acoustical caulking (non-hardening), each of these floor systems depending on site conditions and particular isolation requirements.

For New Construction

The customer should follow the recommendations for construction of the parent room walls and ceiling areas at the direction of their architect or acoustic consultant. The use of the recommended parent room structures will provide the least expensive yet highly effective acoustic shield if desired.

Glossary

Airborne Sound - Sound transmitted through air as a medium rather than through solids or the structure of a building.

Attenuation, Sound - Reducing the intensity of a sound signal.

Coupling - Any means of joining separated masses of any media so that sound energy is transmitted between them.

Damping - Any means of dissipating or attenuating vibrational energy within a vibrating medium. Usually the energy is converted to heat.

Decibels - Ten times the logarithm (to the base of 10) of the ratio of two mean square values of sound pressure, voltage or current. The abbreviation for “decibels” is dB.

Flanking Paths - Transmission paths which transmit acoustic energy around a sound barrier; paths which “bypass” the intended barrier.

Frequency - The number of cyclical variations per unit time. Frequency is generally expressed in cycles per second (cps), also denoted Hertz (Hz).

Mass Law - An approximation that describes the Sound Transmission Loss (STL) of a limp, flexible barrier in terms of mass density and frequency. For each doubling of the weight or frequency of a partition, Mass Law predicts a 6 dB increase in STL. The Mass Law provides rough estimates of STL for single wall structures; however, deviations from laboratory-measured results may be 10 dB or more. For double wall or other complex structures, the Mass Law does not apply.

Noise Isolation Class (NIC) - A single number noise reduction rating of a partition, room or enclosure where sound pressure level differentials are measured in one-third octave bands and compared with standard contours as per ASTM E 413.

Noise Reduction (NR) - The difference in sound pressure level between any two points along the path of sound propagation. As an example, noise reduction is the term used to describe the difference in sound pressure levels between the inside and outside of an enclosure. Noise reduction is usually expressed as a function of full octave or one-third octave bands.

Noise Reduction Coefficient (NRC) - The arithmetic average, to the nearest multiple of 0.05, of the sound absorption coefficients in the one-third octave bands centred at 250 Hz, 500 Hz, 1,000 Hz and 2,000 Hz. By convention, the maximum NRC used is 0.95, even though the published laboratory average may be greater.

Octave Bands - Frequency ranges in which the upper limit of each band is twice the lower limit. Octave bands are identified by their geometric mean frequency or centre frequency.

One-Third Octave Bands - Frequency ranges in where each octave is divided into one-third octaves with the upper frequency limit being 2 1/3 (1.26) times the lower frequency. Identified by the geometric mean frequency of each band.

Reverberation Time - Time required for average sound pressure level in a room to decrease 60 dB after a steady state source stops generating sound.

Sound Absorption Coefficient (a) - The dimensionless ratio of sound energy absorbed by a given surface to that incident upon the surface.

Sound Power Level (Lw) - The acoustic power radiated from a given sound source as related to a reference power level (typically 10-12 watts) and expressed in decibels.

Sound Pressure Level (SPL) - The ratio, expressed in decibels, of mean-square sound pressure to a reference mean-square pressure which by convention has been selected to be equal to the assumed threshold of hearing.

Sound Transmission Class (STC) - A single number decibel rating of the transmission loss properties of a partition. Measured transmission loss data is plotted versus frequency and compared with standard contours according to rules outlined in ASTM E 90 and ASTM E 413.

Sound Transmission Coefficient (t) - The ratio of sound transmitted through a partition of that incident upon the partition.

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Sound Transmission Loss (STL) - A logarithmic ratio of the sound power incident on one side of a partition to the sound power transmitted on the other side. STL is usually rated in one-third octave bands or full octave bands.

STC or NIC Determination - Based on comparisons with reference contours specified in ASTM 413 at one-third octave bands ranging from 125 Hz to 4,000 Hz, STL is plotted versus frequency for STC determination, while NR is plotted for arriving at NIC. The following maximum deviations from STC contours are permitted:

1. The algebraic sum of deficiencies below the contour must not be greater than 32 dB for bands between 125 and 4,000 Hz.
2. The largest single band deficiency is not greater than 8 dB.
3. The STC or NIC rating is the decibel level corresponding to the level of the contour at 500 Hz.
4. British Standard 5821 Part 1-1984, and ISO 717/1-1982, "Rating the Sound Insulation in Buildings and of Building Elements," Rw, weighted sound reduction index, plots one-third octave bands between 100 and 3, 150 Hz. Deviations, divided by 16 frequencies, must not exceed2 dB.

Structure-borne Noise - Generation and propagation of time-dependent motions and forces in solid materials which result in unwanted radiated sound.

Structure-borne Sound - Sound energy transmitted through the solid media of the building structure.

Vibration Isolation - Reduction of force or displacement transmitted by a vibratory source. Often attained by use of resilient mount.

About Us

Established in 1996, European EMC Products (EEP) are an established British company whose experience and understanding of the science of shielding makes it an ideal partner in whom you can place your trust with confidence. The purpose of installing EEP shielding systems is to protect people and equipment against the threats posed by electromagnetic and radio frequency (RF) interference, radiation, magnetic fields and electromagnetic pulses. Our diverse range of turnkey products and services, including design, project management, testing and consultancy are delivered across multiple sectors to an international client base.

Quality

European EMC Products Limited are registered to BS EN ISO 9001:2015, Certificate Number FS38901.
Registered Scope: The design, assembly, installation, servicing and testing of RF Shielded Structures and equipment including EMI Shielding, Blast Doors, Gas Tight Doors and specialised mobile Electromagnetic Pulse Protection (EMPP) containers.

Radio Frequency, Magnetic Shielding and Quench systems for MRI (Magnetic Resonance Imaging) scanners.
The design, assembly and installation of Ionising Radiation Protection facilities.
The design, manufacture and installation of LED lighting systems for medical applications.
EEP Filters Limited are registered to BS EN ISO 9001:2015, Certificate Number FS38901.
Registered Scope: The design, manufacture, management of installation and testing of high performance EMC and EMP Power and Data Line Filters.

Disclaimer

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