

## **MRI RF SHIELDING DESIGN**

Nelco's MRI RF Shielding is specifically designed for the MRI industry.

Our engineers have developed a shielded enclosure made entirely of nonmagnetic materials that is unsurpassed in quality and performance. We used technology developed for our military and space industry customers (who require the most demanding RF performance) in order to design the RF shield for use with MRI. Our standard MRI RF shield exceeds all current MRI manufacturer specifications.

Nelco is the only manufacturer that currently offers a lifetime Guarantee on the RF performance of every MRI shielded enclosure we build.



## **Purpose of Radio Frequency (RF) Shielding in MRI**

A Magnetic Resonance Imaging (MRI) unit uses a strong magnetic field, a RF signal and a sophisticated computer system to produce images of the human body. Because the unit utilizes a RF signal in its imaging process, it is susceptible to interference from outside RF sources such as radio & television stations, two way radios, cellular telephones, etc. External interference of this type will cause distortions in the images.

In order to eliminate the chance of outside RF interference, the MRI unit is placed inside of an RF shielded enclosure. The enclosure stops all unwanted RF signals from entering the room and allows the MRI unit to produce the best possible images.

## **Methods of Construction – General**

Nelco's RF shielded MRI enclosure was designed specifically for the MRI industry. Our system is not based on or adapted from any other MRI RF shielding system currently on the market. Instead, our design is based on RF shielded enclosures we have built to meet much more stringent shielding requirements.

Nelco's primary RF shield consists of 5 ounce copper sheet continuously soldered together. All joints are sweat soldered together with at least ¾" of overlap. This soldering technique is used to guarantee that our customer receives a flexible and permanent high performance RF shielded enclosure. Our soldered together copper enclosure carries a Lifetime Warranty.

When a steel RF enclosure is required for the MRI equipment, Nelco will build a high performance bolt-together RF room. In lieu of clamping bars, we utilize galvanized steel pans bolted together every 2" on center. The joints are also gasketed for better RF performance. This RF enclosure carries a five (5) year warranty.

We have experience with other types of RF shielded enclosures including clamp-together and tape-together rooms. In either case, the method used to connect the RF panels together is not sufficient for a permanent RF shielding installation such as a MRI room.

In a clamp-together RF room, the clamping members tend to loosen over time because of building movement, thermal expansion and contraction, or even movement or vibration from related building construction. RF shielding performance is decreased in any case. Corrosion of a clamping joint would also continually degrade performance.

Similarly in a tape together room, the integrity of the RF shield is dependent on the adhesive on the tape. It has been well documented that shielding performance will begin to deteriorate in as little as six months as the adhesive dries out. Repair is often expensive because of removal of all interior finishes necessary to remedy the RF shielding problem.

## **Floor Construction**

Nelco RF shielded floor consists of 12 ounce copper sheet continuously soldered together at the seams.

Our copper shield is integrated into either of the following floor details:

### **A. Recessed Concrete Floor**

The 12 oz. copper RF shield is isolated from the concrete sub floor by a 6 mil plastic vapor barrier and a layer of 18" Masonite. Another layer of 1/8" Masonite is laid on top and finally a 6 mil plastic vapor barrier is applied before the finish concrete is poured.

The finish slab should be at least 3" thick to prevent damage to the RF shield and provide sufficient strength for setting the MRI unit.

Floor finished (by others) may be applied directly to the concrete finish slab.



### **B. Built Up Plywood Floor**

The 12 oz. copper RF shield is isolated from the concrete floor by a 6 mil plastic vapor barrier and a layer of 3/4" CDX plywood. A layer of 1/2" finish plywood is then applied to the floor system.

Floor finished (by others) may be applied directly to the 1/2" finish slab.



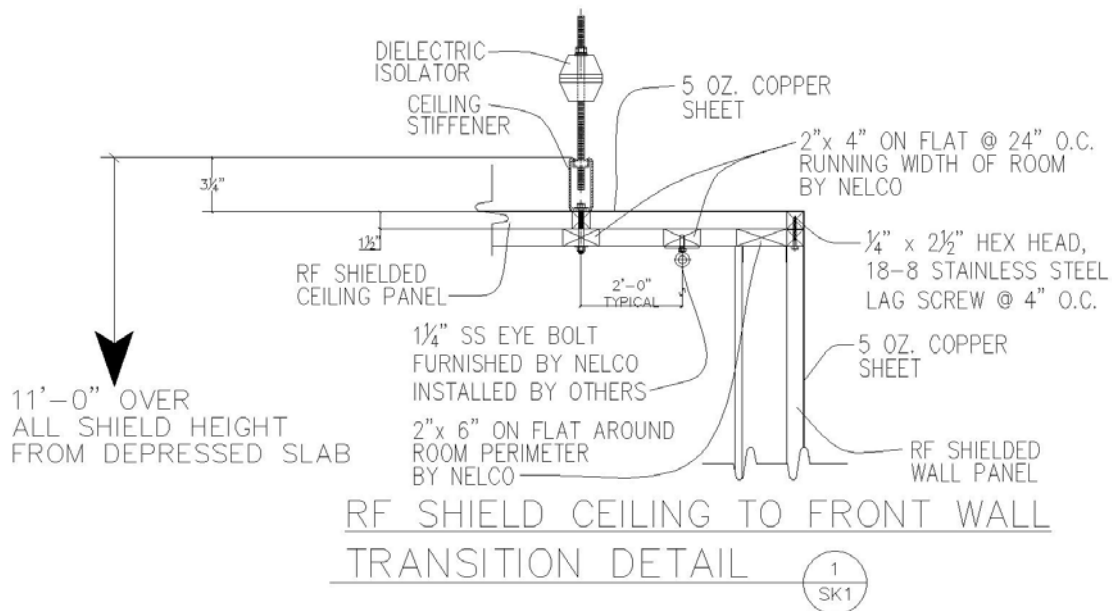
## RF Ceiling and Wall Construction

The ceiling and walls of Nelco's copper RF shielded enclosure are built using 3' x 8' panels consisting of 5 oz. copper and 1/4" flake board. The panels are attached to wood framing placed on 16" on center. The copper hangs over the flake board at two edges leaving an overlap which is then continuously soldered in place.

Room finishes may be applied after the initial RF test. The details described below are found on the following page.

### Detail A – Ceiling

The finished ceiling is typically suspended from the RF shielded ceiling to allow room for recessed lighting and mechanicals. Nelco supplies special brass "T" clip supports and stainless steel fasteners for support of the acoustical ceiling and/or any mechanical runs within the room. Great care must be taken that the fasteners are mounted firmly into the wood framing about the RF ceiling.



The walls of the MRI room can be finished using either of the following details:

**Detail B – Drywall Layover**

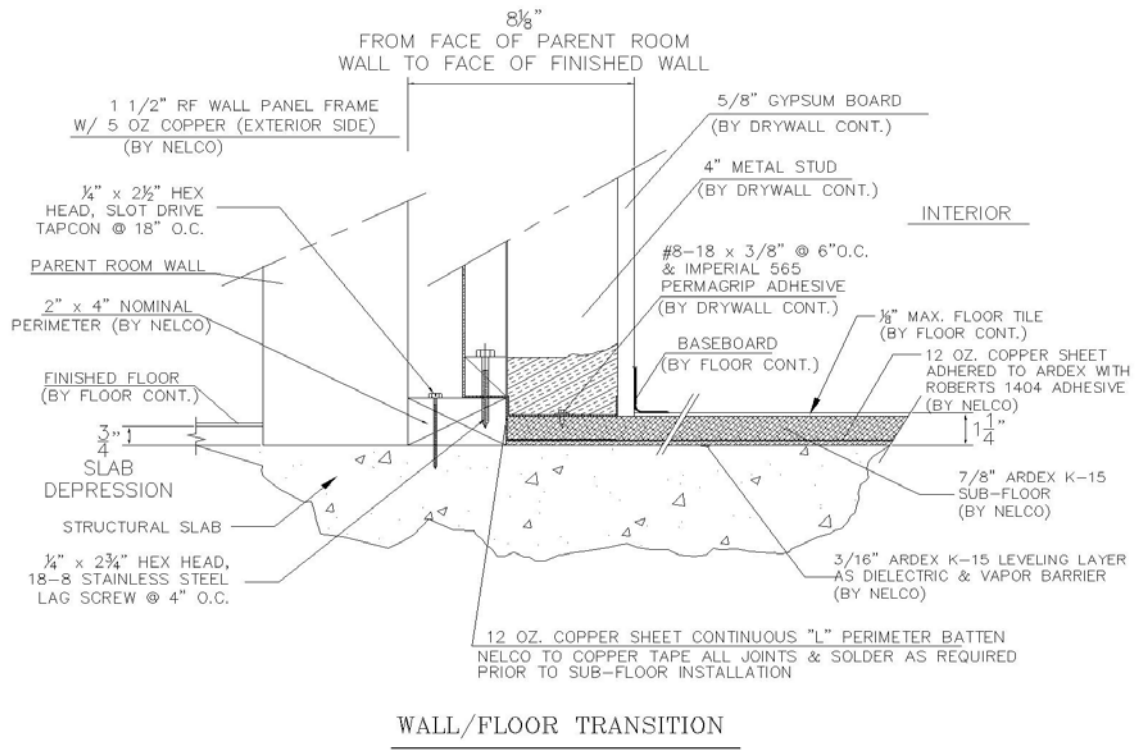
The finished drywall surface is applied directly over the copper panels using copper plated drywall screws supplied by Nelco. Great care must be taken that the fasteners hit the wood framing behind the RF shield. A loose or “spun out” screw will degrade shielding performance. It is better to remove these fasteners and relocate to solid framing. The small hole left behind will not cause a problem.

In a drywall layover detail, Nelco can build copper chases into the stud place to allow for electrical conduit, boxes or other recessed fixture mounting. The number and location of the chases required must be identified before installation of the RF shield begins.

**Detail C – Interior Wall**

Alternately, a secondary interior wall may be constructed inside of the RF shield for support of room finishes. Nelco supplies special brass “T” clip supports and stainless steel fasteners for support of the interior walls. Once again, the “T” clips must be installed so that the fasteners mount firmly into the framing behind the RF shield. This detail is used quote often in a high performance application, i.e. functional MRI.

Electrical conduit boxes or other recessed fixture can be installed in the interior wall space utilizing standard construction techniques.



## **RF Shielded Door Construction**

Nelco's RF shielded MRI doors are specifically designed to meet the requirements and needs of the MRI industry. Each door is a factory assembled unit consisting of frame/threshold, door leave, hardware, and RF seal. Each unit is manufactured at our facility for a specific MRI project.

Nelco offers two main types of RF shielded doors for the MRI industry. Both doors meet all current MRI system manufacturer specifications:

### **A. Standard MRI Door**

Our standard MRI door is easy to open and weighs less than a comparably sized hollow metal door.

The door frame and threshold are fabricated from preformed 12 gauge stainless steel. Our frame finishes the door opening much like a hollow metal door frame. The frame can be a field painted to match other door frames on the project. The door leaf is constructed utilizing a 2" x 3" stainless steel tube around the perimeter and is finished to match other doors on the project.

The standard hardware set includes a heavy duty full length 'Ronton' hinge, twist/pull handles on each side, a deadbolt lock requiring a mortised cylinder, and a stainless steel pull handle for pulling the door closed.

The RF seal is made by a single row of electrical contact strips mounted around the entire perimeter of the door frame.

Nelco's standard MRI door is very flexible and can meet the requirements of almost any project. We can customize the threshold, the door finish, or the hardware set. The door can also be manufactured to include and size borrowed light up to and including a full glass door leaf.

### **B. Pneumatic MRI Door**

Our pneumatic MRI door offers the highest performance available in the marketplace along with almost completely maintenance free operation.

The door frame and threshold are fabricated from the structural stainless steel tubes. The frame is anchored in place and continuously soldered to the cooper RF shielded enclosure. The door leaf utilizes a bent stainless steel pan and an 18 gauge stainless steel face sheet. The leaf is finished with veneer or plastic laminate to match other doors on the project.

The standard hardware set includes 1-1/2 pair of heavy duty hinges, stainless steel pull handles on each side of the door and a deadbolt on the outside.

The RF seal is made through the use of a continuous pneumatic tube around the perimeter of the door leaf. The tube is wrapped with a Monel gasket for a very high performance FRF seal. The pneumatic RF seal requires 30-35 psi of air to operate and Nelco supplies all pneumatic control tubing, switches, etc. to operate the door. If site air is not available, we will supply a 120 V AC compressor.





### **View Window Construction**

The RF shielded window unit is factory assembled and consists of a window frame, RF screen section and glazing. The screen assembly utilizes two layers of 18x14 mesh bronze screen and can be removed easily with ordinary hand tools. The screens are blackened for improved visibility and are protected by two pieces of 1/4" plate glass.

Nelco manufactures each window assembly specifically for a single project. The system is very flexible and can meet most job site conditions.



### **Thermally Broken RF Window**

Nelco offers a once piece thermally broken RF shielded window. This unit acts as both an RF shielded window and an exterior window in the MRI facility. The RF screen section is protected by a piece of 1/4" glass on the inside and 1" insulated glass is installed on the outside for weather protection. The stainless steel tube frame is also insulated from the elements.





## **HVAC Penetrations**

A RF shielded waveguide vent is required for each HVAC penetration into the MRI room. The HVAC waveguide vents are of brass honey comb and brass “T” construction.

The HVAC contractor must use a nonconductive material to attach to the outside of the penetration or the single point grounding system will be defeated. The duct may be connected directly to the waveguide on the inside of the MRI room.



## **Plumbing Penetrations**

Pipe penetrations are utilized to bring sprinkler line pipes, medical gases and the like into the RF shielded enclosure. All pipe runs are to be attached directly to the pipe penetration on the inside and outside of the room. A pipe may NOT pass through one of the RF pipe penetrations.

All plumbing penetrations should be dielectrically separated from the shield on the outside of the room. If dielectric unions are NOT allowed due to local codes, the connections to the plumbing penetrations on the outside of the shielded room are only to be made after the ground requirements have been achieved and recorded.



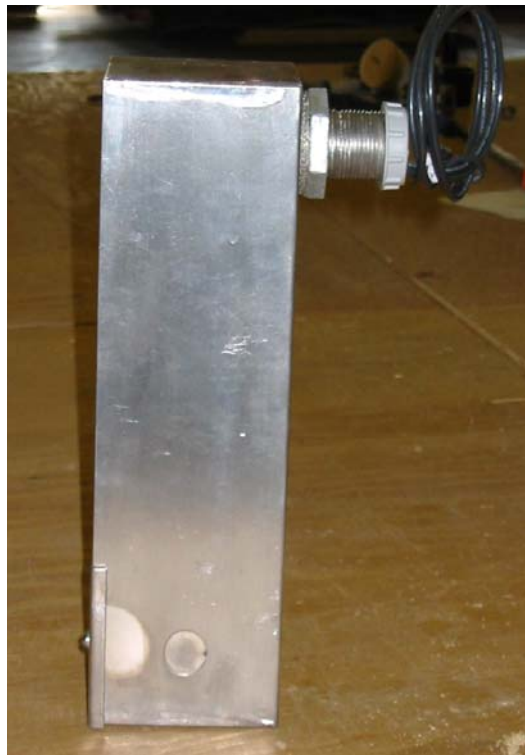
## Electrical Filters

An electrical filter is required for every circuit entering the MRI room. Types of circuits include but are not limited to lighting, power, smoke alarm, thermostat, nurse call, intercom, etc. Each pair of wires must be identified by intended use, voltage, and current rating.

The type and current ratings of the power line and signal filters varies with each project. The following is a suggestion for minimum requirements needed for a standard MRI installation:

- Two (2) dual 30A power filters for lighting.
- One (1) dual 30A power filter for receptacles.
- One (1) dual 5A power line filter for oxygen sensor or emergency stop.
- Two (2) dual low voltage filters for smoke alarm and/or thermostat.

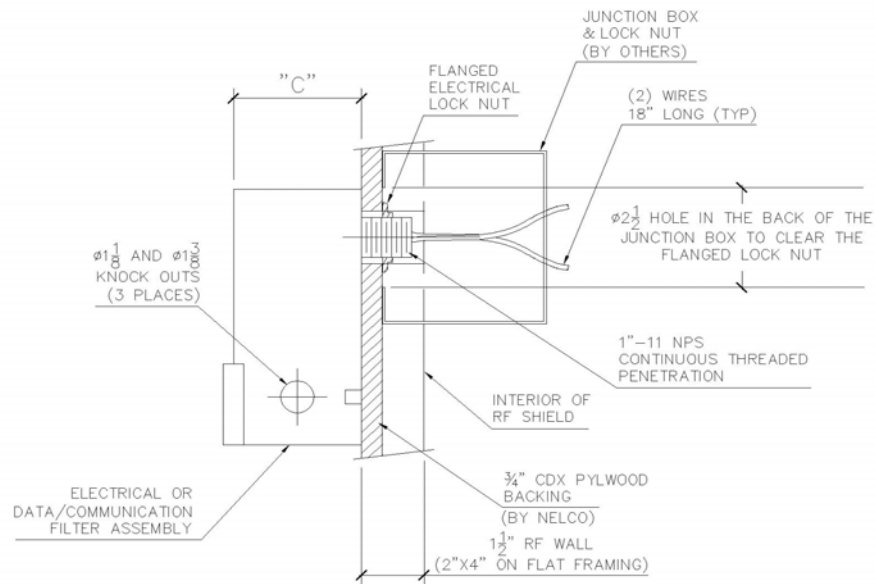
Below you will find standard details for a power filter and a smaller signal type filter. Recommended installation/construction methods are found on the following page.



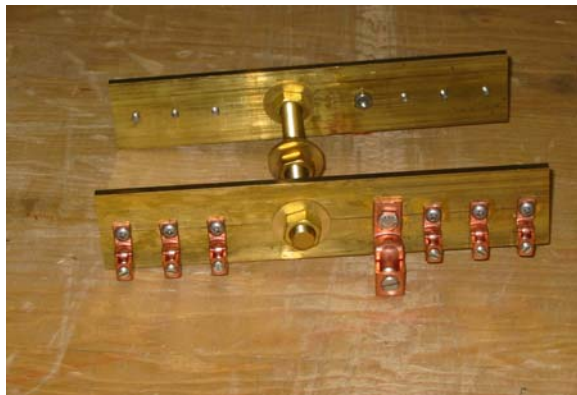
## Electrical Filter Installation

The exact location of the electrical filters will be determined during construction of the RF shield and coordinated with the architect, MRI equipment manufacturer, and electrical contractor.

The filters can be grouped together in one central location as depicted in Detail A below or located in between ceiling joists or wall studs as shown in Detail B. In either case, the location of the filters must be coordinated to ensure that the connections do not interfere with room finishes. Locations between the RP ceiling and the finish ceiling or behind closet doors are most common.



A ground buss bar for the enclosure will be supplied and installed near the electrical RFI filters. The exact location will be coordinated with the MRI equipment manufacturer and the electrical contractor.



## **Removable Panel Construction**

A removable panel section through the RF shield and associated finished partition is required for MRI magnet access into or out of the MRI room. The size of the removable section is determined by the MRI equipment manufacturer. The removable panel section is usually located in a wall of the MRI room, but sometimes site conditions require it be located in the ceiling.

In any case, Nelco can meet specific site conditions and a RF window or even a RF door can be designed as part of the removable panel section.

Below are details of a standard removable panel section located in the wall of an MRI room. The framing for the opening is similar to that of a large bay window. The removable section would be framed  $\frac{1}{2}$ " smaller at each jamb and 1" smaller at the head for easy removability.



## **RF Shielding Effectiveness**

RF testing is performed to validate the shielding performance of the enclosure. Typically, the enclosure will be tested two times; once as soon as the RF shield is complete and a second time after the MRI magnet is delivered.

The performance of the RF shield is measured at various points and frequencies and is recorded in the units of decibels of attenuation. Common test points include the RF door, RF window, HVAC and plumbing penetrations, electrical filter penetrations and removable panel.

The performance requirements for an MRI room are determined by the MRI equipment manufacturer. Different MRI magnets operate in different frequency ranges and as shown in the chart below, attenuation specifications vary per manufacturer.

Nelco's RF shielded MRI enclosures exceed performance requirements of all manufacturers and for all magnet types.

## **Guarantee**

Nelco guarantees materials and workmanship in its RF shielded enclosure for the life of its intended use. The confidence we have in the design and construction of our MRI RF shielded enclosures allows us to offer this guarantee without hesitation. A copy of our warranty is available upon request.