DESIGN & CONSTRUCTION GROUP
THE GOVERNOR NELSON A. ROCKEFELLER
EMPIRE STATE PLAZA
ALBANY, NY 12242

ADDENDUM NO. 1 TO PROJECT NO. 46218

CONSTRUCTION, HVAC, PLUMBING AND ELECTRICAL WORK
PROVIDE IMAGING BAY, BUILDING 35
NATHAN KLINE RESEARCH INSTITUTE
140 OLD ORANGEBURG RD
ORANGEBURG, NY

October 30, 2025

NOTE: This Addendum forms a part of the Contract Documents. Insert it in the Project Manual. Acknowledge receipt of this Addendum in the space provided on the Bid Form.

BIDDING REQUIREMENTS – COMMON DOCUMENTS

1. DOCUMENT 001114 ADVERTISEMENT FOR BIDS: The last date for receipt of bids is changed from Wednesday, November 5, 2025, to Wednesday, November 19, 2025.

2. DOCUMENT 002113 INSTRUCTIONS TO BIDDERS: Section 4: Add Paragraph 4.8 to Read:

   "4.8. All bidders must certify compliance in accordance with State Finance Law § 139-m.
   4.8.1. For electronic bids: Complete and submit bid form within the Bid Express® website.
   4.8.2. For paper bids: Complete State Finance Law § 139-m Policy Attestation and include it with the Bid Form."

CONSTRUCTION WORK SPECIFICATIONS

3. SECTION 033000 CAST IN PLACE CONCRETE: Discard the Section bound in the Project Manual and substitute the accompanying Section (pages 033000 – 1 thru 033000 – 13) noted "Revised 10/17/2025".

APPENDIX – COMMON DOCUMENTS

4. MAGNET INSTALLATION MANUAL: Discard the Appendix item bound in the Project Manual and substitute the accompanying Appendix item (pages 1 thru 75) noted "Revised 10/17/2025".

5. STATE FINANCE LAW § 139-M POLICY ATTESTATION: Add the accompanying Document to the project manual.

END OF ADDENDUM

Brady Sherlock, P.E.
Director, Division of Design
Design & Construction

SECTION 033000

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. Concrete Formwork: Section 031100.

B. Steel Concrete Reinforcement: Section 032100.

C. Vapor Barrier Under Slabs on Grade: Section 072600.

1.02 REFERENCES

A. Except as shown or specified otherwise, the Work of this Section shall conform to the requirements of American Concrete Institute (ACI) and American Society for Testing and Materials (ASTM) documents.

1. ACI 117-10: Specifications for Tolerances in Concrete Construction and Materials
2. ACI 212.3R-10:Report on Chemical Admixtures for Concrete; Chapter 15 Permeability Reducing Admixtures
3. ACI 301-16: Specification for Structural Concrete for Buildings.
4. ACI 302.1R-15: Guide for Concrete Floor and Slab Construction.
5. ACI 302.2R-06: Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials.
6. ACI 304.2R-96: Placing Concrete by Pumping Methods.
7. ACI 305R-10: Guide for Hot Weather Concreting.
8. ACI 306R-10: Guide to Cold Weather Concreting.
9. ACI 308.1-11: Standard Specification for Curing Concrete.
10. ACI 318 -14 Building Code Requirements for Structural Concrete.
11. ACI 360R-10: Guide to Design of Slabs on Grade
12. ASTM C 94/C 94M – 11b: Standard Specification for Ready- Mixed Concrete.
13. ASTM C 494/C 494M - 11: Standard Specification for Chemical Admixtures for Concrete.
14. ASTM F 710- 11: Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring.

1.03 DEFINITIONS

A. ACI 301, Section 1.2 - Definitions:

1. Add the following definitions:
   a. Cementitious Material: Cementitious materials include cement, ground blast furnace slag and fly ash.
   b. Corrosion Inhibitor Admixture: A liquid admixture, calcium nitrite that inhibits corrosion of concrete-embedded steel in the presence of chloride ions.
   c. Pumped Concrete: Concrete that is conveyed by pumping pressure through rigid pipe or flexible hose.

d. Water-to-Cementitious Ratio (w/c): A ratio representing quantity in pounds of free moisture available for cement hydration divided by quantity of cementitious materials in pounds per cubic yard concrete.

1.04 SUBMITTALS

A. Submittals Package: Submit product data for design mix(es) and materials for concrete specified below at the same time as a package.

B. Submit an Environmental Product Declaration (EPD) from the manufacturer for concrete within this specification section, if available. A statement of the contractor's good faith effort to obtain the EPD shall be provided if not available.
1. Manufacturer-provided EPDs must be Product Specific Type III (Third-Party Reviewed), in adherence with ISO 14025 *Environmental labels and declarations*, ISO 14044 *Environmental management – Life cycle assessment*, and ISO 21930 *Core rules for environmental product declarations of construction products and services.*

C. Product Data:
1. Mix Design: Submit proposed concrete design mix(es) together with name and location of batching plant at least 28 days prior to the start of concrete work.
   a. Include test results of proposed concrete proportions based on previous field experience or laboratory trial batches in accordance with ACI 301, Section 4.
   b. Pumped Concrete: Include test results of proposed design mix(es) tested under actual field conditions with the maximum horizontal run and vertical lift required for this project.
2. Portland Cement: Brand and manufacturer's name.
3. Fly Ash: Name and location of source, and DOT test numbers.
4. Air-entraining Admixture: Brand and manufacturer's name.
5. Water-reducing Admixture: Brand and manufacturer's name.
6. High Range Water-reducing Admixture (Superplasticizer): Brand and manufacturer's name.
7. Corrosion Inhibitor Admixture: Brand and manufacturer's name.
8. Accelerating Admixture: Brand and manufacturer's name.
9. Aggregates: Name and location of source, and DOT test numbers.
10. Lightweight Coarse Aggregates: Brand and manufacturer's name.
11. Chemical Hardener (Dustproofing): Brand and manufacturer's name, and application instructions.
12. Chemical Curing and Anti-Spalling Compound: Brand and manufacturer's name, and application instructions.
13. Bonding Agent (Adhesive): Brand and manufacturer's name, and preparation and application instructions.
14. Expansion Joint Fillers: Brand and manufacturer's name.
15. Waterstop: Brand and manufacturer's name, and installation instructions.
16. Emery Aggregate: Brand and manufacturer's name, and application instructions.

17. Integral Water-Repellent Admixture: Brand, manufacturer name, specifications, and application instructions.

D. Quality Control Submittals:
1. Batching Plant Records: At the end of each day of placing concrete, furnish the Director's Representative with a legible copy of all batch records for the concrete placed.
2. Concrete Pumping Equipment Data: Include manufacturer's name and model of principal components, type of pump, and type and diameter of pipe/hose.

1.05 QUALITY ASSURANCE

A. Qualifications of Crew Pumping Concrete: Workers pumping concrete shall have had at least one year of experience pumping concrete.

B. Concrete batching plants shall be currently approved as concrete suppliers by the New York State Department of Transportation.

C. Truck mixers for concrete shall be currently approved by the New York State Department of Transportation.

D. Pumping equipment for pumped concrete shall be subject to the approval of the Director.

E. Fly ash supplier shall be on the New York State Department of Transportation's current "Approved List of Suppliers of Fly Ash".

F. Source Quality Control: The Director reserves the right to inspect and approve the following items, at his own discretion, either with his own forces or with a designated inspection agency:
1. Batching and mixing facilities and equipment.
2. Sources of materials.

G. ACI 301, Section 1.4 Reference standards and cited publications:
1. Add the following to the list of ASTM Standards:
   a. C 311-11a Standard Methods of Sampling and Testing Fly Ash or Natural Pozzolans For Use As A Mineral Admixture in Portland Cement Concrete.

H. Pre-Construction Conference: A minimum of 14 days prior to the initial submission of shop drawings, a conference will be held by the Director's Representative at the Site for the purpose of reviewing the Contract Documents, and discussing the requirements and procedures for submittals and for the Work. The conference shall be attended by the Contractor, the concrete supplier representative, and the reinforcement fabricator's project coordinator.
1. If resilient flooring is to be placed on slab-on-grade, the meeting will also include discussion of curing procedures and moisture mitigation measures.

1.06 DELIVERY

A. ASTM C 94/C 94M, Article 14 - Batch Ticket Information: In addition to the information required by Paragraph 14.1, also include the following:
   1. Type and brand, and amount of cement.
   2. Weights of fine and coarse aggregates.
   3. Class and brand, and amount of fly ash (if any).

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement: ASTM C 150, Type I or II Portland cement.

B. Water: Potable

C. Air-entraining Admixture: ASTM C 260, and on the New York State Department of Transportation's current "Approved List".

D. Water-reducing Admixture: ASTM C 494/C 494M, Type A, and on the New York State Department of Transportation's current "Approved List".

E. High Range Water-reducing Admixture (Superplasticizer): ASTM C 494/C 494M, Type F, and on the New York State Department of Transportation's current "Approved List".

F. Corrosion-Inhibiting Admixture: ASTM C 494/C 494M, for use in resisting corrosion of steel reinforcement.
   1. DCI Corrosion Inhibitor by W. R. Grace & Co., - Conn., 62 Whittemore Ave., Cambridge, MA 02140, (617) 876-1400 and MasterLife CNI by Master Builders/ BASF Building Systems, 23700 Chagrin Blvd., Cleveland, OH 44122, (800) 628-9990.
   2. DCI - S Corrosion Inhibitor by W. R. Grace & Co., - Conn., 62 Whittemore Ave., Cambridge, MA 02140, (617) 876-1400.

G. Retarding Admixture: ASTM C 494, Type D, Water-reducing and retarding, for use in hot weather concreting, and on the New York State Department of Transportation's current "Approved List".

H. Accelerating Admixture: Non-corrosive admixture, containing no chloride, complying with ASTM C 494, Type C or E, and on the New York State Department of Transportation's current "Approved List".

I. Fly Ash: ASTM C 618, including Table 1 (except for footnote A), Class F except that loss on ignition shall not exceed 4.0 percent.

J. ACI 301, Section 4.2.1.2 - Aggregates:
   1. Add the following paragraph:
      a. Fine aggregate for pumped concrete shall meet the requirements of ASTM C 33, except 15 to 30 percent shall pass the No. 50

sieve and 5 to 10 percent shall pass the No. 100 sieve. The fineness modulus of the fine aggregate for pumped concrete shall not vary more than 0.20 from the average value used in proportioning.

2 Add the following paragraph:

a. Aggregates shall be taken from storage silos or other approved locations that have been tested and approved by the New York State Department of Transportation, unless otherwise approved in writing by the Director.

K. Chemical Curing and Anti-Spalling Compound: ASTM C-309, Type 1D, Class B, with a minimum 18 percent total solids content. No thinning of material allowed.

1. SureCure Emulsion, Kaufman Products, Inc. 3811 Curtis Avenue, Baltimore, MD 21226, (800) 637-6372.
2. Cure & Seal by Symons Corp., 200 East Touhy Ave., PO Box 5018, Des Plaines, IL 60017-5018, (847) 298-3200.
3. MasterKure CC 180 WB by Master Builders/ BASF Building Systems, 23700 Chagrin Blvd., Cleveland, OH 44122, (800) 628-9990.
4. Cure & Seal 25 UV (J-22 UV) by Dayton Superior Corp., 1125 Byers Rd.,., Miamisburg, OH 45342, (800) 745-3700.
5. Acrylseal HS by Master Builders/ BASF Building Systems, 23700 Chagrin Blvd., Cleveland, OH 44122, (800) 628-9990.

L. Chemical Hardener (Dustproofing): Colorless aqueous solution of magnesium-zinc fluosilicate.

1. MasterKure HD 300WB by Master Builders/ BASF Building Systems, 23700 Chagrin Blvd., Cleveland, OH 44122, (800) 628-9990..
2. Surfhard by The Euclid Chemical Co., 19218 Redwood Rd., Cleveland, OH 44110, (216) 531-9222.
3. Liqui-Hard by W.R. Meadows, Inc., PO Box 543, Elgin, IL 60121, (847) 683-4500.
4. FluoHard by L & M Construction Chemicals, Inc., 14851 Calhoun Rd., Omaha, NE 68152, (402) 453-6600.
5. Armortop by Anti Hydro International, Inc., 265 Badger Ave., Newark, NJ 07108, (800) 777-1773.
6. Diamond by Kaufman Products , Inc., 3811 Curtis Avenue, Baltimore, MD 21226, (800) 637-6372.

M. Type 1 Expansion Joint Filler: Preformed, resilient, nonextruding cork units complying with ASTM D 1752, Type II.

N. Epoxy Bonding Agent (Adhesive): 100 percent solids epoxy-resin-base bonding compound, complying with ASTM C 881, Types I, II, IV and V, Grade 2 (horizontal areas) or Grade 3 (overhead/vertical areas), and Class B (40-60 degrees Fahrenheit) or Class C (60 degree Fahrenheit and above).

1. SurePoxy HM Series by Kaufman Products, Inc., 3811 Curtis Avenue, Baltimore, MD 21226, (800) 637-6372.
2. Sikadur Hi-Mod 32 by Sika Corporation, 201 Polito Avenue, Lyndhurst, NJ 07071, (800) 933-7452.

3. MasterEmaco ADH 327 RS by by Master Builders/ BASF Building Systems, 23700 Chagrin Blvd., Cleveland, OH 44122, (800) 628-9990.

O. Emery Aggregate: Natural emery, crushed, polyhedral in shape, with not more than 10 percent flat or elongated pieces, properly screened, graded and packaged in the manufacturer's plant, and delivered to the Site in sealed, labeled packages.
1. Emerundum by Anti Hydro International, Inc., 265 Badger Ave., Newark, NJ 07108, (800) 777-1773.
2. Non-Slip Aggregate by Setcon Industries, Inc., 5 Mathews Ave., Riverdale, NJ 07457-1020, (201) 283-0500.
3. MasterTop 120SR by Master Builders/ BASF Building Systems, 23700 Chagrin Blvd., Cleveland, OH 44122, (800) 628-9990.

P. Waterstop: Extruded from virgin polyvinyl chloride plastic compound containing no scrap or reclaimed material or pigment.
1. Size: Minimum 6 inches wide by 3/8 inch thick, unless otherwise indicated.
2. Minimum Tensile Strength (ASTM D 412): 2000 psi.
3. Minimum Ultimate Elongation (ASTM D 412): 350 percent.
4. Shore A/10 Durometer Hardness (ASTM D 2240): Minimum 65; Maximum 83.
5. Maximum 24-Hour Water Absorption (ASTM D 570): 0.15.

Q. Expansion Joint Dowels: Smooth steel expansion joint dowel with minimum 5-inch-long steel dowel cap, unless otherwise indicated.

2.02 PROPORTIONING OF MIXES

A. Cast-in-place concrete shall be air-entrained normal weight concrete except where lightweight concrete is indicated on the drawings.
1. Normal weight concrete, except as otherwise specified, shall have a minimum compressive strength as required by ACI 318-14 Table 19.3.2.1."Requirements for concrete by exposure class". Slump: Maximum 4 inches; minimum 2 inches before the addition of any water-reducing admixtures or high-range water-reducing admixtures (superplasticizers) at the Site.

B. Lightweight concrete shall be air-entrained concrete having a minimum compressive strength as required by ACI 318-14 Table 19.3.2.1 "Requirements for concrete by exposure class", and Table 19.2.4.2 "Modification factor **λ"** Lightweight concrete shall be made with normal fine aggregate; lightweight fine aggregate shall not be used. Slump: Maximum 4 inches; minimum 1 inch before the addition of any water-reducing admixtures or high-range water-reducing admixtures (superplasticizers) at the Site.

C. Slump for Pumped Concrete: When a water-reducing admixture is not used, maximum slump shall be 4 inches. When a water-reducing admixture is used, maximum slump shall be 6 inches and when a high-range water-reducing admixture (superplasticizers) is used, maximum slump shall be 8 inches.

D. Design Air Content: Design air content for concrete shall be according to ACI 318-14 Table 19.3.2.1 "Requirements for concrete by exposure class", and ACI 318-14 Table 19.3.3.1 "Total air content for concrete exposed to cycles of freezing and thawing" with an allowable tolerance of plus or minus 1.5 percent for total air content, except as otherwise specified. Use air-entraining admixture, not air-entrained cement.

E. Water-Cement Ratio: Cast-in-place concrete shall have a maximum water-cement ratio as required by ACI 318-14 Table 19.3.2.1"Requirements for concrete by exposure class".

F. ACI 301, Section 4.2.2.3: Change article to read as follows:

1. 4.2.2.3 - Size of Coarse Aggregates:
   a. 4.2.2.3.a Normal Weight Concrete: Coarse aggregates shall conform to graduation requirements for various sizes as tabulated in Table No. 2 of ASTM C 33. The sizes of coarse aggregates for various classes of Work shall be as follows with all percentages being determined by weight.
   b. 4.2.2.3.b For concrete floors, floor and roof slabs, reinforced beams and girders, columns and piles, concrete encasing underground electric conduits, and concrete in which the space between restricting objects is 2 inches or less, the course aggregate shall be Size No. 67.
   c. 4.2.2.3.c For other concrete Work having a minimum cross-sectional dimension of not more than 6 inches, the coarse aggregate shall be a well graded mixture of No. 67 and No. 57, provided that not more than 50 percent nor less than 30 percent shall be Size No. 67 and not more than 70 percent nor less than 50 percent shall be Size No. 57.
   d. 4.2.2.3.d For other concrete Work having a minimum cross-sectional dimension greater than 6 inches and not more than 12 inches, the coarse aggregate shall consist of a mixture of No. 67, No. 57 and No. 467, providing that not more than 25 percent nor less than 10 percent shall be Size No. 67 and not more than 40 percent shall be Size No. 467.
   e. 4.2.2.3.e For other concrete Work having a minimum cross-sectional dimension of more than 12 inches, the coarse aggregate shall consist of a mixture of No. 67, No. 57 and No. 357, providing not more than 25 percent nor less than 10 percent shall be Size No. 67 and not more than 40 percent shall be Size No. 357.
   f. 4.2.2.3.f Lightweight Concrete: Lightweight aggregates shall be graded from 3/4 inch to No. 4 sieve size in conformance with Table No. 1 of ASTM C 330.

G. Application Rate for Corrosion-Inhibiting Admixture: The application rate for the corrosion-inhibiting admixture shall be 5 gallons per cubic yard of concrete for all concrete placements where indicated on the drawings.

H. Admixtures: Do not use admixtures in concrete unless specified or approved in writing by the Director.

I. ACI 301, Section 4.1.2.1 - Mixture Proportions:
1. Add the following to paragraph 4.1.2.1:
a. Proposed design mix(es) for pumped concrete and the pumping equipment shall have been tested under actual field conditions with the maximum horizontal run and vertical lift required for this project.

2.03 JOINTS

A. ACI 301, Section 5.3.2.6 - Construction joints and other bonded joints:
1. Delete the following subparagraphs:
a. Use an acceptable surface retarder in accordance with manufacturer's recommendations;
b. Roughen the surface in an acceptable manner that exposes the aggregate uniformly and does not leave laitance, loosened particles of aggregate, or damaged concrete at the surface; or
2. Add the following in place of the above subparagraph:
a. The use of cement grout.

B. ACI 301, Section 10.2.5 – Isolation-joint filler materials:
1. Add the following paragraphs:
a. Except as otherwise shown on the Drawings, expansion joints shall be as follows:
b. In joints required to receive a sealant, the joint filler shall be 1/2-inch-thick and recessed as required to form a caulking slot.
c. In joints not required to receive a sealant, the joint filler shall be 1/2-inch-thick and extend through the full cross-section of the concrete.
d. Tool edges of concrete with 1/8-inch radius edging tool.

2.04 PRODUCTION OF CONCRETE

A. Provide ready-mixed concrete, either central-mixed or truck-mixed, unless otherwise approved in writing by the Director.

B. ACI 301, Section 7 - Lightweight Concrete:
1. Add the following paragraph:
a. Lightweight coarse aggregate shall be presoaked with water a minimum of 24 hours prior to use in a concrete mix to be pumped. Presoaking may be accomplished by suitable sprinkling.

C. ACI 301, Section 5.3.2.1 Weather considerations
1. Delete paragraph under 5.3.2.1.c - Hot Weather, and add the following:
a. 5.3.2.1.c Provide adequate controls to insure that the temperature of the concrete when placed does not exceed 90 degrees F., and make every effort to place it at a lower temperature. The temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set or cold joints. Ingredients may be cooled before mixing by shading

the aggregates, fog spraying the coarse aggregate, chilling the mixing water or other approved means. Mixing water may be chilled with flake ice or well-crushed ice of a size that will melt completely during mixing, providing the water equivalent of the ice is calculated into the total amount of mixing water.

D. Protect concrete from physical damage or reduced strength due to weather extremes during mixing, placement and curing.
   1. In cold weather, comply with ACI 306R.
      a. When air temperature is below 40 degrees F (4 degrees C) heat the mixing water and, if necessary, the aggregates to obtain a concrete mixture temperature of not less than 50 degrees F (10 degrees C) and not more than 80 degrees F (27 degrees C) at point of placement. If the mixing water is heated, do not exceed a temperature of 140 degrees F at the time it is added to the cement and aggregates.
   2. In hot weather, comply with ACI 305R.
      a. When air temperature is between 85 degrees F (30 degrees C) and 90 degrees F (32 degrees C), reduce mixing and delivery time from 1 1/2 hours to 75 minutes, and when air temperature is above 90 degrees F (32 degrees C), reduce mixing and delivery time to 60 minutes.

PART 3 EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Do not use items of aluminum for mixing, chuting, conveying, forming or finishing concrete, except magnesium alloy tools may be used for finishing.

B. Check items of aluminum required to be embedded in the concrete and insure that they are coated, painted or otherwise isolated in an approved manner.

C. Install waterstops in accordance with manufacturer's printed instructions.

D. Hardened concrete, reinforcement, forms, and earth which will be in contact with fresh concrete shall be free from frost at the time of concrete placement.

E. Do not deposit concrete in water. Keep excavations free of water by pumping or by other approved methods.

F. Prior to placement of concrete, remove all hardened concrete spillage and foreign materials from the space to be occupied by the concrete.

3.02 ADMIXTURE ADDITIONS AT THE SITE

A. Site additions shall be limited to high-range water-reducers, non-chloride accelerators, and corrosion inhibitors. Comply with manufacturers' printed instructions for discharge of admixtures shall be furnished.

B. High-Range Water-Reducers:
   1. Concrete shall arrive at a slump of 2 to 4 inches (50 to 100 mm). Water additions at the Site shall be limited to comply with water-to-cementitious ratio requirements.
   2. Following addition of high-range water-reduced concrete, a minimum of 70 revolutions or 5 minutes of mixing shall be completed to assure a consistent mixture.

C. All concrete with other admixture additions shall mix a minimum of 70 revolutions or 5 minutes to assure a consistent mixture.

3.03 PLACING

A. ACI 301, Section 5.3.2.3 Conveying equipment:
   1. Add the following paragraphs:
      a. 5.3.2.3.d When pumping concrete, the lubricating mortar for the delivery line shall not be discharged into an area of concrete placement.
      b. 5.3.2.3.e The inside diameter of the delivery lines for pumped concrete shall be the greater of either a minimum of 5 inches or 3 times the maximum size of coarse aggregate.

B. ACI 301, Section 5.3.2.2 - Conveying:
   1. Add the following paragraph:
      a. Operation of truck mixers and agitators and discharge limitations shall conform to the requirements of ASTM C 94.

C. ACI 301, Section 5.3.2.4 - Depositing:
   1. Add the following paragraph:
      a. Do not allow concrete to free fall more than 4 feet.

3.04 REPAIRING SURFACE DEFECTS

A. ACI 301, Section 5.3.7 – Repair of surface defects:
   1. Add the following paragraph:
      a. 5.3.7.1.a Finish patched areas to match the texture of the surrounding surface.

B. ACI 301, Section 5.3.7.2 - Repair of tie holes:
   1. Delete last sentence in 5.3.7.2 and replace with the following:
      a. The patch mixture shall consist of a mixture of dry-pack mortar, consisting of one-part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for placing and handling. For surfaces exposed to view, blend white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Provide test areas at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.

3.05 SLABS

A. Slabs On Grade: Provide key type joints unless otherwise shown. Tool exposed joints.

B. ACI 301, Section 5.3.4 – Finishing unformed surfaces:
   1. Add the following paragraph to section 5.3.4.1 Placement:
      a. Provide monolithic finishes on concrete floors and slabs without the addition of mortar or other filler material. Finish surfaces in true planes, true to line, with particular care taken during screeding to maintain an excess of concrete in front of the screed so as to prevent low spots. Screed and darby concrete to true planes while plastic and before free water rises to the surface. Do not perform finishing operations during the time free water (bleeding) is on the surface.

C. Finish Schedule: Except where indicated otherwise on the Drawings, provide the finishes below:
   1. Floated Finish for:
      a. Treads and platforms of exterior steps and stairs.
      b. Slabs and fill over which waterproofing, roofing, vapor barrier, insulation, terrazzo, or resin bound flooring is required.
   2. Troweled Finish for:
      a. Interior slabs that are to be exposed to view.
      b. Slabs and fill over which resilient wood flooring, resilient tile or sheet flooring, carpet, or thin-film coating system is required.
      c. Slabs and fill over which thin-set ceramic tile is required, except fine-broom finished surface.
      d. Treads and platforms of interior steps and stairs.
   3. Broom or Belt Finish for:
      a. Exterior slabs. Texture as approved by the Director's Representative.
   4. Scratched Finish for:
      a. Surfaces to be covered with ceramic tile set in a bonded thick mortar bed, except screed to a Class B tolerance.
      b. Surfaces to be covered with floor topping.
   5. Integral Emery Aggregate Surfacing with Floated Finish for:
      a. Interior pedestrian ramps.

D. ACI 302.1R Chapter 10.2 - Tools for jointing; Saw-cutting.
   1. Add the following paragraph:
      a. Early-entry dry-cut saws are preferred in place of conventional wet-cut saws.

E. ACI 302.1R Chapter 10.3
   1. Add the following to Conventional wet-cut saw cutting:
      a. Begin saw-cutting as soon as the saw will not dislodge the aggregate or ravel the edge of the saw-cut, but in no case longer than 12 hours after the slab is placed. Saw-cut leaving a clean, sharp edge in the pattern shown on the Contract Documents. Provide sufficient personnel and equipment to complete saw-cutting operations within 18 hours after the slab is placed.

F. Exposed surfaces with fibrous reinforcement: After curing of the concrete, remove any protruding fibers in a manner which will not harm the parent concrete.

G. Floor flatness and levelness tolerances: For flatness and levelness tolerances of floor slabs refer to ACI 302 Chapter 10.1. Floor surface tolerances shall be 1/8 inch over a horizontal distance of 10 feet in any direction, unless otherwise specified by floor profile quality classifications in ACI 302.
   1. When flatness or levelness tolerances are not met then the floor shall be ground or scarified and repoured to meet specifications.

3.06 CURING AND PROTECTION

A. Hot Weather Concreting: Comply with ACI 305R whenever the atmospheric temperature or the form surface temperature is at or above 90 degrees F., or climatic conditions of wind and/or low humidity will cause premature drying of the concrete.

B. Curing Temperature: Maintain the temperature of the concrete at 50 degrees F. or above during the curing period. Keep the concrete temperature as uniform as possible and protect from rapid atmospheric temperature changes. Avoid temperature changes in concrete which exceeds 5 degrees F. in any one hour and 50 degrees F. in any 24-hour period.

C. Curing and Moisture Mitigation for Resilient Flooring:
   1 Acceptable curing and drying conditions include a minimum ambient temperature of 70 degrees F and a maximum relative humidity of 50%.
      a. Air movement at 15 mph.
   2. Do not cure slabs by adding water; ponding or wet burlap method.
   3. Do not use curing compounds or cure-and-seal materials unless such use is approved in writing by the adhesive and floor covering manufacturers. The curing product manufacturer's conformance to ASTM C 1315 is not a substitute for the adhesive and floor covering manufacturer's approval.
   4. Cure the slab by covering with waterproof paper, plastic sheets, or a combination of the two for 3 to 7 days.

3.07 CHEMICAL HARDENER (DUSTPROOFING)

A. Apply chemical hardener to all troweled finished interior floors which are to be left exposed.

B. Do not apply chemical hardener until concrete has cured the number of days recommended in manufacturer's instructions.

C. Prepare surfaces and apply chemical hardener in accordance with manufacturer's printed instructions and recommendations.

3.08 FIELD QUALITY CONTROL

A. ACI 301, Section 1.6.3.2 - Testing Services:

1. Add the following paragraph:
   a. Strength Tests for Pumped Concrete: Prepare strength test specimens and make strength tests from concrete samples obtained at the truck discharge chute and at the end of the pump delivery line.

B. ACI 301, Section 1.6.2.3 – Tests required of Contractor's testing agency:
   1. Add the following paragraph:
      a. Make available to the Director's Representatives whatever test samples are required to make tests. Furnish shipping boxes for compression test cylinders.

C. Adjustment to Concrete Mixes: Mix design adjustments may be requested by the Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, at no additional cost to the State and as accepted by the Director. Laboratory test data for revised mix design and strength results must be submitted to and accepted by the Director's Representative before using in the work.

D. Test results will be reported in writing to the Director's Representative, Ready-Mix Producer, and Contractor within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day tests and 28-day tests.

E. Nondestructive Testing: Impact hammer, Windsor probe, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.

F. Additional Tests: The State shall make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by the Director's Representative. The testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. Pay for such tests when unacceptable concrete is verified, including all inspection and Engineering fees when non-conforming work is verified.

G. Moisture Testing: Test all slabs-on-grade for moisture content that will receive resilient flooring. For a preferred moisture testing method and limits; consult the written instructions of the floor covering manufacturer, the adhesive manufacturer, the patching/underlayment manufacturer, or combination thereof. Test repeatedly until the desired moisture content is obtained.

H. pH Testing: Test concrete floors for pH level prior to the installation of resilient flooring. Do not exceed the recommended pH level of the resilient flooring manufacturer or the adhesive manufacturer, or both.

END OF SECTION

Revised 10/17/2025

9.4 T Magnet, Magnet Room and Related Areas Design, Installation and Testing Manual

Note: This document is provided to Contracts C, P, H and E as a guide to the design, installation and testing requirements of the Magnet Room, related spaces and equipment. Each Contractor shall familiarize themselves with this document. In executing the work of each contract, each Contractor shall follow the requirements that apply to that contract. Each Contractor shall perform the tests and operational startup procedures described in this manual. Each Contractor's Lump Sum Bid Price shall include any costs associated with the procedures described herein.

Contents

Chapter 7 Appendix

7.1 MR Site Vibration Test Guidelines

7.2 RF Shielding Effectiveness and Ground Isolation Testing

7.3 Acoustic Background and Design Guidelines

7.6 Feeder Sizing Criteria with Examples

7.7 Sample control schematic for Contractor-supplied MDP

7.8 Selecting Anchor Size

7.9 Magnet Cryogenic Venting Pressure Drop

Chapter 1 Introduction

1.1 Preinstall Manual Introduction

1.1.1 Document Purpose

This preinstallation manual provides the necessary information to prepare a site for system installation. Specifically, this manual provides information:

1. To define system requirements and interactions.
2. For the effective arrangement and interconnection of system components.
3. The Contractor is responsible for:
    a. Compliance with all local and national codes and regulations
    b. Siting requirements for Contractor-specific site procedures (medical, MR, safety, and so on)
    c. Any special architectural requirements (for example, seismic codes)

The implementation of all requirements and adherence to all specifications in this manual is the responsibility of the Contractor or its architect and engineers. Refer any questions to the GE Healthcare Project Manager of Installation (PMI).

1.1.2 Intended User

The primary users of this manual are the Contractor

1.1.3 Document Overview

This manual describes requirements and specifications for the following:

1. General system requirements that apply to the entire MR suite
2. Shipping and delivery
3. Magnet Room
4. Equipment Room
5. Control Room
6. Interconnects within and between the rooms listed above

Chapter 2 General System Level

2.1 System Level Requirements for Installing into Existing MR Suite

When planning for the installation of this system in an existing GE Healthcare MR suite or a non-GE Healthcare MR suite, all requirements in this manual must be met because these rooms are considered new installations.

1. If the existing MR suite contains a GE system, the vibration environmental assessment must be done using the High Speed (magnetic field) Stability tool.
2. Some GE Healthcare MR suites with overhead cabling may need to be modified to meet current cable tray requirements, such as minimum width and position. See 6.2 MR System Interconnects Routing Requirements on.
3. Remove, cover, or fill in abandoned ducts or troughs from the Equipment and Magnet Rooms.

   Access/computer room flooring in the Equipment Room can either be removed or assessed and reinforced to support heavier cabinets.
4. Structural vibration levels may be higher at some frequencies than other MR Systems, which may increase acoustic levels. Refer to 2.6.2 Structure-borne Vibration Control Specifications
5. The VibroAcoustic damping kit must be surface mounted (if the floor is recessed, it must be filled in and level). For upgrades that reuse the existing magnet, recessed floors can be filled with magnet spacers (25 mm (1 in.) aluminum) that were included when the magnet shipped.
6. RF vendor responsibilities:
   a. The old dock anchor cannot be reused. It 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.
   b. The RF shield ceiling must support the cable routing mechanism and cables. Reinforce RF shield ceiling (see 6.2 MR System Interconnects Routing Requirements).
   c. Two penetration panel openings are required and must meet the requirements in: 3.5 RF Shielded Room Requirements.
   d. RF shield attenuation must comply with: 3.5 RF Shielded Room Requirements.
7. Cryogen vent may need to be relocated to align with the Magnet Cryogen Vent opening. The cryogen vent must meet all cryogen venting requirements (see 3.8 Magnet Room Venting Requirements).

2.2 System components

2.2.1 Magnet Room

1. 9.4 T Active Shield Magnet and Magnet Enclosure (MAG)
2. 9.4 T Magnet and Magnet Enclosure
3. Rear Pedestal (PED)
4. Patient Transport Table (PT)
5. Remote Oxygen Sensors
6. Magnet Rundown Unit (MRU)

2.2.2 Equipment Room

1. Main Disconnect Panel (MDP)
2. Integrated System Cabinet (ISC)

3. Integrated Cooling Cabinet (ICC)
4. Penetration Panel Cabinet (PEN)
5. Secondary Penetration Wall (SPW)
6. Integrated System Cabinet (ISC) Penetration Wall (PW)
7. Integrated Cooling Cabinet (ICC) Secondary Penetration Wall (SPW)
8. Cryocooler Compressor Cabinet (CRY)
9. Cryocooler Compressors (CRY1 and 2)
10. Magnet Monitor (MON)
11. RF Amplifier Cabinet
12. High Order Shim Power Supply Cabinet

2.2.3 Control Room

1. Operator Workspace equipment (OW)
2. Pneumatic Patient Alert System (PA1)
3. Oxygen Monitor (OXY)

2.2.4 Accessories

1. Patient accessories, including RF coils, phantoms, cushions, sponges, straps, and wedges
2. Gating accessories, including patient cardiac leads, peripheral gating probe, and respiratory bellows

Table 6 Guidance And Manufacturer's Declaration – Electromagnetic Immunity

The system is intended for use in the electromagnetic environment specified below. The Contractor or the user of the system should assure that it is used in such an environment.		
Immunity Test	***IEC 60601 Test level***	***Compliance Level***
Electrostatic discharge (ESD) IEC 61000-4-2	± 8 kV contact	± 8 kV contact
	± 2 kV, ± 4 kV, ± 8 kV, ± 15 kV air	± 2 kV, ± 4 kV, ± 8 kV, ± 15 kV air
Radiated RF IEC 61000-4-3	3 V/m[b] 80 MHz to 2.7 GHz	3 V/m[b] 80 MHz to 2.7 GHz
Electrical fast transient / burst IEC 61000-4-4	± 2 kV for power supply lines	± 2 kV for power supply lines
	± 1 kV for input/output lines	± 1 kV for input/output lines
Surge IEC 61000-4-5	± 0.5 kV, ± 1 kV Line to line	± 0.5 kV, ± 1 kV Line to line
	± 0.5 kV, ± 1 kV, ± 2 kV Line to ground	± 0.5 kV, ± 1 kV, ± 2 kV Line to ground
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz 6 Vrms 150 kHz to 80 MHz at ISM bands[a]	3 Vrms 150 kHz to 80 MHz 6 Vrms 150 kHz to 80 MHz at ISM bands[a]

Short interruptions and voltage variations on power supply input lines IEC 61000-4-11	U_T = 0%, 250/300 cycles	U_T = 0%, 250/300 cycles

Guidance And Manufacturer's Declaration – Electromagnetic Immunity continued		
The system is intended for use in the electromagnetic environment specified below. The Contractor shall assure that it is used in such an environment.		
Immunity Test	***IEC 60601 Test level***	***Compliance Level***
Voltage dips IEC 61000-4-11	U_T = 0%, 0.5 cycle (0, 45, 90, 135, 180, 225, 270, and 315 degrees) U_T = 0%, 1 cycle U_T = 70%, 25/30 cycles (0 degrees)	Not applicable
Power Frequency (50/60 Hz) magnetic field IEC 61000-4-8	30 A/m 50 Hz or 60 Hz	30 A/m 50 Hz or 60 Hz
U_T is the AC mains voltage prior to application of the test level. **a:** The ISM (industrial, scientific and medical) bands between 0.15 MHz and 80 MHz are 6.765 MHz to 6.795MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.66 MHz to 40.70 MHz. **b:** For additional information, see Table 7.		

Table 7 Guidance and Manufacturer's Declaration – Electromagnetic Proximity field Immunity

The MR System is intended for use in a typical health care electromagnetic environment specified below. The Contractor shall assure that it is used in such an environment.							
Test Frequency (MHz)	**Band (MHz)**	**Service**	**Modulation**	**Maximum Power (W)**	**Distance (m)**	**IEC 60601 Test Level**	**Compliance Level**
385	380 ~ 390	TETRA 400	Pulse Modulation 18 Hz	1.8	0.3	27 V/m	27 V/m
450	430 ~ 470	GMRS 460, FRS 460	FM ± 5 kHz deviation 1 kHz sine	2	0.3	28 V/m	28 V/m
710	704 ~ 787	LTE Band 13, 17	Pulse Modulation 217 Hz	0.2	0.3	9 V/m	9 V/m
745							
780							
810	800 ~ 960	GSM 800/900, TETRA 800, iDEN 820, CDMA 850, LTE Band 5	Pulse Modulation 18 Hz	2	0.3	28 V/m	28 V/m
870							
930							

Guidance And Manufacturer's Declaration – Electromagnetic Proximity field Immunity continued							
The MR System is intended for use in a typical health care electromagnetic environment specified below. The Contractor shall assure that it is used in such an environment.							
Test Frequency (MHz)	**Band (MHz)**	**Service**	**Modulation**	**Maximum Power (W)**	**Distance (m)**	**IEC 60601 Test Level**	**Compliance Level**
1720 1845 1970	1700 ~ 1990	GSM 1800; CDMA 1900; GSM 1900; DECT; LTE Band 1, 3, 4, 25; UMTS	Pulse Modulation 217 Hz	2	0.3	28 V/m	28 V/m
2450	2400 ~ 2570	Bluetooth, WLAN, 802.11 b/g/n, RFID 2450, LTE Band 7	Pulse Modulation 217 Hz	2	0.3	28 V/m	28 V/m
5240 5500 5785	5100 ~ 5800	WLAN 802.11 a/n	Pulse Modulation 217 Hz	0.2	0.3	9 V/m	9 V/m
NOTE The distance values represent the recommended separation distance between interfering equipment and components of the MR System.							

2.4 IEC EMC Compliance

Per IEC 60601-1-2, Medical Electrical Equipment requires special precautions regarding Electromagnetic Compatibility (EMC) and must be installed and put into service according to the EMC information provided in the following tables. The tables below provide details about the level of compliance and provide information about potential interactions between devices. Full declaration is stored on-site in the Operator Manual delivered with the system.

Portable and mobile RF communications equipment can affect Medical Electrical Equipment. The MR System

is designed and tested to the following standards:

Table 5 Guidance And Manufacturer's Declaration – Electromagnetic Emissions

The MR System is intended for use in a typical health care electromagnetic environment specified below. The customer or the user of the MR System should assure that it is used in such an environment.		
Emissions Test	***Compliance***	***Electromagnetic Environment – Guidance***

RF emissions CISPR 11	Group 2	The MR System must emit electromagnetic energy in order to perform its intended function. Nearby electronic equipment may be affected.
RF emissions CISPR 11	Class A	The MR System is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Not Applicable	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Not Applicable	

Table 6 Guidance And Manufacturer's Declaration – Electromagnetic Immunity

The system is intended for use in the electromagnetic environment specified below. The customer or the user of the system should assure that it is used in such an environment.		
Immunity Test	***IEC 60601 Test level***	***Compliance Level***
Electrostatic discharge (ESD) IEC 61000-4-2	± 8 kV contact	± 8 kV contact
	± 2 kV, ± 4 kV, ± 8 kV, ± 15 kV air	± 2 kV, ± 4 kV, ± 8 kV, ± 15 kV air
Radiated RF IEC 61000-4-3	3 V/m[b] 80 MHz to 2.7 GHz	3 V/m[b] 80 MHz to 2.7 GHz
Electrical fast transient / burst IEC 61000-4-4	± 2 kV for power supply lines	± 2 kV for power supply lines
	± 1 kV for input/output lines	± 1 kV for input/output lines
Surge IEC 61000-4-5	± 0.5 kV, ± 1 kV Line to line	± 0.5 kV, ± 1 kV Line to line
	± 0.5 kV, ± 1 kV, ± 2 kV Line to ground	± 0.5 kV, ± 1 kV, ± 2 kV Line to ground
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz 6 Vrms 150 kHz to 80 MHz at ISM bands[a]	3 Vrms 150 kHz to 80 MHz 6 Vrms 150 kHz to 80 MHz at ISM bands[a]
Short interruptions and voltage variations on power supply input lines IEC 61000-4-11	U_T = 0%, 250/300 cycles	U_T = 0%, 250/300 cycles

Guidance And Manufacturer's Declaration – Electromagnetic Immunity continued

The system is intended for use in the electromagnetic environment specified below. The customer or the user of the system should assure that it is used in such an environment.		
Immunity Test	***IEC 60601 Test level***	***Compliance Level***
Voltage dips IEC 61000-4-11	U_T = 0%, 0.5 cycle (0, 45, 90, 135, 180, 225, 270, and 315 degrees) U_T = 0%, 1 cycle U_T = 70%, 25/30 cycles (0 degrees)	Not applicable
Power Frequency (50/60 Hz) magnetic field IEC 61000-4-8	30 A/m 50 Hz or 60 Hz	30 A/m 50 Hz or 60 Hz

U_T is the AC mains voltage prior to application of the test level.

a: The ISM (industrial, scientific and medical) bands between 0.15 MHz and 80 MHz are 6.765 MHz to 6.795MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.66 MHz to 40.70 MHz.

b: For additional information, see Table 7 on page 11.

Table 7 Guidance And Manufacturer's Declaration – Electromagnetic Proximity field Immunity

The MR System is intended for use in a typical health care electromagnetic environment specified below. The customer or the user of the MR System should assure that it is used in such an environment.							
Test Frequency (MHz)	**Band (MHz)**	**Service**	**Modulation**	**Maximum Power (W)**	**Distance (m)**	**IEC 60601 Test Level**	**Compliance Level**
385	380 ~ 390	TETRA 400	Pulse Modulation 18 Hz	1.8	0.3	27 V/m	27 V/m
450	430 ~ 470	GMRS 460, FRS 460	FM ± 5 kHz deviation 1 kHz sine	2	0.3	28 V/m	28 V/m
710	704 ~ 787	LTE Band 13, 17	Pulse Modulation 217 Hz	0.2	0.3	9 V/m	9 V/m
745							
780							
810	800 ~ 960	GSM 800/900, TETRA 800, iDEN 820, CDMA 850, LTE Band 5	Pulse Modulation 18 Hz	2	0.3	28 V/m	28 V/m
870							
930							

Guidance And Manufacturer's Declaration – Electromagnetic Proximity field Immunity continued							
The MR System is intended for use in a typical health care electromagnetic environment specified below. The customer or the user of the MR System should assure that it is used in such an environment.							
Test Frequency (MHz)	**Band (MHz)**	**Service**	**Modulation**	**Maximum Power (W)**	**Distance (m)**	**IEC 60601 Test Level**	**Compliance Level**
1720 1845 1970	1700 ~ 1990	GSM 1800; CDMA 1900; GSM 1900; DECT; LTE Band 1, 3, 4, 25; UMTS	Pulse Modulation 217 Hz	2	0.3	28 V/m	28 V/m
2450	2400 ~ 2570	Bluetooth, WLAN, 802.11 b/g/n, RFID 2450, LTE Band 7	Pulse Modulation 217 Hz	2	0.3	28 V/m	28 V/m
5240 5500 5785	5100 ~ 5800	WLAN 802.11 a/n	Pulse Modulation 217 Hz	0.2	0.3	9 V/m	9 V/m
NOTE The distance values represent the recommended separation distance between interfering equipment and components of the MR System.							

2.6 MR Suite Acoustic Specifications

2.6.1 MR Suite Acoustic Specifications

The following table lists the acoustic output of GE Healthcare equipment:

Table 8 Acoustic Specifications (Under Ambient Conditions)

Room	GE Equipment Acoustic Output
Control Room	≤ 62 dBA
Equipment Room	≤ 83.6 dBA
Magnet Room	See 3.4 Magnet Room Acoustic Specifications

NOTE

All GE equipment acoustic output values are for base equipment configuration in each room.

1. The customer must use acoustic noise containment solutions to control leakage of acoustic noise from one room to the next. See 7.4 Acoustic Background and Design Guidelines for guidance to contain the noise within the Magnet Room.
2. The level indicated for Equipment Room in Table 8 is for GE equipment only. The Equipment Room acoustic level must not exceed 85 dBA.

2.6.2 Structure-borne Vibration Control Specifications

Structure-borne acoustic issues tend to occur at MR installations above the ground floor of the facility. If required, the customer should consult an acoustic engineer for a solution to attenuate this transmitted vibration.

Low Frequency Magnet Floor Vibration Notes:

NOTE

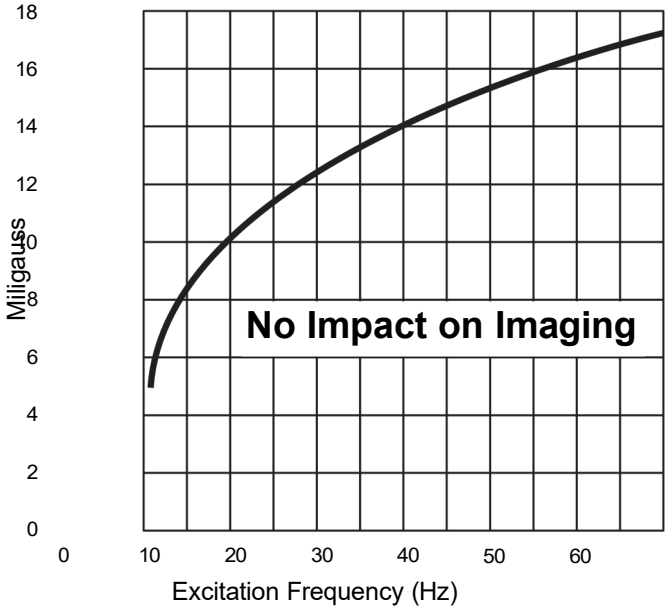
1. Vibration transfer may be the result of customer specific building construction as low levels of vibration transmit into the building through air- and structure-borne paths. Customer MR clinicians recognize the vibration defined in the tables is typically short bursts of vibration repeated multiple times as the scan progresses.
2. The customer should consider the impact of this vibration for the evaluation and design solution.
3. Low frequency vibration that may displace the floor, between 1 Hz and 25 Hz, is less than $0.12\ m/s^2$.

2.7.3 Electrical Current

1. Electrical current in high voltage power lines, transformers, motors, or generators near the magnet may affect magnetic field homogeneity.
2. Magnetic field interference at 50 or 60 Hz must not exceed 1.695 mT (16.95 mG) or 1.790 mT (17.90 mG) RMS respectively at the magnet location (see Figure 7 on page 19).
3. The following equation can be used as a general guide in determining allowable current in feeder lines at a given distance from the magnet isocenter:
   a. For 7T Magnet: $I= (8.95X^2)/S$, where:
   b. I = Maximum allowable RMS single phase current (in amps) or maximum allowable RMS line current (in amps) in three phase feeder lines
   c. S = Separation (in meters) between single phase conductors or greatest separation between three phase conductors
   d. X = Minimum distance (in meters) from the feeder lines to isocenter of the magnet

Figure 7 Magnet Allowable Milligauss vs. Line

Frequency for AC Equipment



2.9 MR Suite Temperature and Humidity

2.9.1 Temperature and Humidity Requirements

1. The temperature requirements must not be exceeded at any point during the day (both working or non-working hours).
2. A separate thermostat must be provided for the Magnet Room.
3. Magnet room must have 12 air changes per hour

Table 11 Room Temperature and Humidity Requirements

Room	*Temperature*		*Humidity*	
	Range °C (°F)	**Change °C/Hr (°F/Hr)[1]**	**Range %RH**	**nge %RH/Hr[2]**
Equipment Room (at Inlet to Equipment)	15-32 (59-89.6)[3]	3 (5)	30-75	5
Magnet Room	15-21 (59-69.8)	3 (5)	30-60	5
Operator Room	15-32 (59-89.6)	3 (5)	30-75	5

s:

1. Operating temperature gradient limits shall be between -3°C/Hr (-5°F/Hr) and 3°C/Hr (5°F/Hr), when averaged over 1 hour.
2. Operating humidity gradient limits shall be between -5% RH/hour and 5% RH/hour, when averaged over 1 hour.
3. Maximum ambient temperature is derated by 1°C per 175 m above 950 m (not to exceed 2600 m).

2.9.2 Equipment Heat Output Specifications

This section details the heat output for specific components. These heat outputs define the minimum, maximum and an assumed average condition over a 12-hour period. Actual heat output and room temperature may vary due to environmental factors, room insulation, clinical usage, and any non-GE Healthcare equipment used in the MR suite. Also, due to large variations in heat loads, the HVAC system may require unloaders, hot gas bypass, and reheat to maintain humidity levels.

Table 12 System Heat Output for Air Cooling - Magnet Room

Component	***Maximum*** **W (BTU/hr)**	***Average*** **W (BTU/hr)**	***Idle*** **W (BTU/hr)**
Magnet (MAG) and Patient Transport Table (PT)	2720 (9289)	2720 (9289)	2720 (9289)
Primary Pen Wall	0	0	0
Secondary Pen Wall	300 (1023)	150 (512)	0
Main Disconnect Panel (MDP)	0	0	0

Table 13 System Heat Output for Air Cooling - Equipment Room

Component	**Maximum W (BTU/hr)**	**Average W (BTU/hr)**	**Idle W (BTU/hr)**
Primary Pen Wall	0	0	0
Secondary Pen Wall	300 (1023)	150 (512)	0
Main Disconnect Panel (MDP)	285 (972)	132 (450)	132 (450)
Integrated System Cabinet (ISC)	11500 (39215)	5500 (18755)	2950 (10060)
Integrated Cooling Cabinet (ICC)	1000 (3410)	600 (2046)	250 (853)
Cryocooler Compressor (CRY)	500 (1705) x2	500 (1705) x2	500 (1705) x2
Magnet Monitor (MON)	240 (818)	240 (818)	240 (818)

RF Cabinet	6200 (21156)	1000 (3413)	1000 (3413)
HOS Cabinet	1624 (5541)	612 (2088)	612 (2088)

Table 14 System Heat Output for Air Cooling - Control Room

Component	Maximum W (BTU/hr)	Average W (BTU/hr)	Idle W (BTU/hr)
Main Disconnect Panel (MDP)	0	0	0
Operator Workspace equipment (OW)	1450 (4945)	1450 (4945)	1450 (4945)

2.10Facility Coolant Requirements

2.10.1 Integrated Cooling Cabinet (ICC) Coolant Requirements

1. The facility must provide an uninterrupted supply of liquid coolant to the Integrated Cooling Cabinet (ICC) at magnet delivery. Coolant circuit must be operational at magnet delivery.
2. Each of the two cryocooler compressors require their own dedicated facility coolant supplies with flow meter, pressure gauge, and flow regulation control.
3. The facility must provide pipe/hose, filter, and connectors to the ICC.
4. The vertical distance between the coolant connection points of the ICC and the Gradient Coil must be less than ± 5 meters (± 196.8 in.).
5. The Contractor must provide and install an in-line flow meter on either the supply or return facility coolant hose. The flow meter must be capable of visually displaying volumetric flow between 76 and 189 L/min (20 and 50 GPM) and configured for the properties of the cooling fluid in use within the ICC coolant circuit.

Table 15 Facility Liquid Coolant Requirements

Parameter	Requirements
Availability	Continuous
Antifreeze or treated process water	No more than 50% propylene glycol-water (PGW) or ethylene glycol-water (EGW)
Minimum Flow	114 L/min (30 GPM)
Maximum Flow	132 L/min (35 GPM)
Maximum Pressure Drop in ICC at Minimum Flow	2.2 bar (32.0 psi) with 50% propylene glycol-water; 1060 kg/m^3 density X bar (Y psi) with pure water; 994 kg/m^3 density
Maximum Pressure Drop in ICC at Maximum Flow	2.9 bar (42 psi) with 50% propylene glycol-water; 1060 kg/m^3 density X bar (Y psi) with pure water; 994 kg/m^3 density

Temperature rise at Minimum Flow	14°C (25°F) with 50% propylene glycol-water; 3346 J/(kg K) specific heat; 1060 kg/m^3 density; 94 kW heat
Temperature rise at Maximum Flow	12°C (22°F) with 50% propylene glycol-water; 3346 J/(kg K) specific heat; 1060 kg/m^3 density; 94 kW heat

Facility Liquid Coolant Requirements continued	
Parameter	**Requirements**
Maximum Inlet Pressure to ICC	6 bar (87 psi)
Chiller Size	94 kW
Condensation Protection	Facility Plumbing to the ICC must be properly routed and insulated to prevent equipment damage or safety hazards
Minimum Continuous Heat Load	15 kW (2 cryocoolers)
Inlet Temperature	5 to 12°C (41 to 54°F) measured at the inlet to the ICC
Contractor supplied feeder hose (from main water supply to ICC)	38.1 mm (1.5 in.) minimum hose inside diameter
Hose connections to the ICC	38.1 mm (1.5 in.) male NPT
Hose connections to the Cry-ocooler compressors (supply and return)	12.5 mm (0.5 in.) onto hose barb and clamp

Figure 10 Allowable Facility Water Temperature and Flow

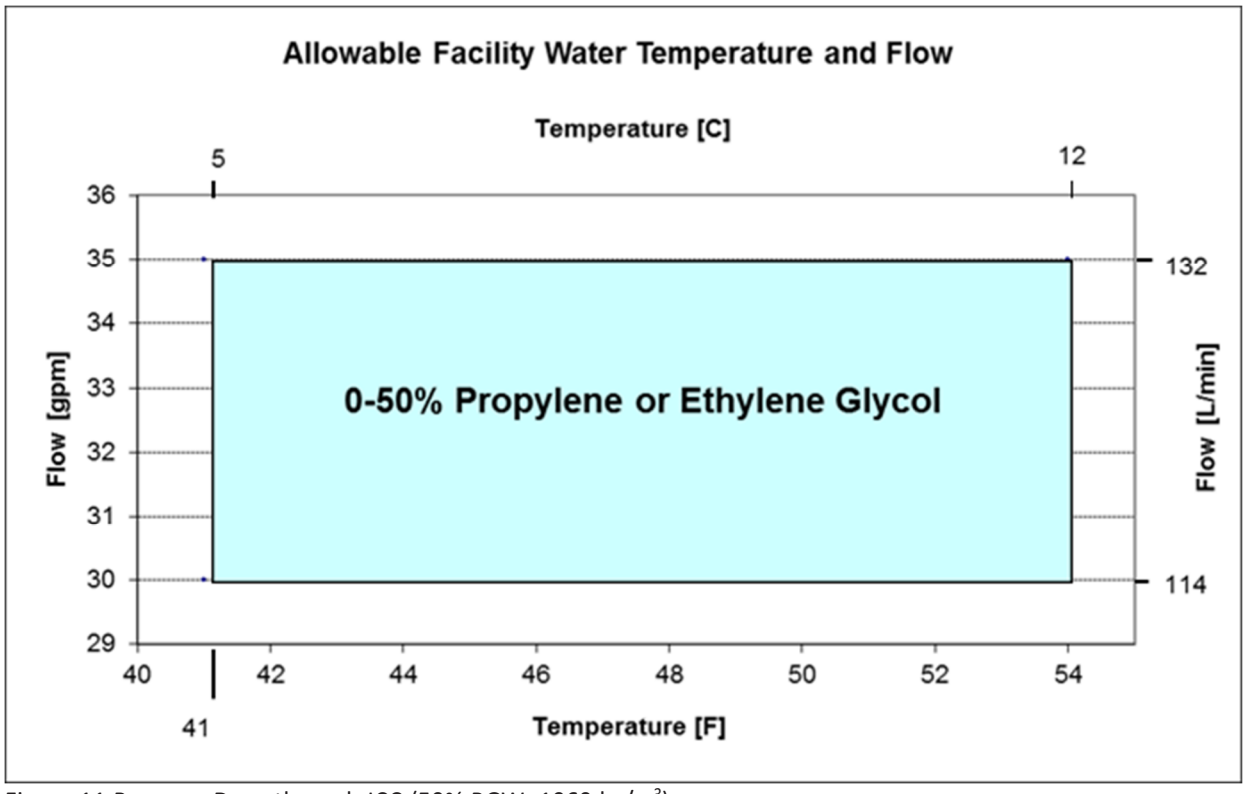


Figure 11 Pressure Drop through ICC (50% PGW, 1060 kg/m^3)

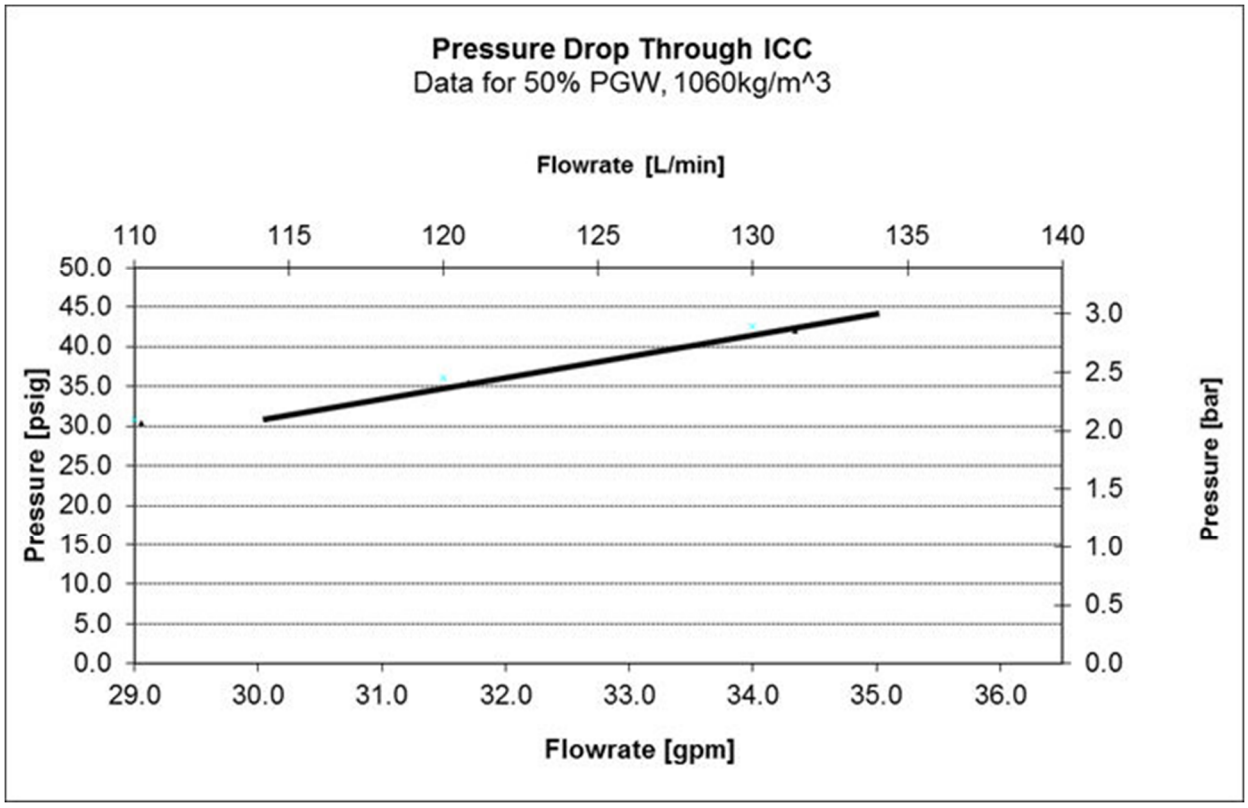
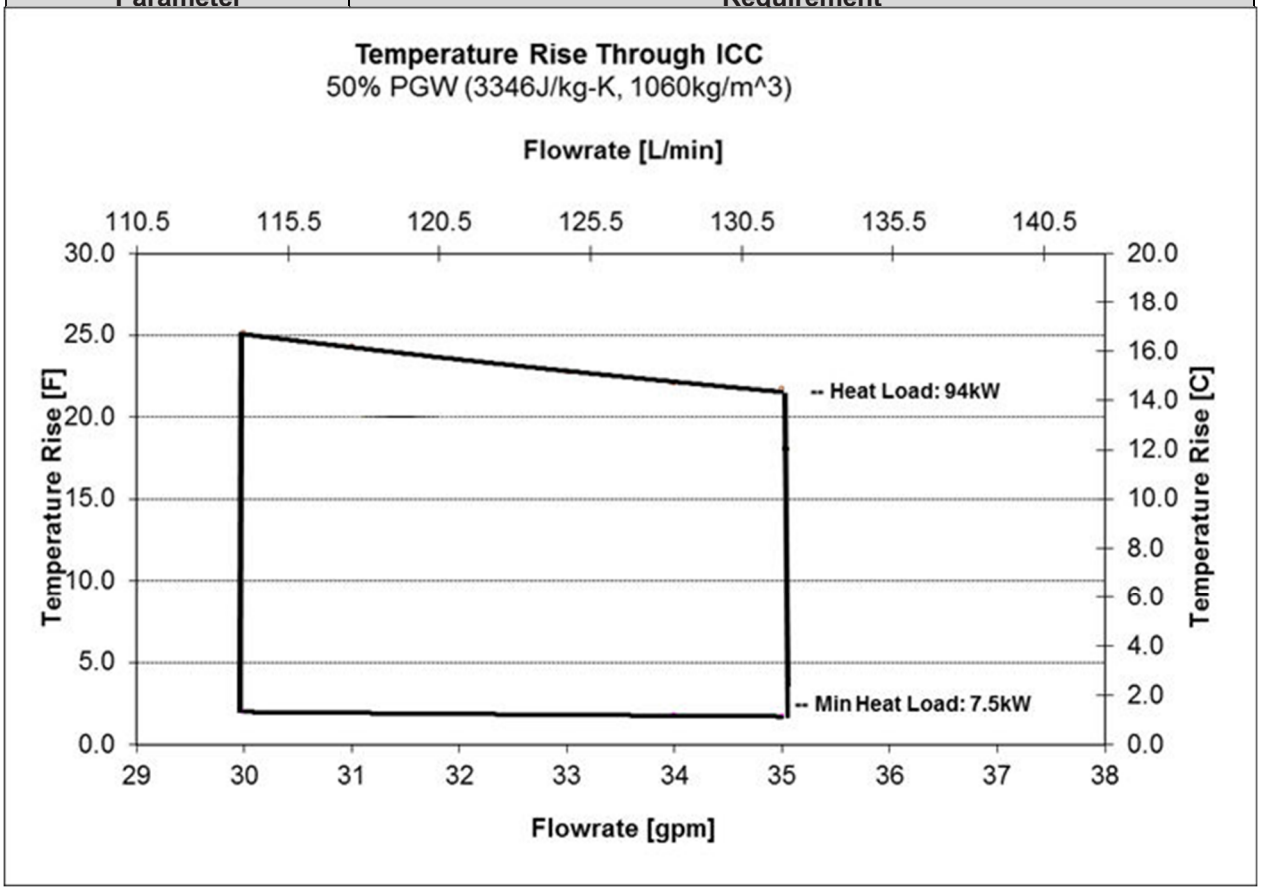


Figure 12 Temperature Rise through ICC (50% PGW, 3346 J/kg-K, 1060 kg/m^3)

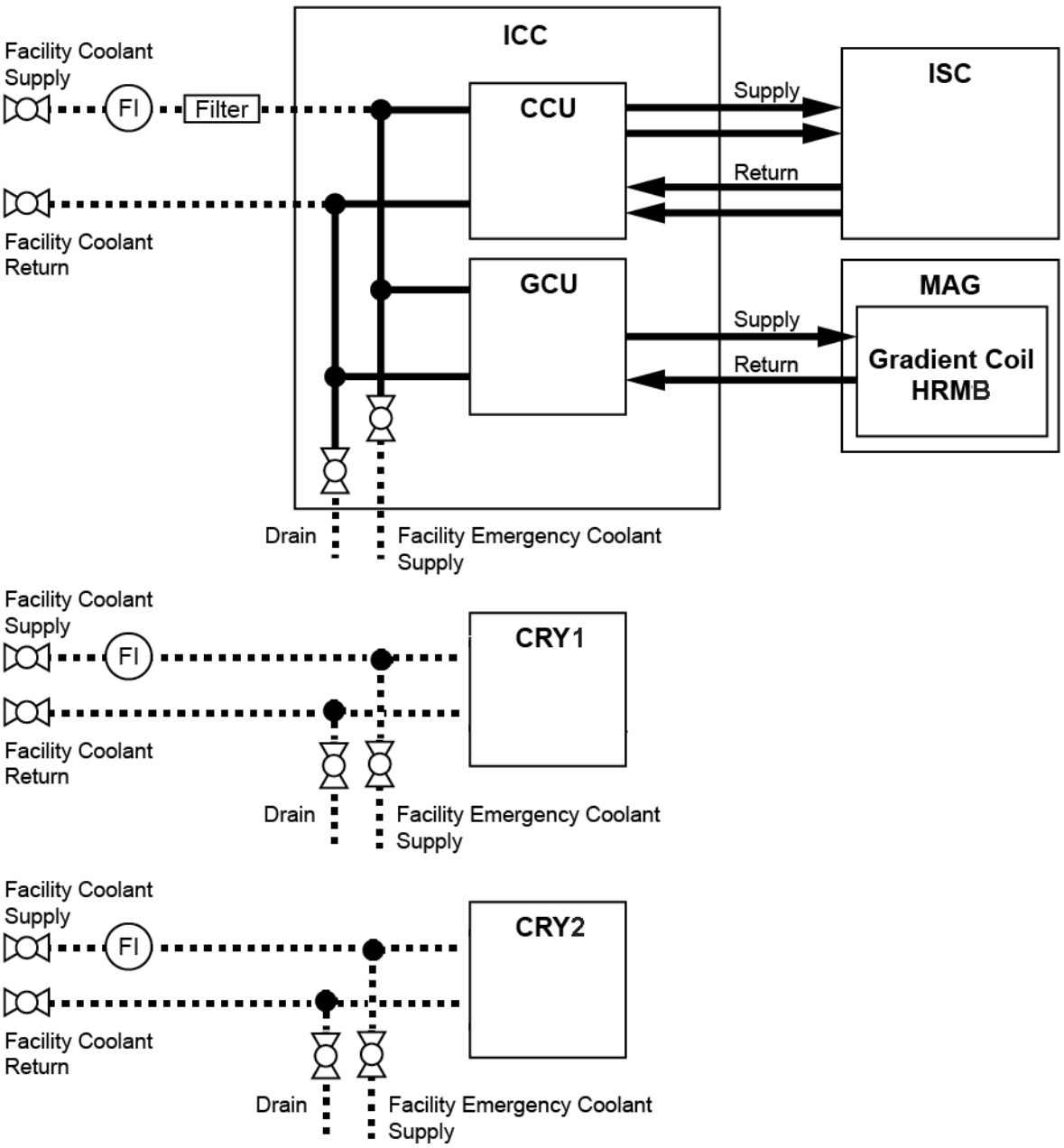
Table 16 Facility Water Quality Requirements

Parameter	Requirement



Facility Water Quality Requirements continued	
Parameter	**Requirement**
Sulfide Ion	None, not detectable
Ammonium Ion	< 1.0 ppm
Residual Chlorine	< 0.3 ppm
Free Carbon Dioxide	< 4.0 ppm
Stability Index	6.0 to 7.0
Suspended Matter	< 10 ppm
Particle Size	< 100 micron (with field changeable filter)

Figure 13 MR System Water Cooling Block Diagram



2.10.2 Cryocooler Compressor Coolant Requirements

1. Cryocooler connection: 12.5 mm (0.5 in.) hose barb listed in Facility Liquid Coolant Requirements
2. Coolant must meet water quality requirements listed in Facility Water Quality Requirements.
3. Coolant must meet the flow, temperature, and pressure requirements shown in .4

2.10.3 Emergency Backup Facility Coolant Requirements

Emergency backup coolant is required for full system functionality as listed below. However, separate dedicated emergency backup coolant supplies must be provided for each of the Cryocooler Compressors in all cases (see Figure 13).

1. Cryocooler Compressor backup only:

   Backup coolant may be routed to the ICC backup water port for the Cryocooler compressor at the location indicated in Figure 13 with the following requirements:

a. The emergency coolant supply must be drained to the facility through Contractor supplied 12.5 mm (0.5 in.) hose and must not back-feed to the ICC.

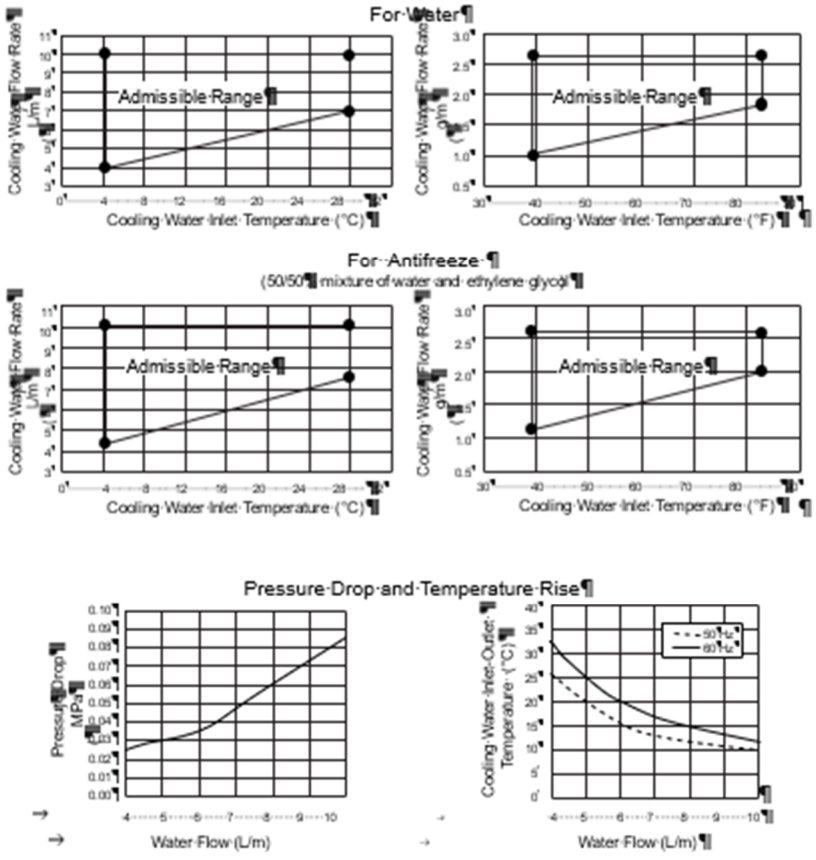
b. Coolant must meet all other ICC coolant requirements listed in 2.10.1 Integrated Cooling Cabinet (ICC) Coolant Requirements .

c. The Contractor is responsible for coolant, 12.5 mm (0.5 in.) pipe/hose, filters, and connectors to supply the coolant to the ICC emergency facility coolant supply line (12.5 mm (0.5 in.) hose with a female threaded connector). The emergency coolant supply line is available from the Contractor on the ICC. The hose comes out from the bottom rear of the ICC.

d. The Contractor is also responsible for coolant, 12.5 mm (0.5 in.) pipe/hose, and connectors to supply the coolant to each of the separate dedicated Cryocooler Compressor emergency supply feeds.

e. The charts below show the coolant flow rate and temperature requirements for the Cryocooler Compressor:

Figure 14 Cryocooler Water Cooling Requirements



1 Mpa = 10 Bar = 145 PSI

2.11 MR Suite Electrical Requirements

2.11.1 General Electrical Requirements

1. A GEHC supplied MDP is required for the system (refer to Figure 15).
2. The Contractor must provide system power to the MDP.
3. All associated transformers and cables must be correctly sized for system power requirements.

4. The Contractor must provide cabling from the MDP to the two PDUs in the Integrated System Cabinet (ISC) and provide cabling from the MDP to the two Cryocooler Compressors (F-70).
5. The power voltage levels vary globally, and incoming feeder currents will be based on corresponding voltage levels at the site. Therefore, the feeder size must be determined for the respective current, including any regulatory margins.

   It is calculated using the full load current needed, minimizing any voltage drop due to the cable loss. For examples on how to calculate feeder cable size, see 7.6 Feeder Sizing Criteria with Examples.
6. All feeder circuits require dedicated ground wires.

Table 17 Facility Power Requirements

Component	Parameter	Requirements	
At Main Disconnect Panel (MDP)	Voltage / Frequency	480 VAC	60 ±3 Hz
		415 VAC	50 ±3 Hz, 60 ±3 Hz
		400 VAC	50 ±3 Hz, 60 ±3 Hz
		380 VAC	50 ±3 Hz, 60 ±3 Hz
	Daily Voltage Variation	Contractor to provide +10% / -10% from nominal at MDP input under all line and load conditions. This includes variation of power source and transmission losses up to the MDP.	
	Phase	Input power to the MDP may use one of the following configurations: • A 3 phase solidly grounded WYE with Ground (3 Wire + Ground) A neutral conductor is not required for MR System operation. If a neutral conductor is present, it can be terminated on the neutral bus provided in the GE supplied MDP. • A 3 phase floating DELTA with Ground (3 Wire + Ground). Do not connect a corner grounded DELTA source. **NOTE** Some UPS options may require a neutral (refer to manufacturer documentation for requirements).	
	Phase Balance	Difference between the highest phase line-to-line voltage and the lowest phase line-to-line voltage must not exceed 2%	

	Power Quality	Recommended THD-V of less than 2.5%

Facility Power Requirements continued			
Component	**Parameter**	**Requirements**	
	Facility Zero Voltage Reference Ground	• The facility ground for the MR System must originate at the system power source (that is, transformer or first access point of power into the facility) and be continuous to the MR System Main Disconnect Panel (MDP) in the room. • Main facility ground conductor to Main Disconnect Panel (MDP) must be appropriately sized insulated copper wire. • The main facility ground to the Main Disconnect Panel (MDP) must meet local codes.	
	Power Availability	Continuous, facility power is required at all times for operation of the two Cryocoolers (CRY1 and CRY2) to minimize cryogen consumption.	
Service receptacle in Magnet Room	Voltage / Frequency	100-120 VAC 60 Hz (North America) 200-240 VAC 50/60 Hz (International)	Receptacle required for small power tools. Local voltage and portable transformers for voltage values.
	Phase	1	
	Maximum Current	20A (North America) 16A (International)	

Table 18 System Power Demand

Equipment	Power Draw (kVA)
	9.4T
Cryo Compressor Continuous Power	18 (2 compressors)
Total System 50 Millisecond Power	349 KVA
Total System 15 minute Power	190
Total System Continuous Power	153
Standby Power Requirement (no scan) (PDU, CRY)	< 26

- Emergency Off and LOTO required for facility backup power.

2.11.2 Main Disconnect Panel (MDP) Requirements

NOTE

Refer to 7.7 Sample control schematic for MDP.

1. MDP shall provide Auto-Restart to the two Cryocooler

Compressors. See Table 18

2. Manual Restart Capability
    a. The MDP shall disconnect the PDU circuits upon power loss.
    b. The MDP shall require a manual restart on the PDU circuits when power is reapplied after an outage.
3. Emergency Off Circuit
    a. The MDP shall have an emergency off control circuit that disables power to the entire MR System.
    b. The emergency off circuit shall be actuated by remotely located push button(s).
    c. Manual reset of the emergency off circuit shall be required to restore power to the entire system.
4. Lock-out/Tag-out:
    a. The MDP shall provide single point lock-out/tag-out for the entire system and a means to lock- out/tag-out each output breaker independently.
    b. The lock-out/tag-out feature shall accommodate a standard sized lock hasp.
    c. The lock-out/tag-out features shall be accessible from the outside of the panel, without the need to open the panel door(s).
5. The MDP shall meet national/local regulations.
6. The MDP shall provide terminations for all grounds entering, leaving and residing within the panel.
7. The MDP shall provide terminations of appropriate size for all power wiring entering and leaving the panel. Refer to 2.11.3 GE Healthcare MDP Features. All wire types, color, and sizing are to be selected in accordance with governing electrical codes.

2.11.3 GE Healthcare MDP Features

The GE Healthcare supplied MDP is specified in the table below.

Table 19 5pecifications for GE Healthcare Supplied MDPs

Part Number	P/N 5792781
Description	7T MDP 480V 60Hz
Mains Input Breaker	Frame: 400A Rating Plug: 300A
Gradient PDU Breaker	Frame: 250A Rating Plug: 200A
System PDU Breaker	Frame: 60A Rating Plug: 60A
Cryo Compressor #1 Breaker	Frame: 30A Rating Plug: 30A
Cryo Compressor #2 Breaker	Frame: 30A Rating Plug: 30A

1. The panels have a short circuit current interrupting rating of 25,000 Amps.
2. Auto restart on the cryocooler compressor circuit.
3. Emergency off circuit including 2 push buttons to be installed external to the MDP.
4. Terminal blocks can accept the wire sizes below:

Table 20 Terminal Block Wire Sizes

	MDP 480V (M7700A - 5792781)
Mains Input Breaker	(2) 70 mm^2 - 240 mm^2 (2/0 AWG - 00 MCM) (1) 10 mm^2 - 300 mm^2 (8 AWG - 600 MCM)
Gradient PDU Breaker	10 mm^2 - 185 mm^2 (8 AWG - 350 MCM)
System PDU Breaker	4 mm^2 - 95 mm^2 (12 AWG - 3/0 AWG)
Cryo Compressor Breakers (2)	2.5 mm^2 - 90 mm^2 (14 AWG - 8 AWG)
Neutral Block	16 mm^2 - 300 mm^2 (6 AWG - 600 MCM)

5. Input neutral terminal block.
6. Multiple ground terminal blocks as required by panel design.
7. Listed and labeled by a Nationally Recognized Testing Lab (NRTL) in accordance with UL 508A and IEC/EN 60204–1 and bear the CE Marking in accordance with the EU Low Voltage Directive (2006/95/EC) and Electromagnetic Compatibility Directive (2004/108/ED).
8. Power on indicators.
9. Two isolated, normally open contact pairs that open when E-off is pressed for use with optional accessories.

2.11.4 Emergency Power Backup 5pecifications (Optional)

The following facility backup power is recommended for continuous operation of the cryocooler compressor and Magnet Monitor:

NOTE

If the compressor must operate on emergency backup power, it still requires chilled water defined in the 2.10.3 Emergency Backup Facility Coolant Requirements.

- The Contractor must provide a dedicated, single power supply to the two compressors.
- Magnet Monitor emergency power (110V / 220V, 2A). Refer to Magnet Monitor (MON) Requirements and Specifications.
- Emergency Off Circuit (E-Off) for the emergency backup to the compressor. LOTO is required for the power source between the generator and compressor.
- A transfer switch to remove the primary power source from the compressor when in

emergency backup power mode.

Table 21 Emergency Power Requirements to Cryocooler Compressors (For Each Compressor)

Power Line Voltage	AC 480V / 60 Hz, 3P +GND or 3P +N +GND Commercial Power Source  **WARNING** Do not use an inverter for the main power source.
Operating Current	Max. 13A (60 Hz)
Starting current	75 / 80 A (60 Hz)
Minimum Circuit Ampacity	17A
Maximum Fuse or Circuit Breaker Size	30A
Power Requirement	Minimum 8.5 kVA
Power Consumption	Max. 8.3 kW / Steady State 7.5 kW at 60 Hz Max. 7.2 kW / Steady State 6.5 kW at 50 Hz

Chapter 3 Magnet Room

3.1 Magnet Room Introduction

The Magnet Room is best understood as a series of layers, or “rooms within a room.” Each of these rooms has a specific function and associated requirements. All requirements in this chapter must be followed to ensure safe and correct operation of the MR System.

1. The Magnetic shielded room contains the MR Magnet fringe field within a confined space. A site survey is required to determine magnet shield requirements (not all sites require magnetic shielding). Because of the added cost of magnetic shielding, room location should be carefully considered.
2. The Acoustic room is a layer used to help attenuate the noise produced during a scan. An acoustic engineer is strongly recommended to assess the environment.
3. The RF shielded room is critical to the correct MR System operation. RF shielding prevents interaction of external RF radiation with MR System operation and it also prevents MR System RF radiation from interfering with external systems, such as aircraft control. Special care must be used when installing all fixtures penetrating the RF shield (for example, vents, electrical conduit, penetration panels) to ensure the integrity of the RF shield is maintained. See 3.5 RF Shielded Room Requirements on page 51.
4. The Finished room includes the wall coverings, ceiling tile, ceiling grid, other fixtures, Magnet (MAG) and Patient Table (PT). When planning the finished room, ensure the following: a. All building codes are met (such as maintaining egress routes).

b. Items which may generate or create RF interference (including florescence lighting) are not allowed for installation within the Magnet Room.

c. Smoke detectors should be located outside of the Magnet Room (for example, within the return air duct) whenever possible. If code does not allow this, use only simple two wire nonaddressable smoke detectors in the Magnet Room.

d. Ferrous or metallic items which could become projectiles when the magnet is installed (including wall coverings, ceiling tile, ceiling grid, or other fixtures) are not used or are correctly secured.

3.1.1 Environmental Steel Limits

A static magnetic field extends in a three-dimensional space around the magnet isocenter. Environmental steel within the static magnetic field affects the uniformity (or homogeneity) of the field. Field uniformity is critical to both image quality and chemical shift analysis (spectroscopy). An analysis of the environmental steel is required within a 10 m (+/- 33 ft.) spherical radius of the magnet isocenter. Environmental steel includes ferrous pipes, beams, concrete rebar, or any other structural steel in the floors, walls, or ceiling.

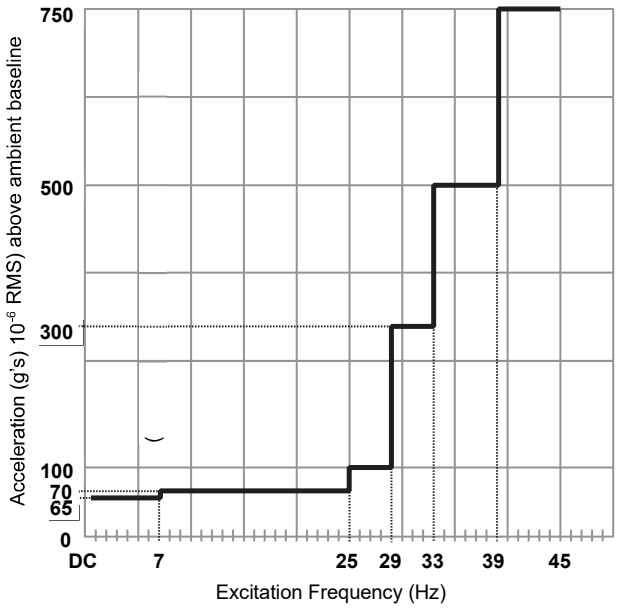
1. Non-movable steel construction material such as rebar and metal decking
2. Existing or proposed RF/magnetic shielding or shim plates
3. 3.2.2 Environmental Steel Limits on page 47 defines the limits of use as a guideline to help the customer understand allowable amounts of ferrous rebar, steel decking, or other components as they design the MR suite and Magnet Room floor structure.
4. The customer must provide detail defining ferrous material below the magnet to the Project Manager so the GE Healthcare MR Siting and Shielding team can review for compliance.

3.1.2 Vibration Requirements

Excessive vibration can affect MR image quality. Vibration testing must be performed early in the site planning process to ensure vibration is minimized. Both steady state vibration (exhaust fans, air conditioners, pumps, and so on) and transient vibrations (traffic, pedestrians, door slamming, and so on) must be assessed (see Figure 19). Specific requirements for vibration mitigation, include:

1. The Magnet (MAG) cannot be directly isolated from vibration. Any vibration issue must be resolved at the source.
2. MR Suite HVAC must have vibration isolation.
3. A vibration analysis must be performed at the proposed site with the results (and any mitigation) forwarded to the GE Healthcare Project Manager of Installation (PMI). See the 7.2 MR Site Vibration Test Guidelines.
4. A transient vibration test must only be performed after a steady-state test has been performed and all steady-state sources of vibration have been mitigated.
5. Transient vibration levels above the specified limits in the 7.2 MR Site Vibration Test Guidelines must be given to the PMI for review.
6. Any transient vibration that causes vibration to exceed the steady-state level must be mitigated.
7. The vibration test consultant must account for non-mechanically induced signals such as test equipment instabilities, thermal drift or RF interference.

Figure 19 Magnet Steady State Vibration 5pecifications



3.1.3 Magnetic Shielded Room Requirements

Magnetic shielding prevents interaction between the magnet and nearby sensitive devices. Because of the added cost of magnetic shielding, room location should be carefully considered. All sites, including upgrade sites, must be evaluated for magnetic shielding requirements. Existing magnetic shielding at an upgrade site may not be sufficient for the new system. Contact the GE Healthcare Project Manager of Installation (PMI) to request a site evaluation.

See MR Suite Magnetic Field Specifications for detailed magnetic proximity limit information.

1. The GE Healthcare Project Manager of Installation (PMI) works to coordinate the magnetic shielding site evaluation.
2. Contractor C is responsible for installation of all magnetic shielding.
3. If rear wall magnetic shield or steel RF wall is closer than 2500mm (98.4 in.) from isocenter, it should be verified by GEHC PMI.

3.2 Magnet Room Acoustic Specifications

The acoustic room is a layer used to help contain the noise (within the Magnet Room) which is produced during clinical scanning. The following information is provided for the acoustic engineer to design for acoustic noise containment within the Magnet Room.

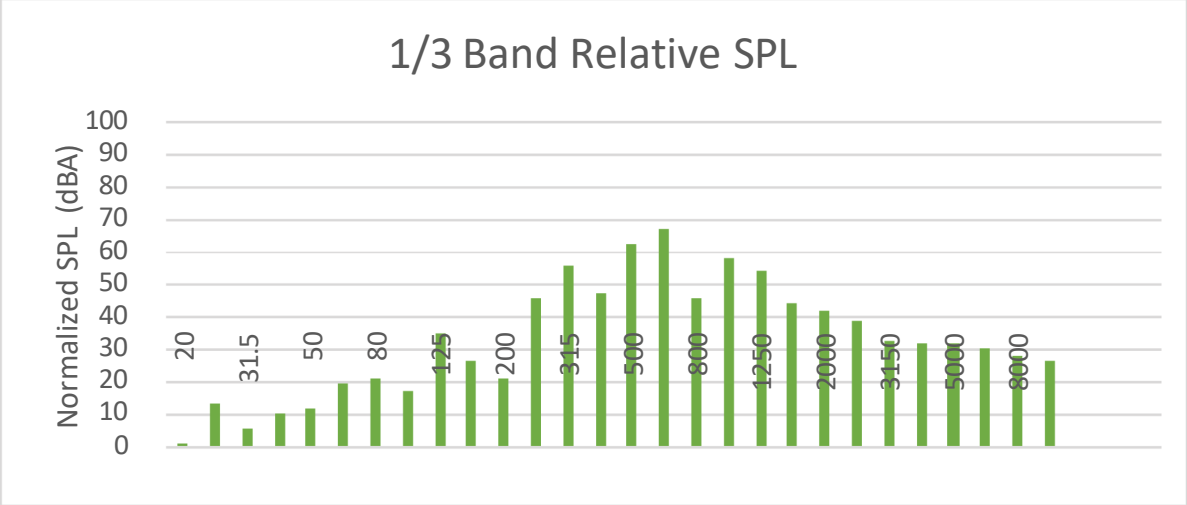
Table 26 Acoustic Specifications for the Magnet Room

Location	Maximum Sound Pressure Level[1]	Frequency Distribution[2]
Magnet Bore	128 dBA	Figure 20
Front of Magnet - 800 mm from bore opening	Magnet Bore – 4 dBA	

Notes:

1. The magnet bore specification is based on the worst case or 20-second average acoustic noise. An 8-hour average will be much less.
2. The total energy, SPL, is derived through the log sum of each 1/3 band octave totaling 128 dBA (for 3.0T magnets) or 122 dBA (for 1.5T magnets). That is, the maximum single 1/3 band is lower than the published values at the front of the magnet.

Figure 20 Sound Pressure Spectral Distribution (Normalized for 20 Hz SPL as 1 dBA)



NOTE

The MR product clinical operation will generate sound pressure proportional to the specific clinical application. The entire spectra (envelope) shown above (Figure 20) represents the relative 1/3 band octave sound pressure the MR scanner may transmit into the air. The acoustic room will best suit the Contractor when the 128 dBA is proportionally distributed as defined by the figure above.

See Acoustic Background and Design Guidelines for acoustic design information.

3.3 RF Shielded Room Requirements

3.3.1 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. See 2.4 IEC EMC Compliance.

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

3.3.2 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.

3.3.3 Contractor Responsibilities

C Contractor is responsible for:

1. The selection of a quality RF shielded room vendor who understands the RF shielding room purpose described in 3.5.1 RF Shielded Room Purpose.
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 3.5.4 RF Shield Requirements.

   This includes installation of the dock/table frame anchor(s) and seismic anchoring as applicable. See 3.5.5 Dock/Table Frame Anchor Mounting Requirements.
3. The RF shielded room may not be in a temperature or humidity controlled environment. The Contractor must take local measures to prevent RF shield effectiveness degradation.
4. 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.
5. 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.

3.3.4 RF Shield Requirements

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

   a. 40.00 +/- 0.5 MHZ
   b. 400.15 +/- 0.5 MHZ
   c. 480.65 +/- 0.5 MH
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.
4. RF shielded room installation materials must meet steel mass limits listed in 3.2 Magnet Room Structural Requirements to keep magnetic field homogeneity.
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 3.8 Magnet Room Venting Requirements

ISC and ICC Wall Opening Requirements

1. The Equipment Room and the Magnet Room must share at least one common wall to mount the ISC and ICC panels.
2. The penetration panel opening requirements are shown in Figure 22 .
3. Two GE-supplied penetration panel adaptor plates are used to connect the ISC and ICC panels to the wall openings. Connection details are shown in Figure 22 .
4. The RF vendor must supply 168 fasteners for hole size of Ø8 (total quantity for both panels) and install each penetration panel adaptor plate to the wall through the outer ring of holes in the plate.

   NOTE

   GE-supplied bolts connect the penetration panels to each adaptor plate through the inner ring of holes in the plate.

5. RF shielding in the Magnet Room walls must completely wrap around all edges of the penetration wall openings and continue through the openings to the inside of the Equipment Room to provide full shielding continuity with the penetration panel adaptor plate. The minimum overlay in the Equipment Room is 70 mm (2.4 in.).
6. A minimum of 102 mm (4 in.) is required between the floor and the bottom of the PEN panel opening to provide clearance for the adaptor plate.
7. The maximum distance between the penetration panels is 3175 mm (125 in).

3.3.5 RF Shielding Integrity (Shielding Effectiveness) Reliability Requirements

1. The RF shielded room must be designed and installed to meet or exceed the 100 dB of shielding effectiveness (SE).
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 7.3 RF Shielding Effectiveness and Ground Isolation Testing.
4. Ensure all joints and mechanical connections remain secure:
   a. All solder joints clean and properly prepared
   b. All mechanical fasteners sufficiently tightened and secured
   c. Do not use rivets or self-tapping screws (as these tend to loosen over time due to vibration).
5. Prevent RF shield corrosion:
   a. Avoid contact between dissimilar metals.
   b. 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.
    a. The RF vendor must supply and install RF door switches on all RF shielded doors.
    b. 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.
    c. The GE-supplied cable (two loose lead conductors) will attach to the RF vendor-supplied cable.
    d. 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).

3.4 Finished Room Requirements

3.4.1 Ferrous Materials in the Magnet Room

1. Non-ferrous (non-metallic) materials or components should be used in the Magnet Room.
2. Ferrous components or material in the Magnet Room that could be removed for servicing, cleaning, or replacement must be secured to prevent the ferrous material from becoming a projectile (ferrous components or material must also be identified as ferrous to prevent untrained personnel from working on the ferrous material while the magnet is energized).

3.4.2 Walls

See Acoustic Room Specifications. Hard, bare wall surfaces may create a harsh Magnet Room environment. Finished walls with acoustic detailing can reduce reflected noise.

1. GE Healthcare recommends finished walls to protect the RF shielding.
2. Walls and any millwork, cabinets, storage areas, acoustic coverings, and so on, must remain outside the minimum service area.
3. A metallic electrical conduit inside walls and ceilings may be used. Conduit for receptacles must be metallic.

3.4.3 Penetration Wall Closet

1. An enclosure (that is, the penetration wall closet) must be provided to restrict access to the penetration panels and for storage of excess interconnections.
    a. The penetration wall closet must meet the minimum penetration wall closet outline as shown in 4.10 Penetration Panel Closet Specifications.
    b. The penetration wall closet must have a mechanical locking mechanism to restrict access to the penetration panels.
    c. The penetration wall closet may be expanded to provide an area for excess cable storage with the following requirements:
        i. Excess cable must not be stored within the minimum closet service area.
        ii. Excess cable must not interfere with access or servicing of the ISC or ICC

penetration walls.

iii. The area within the penetration wall closet to store the cable should be sized to accept a 300 mm (11.8 in.) cable loop.

d. The PEN closet must allow free air exchange of 680 m^3/hour (400 cfm) between the Magnet Room and PEN closet for MR System blowers. Airflow may be achieved through door louvers or other openings in the PEN closet that meet all other PEN closet requirements.

e. The primary source of airflow must be from the Magnet Room. Openings into the area above a false ceiling or other storage areas should be minimized.

f. The penetration walls may be enclosed by separate closets with the following requirements:

i. The maximum distance between the penetration walls is 2743 mm (108 in.).

ii. The separate closets must meet all other service area requirements for each penetration panel.

iii. Airflow as listed above must be provided for both closets.

iv. Both closets must have mechanical locks.

3.4.4 Doors, Magnet Access Openings, and Patient Viewing Windows

1. The finished opening of the Magnet Room main door must be at least 1092 mm (43 in.) wide to allow for helium dewars and patient tables.
2. Threshold height must not exceed 25 mm (1 in.) on both sides of the door with a maximum 10- degree threshold inclination.
3. IEC requires the patient, while in the bore, be in full view of the operator.
4. The magnet delivery requires an opening into the room to allow access for the magnet delivery, rigging, and personnel access.

3.4.5 Finished Ceiling

1. The Contractor is responsible for the finished ceiling.
2. The finished ceiling grid must be non-ferrous.
3. Ceiling preparation should be completed prior to magnet delivery. See 3.6.5 Finished Ceiling for ceiling opening dimensions.
4. The space above the cable concealment opening must be clear of any obstructions, up to a height of 2794 mm (110 in.) from the finished floor, for cables to be routed to the magnet. Refer to 6.2.4 Cable Tray Requirements and Examples for height requirements for the trays that route cables through this opening.

3.4.6 Magnet Room Floors

1. The finished floor must support the weight of all components throughout operation and service life. This includes the magnet, patient table, and gradient coil replacement cart.
2. For gradient coil replacement, field engineers remove the patient table from the

Magnet Room before they move the gradient coil replacement cart into the Magnet Room.

3. The finished floor must be water resistant to protect the subfloor and shielding from water damage.
4. The Contractor is responsible for providing flooring to prevent the buildup to 8 kV.
5. The Magnet is mounted directly to the floor as shown in Figure 23.

   The flooring for the magnet footprint should be flat and level to 6 mm (0.23 in.) across the footprint area of 3300 mm long x 2900 mm wide (130 in. long x 114 in. wide).

   Anchor points are provided when the magnet will be anchored to the floor is areas with seismic activity.
6. The raised floor should be flat and level to 0.125 in. (3 mm) in the shaded area (patient table, rear pedestal, and area around the magnet).

3.5 Magnet Room Venting Requirements

3.5.1 Venting System Requirements

The Magnet Room requires the following venting systems:

1. HVAC
2. Emergency exhaust
3. Pressure equalization
4. Cryogenic venting

3.5.2 HVAC Vent Requirements

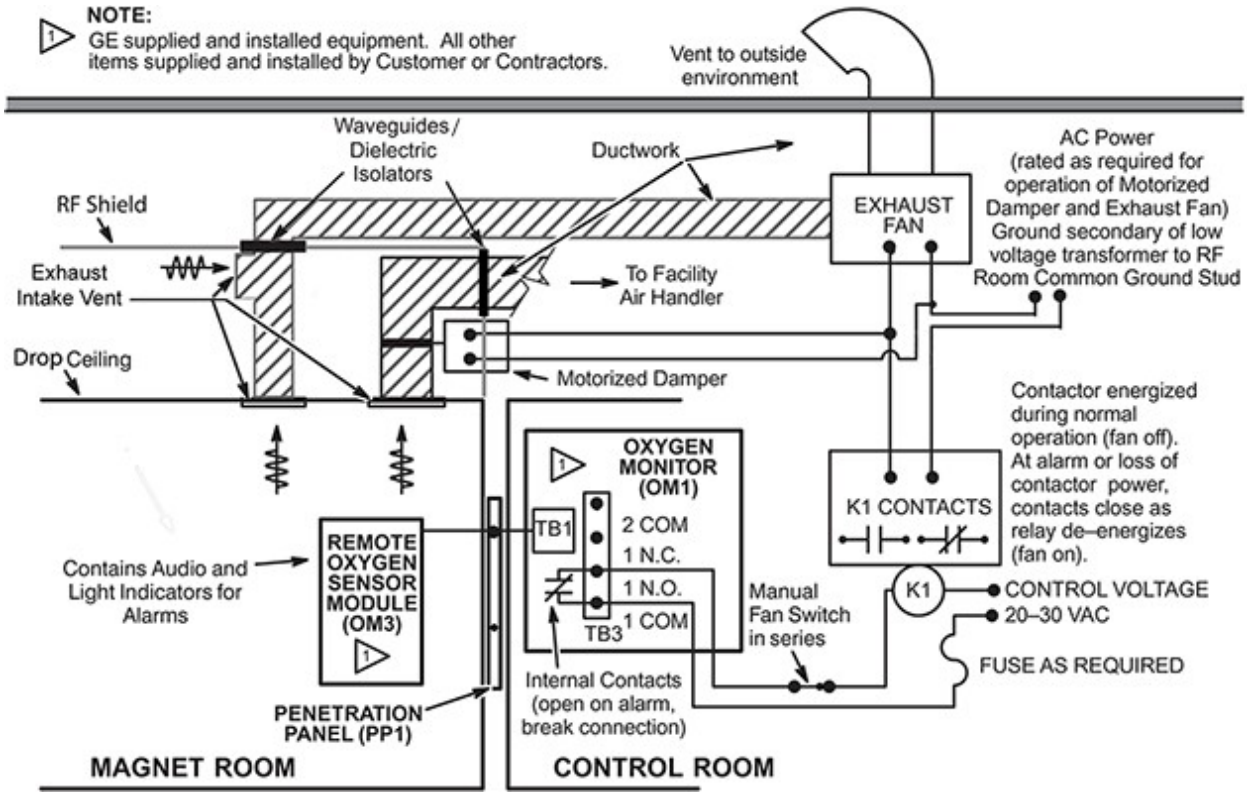
1. The HVAC vendor must comply with Magnet Room temperature and humidity specifications and RF shielding specifications.
2. The RF shield vendor must install open pipe or honeycomb HVAC waveguides.
3. All serviceable parts in the Magnet Room (for example, diffusers) must be non-ferrous.
4. Waveguides must be non-ferrous and electrically isolated.
5. Incoming air must contain at least 5% air from outside the Magnet Room (inside or outside the facility) to displace residual helium.

3.5.3 Emergency Exhaust Vent Requirements

1. The Magnet Room exhaust vent system is supplied by the Contractor.
2. All items within the RF enclosure must be non-ferrous.
3. The magnet exhaust vent system must be tested and operational before the magnet is installed.
4. The exhaust intake vent must be located at the highest point on the finished or drop ceiling.
5. Any space between the finished ceiling and the RF ceiling must contain an additional exhaust intake vent (to prevent helium from pooling above the finished ceiling).
6. If there is no space between the RF ceiling and finished ceiling, the intake vent may be located on a side wall (must be on the coldhead side of the magnet, near the coldhead, with the top edge of the vent flush to the finished ceiling).

7. If used, vent diffusers must not extend beyond the vent opening to prevent helium from pooling between the edge of the diffuser and the ceiling.
8. The Magnet Room exhaust fan and exhaust intake vent must have a capacity of at least 34 m^3/ minute (1200 CFM) with a minimum of 12 room air exchanges per hour.
9. The exhaust fan must be installed outside of the RF shield and must remain fully functional in the magnetic field per the fan specification sheet.
10. The exhaust fan must have appropriate waveguides and dielectric break to maintain the RF shield requirements. (See 3.5 RF Shielded Room Requirements.)
11. The system must have a manual exhaust fan switch near the Operator Workspace (OW) and in the Magnet Room near the door (the switches must be connected in parallel).
12. If the Magnet Room contains an optional oxygen monitor that is tied to the exhaust fan, the Magnet Room switch is not required.
13. All emergency exhaust vent system components must be accessible for inspection, cleaning, and maintenance.
14. If building code requires that a fire dampening system must be installed, it must not compromise the overall magnet vent system, and only fusible link fire dampers can be used (with annual inspection).

Figure 30 Magnet Room Exhaust Fan Schematic with Oxygen Monitor



3.5.4 Pressure Equalization Vent Requirement

1. A pressure equalizing vent is required in the Magnet Room ceiling or in the wall, at the highest point possible.

2. The vent minimum size must be 610 x 610 mm (24 x 24 in.) or equivalent area.
3. The pressure equalization vent must be located so any helium gas is not vented into occupied areas.

3.5.5 Cryogenic Venting

The MR System (magnet) requires a cryogenic venting system to direct helium gas to an unoccupied space in the event of a magnet quench. The cryogen venting system must direct all the helium gas outside the facility, and it must prevent helium from entering all nearby facilities.

NOTE

During a quench, the liquid helium in the magnet will rapidly change phase from liquid to gas, and the gas expands at a rapid and continuing rate as it moves toward the vent exit.Magnet Room

Venting systems may increase in pipe diameter, never decreasing, as the venting system length increases from the magnet to the vent exit.

The cryogen vent designer must adhere to the following requirements for the material, construction, and maintenance of the vent. The Contractor is responsible for the entire cryogenic venting system.

Note the following:

1. All pipe or tube dimensions specified in this document are outside diameters unless otherwise noted.
2. See Magnet Cryogenic Venting Pressure Drop Reference Tables to calculate pressure drop for a specific magnet.

Table 28 Magnet Cryogen 5pecifications

Magnet Types	Helium Volume liters (gallons)	Peak Helium Flow During Quench m^3 per min (ft^3 per min)	Magnet Vent Pipe OD mm (in.)
9.4T			Quench vent ID = 12 inches @ 9.4T

WARNING

PREVENTING CRYOGEN SAFETY RISK IN THE INSTALLED SYSTEM

Failure to comply with the requirements in this section can cause extremely cold helium gas to enter the Magnet Room or other occupied building space. Direct contact could cause cryogenic burns. Helium displaces oxygen, which could cause asphyxiation and death.

Make sure the Magnet Room meets all requirements in this section.

3.5.6 Vent Requirements Inside the Magnet Room

3.5.6.1 Vent Size

1. The sizing requirements of the vent are determined by the total pressure drop of the cryogenic vent system from the magnet vent interface to, and including, the vent cap.
2. The pressure drop of the RF shield waveguide must be included in the overall

calculation. Refer to Magnet Cryogenic Venting Pressure Drop Reference Tables.

Table 29 Requirements for Total Pressure Drop

Magnet Series	Total Pressure Drop
AK series magnet	less than 34.5 kPa (5 psi)

3.5.6.2 Vent Materials

1. The vent pipe must withstand a maximum pressure of 241.4 kPa (35 psi).
2. Waveguide vent material must match the outside diameter of the magnet flanged vent adaptor.
3. Refer to the magnet site planning document for all other vent material details.

3.5.6.3 Cryogen Vent Support

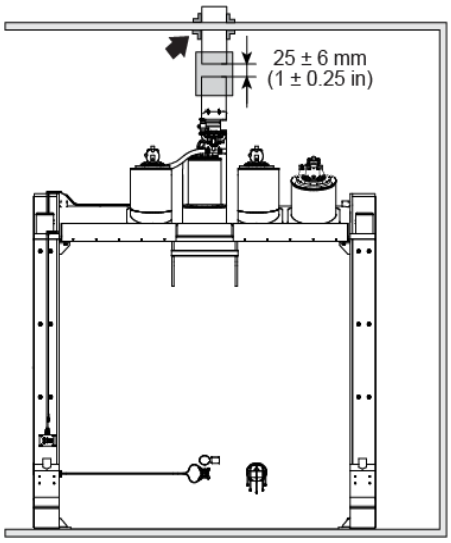
1. The venting system (including supports) must be sized to withstand 1700 N (382 lb.) helium flow reaction force at vent elbows.
2. Any vent support connected to the RF shield must have a dielectric break.
3. The vent support must be designed to prevent any transfer of load across the dielectric break.
4. The Ventglas joint (GE-supplied) must not be used as a vent system support.
5. Vent support must consider expansion and contraction of piping due to temperature change, including during a quench.

3.5.6.4 Construction

1. A single dielectric break (i.e., Ventglas connection) in the vent system is required in the Magnet Room.
    a. The gap between the RF waveguide and GEHC-supplied magnet vent adaptor must be 10 to 32 mm (0.4 to 1.25 in.).
    b. The outside diameter of the waveguide must match the outside diameter of the magnet vent adaptor within ± 3 mm (0.125 in.).
    c. We recommend a pipe deflection of less than 0.5 mm (0.02 in.) between the magnet vent adaptor and waveguide.
    d. The Ventglas connection inside the Magnet Room must be accessible for maintenance and annual inspection.
2. The Ventglas connection may also serve as a thermal expansion joint.
3. All pipe section connections must be welded or brazed.
4. All isolation or thermal expansion elements (except the Ventglas joint) must be rated to 4.5 K (-451°F or -268°C) and 241.4 kPa (35 psi).
5. The vent system must be insulated with 38 mm (1.5 in.) thick flexible unicellular insulation to prevent condensation during magnet ramping. Exposed insulation must be covered with a white PVC jacket.

6. A minimum clearance of 102 mm (4 in.) is required between the ceiling or wall and the dielectric break both inside and outside the Magnet Room. The overall length of the waveguide must be at least 812 mm (32 in.).

Figure 32 Pipe Supports to Remove Vent Load from Ventglas Connection



3.5.7 Vent Requirements Outside the Magnet Room

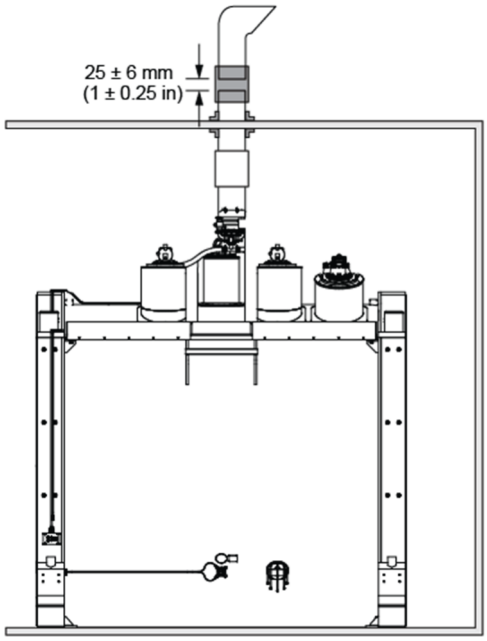
The Contractor is responsible for construction, and maintenance of all cryogenic venting materials outside the Magnet Room from the shielded room waveguide to the vent cap.

3.5.7.1 Vent Construction

1. GE Engineering recommends that the cryogen vent be constructed to the same specification as required inside the Magnet Room.
2. The vent must be routed as directly as possible to the vent cap (that is, the venting system external protective cover).
3. Expansion or contraction elements must be provided for a temperature decrease from ambient to 4.5 K (-451°F or -268°C).
4. A dielectric break must be installed adjacent to the waveguide. See Figure 33.
   a. The dielectric break gap must be 25 ± 6 mm (1.0 ± 0.25 in.).
   b. A Contractor-supplied clamp may be used to connect the dielectric break.
   c. The dielectric break must be accessible for inspection or maintenance.
   d. The dielectric break and vent pipe support must be designed to prevent load transfer across the dielectric break.
5. All components must be rated to withstand the helium flow reaction force at temperatures from ambient to 4.5 K (-451°F or -268°C).
6. Electromechanical fire dampers must not be used. Fusible link fire dampers may be used (with annual inspection).
7. The vent cap must prevent ingress of weather elements (for example, rain, snow, hail, sand, and so on) and foreign material debris (for example, leaves, bird nests, and so on).
8. Condensate must be prevented from pooling inside any section of the venting system

(for example, a downward tilted vent system or local minima with weephole).

Figure 33 Outside Dielectric Break



Magnet Roo

3.5.7.2 Vent Exit

WARNING

CRYOGENIC BURNS OR ASPHYXIATION

During a quench, extremely cold gas or particles are released from the cryogenic venting system. A quench may occur at any time.

Make sure access to the cryogen vent exhaust area is restricted and the released gas does not reenter the building. Refer to the specifications below.

1. An exhaust area in front of the vent extending to 30000 mm (1181.1 in.) is required (Figure 34).
   a. The vent exit area must not include air intake vents to prevent cryogen exhaust from reentering the facility.
   b. The vent exit area must not include any personnel, building components, or objects (movable or stationary).
   c. The facility is responsible for any exhaust area barriers, restrictions, and warning signs.
2. For a rooftop exit:
   a. Use either a horizontal exhaust vent with a 90° elbow with minimal pressure drop, or a roof cap with low pressure drop and a high flow rate.
   b. The bottom of the 90° elbow must be at least 914 mm (36 in.) above the roof deck (or higher if at risk of being blocked by drifting snow, sand, and so on).
   c. The outlet must be covered with a 12.7 mm (0.5 in.) square screen mesh.

d. The exhaust vent cover or cap must be included in the pressure drop calculation.

e. Physical barriers must be used to keep all persons out of the exclusion area.

3. For a sidewall exit:

   a. You can use an exhaust vent with a 45° elbow (with a deflector rated for the helium reaction force), a 90° elbow, or vent cap with no restriction in gas flow.

   b. The exhaust exit must be at least 3660 mm (144 in.) above the ground.

   c. The outlet must be covered with a 12.7 mm (0.5 in.) square screen mesh.

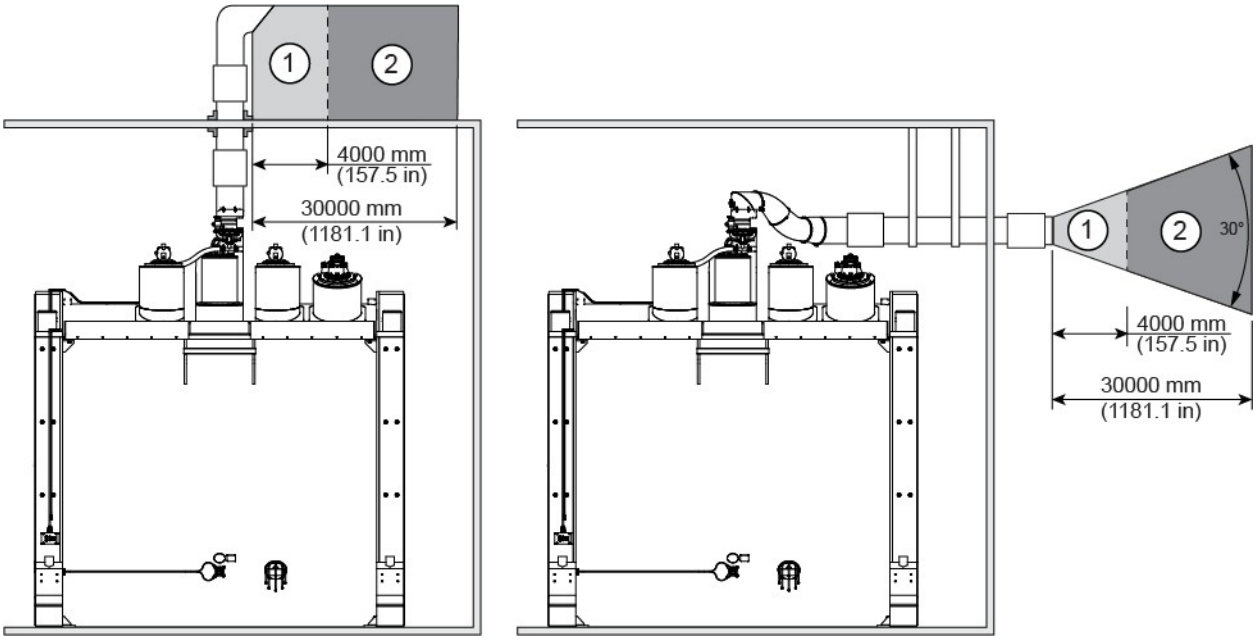
   d. The vent exit must be covered to prevent foreign material from entering or blocking the opening (for example, louvers).

   e. The exhaust vent exit must be included in the pressure drop calculation.

4. The exclusion area shown below must not include any personnel, building components, or objects (movable or stationary).A minimum height of 3660 mm (144 in.) is needed for safe operation of the venting system.

5. If the height from the vent to the ground is greater than 3660 mm (144 in.) and less than 5000 mm (197 in.), physical barriers must be used to keep all persons out of the exclusion area. If the height from the vent to the ground is greater than 5000 mm (197 in.), physical barriers are not required. See 3.8.7.2 Vent Exit.

Figure 34 Cryogenic Exterior Venting Volume



1	No impedances in this region
2	No unrestricted access to anyone in this region

3.6 Magnet Room Electrical and Grounding Requirements

3.6.1 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.

3.6.2 Magnet Room Lighting Requirements

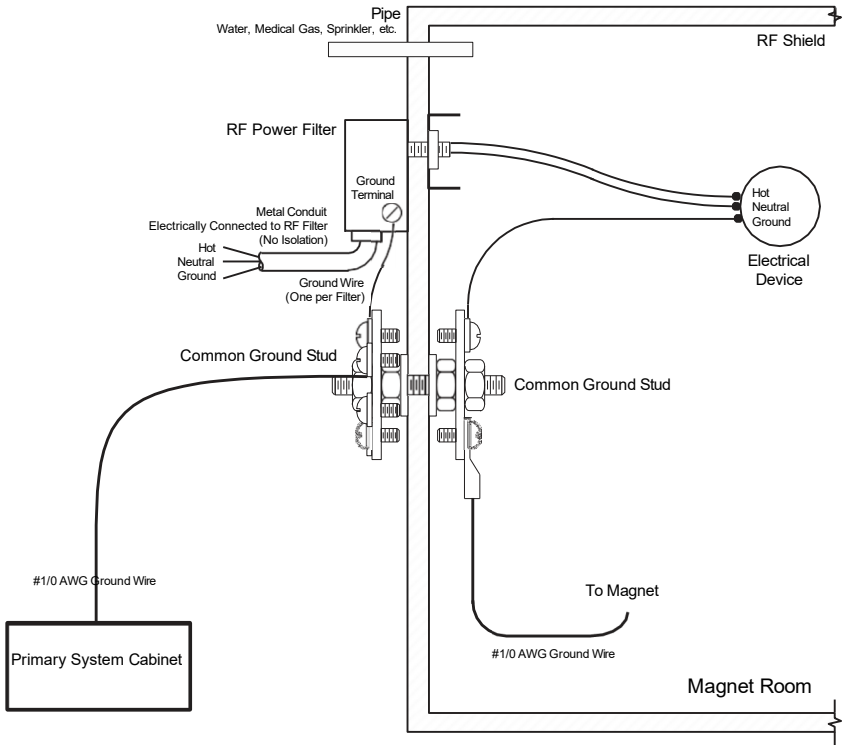
1. All lighting fixtures and associated components must meet all RF shielded room and RF grounding requirements (for example, track lighting is not recommended due to possible RF noise).
2. All removable lighting fixtures and associated components must be non-magnetic.
3. All lighting must use direct current (the DC must have less than 5% ripple).
4. At least 300 lux must be provided at the front of the magnet for patient access and above the magnet for servicing.
5. Fluorescent lighting must not be used in the Magnet Room.
6. Lighting must be adjusted using a discrete switch or a variable DC lighting controller.
7. SCR dimmers or rheostats must not be used.
8. DC LED lighting may be used if the DC power converter and RF sources are all located outside the Magnet Room RF Shield.
9. Battery chargers (for example, used for emergency lighting) must be located outside the Magnet Room.
10. Short filament length bulbs are recommended.

3.6.3 Grounding Requirements

1. If Contractor prepares the RF Common Ground Stud, it is connected with Penetration Wall of the ISC. (See Figure 36.)
2. Both the Penetration Panel Wall and Secondary Pen Wall are ground connected to the GND bus bar. The Penetration Panel Wall uses E4009. The Secondary Pen Wall uses E4010.
3. All power lines into the RF shielded room require an RF filter.
4. 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.

   Alternatively, electrical devices can be grounded at the Cabinet Rear Panel.
5. The common ground stud must be installed near both penetration panels, into the RF shield between the equipment room and Magnet Room.
6. Resistance between any two grounded devices must not exceed 0.1 ohm to ensure equal potential ground system within the Magnet Room (for example, MGD to PDU).
7. Do not ground non-MR equipment to the MR ground system.
8. See the figure below for a typical ground layout.

Figure 36 Typical Magnet Room Grounding



NOTE

See MR System Interconnects Specifications for usable cable lengths

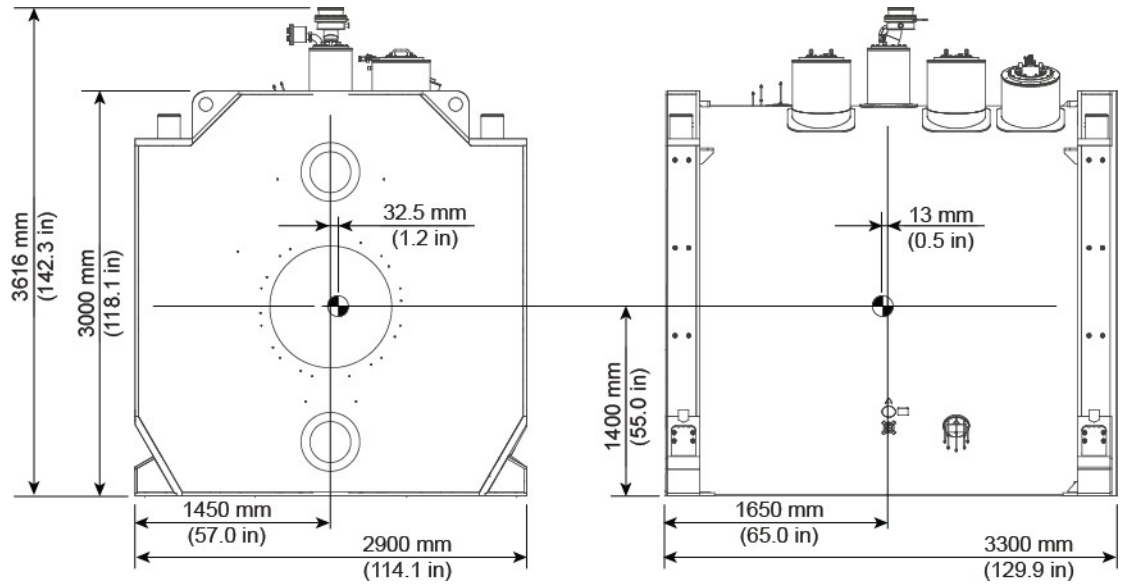
3.7 Magnet Room Equipment Specifications

3.7.1 Magnet (MAG) Assembly Specifications

Table 27 Magnet Component Weight

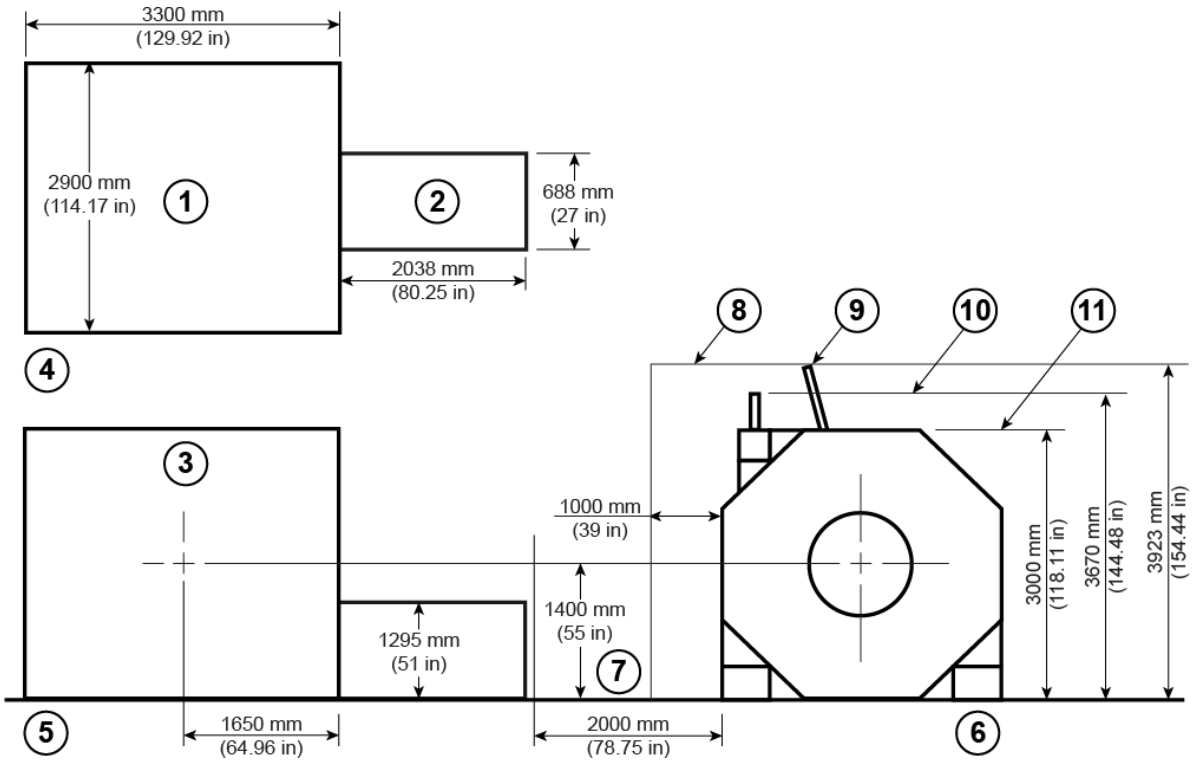
Item Description	Max Weight
Magnet (bare, plus cryogens)	45312 kg (99896 lb.)
Magnet (dry)	45000 kg (99208 lb.)
Gradient Coil (HRMb)	841 kg (1850 lb.)
Enclosures	171 kg (378 lb.)
Cryogens	312 kg (688 lb.)
Total weight shipped (includes frame)	48534 kg (107000 lb.)
All dimensions are for reference and are controlled on the component level drawings.	
The replacement Gradient Coil Assembly weight is approximately 860 kg (1900 lb.), the shipping cradle is 60 kg (132 lb.), and the Gradient Coil Assembly shipping and installation cart weighs 388 kg (855 lb.). The coil assembly outside diameter x length dimensions are 908 x 1452 mm (35.7 x 57.2 in.).	

Figure 25 Magnet (MAG) Dimensions



Magnet Room

Figure 26 Magnet (MAG) and Rear Pedestal



Item	Description
1	Magnet
2	Rear Pedestal
3	Center of gravity
4	Top view
5	Side view
6	Front view
7	Service clearance
8	Service clearance ceiling envelope
9	Current Lead Service height
10	Cold Head Service height
11	Magnet height

Magnet Room

Table 27 Magnet Component Weight

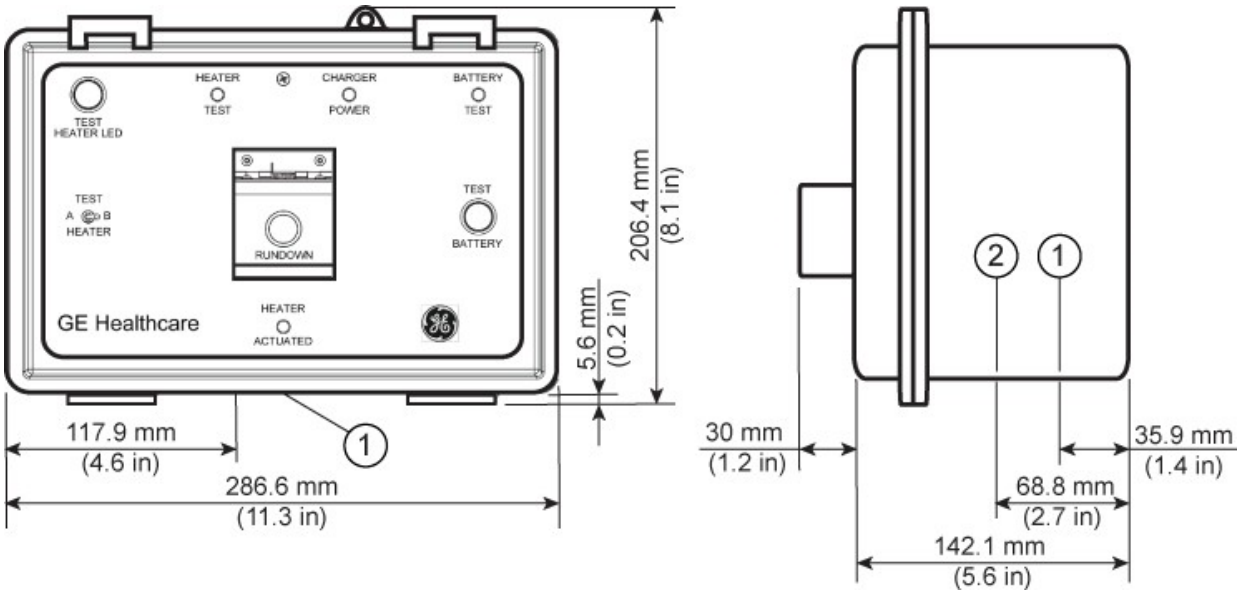
Item Description	Max Weight
Magnet Total plus shimtube, flange	34,000 kg
Magnet (dry)	32,000 kg
Gradient Coil (HRMb)	570 kg

Cryogens	312 kg (688 lb.)
Total weight shipped (includes frame)	48534 kg (107000 lb.)
All dimensions are for reference and are controlled on the component level drawings.	
The replacement Gradient Coil Assembly weight is approximately 860 kg (1900 lb.), the shipping cradle is 60 kg (132 lb.), and the Gradient Coil Assembly shipping and installation cart weighs 388 kg (855 lb.). The coil assembly outside diameter x length dimensions are 908 x 1452 mm (35.7 x 57.2 in.).	

3.7.3 Magnet Rundown Unit (MRU) Specifications and Requirements

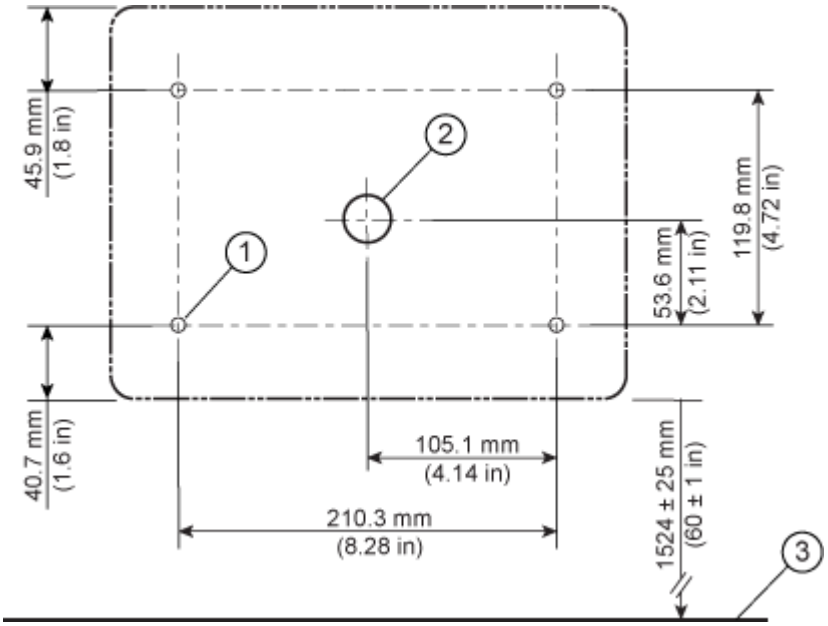
1. Location: The bottom edge of the MRU must be mounted 1524 ± 25 mm (60 ± 1 in.) above the Magnet Room floor near the front of the magnet enclosure.
2. Weight: 3.2 kg (7 lb.)
3. Magnetic Field Limit: 20 mT (200 G)
4. The MRU is installed by the facility contractor.

Figure 27 Magnet Rundown Unit (MRU)



Item	Description
1	Cable access
2	Power access

Figure 28 MRU Mounting Pattern



Item	Description
1	26 mm (1.025 in.) diameter cable access
2	7 mm (0.275 in.) diameter mounting hole
3	Finished floor

3.7.4 Oxygen Monitor Sensor Specifications

See Oxygen Monitor (OXY) Option.

Chapter 4 Equipment Room

4.1 Equipment Room Overview

1. The vertical distance between the coolant connection points of the HEC and the Gradient Coil must be less than 5 meters (196.8 in.).
2. The ICC, ISC, and cryo compressors must be located on the same floor.

4.2 Main Disconnect Panel (MDP) Requirements and Specifications

4.2.1 Specifications

A GEHC Main Disconnect Panel (MDP) is supplied with the following specifications.

1. 480V Part Number 5792781. Weight 275 kg (606 lb.)

4.4 High Order Shim (HOS) Power Supply 5pecifications

1. Weight: 89.8 kg (606 lb.)
2. Magnetic Field Limit: 20 mT (200 G)

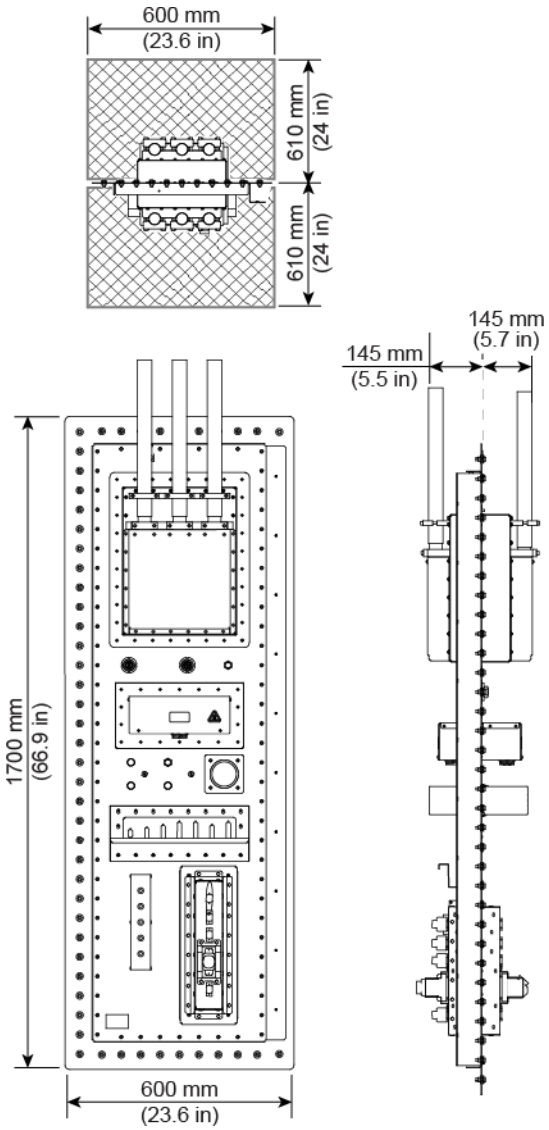
4.5 Integrated System Cabinet (ISC) Penetration Wall (PW) 5pecifications

The Integrated System Cabinet (ISC) penetration wall (PW) provides interconnects from the Equipment Room through the Magnet Room RF Shield.

Equipment Room

1. Maximum Magnetic Field: 20 mT (200 G)
2. See RF Shielded Room Requirements mounting and location requirements
3. The service area for the ISC PW is 914 mm (36 in.) from both sides the RF wall, and from floor to cable trays.

Figure 43 Integrated System Cabinet (ISC) Penetration Wall (PW)



4.6 Integrated Cooling Cabinet (ICC) Secondary Penetration Wall (SPW) specifications

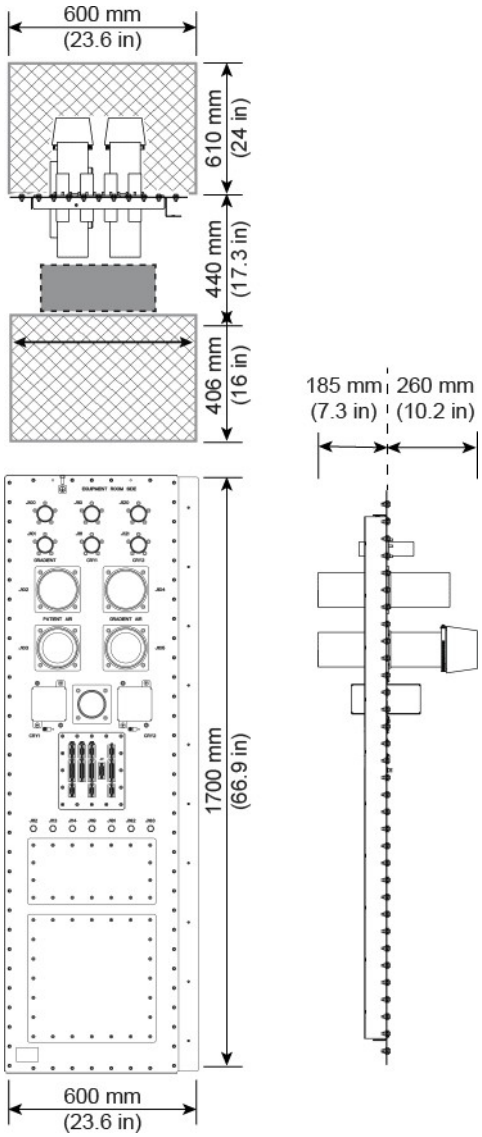
The Integrated Cooling Cabinet (ICC) secondary penetration wall (SPW) provides interconnects from the Equipment Room through the Magnet Room RF Shield.

1. Maximum Magnetic Field: 20 mT (200 G)

2. See RF Shielded Room Requirements mounting and location requirements
3. The service area for the ICC SPW is 610 mm (24 in.) on the Magnet Room side of the RF wall, and from floor to cable trays.

   On the equipment room side of the RF wall, 440 mm (17.3 in.) of space is needed for air and water hoses, plus 406 mm (16 in.) for service area.

Figure 44 Integrated Cooling Cabinet (ICC) Secondary Penetration Wall (SPW)



4.7 Cryocooler Compressor (CRY) 5pecifications

The system includes two F-70 Cyrocooler Compressors (CRY). Water cooling for the compressors is provided by the facility.

1. Weight: 100 kg (220 lb.) each

4.8 Integrated System Cabinet (ISC) 5pecifications

Weight, ISC 1 (Gradient PDU): 1035 kg (2282 lb.)

Weight, ISC 2 (System PDU): 1025 kg (2260 lb.)

Total Weight: 2060 kg (4542 lb.)

Magnetic Field Limit: 5 mT (50 G) (Penetration

Panel side) The seismic anchor mounting holes

are M8 threads.

Seismic mounting of the ISC must be performed at the front and the sides of the cabinet. Refer to Figure 48 and Figure 49.

ISC 1 and ISC 2 each have 4 lifting points at the top corners of each cabinet for size M16 course threaded eye bolts.

4.9 Integrated Cooling Cabinet (ICC) 5pecifications

F-50SH Cryocooler Compressor weight: Approx 125

kg (276 lb.) Weight without Cryocooler Compressor:

560 kg (1235 lb.) Weight with F-50SH Cryocooler

Compressor: 615 kg (1353 lb.) Magnetic Field Limit:

5 mT (50 G) (Penetration Panel side)

The seismic anchor mounting holes are M12 threads

The ICC has 4 lifting points at the top corners of the cabinet for size M12 course threaded eye bolts.

4.11 Magnet Monitor (MON) Requirements and Specifications

4.11.1 Requirements

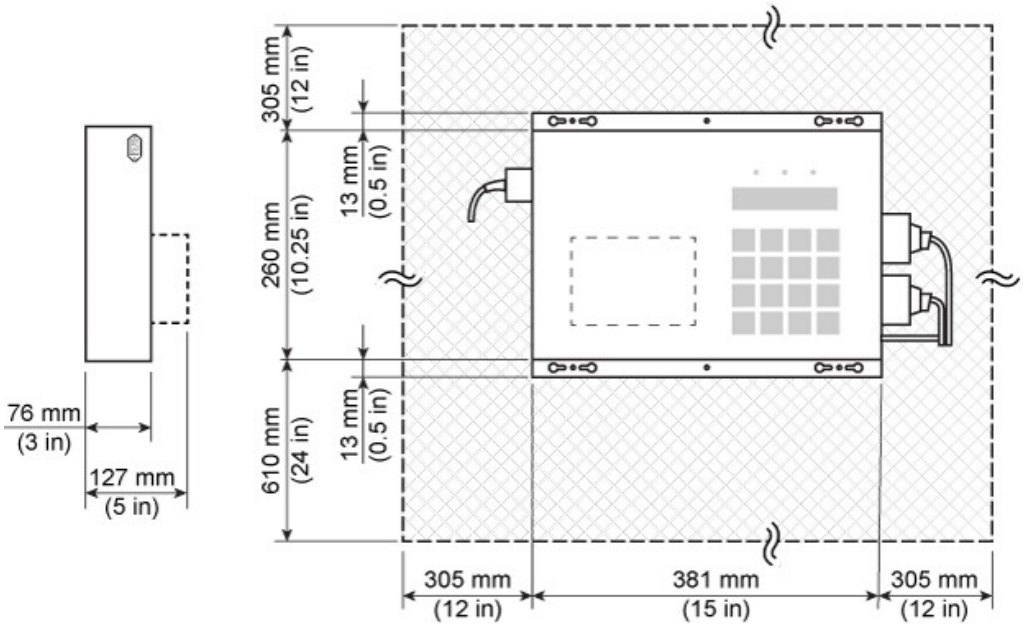
1. Contractor must supply T100 network connection with RJ45 connector to the Magnet Monitor (MON). Network connectivity must be active prior to magnet delivery.
2. The cable must be Cat 5 or better.
3. The network connection must not be routed through the Ethernet switch in the Global Operator Cabinet (GOC).

4.11.2 Specifications

1. Mounting location: On the wall or on either side of the ICC
2. Weight: 4.5 kg (10 lb.)
3. Maximum gauss limit: 20 mT (200 gauss)
4. Power cord length: 1829 mm (72 in.)

Chapter 5 Control Room

Figure 52 Magnet Monitor (MON)

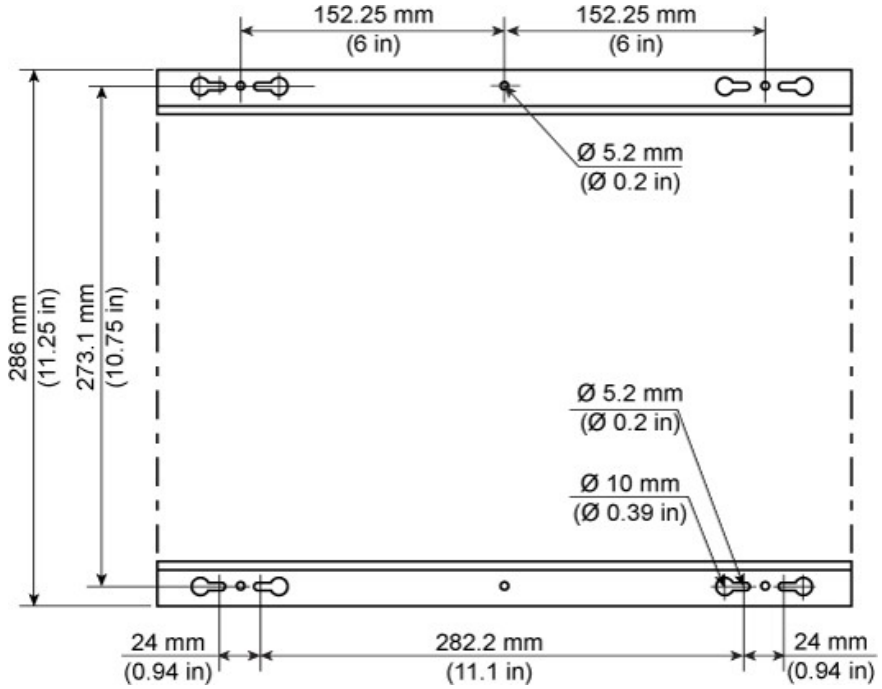


5.2 Oxygen Monitor (OXY) Specifications

The system includes two Oxygen Monitors. Each Oxygen Monitor system consists of the Oxygen Monitor, the Remote Oxygen Sensor Module, and interconnects through the Pen Wall in ICC. The Oxygen Monitor alarm located near the Operator Workspace is activated by the Remote Oxygen Sensor Module in the Magnet Room.

1. Oxygen Monitor Weight: 3.6 kg (8 lb.)
2. Oxygen Sensor Module Weight: 0.9 kg (2 lb.)

3. Magnetic Field Limit: 5 mT (50 G)Chapter 6 MR System Interconnects



Chapter 6 MR System Interconnects

6.1 MR System Interconnects Specifications

6.1.1 Component Designator Definitions

GE Healthcare uses Component Designators to identify system components. All subsystem cabinets and other components are referred to by their component designators in the Interconnect Data diagrams and tables.

Table 33 MR System Component Designators

Component Designator	Description
CRY1, CRY2	Cryocooler Compressor 1 and 2
DS, DS1	Door Switch
E01, E02, and so on	Emergency-Off (E-Off) Buttons
HOS PS	High Order Shim Power Supply Cabinet
ICC	Integrated Cooling Cabinet
ISC	Integrated System Cabinet
MAG	Magnet and Enclosure (all magnet enclosure components in Magnet Room)
MDP	Main Disconnect Panel
MNS	MNS I/O of RF cabinet
Modem	Modem for Magnet Monitor
MON	Magnet Monitor
MRU	Magnet Rundown Unit
OW	Operator Workstation
PA1	Pneumatic Patient Alert Control Box
PDU	Power Distribution Unit (PDU) is a module in the ISC cabinet
PED	Rear Pedestal

MR System Component Designators continued	
Component Designator	**Description**
PT	Patient Transport Table
RF	RF Cabinet

6.2 MR System Interconnects Routing Requirements

6.2.1 General Requirements

1. The Contractor responsible for the purchase and installation of all cable support mechanisms.

2. Any type of nonferrous cable support can be used, such as a commercially available ladder or wire rack style cable trays, if the cable trays meet all MR System requirements.
3. The distance between cable supports must be less than 305 mm (12 in.). For example, the distance between rungs on a ladder tray, or the distance from the end of a cable tray to a final nonferrous cable support must be 305 mm (12 in.) or less.
4. The cable supports must have the minimum cable bend radius per MR System Cable Specifications. For example, the vertical and horizontal bends of the gradient cables must have a bend radius of 330 mm (13 in.).
5. Cable supports can be stacked or side-to-side.
6. If trays are stacked, the air, water, and cryogen lines must be run in the lower support (see Figure 61).
7. Each cable tray must support a weight of at least 74.8 kg/m (50 lb./ft.).
8. If stacked, each cable tray must support the weight of both cable trays: that is 149.6 kg/m (100 lb./ft.).
9. Cables must be accessible on at least one side of the cable support and require a minimum of 254 mm (10 in.) from the top of the tray. (For example, see Figure 62 or Figure 63) If this is not possible due to obstructions, see the exceptions below.
10. All individual cable supports (for example, rungs) require lateral support to maintain the positions specified in the illustrations both during installation and after installation of the interconnects (for example, cables).

Exceptions for Obstructions:

1. The top of the cable tray must not touch an obstruction. A minimum of 254 mm (10 in.) of clearance is required on either side of the obstruction. See Figure 60.
2. A minimum of 178 mm (7 in.) of clearance is required from the top of the tray rung to the lowest point of any obstruction.

NOTE

The illustration below shows how to route cable trays around HVAC ducts, light fixtures, medical gases, structural beams, and other obstructions. If local code permits, a tray with a bend can route the cables underneath an obstruction. At the rear of the magnet, the cable tray must be installed at the minimum height. The part of the cable tray that is under the obstruction can be installed at a lower height. The tray bend must provide the minimum cable bend radius.

6.2.2 Magnet Room Requirements

1. Two cable trays must be used, each at least 457 mm (18 in.) wide.
2. Installation and routing of cable trays must be coordinated with the RF shield vendor.
3. Side-to-side trays in the Magnet Room must not touch to prevent RF broadband noise caused by metal-to-metal sidewall contact.
4. Ceiling grid work, medical gas lines, lighting fixtures, and so on, must not touch MR System cabling or cable supports.
5. Excess cable length in the Magnet Room must be stored in either:
    a. Penetration Panel closet. If utilizing the Penetration Panel Closet for cable

storage, the supports and anchors must be able to hold up to 22.7 kg (50 lb.).

b. Magnet Room cable trays (excess cable must be at least 915 mm (36 in.) from the magnet end of the tray)

6.2.3 Cable Tray Requirements and Examples

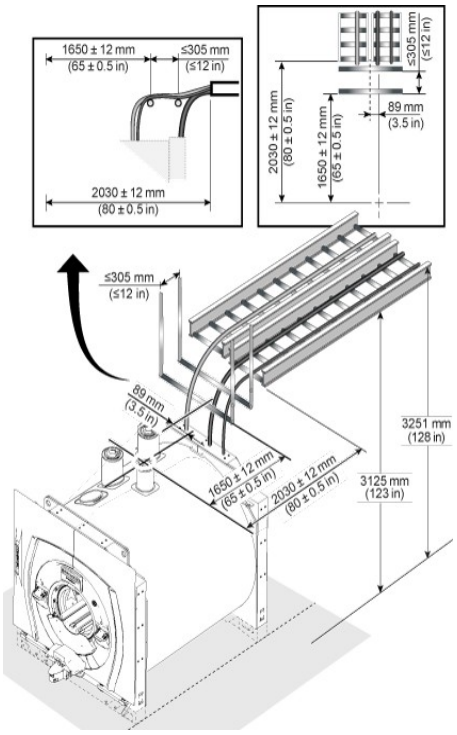
1. The gradient cable support must end at the back of the magnet 2030 ± 12 mm (80 ± 0.5 in.) from the geometric isocenter. See Figure 62
2. Supports for all other cables and hoses must end at the back of the magnet 1650 ± 12 mm (65 ± 0.5 in.) from the geometric isocenter.
3. Cable supports must have a minimum height of 3125 mm (123 in.) at the back of the magnet measured from the recessed floor. See Figure 62.

NOTE

Supports may be lower at other points along the route to clear obstructions as long as all other requirements are met.

4. The top of the cable tray must be less than 3251 mm (128 in.) above the recessed floor. See Figure 62

Figure 62 Cable Tray Requirements Example (Side-By-Side)



6.2.4 Equipment Room Requirements

1. All equipment interconnects must route overhead
2. Cables or hoses must drop through the bottom or off the end of the cable support directly to the top of the cabinets (see individual components in Chapter 4 for height requirements).
3. Cable tray must be above the minimum ceiling height (400 mm (15.7 in.) above the ISC cabinet).
4. Excess cable length must be stored in the Equipment Room.

5. For multiple MR System installations, cables from different MR Systems must not share the same cable support.

6. The table below lists the minimum width for cable trays between Equipment Room (and Operator Workspace) components.

Table 36 Minimum Cable Tray Width

	ICC	OW
ISC	450 mm (18 in.) Electrical, Water	300 mm (12 in.) Electrical

6.4 Facility-Supplied System Interconnects Specifications

Table 38 Facility-Supplied System Interconnects

Group	etween Units		Comments	Requirements
	From	To		
C01	Facility Power	MDP	Facility Power and Ground	MR Suite Electrical Requirements
C02	MDP	CRY1	Cryocooler Compressor Power	
	MDP	CRY2	Cryocooler Compressor Power	
C03	MDP	ISC	PDU1 Power	
	MDP	ISC	PDU2 Power	
	Facility Cooling Water	ICC	Cooling Water Supply	MR System Facility Water Requirements
	Facility Cooling Water	ICC	Cooling Water Return	
	Facility Cooling Water	CRY1	Cooling Water Return	
	Facility Cooling Water	CRY1	Cooling Water Return	
	Facility Cooling Water	CRY2	Cooling Water Return	
	Facility Cooling Water	CRY2	Cooling Water Return	
C04	Facility Network	MON	Facility must provide separate network access for the Magnet Monitor (MON) and Global Operator Cabinet (GOC). The MON connection must be available at all times.	Magnet Monitor (MON) Requirements and Specifications
	Facility Network	GOC		

C05	MDP	E-Off Switch	Facility must supply cable from the MDP to the E-Off Switch in the Equipment Room.	MR Suite Electrical Requirements
	Facility Power	Outlet near MON	Facility outlet for MON power	Magnet Monitor (MON) Requirements and Specifications
	Facility Power	MRU	Facility power to MRU	Magnet Room Equipment Specifications

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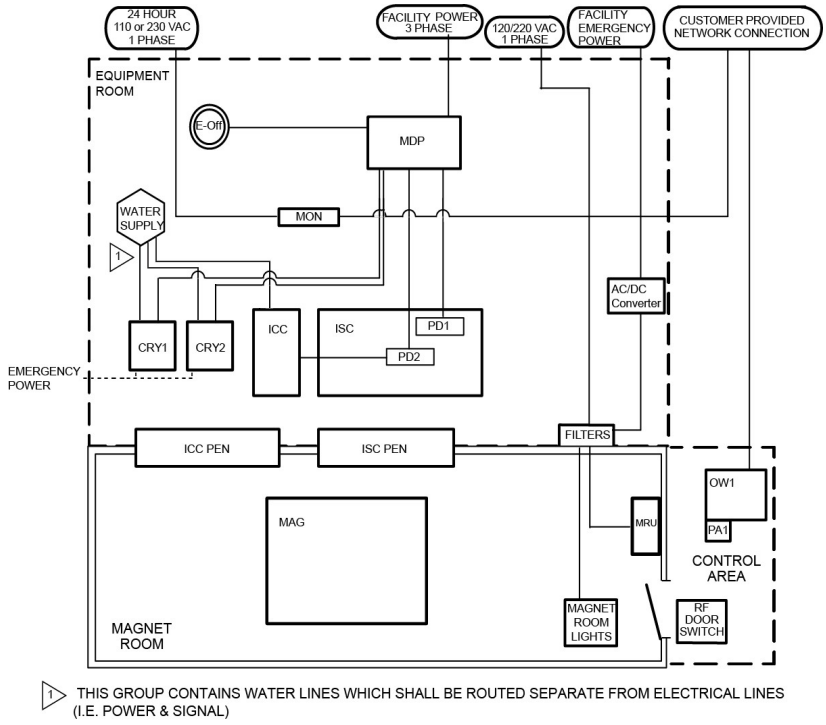
Figure 65 Facility-Supplied System Interconnects



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NOTE

- GE Healthcare recommends installing the RF Door switch on the outside wall of the Magnet Room.
- The illustration is not to scale and component positioning/interconnect runs are typical.
- Solid lines are facility required interconnects; dashed lines are GE-supplied interconnects; both are shown where both are options.
- Only GE Healthcare equipment interconnects are shown. Additional facility interconnects are required for non-GE Healthcare equipment (for example, Magnet Room DC Lighting).
- The E-Off button placement and cable routing shown indicates one possible configuration. Final E-Off button placement and cable routing is the responsibility of the customer.

The RF Shielded Room Vendor is responsible for installing the RF door switches. See 3.5.7 RF Shielding Integrity (Shielding Effectiveness) Reliability Requirements

Chapter 7 Appendix

7.2 MR Site Vibration Test Guidelines

7.2.1 Test Measurements

1. Vibration measurements must be in the range of 10^{-6} g. Test equipment must have the required sensitivity to these levels.
2. Instrumentation must have a low tolerance to temperature effects since many times the low frequency thermal drift may influence the measurements.
3. All measured data must be acquired real time. Recording of vibration data will not allow for a correct site survey, specifically when studying transient vibration and when searching for specific vibration sources.
4. All analyses must be narrow-band Fast Fourier Transforms (FFT) over the frequency bands listed in Table 39.
5. Time histories of the vibration must be recorded as acceleration levels vs. time. The resolution of the time history must be adjusted to clearly capture the transient event. The analyzer set-up will be site dependent and, in special cases, vibration response dependent. It is the responsibility of the vibration consultant to study the transient environment, capture data to confirm that transient activity exceeds the trigger level, then expand the time history data to exhibit the structural response.

Table 39 Frequency Bands for FFT

Frequency Band	*Frequency Resolution*
0.2 to 50 Hz	Δf= 0.125 Hz

7.2.2 Equipment (Spectral Analyzer) Set-Up

1. Frequency average should be a minimum of 20 linear averages (Do not use peak hold or 1/3 octave analysis).
2. Average and store should be a minimum of 20 plots steady state and 20 plots transient to support the consistency of the site vibrations.
3. Hanning windows must be applied to the entire spectra.
4. Spectrum analyzers capable of these measurements include models, such as the HP 3560A, Nicolet Phaszer, B&K Pulse, and HP 35670, are all capable of making the site vibration measurements. Accelerometers must have the capability to measure from 0.2 Hz beyond 50 Hz. Time histories can be recorded using any of the analyzers listed above.
5. The equipment mentioned is for example only. It is the responsibility of the Engineering Test Firm to provide equipment that will allow measurements compliant with this guideline.

7.2.3 Ambient Baseline Condition

1. All of the measurements listed above must be made in a “quiet” environment—that is, areas where excessive traffic, subway trains, and so on, do not exist. A vibration measurement must also be made during periods without traffic or during periods of light traffic. Measurements must define the lowest levels of vibration possible at the site.
2. The source of any steady state vibration, whose level exceeds the magnet specifications found in

Magnet Room Structural Requirements, must be identified. A second measurement should be made with all of the identified contributors powered down if possible. In situations where it is not possible to power down equipment, vibration data must be collected to identify the specific source of the vibration concern. The majority of steady state vibration problems can be negated by isolating the vibration source.

7.2.4 Normal Condition

1. All of the vibration measurements listed above must be repeated during periods of "normal" environmental conditions, including the Fast Fourier Transforms (FFTs) and time histories. The transient measurements must be provided to define the dynamic disturbances the MR System may be exposed to. Transient analysis is required for a true assessment of the site.
2. Special attention must be paid to the site assessment during the entire analysis. Since transient vibration is not easily addressed once the MR suite is fully constructed, the test consultant must fully understand the needs for this analysis. The source of any transient vibration must be identified and supported with vibration plots.
3. Transient vibration can be difficult to assess if the details are not understood. The ***0.0005 g, zero-to-peak trigger level*** is a starting point to understanding the vibration stability. The transient vibration peak amplitude, structural (time variant) response, decay rate and an estimate of the number of events per unit of time would constitute a complete transient analysis. All transient failures must be supported by time history plots. The plots must clearly show the structural response, the frequency of the signature and the decay rate. From this data, GE Healthcare can help determine compliance with the vibration guidelines.
4. The test consultant must provide site data to show the design recommendations for all sites/ building structures meet the magnet specifications found in Magnet Room Structural Requirements.

7.2.5 Presentation/Interpretation of Results

1. The recommended format for site vibration data collection, presentation, and analysis is demonstrated in the examples in 7.2.5 Presentation/Interpretation of Results , Figure 66 and Figure 67. Presentation of the data in any other format (linear units only) may result in incorrect interpretation and diagnosis of the site. Additional data collection or presentation methods are at the option of the vibration testing service.
2. All plots must be properly annotated with:
    a. Instrumentation setup including number of averages, frequency resolution, and so on
    b. Test location
    c. Test conditions:
        i. Steady state
        ii. Transient
        iii. Heel drop
        iv. Normal environment
        v. Typical traffic
        vi. Any other conditions necessary to demonstrate understanding of potential sources of vibration
3. The vibration testing service is responsible for interpreting the results and determining if that site meets GE Healthcare specifications.

4. If the vibration levels are too high, additional data acquisition may be necessary to:
   a. Determine the source of the vibration
   b. Propose a solution to the problem
   c. Find an alternate site location
5. Any questions regarding test equipment requirements, test parameters, or general questions should be discussed with the GE Healthcare Project Manager of Installation (PMI).

Figure 66 Acceleration Time History

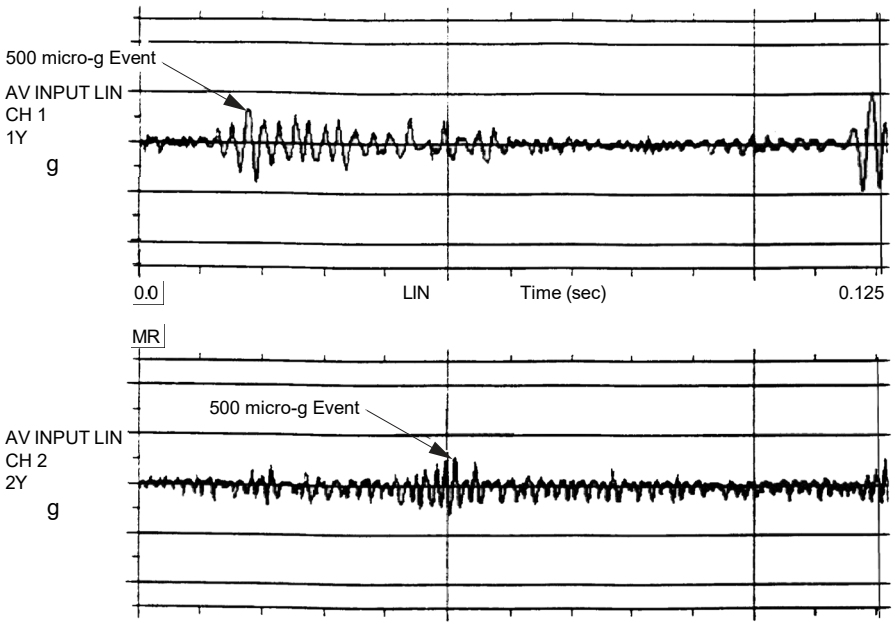

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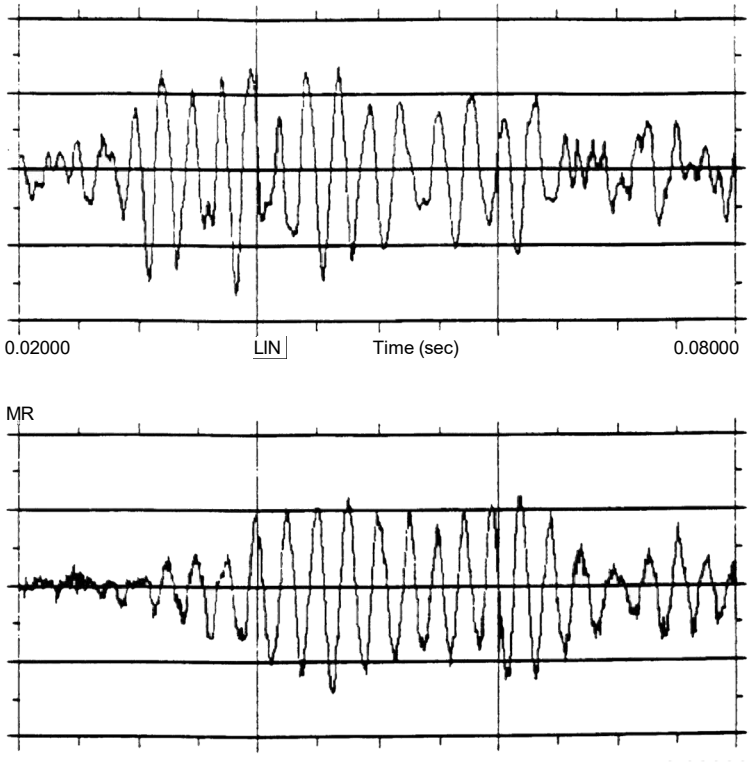
Figure 67 Acceleration Time History (Zoomed In on Transient Event)



7.3 RF Shielding Effectiveness and Ground Isolation Testing

7.3.1 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.

7.3.2 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.

7.3.3 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:
    a. Lighting fixtures
    b. Track lighting
    c. Emergency lighting
    d. Battery chargers
    e. Outlets
4. Ducting for HVAC and cable routing
5. RF shield seals (walls, doors, windows, and so on)

7.3.4 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 table below:

3. RFI site surveys are to be performed by cycling through the preceding frequency bands and a broadband range up to 145 MHz ± 10 MHz. 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.
4. 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 7.0 Tesla 298.04 MHz)

Table 40 Radio Frequency Survey Specifications

Isotope	Bandcenter MHz	Bandwidth MHz
1H	400.13	1.2
1H	400.13	0.7
19F	376.50	0.5
3He	304.82	0.5
31P	161.98	0.45
7Li	155.51	0.45
129Xe	111.28	0.35
23Na	105.84	0.3
13C	100.61	0.3
2H	61.42	0.24
15N	40.56	0.2

7.3.5 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.

7.3.6 RF Shield Test Requirements and Test Setup

1. The minimum test points for shielding effectiveness must be the following locations:
   a. Walls
   b. Penetration panels
   c. Doors
   d. Blower box removal hatch (if present)
   e. All windows, including patient viewing window
   f. Skylights
   g. Penetration waveguides installed for GE Healthcare and Non-GE Healthcare options
   h. Power filters
2. When measuring shielding effectiveness (SE), the following must be installed for the RF shielded room:
   a. The magnet
   b. All floor mounting bolts (including dock anchor bolt)
   c. RF shielded door(s)
   d. Waveguide penetrations, HVAC, cryogen vents, medical gas lines, system options (including FUS, MRE, and so on)
   e. AC power supplied through low-pass filters
   f. Patient view window, skylights, windows, hatches, and so on
   g. 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.
4. The calibration cycle of equipment must be no greater than two years.
5. 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.

7.3.7 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.

7.3.8 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.

7.3.9 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 7.3.17 RF Shield Test Report 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:
    a. Frequency Synthesizer or Signal Generator
    b. RF Power Amplifier (if required)
    c. DC Power Supply (if required)
    d. 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:
    a. Spectrum Analyzer
    b. RF Preamplifier (if required)
    c. In-line Attenuator (if required)
    d. DC Power Supply (if required)
    e. 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.

7.3.10 Test Frequency

The test frequencies for shielding effectiveness (SE) measurement are defined in 3.5.4 RF Shield Requirements. Test frequencies used must be noted in the RF shield test report.

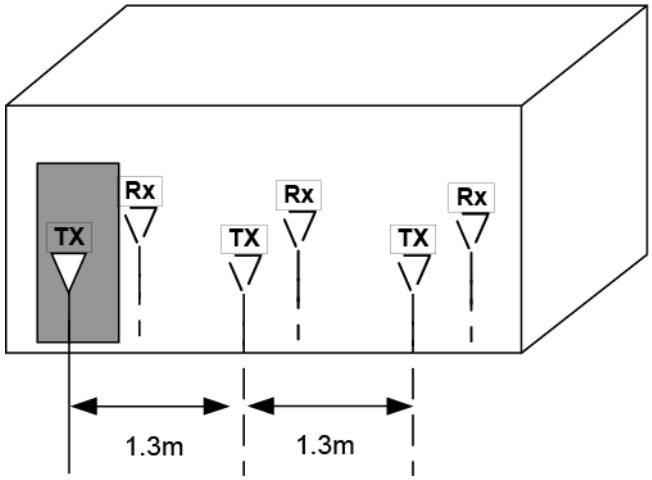
7.3.11 Measurement Procedure

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:

7.3 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.

7.3.12 Shielding Effectiveness Measurement

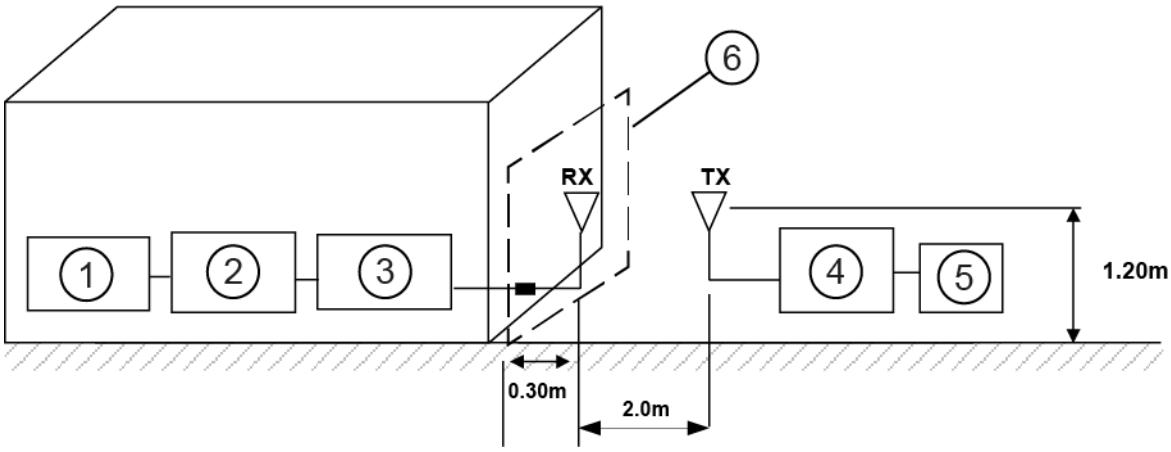
Three main steps are required to complete the Shielding Effectiveness measurement at each test position:

1. Take the reference level measurement (7.3.13 Reference Level Measurement).
2. Take the attenuated level measurement (7.3.14 Attenuated Level Measurement).
3. Calculate the Shielding Effectiveness (7.3.15 Shielding Effectiveness Calculation).

7.3.13 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 69 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).
    a. Reference Level at horizontal polarization:
        i. The reference level measurement is taken over a plane area covered as described below.
        ii. 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.
        iii. Record the maximum measurement reading in this plane.
    b. Reference Level at vertical polarization:
        i. The reference level measurement is taken over a plane area covered as described below.
        ii. With vertical polarization for both antennas, the receive antenna (RX) must be moved

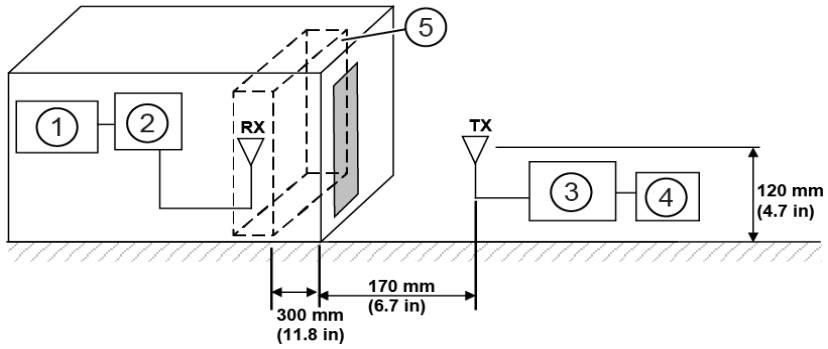
horizontally right 1 m (39.37 in.) from the initial position, and then moved left from the initial position to 1 m (39.37 in.). Then starting 1 m (39.37 in) above the initial position, move slowly horizontally right 1 m (39.37 in.) and then horizontally left 1 m (39.37 in.) from initial position. Repeat 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.).

iii. Record the maximum measurement reading in this plane.

7.3.14 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 70 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).
   a. Attenuated Level at Horizontal Polarization:
      i. Both tuned receive (RX) and transmit (TX) antennas are in horizontal polarization.
      ii. 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.
      iii. 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 70).

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

b. Attenuated Level at Vertical Polarization:

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

ii. 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.

iii. 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.

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

7.3.15 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

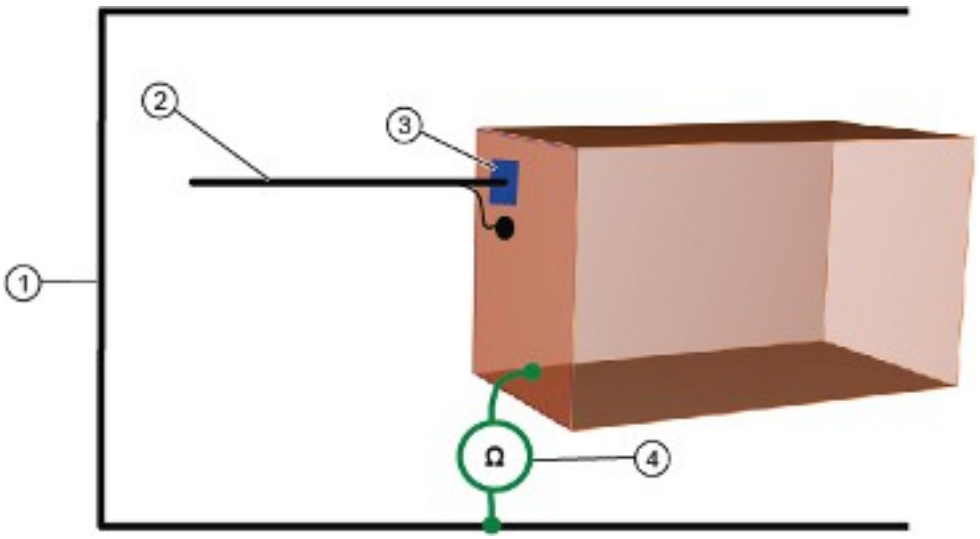
in dBm

7.3.16 RF Shielded Room Ground Isolation Resistance Measurement Method

ELECTRICAL SHOCK HAZARD

The RF shielded room must be properly grounded.

Figure 71 RF Shielded Room



Item	Description
1	Hospital ground grid
2	AC lines and ground wire
3	Filter
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:
    a. All power to the enclosure is removed. For safety reasons, an AC voltage measurement will be made to verify that no power is connected.
    b. With electrical power and intentional ground disconnected, connect the test instrument between the shielded enclosure and AC power ground.
    c. Take a reading and record the value.
    d. Reconnect the lines to ground.

7.3.17 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 7.3.6 RF Shield Test Requirements and Test Setup)
12. The following information for each piece of all calibrated equipment used for measurement:
    a. Manufacturer
    b. Model
    c. Serial number
    d. 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:
    a. Overall view of RF shielded room
    b. Window(s), door(s), filter(s), skylights, patient view window
    c. Blank penetration panels
    d. Installed additional penetration points (waveguides, vents, ducts, and so on)
    e. Test setup for reference level measurement
    f. Test setup for attenuated level measurement

7.4 Acoustic Background and Design Guidelines

7.4.1 Acoustic Background

The acoustic information is provided for site planning and architectural design activities to address acoustics to meet local regulations. For more information about recommended safety procedures regarding patient exposure to MR generated acoustic levels, see the MR Safety Guide included with the system Operator Manual.

A typical MR suite has two types of acoustic noise issues:

- Acoustics within the rooms in which the patients and technicians are impacted by the noise of the MR System as the system scans
- Noise transmitted to other spaces through airborne and structure-borne paths. Refer to the system Preinstallation Manual for details on structure-borne acoustic management.

7.4.2 Airborne Acoustic Background

The airborne transmission path entails the excitation of air within the Magnet Room; the resonator module consisting of the magnet, RF coil, and gradient coil generates acoustic noise similar to an intense loud speaker. The airborne noise passes through walls through any openings (for example, small holes, cracks, HVAC ducts, and waveguides) into surrounding spaces within, and possibly beyond, the confinements of the building. Acoustic energy can transmit across distances of significant length.

Examples of airborne acoustics issues may include the following (not limited to only these) :

- MR Operator exposure at Operator Workstation (For example, Operator viewing in-line with the patient inside the magnet may require a higher acoustic attenuation window.)
- Image reading rooms adjacent to Magnet Room (may be separated by hallways)
- Secretarial, offices, meeting rooms, patient rooms (ICU, exam, primary care, and so on)
- Adjacent residential areas or spaces
- In-house library facilities

7.4.3 Structure-borne Acoustic Background

The structure-borne transmission path is the result of mechanical excitation of the floor or building structure causing the building to vibrate. The vibration of the surfaces at surrounding spaces then radiates as acoustic noise. Acoustic energy can transmit across distances of significant length.

Examples of structure-borne acoustic issues may include the following (not limited to only these):

- Areas directly above or below the Magnet Room (may not always be an issue)
- Image reading rooms adjacent to Magnet Room (may be separated by hallways)
- Secretarial, offices, meeting rooms, patient rooms (ICU, exam, primary care, and so on)
- Adjacent residential areas or spaces
- In-house library facilities

7.4.4 Acoustic Design Guidelines for the Magnet Room

Noise generated by the MR System is inherent to the operation of the system. The sound quality (human perception) within the Magnet Room can be modified by including sound absorbing materials to make the room sound more subdued and less harsh by absorbing sound energy at some frequencies, while not impacting the overall sound level.

- Use ceiling tiles with fiberglass panels having a 51 mm (2 in.) thickness set into the standard T-bar grid system.
- Adding fiberglass panels to the side walls covering approximately 20% of the side wall surface area. The panels should focus on covering the top half of the side walls. Panels could take many different and decorative shapes to improve the sterile look of the rooms. Typically panels might be on the order of 1.2 m x 1.8 m (4 ft. x 6 ft.) with a thickness of 102 mm (4 in.) or equivalent. Panel shape could vary to produce mosaic effects. Any decorative materials used to cover the wall panels must be porous so that sound waves can pass through with ease. In principle, a person should be able to breathe through the material with ease. Fire retardant cloth should be used. The NRC (Noise Reduction Coefficient) of the panels should be 0.95 or better when mounted against a hard surface such as drywall or concrete.

7.4.5 Acoustic Design Guidelines for Inter-spacial Areas

Acoustic noise control to mitigate noise from being transmitted to other spaces often amounts to paying attention to small details while working with ordinary construction materials. The key objectives are to eliminate all cracks and gaps in the wall construction while making sure that the doors, walls, floor, and ceiling have adequate transmission loss through mass or special double wall construction, along with good fitting massive doors.

The entire magnet must be surrounded by walls with substantial mass and/or double wall construction so that noise is contained in the room and not allowed to pass through into nearby spaces. Wall junctions must be sealed with acoustical sealant so that noise waves to do not escape from the room. In principle, if the room were filled with smoke and under a positive pressure, no smoke would leak from the room.

7.4.6 Wall Construction

Wall Construction will entail ordinary building materials in a careful configuration.

- The preferred wall construction should have a Weighted Sound Reduction Index (Rw) rating of 46 or an ASTM Sound Transmission Coefficient (STC) of 50. This entails the use of standard wall construction of steel studs (typically 92 mm (3-5/8 in.)) with 2 layers of Type X drywall (typically 16mm (5/8 in.)) on each side (a total of 4 layers) and fiberglass batt in the stud cavity. All drywall must be overlapped by 152 mm (6 in.) or more. Beads of (USG) acoustical caulking (non-hardening) would be used around the entire perimeter of the drywall. Any form of wall penetration should be avoided. Any necessary wall penetrations must be sealed using combination of acoustical caulking (non- hardening) and fiberglass batt material. See Figure 72 and Figure 73.
- The top of the wall must join the ceiling or floor above so that no cracks or gaps occur. If metal pan is used on the ceiling or floor (above), then flute seals would be used to seal the gaps between the drywall and the pan. Alternately, drywall can be cut out to fit into the flutes. Acoustical caulking (non-hardening) will be used to seal the remaining cracks and gaps.

7.4.7 High Bay RF Room

A high bay RF Room is a self-contained RF Room which has open air space between the RF Room ceiling and the building floor above. The air space is an acoustic transmission path. Acoustic energy must be reduced to minimize this transmission of energy through this path.

In cases where the magnet is to be installed in a high bay, it may be most effective to enclose the RF Room with its own drywall and steel stud room. The key difference being a ceiling assembly that mimics the sidewall construction to contain noise.

- Normal high STC stud walls from above would be used to support a ceiling assembly constructed of structural C channel with two layers of drywall on each side (a total of 4 layers) with fiberglass batt in the cavity.
- Penetrations should be avoided through the use of surface mounted lights. HVAC and ducts passing through the ceiling, party wall or side walls would require acoustic noise attenuation in the form of inline silencers. Gaps and cracks would be sealed between the ceiling, party wall or vertical side walls and the cryogen vent plumbing. In essence the magnet would be enclosed in a drywall "doghouse."

7.4.8 Miscellaneous Plumbing, RF Windows and RF Doors

Other construction details are equally important to mitigate noise transmission to meet the intended goal.

- Pipes (gas or water) and electrical conduit or Magnet Room signal cables must be sealed where they penetrate the walls or ceiling. A heavy mastic material such as Duxseal™ is appropriate.

- RF windows should be purchased as window or frame units with an STC rating obtained from laboratory testing per ASTM standards. Rw 46 (STC 50) windows are needed. The installation must include correct sealing to avoid sound leaks.

- RF doors should be selected to provide Rw 46 (STC 50) to quell the noise. Contact the RF Shield Room supplier for selection of RF doors that meet the local acoustic codes and site acoustic requirements. RF door seals must be selected to prevent small gaps around the door perimeter and at the door threshold. RF door seals would either require periodic replacement or a door seal that would last the life of the Magnet Room

7.5 Sample Calculation AC Power Equipment Minimum Distance

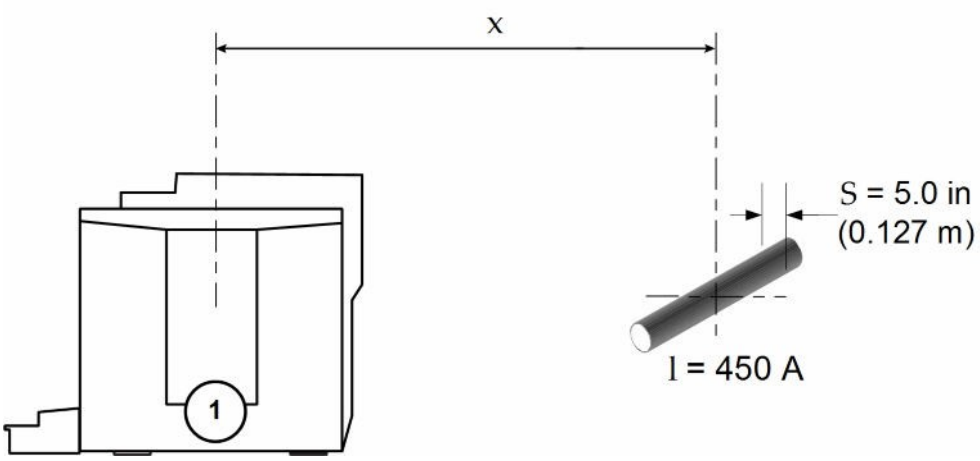
This is a sample calculation to determine minimum distance from a feeder, transformer, or other AC electrical source, using the formula found in 2.7.3 Electrical Current on page 18 to determine minimum distance from a feeder, transformer, or other AC electrical source.

Note that the formula has three variables. If you have two of them, you can calculate the third. In this example, we calculate the minimum distance ***x*** from the source—in this case, a main electrical feeder carrying 450 amps of current in a 127 mm (5 in.) conduit.

Rearranging:	$x^2 = \frac{I \times S}{8.55}$ $x = \sqrt{\frac{I \times S}{8.55}}$
where:	
x	Minimum distance (in meters) from the feeder lines to isocenter of the magnet
I	Maximum allowable RMS single phase current (in amps) or maximum allowable RMS line current (in amps) in three phase feeder lines
S	Separation (in meters) between single phase conductors or greatest separation between three phase conductors

The separation **S** is the spacing between the conductors, and when all 3 conductors are run in a single conduit, **S** is simply the diameter of the conduit.
S = 5 inches = 0.127 meters

8



Item	Description
1	Magnet

9 In other situations, the spacing **S** may be the spacing between HV feeders, the distance between transformer lugs, or the spacing between conduits when the phase conductors are run in separate conduits.

10 **What if it is too close?**

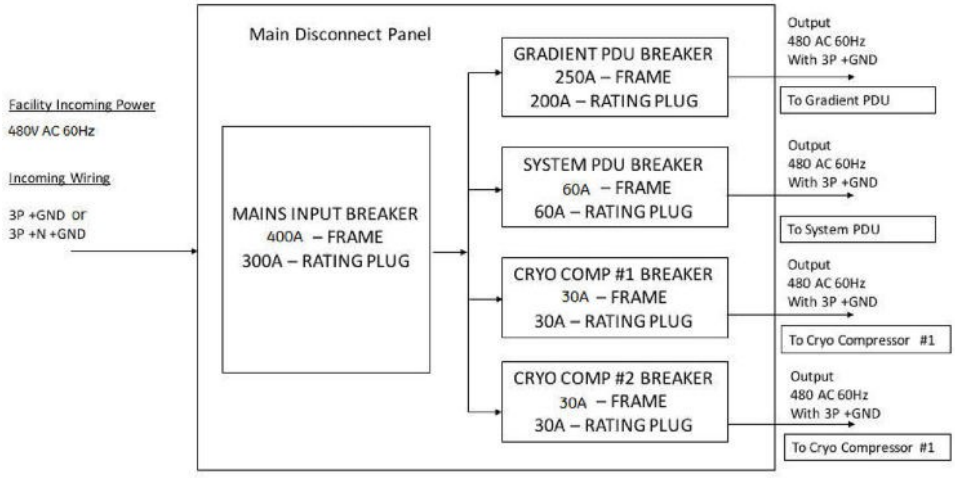
11 If this is an existing condition, you should request an *EMI study* to quantify the magnitude and direction of the AC disturbances. The calculation is worst-case and does not take into account the vector direction of the AC interference. The magnet is only sensitive to AC disturbances that are directed horizontally (magnet z-axis). Also, the calculation does not account for any magnetic shielding effect of steel conduit.

7.6 Feeder Sizing Criteria with Examples

7.6.1 Feeder Sizing Criteria

This example shows how to estimate the input power cable sizing for the MR System under consideration. The first step is to estimate the continuous Full Load Current (FLA) and the estimated voltage drop due to cable loss, based on the distance between the power source and the MDP. Based on this information, the customer electrician can suggest and procure the appropriate feeder.

Figure 74 MR Power One-Line



The formulas below show how to calculate current loss and voltage loss for the following values used in this example:

- Continuous power: 181 KVA
- Peak power: 349 KVA
- $V_{ph\text{-}ph}$: 480 V
- Safety factor: 25%
- Estimated cable loss: 4% (2-4 typically)

NOTE

GE recommends allowing a maximum of 2-4% due to the feeder cable at peak current level.

- Cable length: 400 ft

$$I_{rms} = \frac{181{,}000}{480 * \sqrt{3}} = 218 \text{ A}$$

$$FLA = 218 \text{ A} * 1.25 = 272 \text{ A}$$

$$I_{pk} = \frac{349{,}000}{480 * \sqrt{3}} = 420 \text{ A}$$

$$V_{loss} = 480 * 4\% = 19.2 \text{ V}$$

$$R_{total} = \frac{V_{loss}}{I_{pk} * \sqrt{3}}$$

$$\text{Cable Resistance} = \frac{R_{total}}{\text{Cable length}}$$

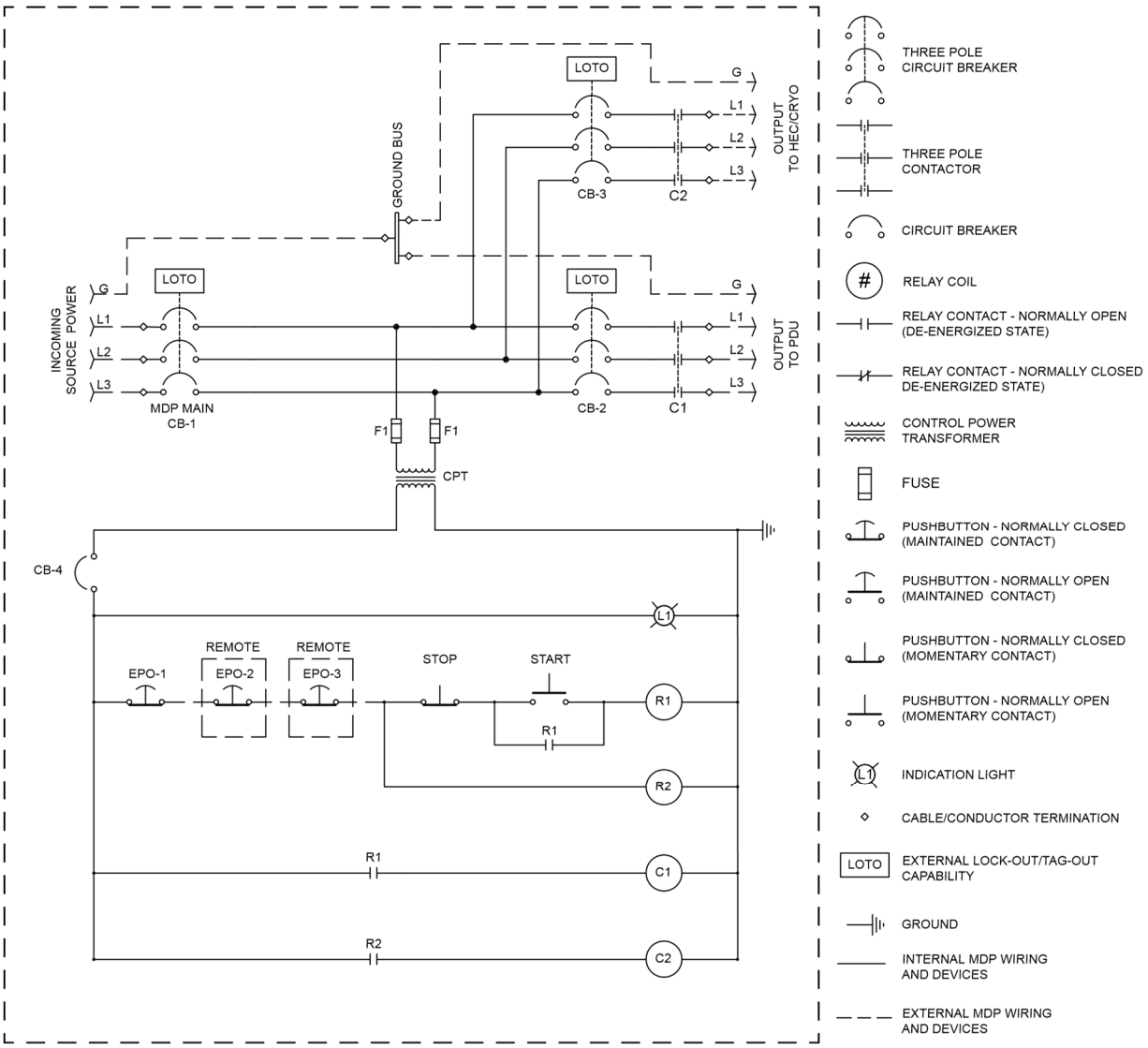
Per the calculations in this example, the site would choose:

- Cable rated to handle 272 A continuous current in the delivery method for the site.
- Cable with a resistance less than 0.026 ohms.
- For ground wire sizing, use NEC Table 250.122. This is based on rating of the overcurrent device upstream. The complete path of the ground wire must be copper.
- MDP Primary accepts 8 awg – 350 MCM
- MDP Primary Ground accepts 6 awg – 250 MCM

7.7 Sample control schematic for customer-supplied MDP

This section provides an example of a control schematic for the auto-restart and Emergency Power Off (EPO) functions that meets the minimum GE Healthcare PIM requirements. This schematic does not include control, protection, wiring or devices that may be required due to local safety and regulatory requirements. Only the minimum equipment, devices and wiring is shown to meet the performance requirements of GEHC equipment. The final MDP design must be compliant with applicable local codes and regulations.

Figure 75 Customer MDP control schematic



7.8 Selecting Anchor Size

1. Magnet clamping force = 18,000 N
2. Anchor loads shall comply with the following chart:

Table 42 Allowable Anchor Loads in Concrete (Metric Units)

Anchor Diameter	Embed-ment Depth mm (in.)	13.8 MPa (2000 psi)		20.7 MPa (3000 psi)		27.6 MPa (4000 psi)		41.4 MPa (6000 psi)	
		Tension kN (lb.)	Shear kN (lb.)	Tension kN (lb.)	Shear kN (lb.)	Tension kN (lb.)	Shear kN (lb.)	Tension kN (lb.)	Shear kN (lb.)
M24	155 (6 1/8)	30.0 (6735)	61.2 (13760)	36.9 (8300)	70.5 (15855)	43.9 (9860)	29.8 (17950)	57.7 (12980)	95.6 (21490)

NOTE

All bolded values in this table fail to meet the clamping force (tension), and are therefore not acceptable anchors.

7.9 Magnet Cryogenic Venting Pressure Drop

3.0T Magnet Cryogenic Vent System Pressure Drop Matrix continued														
Outer Diame- ter of Pipe (OD)	**Distance of vent system component from mag- net**		**Pressure drop for straight pipe**		**Standard sweep 45° elbow**		**Long sweep 45° elbow**		**Standard sweep 90° elbow**		**Long sweep 90° elbow**		**90 miter bend**	
	m	**ft.**	**kPa/m**	**psi/ft.**	**kPa**	**psi**	**kPa**	**psi**	**kPa**	**psi**	**kPa**	**psi**	**kPa**	**psi**
300 mm (12 in.)	6.10-12. 22	20-40	0.994	0.044	2.997	0.435	1.994	0.289	5.609	0.813	3.739	0.542	11.217	1.627

Design and Construction
State Finance Law § 139-M Policy Attestation

Contractor Name: _____

Contractor FEIN: _____

Project Number: _____

Project Trade: _____

In accordance with State Finance Law § 139-m, by submission of this bid, each bidder and each person signing on behalf of any bidder certifies, and in the case of a joint bid each party thereto certifies as to its own organization, under penalty of perjury, that the bidder has and has implemented a written policy addressing gender-based violence and the workplace and has provided such policy to all of its employees, directors and board members. Such policy shall, at a minimum, meet the requirements of subdivision 11 of section five hundred seventy-five of the executive law.

If the bidder cannot make the foregoing certification, such bidder shall so state and shall furnish with the bid a signed statement that sets forth in detail the reasons that the bidder cannot make the certification.

Vendor/Company Name: _____

Signature: _____

By: _____

Title: _____

Date: _____