UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION TABLE OF CONTENTS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13 49 21

RADIO FREQUENCY (RF) SHIELDING: MAGNETIC RESONANCE IMAGING (MRI)

11/20

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 QUALITY CONTROL
1.3.1 Qualifications
1.3.1.1 RF Shielding Vendor Qualifications
1.3.1.2 RF Shielding Supervisor Qualifications
1.3.1.3 Medical Physicist/MR Scientist Qualifications
1.3.2 RF Shielding Shop Drawings
1.3.3 Material and Component Certification
1.3.4 Field Quality Control Plan
1.3.5 Pre-Construction Conference
1.4 DELIVERY, STORAGE, AND HANDLING
1.5 [PROJECT][SITE] CONDITIONS
1.6 MAINTENANCE
1.6.1 Maintenance Materials
1.6.1.1 Filters
1.6.1.2 RF Shielded Doors
1.6.2 Operating And Maintenance Manual
1.7 RF SHIELDING ENCLOSURE WARRANTY

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 RF Shielding System Components
2.1.2 RF Attenuation Performance Requirements
2.2 MATERIALS
2.2.1 Materials, Equipment, And Manufactured Units
2.2.2 Nameplates
2.3 RF SHIELDING ENCLOSURE CONSTRUCTION
2.3.1 Copper Enclosure Construction
2.3.2 Dielectric Decoupling
2.3.3 Grounding

2.4 RF SHIELDED DOORS
2.5 RF SHIELDED WINDOWS
2.6 OVERPRESSURE RELIEF HATCH
2.7 MAGNET DELIVERY ACCESS PANEL
2.8 POWER AND COPPER SIGNAL RF FILTERS
2.9 WAVEGUIDE ASSEMBLIES

PART 3 EXECUTION

3.1 EXAMINATION
3.2 INSTALLATION
3.2.1 Coordination
3.2.2 Process
3.3 FIELD QUALITY CONTROL
3.3.1 Inspection
3.3.2 Ground Isolation Monitoring
3.3.3 RF Attenuation Field Testing
3.3.3.1 In Progress RF Testing
3.3.3.2 Preliminary RF Testing
3.3.3.3 Final RF Testing
3.4 GROUNDING

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA **UFGS-13 49 21 (November 2020)**

Preparing Activity: USACE **New**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 13 49 21

RADIO FREQUENCY (RF) SHIELDING: MAGNETIC RESONANCE IMAGING (MRI)
11/20

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NOTE: This guide specification covers the requirements for radio frequency (RF) interference shielding for magnetic resonance imaging (MRI) facilities of copper construction with a delegated design by the RF Shielding Vendor in conjunction with a Medical Physicist/MR Scientist, and evaluation of site conditions with electromagnetic interference (EMI) field measurements.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be as a Criteria Change Request (CCR).

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN COLLEGE OF RADIOLOGY (ACR)

ACR	MRI Accreditation Program Requirements, Latest Edition

ASTM INTERNATIONAL (ASTM)

ASTM B370	(2022) Standard Specification for Copper Sheet and Strip for Building Construction

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE 299	(2006; R 2012) Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity

or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

RF Shielding Vendor Qualifications[; G, [_____]]

RF Shielding Supervisor Qualifications[; G, [_____]]

Medical Physicist/MR Scientist Qualifications[; G, [_____]]

Field Quality Control Plan[; G, [_____]]

RF Attenuation Performance Requirements[; G, [_____]]

SD-02 Shop Drawings

RF Shielding Shop Drawings[; G, [_____]]

SD-03 Product Data

Materials, Equipment, and Manufactured Units [; G, [_____]]

SD-06 Test Reports

In Progress RF Testing[; G, [_____]]

Preliminary RF Testing[; G, [_____]]

Final RF Testing[; G, [_____]]

SD-10 Operation and Maintenance Data

Operating And Maintenance Manual[; G, [_____]]

SD-11 Closeout Submittals

RF Shielding Enclosure Warranty[; G, [_____]]

1.3 QUALITY CONTROL

Supervise and inspect all work under this section, approve all materials and equipment, coordinate shielding work with all other work and trades.

Ensure that RF shielding system fully complies with the MRI equipment manufacturer's requirements, is fully compatible with ACR accreditation, and complies with all applicable codes.

1.3.1 Qualifications

Ensure minimum qualifications as indicated.

1.3.1.1 RF Shielding Vendor Qualifications

A firm that has continuously executed the design installation, supervision, and testing of equivalent RF shielding systems for the previous 5 years for all the RF shielding work.

Submit a project experience list of projects of similar scope completed during the previous 5 years for approval. Include project completion dates, name and contact information of the user and/or owner. Include installation materials, construction system, responsibilities, and performance.

1.3.1.2 RF Shielding Supervisor Qualifications

RF Shielding Vendor to provide a supervisor continuously engaged in the design, installation, supervision, and testing of equivalent RF shielded systems for the previous 5 years to supervise all RF shielding installation work.

Submit the name, qualifications and a list of projects of similar scope completed during the previous 5 years for approval. Include project completion dates, name and contact information of the user and/or owner. Include field investigations and measurements, installation materials, construction system, testing method, responsibilities, and performance.

1.3.1.3 Medical Physicist/MR Scientist Qualifications

RF Shielding Vendor to engage a Medical Physicist/MR Scientist, meeting the minimum ACR requirements, who has been continuously engaged in the design, installation, supervision, and testing of equivalent RF shielded systems for the previous 5 years.

Submit the name, qualifications and a list of projects of similar scope

completed during the previous 5 years for approval. Include, project completion dates, name and contact information of the user and/or owner. Include field investigations and measurements, installation materials, construction system, testing method, responsibilities, and performance.

1.3.2 RF Shielding Shop Drawings

Submit shop drawings for the RF shielding system including: the construction method, materials, arrangement and attachment of the RF walls, ceiling and floor, method of RF sealing joints, the connection and method of RF sealing RF shielding system components and any other attachment to the RF shield. Include attachment details for interior elements, including suspended ceiling, wall finish and floor finish systems.

Locate and label all RF shielding system components and equipment locations.

1.3.3 Material and Component Certification

Where certification is required, provide materials and equipment with Underwriters Laboratories or other nationally recognized testing laboratory label and listing. Comply with NFPA 70, [UL 486A-486B,]and UL 1283 for filter and electrical work.

1.3.4 Field Quality Control Plan

Submit a field quality control plan to demonstrate compliance with contract requirements. Include: schedule, personnel, methodology, inspection and testing stages and procedures, test equipment and the proposed test report format.

1.3.5 Pre-Construction Conference

Hold a pre-construction conference with all contractors and installers associated with the RF shielding construction and fit out. Review requirements and coordination to ensure the integrity of the RF shielding. Include: Sequence and schedule, coordination of trades, penetrations, attachment of other construction and equipment, and modification and notification procedures.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver equipment, components, and materials in original packaging, labeled with the manufacturer/vendor, brand name and part number.

Inspect equipment, components, and materials upon receipt. Remove and replace damaged items. Minor damage may be repaired at the discretion of the Contracting Officer and the repair matches the new condition.

Comply with manufacturers/vendors instructions and recommendations for storage and handling of all equipment, components, and materials.

Protect materials and components from deleterious environments including weather, direct sunlight, moisture, contamination, corrosion, and construction traffic.

1.5 [PROJECT][SITE] CONDITIONS

Construct the RF shield in a weather enclosed building or environmentally controlled building, according to the RF shielding vendor's or MRI manufacturers' requirements, whichever is more stringent.

1.6 MAINTENANCE

1.6.1 Maintenance Materials

1.6.1.1 [Filters

Provide one RF power filter and one communications filter of each type used on the project as a spare.
]

1.6.1.2 RF Shielded Doors

Provide one set of manufacturer recommended spare parts for each type of RF shielded door[and 2 sets of knife edge RF door seals].

Provide one full set of tools required to maintain the doors if not typically available from tool vendors.

1.6.2 Operating And Maintenance Manual

Submit an Operation and Maintenance Manual for the RF Shielding system. Address all components and aspects of the RF shielding and including:

a. The system RF attenuation performance requirements.

b. The RF shielding shop drawings.

c. The construction specification for the RF shielding.

d. RF shielding penetration schedule.

e. RF power filter schedule.

f. RF signal filter schedule.

g. RF test plan.

h. Vendor/manufacturer maintenance data.

i. Spare parts data.

1.7 RF SHIELDING ENCLOSURE WARRANTY

Submit an RF shielding system warranty for the RF attenuation performance of the complete RF shielding system, to meet the MRI equipment manufacturer's requirements and be fully compatible with ACR accreditation of [5] [_____] years from date of completion of the final RF test for defective design, materials and/or workmanship.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 RF Shielding System Components

The RF shielding system includes, but is not limited to:

a. RF complete metallic enclosure including walls, floor and ceiling.

b. RF shielded doors.

c. RF shielded windows.

d. Over-pressure relief hatch.

e. Magnet delivery access panel.

f. All electrical, mechanical, utility, signal, and cryogen ventilation penetrations, penetration plates and wave guides.

g. Dielectric fittings.

h. Power filters.

i. Signal filters.

j. Access panels.

2.1.2 RF Attenuation Performance Requirements

Submit RF attenuation performance requirements based on Medical Physicist/MR Scientist electromagnetic interference (EMI) field measurements,and evaluation of site conditions, in consultation with the MRI equipment manufacturer. Ensure that RF shielding system fully complies with the MRI equipment manufacturer's requirements and is fully compatible with ACR accreditation.

2.2 MATERIALS

2.2.1 Materials, Equipment, And Manufactured Units

Provide equipment and manufactured units that have been continuously in production and documented for at least 2 years, with a service organization that provides maintenance, parts and support.

Submit product data for all materials, equipment, and manufactured units forming or integrated with the RF shielding including the RF shielding walls, floor and ceiling materials/construction, doors, windows, overpressure relief hatch, power filters, signal filters, and wave guides.

2.2.2 Nameplates

Provide the manufacturers' nameplate including: name, model type, model number, and serial number, on all items of equipment and manufactured units.

2.3 RF SHIELDING ENCLOSURE CONSTRUCTION

2.3.1 Copper Enclosure Construction

Form a continuous RF shielding enclosure including floor, walls, and ceiling, incorporating all RF shielding system components, and conforming to the Medical Physicist/MR Scientist RF attenuation performance requirements. Acceptable enclosure types:

a. Solid copper sheet conforming to ASTM B370 on non-ferrous sub-frame.

b. Annealed copper foil on non-ferrous panel or composite substrate.

c. Other enclosure types pre-approved in writing.

Use soldered connections only on horizontal joints of solid copper sheet. Overlap copper a minimum of 51 mm 2 inches at all joints, and continuously solder.

Use continuously fastened mechanical connections on all vertical or overhead joints. Seal over all mechanical connection fastener penetrations with not less than 51 mm 2 inches wide conductive copper foil tape with conductive adhesive.

Use stainless steel screws to attach RF doors, windows, overpressure relief hatch, and other opening frame assemblies or attachments.

Provide a minimum 51 mm 2 inches deep isolation space between the back of the RF shielding walls and any adjacent building walls or structure.

Provide vapor barrier isolation membrane below RF shielding floor where required/recommended.

Provide isolated support for RF shielding walls and ceiling as required by the Medical Physicist/MR Scientist.

Use copper material free of oil, dents, and defects.

Comply with all applicable codes.[

Include seismic bracing as required by code.]

2.3.2 Dielectric Decoupling

Provide dielectric decoupling of conductive services including piping and ductwork. Do not penetrate RF shielding with continuously conductive elements.

2.3.3 Grounding

Electrically ground the shielding enclosure at a single point, with a minimum resistance to alternate ground of 1,000 ohms. Coordinate with Medical Physicist/MR Scientist.

2.4 RF SHIELDED DOORS

Provide door[s], frame[s], hardware and threshold[s] as indicated with purpose manufactured MRI door system with a demonstrated life cycle test rating of at least [10,000] operational cycles without loss of specified

RF attenuation, from a single manufacturer with a minimum of 5 years track record[and 2 years for the products supplied]. Supply assemblies complete with a rigid structural frame, hardware, seals and parts necessary for operation.

Provide door[s] meeting MRI manufacturer's acoustic requirements/recommendations.

2.5 RF SHIELDED WINDOWS

Provide window[s] as indicated with purpose manufactured high visibility MRI window system from a single manufacturer with a minimum of 5 years track record[and 2 years for the products supplied]. Supply assemblies complete with frame, glazing, and seals.

2.6 OVERPRESSURE RELIEF HATCH

Provide a clearly visible, easily accessible and instantly operable overpressure relief hatch for an overpressure emergency. Operate from inside by pushing the hatch. Operate from outside by pulling the hatch, with an appropriate device operated by a person located a minimum of four feet from the hatch. Mitigate the effects of the outflow of super-cooled gas when locating the hatch to avoid injury or hazardous conditions in adjacent areas.

Provide permanent signage inside and outside the MRI room stating: "OVERPRESSURE RELIEF HATCH OPEN IN CASE OF EMERGENCY"

2.7 MAGNET DELIVERY ACCESS PANEL

Provide a magnet delivery access panel for removal and replacement of the MRI magnet without dismantling the RF shielding enclosure. Coordinate the location and dimensions with the magnet delivery path, the MRI equipment manufacturer and clearances for rigging.

2.8 POWER AND COPPER SIGNAL RF FILTERS

Provide a filter for each power, and cable signal line penetrating the enclosure, including power, lighting, HVAC control, alarms, and communications to achieve RF attenuation specified. Factory test filters. Comply with NFPA 70, UL 486A-486B, and UL 1283.

2.9 WAVEGUIDE ASSEMBLIES

Provide waveguide-below-cutoff (WBC) protection for all piping, ventilation, fiber signal and cable penetrations of the RF shielding to achieve RF attenuation performance requirements. Use no less than 1.5 times the highest frequency of the RF attenuation performance requirements for the cutoff frequency.

Provide exterior dielectric collars to maintain a minimum of [1,000] ohms DC resistance to ground earth.

Provide exhaust cryogenic gas waveguide assemblies of sufficient structural strength for magnet quench.

PART 3 EXECUTION

3.1 EXAMINATION

Verify site dimensions, conditions, and electromagnetic interference (EMI) measurements before commencing work.

3.2 INSTALLATION

3.2.1 Coordination

Ensure that all relevant construction, testing, and supply organizations, and personnel are aware of RF attenuation critical installation requirements.

Co-ordinate internal services and finishes to MRI equipment manufacturer's requirements, all applicable codes and to be fully compatible with ACR accreditation.

Ensure that the interior suspended ceiling and walls within the RF shielding enclosure are constructed entirely with non-ferrous materials.

Ensure that fluorescent fixtures, magnetic ballasts, magnetic dimmers or similar equipment are not located within the RF shielding enclosure.

Ensure that building elements or equipment that require access, maintenance or servicing are not located in inaccessible spaces including between the RF shielding enclosure and adjacent walls, floors or ceilings.

Ensure that building services that cross the MRI room pass[in the interstitial space] above the RF shielding enclosure and do not pass through the enclosure.

3.2.2 Process

Verify the installation process for compliance with the contract documentation, shop drawings, equipment and material submissions and specifications, and coordinate the work of all trades.

3.3 FIELD QUALITY CONTROL

3.3.1 Inspection

Inspect installation for compliance with the contract documentation, shop drawings, equipment and material submissions and specifications. Inspect prior, during and following the application of coverings and finishes.

3.3.2 Ground Isolation Monitoring

Continuously monitor alternate ground earth isolation for a minimum of [1,000] ohms DC resistance prior to connection to ground earth.

3.3.3 RF Attenuation Field Testing

Perform systematic field control inspection and testing. Include the method of inspection and testing, equipment used, personnel, location of tests, test results and corrective action taken or to be taken within RF test reports.

3.3.3.1 In Progress RF Testing

Perform in-progress RF enclosure inspection and testing by the RF shielding vendor as construction proceeds to monitor shielding effectiveness and rectify shielding defects as shielding construction progresses. Include visual inspection and where possible, RF shielded enclosure leak detection system (SELDS) testing of all component parts including seams, penetrations and installations as work progresses.[Submit in progress RF test reports within 3 days of inspection/testing.] Conduct testing to IEEE 299, to validate the minimum RF attenuation performance requirements.

3.3.3.2 Preliminary RF Testing

Perform preliminary RF enclosure inspection and testing, by the[RF shielding vendor,][and the Medical Physicist/MR Scientist,][and the MRI equipment manufacturer,] prior to the application of coverings and finishes to demonstrate completed RF shielding RF attenuation prior to installation of any closure over the RF shield. Include visual inspection and RF SELDS testing of all component parts including seams, corners, penetrations and installations. Conduct testing to IEEE 299 to validate the minimum RF attenuation performance requirements. Submit preliminary RF test report for approval prior to installation of any closure or finish.

3.3.3.3 Final RF Testing

Perform final RF enclosure inspection and testing, by[RF shielding vendor,][and the Medical Physicist/MR Scientist,][and MRI equipment manufacturer,] following the application of all coverings and finishes, when the facility is complete and is ready for occupancy to demonstrate completed construction RF attenuation. Include visual inspection and RF SELDS testing of all component parts including seams, corners, penetrations and installations. Conduct testing to IEEE 299 to validate the minimum RF attenuation performance requirements. [Notify the Contracting Officer in writing 14 days prior to tests and assist monitoring by client representatives.] Submit the final RF test report.

3.4 GROUNDING

Use an equipotential grounding plane method in accordance with IEEE 142, NFPA 70, and UL 1283.

-- End of Section --