MRI Radio Frequency Shielding

Site Planning Guide

AlbatrossProjects

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Table of Contents

Introduction

This guide provides comprehensive guidelines for professionals involved in MRI RF shielding planning and installation. MRI facilities must be shielded effectively to block external RF interference and ensure accurate diagnostic imaging.

Audience and Purpose

This Site Planning Guide is designed for review by facility managers, electrical and mechanical contractors, architects, and designers involved in the planning and implementation of MRI facilities.
The information contained within this guide serves as a foundational resource to enhance your understanding of key considerations when designing and constructing MRI environments. While this guide provides valuable insights, it should not replace the specific site planning documentation provided by your MRI equipment vendor. Each MRI installation is unique, and it is crucial to consult the vendor's guidelines to address the specific requirements of the system being installed.

Disclaimer

This guide is not a substitute for the specific planning and safety requirements provided by MRI equipment vendors.

Magnetic Resonance Imaging (MRI) is a sophisticated diagnostic imaging modality that utilizes radiofrequency (RF) signals and strong magnetic fields to generate detailed images of the body's internal structures. To ensure optimal performance, MRI systems must be effectively shielded from external RF noise, such as signals from local television stations and mobile devices. This shielding is essential for isolating the MRI exam room to accurately detect the patient's response to the RF frequencies emitted by the system.

For any questions or further clarification regarding this guide, please contact:

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Email: inquiry@shieldingsystems.com

Unlike CT or X-ray shielding, which typically requires protection along the direct path of radiation—commonly referred to as "line of sight“

MRI shielding addresses both the strong magnetic fields and RF frequencies essential for image creation.

The 5-gauss field serves as a critical benchmark for safeguarding individuals with pacemakers or metallic implants from the MRI-generated magnetic field. If this 5-gauss field extends into areas such as hallways or waiting rooms—designated as "uncontrolled" spaces—appropriate magnetic shielding becomes imperative to protect individuals from potential exposure. Furthermore, external magnetic fields can disrupt the MRI's performance, leading to compromised image quality. While magnetic shielding may mitigate some of these disturbances, it is not always sufficient. MRI vendors often collaborate with hospitals or clinics to determine an appropriate distance for the MRI system to minimize interference. When maintaining this distance is not feasible, the implementation of magnetic shielding is essential.

External magnetic fields from nearby sources like moving vehicles, electrical substations, and power lines can significantly impact MRI system performance, leading to degraded image quality and compromised diagnostic accuracy. To prevent such disruptions, a thorough site evaluation and the implementation of effective shielding measures are essential to protect the MRI environment from external magnetic interference.

Shielding requirements differ for each facility, making early collaboration with MRI or RF shielding experts essential. Engaging specialists from the start helps avoid complications and ensures a smooth planning, construction, and installation process.

It is important to note that MRI systems generate significant noise during imaging sequences. Therefore, careful planning for effective soundproofing is essential in the construction of the MRI room. The primary sound attenuation will be achieved through the design and construction of the walls, ceiling, and floor. While the RF shield contributes to some sound reduction, key components for sound attenuation include the RF door and window.

The RF door should be designed to provide robust sound insulation, with a recommended Sound Transmission Class (STC) rating of 40 or higher. Typically, the RF window is constructed with two layers of glass; A conductive mesh, usually made of copper or silver, is embedded between layers of glass or polycarbonate. This mesh blocks external RF signals from entering the MRI room while maintaining visibility. The mesh must have very small openings to block the high-frequency RF waves without affecting the transparency of the window.

MRI systems typically use liquid helium for cooling, requiring a quench pipe to vent safely outside the building. In the event of a quench—an occurrence that has been reported in approximately 1 in 200 MRI installations globally—rapid gas expansion can pose serious safety risks. To mitigate these, MRI vendors provide detailed instructions to mechanical contractors for proper quench pipe installation. Additionally, the powerful magnetic fields of MRI machines, which can reach up to 60,000 times the strength of the Earth’s magnetic field, can attract nearby ferromagnetic objects with dangerous force, creating potentially fatal hazards. While current regulations do not mandate specific preventive measures, industry discussions are ongoing to establish safety standards that prevent ferrous materials from entering MRI rooms.

CHAPTER ONE

Overview of MRI

1

MRI Basics

Magnetic Resonance Imaging (MRI) is a sophisticated diagnostic imaging modality that utilizes radiofrequency (RF) signals and strong magnetic fields to generate detailed images of the body's internal structures. To ensure optimal performance, MRI systems must be effectively shielded from external RF noise, such as signals from local television stations and mobile devices. This shielding is essential for isolating the MRI exam room to accurately detect the patient's response to the RF frequencies emitted by the system.

Magnetic Resonance Imaging, or MRI, is a non-invasive imaging technique that uses powerful magnets, radio waves, and a computer to produce detailed images of the inside of the body

MRI scans work as an imaging method due to the unique make-up of the human body. We are comprised entirely of cells which all contain water principally made of hydrogen ions (H2O).

The magnet embedded within the MRI scanner can act on these positively charged hydrogen ions (H+ ions) and cause them to 'spin' in an identical manner. By varying the strength and direction of this magnetic field, we can change the direction of 'spin' of the protons, enabling us to build layers of detail.

When the magnet is switched off, the protons will gradually return to their original state in a process known as precession. Fundamentally, the different tissue types within the body return at different rates and it is this that allows us to visualize and differentiate between the different tissues of the body.

In MRI, B_0 refers to the main static magnetic field produced by the MRI scanner. It is a crucial aspect of MRI operation, as it determines the strength of the magnet and influences the quality and resolution of the images Ref Image 1

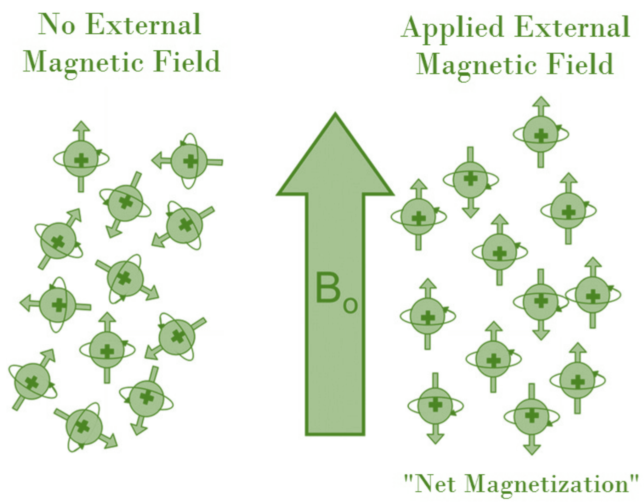


Image 1 : **Protons Reaction During B_0**

Science Behind MRI

Once the patient is positioned, the MRI table moves into the scanner's bore, where the main static magnetic field (B_0) is generated

Inside the strong magnetic field, the protons (primarily in water molecules) in the patient's body align with the direction of B_0.

A specific radiofrequency (RF) pulse is applied through the RF coil. This pulse excites the protons, knocking them out of alignment with the magnetic field.

The protons absorb the energy from the RF pulse and are momentarily deflected into a higher energy state.

Once the RF pulse is turned off, the protons begin to return to their original alignment with B_0. This process is known as relaxation.

As the protons relax, they release the absorbed energy in the form of radiofrequency signals. These signals are detected by the RF coils.

The emitted RF signals are collected by the RF coils and sent to the computer for processing.

Using the gradient fields, the MRI scanner selects specific "slices" of the body to image. This can be done in different planes (axial, coronal, sagittal).

The computer reconstructs the signals from each slice into detailed images that represent the anatomy and pathology of the scanned body part. (Image 2 shows the complete process of Brain scanning)

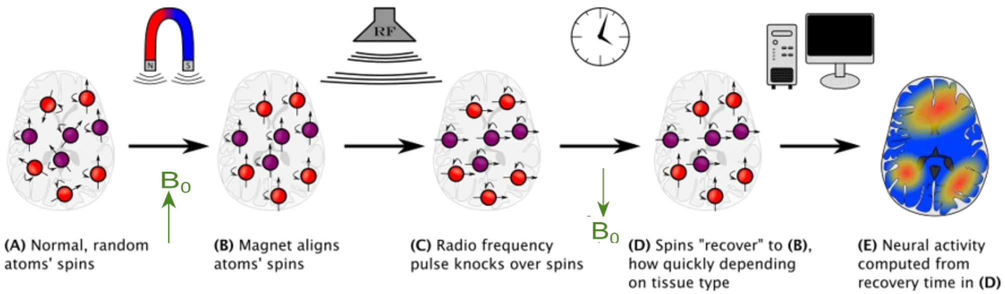


Image 2 : **Brain Imaging Process**

MRI Anatomy

When planning an MRI system, one should take care not to place it near large metal objects, i.e., not to place an MRI directly above a structural beam. The metal beam being so close to the MRI will prevent the MRI from establishing a "homogeneous" area where the patient is to be scanned. Thus, when magnetic shielding is to be used, the magnetic shield designer should take care to ensure that no significant amount of steel is too close to the MRI such that it cannot compensate for the steel. This is called "shimming."

The strength of an MRI is measured in TESLA. A 3.0 Tesla (30,000 gauss) MRI system is approximately twice as strong as a 1.5 Tesla (15,000 gauss) MRI system. For comparison, you can expect to measure 0.5 gauss if you are standing in an open field, away from anything that might artificially create a magnetic field; this is called the earth's natural magnetic field. (Image 3 shows the Key MRI Components with Patient Positioned Inside the Scanner)

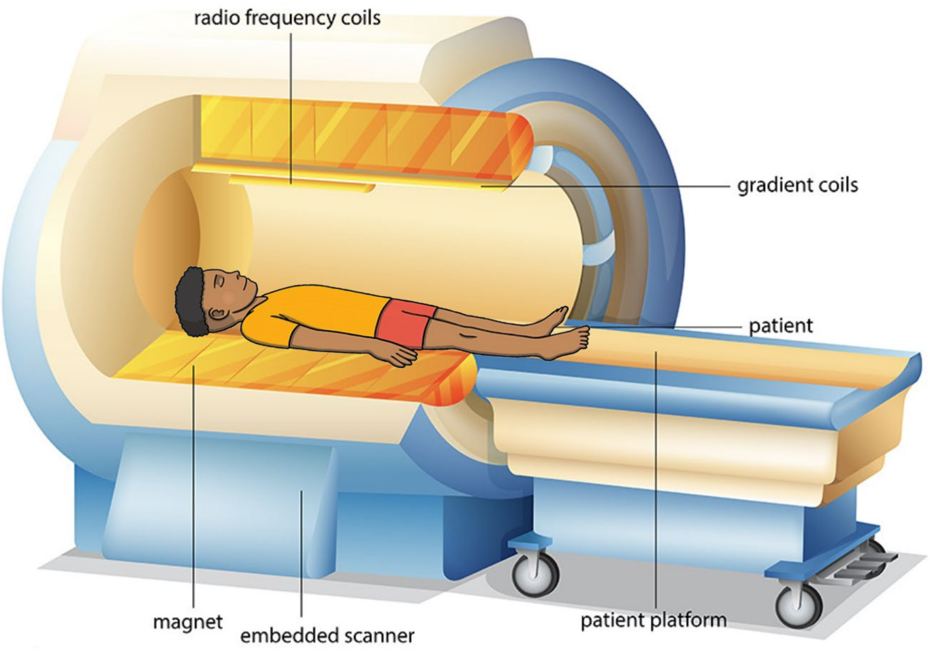


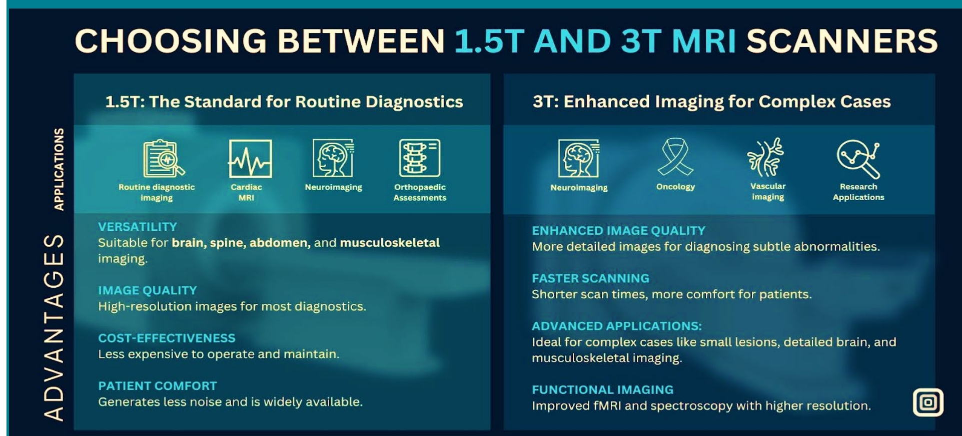
Image 3 : **Key MRI Components with Patient Positioned Inside the Scanner**

Benefits of Strong MRI

High-field MRI machines, particularly those with 3 Tesla (3T) or greater field strengths, bring substantial benefits to medical imaging, especially through their superior **signal-to-noise ratio (SNR)**. The enhanced SNR allows for sharper, more detailed images, enabling clinicians to pinpoint small anatomical structures and detect subtle abnormalities with greater accuracy. This level of detail is crucial for diagnosing complex conditions in areas such as the brain, spine, and joints, where precision is paramount to identifying issues that may otherwise go unnoticed in lower-field scans. As a result, high-field MRIs support more accurate and confident diagnoses, ultimately improving patient outcomes in intricate clinical cases.

In addition to superior image clarity, strong MRI systems reduce scanning time by enabling faster data acquisition, resulting in shorter exam durations for patients. They also support advanced imaging techniques such as magnetic resonance spectroscopy (MRS) and diffusion tensor imaging (DTI), which provide deeper insights into tissue metabolism and structural connectivity, further enhancing diagnostic capabilities.

Beyond clinical applications, high-field MRI machines are indispensable in research environments, particularly in neurology and cardiology. The improved SNR they offer reduces the likelihood of artifacts, improves contrast agent performance, and allows for more accurate imaging in both functional and anatomical studies. This makes them a critical tool for advancing medical research and improving patient care.



> Studies indicate that **15-20%** of MRI scan quality issues are linked to RF interference. Shielding is necessary to prevent image noise, artifacts, or distortions, which can lead to misdiagnosis or the need for repeat scans.

CHAPTER TWO

Radio Frequency Shielding

2

RF Shielding 101

RF shielding is crucial in MRI suites to block external interference, often reducing RF levels by 99.9%. The shielding typically forms a "Faraday cage" around the MRI room, preventing unwanted RF signals from entering.

What is RF Shielding?

RF (Radiofrequency) shielding is the process of protecting a designated area or device from external radiofrequency electromagnetic interference (EMI). In the context of MRI (Magnetic Resonance Imaging) suites, RF shielding prevents external RF signals—such as those from radios, cell phones, or other electronic devices—from interfering with the MRI's sensitive equipment.

This is crucial because MRI machines use strong magnetic fields and radiofrequency signals to generate detailed images of the body, and any external interference can distort these images, compromising their quality and diagnostic accuracy.

How does it Work?

RF shielding involves enclosing the MRI room in a conductive material, typically galvanized, copper or aluminum, which forms a "Faraday cage" around the MRI machine. This cage blocks external RF signals from entering the room and also prevents RF signals generated by the MRI from escaping. The shielding materials reflect and absorb RF energy, effectively neutralizing it.

Key Features of RF Shielding

Materials The shielding is typically made of conductive materials like galvanized, copper, or aluminum. Galvanized steel is widely used because of durability, cost-effectiveness, resistance to corrosion, and easy to install. Copper is often preferred for its high conductivity and durability.

Enclosure The shielding must cover all six sides of the room—walls, floor, and ceiling—to create a complete RF-tight enclosure.

Sealing Special attention is needed for doors, windows, and penetrations (e.g., for HVAC, cables, and ducts) to ensure that these points do not allow RF interference to enter.

Attenuation The effectiveness of the shielding is measured in decibels (dB) of attenuation, which indicates how much RF energy is blocked. MRI shielding typically achieves an attenuation **of 90-100 dB**, which significantly reduces the level of interference.

Importance of RF Shielding in MRI Rooms

1. **Prevents Image Distortion**
   Without proper RF shielding, external interference can cause artifacts and distortions in MRI images, reducing their clarity and diagnostic value.

2. **Ensures Safety**
   Shielding helps protect sensitive medical equipment from malfunctioning due to RF interference, ensuring patient and staff safety.

3. **Compliance with Standards**
   Proper RF shielding is required to meet international safety and performance standards for MRI installations, such as ASTM F2549 and IEC 60601-2-33

When designing MRI suites, architects must ensure effective RF shielding to block external interference, balancing material performance, installation complexity, cost, and long-term functionality. Understanding and selecting the right RF shielding materials is essential for optimal MRI suite design.

Types of RF Shielding

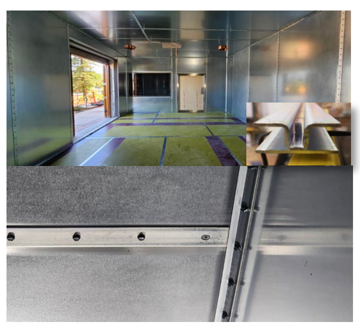
Albatross Projects systems is specialized in two key types of shielding out of the three most widely used types of shielding available in the market.

Galvanized RF Shielding
Soldered Copper Shielding
Copper Panel Shielding **

Our comprehensive offerings ensure optimal imaging quality and safety by preventing external RF signals from disrupting critical operations. With a focus on compliance and innovative materials, we deliver tailored shielding systems that meet the unique needs of each facility.

Galvanized RF Shielding

The RF shielding system, constructed using galvanized modular panels, creates an enclosure that blocks radio frequency (RF) interference. This controlled environment is critical to ensuring the MRI equipment's accuracy and performance, as it protects the MRI scans from external electromagnetic disruptions.



Soldered Copper RF Shielding

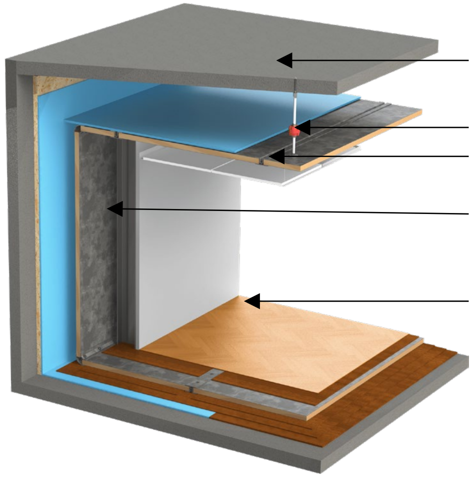
Copper is widely used for RF shielding in MRI suites due to its exceptional conductivity and durability. Various installation methods are available; in this case, copper is applied as a wallpaper over a wooden framework that covers the walls, floors, and ceilings, forming a complete Faraday cage.

Copper Panel RF Shielding

In this case copper prefabricated in factory as panels based on the sizes required then installed in the walls, floors, and ceilings, forming a complete Faraday cage

**Major drawback of Copper panel solution is susceptible to damage in construction environments and more installation time make it not a reliable solution.

Every MRI needs RF shielding



Galvanized RF Shielding

- **Cost-Efficient**: Galvanized materials offer a balance between performance and affordability compared to alternatives like copper.
- **Easy Installation**: Pre-fabricated panels make the installation process faster and more efficient, especially in large-scale projects.

Performance & Stats

- **High Attenuation -** Offers 100-120 dB attenuation across 10 kHz to 10 GHz frequency range, providing robust RF isolation.
- **Durability & Longevity -** Galvanized coating provides excellent corrosion resistance, extending system lifespan in harsh environments by up to 25+ years.

Architectural Considerations

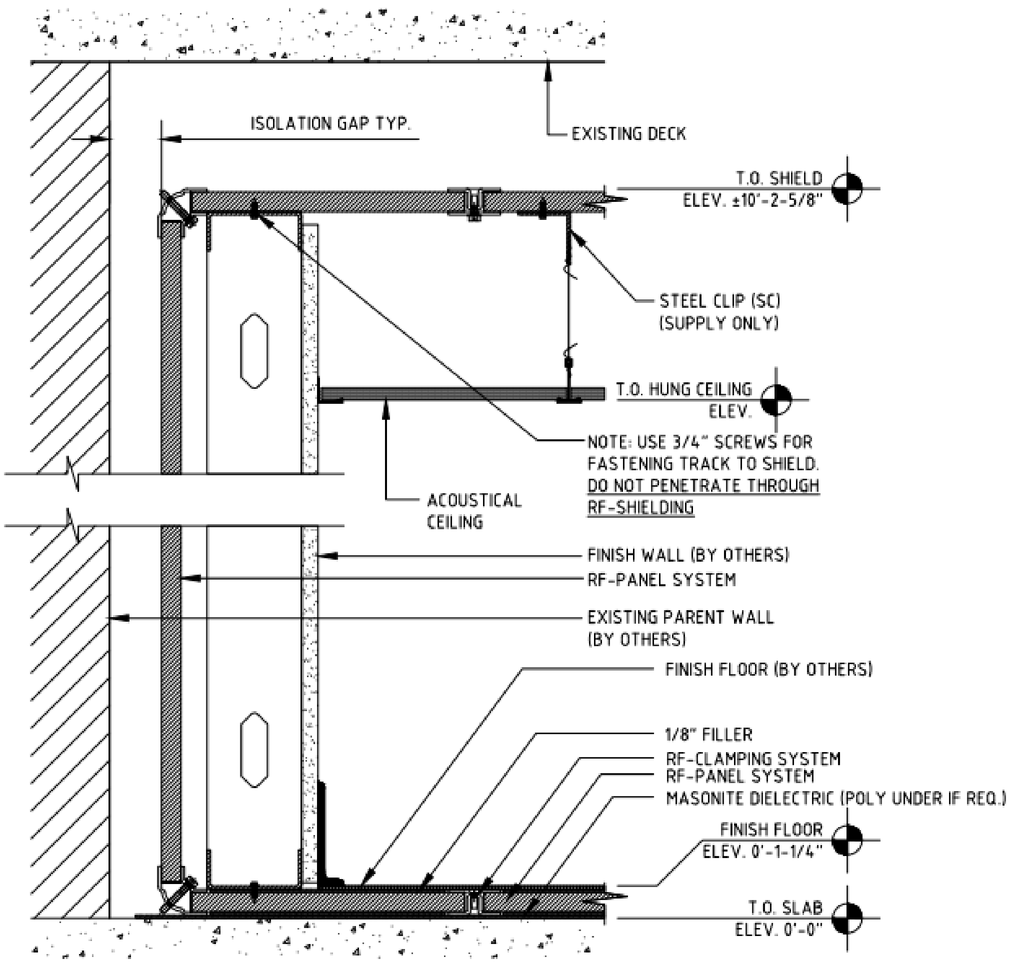
- **Space & Clearance -** Ensure adequate room for 3-6-inch-thick panels, accounting for modular assembly and necessary framing.
- **Shielded Components -** Incorporate RF-shielded doors, windows, and waveguides for ventilation, ensuring the shielding system maintains full integrity.

Installation Requirements

- **Healthcare & Research -** Ideal for MRI rooms and labs where 100+ dB shielding is critical to avoid signal interference with medical equipment or experiments.
- **Industrial & Telecom -**Effective in EMI-heavy environments such as telecom centers and industrial sites, protecting sensitive equipment from RF disturbances.

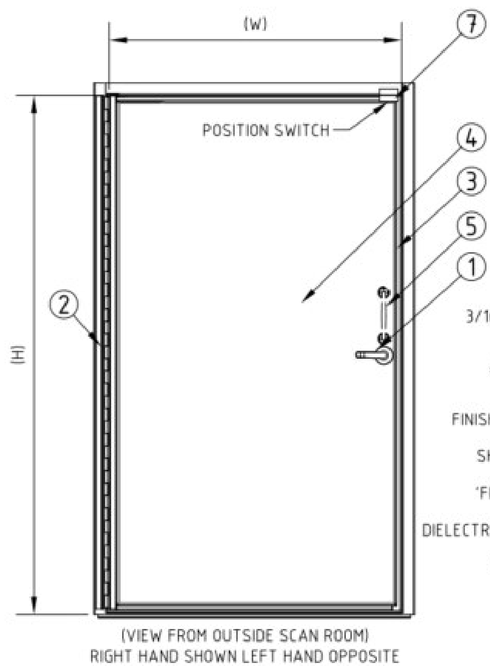
Construction Details - Galvanized Panel

A·1 Wall Section (Ceiling to floor)
A·2 RF Door – Outswing
A·3 RF Door – Inswing
A·4RF Window
A·5 Sprinkler Waveguide / Medical Gas Waveguide
A·6 HVAC Waveguide
A·7 Hanger Detail
A·8 CRYO Penetration Details
A.9 RF Power Filter Details



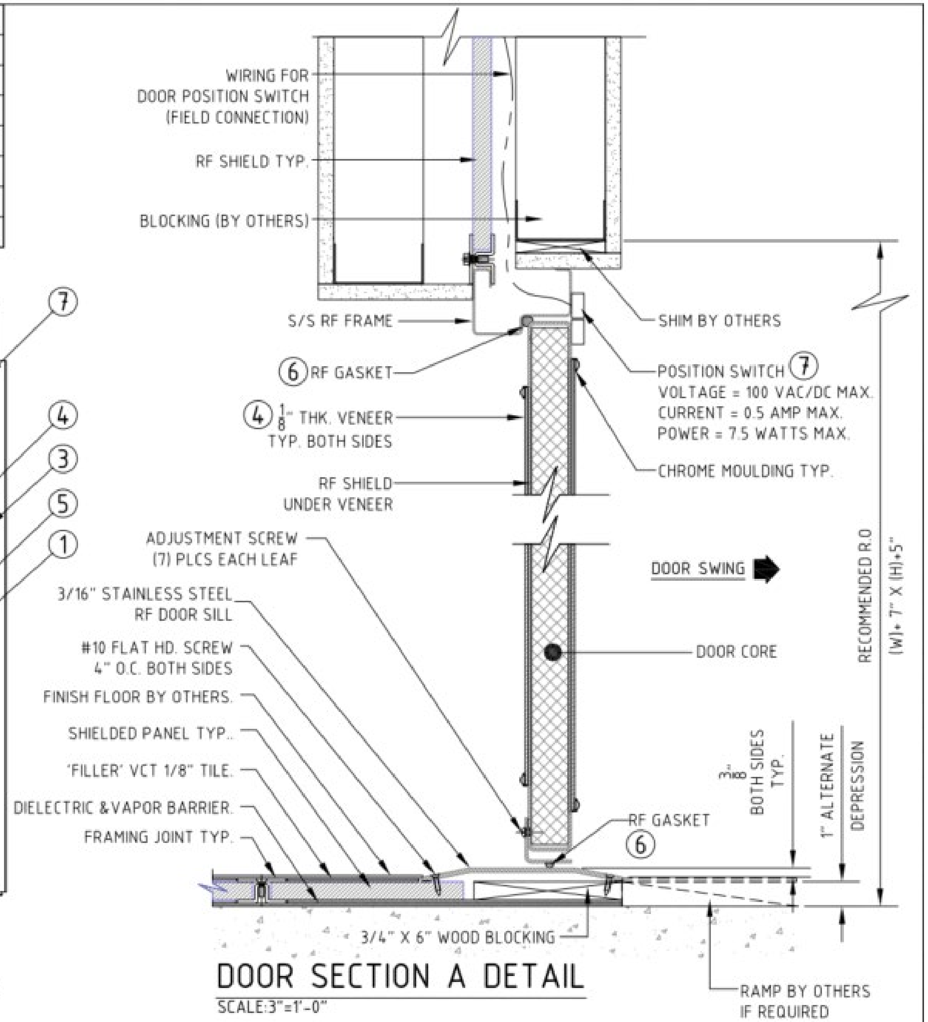
RF WALL SECTIONS
SCALE: 3"=1'-0"

ITEM	QTY	DESCRIPTION
1	1	SARGENT CLASSROOM LOCK (A.D.A.) TYPE 11G37
2	1	CONTINUOUS HINGE, FULL #081390
3	1	GPS RF DOOR ASSEMBLY
4	1	VENEER- SEE SCHEDULE
5	1	'D' PULL BATTALION, #5U628
6	1	GASKET, SG375500-48
7	1	DOOR POSITION SWITCH



DOOR ELEVATION DETAIL

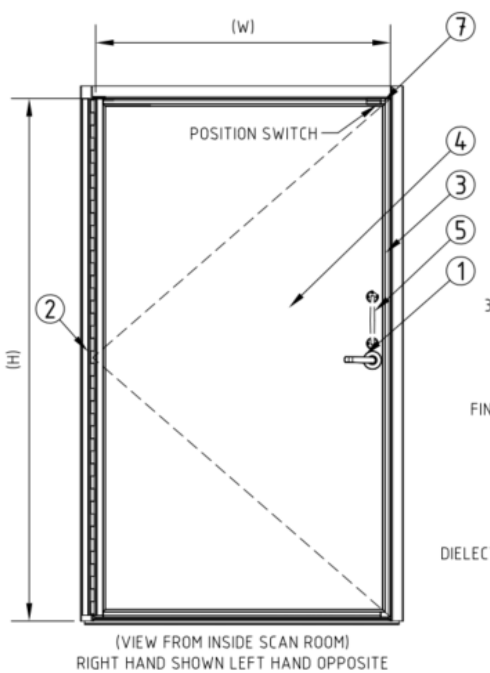
SCALE:3/4"=1'-0"



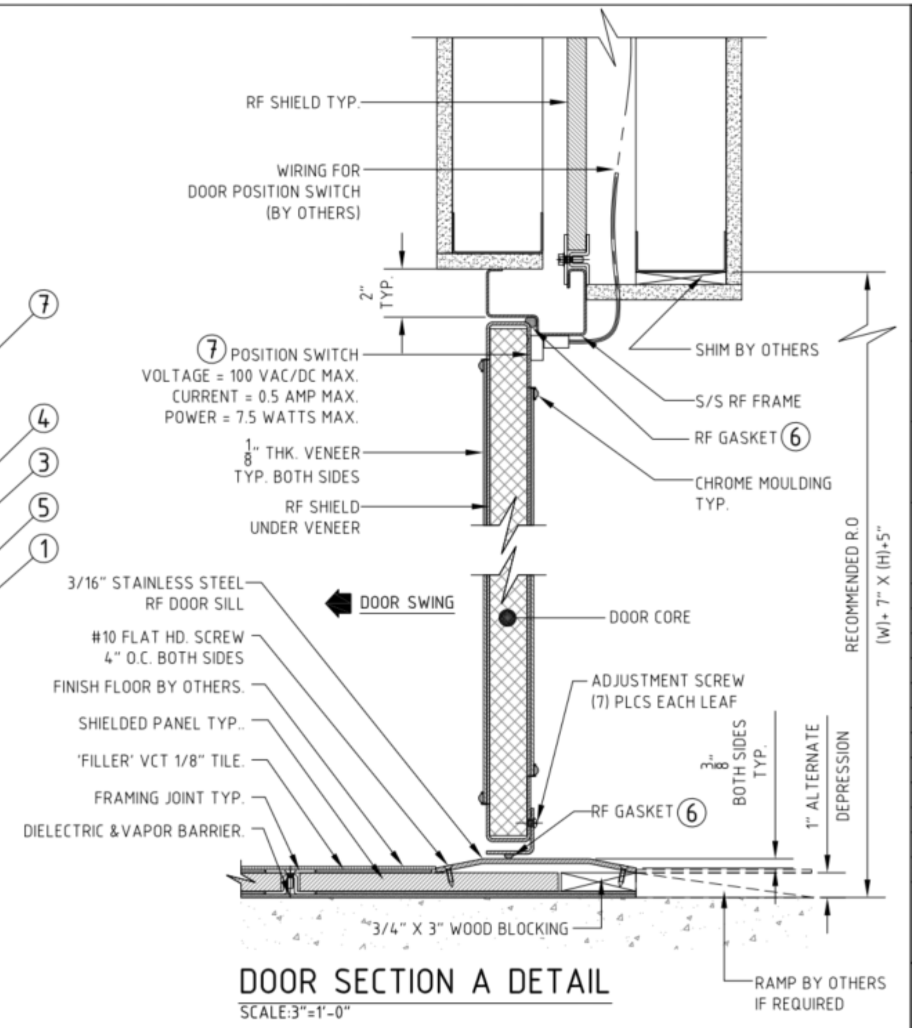
DOOR SECTION A DETAIL

SCALE:3"=1'-0"

ITEM	QTY	DESCRIPTION
1	1	SARGENT CLASSROOM LOCK (A.D.A.) TYPE 11G37
2	1	CONTINUOUS HINGE, FULL #081390
3	1	GPS RF DOOR ASSEMBLY
4	1	VENEER- SEE SCHEDULE
5	1	'D' PULL BATTALION, #5U628
6	1	GASKET, SG375500-48
7	1	DOOR POSITION SWITCH

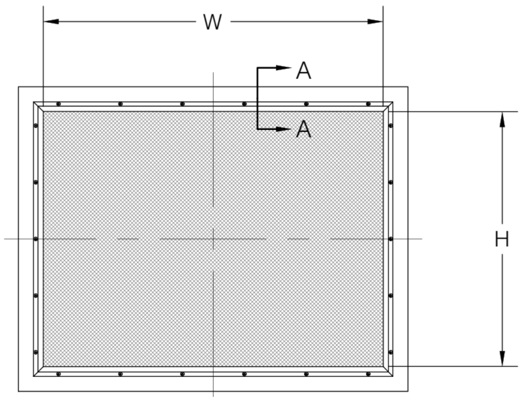


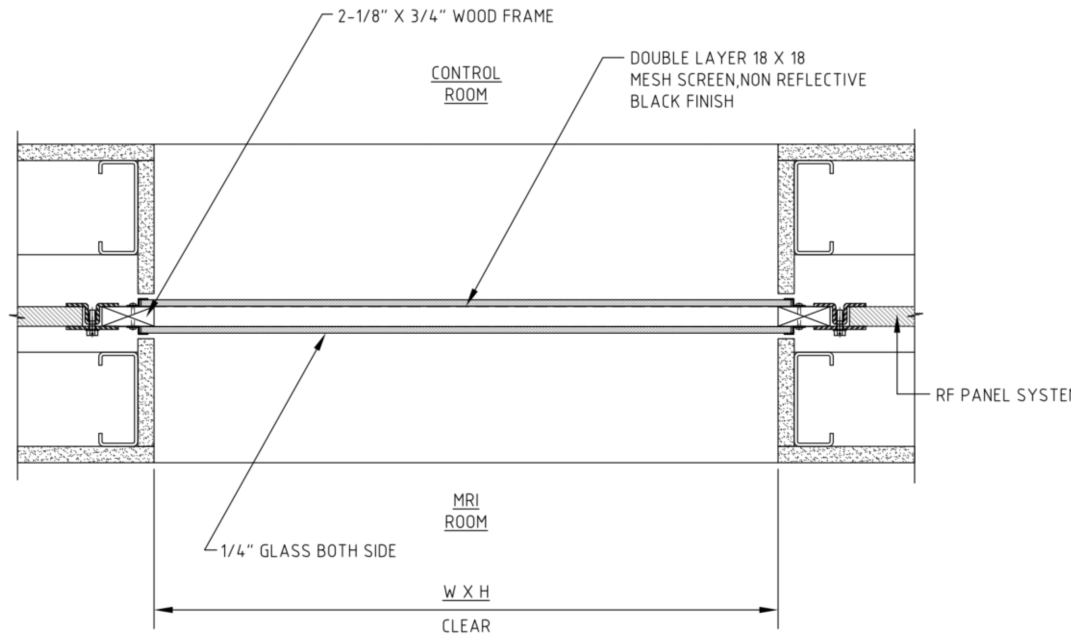
DOOR ELEVATION DETAIL
SCALE:3/4"=1'-0"

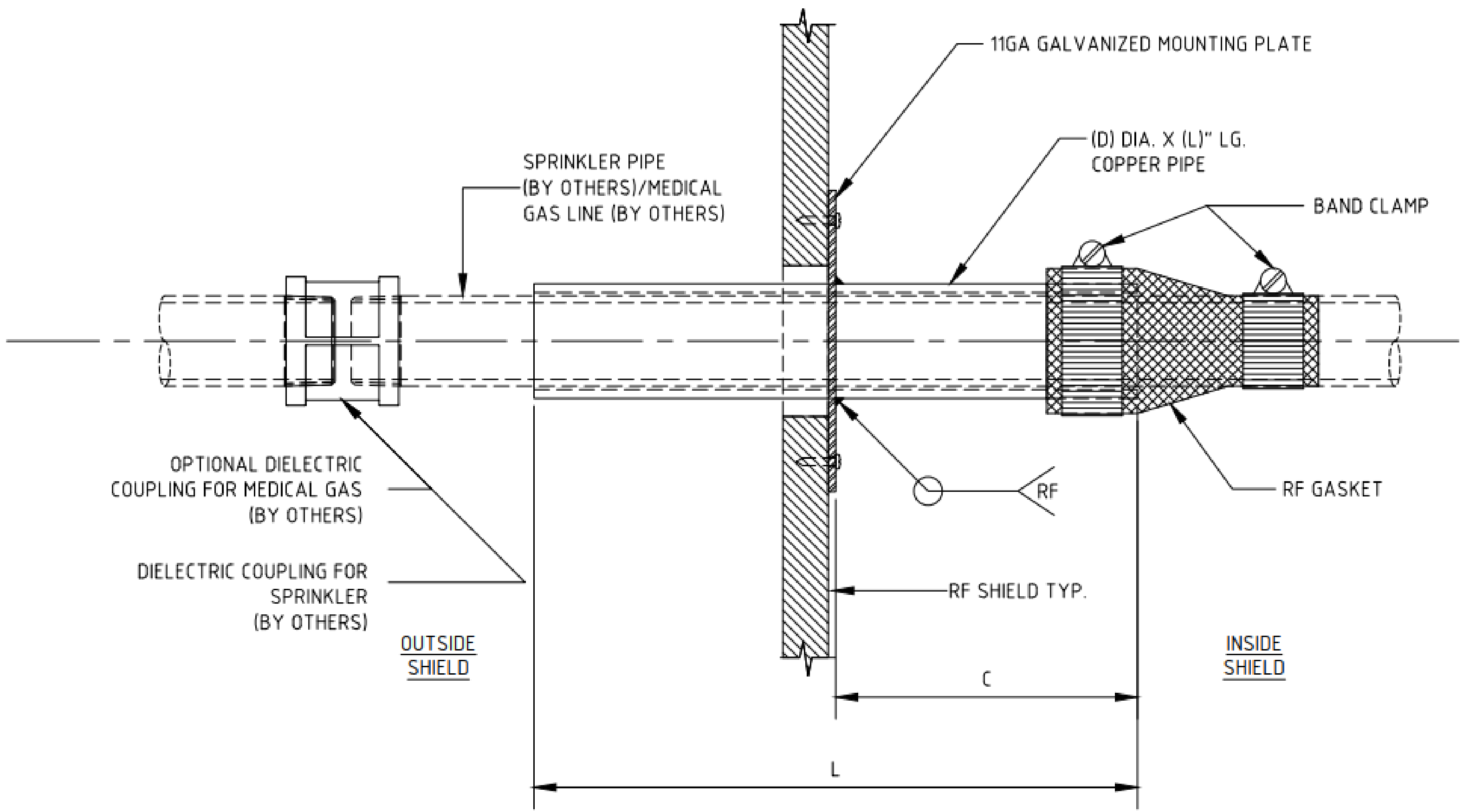


DOOR SECTION A DETAIL
SCALE:3"=1'-0"

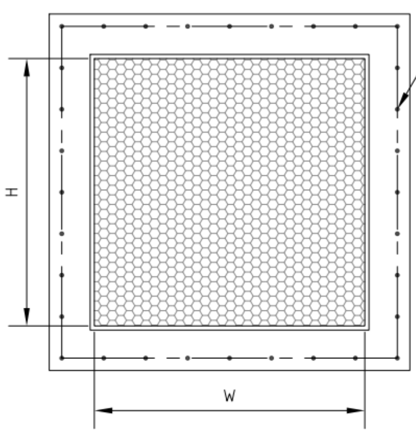
A. Galvanized Panel Shielding		+1 (973) 574-9077
A·4 RF Window	Head-on and Side Detail	www.albatross-projects-americas.com

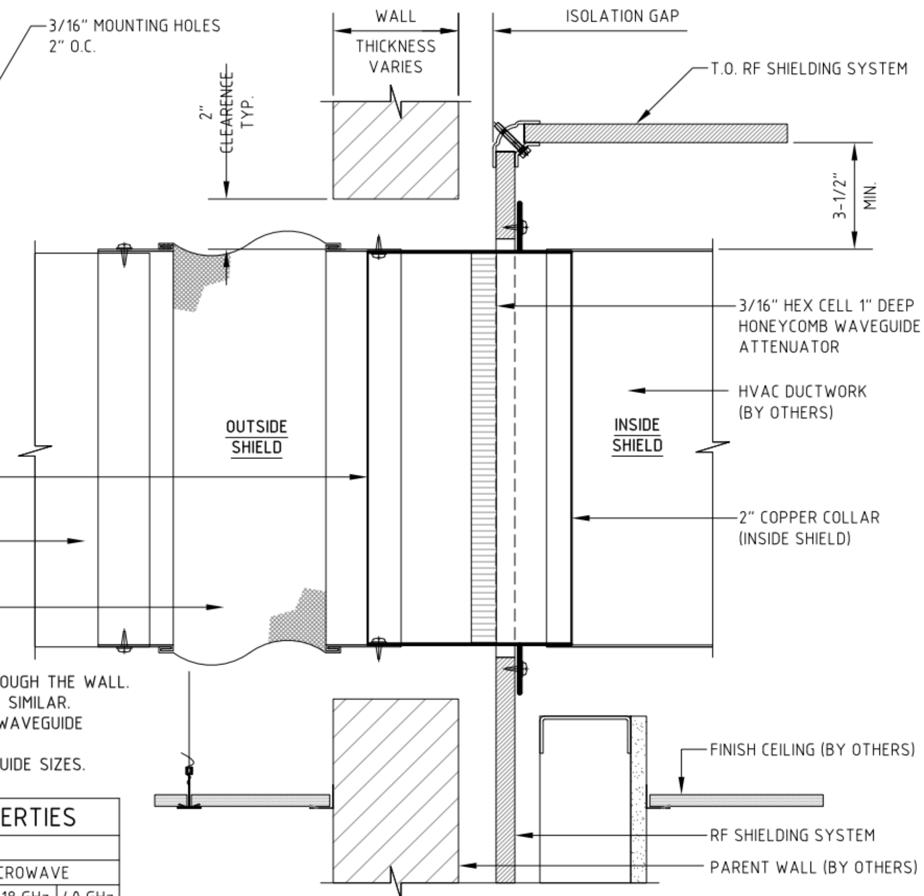






11GA GALVANIZED MOUNTING PLATE
SPRINKLER PIPE (BY OTHERS)/MEDICAL GAS LINE (BY OTHERS)
(D) DIA. X (L)" LG. COPPER PIPE
BAND CLAMP
OPTIONAL DIELECTRIC COUPLING FOR MEDICAL GAS (BY OTHERS)
RF
RF GASKET
DIELECTRIC COUPLING FOR SPRINKLER (BY OTHERS)
RF SHIELD TYP.
OUTSIDE SHIELD
INSIDE SHIELD
C
L





NOTES:
1. DETAIL ILLUSTRATES A VERTICAL PENETRATION THROUGH THE WALL. HORIZONTAL PENETRATIONS THROUGH THE CEILING ARE SIMILAR.
2. SILICON CAULKING CAN BE USED TO SEAL DUCT AT WAVEGUIDE FLANGES.
3. SEE SCHEDULE OF VALUES ON DWG 050 FOR WAVEGUIDE SIZES.

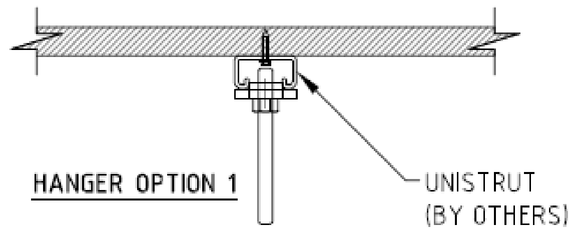
3/16" X 1" HONEYCOMB CELL PROPERTIES

SHIELDING EFFECTIVENESS								
MAGNETIC		ELECTRIC		PLANEWAVE		MICROWAVE		
1 kHz	20 kHz	100 kHz	10 MHz	100 MHz	1 GHz	10 GHz	18 GHz	40 GHz
25 dB	100 dB	120dB	120dB	120dB	120dB	120dB	120dB	N/A

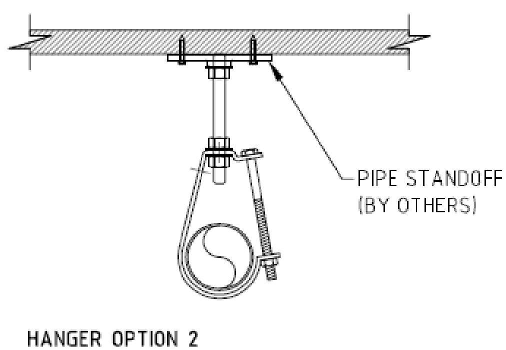
PRESSURE DROP				
INCHES OF WATER	0.015	0.025	0.042	0.065
AT FEET PER MINUTE	400	600	800	1000

RF WAVEGUIDE SECTION

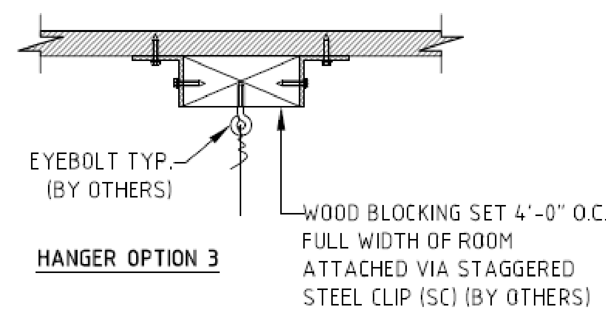
SCALE:3"=1'-0"



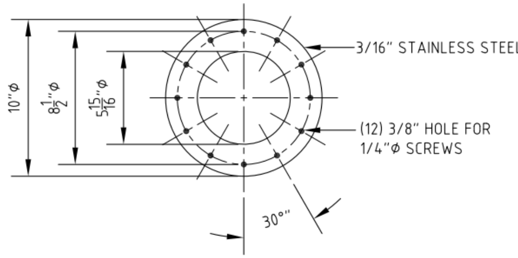
HANGER OPTION 1
UNISTRUT
(BY OTHERS)



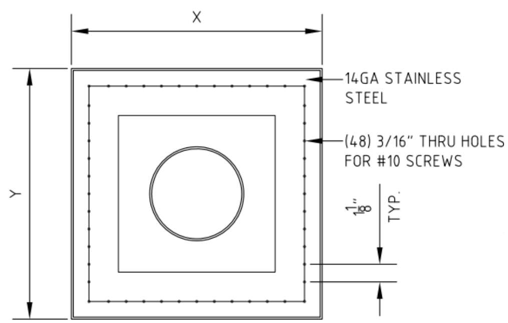
PIPE STANDOFF
(BY OTHERS)
HANGER OPTION 2



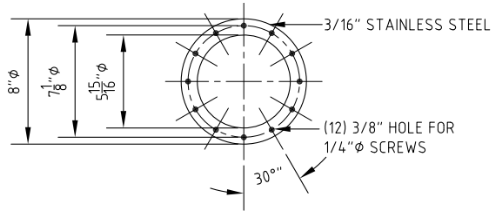
EYEBOLT TYP.
(BY OTHERS)
HANGER OPTION 3
WOOD BLOCKING SET 4'-0" O.C.
FULL WIDTH OF ROOM
ATTACHED VIA STAGGERED
STEEL CLIP (SC) (BY OTHERS)



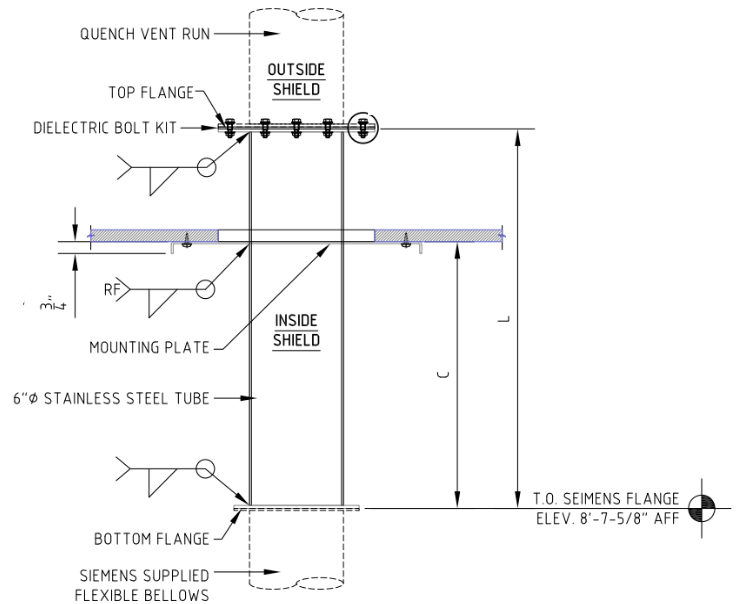
TOP FLANGE DETAIL



MOUNTING PLATE DETAIL

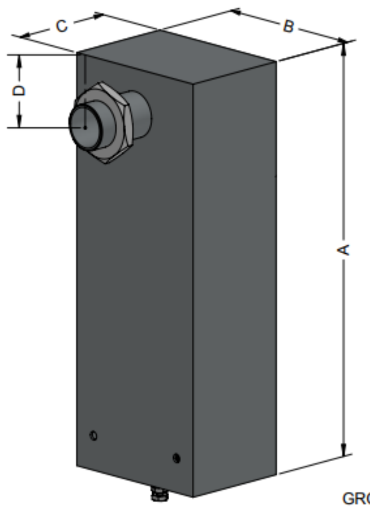


BOTTOM FLANGE DETAIL

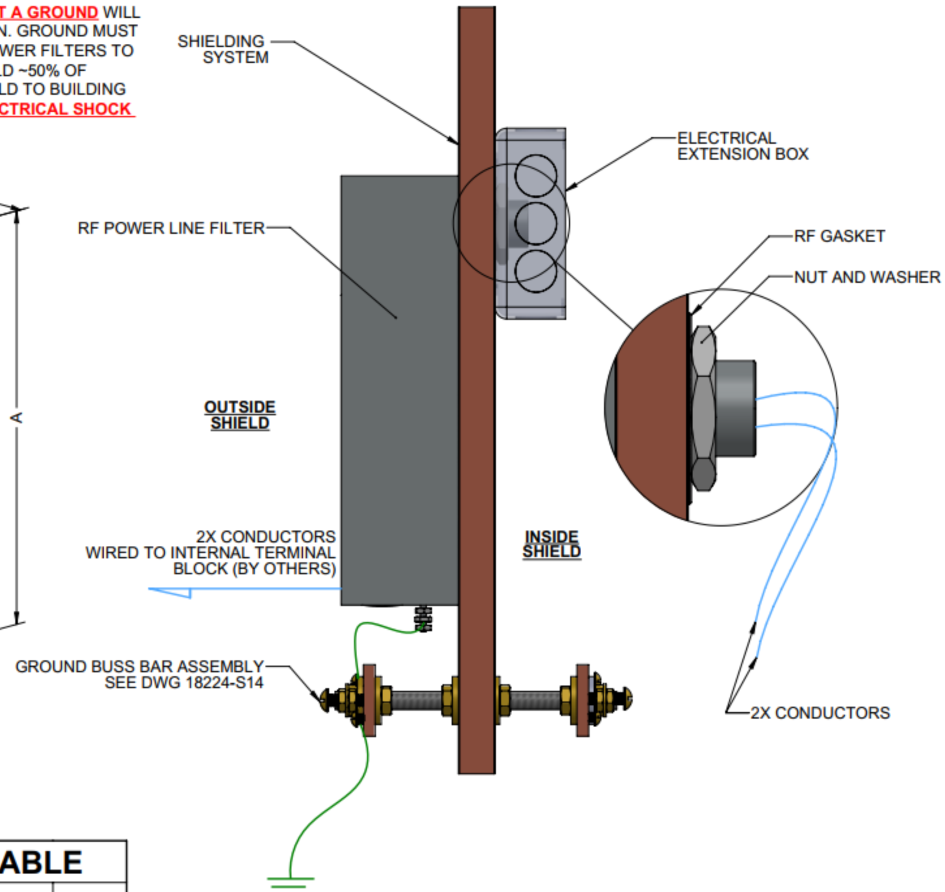


NOTE: According to the OEM & machine capacity the CRYO penetration and its size changes.

WARNING NOTE:
CONNECTION OF THE POWER FILTERS **WITHOUT A GROUND** WILL CAUSE A POTENTIALLY **DANGEROUS** CONDITION. GROUND MUST BE CONNECTED PRIOR TO ENERGIZING THE POWER FILTERS TO PREVENT VOLTAGE BACK FEED INTO THE SHIELD ~50% OF APPLIED VOLTAGE WILL PRESENT ON THE SHIELD TO BUILDING GROUND IF NOT ADDRESSED, CAUSING AN **ELECTRICAL SHOCK HAZARD.**



TYPICAL FILTER DETAIL

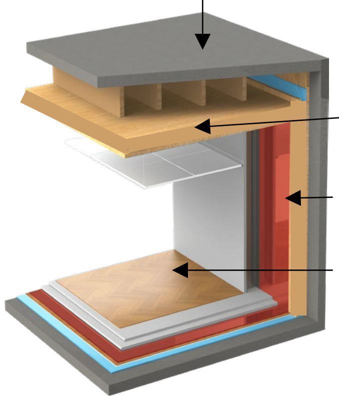


RF POWER FILTER DETAIL
N.T.S.

FILTER PROPERTIES TABLE

RATING (AMP)	MAX. VOLTAGE RATING	HEIGHT (A)	WIDTH (B)	DEPTH (C)	PIPE OFFSET (D)
2X30A	277VAC-600VDC	10-1/16"	4-3/8"	3	1-3/4"

Copper RF Shielding



- Finish Floor
- Double Layer of Durock Concrete Board
- 3oz Copper Shield
- Masonite Dielectric
- Magnetic Shielding (If applicable)
- 6 mil Vapor Barrier

Performance & Stats

- **Attenuation -** Achieves **100+ dB** attenuation, blocking nearly all RF interference.
- **Conductivity** - **5.96×10^7 S/m** (Siemens per meter), the highest among common materials.

Architectural Considerations

- **Integration -** Copper is versatile and can be installed on most surfaces, but its weight may require structural reinforcement in certain building designs.
- **Flexibility -** It can be shaped to fit any room configuration, including custom designs.

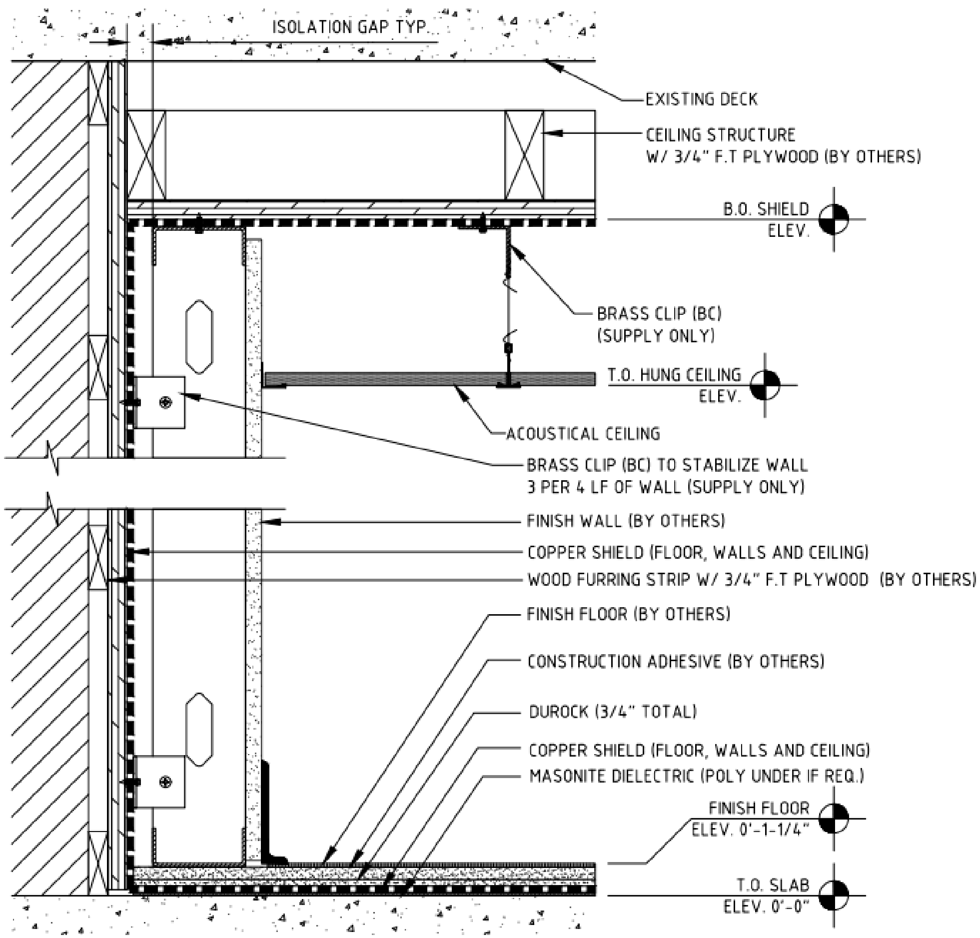
- **Cost -** Higher upfront costs due to the price of copper, but long-term durability justifies the investment.
- **Durability-** Highly resistant to corrosion, making it ideal for MRI rooms that may remain in use for decades.

Works best for

- High-performance MRI suites in facilities where image quality is paramount.
- Large hospitals or imaging centers where budget allows for premium materials.

Construction Details

B·1 Wall Section (Ceiling to floor)
B·2 RF Door – Outswing
B·3 RF Door – Inswing
B·4RF Window
B·5 Sprinkler Waveguide / Medical Gas Waveguide
B·6 HVAC Waveguide
B·7 Hanger Detail
B·8 CRYO Penetration Details
B.9 RF Power Filter Details



RF WALL SECTIONS
SCALE: 3"=1'-0"

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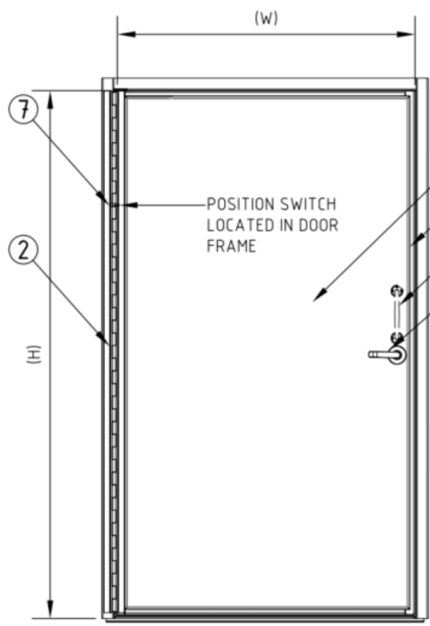
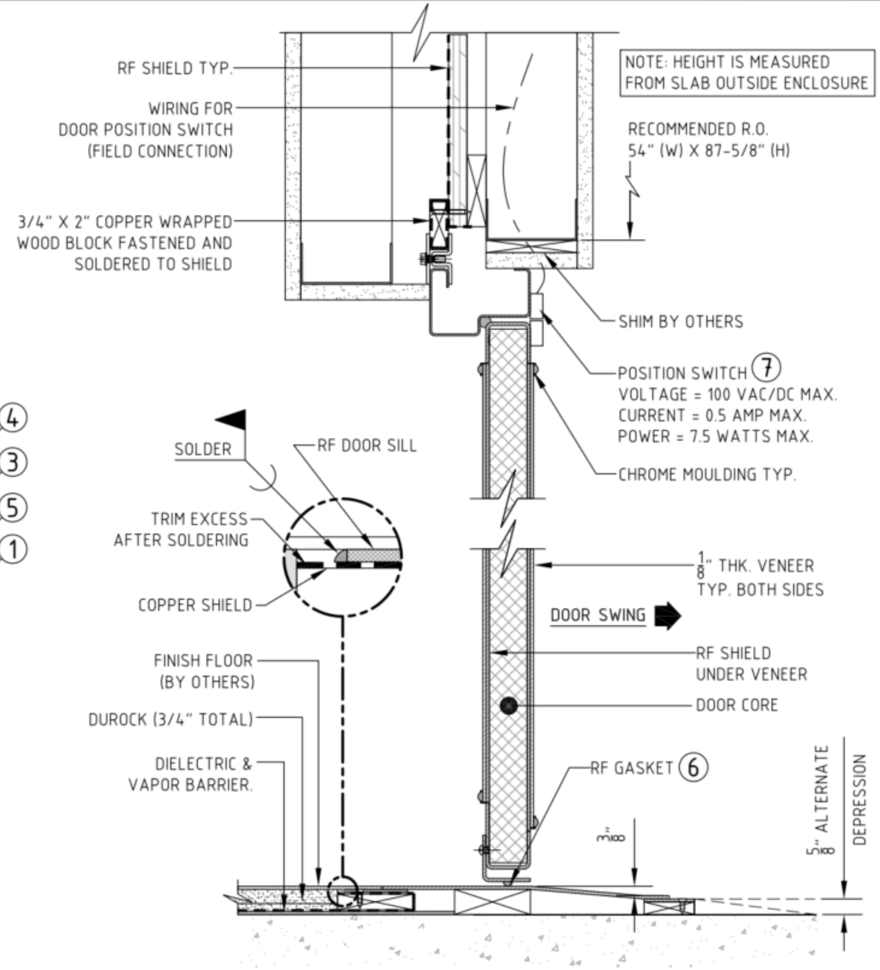
4	1	VENEER- SEE SCHEDULE
5	1	'D' PULL BATTALION, #5U628
6	1	GASKET, SG375500-48
7	1	DOOR POSITION SWITCH



(VIEW FROM OUTSIDE SCAN ROOM)
RIGHT HAND SHOWN LEFT HAND OPPOSITE

DOOR ELEVATION DETAIL

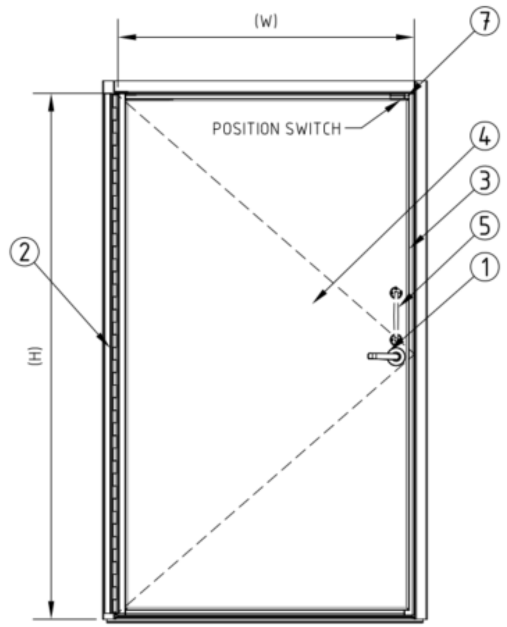
SCALE:3/4"=1'-0"



DOOR SECTION A DETAIL

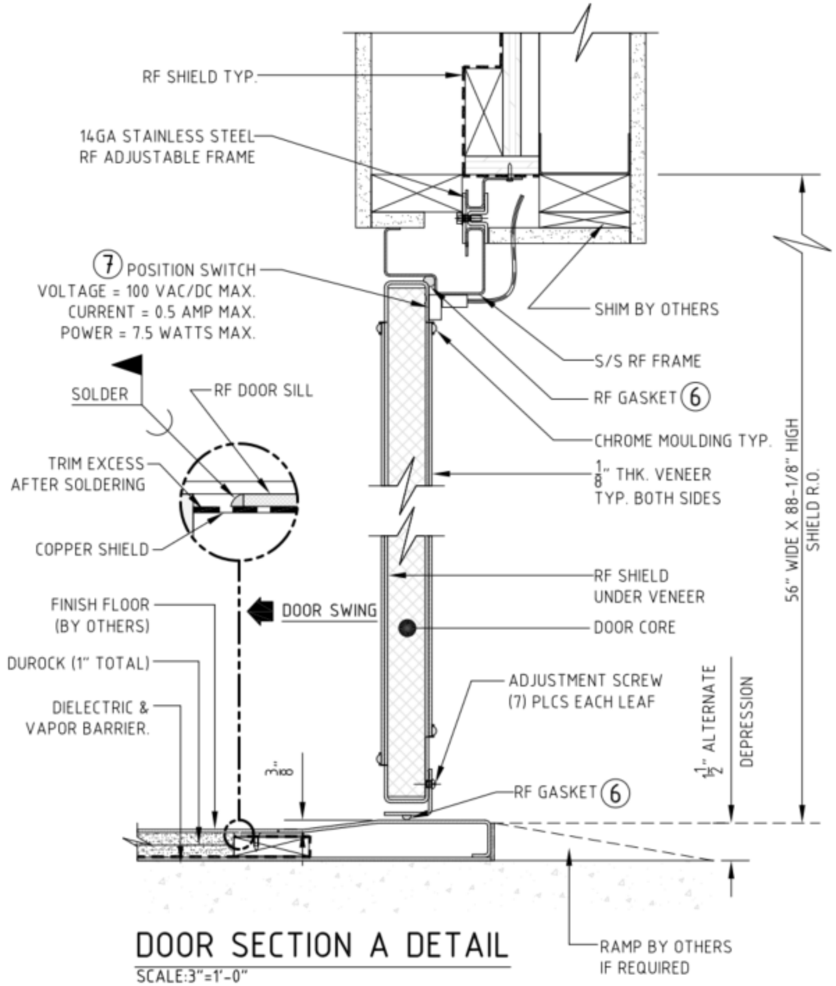
SCALE:3"=1'-0"

ITEM	QTY	DESCRIPTION
1	1	SARGENT CLASSROOM LOCK (A.D.A.) TYPE 11G37
2	1	CONTINUOUS HINGE, FULL #081390
3	1	GPS RF DOOR ASSEMBLY
4	1	VENEER- SEE SCHEDULE
5	1	'D' PULL BATTALION, #5U628
6	1	GASKET, SG375500-48
7	1	DOOR POSITION SWITCH

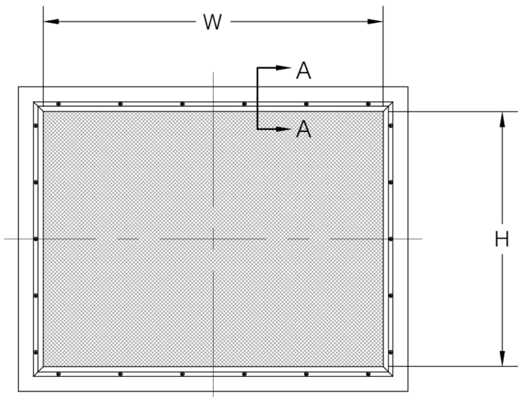


(VIEW FROM INSIDE SCAN ROOM)
RIGHT HAND SHOWN LEFT HAND OPPOSITE

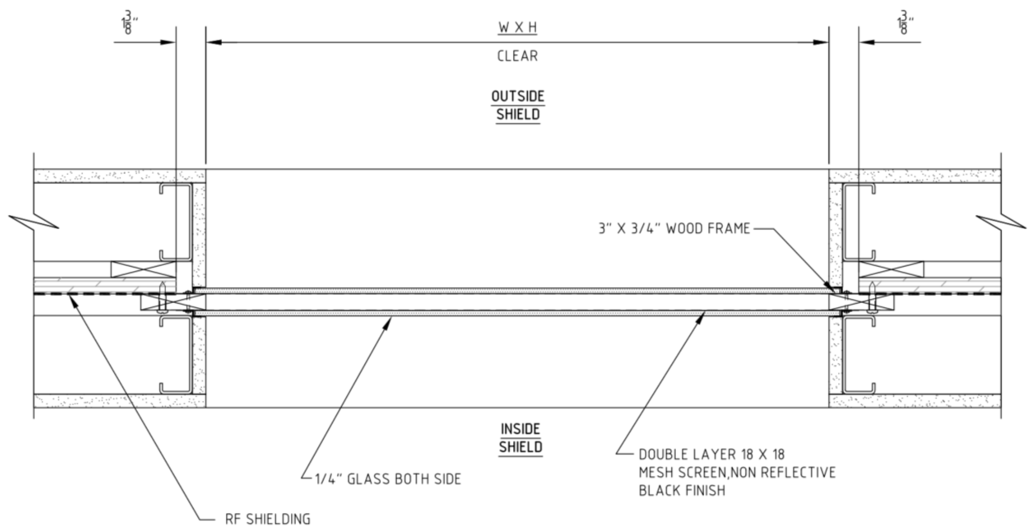
DOOR ELEVATION DETAIL
SCALE:3/4"=1'-0"



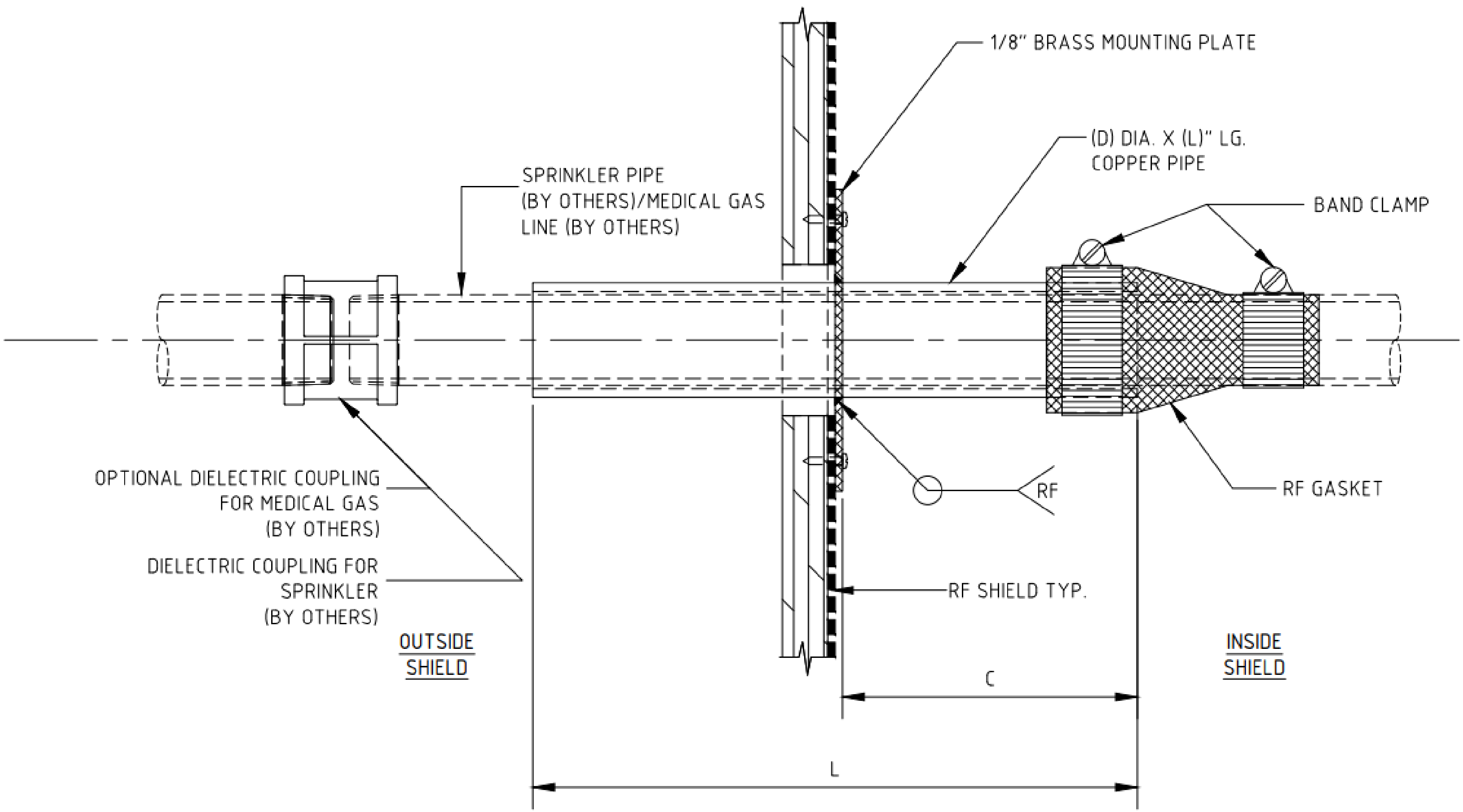
DOOR SECTION A DETAIL
SCALE:3"=1'-0"



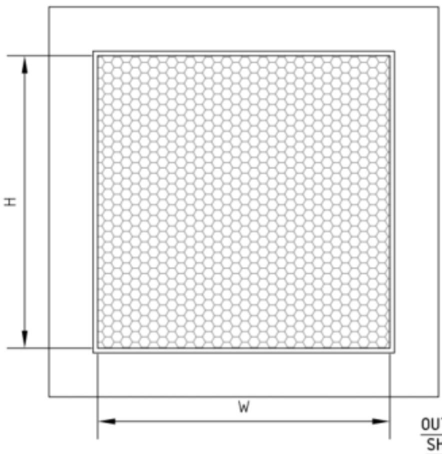
W
A
A
H

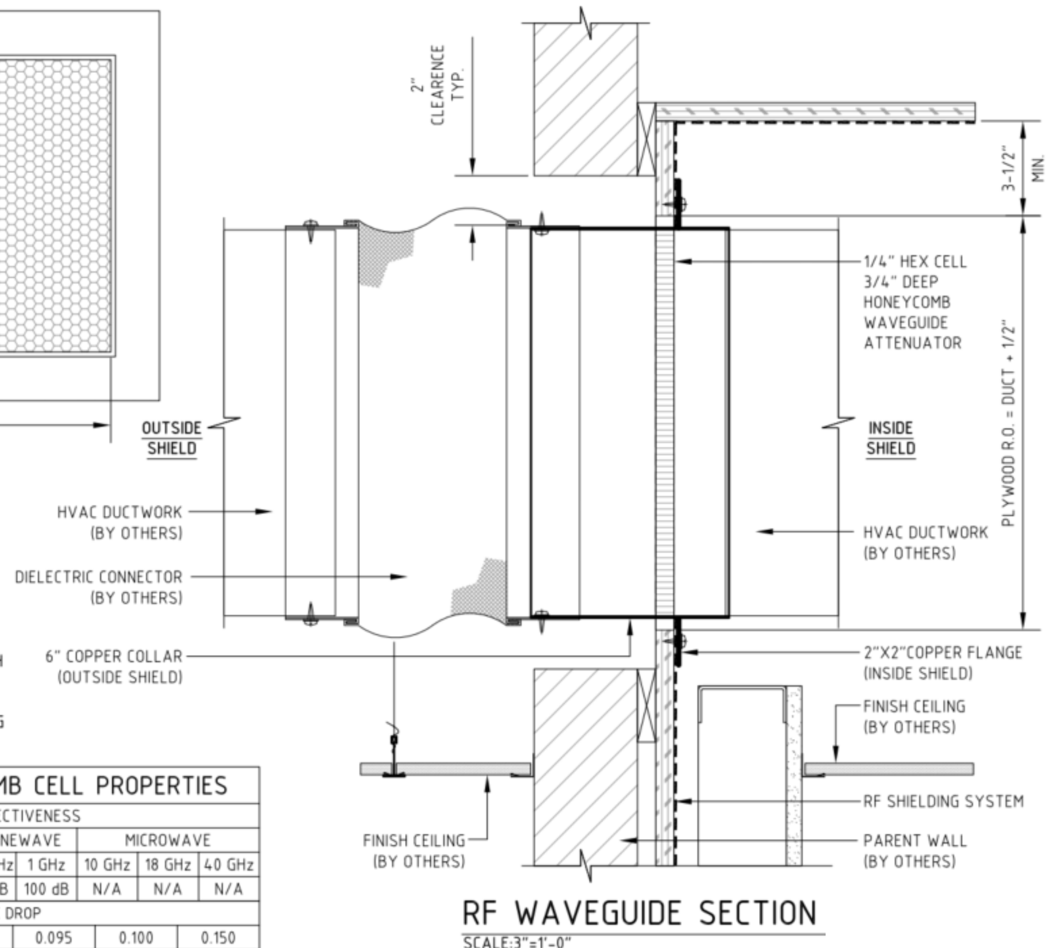


3/8"
W X H
CLEAR
3/8"
OUTSIDE SHIELD
3" X 3/4" WOOD FRAME
INSIDE SHIELD
1/4" GLASS BOTH SIDE
DOUBLE LAYER 18 X 18 MESH SCREEN,NON REFLECTIVE BLACK FINISH
RF SHIELDING



1/8" BRASS MOUNTING PLATE
(D) DIA. X (L)" LG.
COPPER PIPE
BAND CLAMP
SPRINKLER PIPE
(BY OTHERS)/MEDICAL GAS
LINE (BY OTHERS)
OPTIONAL DIELECTRIC COUPLING
FOR MEDICAL GAS
(BY OTHERS)
DIELECTRIC COUPLING FOR
SPRINKLER
(BY OTHERS)
RF
RF GASKET
RF SHIELD TYP.
OUTSIDE
SHIELD
INSIDE
SHIELD
C
L





RF WAVEGUIDE SECTION

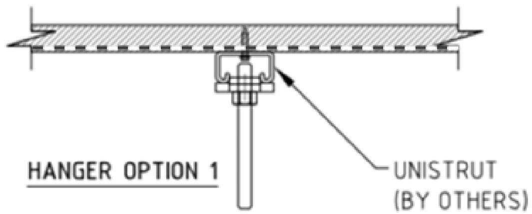
SCALE:3"=1'-0"

NOTES:

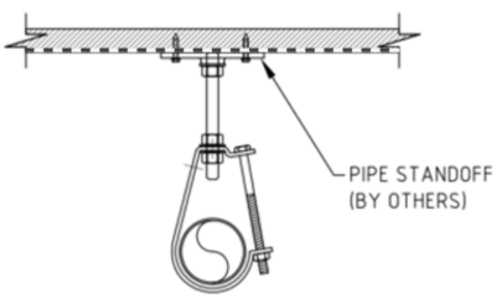
1. DETAIL ILLUSTRATES A VERTICAL PENETRATION THROUGH THE WALL. HORIZONTAL PENETRATIONS THROUGH THE CEILING ARE SIMILAR.

2. SEE SCHEDULE OF VALUES ON DWG 050 FOR WAVEGUIDE SIZES.

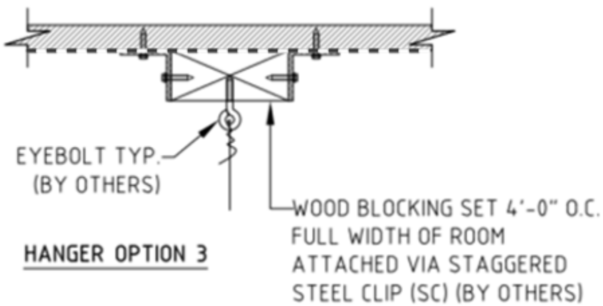
1/4" X 3/4" HONEYCOMB CELL PROPERTIES								
SHIELDING EFFECTIVENESS								
MAGNETIC		ELECTRIC		PLANEWAVE		MICROWAVE		
1 kHz	20 kHz	100 kHz	10 MHz	100 MHz	1 GHz	10 GHz	18 GHz	40 GHz
25 dB	100 dB	100 dB	100 dB	100 dB	100 dB	N/A	N/A	N/A
PRESSURE DROP								
INCHES OF WATER	0.065	0.095	0.100	0.150				
AT FEET PER MINUTE	800	1000	1200	1400				



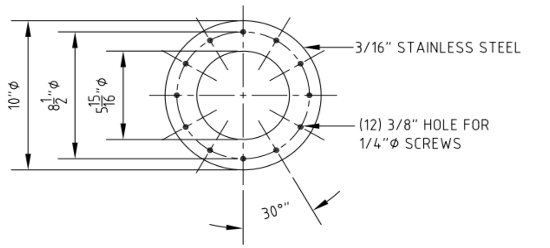
HANGER OPTION 1



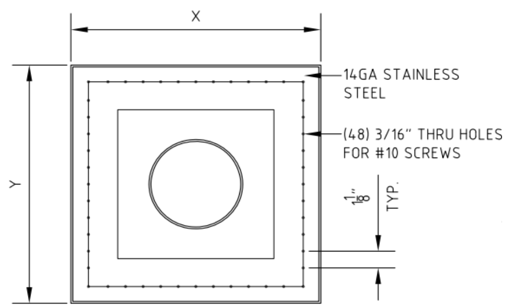
HANGER OPTION 2



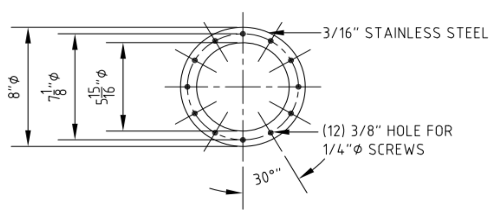
HANGER OPTION 3



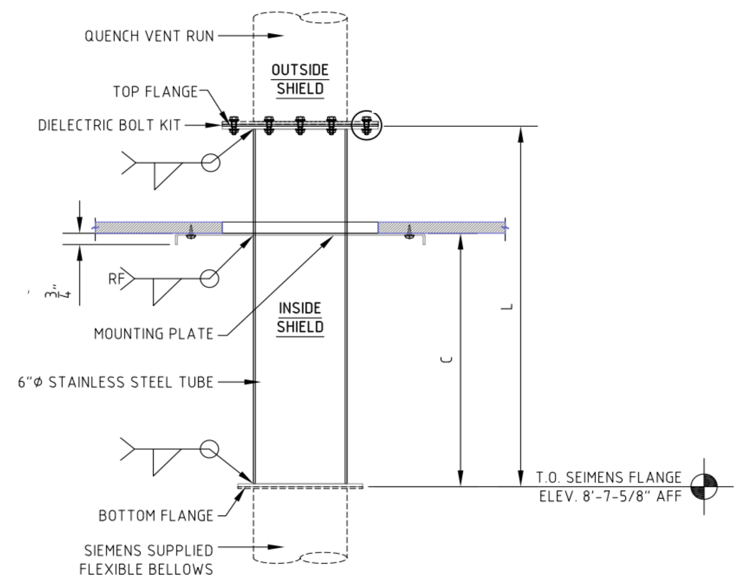
TOP FLANGE DETAIL



MOUNTING PLATE DETAIL

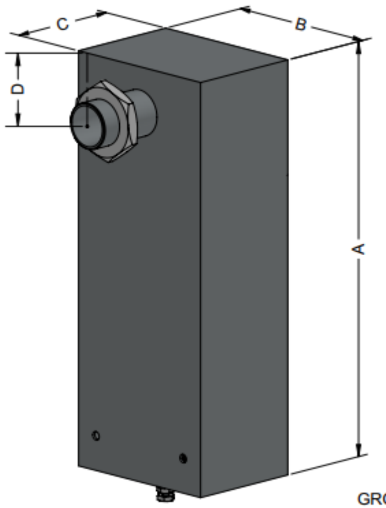


BOTTOM FLANGE DETAIL

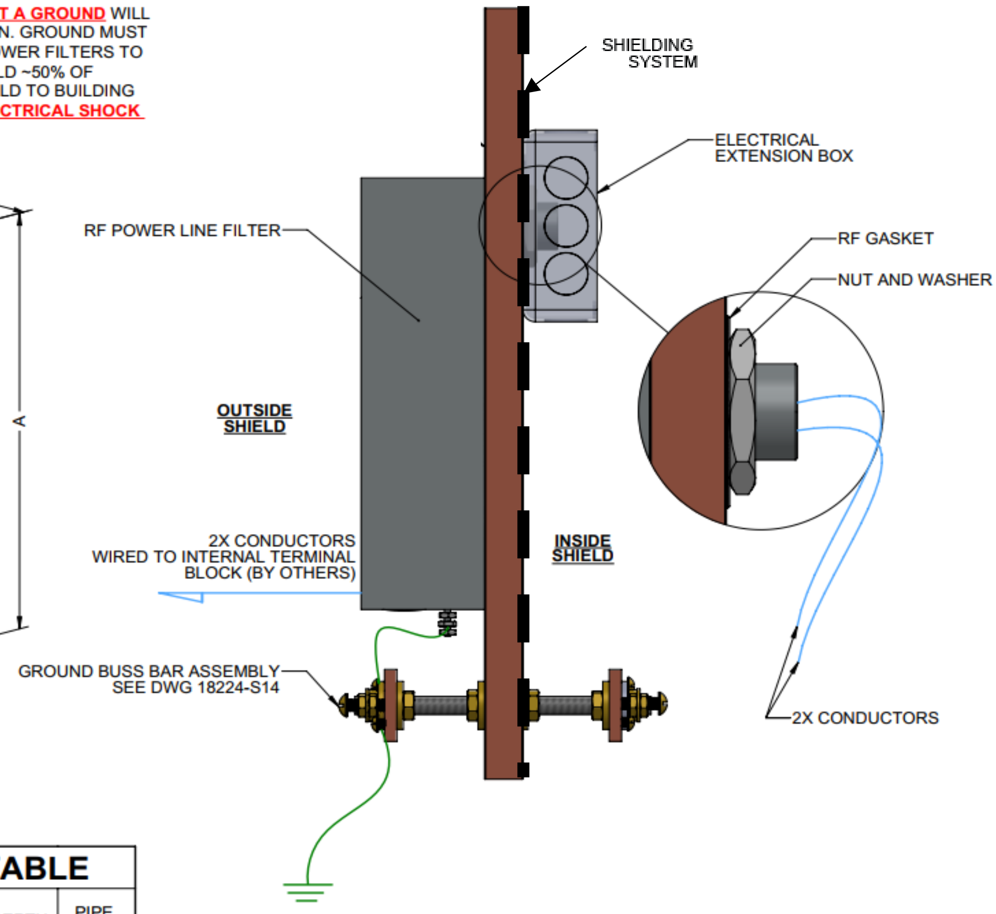


NOTE: According to the OEM & machine capacity the CRYO penetration and its size changes.

WARNING NOTE:
CONNECTION OF THE POWER FILTERS **WITHOUT A GROUND** WILL CAUSE A POTENTIALLY **DANGEROUS** CONDITION. GROUND MUST BE CONNECTED PRIOR TO ENERGIZING THE POWER FILTERS TO PREVENT VOLTAGE BACK FEED INTO THE SHIELD ~50% OF APPLIED VOLTAGE WILL PRESENT ON THE SHIELD TO BUILDING GROUND IF NOT ADDRESSED, CAUSING AN **ELECTRICAL SHOCK HAZARD.**



TYPICAL FILTER DETAIL



RF POWER FILTER DETAIL
N.T.S.

FILTER PROPERTIES TABLE

RATING (AMP)	MAX. VOLTAGE RATING	HEIGHT (A)	WIDTH (B)	DEPTH (C)	PIPE OFFSET (D)
2X30A	277VAC-600VDC	10-1/16"	4-3/8"	3	1-3/4"

CHAPTER THREE

Magnetic Shielding

3

Moving Metal

Magnetic shielding is critical in mitigating the effects of external magnetic fields on MRI systems. The presence of large metallic masses—such as vehicles, elevators, and electrical infrastructure (e.g., switchgear and transformers)—can induce magnetic field fluctuations that compromise the integrity of MRI imaging. These fluctuations can lead to artifacts and degradation of signal-to-noise ratios, negatively impacting diagnostic outcomes. To maintain optimal imaging conditions, it is recommended to maintain a minimum separation distance of at least 15 feet from potential interference sources. This distance is crucial for preserving magnetic field homogeneity and ensuring high-quality diagnostic images. (Image 4 shows the magnet moving metal sensitivity line plot)

(Note: For precise statistics on the impact of magnetic interference on imaging quality, consult relevant studies and industry guidelines.)

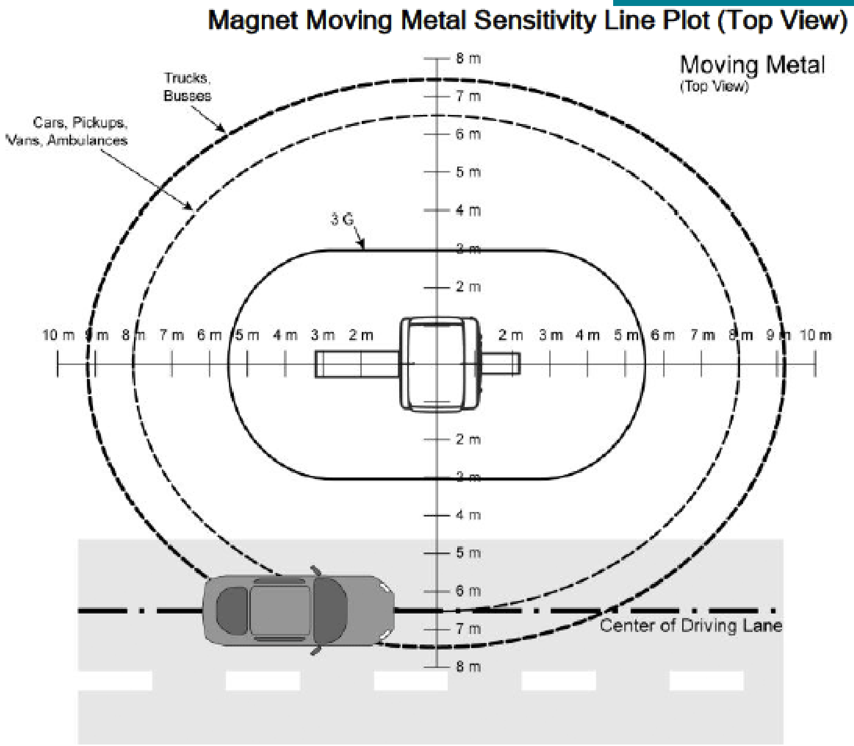


Image 4 : **The Magnet Moving Metal Sensitivity Line Plot**

The presence of moving metal outside the MR suite but interacting with the main magnetic field needs to be considered in site planning. Cars, buses, subways, and elevators may all affect the main fie

Magnetic Interference

Image 5: **Magnetic Shielding Below the MRI Room.**

Current MRI magnetic shielding typically uses silicon steel, ranging from 1/8" to 1" thick, with high-field applications like 11 Tesla MRIs potentially requiring steel plates several inches thick. The MRI system provider is responsible for the magnetic shield design, as each scanner's specifications impact operational integrity and image quality.

Preliminary designs from shielding vendors can aid in budgeting, but final designs must come from the MRI vendor.

Not all MRI installations require magnetic shielding—its necessity depends on MRI model, physical dimensions, and surrounding conditions. Unlike RF shielding, magnetic shielding may not require full enclosure. (Image 5 shows magnetic shielding below the MRI room.

To determine if magnetic shielding is needed, evaluate the MRI's environment, magnetic field strength, and surrounding infrastructure. Consult the MRI manufacturer and ensure EMI and vibration testing is conducted to assess site suitability.

Not all MRI needs Magnetic shielding

Active Magnetic Canceling System (AMCS)

Active magnetic cancellation systems can be employed to counteract environmental magnetic fields. These systems measure the surrounding magnetic environment and generate a canceling field, akin to the noise-cancellation technology in headphones. Their purpose is to shield the MRI system from external magnetic interference, such as that from electrical switchgear, or the movement of large vehicles like trucks and trains. While active magnetic cancellation has proven effective in many cases, it carries inherent risks. If the system fails, there may be limited alternatives, potentially impacting the MRI's operational performance. This risk is heightened by the fact that system effectiveness often cannot be fully verified until after MRI installation.

If an MRI is near a subway, elevator or electrical switchgear or distribution unit, it may require an AMCS. Most MRI, fortunately are not in close proximity of these things and have no need for an AMCS.

Environmental Protection through Magnetic Shielding

Magnetic shielding is essential to prevent the MRI's magnetic field, which can exceed 5 Gauss (0.5 mT) at certain distances, from spreading beyond the MRI room. For context, the earth's magnetic field is around 0.5 Gauss (0.05 mT). Exceeding even 5 Gauss can disrupt nearby electronics, interfere with other medical equipment, and affect devices like pacemakers or implants.

In high-field MRI systems, such as 3T or higher, magnetic fields can reach 50 Gauss (5 mT) or more within a few feet outside the magnet. Proper magnetic shielding reduces this stray field back to safe levels, often below 1 Gauss, by containing it within the room. This containment helps ensure the surrounding areas remain safe and compliant with facility safety standards, allowing adjacent spaces to be used for other clinical or administrative purposes without interference. (Image 6 shows Magnetic Shielding Blocking 5G Signals from Passing Through Walls)

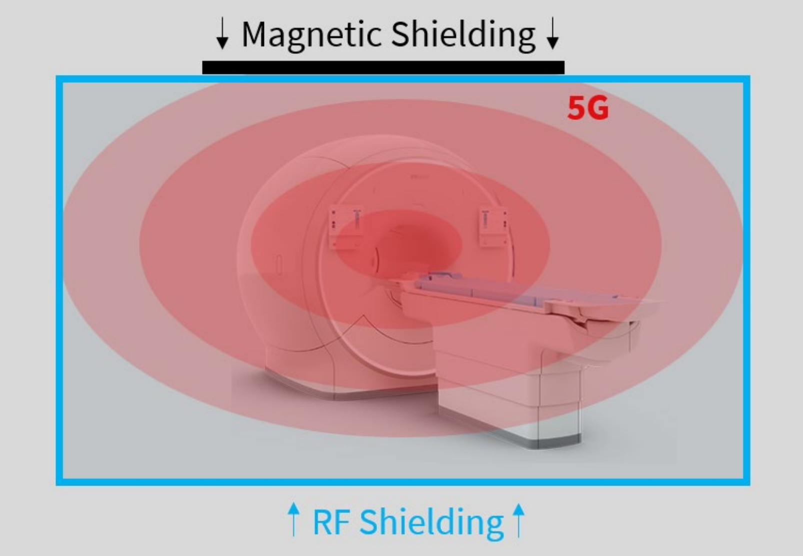


Image 6: **Magnetic Shielding Blocking 5G Signals from Passing Through Walls.**

CHAPTER FOUR

Planning and Design Overview

4

Planning Timeline

The construction timeline for an MRI room can vary depending on several factors, including the complexity of the project, the size of the room, the specific requirements for RF shielding, the availability of materials, and local regulations. However, on average, the construction of a standard MRI room typically takes **3 to 6 months** from start to finish. (Table 1 Shows the sample Gantt chart)

Here's a general breakdown of the timeline:

- **Planning and Design (4-8 weeks):** This includes site evaluation, designing the room layout, and coordinating with architects, engineers, and MRI equipment vendors. It also involves obtaining the necessary permits.

- **Site Preparation (2-4 weeks):** This stage includes demolishing existing structures (if necessary), leveling the site, and preparing the space for construction. Utility connections (electricity, plumbing, HVAC) are also set up during this phase.

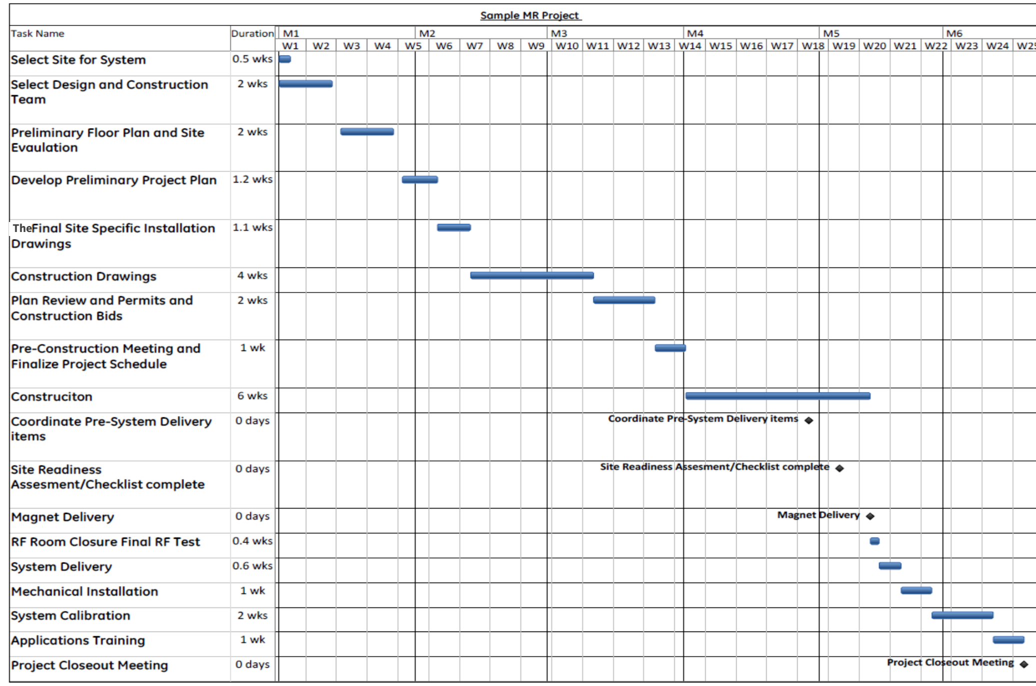


Table 1: **Sample Gantt chart.**

- **Construction and RF Shielding Installation (6-12 weeks):** The room is constructed, including walls, floors, and ceilings, with a focus on installing RF shielding components such as galvanized, copper or aluminum lining, doors, windows, and waveguides.

- **Equipment Installation and Testing (2-4 weeks):** Once the room is built, the MRI machine and associated equipment are installed. This is followed by calibration, testing, and quality checks to ensure everything meets safety and operational standards.

- **Final Inspections and Certification (1-2 weeks):** After construction, the room undergoes final inspections to ensure compliance with all regulatory and safety standards. Once approved, the room is certified for use.

This timeline can be shorter or longer depending on the complexity of the project and the efficiency of the project management process.

Design Considerations

From an architect's perspective, pre-installation specifications for an MRI suite are critical to ensure proper functionality and seamless integration of the MRI system. Key considerations include ensuring the room's dimensions and structural integrity can support the weight and size of the MRI machine, typically requiring reinforced floors. Adequate RF shielding needs to be incorporated into the walls, ceiling, and floor during construction to prevent interference, while the room's layout must account for clear zoning (Zones I-IV) with precise management of the 5-Gauss line. Proper power supply planning is essential, as MRI machines typically require dedicated electrical systems, including uninterrupted power supply (UPS) backups, as well as specialized HVAC systems to maintain temperature and humidity levels. Lastly, routing pathways for equipment delivery must be designed to accommodate the machine's size and weight, ensuring a smooth and safe installation process.

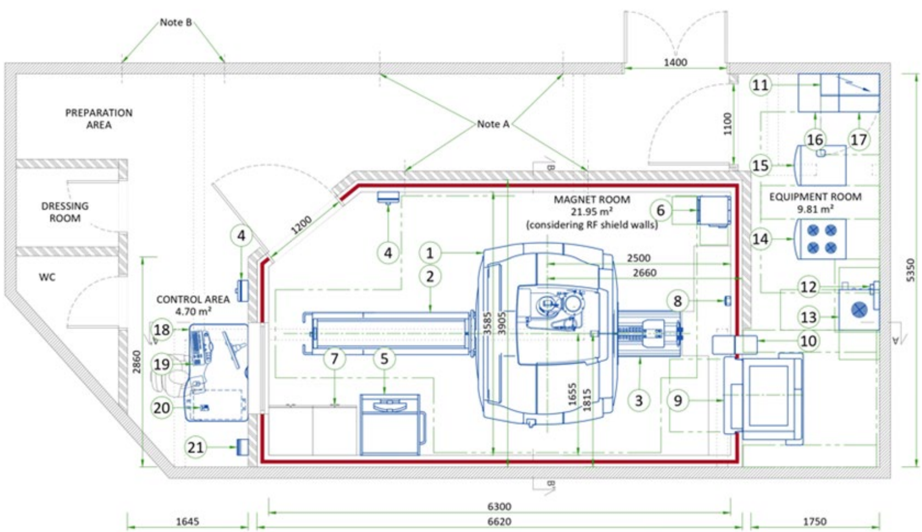


Image 7: **Sample Room Layout**

EQUIPMENT LAYOUT			
ITEM	**DESCRIPTION**	**DIMENSIONS LxWxH (mm)**	**WEIGHT (kg)**
1	MAGNET (MAG)	1938x2468.5x2383	5320
2	FIXED PATIENT TABLE (PT)	2134x572x965	136
3	REAR PEDESTAL (PED)	853x510x956	132
4	MAGNET RUNDOWN UNIT (MRU)	286.6x206.4x172.1	3.2
5	PHANTOM SET STORAGE CABINET (SPT)	825x889x1524	136
6	BLOWER BOX (MG6)	381x453x558	21
7	FURNITURE FOR COILS	650x600x1200	-
8	OXYGEN REMOTE SENSOR (OM2)	121x121x78	0.9
9	SYSTEM CABINET (SC)	1250x960x2200	890
10	PENETRATION PANEL (PP)	250x800x750	-
11	POWER DISTRIBUTION BOX (PDB)	800x300x1000	64
12	MAGNET MONITOR (MON)	381x260x127	4.5
13	AIR COOLED SHIELD/CRYO COOLER COMPRESSOR (CRY)	550x550x885	142
14	WATER CHILLER FOR SYSTEM CABINET (WC2)	544x705x811	100
15	WATER CHILLER FOR BRM GRADIENT COIL (WC1)	544x705x811	134
16	11.5 kVA STEP DOWN TRANSFORMER FOR CRY	552x518x712	160
17	4.6 kVA STEP DOWN TRANSFORMER FOR WC1	552x518x712	160
18	OPERATOR WORKSPACE (OW)	1300x875x750	57
19	OPERATOR CONSOLE (GOC)	-	64
20	PNEUMATIC PATIENT ALERT (PA)	101.6x76.2x63	0.2
21	OXYGEN MONITOR (OXY)	214x266x150	4

(hatched)	WALL - ACCORDING TO RECEIVED DRAWING
(dotted)	WALL TO DEMOLISH
(hatched)	WALLS - RECOMMENDED MODIFICATIONS BY GE
(red)	RF SHIELD - 100 dB ATTENUATION

EXAM ROOM HEIGHT	
FINISHED FLOOR TO SLAB HEIGHT	3.14 m
FALSE CEILING HEIGHT	2.70 m

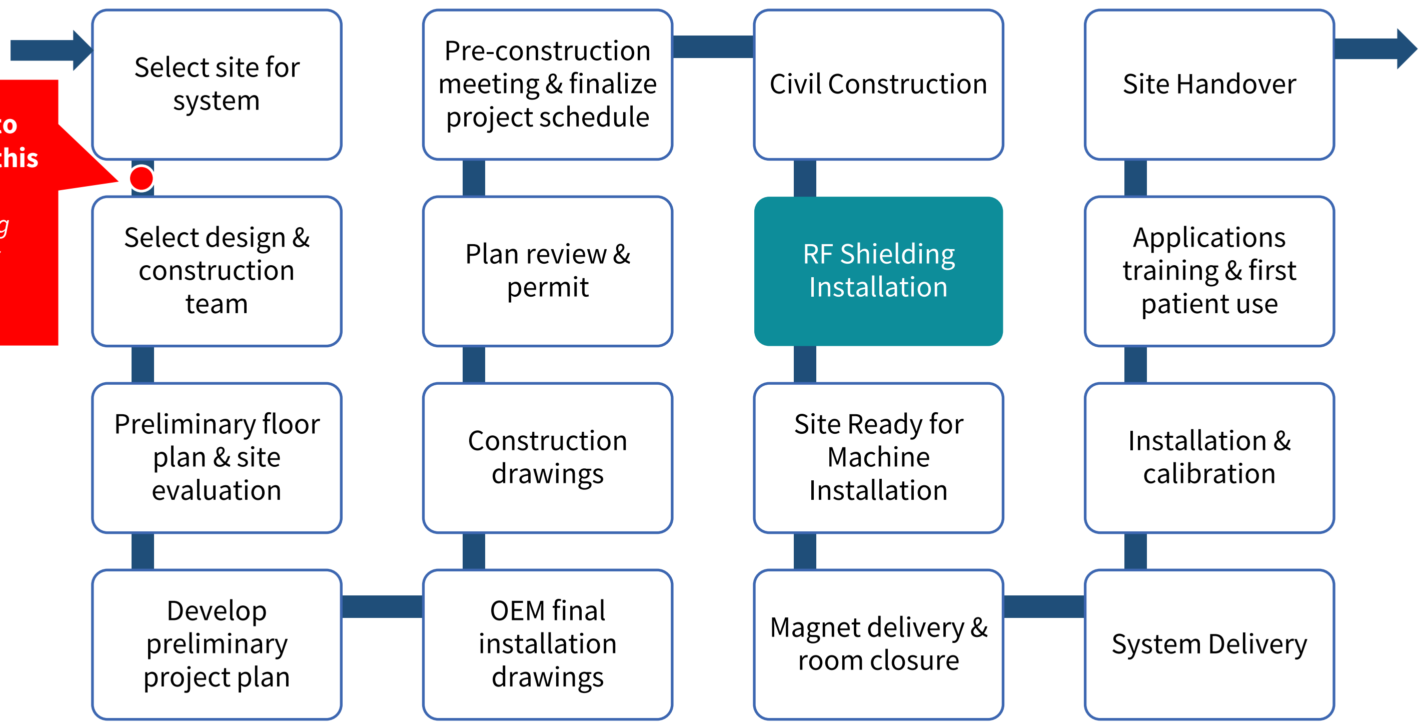
Table 2: **Equipment Layout**

Project Plan

Process Flow

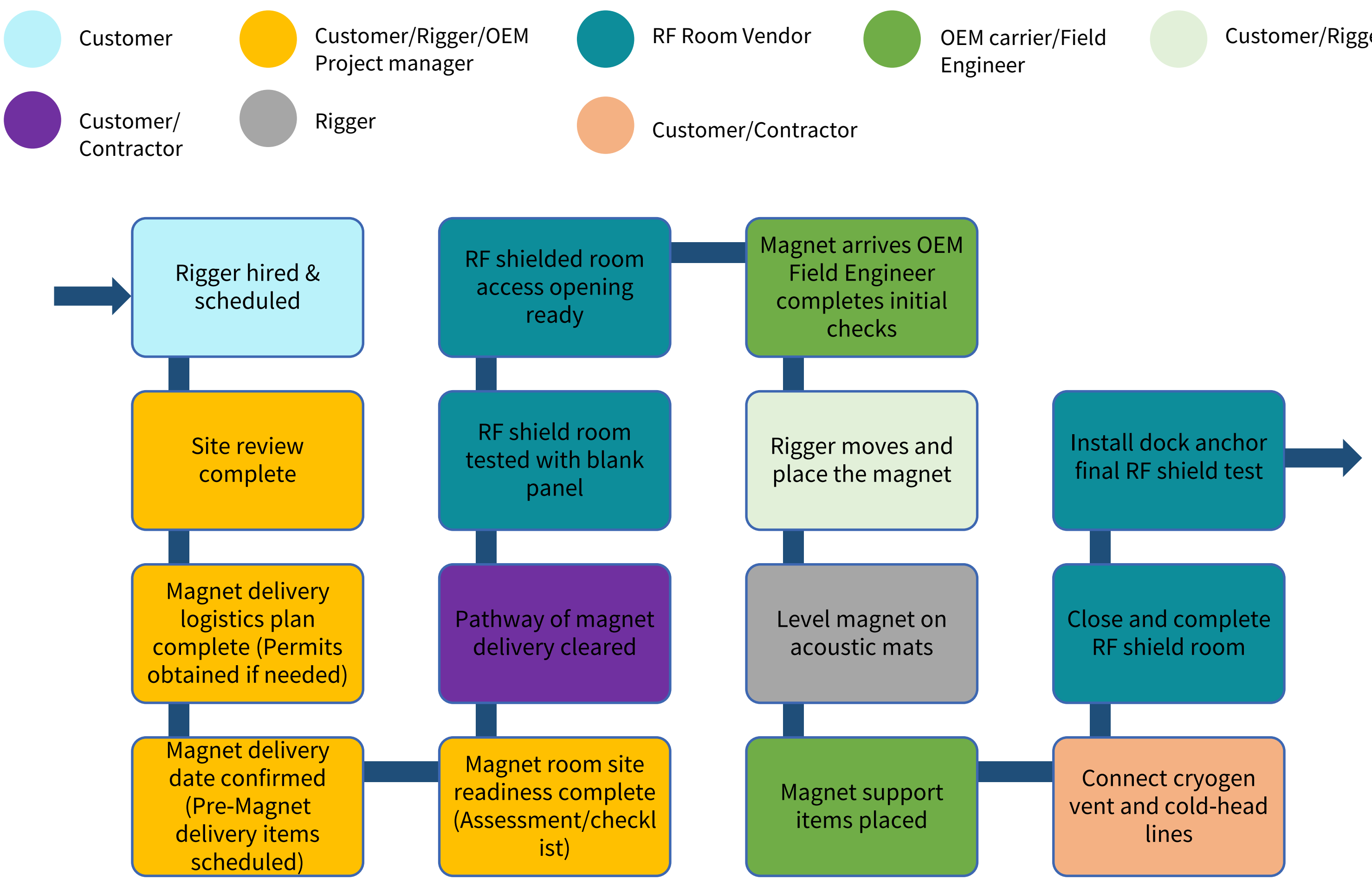
An understanding of the process steps by team members supports the creation of an objective schedule flow and do this, all team members should have a good understanding of the steps in this process. This process flow describes the typical project implementation process steps. Determine if your project has special needs not addressed by this typical process flow and develop a specific schedule for your project. Machine vendor will provide you with assistance during various steps of your site preparation project as indicated in this guide.

When do you have to call the RF vendor in this process?
"Contacting a shielding company early is best practice"



Scan to get in touch with us

Magnet Delivery - Roles and Responsibilities



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CHAPTER FIVE

Testing & Commissioning

5

RF Testing

We conduct shielding effectiveness tests to evaluate the ability of a shielded enclosure, such as an MRI room, to block electromagnetic interference (EMI) and maintain the integrity of the MRI's imaging quality. Shielding effectiveness is typically measured in **decibels (dB)** and reflects how well the RF shielding materials attenuate electromagnetic signals. For MRI applications, effective shielding is crucial to prevent external RF signals from distorting imaging, which can compromise diagnostic accuracy. Key components such as doors, windows, and the north, south, east, and west walls must all undergo rigorous testing to ensure they meet the required attenuation levels. For MRI suites, shielding is often designed to block frequencies from 10 kHz to 10 GHz, and typical attenuation requirements range between 100 dB to 120 dB, depending on the level of protection needed.

Testing must adhere to **IEEE STD 299**, which is the recognized standard for measuring the shielding effectiveness of enclosures. IEEE STD 299 outlines the methodologies for performing comprehensive tests at different frequencies to assess the attenuation properties of each section of the enclosure, including seams, joints, and penetrations like doors and waveguides. For instance, shielded doors, which are often the weakest points in an RF enclosure, are tested to ensure they provide attenuation comparable to the surrounding walls. Ensuring compliance with IEEE 299 standards not only guarantees that the MRI suite is adequately protected from external interference but also certifies that the room will maintain high imaging fidelity, meeting the safety and performance standards necessary in healthcare environments. (Image 8 Shows Albatross Projects RF test receiver and transmitter picture)

Receiver

Transmitter

Image 8: **shows RF test (Receiver & Transmitter).**

Note: Calibration of RF tools are essential for accurate measurement.

Measurement Procedure

Image 9 Illustration: ***Antenna Positioning***

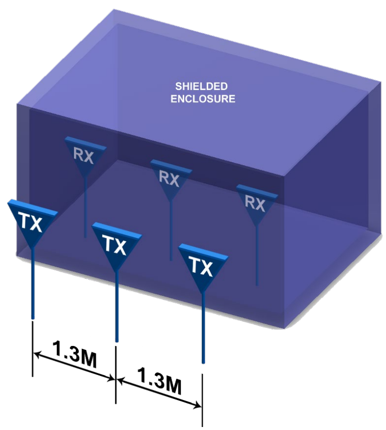
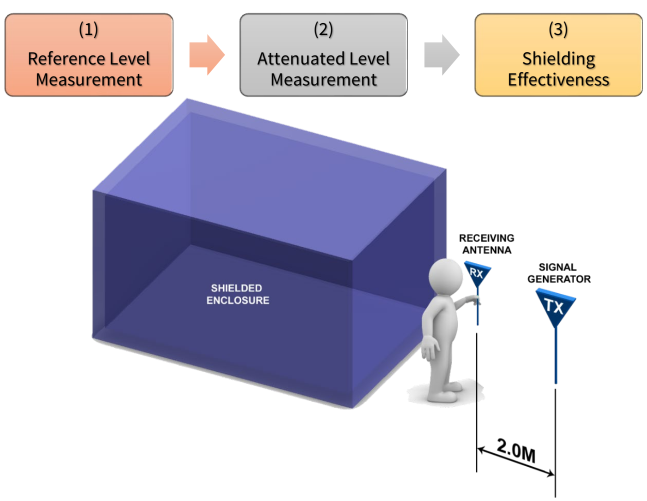


Image 10 Illustration: ***Reference Level Measurement***



Measurement Procedure

- Each wall of the R.F. shielded room that is accessible for the measurement will be tested. For areas that are inaccessible for the direct location of the transmitting antenna, the inside of that area will still be scanned using the receiving antenna with the transmitting antenna positioned as close as possible to the intended test position, that position will be noted on the test data document.
- Each accessible plane of the wall is subdivided so that the horizontal spacing is no more than 1.3 m Ref Image 9 (4 ft 3 in.) for the Transmit Antenna (TX) and Receive Antenna (R.X.) horizontal positions.
- Measurements are taken with a vertical antenna polarization. Both Transmit (TX) and Receive (R.X.) antennas will be aligned with the same polarization.
- For localized testing of shielded room items such as doors, windows, filters, penetration areas, etc. the transmitting antenna (as well as receiving antenna) will be positioned in front of the items that is being test

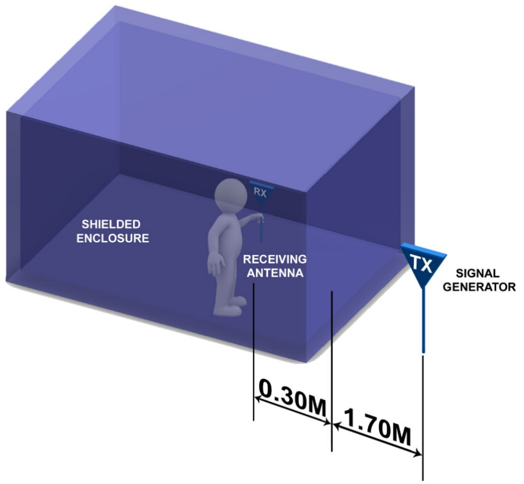
Reference Measurement

- The reference level is the value of signal measured by the receiver equipment with the receiving antenna located at a prescribed distance from the transmit antenna and located outside of the shielded enclosure. Ref Image 10

Attenuated Level

- Both Receive and Transmit Antennas are in Vertical Polarization
- In all the following measurements the Receive Antenna is held in Vertical Polarization and kept at a distance of 0.3 m from the wall
- Starting with the Receive Antenna directly parallel to the Transmit Antenna begin to slowly move the Receive Antenna in a Volume Parallel to the shielded room wall 1 m above the initial position and 0.3 m above the floor (measure 0.3 m from the floor to the bottom of the antenna) and 1 m to the left and right of the initial position. Ref Image 11.
- Measure and record the highest power in this volume
- Take test on all possible sides of the shielding specially the penetration points, doors, windows etc..

Image 11 Illustration: **Attenuation Level Measurement**



Test Results

Any value above 100dB is an excellent shield effectiveness. Always refer to the OEM vendor manual for the required effectiveness.

Grounding Monitor

The grounding resistance in an MRI suite is typically measured *against the earth ground or the building's main grounding system. The goal is to achieve a resistance of 1 ohm or less between the MRI room's RF shield and this ground reference. This standard is based on IEEE and NEC recommendations to ensure efficient dissipation of fault currents and electromagnetic interference (EMI).

Achieving a low resistance is critical because high resistance values can hinder the effective grounding of electrical surges, potentially leading to safety hazards or equipment malfunction. The grounding resistance is measured using an ohmmeter, and values higher than 1 ohm may indicate insufficient bonding or inadequate grounding infrastructure, requiring corrective actions like improving ground rods, bonding connections, or reducing path impedance to ensure compliance with safety standards such as IEEE 142, NFPA 99, and NEC NFPA 70 (Article 250). (Image 12 shows the Albatross Projects Ground Monitor)

Image 12: **Ground Monitor**

start with trust.

Albatross Projects

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