GE HealthCare

RF Shielded Room

Preinstallation Requirements for MR Systems

5850260-1EN
Revision 5

Language Policy

DOC0371395 - Global Language Procedure

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Contents

1 Purpose

1.1 Who Should Read This Manual

The following personnel must be aware of the contents of this manual:

Icon	Personnel
	RF Vendor
	Architect

1.2 Introduction

This document details the RF shielding requirements for the Magnet Room for all new production systems. This information was previously located in the system Preinstallation Manual. Since there are common elements to RF shielding requirements for the different systems and magnets, this manual has been created, and the RF shielding requirements have been removed from the individual system Preinstallation Manual.

1.3 RF Shielded Room Purpose

WARNING

MR SYSTEM PERFORMANCE DEGRADATION

Failure to use this equipment in the specified type of shielded location could result in degradation of the performance of this equipment, interference with other equipment, or interference with radio services.

Make sure the RF shield conforms to the requirements in this manual to maintain optimal performance of the MR System.

The RF shielded room is critical to the correct clinical operation of the MR System. RF shielding attenuates the external RF electromagnetic fields. Low RF environments present lower risk to RF impacts to image quality. The RF shielding must also prevent the MR System RF emissions from interfering with RF receiving systems such as other MR Systems, aircraft control and communication systems. Refer to *IEC EMC Compliance Preinstallation Requirements for MR Systems*, 5850261-1EN.

RF shielding requirements consider the current RF environment at the site as well as future conditions, such as expansion, with the addition or upgrade of multiple MR Systems, as well as changes to the RF environment at the time of installation. The RF shielding requirement also considers the expected degradation over time from the RF shielded room from corrosion and use.

The overall RF shielding performance aims to address:

1. IEC EMC Regulatory Compliance
2. MR Clinical image quality for the life of the product

2 Background

2.1 RF Interference from Electronic Devices in the Magnet Room

The MR System operates with a highly sensitive RF receiving front end to be able to capture the signal of an object scanned. The Magnet Room part of the MR System installation provides the RF isolation to reduce the interference from electrical devices outside the shielded location.

It is possible that any device that functions with active electronic circuitry may potentially interfere with the operation of the MR System if such device is introduced inside the Magnet Room even though the device does not have an intentional RF Transmitter. Extreme EMC measures must be taken into account in the design and manufacturing of an electrical device if such device is intended to operate inside the Magnet Room.

Devices that may potentially interfere with the MR System if introduced inside the Magnet Room are those containing active electronics. Some examples include: Switching Mode Power Supply (SMPS), microprocessor, Digital Signal Processors, analog to digital converters, LCD displays, keypad controllers, motors, battery operated devices.

Avoid thermostats, nurse calls, and smoke detectors that are digital or addressable in the magnet room.

2.2 RF Definitions

Broadband Interference

Broadband interference is caused by electrical discharge within the Magnet Room. Potential sources of interference can be reduced by limiting static discharge, ensuring all metal-to-metal contact is tight and secure, and ensuring all electrical and grounding requirements are met.

Discrete Interference

Discrete interference is fixed-frequency, narrowband RF noise. Potential sources of discrete interference are radio station transmitters and mobile RF transmitting devices. Magnet Room RF shielding prevents external RF energy from entering the room and degrading the MR System RF receivers.

Electromagnetic Environment

The totality of electromagnetic phenomena existing at a given location.

Plane Wave

An electromagnetic wave which predominates in the far-field region from an antenna (or source), and with a wave front which is essentially a flat plane.

Penetration

The passage through a partition or wall of an equipment or enclosure by a wire, cable, pipe, waveguide, or other conductive object.

Shield

A housing, screen, or cover which substantially reduces the coupling of electric and magnetic fields into or out of circuits or prevents the accidental contact of objects or persons with parts or components operating at hazardous voltage levels.

Shielding Enclosure (Faraday Cage)

An area (box, room, or building) specifically designed to attenuate electromagnetic radiation or acoustical emanations, originating either inside or outside the area.

Shielding Effectiveness (SE)

A measure of the reduction or attenuation in the electromagnetic field strength at a point in space caused by the insertion of a shield between the source and that point.

Primary Ground

All RF shield components (walls, floor, ceiling, and so on) must be electrically bonded together to form one common ground plane which is connected to the Facility Grounding Conductor.

Secondary Ground

Other grounds that connect the outside of the RF shielded room to earth grounds are called secondary grounds.

3 Requirements

3.1 Customer Responsibilities

The Customer is responsible for:

1. The selection of a quality RF shielded room vendor who understands the RF shielding room purpose described in 1.3 RF Shielded Room Purpose on page 6.

   NOTE

   On request, the GE Healthcare Project Manager of Installation (PMI) can supply a list of RF shielding room vendors.

2. Contracting with the RF shield vendor for design, installation, maintenance and repair of the RF shielded room, to include, but not limited to, shielding effectiveness (SE), door threshold, door seal, and pressure equalization vent operation for the life of the MR System. Refer to 3.2 RF Shield Requirements on page 10.

   This includes installation of the dock/table frame anchor(s) and seismic anchoring as applicable. See 3.3 Dock/Table Frame Anchor Mounting Requirements on page 12.

3. To ensure ongoing effectiveness of the RF shield, the customer is advised to:

   - periodically clean and inspect the RF access door(s). RF shielding performance of the RF access door(s) is compromised if the door is damaged or if dirt and debris is accumulated on the door perimeter.
   - disallow any unauthorized electrical cables to enter the RF shielded room.
   - disallow any unauthorized modifications to the RF shielded room.

4. In some cases, the RF shielded room is not in a temperature or humidity controlled environment. The customer must take local measures to prevent RF shield effectiveness degradation.

5. Special care should be used when installing all fixtures penetrating the RF shield (for example, vents, electrical conduit, penetration panels, and so on) to ensure the integrity of the RF shielded room is maintained.

6. Refer to the Preinstallation Manual (for the applicable system) for details concerning any Magnet Room openings such as PEN Panel openings and optional service hatch requirements.

3.2 RF Shield Requirements

1. The RF shielded room with installed blank penetration panels shall provide a **minimum of 90 dB** of shielding effectiveness (SE) for the entire room, and a **minimum of 100 dB** of shielding effectiveness for adjacent MRI systems, at the following frequencies:

   (For all 1.5T systems)

   1.1. 63.86 MHz ± 0.5 MHz

   1.2. 51.00 MHz ± 0.5 MHz

   1.3. 76.60 MHz ± 0.5 MHz

(For all 1.49T systems)

1.1. 63.43 MHz ± 0.5 MHz

1.2. 50.66 MHz ± 0.5 MHz

1.3. 76.09 MHz ± 0.5 MHz

(For all 3.0T systems)

1.1. 127.72 MHz ± 0.5 MHz

1.2. 102.20 MHz ± 0.5 MHz

1.3. 153.30 MHz ± 0.5 MHz

(For all 7.0T systems)

1.1. 238.4 MHz ± 0.5 MHz

1.2. 298.0 MHz ± 0.5 MHz

1.3. 357.6 MHz ± 0.5 MHz

Adjacent MRI systems are defined as two or more MRI systems with shared equipment rooms, **or** shared control rooms, **or** magnets with intersecting 0.1 mT (1 G) lines.

GE HealthCare recommends that newly constructed RF shielded rooms achieve 100 dB shield effectiveness to maximize expected performance lifetime.

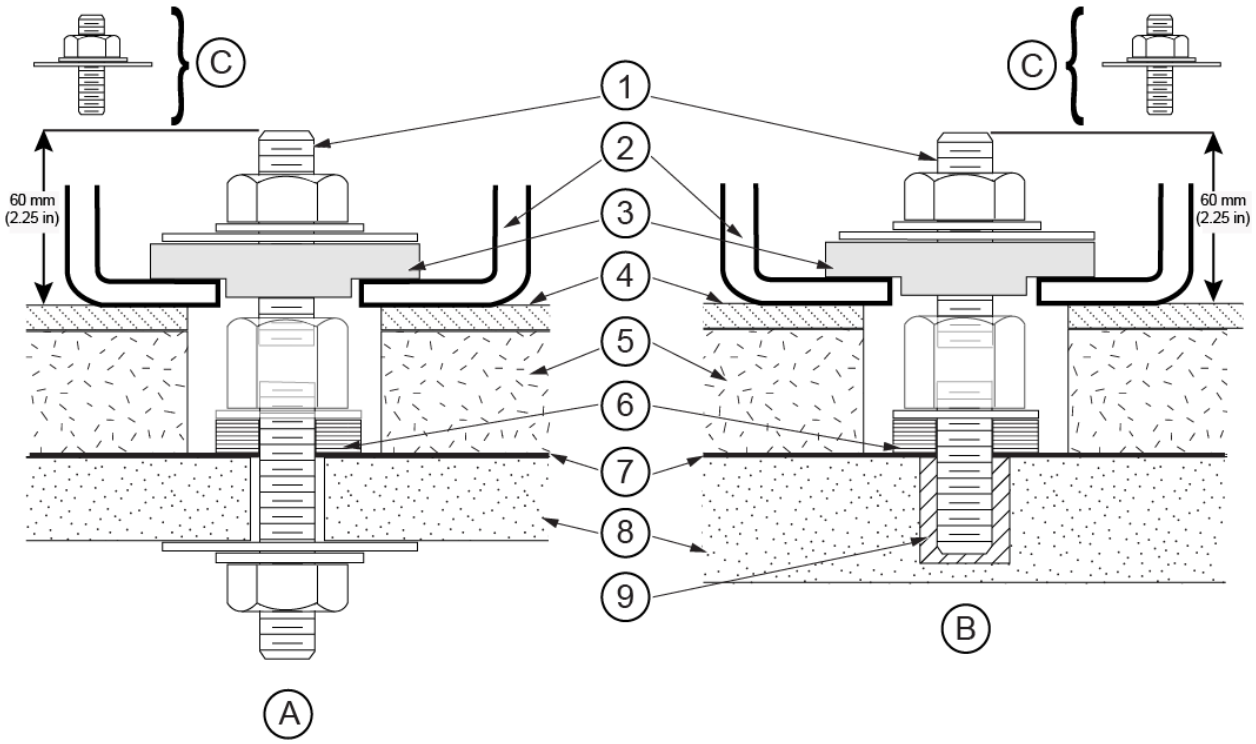
2. The RF shielded room must be isolated from earth ground by more than 1000 ohms DC resistance during construction (before electrical installation).
3. The RF shielded room must be grounded to the RF common ground stud.

   The common ground stud is grounded back to the Power Distribution Unit in the PGR (Power, Gradient, RF) cabinet, System Cabinet or ISC (Integrated System Cabinet) (whichever cabinet ships with the system).

   See Grounding Requirements on page 15 for RF shield room grounding details.
4. RF shielded room installation materials must meet steel mass limits listed in *Magnet Room Structural Requirements* to keep magnetic field homogeneity. Refer to the Preinstallation Manual for the applicable system.
5. Any moving part (such as doors) must not contain ferrous materials.
6. Any venting in or out of the Magnet Room should follow the requirements in *Magnet Room Venting Requirements*, 5850263-1EN.
7. For systems utilizing Multi-Nuclear Spectroscopy (MNS) Magnetic Resonance Imaging, it is recommended to also perform SE testing at the lowest isotope frequency.

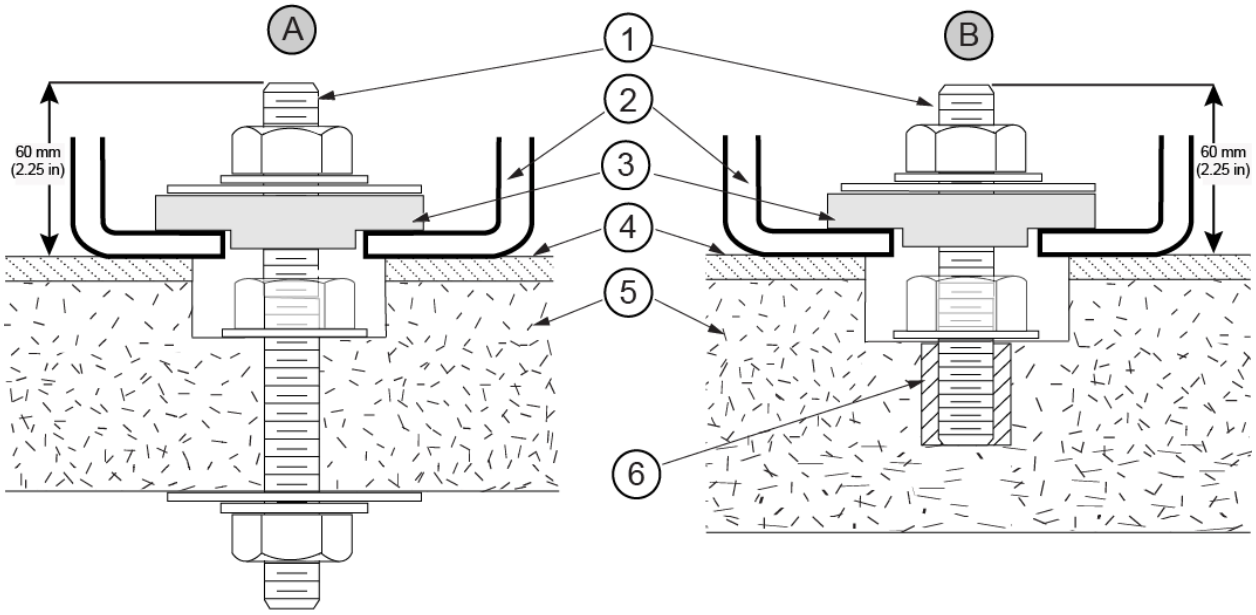
3.3 Dock/Table Frame Anchor Mounting Requirements

Figure 3-1 Dock Anchor Mounting Options (For 1.49T/1.5T/3.0T systems)



Item	Description
A	Bolted Method (cutaway side view)
B	Female Anchor Method (cutaway side view)
C	Removable
1	Removable anchor rod (Male insert)
2	Dock
3	Clamp bracket
4	Finished floor
5	Filler board or grout
6	Conductive fibrous washer (RF seal)
7	RF shield
8	Concrete
9	Female anchor insert

Figure 3-2 Dock Anchor Mounting Options (For 7.0T systems)



Item	Description
A	Bolted Method (cutaway side view) (removable)
B	Female Anchor Method (cutaway side view) (removable)
1	Removable anchor rod (Male insert)
2	Dock
3	Clamp bracket
4	Finished floor
5	Raised floor
6	Female anchor insert

Notes:

- The location of the dock/table frame varies by system. See the appropriate Preinstallation Manual for the correct locations.
- For table frame anchor hole location, refer to the *Finished Room Requirements* section in the Preinstallation Manual for the applicable system.

1. If the system is being installed in an existing MR suite, the original dock anchor must be removed and the hole filled in. The new anchor is reset after the magnet is installed. For upgrades that reuse the existing magnet, contact the PMI for further details about the potential reuse of the old dock anchor.
2. The RF shield vendor must design and install the dock/table frame anchor bolt.
3. The anchor bolt must be installed after the magnet is installed.
4. The dock/table frame anchor must not contact floor rebar or other structural steel.
5. The dock/table frame anchor must electrically contact the RF shield at point of entry.

6. The dock/table frame anchors must have the following properties:
   6.1. Anchors must be two-part assembly (male/female).
   6.2. Female side must be expansion- or epoxy-type.
   6.3. Male side must be a bolt or threaded rod with appropriate-sized nut (bolt or rod must be removable—not epoxied or cemented in place).
   6.4. Anchors must be electrically conductive.
   6.5. Anchors must be non-ferrous.
   6.6. Anchors must not induce galvanic corrosion with the RF shield.
   6.7. Anchors must be commercially procured.
   6.8. If anchoring a table, the anchor rod hole clearance in the table frame anchor base is 11 mm (0.43 in.). The anchor rod diameter must be sized appropriately.
   6.9. Anchors must meet the following clamping force: 2669 N (600 lb.)
   6.10. The anchor rod must extend 40 ± 13 mm (1.57 ± 0.5 in.) above the finished floor.
   6.11. The anchor rod must be less than 152 mm (6 in.) in total length (length above the floor plus embedded length).
   6.12. If the underside of the deck is metallic, then insulating bushing must be added to the through bolt hardware to prevent grounding of the shield at this point.
7. The RF shield vendor must perform a pull test on the anchor (equal to the clamping force). Results must be provided to the GE Healthcare Project Manager of Installation (PMI).

3.4 RF Shielding Integrity (Shielding Effectiveness) Reliability Requirements

1. The RF shielded room must be designed and installed to meet or exceed the 90 dB of shielding effectiveness (SE). See 3.2 RF Shield Requirements on page 10 for conditions where 100 dB of shielding effectiveness is required.
2. The final shielding effectiveness performance of the RF shielded room is determined based on the lowest measurement of all test point locations.
3. The RF shielded room vendor is responsible for testing RF shielding effectiveness and ground isolation resistance. See Chapter 4, *RF Shielding Effectiveness (SE) and Ground Isolation Test Methods*.
4. Ensure all joints and mechanical connections remain secure:
   4.1. All solder joints clean and properly prepared
   4.2. All mechanical fasteners sufficiently tightened and secured
   4.3. Do not use rivets or self-tapping screws (as these tend to loosen over time due to vibration).
5. Prevent RF shield corrosion:
   5.1. Avoid contact between dissimilar metals.
   5.2. Ensure all joints and seams are correctly dressed using correct materials.

NOTE

Sacrificial anodes are recommended.

6. Doors and door frames must be structurally stiff to prevent physical changes to the RF shield.
7. The RF door switch must be installed on the outside wall of the Magnet Room.
   7.1. The RF vendor must supply and install RF door switches on all RF shielded doors.
   7.2. The RF vendor must connect all door switches in series, and then supply a cable with two loose lead conductors. This cable will then connect to a GE-supplied cable.
   7.3. The GE-supplied cable (two loose lead conductors) will attach to the RF vendor-supplied cable.
   7.4. RF switches must be rated for 12V DC maximum and the switches must be in the open position when the doors are open (switch contacts close when the doors are completely closed).

3.5 Electrical Line and Filter Requirements

1. The RF shielded room vendor and electrical contractor must design and install all electrical lines through the RF shielding.
2. The RF shielded room vendor must supply electrical line filters for all lines through the RF shielding (excluding electrical lines through the GE-supplied penetration panels) to ensure compliance with the RF shielded room attenuation requirements.
3. Electrical line filters must be located outside the 20 mT (200 G) line.

3.6 Grounding Requirements

Table 3-1 Grounding Connections by System

System	From	To
SIGNA Pioneer (Standard (On the Wall) Siting configuration)/Hero (Standard (On the Wall) Siting configuration)/Voyager (Standard (On the Wall) Siting configuration)/Champion	ISC Penetration Wall	RF Common Ground Stud (customer-supplied ground cable)
SIGNA Artist Platform/Artist Evo/Pioneer (Remote (Off the wall) Siting configuration)/Hero (Remote (Off the wall) Siting configuration)/Voyager (Remote (Off the wall) Siting configuration)	Penetration Panel (PP)	RF Common Ground Stud with the GE-supplied ground cable
SIGNA Premier/Architect/Artist Legacy/7T/Discovery MR750w, SIGNA PET/MR, and Optima 450w	Penetration Panel (PP) and Secondary Pen Wall (SPW)	RF Common Ground Stud with the GE-supplied ground cable
SIGNA Prime/Prime MAX/ Prime Elite/Creator/Explorer/MR355/ MR360/MR380/Star/Aviator/Victor	System Cabinet	RF Common Ground Stud (customer-supplied ground cable)

1. **For all MR System types:**
   - All power lines into the RF shielded room require an RF filter.

- All electrical devices (for example, outlets, light fixtures, and so on) must have a ground wire from device power source and be grounded to the RF Shield at the RF Common Ground Stud.
- Resistance between any two grounded devices must not exceed 0.1 ohm to ensure equal potential ground system within the Magnet Room.
- Do not ground non-MR equipment to the MR ground system.

2. **(For SIGNA Prime/Prime MAX/Prime Elite/Creator/Explorer/MR355/MR360/MR380/Star/Aviator/Victor)** If needed, electrical devices can be grounded at the Cabinet Rear Panel.
3. The common ground stud must be installed near the penetration point(s) of the GE equipment, into the RF shield between the Equipment Room and Magnet Room.
4. See the appropriate figure below for a typical ground layout for the system being installed.

Figure 3-3 Typical Magnet Room Grounding (For SIGNA Premier/Architect/Artist/Artist Evo/Pioneer (Remote (Off the wall) Siting configuration)/Hero (Remote (Off the wall) Siting configuration)/Voyager (Remote (Off the wall) Siting configuration), SIGNA PET/MR, SIGNA 7T, Discovery MR750w, and Optima 450w)

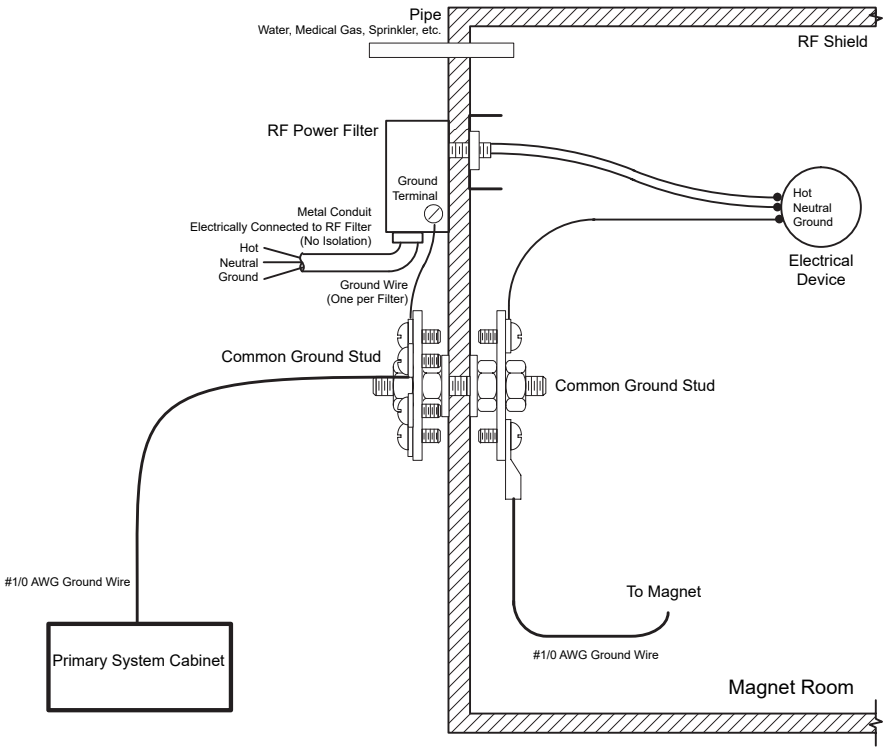
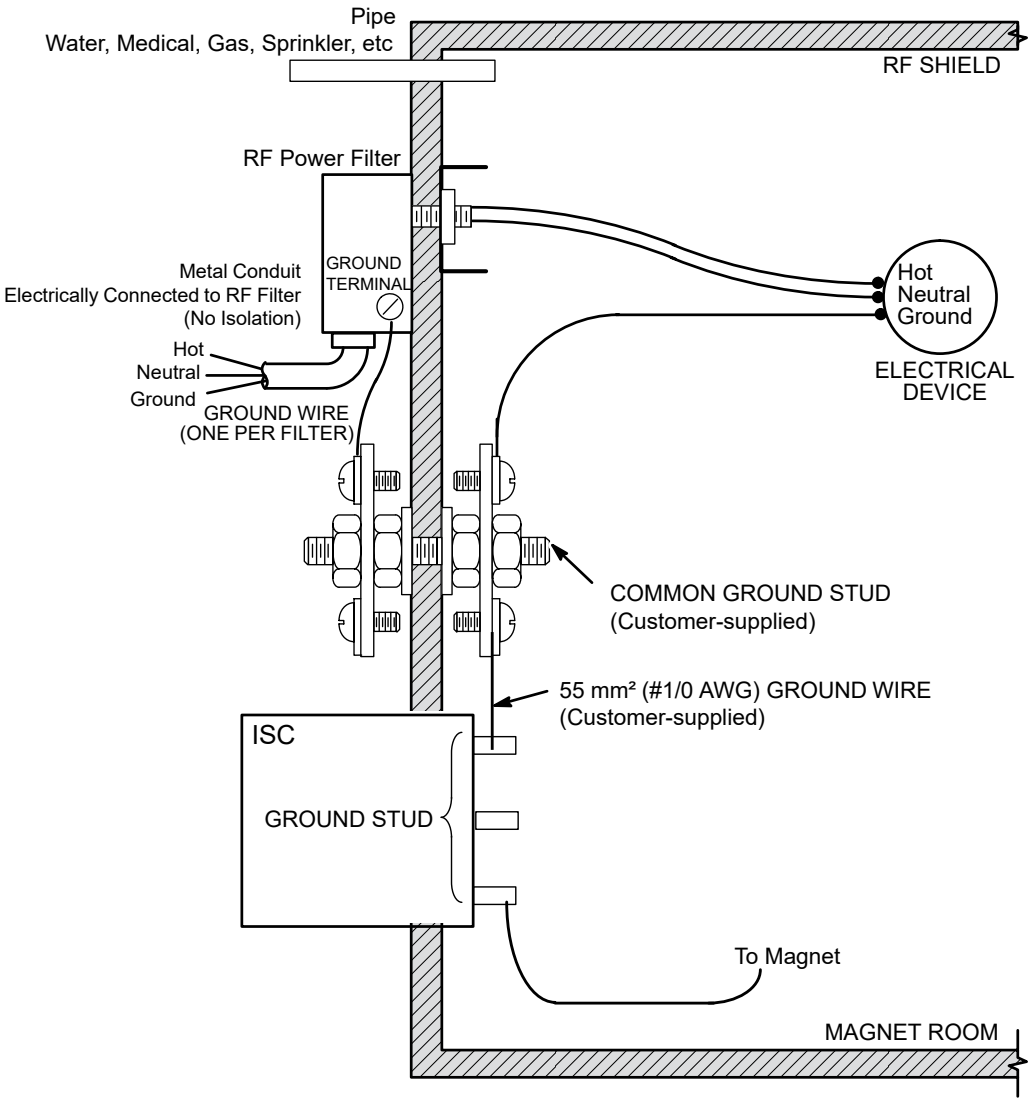


Figure 3-4 Typical Magnet Room Grounding (For SIGNA Creator/Explorer/MR355/MR360/MR380/Prime/Prime MAX/Prime Elite/Pioneer (Standard (On the Wall) Siting configuration)/Hero (Standard (On the Wall) Siting configuration)/Voyager (Standard (On the Wall) Siting configuration)/Champion/Star/Aviator/Victor)



4 RF Shielding Effectiveness (SE) and Ground Isolation Test Methods

4.1 Ambient Radio Frequency Interference (RFI)

The MR System operates with a highly sensitive RF receiving front end to be able to capture the signal of an object scanned. A limited level of RF Interference (RFI) at the installation site is needed for the correct operation for the MR System. The RFI level will depend on the electromagnetic environment and the equipment installed in the vicinity of the installation site, for example, radio stations and land mobile radio transmitter stations. RF sources that can adversely affect image quality may be generated by discrete frequency or broadband noise (RF) sources.

4.2 Discrete RF Interference

Discrete RF interferences are narrowband and fixed frequency. The Magnet Room must be RF shielded from RFI sources so external RF energy does not degrade the MR System RF receivers at the system imaging frequencies. Some potential sources for discrete frequency signals are radio station transmitters, mobile or hand-held RF transmitting devices—in general, any intentional RF transmitter or non-intentional transmitters that have clocked digital electronic circuits.

4.3 Broadband RF Interference

Broadband RF noise is a single transient or continuous series of transient disturbances caused by an electrical discharge. Low humidity environmental conditions will have higher probability of electrical discharge. The electrical discharge can occur due to electrical arcing (micro-arcing) or merely a static discharge. Some potential sources capable of producing electrical discharge include:

1. Loose hardware or fasteners vibration or movement (electrical continuity must always be maintained)
2. Flooring material, including raised access flooring (panels and support hardware) and carpeting
3. Electrical fixtures, including:
    - 3.1. Lighting fixtures
    - 3.2. Track lighting
    - 3.3. Emergency lighting
    - 3.4. Battery chargers
    - 3.5. Outlets
4. Ducting for HVAC and cable routing
5. RF shield seals (walls, doors, windows, and so on)

4.4 RF Shielding Effectiveness (SE) and Ground Isolation Test Methods

The shielding effectiveness test method defined within this chapter is in accordance with methods and requirements from IEEE Std 299-2006 - IEEE STANDARD METHOD FOR MEASURING THE EFFECTIVENESS OF ELECTROMAGNETIC SHIELDING ENCLOSURES.

This chapter provides details on the Shielding Effectiveness (SE) test method. The MRI scanner is highly sensitive to RF energy from sources outside of the RF shielded room. To ensure correct operation of the MRI scanner, the RF shielded room is installed to reduce the interaction of external RF electromagnetic fields with the MR scanner operation (it also prevents MR System RF radiation from interfering with external RF systems, such as aircraft control).

NOTE

Impinging electromagnetic fields at the frequencies to test the RF shielded room may not be planar.

4.5 Ambient Radio Frequency Interference (RFI) Site Survey

When an RFI site survey is considered, it is recommended to be completed before the purchase and installation of the RF shielded room.

1. The ambient RFI measured should be less than 100 millivolt per meter (100 dB microvolt per meter).
2. The recommended centerband and bandwidth frequencies to be used when measuring RFI are listed in the tables below:
   - Table 4-1 Radio Frequency Survey Specifications **(For 1.5T systems)** on page 19
   - Table 4-2 Radio Frequency Survey Specifications **(For 1.49T systems)** on page 20
   - Table 4-3 Radio Frequency Survey Specifications **(For 3.0T systems)** on page 20
   - Table 4-4 Radio Frequency Survey Specifications **(For 7.0T systems)** on page 20

   These tables include frequency bands important for both imaging and spectroscopy:

Table 4-1 Radio Frequency Survey Specifications (For 1.5T systems)

Isotope	Bandcenter MHz	Bandwidth Hz
^{1}H	63.86	916138
^{19}F	60.12	981882
^{31}P	25.88	390296
^{23}Na	16.90	242773
^{13}C	16.06	233925

Table 4-2 Radio Frequency Survey Specifications (For 1.49T systems)

Isotope	Bandcenter MHz	Bandwidth Hz
^{1}H	63.43	916138
^{19}F	59.72	981882
^{31}P	25.71	390296
^{23}Na	16.79	242773
^{13}C	15.95	233925

Table 4-3 Radio Frequency Survey Specifications (For 3.0T systems)

Isotope	Bandcenter MHz	Bandwidth Hz
^{1}H	127.72	681183
^{19}F	120.23	641229
^{31}P	51.75	276010
^{23}Na	33.80	180291
^{13}C	32.13	171335

Table 4-4 Radio Frequency Survey Specifications (For 7.0T systems)

Isotope	Bandcenter MHz	Bandwidth Hz
^{1}H	298.04	2046709
^{31}P	120.76	371941
^{129}Xe	82.43	162746
^{23}Na	78.77	239027
^{13}C	74.99	242117

3. **(For 1.5T/1.49T systems)** RFI site surveys are to be performed by cycling through the preceding frequency bands and a broadband range up to 100 MHz ± 10 MHz (up to 145 MHz ± 10 MHz is recommended for new sites to accommodate upgrades).

   (For 3.0T systems) RFI site surveys are to be performed by cycling through the preceding frequency bands and a broadband range up to 145 MHz ± 10 MHz.

   (For 7.0T systems) RFI site surveys are to be performed by cycling through the preceding frequency bands and a broadband range up to 320 MHz ± 10 MHz.

4. Special emphasis, however, should be placed on the 1H band since this is used in proton imaging. The RFI site survey should be performed for a length of time necessary to determine, within a reasonable degree of certainty, the maximum field strength.

5. To ensure that RF noise peaks outside the bandwidths specified above do not actually extend into these bandwidths and exceed the 100 millivolt per meter limit, adjust the resolution of the test equipment (spectrum analyzer) according to the equation:

BW (resolution) = f_0 /50

where: BW = Bandwidth (resolution)

f_0 = Center frequency (for 1H: at 1.5 Tesla 63.86 MHz)

f_0 = Center frequency (for 1H: at 1.49 Tesla 63.43 MHz)

f_0 = Center frequency (for 1H: at 3.0 Tesla 127.72 MHz)

f_0 = Center frequency (for 1H: at 7.0 Tesla 298.04 MHz)

4.6 RF Shield Test Requirements and Test Setup

1. The minimum test points for shielding effectiveness must be the following locations:
   1.1. Walls
   1.2. Penetration panels
   1.3. Doors
   1.4. Blower box removal hatch (if present)
   1.5. All windows, including patient viewing window
   1.6. Skylights
   1.7. Penetration waveguides installed for GE Healthcare and Non-GE Healthcare options
   1.8. Power filters
2. When measuring shielding effectiveness (SE), the following must be installed for the RF shielded room:
   2.1. The magnet
   2.2. All floor mounting bolts (including dock anchor bolt)
   2.3. RF shielded door(s)
   2.4. Waveguide penetrations, HVAC, cryogen vents, medical gas lines, system options (including FUS, MRE, and so on)
   2.5. AC power supplied through low-pass filters
   2.6. Patient view window, skylights, windows, hatches, and so on
   2.7. PEN Panel frames and blank penetration panels installed, dimensionally equivalent to the GE panel and the same mounting hardware to be used with the GE penetration panels
3. Shielding Effectiveness (SE) test equipment must be calibrated.

   NOTE

   - The calibration cycle of equipment must be no greater than two years.
   - A GE Field Engineer is responsible for disconnecting cryocooler lines. For safety reasons, the enclosure will be electrically grounded during the shielding effectiveness test. Any variances from the normal configuration will be noted in the RF shield test report.

4.7 Shielding Effectiveness (SE)

The final shielding effectiveness performance of the RF shielded room is determined based on the lowest measurement of all test point locations.

4.8 Reference Level and Dynamic Range

1. The reference level is the value of signal measured by the receiver equipment with the receiving antenna (RX) located at a prescribed distance from the transmit antenna (TX) and located outside of the shielded enclosure.
2. The dynamic range (DR) is the range of amplitudes over which the receive system operates linearly. The dynamic range must be at least 6 dB greater than the SE to be measured. For SE measurement, the dynamic range is the difference of the reference level to the noise floor.

4.9 Test Equipment

1. Test equipment must be selected to provide measuring capabilities as described in this test method.
2. Any piece of equipment, whose operation directly affects the numerical value of the Shielding Effectiveness (SE), must be in calibration before any critical measurements are begun. Dates of calibration traceable to a national standard must be provided in the test report (see 4.17 RF Shield Test Report on page 28 for test report requirements) and must be within the calibration cycle of the equipment. The calibration cycle of equipment must be no greater than two years.
3. All equipment must be verified for correct operation between and after each series of tests by repeating the reference readings at the specified frequency.
4. Required equipment for transmit chain of measurement system:
   - 4.1. Frequency Synthesizer or Signal Generator
   - 4.2. RF Power Amplifier (if required)
   - 4.3. DC Power Supply (if required)
   - 4.4. Tuned λ/2 dipole antenna at the test frequencies or broadband biconical antenna

     NOTE

     Considering the dimensions for a tuned λ/2 dipole antenna at lower frequencies, it is more practical to use a broadband biconical antenna below 100 MHz.
5. Required equipment for receive chain of measurement system:
   - 5.1. Spectrum Analyzer
   - 5.2. RF Preamplifier (if required)
   - 5.3. In-line Attenuator (if required)
   - 5.4. DC Power Supply (if required)
   - 5.5. Tuned λ/2 dipole antenna at the test frequencies or broadband dipole antenna

     NOTE

     Considering the dimensions for a tuned λ/2 dipole antenna at lower frequencies, it is more practical to use a broadband biconical antenna below 100 MHz.
6. The transmit (TX) and receive antenna (RX) must be of the same type for each measurement.
7. When using a biconical antenna, the separation distance between antennas shall be the distance between the closest points of each antenna's element.

4.10 Test Frequency

The test frequencies for shielding effectiveness (SE) measurement are defined in 3.2 RF Shield Requirements on page 10. Test frequencies used must be noted in the RF shield test report.

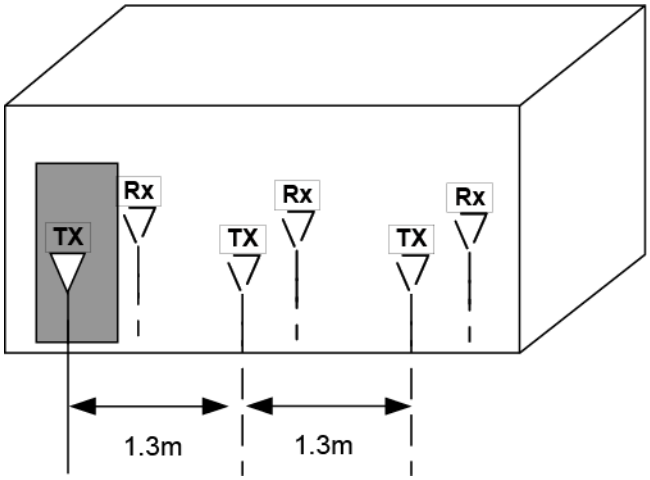
4.11 Measurement Procedure

NOTE

Except when specified, antenna distances are measured at the center of the antenna.

1. Each wall of the RF shielded room that is accessible for the measurement will be tested. For areas that are inaccessible for the direct location of the transmitting antenna (TX), the inside of that area will still be scanned using the receive antenna (RX) with the transmitting antenna (TX) positioned as close as possible to the intended test position. That position must be noted on the test report.
2. Each accessible plane of the wall is subdivided so that the horizontal spacing is no more than 1.3 m (51 in.) for the transmit antenna (TX) and receive antenna (RX) horizontal positions. See the illustration below:

Figure 4-1 Antenna Positioning (RF Shielded Room)



3. Measurements are taken with horizontal and vertical antenna polarizations. Both transmit (TX) and receive (RX) antennas must be aligned with the same polarization. The measured polarization must be part of the test report.
4. For localized testing of shielded room items such as doors, windows, filters, penetration areas, and so on. the transmit antenna (TX) (as well as receive antenna (RX)) must be positioned in front of the items under test.

4.12 Shielding Effectiveness Measurement

Three main steps are required to complete the Shielding Effectiveness measurement at each test position:

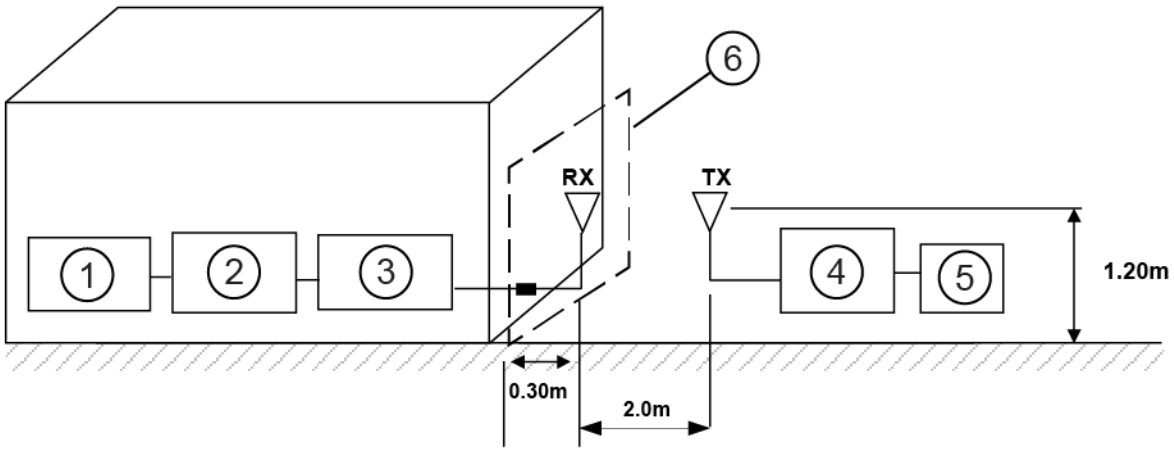
1. Take the reference level measurement (4.13 Reference Level Measurement on page 24).
2. Take the attenuated level measurement (4.14 Attenuated Level Measurement on page 25).

3. Calculate the Shielding Effectiveness (4.15 Shielding Effectiveness Calculation on page 27).

4.13 Reference Level Measurement

1. The reference level is the value of signal measured by the receiver equipment with the receive antenna (RX) located at a prescribed distance from the transmit antenna (TX) and located outside of the shielded enclosure.
2. Measurement setup for the reference level is in accordance with the illustration below:

Figure 4-2 Reference Level Measurement



Item	Description
1	Spectrum Analyzer
2	RF Preamplifier (if required)
3	In-line Attenuator (if required)
4	RF Power Amplifier (if required)
5	Frequency Synthesizer or Signal Generator
6	Measurement plane

3. The antennas must be separated by a minimum distance of 2 m (78.74 in.), unless physical spacing limitations for either the reference level or SE readings preclude maintaining that spacing. In that case, maximum available separation must be used. However, it must not be less than 1 m (39.37 in.), and that separation must be noted on the test report.
4. The coaxial cable from the receive antenna (RX) must be kept perpendicular to the axis of the antenna for a distance of at least 1 m (39.37 in.).
5. The cable from the receive antenna (RX) is preferably routed through the wall of the shield with a bulkhead type of coaxial connector. If this is not possible, it may be routed through a shield door that is opened only far enough to pass the cable. If the open-door method is used, a check for direct coupling to the receiving equipment must be made by putting a dummy load in place of the receive antenna (RX) and verifying that any signal present is at least 10 dB below the reference reading.
6. Reference Level measurement is taken at each test location with antennas at both polarizations (horizontal and vertical).

    6.1. Reference Level at horizontal polarization:

6.1.1. The reference level measurement is taken over a plane area covered as described below.

6.1.2. With horizontal polarization for both antennas, the receive antenna (RX) must be moved vertically up 1 m (39.37 in.) from the initial position, and then moved down from the initial position to 0.3 m (11.81 in.) above the floor. Then starting 1 m (39.37 in.) to the right of the initial position, move slowly vertically up 1 m (39.37 in.) and then down to 0.3 m (11.81 in.) above the floor. Repeat this at 1 m (39.37 in.) to the left of the original position.

6.1.3. Record the maximum measurement reading in this plane.

6.2. Reference Level at vertical polarization:

6.2.1. The reference level measurement is taken over a plane area covered as described below.

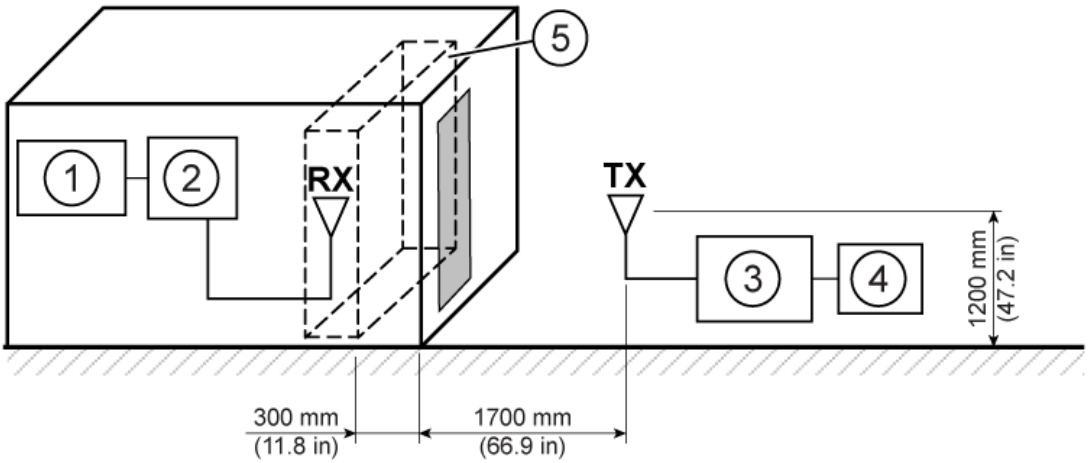
6.2.2. With vertical polarization for both antennas, the receive antenna (RX) must be moved horizontally right 1 m (39.37 in.) from the initial position, and then moved left from the initial position to 1 m (39.37 in.). Then starting 1 m (39.37 in) above the initial position, move slowly horizontally right 1 m (39.37 in.) and then horizontally left 1 m (39.37 in.) from initial position. Repeat this at 0.3 m (11.81 in.) above the floor (measure 0.3 m (11.81 in.) from the floor to the bottom of the antenna). Move slowly horizontally right 1 m (39.37 in.) and then horizontally left 1 m (39.37 in.).

6.2.3. Record the maximum measurement reading in this plane.

4.14 Attenuated Level Measurement

1. The basic measurement procedure consists of positioning the transmit antenna (TX) outside the RF shielded room and the receive antenna (RX) inside the RF shielded room and measuring the magnitude of the largest received signal.
2. The Transmit Power for the RF shielded room measurement is the same as the power used to determine the Reference Level.
3. If an attenuator was used in the Reference measurement, it would be taken out for the RF shielded room measurement and the attenuator value added to the SE in the datasheet.
4. Measurement setup for the attenuated level is in accordance with the illustration below:

Figure 4-3 Attenuation Level Measurement



Item	Description
1	Spectrum Analyzer
2	RF Preamplifier (if required)
3	RF Power Amplifier (if required)
4	Frequency Synthesizer or Signal Generator
5	Measurement plane

5. Attenuated Level measurement is taken at each test location with antennas at both polarizations (horizontal and vertical).

   5.1. Attenuated Level at Horizontal Polarization:

      5.1.1. Both tuned receive (RX) and transmit (TX) antennas are in horizontal polarization.

      5.1.2. In all the following measurements, the receive antenna (RX) is held in horizontal polarization and kept at a distance of 0.3 m (11.81 in.) from the inside shielded room wall.

      5.1.3. Starting with the receive antenna (RX) directly parallel to the transmit antenna (TX), begin to slowly move the receive antenna (RX) in a volume parallel to the shielded room wall 1 m (39.37 in.) above initial position and 0.3 m (11.81 in.) above the floor and 1 m (39.37 in.) to the left and right of the initial position (see Figure 4-3 Attenuation Level Measurement on page 26).

      5.1.4. Measure and record the highest power in this volume.

   5.2. Attenuated Level at Vertical Polarization:

      5.2.1. Both receive (RX) and transmit (TX) antennas are in vertical polarization.

      5.2.2. In all the following measurements, the receive antenna (RX) is held in vertical polarization and kept at a distance of 0.3 m (11.81 in.) from the wall.

      5.2.3. Starting with the receive antenna (RX) directly parallel to the transmit antenna (TX), begin to slowly move the receive antenna (RX) in a volume parallel to the shielded room wall 1 m (39.37 in.) above the initial position and 0.3 m (11.81 in.) above the

floor (measure 0.3 m (11.81 in.) from the floor to the bottom of the antenna) and 1 m (39.37 in.) to the left and right of the initial position.

5.2.4. Measure and record the highest power in this volume.

4.15 Shielding Effectiveness Calculation

The shielding effectiveness is calculated with the reference level measurement and the attenuated level measurement as defined below:

$SE\ (db) = V_{Ref\_max} - V_{Att\_max}$

or

$SE\ (db) = P_{Ref\_max} - P_{Att\_max}$

Where:

SE : Shielding Effectiveness in dB

V_{Ref_max}, V_{Att_max}: Reference measurement in dBµV

P_{Ref_max}, P_{Att_max}: Reference measurement in dBm

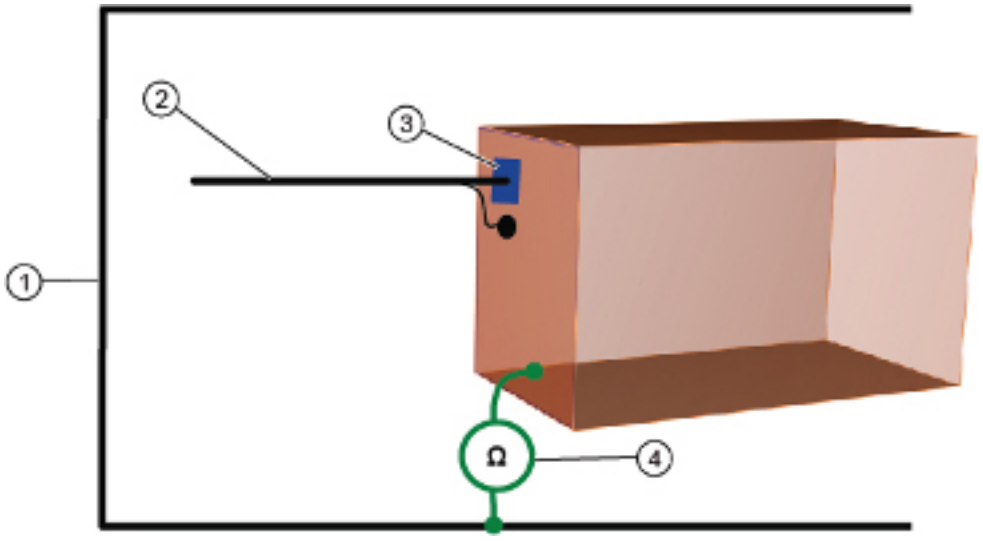
4.16 RF Shielded Room Ground Isolation Resistance Measurement Method

WARNING

ELECTRICAL SHOCK HAZARD

The RF shielded room must be properly grounded.

Figure 4-4 RF Shielded Room



Item	Description	Item	Description
1	Hospital ground grid	3	Filter
2	AC lines and ground wire	4	Low resistance reading

1. This section does not apply to upgrades.
2. This test must be made using either an isolated, current-limited, high-voltage (>150 VDC) DC source and DMM to read the drop across the limiting resistor or a Megger instrument capable of reading values less than 1000 ohms. Conventional resistance meters employing test sources of 9 VDC or less must not be used.
3. The ground isolation resistance measurement is performed by the following procedure:
   3.1. All power to the enclosure is removed. For safety reasons, an AC voltage measurement will be made to verify that no power is connected.
   3.2. With electrical power and intentional ground disconnected, connect the test instrument between the shielded enclosure and AC power ground.
   3.3. Take a reading and record the value.
   3.4. Reconnect the lines to ground.

4.17 RF Shield Test Report

A test report must be prepared by the testing organization performing the shielding effectiveness and ground isolation resistance tests for the RF shielded room. The test report includes data necessary for the evaluation of the shielding effectiveness performance and ground isolation of the RF shielded room. The test report must contain the following information:

1. Name of the owner organization or hospital
2. Name of the testing organization
3. Identification name for the RF shielded room being tested
4. Name of the test personnel
5. Date of the test
6. Frequencies tested
7. Shielding effectiveness measured for each test point location (each test point location must be identified in the test report)
8. RF shielded room drawing showing each test point location
9. The shield test report shall specify the antenna polarity for each test point unless detailed within the test point drawing.
10. A list of all changes pertinent to the test setup or SE results (for example, limited separation distance of antennas, limited access to test points, and so on)
11. Ground isolation test results and the condition of the room when tested (for example, indicate whether all requirements are met in 4.6 RF Shield Test Requirements and Test Setup on page 21)
12. The following information for each piece of all calibrated equipment used for measurement:
    12.1. Manufacturer
    12.2. Model
    12.3. Serial number
    12.4. Current calibration date and calibration due date
13. Results of the dock-table anchor pull test

14. Pass or Fail conclusion

Recommended additional information:

1. Location of RF shielded room relative to the whole building where it is installed
2. Pictures of RF shielded room shielding effectiveness test showing:
    2.1. Overall view of RF shielded room
    2.2. Window(s), door(s), filter(s), skylights, patient view window
    2.3. Blank penetration panels
    2.4. Installed additional penetration points (waveguides, vents, ducts, and so on)
    2.5. Test setup for reference level measurement
    2.6. Test setup for attenuated level measurement

Revision History

English Document review and approval per DOC2348769		
Rev	**Date**	**Description**
Rev 5	October 2023	**Section 3.6, Table 3-1:** Added products SIGNA Artist Evo and SIGNA Champion; added another row to the table **Section 3.6, Figure 3-3 and 3-4:** Updated products listed in Figure title
Rev 4	May 2023	**Section 3.1:** Added new step 3 (SPR HCSDM00695715) **Section 3.2, Step 1:** Changed 100 dB to 90 dB and added additional information. **Section 3.4, Step 1:** Changed 100 dB to 90 dB
Rev 3	September 2022	**Section 3.6:** Added products SIGNA Star AIR, SIGNA Aviator AIR and SIGNA Victor
Rev 2	July 2021	Updated to include 7T specifications and new product SIGNA Hero
Rev 1	July 2020	Initial release of 5850260-1EN based on DOC2348769, Rev. 2

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