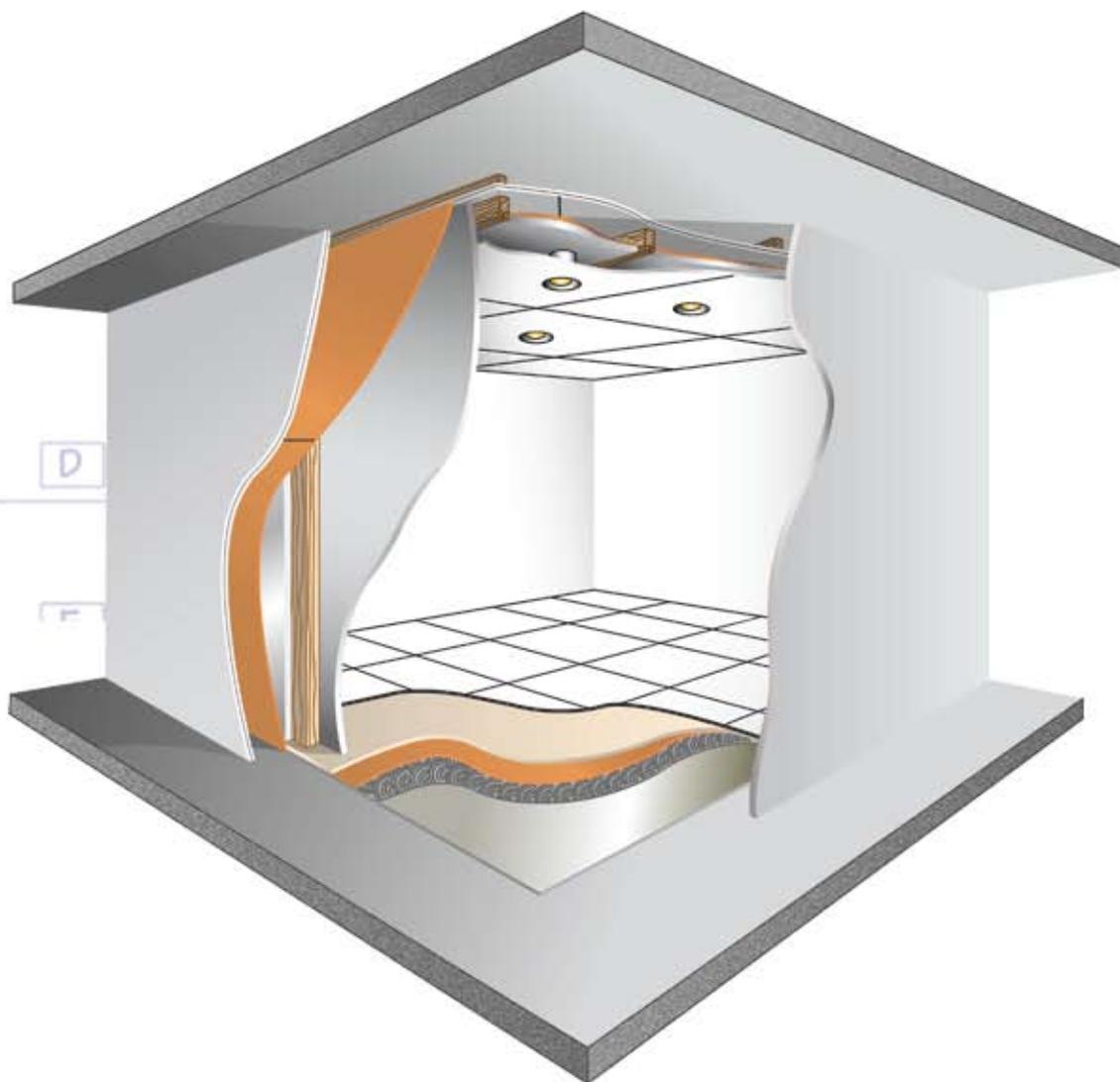


# Acoustic Shielding Solutions for MRI Installations



13/16"  **ETS·LINDGREN**™  
An ESCO Technologies Company

  
Acoustically  
Enhanced

# The Issue: Increasing Noise Levels in MRI Environments

With the introduction of more powerful gradient coils on today's high field MRI scanners, MRI equipment is producing increasingly high noise levels. During a typical scan sequence, many newer MRI systems will produce average sound pressure levels (SPL) as high as 100 to 110 dBA, with peak levels of 120 dB. These high scanner noise levels can interfere with patient comfort, patient-technician communication, and staff working efficiency.

During a scanning procedure, the patient is located at the epicenter of the resonator module (which is comprised of the magnet, RF and gradient coils). While the patient is exposed to the noise for only a short time, technicians and other staff are subjected to long-term noise exposure.

Moreover, the noise can travel from the MRI room into adjoining rooms and corridors, thereby disturbing other building occupants.

Consequently, acoustic shielding or suppression is required in many newer MRI installations, particularly in such sites as:

- New building complexes where adjacent suites will be affected
- Older facilities that were not originally intended for MRI
- Hospitals and clinics, for which

noise suppression specifications often exist

The first step in planning for acoustic shielding is to gain an understanding of noise sources and sound transmission.

The following descriptions of airborne and structure-borne noise, Sound Transmission Loss (STL) and Sound Transmission Class (STC) ratings will help you to better understand acoustic principles as you plan for sound abatement in your MRI suite and adjoining areas.

## Airborne and Structure-borne Noise

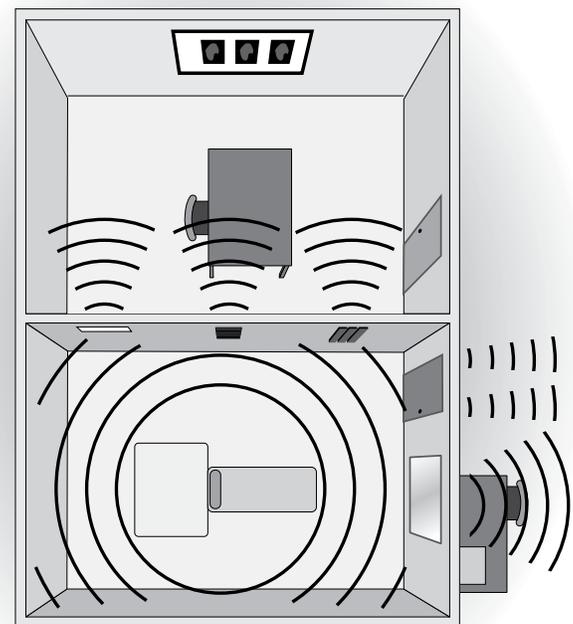
From a given MRI scanner, noise may be generated through two acoustic transmission paths:

1. the air (airborne noise) and/or
2. the building structure (structure-borne noise)

*Airborne* noise is created when the magnet produces a high-energy Sound Pressure Level (SPL) that excites the air within the MRI room. This action is similar to that of a powerful loudspeaker. Airborne noise may be transmitted into surrounding rooms by reflecting off of surfaces, or by escaping through openings such as seams, small holes, HVAC ducts, waveguide entrances, penetration panels, and cracks. The noise can travel great distances.

*Structure-borne* noise is carried through solid structures rather than through the air. Also called gradient noise, structure-borne noise occurs when gradient coils in the scanner

cause mechanical excitation of the floor or building structure, which in turn causes the building to vibrate. The vibration of the surfaces in surrounding spaces then radiates as acoustic noise. The noise concern can be further complicated when the MRI system is installed in an elevated floor condition. Like airborne noise, structure-borne noise can travel great distances.



*Typical weak links in acoustic performance of MRI environment*

# Understanding Sound Transmission

Following are descriptions of Sound Transmission Loss (STL) and Sound Transmission Class (STC) ratings.

## Sound Transmission Loss (STL)

Airborne sound is transmitted through a barrier in much the same manner as is a radio frequency signal. When a sound wave traveling through the air strikes a barrier surface, most of the sound energy is either reflected back into the source room or absorbed in the barrier, but some of the sound energy penetrates the barrier and is detectable in the receiving room. As sound penetration occurs, the sound wave exerts a fluctuating pressure on the barrier, causing the wall to vibrate like a diaphragm and radiate sound to the receiving side of the barrier. The heavier the barrier and the less the vibration, the greater the sound attenuation.

The theoretical relationship describing the Sound Transmission Loss (STL) of a nonporous, homogeneous barrier in terms of weight per square foot or surface area and frequency, is expressed in the “Mass Law” equation. The Mass Law equation is as follows:

$$TL = 20 \log w + 20 \log f - 33.5 \text{ dB}$$

Where

**w = weight of barrier in lbs/ft<sup>2</sup>**

**f = frequency of interest in Hz**

The Mass Law equation states that the transmission loss of a homogeneous barrier increases 6 dB with each doubling of the weight of the construction, and by 6 dB with each doubling of frequency. The heavier the barrier in lbs/ft<sup>2</sup>, the higher the transmission loss.

A single solid panel delivers lower performance than the Mass Law equation would predict. Coincidence effects, related to the panel’s stiffness, may degrade the panel’s performance significantly.

By contrast, a true “double wall” with separate, unconnected studs performs better than the Mass Law equation predicts. The transmission loss tends to increase about 5 dB for each doubling of the air space between studs (minimum air space approximately 2 in).

Equally as effective is the resilient attachment of surface “skins” to studs or other structural surfaces.

Absorptive material in the cavity between studs, particularly for lightweight constructions, also improves transmission loss.

“Viscoelastic” (somewhat

resilient but not fully elastic) materials such as certain insulation boards can serve to “damp” or restrict the vibration of panels. When used with rigid panels (such as gypsum boards), they increase transmission loss appreciably.

## Sound Transmission Class (STC)

Acoustic barriers and materials are typically designated a Sound Transmission Class (STC) rating. The STC rating or number is the average figure, across a frequency band, used to express the decibel loss when sound energy passes through a material or combination of materials. STC numbers are not additive; i.e., adding an STC 30 barrier to an STC 50 barrier does not create an STC 80 assembly. The assembly may have an actual STC number of 53 or 55.

To determine the STC of a material, engineers at qualified independent acoustical laboratories typically subject the material to transmission loss measurements over a series of 16 bands (125 Hz to 4,000 Hz). During a material test, the material sample is placed between two rooms. Sound originating from the source room must pass through the test sample to reach the receiving room.

All other transmission paths are insignificant. Readings are taken at 16 third octave frequency band intervals.

These measured transmission loss levels are plotted on graph paper (preferably transparent) and compared against an ASTM “Criterion” or reference curve. The reference curve is adjusted vertically over the test data curve until the sum of the test data points that are below the reference curve does not exceed 32 db. At the same time, no test data extends below the reference curve by more than 9 dB.

The STC of the sample under test is read at 500 Hz. This STC number is generally published in manufacturers’ data sheets on building materials commonly used for the construction of interior walls.

# Designing for Acoustically Enhanced Rooms

Most acoustic noise is airborne and not only affects patients and technicians in the room, but also travels through walls, floors, ceilings, and structural gaps to affect persons in adjoining spaces. (For structure-borne noise problems, see the section on “Isolation for Structure-borne Noise,” Page 8).

Acoustic noise abatement is made possible with a combination of conventional building materials, fiberglass panels, mineral board fillers, mass loaded vinyl, sealants, and absorbent linings for ducts. In this section, we will examine material and structural design solutions for acoustically enhanced room.

## Planning and Design Considerations

Numerous considerations should be taken into account when planning for acoustic shielding. Addressing each of the following considerations can help to determine the proper acoustic shielding solutions as well as the extent of the shielding needed to

ensure that no issues are left unattended.

An acoustic engineer can help with the analysis of the following considerations. If you are installing acoustic shielding without consulting an acoustic engineer, a sound absorption kit is recommended.

Considerations include:

### 1. Building structure (existing or future).

Determine what, if any, acoustic enhancement exists. Determine the level of transmission loss in the walls, floors and ceilings. If plans are for a new structure, evaluate the building materials and construction plans, and use the “Suggested Design Guidelines,” Page 6 in this manual, to plan for acoustically favorable construction.

### 2. Type of MRI equipment.

Decibel levels will vary according to the type of scanner and its gradient coil

components. These levels can be obtained from the magnet manufacturer. If a site planning or siting manual is not available, then measurements should be taken at a distance of a meter.

**3. Transmission path of noise, if known.** Determine whether the noise is airborne or structure-borne, or both. Each requires a different method of sound absorption.

**4. Surrounding rooms.** Determine what the adjacent rooms are (or will be ) used for, and how often they will be occupied. If the noise is (or will be) a concern to the surrounding room occupants, determine the noise level that is transmitted to adjacent rooms.

**5. Frequency of MRI equipment use/frequency of peak noise.** Evaluate how often, or how many hours per day, the equipment will be operated. Evaluate how often this will involve peak noise levels.

**6. Upgrades or modifications.** Upgrades or modification of the MRI equipment, the MRI suite, surrounding rooms, or the purpose of surrounding rooms should all be considered when planning for acoustic shielding.

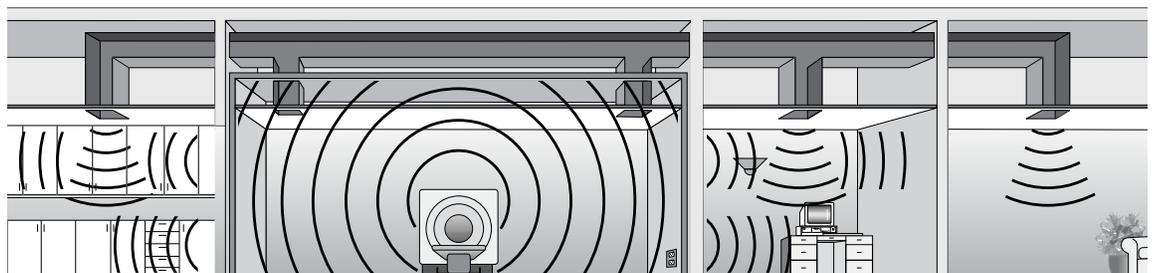
## Suggested Design Guidelines

The following text and diagrams are intended to assist you with information and suggested construction methods for promoting a successful MRI installation. You should always default to proven general construction methods and procedures as the primary means of acoustic noise suppression.

### 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

*Typical paths of transmitted and reflected acoustical noise within MRI suite area*



# Designing for Acoustically Enhanced Rooms CONTINUED

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 fiberglass panels having a 2-in. (51mm) thickness set into the standard T-bar grid system.
- Adding fiberglass 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 4 ft. x 6 ft. (1.2 m x 1.8 m) with a thickness of 4 in. (102 mm) or equivalent. Panel shapes may be varied to produce mosaic effects to meet the customer 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 construction.

- 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.

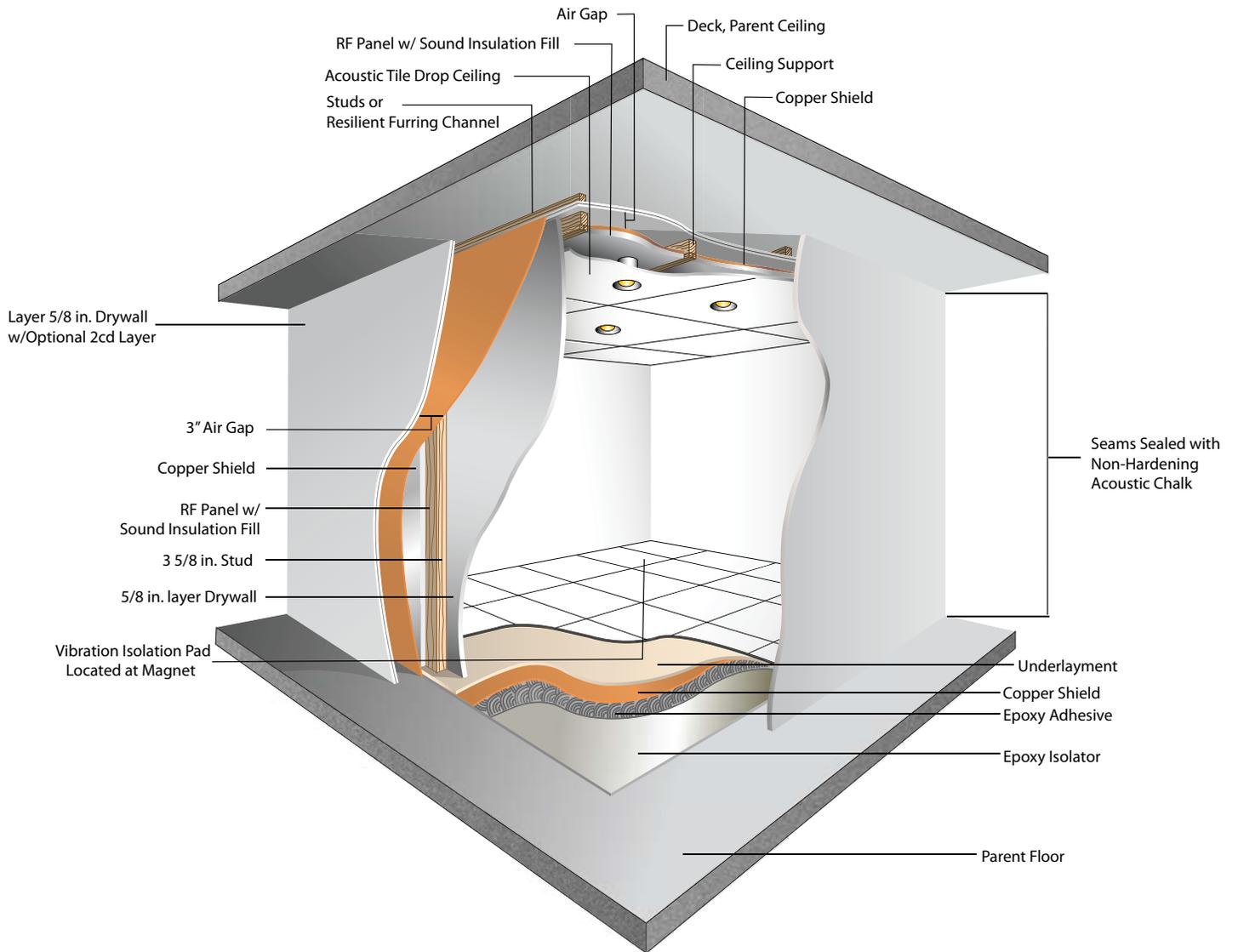
## Wall Construction.

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 GWB (Gypsum Wallboard) typically 5/8 in., with steel studs (typically 3 5/8 in.) and fiberglass 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 6 inches. Beads of USG 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



# Designing for Acoustically Enhanced Rooms CONTINUED

treatments. The cavity wall should be filled with fiberglass insulation. Two layers of 5/8 in. GWB 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.** Lead shielding can be a very effective means of providing sound abatement. Although

more expensive than GWB, lead sheets afford a thinner wall section and are easily formed. Lead sheet is heavy, with a surface density of 59 lbs./sq. ft./in. of 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 minimizes 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.

# ETS-Lindgren Acoustic Solutions

## Acoustically Rated ETS-Lindgren RF Doors

While most RF doors provide little in the way of acoustic performance, ETS-Lindgren's acoustically rated RF doors have been developed and fully tested to deliver outstanding STC ratings for sound abatement. These acoustically enhanced versions of standard MRI RF doors feature proprietary designs on both the door leaf and perimeter jamb area seals that provide the highest STC rating. Without acoustically rated designs, it would require an expensive, massive, and difficult-to-use door to achieve a favorable sound rating in an RF door.

By contrast, the specially developed acoustical seal, design, core material and overall weight of ETS-Lindgren's acoustically rated RF doors help to minimize opening and closing forces to provide ease of use.

For existing construction, ETS-Lindgren offers sound abatement kits for both its MR4 RF door and its fully automatic Auto-Seal™ II RF door. These kits are available in STC 30 and higher configurations. The STC 32 versions provide user-friendly operation and

high RF performance at a reasonable cost.

## Acoustically Rated ETS-Lindgren RF Windows

ETS-Lindgren's acoustically enhanced window assemblies are completely sealed and offer unique construction features to provide an STC rating of 40.

The window construction consists of two layers of high visibility screen material to optimize visibility and to minimize moire distortion. The aluminum flame-sprayed, precision extrusion is fitted with 1/4-inch 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.

ETS-Lindgren's standard RF shielded view window, used between the operator control room and the MRI room, 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.

The use of leaded radiation glass could also be used. The added mass of the leaded glass will further improve the STC rating of the view window area.

## 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. ETS-Lindgren 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



*ETS-Lindgren's ClearShield™ Window Wall*

walls acts to further reduce sound transmission.

## Acoustic Wall Systems

ETS-Lindgren's acoustic wall systems can help achieve STC 50+ ratings of the MRI suite wall assembly. These wall systems feature layered construction and insulating material to provide high STC ratings. Non-hardening acoustical caulking should be used to seal all cracks, gaps, and penetration holes.

## 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 fiberglass inserts (for maximum acoustic contribution). A variety of acoustic panel inserts for your site-specific needs are available.

High-density fiberglass



*ETS-Lindgren's Auto-Seal™ II Door*

# ETS-Lindgren Acoustic Solutions CONTINUED

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 3 1/2 in. slabs and STC 52 for 5 1/8 in. 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:

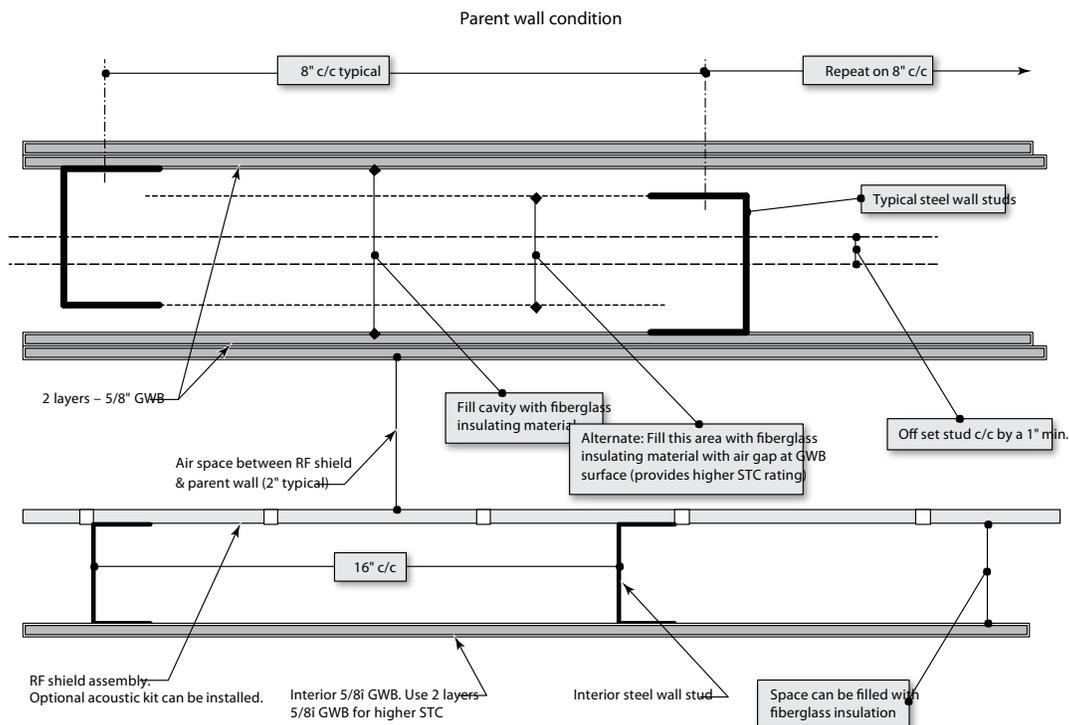
- Floating slabs: entire room or magnet only
- Elastomeric pads: entire floor or magnet footprint only
- Elastomeric isolators: magnet and patient table anchors

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.

ETS-Lindgren can provide



Optimal construction method to achieve STC 50+ acoustic rating of the MRI suite wall assembly

Detail 2

# ETS-Lindgren Acoustic Solutions CONTINUED

each of these floor systems depending on site conditions and particular isolation requirements.

## Acoustic Absorption Kits for RF Shields

As an option, ETS-Lindgren offers sound absorption kits that can be applied directly to the RF shield walls and ceiling. The addition of one of the kits to the RF shield, when no other acoustic construction methods have been instituted to the overall construction of the MRI room, will have only a limited effect on total noise control of the MRI resonator. One must keep in mind that the bulk of the noise reduction control remains with the primary building structures, not the RF shield.

### For New Construction.

The customer should follow the recommendations for construction of the parent room walls and ceiling areas as discussed in this manual, or 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. An optional RF shield acoustic kit can be provided. If an RF acoustic kit is used, it will only

result in an additional 5-17 dB increase in the overall structural performance of the room. The new cavity wall constructed inside of the RF shield should employ acoustic treatments. The cavity wall should be filled with fiberglass insulation. Two layers of 5/8 in. GWB 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 a shield kit 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 the RF kit along with the construction acoustically rated walls within the interior of the RF shield would prove beneficial. Again, the overall contribution of the RF shield kit 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 fiberglass insulation. Two layers of 5/8 in. GWB should be applied as the interior finish surface. Follow the above recommendations for the application of acoustical caulking (non-hardening).

# Glossary and Standards

**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 centered 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 center frequency.

**One-Third Octave Bands-** Frequency ranges in where each octave is divided into one-third octaves with the upper frequency limit being 2<sup>1/3</sup> (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.

**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,” *R<sub>w</sub>*, weighted sound reduction index, plots one-third octave bands between 100 and 3,150 Hz. Deviations, divided by 16 frequencies, must not exceed 2 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.

## Standards

**C 634-** Standard Terminology Relating to Environmental Acoustics

**C 919-** Standard Practice for Use of Sealants in Acoustical Applications

**E 90-** Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

**E 336-** Standards Test Method for Measurement of Airborne Sound Insulation in Buildings

**E 413-** Standard Classification Rating Sound Insulation

## About ETS-Lindgren

The ETS-Lindgren Group is the world's largest and most experienced supplier of shielding solutions for electromagnetic and radio frequency interference (EMI/RFI). With over 6,000 proven MRI installations, we are the worldwide leader in MRI Shielding Systems.

We have installed over 25,000 successful shielded enclosures within a variety of industrial, governmental, and medical environments around the world.

Call upon ETS-Lindgren for our unequalled understanding of both practical and theoretical shielding principles. ETS-Lindgren is highly skilled at applying these principles with a breadth and depth of technical expertise in architectural, mechanical, structural, acoustical, and security related areas.

Because controlling electromagnetic energy is our only business, you can be assured of our commitment to the highest quality and product reliability that stand the test of time.

Our products, materials, and workmanship are backed by a comprehensive warranty and a commitment to customer satisfaction.

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