

GE Healthcare

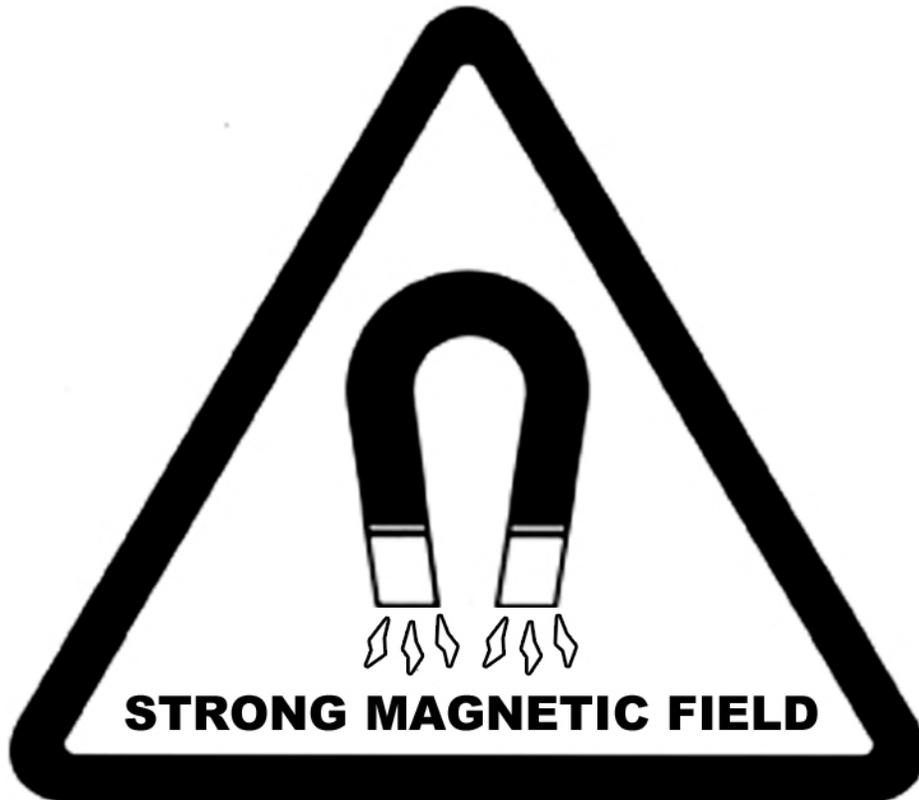
Signa HDxt, HDx, HDi, and Signa Vibrant 1.5T Pre-Installation



OPERATING DOCUMENTATION

5159901
Revision 8.0

WARNING



**NO PACEMAKERS
NO METALLIC IMPLANTS**

Persons with pacemakers, neurostimulators or metallic implants must not enter the magnet area. Serious injury may result.



NO LOOSE METAL OBJECTS

Iron and steel materials must not be taken into the magnet area. Serious injury or property damage may result.

Important Information

LANGUAGE

ПРЕДУПРЕЖДЕНИЕ
(BG) Това упътване за работа е налично само на английски език с изключението на случаите, когато се изисква изрично по друг начин от местното законодателство, или от споразумение на местно ниво.

- Ако доставчикът на услугата на клиента изиска друг език, задължение на клиента е да осигури превод.
- Не използвайте оборудването, преди да сте се консултирали и разбрали упътването за работа.
- Неспазването на това предупреждение може да доведе до нараняване на доставчика на услугата, оператора или пациента в резултат на токов удар, механична или друга опасност.

警告
(ZH-CN) 本维修手册仅提供英文版本，除非当地法律或本地供应协议另有明确要求。

- 如果客户的维修服务人员需要非英文版本，则客户需自行提供翻译服务。
- 未详细阅读和完全理解本维修手册之前，不得进行维修。
- 忽略本警告可能对维修服务人员、操作人员或患者造成触电、机械伤害或其他形式的伤害。

VÝSTRAHA
(CS) Tento provozní návod existuje pouze v anglickém jazyce, pokud není jinak výslovně vyžadováno místními zákony nebo odsouhlaseno na místní úrovni.

- V případě, že externí služba zákazníkům potřebuje návod v jiném jazyce, je zajištění překladu do odpovídajícího jazyka úkolem zákazníka.
- Nesnažte se o údržbu tohoto zařízení, aniž byste si přečetli tento provozní návod a pochopili jeho obsah.
- V případě nedodržování této výstrahy může dojít k poranění pracovníka prodejního servisu, obslužného personálu nebo pacientů vlivem elektrického proudu, respektive vlivem mechanických či jiných rizik.

ADVARSEL

(DA)

Denne servicemanual findes kun på engelsk, medmindre andet kræves i henhold til lokal lovgivning eller lokal aftale.

- Hvis en kundes tekniker har brug for et andet sprog end engelsk, er det kundens ansvar at sørge for oversættelse.
- Forsøg ikke at servicere udstyret uden at læse og forstå denne servicemanual.
- Manglende overholdelse af denne advarsel kan medføre skade på grund af elektrisk stød, mekanisk eller anden fare for teknikeren, operatøren eller patienten.

WAARSCHUWING

(NL)

Deze onderhoudshandleiding is enkel in het Engels verkrijgbaar, tenzij expliciet vereist door plaatselijke regelgeving of overeengekomen op lokaal niveau.

- Als het onderhoudspersoneel een andere taal vereist, dan is de klant verantwoordelijk voor de vertaling ervan.
- Probeer de apparatuur niet te onderhouden alvorens deze onderhoudshandleiding werd geraadpleegd en begrepen is.
- Indien deze waarschuwing niet wordt opgevolgd, zou het onderhoudspersoneel, de operator of een patiënt gewond kunnen raken als gevolg van een elektrische schok, mechanische of andere gevaren.

WARNING

(EN)

This service manual is available in english only except as otherwise expressly required by local law or agreed to at a local level.

- If a customer's service provider requires a language other than english, it is the customer's responsibility to provide translation services.
- Do not attempt to service the equipment unless this service manual has been consulted and is understood.
- Failure to heed this warning may result in injury to the service provider, operator or patient from electric shock, mechanical or other hazards.

HOIATUS

(ET)

See teenindusjuhend on saadaval ainult inglise keeles, kui kohalikud seadused ei ütle teisiti või kui kohalikes õigusaktides ei ole otseselt teisiti ette nähtud.

- Kui klienditeeninduse osutaja nõuab juhendit inglise keelest erinevas keeles, vastutab klient tõlketeenuse osutamise eest.
- Ärge üritage seadmeid teenindada enne eelnevalt käesoleva teenindusjuhendiga tutvumist ja sellest aru saamist.
- Käesoleva hoiatuse eiramine võib põhjustada teenuseosutaja, operaatori või patsiendi vigastamist elektrilöögi, mehaanilise või muu ohu tagajärjel.

VAROITUS

(FI)

Tämä huolto-ohje on saatavilla vain englanniksi, ellei paikallinen laki nimenomaan toisin vaadi tai jos toisin on sovittu paikallisella tasolla.

- Jos asiakkaan huoltohenkilöstö vaatii muuta kuin englanninkielistä materiaalia, tarvittavan käännöksen hankkiminen on asiakkaan vastuulla.
- Älä yritä korjata laitteistoa ennen kuin olet varmasti lukenut ja ymmärtänyt tämän huolto-ohjeen.
- Mikäli tätä varoitusta ei noudateta, seurauksena voi olla huoltohenkilöstön, laitteiston käyttäjän tai potilaan vahingoittuminen sähköiskun, mekaanisen vian tai muun vaaratilanteen vuoksi.

ATTENTION

(FR)

Sauf exigence contraire des lois locales ou accord contraire au niveau local, ce manuel d'installation et de maintenance n'est disponible qu'en anglais.

- Si le technicien d'un client a besoin de ce manuel dans une langue autre que l'anglais, il incombe au client de le faire traduire.
- Ne pas tenter d'intervenir sur les équipements tant que ce manuel d'installation et de maintenance n'a pas été consulté et compris.
- Le non-respect de cet avertissement peut entraîner chez le technicien, l'opérateur ou le patient des blessures dues à des dangers électriques, mécaniques ou autres.

WARNUNG

(DE)

Diese Serviceanleitung existiert nur in englischer Sprache, sofern nichts anderes gesetzlich vorgeschrieben oder auf lokaler Ebene vereinbart wurde.

- Falls ein fremder Kundendienst eine andere Sprache benötigt, ist es Aufgabe des Kunden für eine Entsprechende Übersetzung zu sorgen.
- Versuchen Sie nicht diese Anlage zu warten, ohne diese Serviceanleitung gelesen und verstanden zu haben.
- Wird diese Warnung nicht beachtet, so kann es zu Verletzungen des Kundendiensttechnikers, des Bedieners oder des Patienten durch Stromschläge, mechanische oder sonstige Gefahren kommen.

ΠΡΟΕΙΔΟΠΟΙΗΣΗ

(EL)

Το παρόν εγχειρίδιο σέρβις διατίθεται μόνο στα αγγλικά, εκτός αν η τοπική νομοθεσία απαιτεί κάτι άλλο ή υπάρχει διαφορετική συμφωνία σε τοπικό επίπεδο.

- Εάν ο τεχνικός σέρβις ενός πελάτη απαιτεί το παρόν εγχειρίδιο σε γλώσσα εκτός των αγγλικών, αποτελεί ευθύνη του πελάτη να παρέχει τις υπηρεσίες μετάφρασης.
- Μην επιχειρήσετε την εκτέλεση εργασιών σέρβις στον εξοπλισμό αν δεν έχετε συμβουλευτεί και κατανοήσει το παρόν εγχειρίδιο σέρβις.
- Αν δεν προσέξετε την προειδοποίηση αυτή, ενδέχεται να προκληθεί τραυματισμός στον τεχνικό σέρβις, στο χειριστή ή στον ασθενή από ηλεκτροπληξία, μηχανικούς ή άλλους κινδύνους.

FIGYELMEZTETÉS

(HU)

Ezen karbantartási kézikönyv kizárólag angol nyelven érhető el, kivéve ha a helyi rendelkezések ezt kifejezetten elő nem írják, illetve ha helyi szinten erről külön megállapodás nem születik.

- Ha a vevő szolgáltatója angoltól eltérő nyelvre tart igényt, akkor a vevő felelőssége a fordítás elkészítése.
- Ne próbálja elkezdni használni a berendezést, amíg a karbantartási kézikönyvben leírtakat nem értelmezték.
- Ezen figyelmeztetés figyelmen kívül hagyása a szolgáltató, működtető vagy a beteg áramütés, mechanikai vagy egyéb veszélyhelyzet miatti sérülését eredményezheti.

AÐVÖRUN

(IS)

Þessi þjónustuhandbók er eingöngu fánleg á ensku, nema annað sé sérstaklega krafist, löglega eða samþykkt á landsgrundvelli.

- Ef að þjónustuveitandi viðskiptamanns þarfnast annas tungumáls en ensku, er það skylda viðskiptamanns að skaffa tungumálaþjónustu.
- Reynið ekki að afgreiða tækið nema að þessi þjónustuhandbók hefur verið skoðuð og skilin.
- Brot á sinna þessari aðvörðun getur leitt til meiðsla á þjónustuveitanda, stjórnanda eða sjúklings frá raflosti, vélrænu eða öðrum áhættum.

AVVERTENZA

(IT)

Il presente manuale di manutenzione è disponibile soltanto in inglese, eccetto quando espressamente richiesto dalle normative locali o convenuto a livello locale.

- Se un addetto alla manutenzione richiede il manuale in una lingua diversa, il cliente è tenuto a provvedere direttamente alla traduzione.
- Procedere alla manutenzione dell'apparecchiatura solo dopo aver consultato il presente manuale ed averne compreso il contenuto.
- Il mancato rispetto della presente avvertenza potrebbe causare lesioni all'addetto alla manutenzione, all'operatore o ai pazienti provocate da scosse elettriche, urti meccanici o altri rischi.

警告

(JA)

このサービスマニュアルには英語版しかありません。ただし使用国の法令に別異の定めがある、あるいは現地で別段の合意がある場合を除きます。

- サービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。
- このサービスマニュアルを熟読し理解せずに、装置のサービスを行わないでください。
- この警告に従わない場合、サービスを担当される方、操作員あるいは患者さんが、感電や機械的又はその他の危険により負傷する可能性があります。

경고

(KO)

현지 법률에 따라 명시적으로 요구하거나 현지 수준에서 합의한 경우를 제외하고 본 서비스 매뉴얼은 영어로만 이용하실 수 있습니다.

- 고객의 서비스 제공자가 영어 이외의 언어를 요구할 경우, 번역 서비스를 제공하는 것은 고객의 책임입니다.
- 본 서비스 매뉴얼을 참조하여 숙지하지 않은 이상 해당 장비를 수리하려고 시도하지 마십시오.
- 본 경고 사항에 유의하지 않으면 전기 쇼크, 기계적 위험, 또는 기타 위험으로 인해 서비스 제공자, 사용자 또는 환자에게 부상을 입힐 수 있습니다.

BRĪDINĀJUMS

(LV)

Šī apkalpes rokasgrāmata ir pieejama tikai angļu valodā, izņemot gadījumus, kad vietējie likumi nepārprotami nosaka citādi vai panākta vienošanās vietējā līmenī.

- Ja klienta apkalpes sniedzējam nepieciešama informācija citā valodā, nevis angļu, klienta pienākums ir nodrošināt tulkošanu.
- Neveiciet aprīkojuma apkalpi bez apkalpes rokasgrāmatas izlasīšanas un saprašanas.
- Šī brīdinājuma neievērošana var radīt elektriskās strāvas trieciena, mehānisku vai citu risku izraisītu traumu apkalpes sniedzējam, operatoram vai pacientam.

ĮSPĖJIMAS

(LT)

Šis eksploatavimo vadovas yra tik anglų kalba, išskyrus tuos atvejus, kai vietiniai įstatymai tiesiogiai numato kitokius reikalavimus arba vietiniu lygiu sutarta kitaip.

- Jei kliento paslaugų tiekėjas reikalauja vadovo kita kalba – ne anglų, suteikti vertimo paslaugas privalo klientas.
- Nemėginkite atlikti įrangos techninės priežiūros, jei neperskaitėte ar nesupratote šio eksploatavimo vadovo.
- Jei nepaisysite šio įspėjimo, galimi paslaugų tiekėjo, operatoriaus ar paciento sužalojimai dėl elektros šoko, mechaninių ar kitų pavojų.

ADVARSEL

(NO)

Denne servicehåndboken finnes bare på engelsk, bortsett fra dersom det motsatte uttrykkelig er fastsatt av lokal lovgivning eller det er inngått annen avtale lokalt.

- Hvis kundens serviceleverandør trenger et annet språk, er det kundens ansvar å sørge for oversettelse.
- Ikke forsøk å reparere utstyret uten at denne servicehåndboken er lest og forstått.
- Manglende hensyn til denne advarselen kan føre til at serviceleverandøren, operatøren eller pasienten skades på grunn av elektrisk støt, mekaniske eller andre farer.

OSTRZEŻENIE

(PL)

Niniejszy podręcznik serwisowy dostępny jest jedynie w języku angielskim, chyba że lokalne przepisy lub umowy wyraźnie stanowią inaczej.

- Jeśli dostawca usług klienta wymaga języka innego niż angielski, zapewnienie usługi tłumaczenia jest obowiązkiem klienta.
- Nie próbować serwisować wyposażenia bez zapoznania się z niniejszym podręcznikiem serwisowym i zrozumienia go.
- Niezastosowanie się do tego ostrzeżenia może spowodować urazy dostawcy usług, operatora lub pacjenta w wyniku porażenia prądem elektrycznym, zagrożenia mechanicznego bądź innego.

ATENȚIE

(RO)

Acest manual de service este disponibil numai în limba engleză, cu excepția cazului în care este o cerință obligatorie stipulată de legislația națională sau convenită la nivel local.

- Dacă un furnizor de servicii pentru clienți necesită o altă limbă decât cea engleză, este de datoria clientului să furnizeze o traducere.
- Nu încercați să reparați echipamentul decât ulterior consultării și înțelegerii acestui manual de service.
- Ignorarea acestui avertisment ar putea duce la rănirea depanatorului, operatorului sau pacientului în urma pericolelor de electrocutare, mecanice sau de altă natură.

ОСТОРОЖНО!

(RU)

Данное руководство по техническому обслуживанию предлагается только на английском языке, за исключением тех случаев, когда наличие руководства на национальном языке является требованием местного законодательства или когда выпуск такого руководства согласован с местным представительством.

- Если сервисному персоналу клиента необходимо руководство не на английском, а на каком-то другом языке, клиенту следует самостоятельно обеспечить перевод.
- Перед техническим обслуживанием оборудования обязательно обратитесь к данному руководству и поймите изложенные в нем сведения.
- Несоблюдение требований данного предупреждения может привести к тому, что специалист по техобслуживанию, оператор или пациент получит удар электрическим током, механическую травму или другое повреждение.

UPOZORNENIE

(SK)

Tento návod na obsluhu je k dispozícii len v angličtine, okrem prípadov, kedy tak výslovne vyžadujú miestne zákony alebo je dohodnuté na miestnej úrovni.

- Ak zákaznikov poskytovateľ služieb vyžaduje iný jazyk ako angličtinu, poskytnutie prekladateľských služieb je zodpovednosťou zákazníka.
- Nepokúšajte sa o obsluhu zariadenia, kým si neprečítate návod na obsluhu a neporozumiete mu.
- Zanedbanie tohto upozornenia môže spôsobiť zranenie poskytovateľa služieb, obsluhujúcej osoby alebo pacienta elektrickým prúdom, mechanické alebo iné ohrozenie.

ATENCION

(ES)

Este manual de servicio sólo existe en inglés, salvo que la legislación local exija de forma expresa lo contrario, o así se haya acordado a nivel local.

- Si el encargado de mantenimiento de un cliente necesita un idioma que no sea el inglés, el cliente deberá encargarse de la traducción del manual.
- No se deberá dar servicio técnico al equipo, sin haber consultado y comprendido este manual de servicio.
- La no observancia del presente aviso puede dar lugar a que el proveedor de servicios, el operador o el paciente sufran lesiones provocadas por causas eléctricas, mecánicas o de otra naturaleza.

VARNING

(SV)

Den här servicehandboken finns bara tillgänglig på engelska om inte annat uttryckligen krävs av lokal lag eller har överenskommit på lokal nivå.

- Om en kunds servicetekniker har behov av ett annat språk än engelska, ansvarar kunden för att tillhandahålla översättningstjänster.
- Försök inte utföra service på utrustningen om du inte har läst och förstår den här servicehandboken.
- Om du inte tar hänsyn till den här varningen kan det resultera i skador på serviceteknikern, operatören eller patienten till följd av elektriska stötar, mekaniska faror eller andra faror.

DİKKAT

(TR)

Aksi, yerel bir yasa tarafından açıkça gerekli görülmediği veya yerel bir seviyede kabul edilmediği takdirde, bu servis kılavuzunun sadece İngilizcesi mevcuttur.

- Eğer müşteri teknisyeni bu kılavuzu İngilizce dışında bir başka lisandan talep ederse, bunu tercüme ettirmek müşteriye düşer.
- Servis kılavuzunu okuyup anlamadan ekipmanlara müdahale etmeyiniz.
- Bu uyarıya uyulmaması, elektrik, mekanik veya diğer tehlikelerden dolayı teknisyen, operatör veya hastanın yaralanmasına yol açabilir.

AVISO

(PT-BR)

Este manual de assistência técnica encontra-se disponível unicamente em inglês, salvo disposições em contrário previstas pela legislação local ou acordadas no âmbito local.

- Se outro serviço de assistência técnica solicitar a tradução deste manual, caberá ao cliente fornecer os serviços de tradução.
- Não tente reparar o equipamento sem ter consultado e compreendido este manual de assistência técnica.
- A não observância deste aviso pode ocasionar ferimentos no técnico, operador ou paciente decorrentes de choques elétricos, mecânicos ou outros.

ATENÇÃO

(PT-PT)

Este manual de assistência técnica só se encontra disponível em inglês, salvo requisição expressa pela legislação local ou acordo efectuado a nível local.

- Se qualquer outro serviço de assistência técnica solicitar este manual noutra língua, é da responsabilidade do cliente fornecer os serviços de tradução.
- Não tente reparar o equipamento sem ter consultado e compreendido este manual de assistência técnica.
- O não cumprimento deste aviso pode colocar em perigo a segurança do técnico, do operador ou do paciente devido a choques eléctricos, mecânicos ou outros.

UPOZORENJE

(SR)

Ovo servisno uputstvo je dostupno samo na engleskom jeziku, sem ako lokalni zakon to izričito zahteva ili je dogovoreno na lokalnom nivou.

- Ako klijentov serviser zahteva neki drugi jezik, klijent je dužan da obezbedi prevodilačke usluge.
- Ne pokušavajte da opravite uređaj ako niste pročitali i razumeli ovo servisno uputstvo.
- Zanemarivanje ovog upozorenja može dovesti do povređivanja serviser, rukovaoca ili pacijenta usled strujnog udara ili mehaničkih i drugih opasnosti.

Revision History

Revision	Date	Description
1	17 November 2005	Initial Signa HDx product release
2	22 August 2006	<p>Topic modified throughout direction: GE MDP catalog E4503AT changed to E4502SP (25K AIC configuration).</p> <p>System Configuration Chapter: Incorporated new catalogs for all of the various language Keyboard Kits. Revised catalog flowchart Relocatable info for MDP and Gradient Coil Chiller catalog. Updated html file graphic for Signa HDx 1.5T System New System Catalogs to show M3335PB 1.5T LCC Magnet with HDx Enclosure and M3335KF Patient Table. New System Additional Catalogs illustration deleted catalogs not listed in ePricebook MR pages (E1000LG, M1000NW, M1000MK). Added Note stating Magnet seismic anchoring is the customer's responsibility to coordinate. DC Lighting Controller catalogs changed to E4502SC, E4502SD, E4502SE, and E4502SF for 18K AIC configurations.</p> <p>Room Layout Chapter: Added WC1 to row titled "50 gauss (5mT) or Less". Added exit route wording to heading of Room Dimensions table. MR System Interconnects Routing Requirements/Recommendations table reformatted to number requirements and updated requirements to be consistent with revised Magnet Room floor requirement of metal access floor tiles not allowed anywhere: Row titled Entire MR System; recommendation for use of access flooring deleted. Row titled Magnet Room: deleted access floor note and added metal floor access tiles not allowed with reference to Magnet Room Floors requirement in RF Shielded Room chapter. Blower Box mounting NOTICE deleted raised floor sentence to be consistent with metal floor access tiles not allowed per Magnet Room Floors requirement in RF Shielded Room chapter. Added section with reference to <i>Direction 5182674 GE Healthcare Signa MRI Scanners Customer Site Storage Requirements</i> for size and weight of surface coils and phantoms that require customer provided storage locations. Deleted SPT Cart from illustrations and tables throughout the direction. Table titled Notes For System Components Floor Loading Table, Note 5 2nd sentence changed to Contact your local GE Healthcare Project Manager, Installations for seismic information if the MR system equipment is required by code to be anchored. Deleted dewars information in Floor Loading table since lists cryogen delivery route requirements. Magnet Mounting Recess Area requirements/information updated in Load Pattern tables. Magnet Mounting recessed area depth dimension tolerances changed to 1.5 in. +0 / -0.125 in. (38.1mm +0 / -3.175 mm) to be consistent with Magnet Room Floors specification changes. Added side Service Access Requirement. "Seismic anchor holes" changed to BRACKETS MOUNTING HOLES and brackets callout to "BRACKETS SUPPLIED WITH CABINET FOR MOUNTING, IF REQUIRED."</p> <p>Site Environment Chapter: added Notice with Magnet Systems approval/direction contact info for Magnet located above 8100 ft (2469 m). Ventilation Requirements/Recommendations table reformatted for 1 column with numbered list of requirements. Incorporated Magnet Room ventilation switch placement requirement (removed from RF Shielded Room Chapter). Cryogenic Vent Roof and Wall Exit illustrations updated exhaust opening shaded areas added white behind text to improve text readability.</p> <p>Power Requirements Chapter: Critical Power Requirements table, Configuration row: added missing bullet defining Recommended input configuration 3 phase solidly Grounded WYE.</p> <p>Interconnect Data Chapter: Reformatted Introduction section so subsections are now included in direction table of contents. M3335NL L1/L2 Group 27 provided length changed from 59 ft (17.98 m) to 74 ft (22.56 m). Updated 32 Channel Option Groups C1 and C2 provided lengths (2 lengths) and Run # provided (C1 added 1200 & 1201, C2 added 1185 & 1186).</p>

Revision	Date	Description
2 (continued)		<p>RF Shielded Room Chapter: RF Shielded Room Requirements table, row titled Construction, Note text deleted 'e.g. aluminum'. added missing Magnet Mounting & Vent Location tables with and without vibroAcoustic Damping option (corrected profiling error). Requirements reordered for clarity and completeness. Also added Notice pertaining to Penetration Panel mounting hardware must not loosen over time to maintain RF attenuation requirement. Major changes incorporated:</p> <ul style="list-style-type: none"> • Added Notice for Magnet Mounting recessed area required for all installations. • Rewrote entire section to simplify requirements, used feedback from Project Managers - Installations and Zone Support Engineers. • Same levelness dimension requirements for all Magnet Room floor areas. • Magnet Mounting Recess Area depth and levelness tolerances changed to +0 / -0.125 in. (+0 / 3.175 mm). Added RF Shield material seams MUST NOT be located in projected areas of the VibroAcoustic mats. • Metal access floor time are NOT allowed in Magnet Room. • Illustration revised to show recessed area with Vibroacoustic mats projected locations. <p>Anchor Hardware Requirements RF Shield Room Anchor Details illustration callouts updated to be consistent with Magnet Room Floors rewrite wording for RF Shield Room Vendor supplied Magnet Foot support plates materials.</p> <p>Shipping and Delivery Data Chapter: Patient Table shipping dimensions and weights revised for new packaging. Updated Magnet moving dimensions and weight per 5162096IDW Rev 1 info.</p> <p>Pre-Installation Checklist Chapter: subsection titled "General Pre-Installation Reminders" item 1 revised for customer provided final site construction drawings reviewed using requirements documented in the PIM and MR Typical drawings.</p> <p>Tools and Test Equipment Chapter: Updated several part numbers: -Field Plotting Kit 46-251865G4 - Magnet Ramping Equipment Kit part number updated to 46-260703G5 -Non-Magnetic Tool Kit replaced by new Titanium Non-Magnetic Tool Kits.</p>
3	5 April 2007	<p>Interconnect routing requirements moved to Table titled "MR System Interconnects Routing Requirements/Recommendations", row titled "Magnet Room" from RF Shielded Room Requirements table. Also reworded moved requirements: - added anchors to mechanical fasteners list and clarified mechanical fastener not allowed within 2 ft (0.61 m) of Gradient Cables; - added unsecured or overlapped electrically conductive materials not allowed within 2 ft (0.61m of Gradient Cables. [Resolution for iTrak 13067413 / SPR MRIhc13679, iTrak 13066436, CSO#6979689]. RF Shielded Room Requirements table, Construction row deleted note concerning access floor since that material is not allowed in Magnet Room [iTrak 13076809 / SPR MRIhc15783].</p> <p>Room Layout Chapter: Minimum Room Inside Clear Space Dimensions table added note for site needs to be planned for and included in site room layout drawings; included Direction 5182674 GE Healthcare Signa MRI Scanners Customer Site Storage Requirements website reference [iTrak 13098143]. dimensions revised for new OW Table configuration.</p> <p>Site Environment Chapter: requirements changed to DC Lighting required in Magnet Room and additional rewording for clarification of requirements. Definition of Moving Metal wording revised and Magnet Moving Metal Requirements table deleted 3 gauss line dimensions to be consistent with MR System Specification. Also revised wording for clarification in Distances For AC Power Lines, Transformers And Electric Motors subsection. Revised section wording for traceable requirements. Restructured, reformatted, and revised wording to simplify/clarify requirements. Magnet Room Site Vibration Testing And Requirements table added to list the requirements in place of several paragraphs.</p>
4	29 Nov 2007	Updated title for HDi configuration.
5	03 July 2008	Updated to include Surgical Suite information (MRIhc38215) and new service area dimensions.
6	25 July 2008	Update Preinstall introduction; Pre-Installation Checklist updated and moved to final chapter in book; Glossary moved to Appendix; Cabling and Interconnection Updates: MCAT - PQR13131624, PCN 290178; Van Manufacturer Update; Proximity Limits Table; Update Minimum Room Size: Site Deviation Process; Update Two Magnet Installation Drawing Missing "Magnet Interaction"; Update BRM Cart Drawing Update length; VibroMat/Surface Mount: PQR13172417, 13066434, 13066774; White Pixel: CSO and PQR13173912, 13066429; Water Chiller Update to simplify PQR13151021; Structural Steel update; EMC Update; Removed Altitude Chapter; Design Center Issues PQR13101088; RF Shield Waveguides: PQR13154414, 13162563; Acoustic Specifications: PQR13121153; Cryogenic Venting/ Cryogen Vent Sidewall Exit; Interconnects Updates; HDxt Updates

Revision	Date	Description
7	01 May 2009	Updated for : iTraks: 13210075: Removed high-resistance flooring requirement; 13209995, 13210019: Added center of gravity for magnet and CRY. Sprs MRIhc 40347 and MRIhc 40422: Update to Required Power section. Other: Updated the following sections to match DV formatting, 2, 3.3, 4.5.1, 8.6.5.4. Added gauss limits for equipment; Removed "Tools and Test Equipment" section; Combined "Power Interconnects" section into Power Distribution" section to remove repeated information. Restored illustration 12-7 and 12-8 in the appendix. Removed CSW-71D CRY information. Added Air-Cooled CRY information.
8	13 Nov 2010	Ch 3. Sec 8.1.2.1.4: CAPA 2137265, Updated external copper pipe to copper or PP-R pipe per DOC0519001 Rev3 V5

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Chapter 1 Pre-Installation Introduction

1 Pre-Install Manual Introduction



WARNING

PERSONNEL INJURY OR EQUIPMENT FAILURE
FAILURE TO IMPLEMENT ALL REQUIREMENTS AND ADHERE TO ALL SPECIFICATIONS IN THIS MANUAL MAY RESULT IN PERSONAL INJURY, EQUIPMENT DAMAGE, SCAN FAILURE, OR WARRANTY VOID.

THE IMPLEMENTATION OF ALL REQUIREMENTS AND ADHERENCE TO ALL SPECIFICATIONS IN THIS MANUAL IS THE RESPONSIBILITY OF THE CUSTOMER OR THEIR ARCHITECT AND ENGINEERS. REFER ANY QUESTIONS TO THE GE HEALTHCARE PROJECT MANAGER OF INSTALLATION (PMI).



NOTICE

The site must comply with all local and National codes and regulations.

1.1 Document Purpose

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

1. For the site to meet system requirements
2. For the effective arrangement and interconnection of system components

1.2 Intended User

The primary user of this manual is the installation or architectural planner who has knowledge of the following:

1. MR nomenclature, system functions, and general characteristics
2. National and local building codes
3. Customer site procedures (medical, MR, safety, etc.)
4. Any special architectural requirements (e.g., seismic codes)

1.3 Document Overview

This manual describes requirements and specifications for the following:

1. General System Requirements
2. Shipping and Delivery

3. Magnet Room
4. Equipment Room
5. Control Room
6. Interconnects

Chapter 2 General System Level

1 System Components

The Signa HDxt 1.5T System consists of the following components:

1.1 Magnet Room

1. 1.5T CXK4 Magnet (MS1) and Magnet Enclosure (MG2)
2. Body Gradient (BRM) coil
3. Patient Transport Table (PT1)
4. Magnet Rundown Unit (MS4). An optional Magnet Rundown Unit may be located outside the Magnet Room.
5. Blower Box (MG6)

1.2 Equipment Room

1. RF System (RFS) Cabinet (MR2)
2. High Fidelity Drivers/Power Distribution Unit (HDF/PDU) cabinet (MR3)
3. Shield/Cryo Cooler Compressor Cabinet (MS5). Either Air- or Water-Cooled
4. Penetration Panel (PP1)
5. Main Disconnect Panel (MDP). Either GE Healthcare or customer supplied.
6. Optional: 32 Channel Cabinet (MR11)
7. Optional: Brainwave Lite (BW)
8. Optional: Multi-Nuclear Spectroscopy (MR10)
9. Optional, customer supplied, uninterrupted power supply (UPS)
10. Optional, customer supplied, Magnet Room DC lighting controller

1.3 Control Room

1. Operator Workspace Equipment (OW1)
2. Pneumatic Patient Alert System (PA1)
3. Optional: Oxygen Monitor (OM1)

1.4 Accessories

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

1.5 System Cooling Equipment

1. MR Common Chiller (MRCC)
2. Gradient Water Heat Exchanger (GWHX)

2 Van Manufacturers Contact Information

Pre-Installation requirements may vary for specific Mobile configurations (True Mobile, Transportable, or Relocatable) and between Van Manufacturers. Listed below is contact information for GE Van Manufacturers.

- Ellis & Watts
4400 Glen Willow Lake Lane
Batavia, OH 45103
Telephone: 513-752-9000
FAX: 513-752-4983 USA
- PDC Facilities
700 Walnut Ridge Drive, PO Box 900
Hartland, WI 53029-0900
Telephone: 262-367-7700
FAX: 262-367-7744 USA
- SMIT Mobile Equipment
Buys Ballotstraat 6
3261 La Oud-Beijerland
Holland
Telephone: (31) 186-6-14322
FAX: (31) 186-6-19367
- Oshkosh Specialty Vehicles
16745 South Lathrop Avenue
Harvey, IL 60426
Telephone: 708-596-2480
FAX: 708-596-2480 USA
<http://www.oshkoshsv.com//contactus.aspx>
Oshkosh Trucking is also contact for used AK Specialty Vehicles and Calumet Coach trailers.

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Chapter 3 Room Layouts

1 Introduction

Site Planning an MR magnet requires the site planer to consider the surrounding environment due to the magnetic field. The magnetic field may impact facility occupants or facility equipment outside the Magnet Room and at the same time, the facility environment may interact with the MR magnet.

Selecting the final placement of the MR magnet needs to prevent interaction of the MR magnetic field with medical devices, including cardiac pacemakers, neurostimulators, biostimulation devices, etc. Facility motors (e.g, fan motors, pump motors, etc.), transformers, building structural steel, facility office supplies (e.g., filing cabinets) must be reviewed so as not to impact the main magnetic field.

Selecting a magnet location with sufficient distance to medical devices or facility equipment will resolves most issues with the main magnetic field. When physical space is not available, enclosing the entire magnet room within a magnetic shield offers benefits.

The MR system also requires the magnet to reside within an RF enclosure. RF Shield vendors are responsible for the design and build the RF Shielded rooms.

2 Magnetic Field Proximity Limits

The table below lists stationary equipment known to be sensitive to high magnetic fields. The table is provided as a guide only. Actual Gauss limits are equipment specific and must be determined during the site planning process. Refer to [Chapter 4, Magnetic Field](#) to define the magnetic field plots. Also refer to [Chapter 5, Changing Magnetic Environment Specifications](#) for requirements for moving object sensitivity, including automobiles, elevators cages, etc.

Table 3-1: Magnetic Proximity Limits

Gauss (mT) Limit	Equipment		
0.5 gauss (0.05mT)	Nuclear camera		
1 gauss (0.1mT)	Positron Emission Tomography scanner	Video display (tube)	
	Linear Accelerator	CT scanner	
	Cyclotrons	Ultrasound	
	Accurate measuring scale	Lithotripter	
	Image intensifiers	Electron microscope	
	Bone Densitometers	Nuclear Camera (Discovery NM530c)	
3 gauss (0.3mT)	Power transformers	Main electrical distribution transformers	
5 gauss (0.5mT)	Cardiac pacemakers	Biostimulation devices	
	Neurostimulators		
10 gauss (1mT)	Magnetic computer media	Telephone switching stations	
	Hard copy imagers	Water cooling equipment	
	Line printers	HVAC equipment	
	Video Cassette Recorder (VCR)	Major mechanical equipment room	
	Film processor	Credit cards, watches, and clocks	
	X-ray tubes		
	Large steel equipment, including:		
	Emergency generators	Air conditioning equipment	
	Commercial laundry equipment	Fuel storage tanks	
	Food preparation area	Motors greater than 5 horsepower	
50 gauss (5mT)	Metal detector for screening	Telephones	
	LCD panels		
No Limit	Digital Detectors		
Note: Recommended limits given above are based on general MR site planning guidelines. Actual susceptibility of specific devices may vary significantly depending on electrical design orientation of the device relative to the magnetic field and the degree of interference considered unacceptable.			

3 Minimum Room Sizes

Minimum room sizes list the minimum finished room space requirements to properly and safely operate and service the MR system. The dimensions listed may be increased to accommodate the following:

1. Building code requirements (e.g., exit routes, door placement, local and national electrical codes, etc.)
2. System requirements, including cable run locations, patient observation requirements, and penetration panel placements (e.g., the Equipment room and Magnet room must share a common wall to allow penetration panel installation)
3. Magnetic field or shielding requirements
4. Room shape
5. Penetration Panel (must be located outside 200 Gauss)
6. Non-GEHC equipment options (such as additional AC or water cooling equipment in the Equipment room)
7. Accessory storage. Refer to the *Customer Site Storage Requirements* manual (document number 5182674) or contact the GE Healthcare Project Manager of Installation (PMI) for any additional accessory storage requirements
8. TransMobile Patient Transport (Surgical Suite Option) may require additional Magnet room space or space shared with an adjacent room (see [Illustration 3-3](#))

Table 3-2: Signa HDxt 1.5T System Minimum Room Dimensions

System Configuration	Finished Equipment Room Minimum Dimensions		Finished Magnet Room Minimum Dimensions (See the illustrations below for specific dimensions)			Finished Control Room Minimum Dimensions		Total System Area ft ² (m ²)
	W x Dft-in. (m)	Area ft ² (m ²)	W x D ft-in. (m)	Area ft ² (m ²)	Ceiling Height ft-in. (m)	W x D ft-in. (m)	Area ft ² (m ²)	
System without a MRCC unit or MRCC unit located outdoors	8-0 x 12-0 (2.438 x 3.658)	96.0 (8.919)	11-10.5 x 20-5 (3.62 x 6.223)	213.35 (19.82)	8-9 (2.67)	5 x 7 (1.52 x 2.13)	35 (3.252)	344.35 (31.98)
System with 1 MRCC unit located indoors	8-0 x 17-0 (2.438 x 5.182)	136.0 (12.635)						384.35 (32.68)
Notes:								
1. When the MRCC option is not selected then the customer site must provide water cooling for the LCC Magnet Shield/Cryo Cooler Compressor Cabinet. Minimum Equipment Room for system without the MRCC does not permit placement of equipment which will provide water cooling for Shield/Cryo Cooler Compressor.								
2. Order the low ceiling height option when minimum ceiling height is 98.5 in (2500 mm).								

Illustration 3-1: Finished Magnet Room Minimum Dimensions

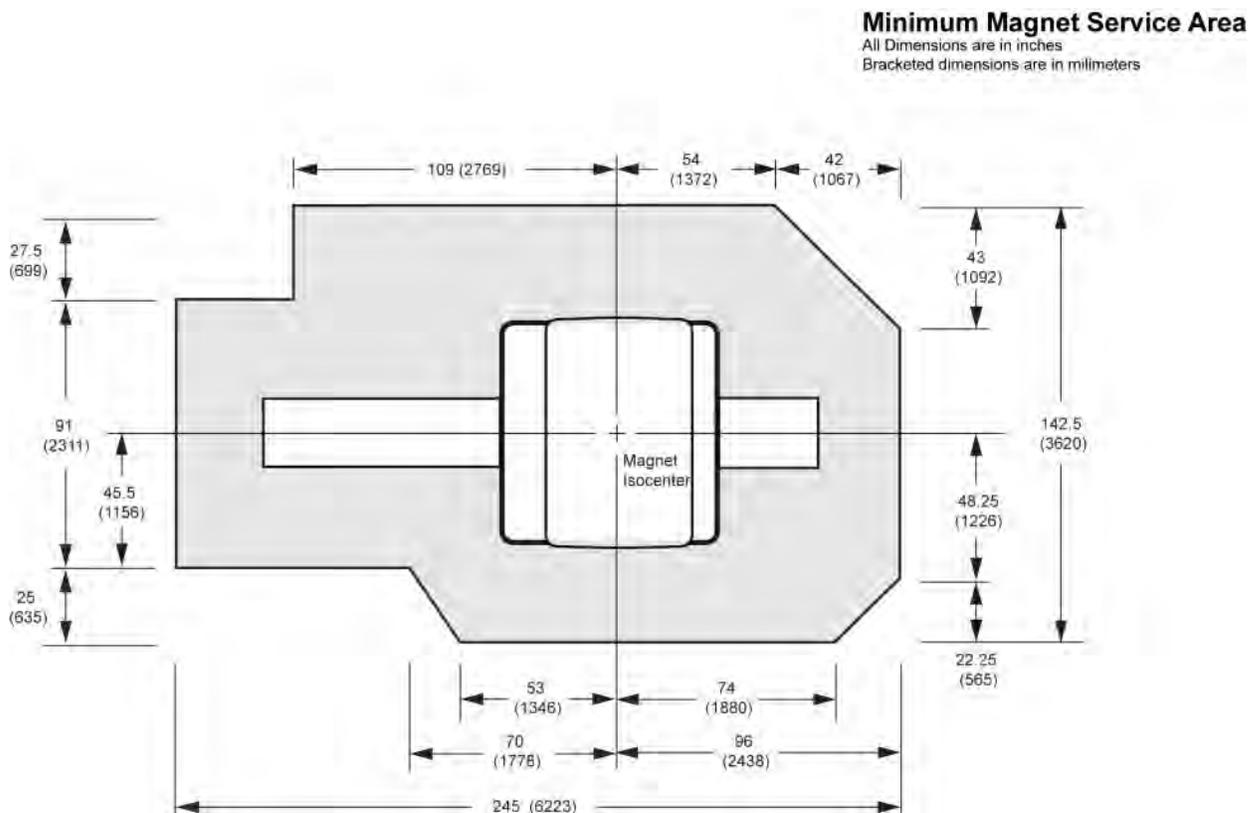


Illustration 3-2: Finished Magnet Room Ceiling Height

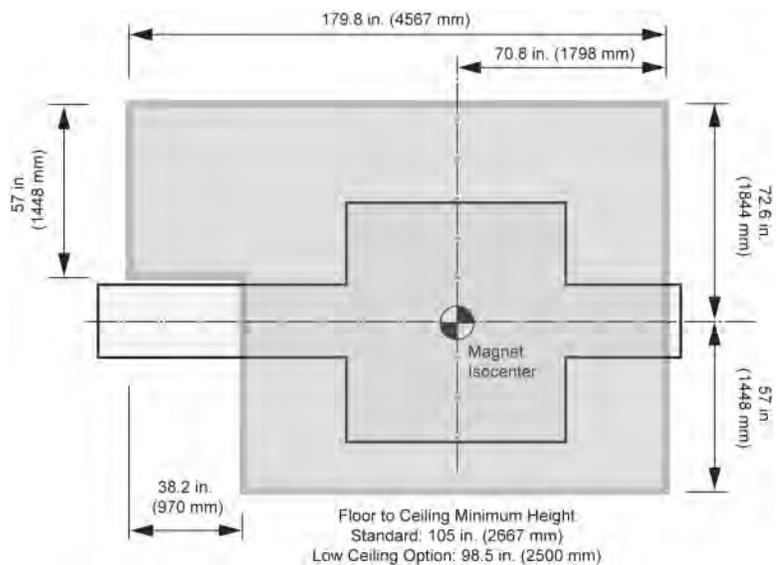
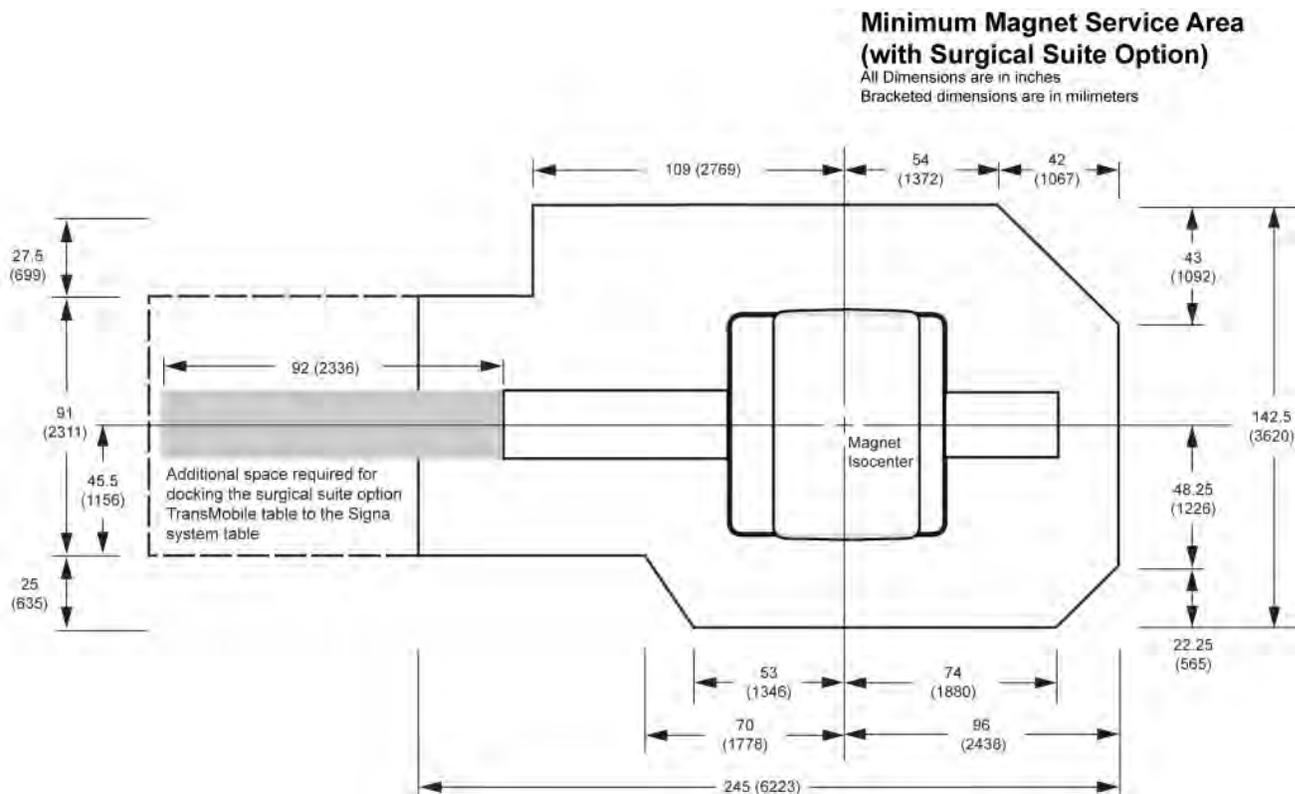


Illustration 3-3: Finished Magnet Room Minimum Dimensions with Surgical Suite Option



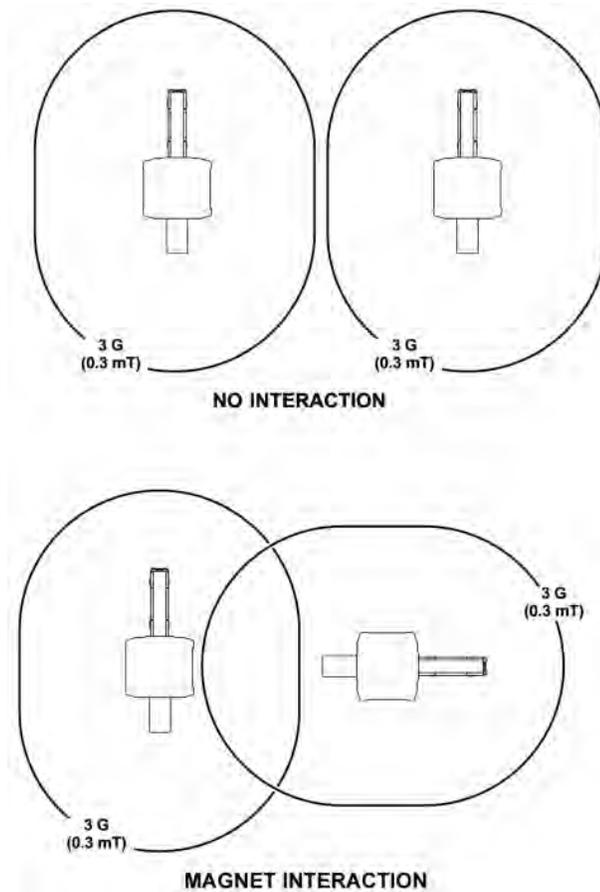
NOTE: See [Chapter 7, Patient Transport Table](#) for Surgical Suite TransMobile Table dimensions.

4 Multiple MR Systems

4.1 Two Magnet Site Layout

Sites planning to install multiple magnets, independent of the MR supplier, must ensure the 3 gauss lines of each magnet do not cross. Crossover of one MR magnets 3 Gauss line into another MR magnet 3 gauss line will result in service or down time for both machines when shim or magnet ramps are performed.

Illustration 3-4: Two Magnet Installation



4.2 Equipment Room Shared by Multiple MR Systems

4.2.1 Introduction

When an Equipment Room is shared by more than one MR system of the same field strength there is a potential for cross-talk of RF energy between the MR systems. RF cross-talk may cause noise artifacts in images. Proper planning and installation of the multiple systems in the shared Equipment Room can reduce the potential for cross-talk.

The potential for cross-talk exists when the RF transmit cables and equipment of two or more MR systems are located in the same Equipment Room. For example, when one system is transmitting, the other system could be in receive mode and therefore pick up the RF energy being transmitted.

NOTE: Cross-talk may also occur between GE Healthcare and non-GE MR Systems with the same field strength.



NOTICE

The RF Shield of the Magnet Room for each system must meet the RF Attenuation specifications in [Chapter 11, RF Shielded Room Specifications](#).

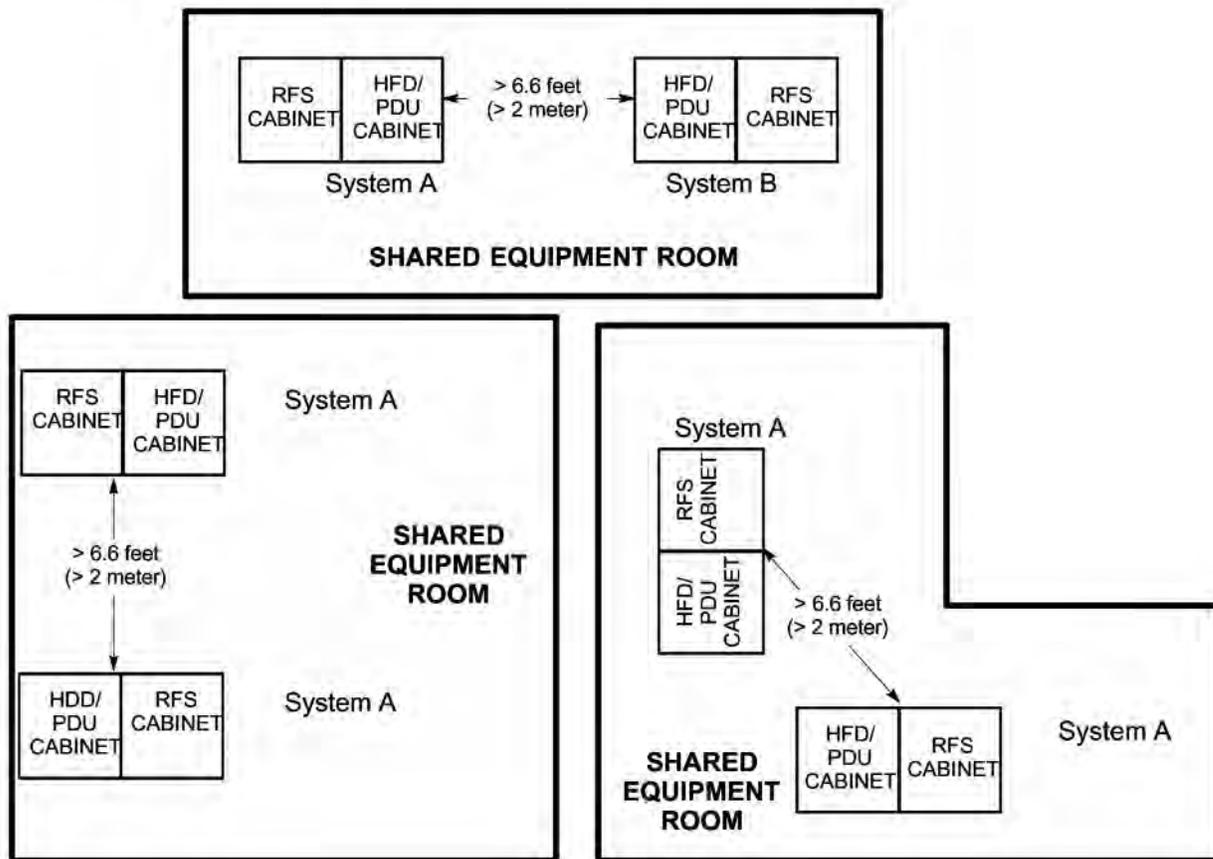
The following subsections provide requirements for shared Equipment Room design, layout, and installation which reduce the potential for RF cross-talk.

4.2.2 Equipment Cabinets Relative Locations

The following are requirements for locating equipment cabinets of one MR system relative to the other MR system equipment cabinets.

- Maximize separation distance between the RF transmitter (RF Amplifier) of one MR system and the RF receiver (RRF Chassis) of the other MR system of the same field strength.
- The RF transmitter (RF Amplifier) of one MR system and the RF receiver (RRF Chassis) of the other MR system of the same field strength must be separated by a minimum of > 6.6 feet (2 meters) in all directions, see [Illustration 3-5](#).
- Signa HDx 1.5T (Release 14.x) and Signa EXCITE HD 1.5T Release 12.x the RF Amplifier and the RRF Chassis are both located in the RFS Cabinet.

Illustration 3-5: Multiple Signa HDxt Systems Electronics Cabinets Spacing



4.2.3 Penetration Panels Locations

The following are requirements for locating the RF Shielded Room Penetration Panel of one MR system relative to the other MR system RF Shielded Room Penetration Panel.

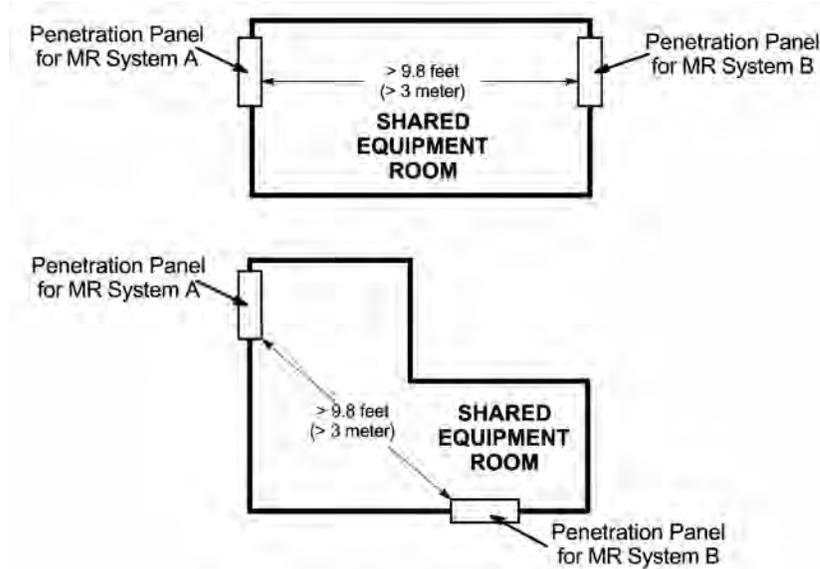


NOTICE

All Penetration Panels must be located outside the 200 Gauss line.

There must be > 9.8 feet (3 meters) separation between the Penetration Panels of each system sharing the Equipment Room space, see [Illustration 3-6](#).

Illustration 3-6: Multiple MR Systems Penetration Panel Spacing

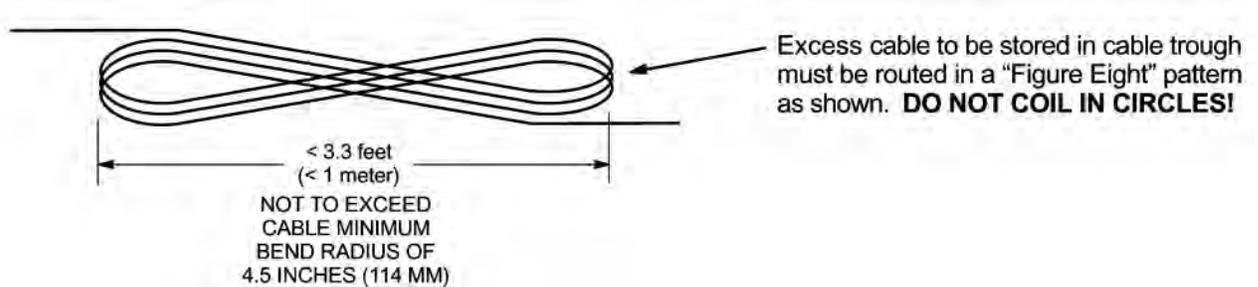


4.2.4 Excess System Cable Requirements

The following are requirements for locating and managing excess RF Receive and Transmit cables of the MR systems sharing the Equipment Room.

- There must be > 6.6 feet (2 meters) separation between the system interconnect cables of each system sharing the Equipment Room space.
- Transmit cables in the Equipment Room must be cut to length to minimize excess cable length reducing the potential for signal coupling with other cables. No excess transmit cable can be stored in the Equipment Room.
- Receive cables excess length must be stored in a "figure 8" with overall dimension of <3.3 feet (<1 meter), see [Illustration 3-7](#).

Illustration 3-7: Proper Storage Of Excess Receive Cables



5 Delivery Route Requirements

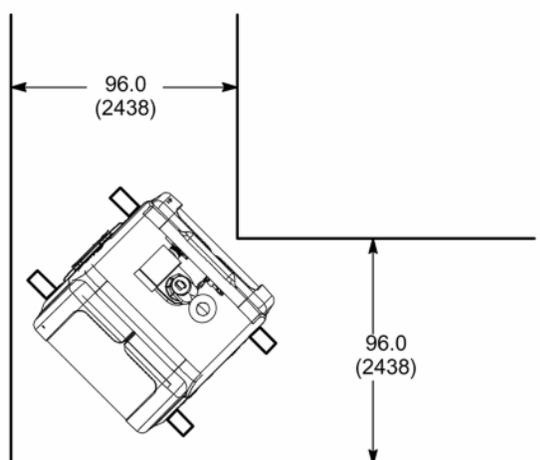
5.1 Minimum Delivery Route Sizes and Capacity

Table 3-3 lists minimum actual clearance opening dimensions for doors and hallways required by the MR system equipment. Installation or replacement of components listed in Table 3-4 must be taken into consideration when determining hallway and door dimensions. Clearance for maneuvering around corners or turns must also be taken into consideration. Refer to Chapter 12, Shipment for Signa Component shipping dimensions.

Table 3-3: Minimum Hallway/Door Dimensions

Component	Minimum Hallway/ Door Width*		Minimum Hallway/ Door Height*		Comments
	in.	mm	in.	mm	
Operator Workspace Table	32	813	80	2032	
Equipment Cabinets	36	914	80	2032	
Cryogen delivery route and Storage Room	43	1092	80	2032	Width requirements due to size of 500 liter dewars. Width and height requirements vary dependent on the dewars used. Check with cryogen supplier.
LCC Magnet	Refer to Note 1		Refer to Note 1		Refer to Table 3-4 for uncrated magnet dimensions.
RF Room Door	Chapter 11, Doors and Other Openings				
Note * Minimum hallway and door dimensions are actual clearance openings. Width and height of rigging equipment is not included in above dimension.					
1. Minimum width depends on access route to removable panels of RF shielded room wall. For straight path (i.e. no bends or turns) recommended to allow 6 in. (153 mm) on both sides of magnet. Appropriate calculations must be performed if turns exist along proposed magnet delivery route. Illustration 3-8 shows dimensions for 90° turn.					
2. Final dimension is dependent on rigger equipment used, refer to Chapter 12, Magnet Shipping Considerations.					

Illustration 3-8: LCC Magnet Minimum Door/Hallway Dimensions 90° Turn



NOTE:

- ALL DIMENSIONS ARE IN INCHES
 ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.

Table 3-4: Component Dimensions For Installation/Replacement

Component	Approximate Weight lbs (kg)	Overall Dimensions W x D x H in. (mm)	Comments
Magnet (uncrated)	11600 (5320)	88 x 77.5 x 93 (2234 x 2400 x 2364)	Refer to Chapter 12, Magnet Considerations for dimensions, illustrations and weights.
Split Bridge	40 (18)	21.5 x 77.3 x 7 (546 x 1969 x 177.8)	Room dimensions in front of the Magnet MUST allow for bridge installation/servicing and Gradient Coil Replacement, See Note 3.
Replacement RF Body Coil	155 (70)	30 x 30 x 60 (762 x 762 x 1524)	Replacement coil is shipped in a protective case. Weight & dimensions are for coil & case.
Replacement BRM Gradient Coil Assembly on a Shipping Cradle/Cart	See Note 1	35.5 x 96.22 x 55.88 (902 x 2441 x 1420) See Note 2 & 3	Initial BRM Gradient Coil Assembly is shipped installed in the Magnet. Shipping/installation cart is used to install replacement coil assembly only. Refer to BRM Gradient Coil Assembly, Cradle and Cart Delivery Requirements
Gradient Coil Replacement Tool Kit Crate	750 (340)	30 x 86 x 28 (762 x 2184 x 711)	See Note 3.
<p>Note</p> <ol style="list-style-type: none"> The replacement BRM Gradient Coil Assembly weight is approximately 2300 lbs (1045 kg), the shipping cradle is 132 lbs (60 kg), and the Gradient Coil Assembly shipping/installation cart weighs 855 lbs (389 kg). Therefore total shipping weight is 3287 lbs (1491 kg). The coil assembly outside diameter x length dimensions are 35.1 x 73.5 in. (892 x 1867 mm). For illustrations of coil/cradle/cart refer to BRM Gradient Coil Assembly, Cradle and Cart Delivery Gradient Coil Assembly and shipping cart dimensions are with cart in lowest position. Cart can be adjusted to maximum height of 61.88 in. (1572 mm). The LCC Magnet MUST USE GE Service Tool Gradient Coil Replacement Kit for replacing the Gradient Coil Assembly. The Gradient Coil Replacement Tool Kit is shipped in a wooden crate on casters. 			

5.2 BRM Gradient Coil Assembly, Cradle and Cart Delivery

Shipping/installation cart is required to be used to install replacement coil assembly. The Gradient Coil Assembly will be delivered on an aluminium (re-useable) cradle. A forklift or crane/hoist rated for 4000 lbs (1818 kg) may be required to position the coil/cradle assembly onto the cart for installing the coil into the magnet, see [Illustration 3-9](#) and [Illustration 3-10](#).

Illustration 3-9: Replacement BRM Gradient Coil Assembly & Cradle

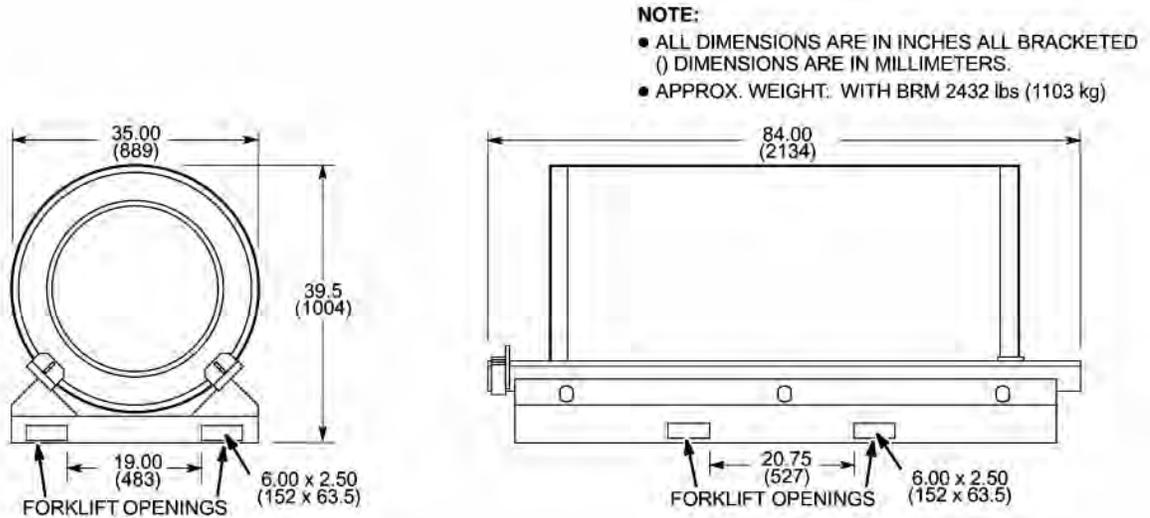
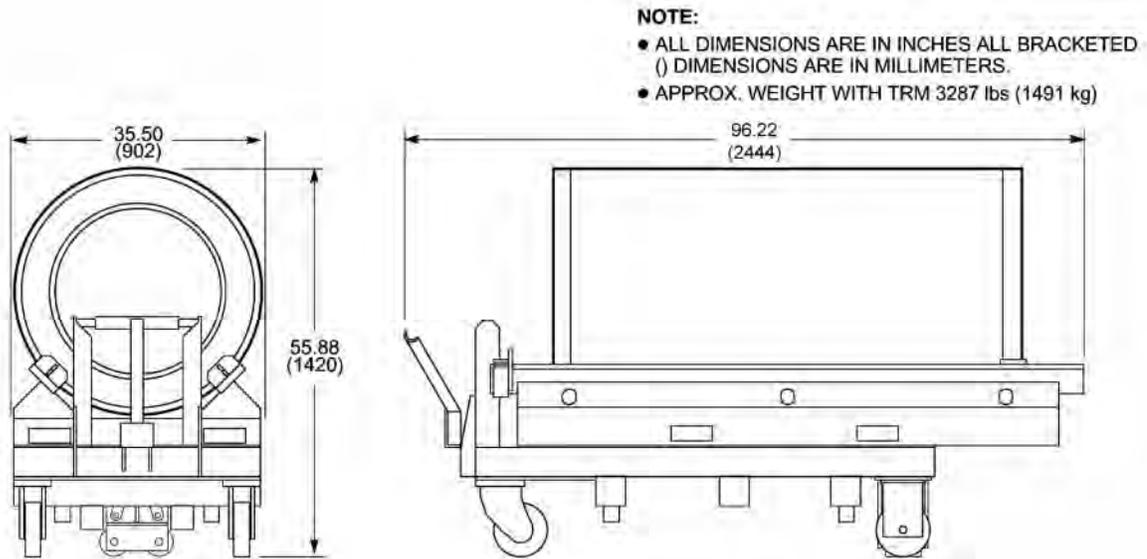


Illustration 3-10: Replacement BRM Gradient Coil Assembly & Cradle On Cart



6 MR System Interconnects Routing

The customer, architect/consultant, and contractor must meet the requirements in [Table 3-5](#).

NOTE:

Table 3-5: MR System Interconnects Routing Requirements/Recommendations

Area	Requirements
Entire MR System	<ol style="list-style-type: none"> 1. Must protect fiber optic interconnects, water lines, hoses and tubing from physical damage including liquids (i.e. condensation, coolants, etc.) 2. MR system cable routing must accommodate cable connector. <ol style="list-style-type: none"> a. Raceway or conduit for routing interconnects must be sized to allow for the dimension of the connectors. b. Raceway or conduit always to be sized to allow the cable to pass through with all other cables already installed. 3. The MR system interconnect cables are FT4 or equivalent rated, not plenum rated. 4. If the area under any access floor is used for an air plenum then the cables may have to be in raceway depending on local and national codes. 5. MR system interconnects must be accessible for equipment servicing.
Magnet Room	<ol style="list-style-type: none"> 1. Metal access floor tiles are NOT allowed anywhere in the Magnet Room, refer to requirements in Chapter 11, Magnet Room Floors. 2. Only non-magnetic metal material can be used when routing cables in the Magnet Room. 3. Any electrically conductive materials utilized for interconnects routing (i.e. raceway, access flooring) must comply with Chapter 11, RF Shielded Room Requirements to minimize the possibilities of electrical discharge which can cause RF broadband noise. <ol style="list-style-type: none"> a. All electrical and mechanical connections and fasteners including screws, nails, nuts, bolts, clips, clamps, concrete anchors, seismic anchors, etc. must be tightened and secured to supplier specifications so as not to become a potential broadband noise source. b. No mechanical fasteners are allowed within 2 feet (0.61 m) of the Gradient Cables inside the RF Shield due to the potential of screws and metal interaction becoming a source of broadband noise. c. Unsecured or overlapped electrically conductive materials (e.g., cable routing dividers, trough/duct joints) must not be located within 2 feet (0.61 m) of the Gradient Cables. d. RF broadband noise can be avoided with quality design and construction that will remain solid over time and usage (i.e. no loose or micro vibrating materials). e. Liners must be continuous lengths, no butt joints, or seams. f. Metal covers must be continuous. g. All fasteners must be solid locking devices such as t-nuts, PEM nuts or welded nuts; no self tapping screws allowed (e.g., fastening metal covers to liners). 4. Floor or wall ducts/raceways used in the Magnet Room must meet the requirements in Chapter 11, RF Shielded Room Requirements and Chapter 11, Floors. 5. Cable routing methods must not interfere with an unobstructed path from the Patient Table to the area directly behind the Magnet Enclosure Rear Pedestal for MR personnel usage.
Recommendations	
<ul style="list-style-type: none"> • Raceway or conduit for routing interconnects should be oversized to allow for the possibility of additional cables being added as the system is upgraded in the future. • Conduit should not be used for running the majority of GE MR system cables in the Magnet Room due to the number and size of conduits needed. 	

7 Flooring

Flooring consists of all materials above the structural floor support including subflooring and equipment support/mounting. Refer to [Table 3-6](#) for requirements and recommendations.

Table 3-6: MR System Flooring Requirements/Recommendations

Area	Requirements	Recommendations
Entire MR System	<ul style="list-style-type: none"> • Flooring materials must support the MR system equipment weight, refer to Floor Loading and Weights. • Floors must support the equipment and any transport device needed to move the equipment. • Flooring throughout the system including Magnet Room must be in accordance with local and national codes. • Floor design must consider the MR system interconnect cables are FT4 or equivalent rated, not plenum rated. 	The area under access flooring if used for an air plenum is recommended to provide a minimum 10 in. (254mm) of clear space. Cabling, plumbing (water lines), etc. routed under the access floor may affect air flow and needs to be considered if used as an air conditioning plenum.
Magnet Room	Refer to Chapter 11, Magnet Room Floors	

8 System Cooling

8.1 System Cooling Siting Requirements



NOTICE

Equipment Failure. A continuous supply of facility liquid coolant is required at all times for proper system operation. Failure to provide liquid coolant with the requirements listed in this section may cause equipment failure. Coolant is required immediately after magnet is installed into the magnet room.

- Installation of the MRCC must be in accordance with local and national codes
- The purchaser of the MR equipment must use licensed electricians and plumbers during installation and servicing of the equipment.

8.1.1 Introduction

The MR System requires water cooling to protect the operation of the Shield/Cryo Cooler Compressor (MS5) and the gradient coil. The room layout must plan floor space based on the cooling solutions the customer selects. The Gradient Coil Chiller is included in the minimum room size dimensions. The site has the option to choose the MR Common Chiller (MRCC) to provide the water cooling to the Shield/Cryo Cooler Compressor cooling system as either an indoor or outdoor unit, or the site can supply its own water chiller. The room size must be modified to accommodate the option selected.

Notes:

- Site may provide a non-GE Healthcare water chiller for the Shield/Cryo Cooler (MS5) Compressor or purchase the indoor or outdoor installed MRCC
- The BRM Water Chiller (WC1) is required for cooling the BRM gradient coil. The closed loop water chiller protects the BRM from contamination
- Mobile System product offerings, including True Mobile, Transportable, and Relocatable, require the Mobile Van cooling system to provide the system cooling

8.1.2 MR Common Chiller (MRCC) Siting Requirements

8.1.2.1 Indoor or outdoor installed MRCC

1. The customer is responsible for installing the MRCC
2. Physical Dimensions:
 - a. Floor Loading (see [Floor Loading and Weights](#))
 - b. Equipment room minimum room size (see the Minimum Room Dimensions table in [Minimum Room Sizes](#))
 - c. MR Common Chiller (MRCC) physical dimensions (see [Chapter 8, MR Common Chiller \(MRCC\)](#))
3. Temperature/Environmental Controls (see [Chapter 5, Temperature and Humidity Specifications](#)):

- a. Direct sunlight or heat output from nearby equipment may compromise the cooling capability of the MRCC unit
- b. Temperature and Humidity Requirements (outdoor units must select mounting location to protect from seasonal conditions, including wind)
- c. Blocked air flow may impact the cooling capability of the MRCC
4. System Interconnection and Physical Separation:
 - a. MRCC must not exceed 98 ft (30 m) above Shield/Cryo Cooler Compressor
 - b. MRCC is not to exceed 9.8 ft (3.0 m) below the Shield/Cryo Cooler compressor
 - c. MRCC indoor units must be located within 100 ft (30.5 m) of Shield/Cryo Cooler Compressor (two lengths 100 ft (61 m), 0.75 inch (19.1 mm) ID water hose is vendor supplied)
 - d. MRCC outdoor units must be located within 200 ft (61 m) of Shield/Cryo Cooler Compressor (two lengths of 100 ft, 0.75 inch (19.1 mm) ID water hose is vendor supplied – customer to supply 100 ft (61 m) copper or PP-R pipe)
 - i. Reduce the rubber hose 1 ft for every 1 ft of additional copper or PP-R pipe used that exceeds 100 ft (30.5 m)
 - ii. Customer supplied copper or PP-R pipe must be contained within thermal insulation
 - iii. AirSys MRCC is fitted with two 0.75 in. (19.1 mm) quick disconnect fittings
 - iv. Water copper or PP-R pipe and rubber hose must be 0.75 inch (19 mm) ID – customer to supply rubber hose between MRCC and copper or PP-R pipe
 - v. Customer to provide copper line hose barbs with ball valves to Shield/Cryo Cooler Compressor
 - e. Airsys provides 3.2 ft (1 m) rubber reducer – 0.75 inch ID to 0.5 inch ID (19 mm to 12.7 mm) to join to the Shield/Cryo Cooler Compressor
 - f. Remote Control Panel must not be separated from the MRCC by a distance greater than 100 ft (30.5 m) total length
5. AirSys provides one data cable that connects the RCP and the MRCC – length 100 ft (30.5 m). Length must include rise and fall along the entire route plus the height to the inside of the MRCC and RCP
6. Power Requirements:
 - a. The facility must supply the MRCC with power. The GE Healthcare MDP does not support the MRCC option
 - b. MRCC maximum wire size is 6 AWG (16 mm²)
 - c. Input power specifications: 15 Amp minimum, 4 380/400 VAC 50 Hz or 460/480 VAC 60 Hz (6.2KVA maximum continuous)
7. Refer to [Chapter 8, MR Common Chiller \(MRCC\)](#) for indoor or outdoor mounting requirements
8. Indoor coolant discharge (floor drain requirements) when switching from MRCC to backup:
 - a. Approximately 1.5 gallons (7 liters) of coolant drain during changeover

- b. Approximately 50/50 Dowfrost HD and de-ionized water discharge from the MRCC cooling loop

8.1.2.2 Non-GE Healthcare water chiller for the Shield/Cryo Cooler (MS5) Compressor:

1. Customer provided water cooling must be closed loop (chemical balanced within cooling loop required to extend life of Shield/Cryo Cooler Compressor)
2. Refer to customer supplier chiller vendor manual for all site planning requirements to determine physical dimensions, weight, Temperature and Humidity, heat output, interconnection routing, switch over collection/drain requirements

8.1.2.3 Water Chiller (WC1) Site Planning Requirements



NOTICE

The BRM water cooling must use a GE Healthcare supplied closed loop indoor system (WC1) to prevent contamination/damage to the BRM coil.

1. Physical Dimensions:
 - a. Equipment room minimum clear space (see [Minimum Room Sizes](#))
 - b. Water Chiller (WC1) physical dimensions (see [Chapter 8, Water Chiller For BRM Gradient Coil Cooling Water](#))
2. GE Healthcare supplies de-ionized water / anti-freeze mixture
3. GE Healthcare supplies 10 AWG / 3 wire 82 ft (24.8 m) power cord
4. WC1 must be located on the same floor or above the MR system. If located below the MR system the reservoir low pressure vent plug will leak
5. The WC1 must provide Gradient Coil water cooling. Temporary or backup water cooling must not be used

Notes:

1. The WC1 water chiller is a dedicated closed loop water chiller unit for BRM Gradient Coil water cooling only and not to be shared with other equipment.
2. GE Healthcare provides flexible hose (0.5 in. (12.7 mm) inside diameter) and adjustable clamps for hose connections
3. Mobile providers supply a chilled water system for the Coldhead Compressor (Mobile, Transportable, Relocatable)
4. Mobile providers supply chilled water to the Gradient Heat Exchanger
5. Transportable and Relocatable providers use the MRCC (Indoor or Outdoor) Air cooled chiller for the Shield/Cryo Cooler Compressor

9 Special Siting Considerations

9.1 Blower Box (MG6)



CAUTION

The Blower Box contains magnetic material which can be attracted to the magnet. The Blower Box must be securely mounted to the floor of the Magnet Room or on a support shelf on the Magnet Room wall or ceiling with support provided under the box.



NOTICE

The Blower Box must be securely mounted per preceding Caution. The Blower Box must not be on a raised floor section within the Magnet Room. RF Shield integrity must be maintained for mounting the Blower Box within the Magnet Room, refer to [Chapter 11, RF Shield Integrity](#), [Chapter 11, Electrical Isolation](#), and [Chapter 11, Physical Characteristics](#).

NOTE: Blower Box mounting requires customer supplied hardware (ie. lag bolts, screws, etc.) appropriate for the surface on which the box will be mounted.

The Blower Box (MG6) provides cooling air for the RF/Gradient Body Coil and the Patient Comfort Module in the Magnet Enclosure. The Blower Box will be mounted within the RF Shielded Room and connects to the Gradient Coil and the Patient Comfort Module by 6.5 inch (165.1 mm) OD and 4.5 inch (114.3 mm) OD flexible vinyl air ducting.

The flexible vinyl air duct routes from the Blower Box through the Magnet Enclosure Rear Pedestal cable access and connects to the Patient Comfort Module in the Magnet Enclosure. Refer to [Chapter 7, Blower Box](#) for box and mounting dimensions.

9.2 Pneumatic Patient Alert (PA1)

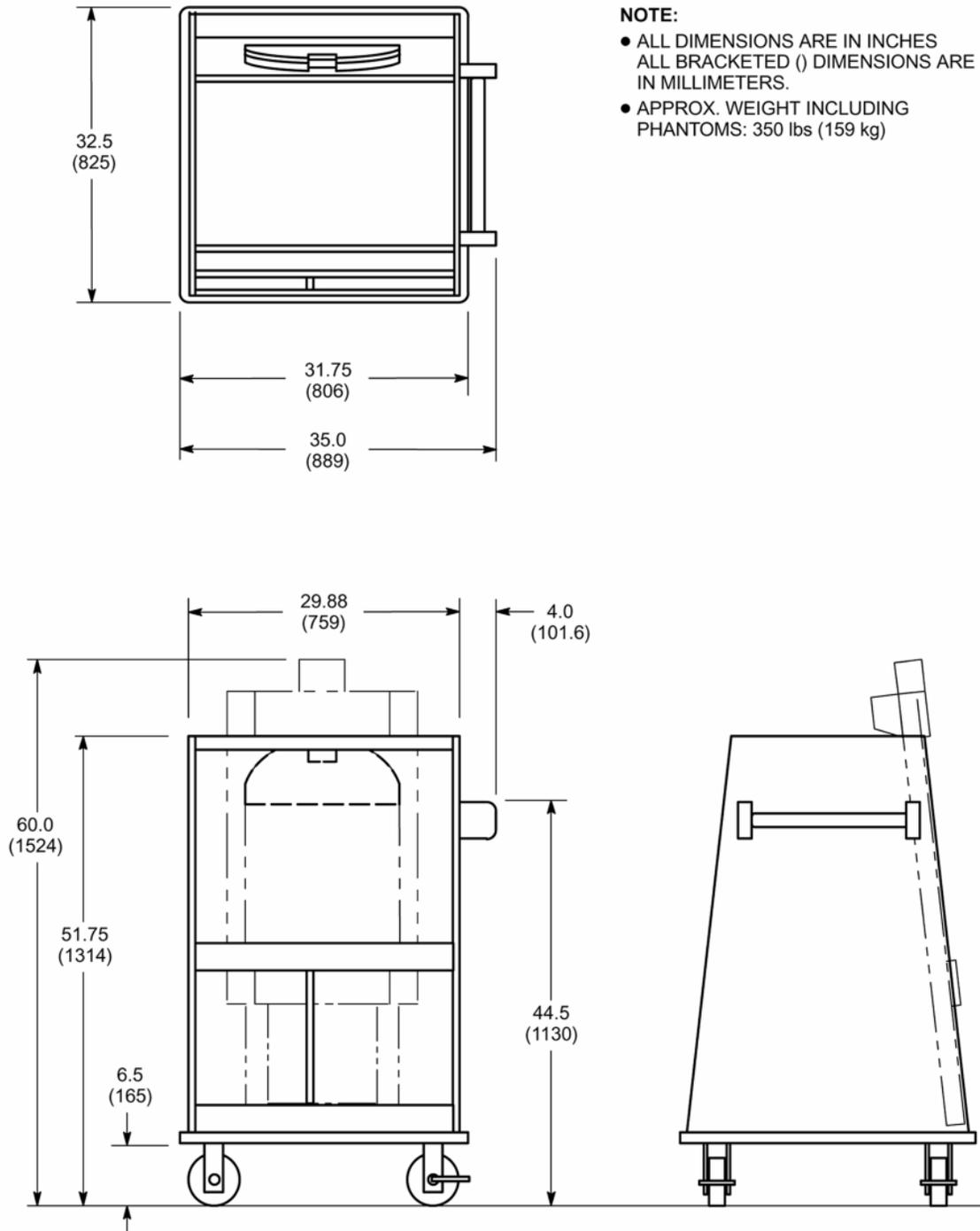
The Pneumatic Patient Alert system is a stand alone system that will allow the Patient to contact the Operator even when the intercom volume is turned down. The Control Box is to be located near the Operator Workspace. The Control Box audible and visual alarm will be activated by the patient squeeze bulb which is located on the Magnet Enclosure and connected by pneumatic tubing through the Penetration Panel to the Control Box. The Control Box should be mounted with consideration for ease of use by operator, remaining within sight of operator, and within 5 ft (1.5 m) of an electrical outlet. The Control Box can be powered from an outlet on the Operator Workspace. Refer to [Chapter 9, Pneumatic Patient Alert](#) for Control Box mounting dimensions.

9.3 Customer Site Storage Requirements

The MR system has several system accessories such as system phantoms and surface coils. There are many optional surface coils available. Storage space for system accessories and supplies must be planned for and included in room layout drawings. Contact the GE Healthcare Project Manager of Installation for specific information.

SPT Phantom Set Shipping and Storage Cart is provided as part of the MR system. System Performance Test (SPT) provides the customer and GE Service with a means to quickly verify whether critical parameters affecting image quality are within specifications. The test uses a set of phantoms and a nesting plate for proper positioning of the phantoms on the Patient Table. The phantom set and nesting plate are provided on a cart which protects the pieces during shipment and storage at site. The cabinet is not magnetic therefore it can be stored inside the Magnet Room if so desired and moved to the Patient Table for ease of positioning the phantoms. See [Illustration 3-11](#) for cart dimensions information.

Illustration 3-11: SPT Phantom Set Shipping/Storage Cart



9.4 Oxygen Monitor Option

The optional Oxygen Monitor should be mounted near the Operator Workspace. The Oxygen Monitor alarm will be activated by the remote oxygen sensor located in the Magnet Room. All cellular telephones, even if not in use, should be kept at least 20 feet (6.1 meters) away from the Oxygen Monitor to prevent possible false trips of Oxygen Monitor alarms. See [Chapter 7, Oxygen Monitor Option](#) illustrations.

9.5 Spectroscopy

9.5.1 Multi-Nuclear Spectroscopy (MNS)

The MNS option consists of the 1.5T MNS Amp Cabinet.

9.6 Magnet Monitor

The Magnet Monitor performs the functions of a cryogen meter and Magnet pressure control with readout display capability on the unit and allows for remote monitoring during system warranty period or available as part of a GE Service contract. Refer to [System Monitoring and Support Connectivity](#) for broadband connectivity requirements.

The Magnet Monitor should be mounted approximately 60 in. (1524 mm) above the floor in the Equipment Room but outside the 10 gauss zone.

NOTE: True Mobile configurations include a Uninterruptible Power System (UPS) for the Magnet Monitor equipment. This UPS provides power to the Magnet Monitor equipment via the Main Disconnect Panel (MDP).

9.7 System Monitoring and Support Connectivity

One of the system monitoring and support connectivity configurations listed in Table 3-7 must be provided for system installation and serviceability purposes. The broadband network connection and telephone lines are to be provided and paid for by the customer.

Table 3-7: System Monitoring & Support Connectivity Requirements

Configuration	Connection Type	Use/Location
Broadband Network Connection & Telephone Line (Recommended)	Two Broadband Internet Accessible connections with individual Static IP addresses	One access located near the Operator Workspace (OW) in the Control Room (RJ45 wall mounted connection minimum speed of 10Mbps).
	See Note 1	One access located near the Magnet Monitor (MSM1) in the Equipment Room for remote monitoring of magnet pressure levels. This Broadband connection must not lose power when the MR system is shutdown (RJ45 wall mounted connection minimum speed of 10Mbps, with Internet access).
	One voice-grade telephone line (voice line)	Available for Service Personnel use, located in the Control Room
Multiple telephone lines (Alternate)	One voice-grade telephone line (voice line)	Available for Service Personnel use, located in the Control Room
	One line must be a dedicated direct-distance-dialing voice-grade line (data line)	Access located near the Operator Workspace (OW) in the Control Room. See Notes 2 & 3. (Standard RJ-11 connection is required)
	One line must be a dedicated direct-distance-dialing voice-grade line (data line)	Access located near the Magnet Monitor (MSM1) in the Equipment Room for remote monitoring. See Notes 2 & 3. (Standard RJ-11 connection is required)
Notes		
<ol style="list-style-type: none"> For Europe: An ISDN Connection with static IP address may be substituted for Broadband Internet Accessible connections. A dedicated direct-distance-dialing voice-grade telephone line can be shared for Operator Workspace (OW) and Magnet Monitor (MSM1) requirement through the use of a multiplexer box. The following multiplexer boxes are available for customer purchase. 46-328475P1 4 Line Phone Multiplexer box; 115 VAC input power 46-328475P3 4 Line Phone Multiplexer box; 220 VAC input power If the customer chooses not to purchase the multiplexer box then the customer must provide an additional line for each requirement as stated in this table. If a Multiplexer Box is used then the Magnet Monitor MUST be Channel 1 to allow for call out after a power outage. 		

9.8 BrainWave HW Lite Option

The BrainWaveHW Lite Option (M1033BL) provides software and hardware stimulus components which are used with 3rd party MR compatible audio and video stimulus devices (headphones, goggles, etc.) to produce brain activation images from MR Blood Oxygen Level Dependent (BOLD) scan data.

The hardware components provided includes the Stimulus PC, keyboard, monitor, and cabinet. The package also includes push-button response boxes, a standard interface panel added to the MR System Penetration Panel, and interconnecting cables. The Stimulus software provided with the BrainWaveHW Lite option package resides on the Stimulus PC. BrainWaveRT (M1033BT) software resides on the MR system host computer and is a prerequisite required for the M1033BL catalog.

The Brainwave HW Lite options consists of the following major items:

- BrainWaveHW Lite Cabinet - Located in the Equipment Room, the BrainWaveHW Lite Cabinet contains the Stimulus PC, LCD Display, keyboard and mouse for the Stimulus PC, and Response Interface Module.
- Interconnect cables The BrainWaveHW Lite Cabinet is powered from the Signa System Cabinet.

9.9 Remote MRU Option

The Remote MRU Option provides a second Magnet Rundown Unit (MRU) which can be located outside the Magnet Room. The Remote MRU is powered by facility supplied receptacle and power, refer to Required Customer Power table in [Chapter 6, System Power Introduction](#) for required customer power.

The option also provides the Remote MRU Connector Box with hardware to mount to the Magnet and system interconnects to enable system connection of both the primary MRU (provided with the Magnet) and the secondary MRU.

10 Architectural Reminders

1. Pay attention to isogauss limits, not only for placement of equipment in rooms, but also for isogauss limits with respect to outside environment.
2. The customer is responsible for the magnetic field exclusion zone, including posting any magnetic field warning signs and controlling access to any areas within the magnetic field. A magnetic field greater than 5 gauss may potentially interfere with Cardiac pacemakers, neurostimulators, and biostimulation devices.
3. Due to the periodic cryogen servicing of the magnet, consideration must be given to the delivery route of the cryogens to the Magnet Room. The service route should be level; avoid steps or steep ramps. Maximum acceptable incline along dewar delivery route is 1:12 (5°).
 - a. Cryogen dewars must not be stored within the Magnet Room due to the safety issues of seismic considerations, spillage effects, fire hazards and explosive effects of compressed gas. Also the magnetic field inhomogeneity is affected by the physical shape of the non-magnetic dewars. All dewars must be stored outside of the Magnet Room and more than 10 ft (3.05 m) from isocenter of the magnet in all directions.
 - b. Means must be provided to secure gas cylinders used for cryogen transfills in an upright position using a removable chain or strap. This is to prevent the cylinders from falling, which may cause injury or damage.
4. If elevators are to be used along cryogen delivery route, verify that elevator dimensions and weight capacity is sufficient to handle the cryogen dewars. Also, elevator must be dedicated with restricted access during cryogen transport (will not allow stops between initial start and final floor destination).
5. The operator seated at the Operator Workspace should have an unobstructed view of the patient on the transport table when table is docked to the magnet.
6. Operators in Magnet Room must have easy access to the scan control switches located on both front side panels of the magnet enclosure.
7. A patient preparation/emergency area should be located near the Magnet Room and direct patient access must be available from the Magnet Room to the patient preparation/emergency area.
8. Customer provided and paid for telephone lines must be supplied for system installation and serviceability purposes per [System Monitoring and Support Connectivity](#).
9. Corrosive chemicals must not be stored or used in the Equipment Room. These include chemicals used for film processor storage tanks, processor chemical recovery systems, etc. Such chemicals can contribute to increased equipment failures, increased system downtime, and decreased reliability. Film processor equipment installation must meet the manufacturer's requirements (e.g. ventilation specifications) and all applicable national and local codes. Also, consideration should be given to the location of this equipment and chemical fumes relative to human contact as it relates to locating this equipment and chemicals in the control area.
10. Recommend protecting floors while moving heavy pieces of equipment (e.g. HFD/PDU Cabinet, Body Coil Assembly, MRCC, etc).

11. There needs to be a site plan for the MR system replacement component delivery (i.e. corridor, doors, elevators, etc.) which meets the specifications in [Minimum Delivery Route Sizes and Capacity](#).

11 Floor Loading and Weights



NOTICE

It is the responsibility of the customer to obtain any and all approvals necessary for the construction of equipment support and seismic anchoring.

Listed in [Table 3-8](#) are the weights, floor loading, and normal mounting methods for the MR system components.

Table 3-8: System Components Floor Loading

Component	Weight & Dimensions See Table 3-9 Note 2 & 5	Normal Mounting Method
CxK4 Magnet, RF/Gradient Body Coils (BRM), and Enclosure including Table Dock and Rear Pedestal	See Table 3-9 Notes 1 & 3. Refer to Chapter 7, Magnet and Enclosure	Magnet & Table Dock Asm. resting on base, for mounting requirements refer to <ul style="list-style-type: none"> • with VibroAcoustic Damping option: • without VibroAcoustic Damping option: Rear Pedestal floor mounting must meet requirements in Flooring .
Patient Table	See Chapter 7, Patient Transport Table	Mobile
Blower Box	See Chapter 7, Blower Box	Anchor to floor or shelf; see Table 3-9 Note 6 for additional mounting requirements.
RFS Cabinet	See Chapter 8, RFS Cabinet	Set on floor on casters
HFD/PDU Cabinet	See Chapter 8, HFD/PDU Cabinet	Set on floor on casters
Shield/Cryo Cooler Compressor Cabinet (See Table 3-9 Note 4)	See Chapter 8, Shield/Cryo Cooler Compressor Cabinet	Set on floor on casters.
Operator Workspace Table with LCD display & GOC Computer Cabinet	See Chapter 9, Operator Workspace	Table set on floor on leveling pads & Cabinet set on floor on casters.
MNS Cabinet*	See Chapter 8, MNS Cabinet	Set on floor on casters.
BrainWave HW Lite Cabinet*	See Chapter 8, BrainWave HW Lite Cabinet Option	Casters for location. Set on floor on leveling pads.
System Water Cooling Equipment Configurations		
Water Chiller for Gradient Coil See Table 3-9 Note 4	See Chapter 8, Water Chiller For BRM Gradient Coil Cooling Water	Set on floor on casters
MR Common Chiller (MRCC)* See Table 3-9 Note 4	See Chapter 8, MR Common Chiller (MRCC)	Indoors: Set on floor on casters. Outdoors: Bolted to mounting pad on ground level external to building or roof mounting pad or structure.

Table 3-9: Notes For System Components Floor Loading Table

Notes	
* Optional Equipment	
1.	Weight of CxK4 Magnet with Enclosure, RF/Gradient (BRM) Body Coil, VibroAcoustic Damping Option mats, and cryogenics is 13,116 lbs (5949 kg). The Rear Pedestal installed weight is 153 lbs (69.4 kg).
2.	Consult a structural engineer on method of calculating proper weight/unit area for floor loading.
3.	Refer to Minimum Delivery Route Sizes and Capacity for Gradient Coil Assembly replacement weight and dimension requirements.
4.	The MR System requires water cooling for the Gradient Coil and the Shield/Cryo Cooler Compressor. <ul style="list-style-type: none"> <input type="checkbox"/> Gradient Coil water cooling must be supplied by Water Chiller (WC1) supplied with the MR system to prevent contamination/damage to the coil and for proper image quality. <input type="checkbox"/> The Shield/Cryo Cooler Compressor water cooling can be provided by a separate MRCC or by customer provided facility water cooling, refer to Chapter 5, Shield/Cryo Cooler Water Cooling For Site Provided Water Cooling. Sites requiring seismic anchoring by code for MRCC option should have the site architect and engineer review the response spectra and/or International Builders Code (IBC) for their location and then contact MRCC Service Provided for assistance in seismic planning of the site.
5.	The center of gravity for MR system components are given in the illustrations for use in seismic calculations. Contact your local GE Healthcare Project Manager, Installations for seismic information if the MR system equipment is required by code to be anchored.
6.	Blower Box mounting must meet the requirements in the following: <ul style="list-style-type: none"> <input type="checkbox"/> Chapter 11, Anchor Hardware For MR Equipment Inside RF Shield <input type="checkbox"/> Chapter 11, Physical Characteristics <input type="checkbox"/> Chapter 11, Clamping Force (Tension) and Pull Test <input type="checkbox"/> Chapter 11, RF Shield Integrity <input type="checkbox"/> Chapter 11, Electrical Isolation

Table 3-10: 32 Channel Option Floor Loading

Component	Weight & Dimensions See Table 3-9 Note 2 & 5	Normal Mounting Method
32 Channel Cabinet	See Chapter 8, 32 Channel Cabinet Option	Set on floor on casters

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Chapter 4 Magnetic Field Consideration

1 Introduction

The static magnetic field is three-dimensional and extends into space above and below the magnet as well as to the surrounding space on the same level. Objects within this three-dimensional space can be affected by the magnetic field or can affect the magnetic field. Refer to [Chapter 3, Proximity Limits](#). All ferromagnetic material within this three-dimensional magnetic field must be thoroughly examined to ensure it is not significantly affected by nor affects the magnetic field.

2 Impact of Structural Steel

Structural steel, within the static magnetic field of a magnet, has a definite impact on the homogeneity or uniformity of the field. The magnet's field homogeneity is an important criteria that impacts both image quality and chemical shift analysis (spectroscopy).

3 Structural Steel Evaluation of Proposed Site

Excessive steel, including structural steel, will degrade the homogeneity of the magnet and the system performance. Refer to [Chapter 5, Magnet Room Floors Magnetic Properties](#) under Construction Materials in Site Environment chapter. An evaluation of the effects of structural steel on the magnet is required in some instances.

The customer must provide information indicating mass and location of all iron and steel within an 8 foot (2.5 meter) radius of the CxK4 Magnet isocenter. This 8 foot (2.5 meter) radius is shown as the shaded region in the isogauss line plot illustrations in [Magnetic Field](#). This includes iron near the magnet, such as sewer pipes, existing magnetic shielding, floor beams and any steel rebar in the concrete floor or structural members. Any structural steel required for the installation of the magnet at the particular site (i.e., floor reinforcement) must also be indicated.

4 Magnetic Shielding



NOTICE

If a site has an existing magnetic shield, the existing shield must be evaluated by the GE Healthcare MR Siting and Shielding Group.

Magnetic shielding is used to reduce the fringe field around the magnet. Refer to [Magnetic Field](#) for the fringe field plots for the magnet.

Room magnetic shielding generally consists of iron plates in the room walls, floor, and ceiling. Special consideration should be given when selecting a magnet site location due to the expense and effort required to provide magnetic shielding.

Designing a magnetic shield requires a comprehensive computer analysis that predicts the effect the shield will have on the magnetic field, as well as the effect of the shield on the homogeneity of the magnet. The structural capacity of the site and space availability are important factors in the design of the shield.

5 Magnetic Field Definition

5.1 Fringe Field

[Illustration 4-1](#), [Illustration 4-2](#), and [Illustration 4-3](#) are the fringe field plots for the CxK4 Magnet. These plots illustrate the three-dimensional area of magnetic field without the influence of any nearby ferrous objects or the earth's ambient magnetic field. Actual magnetic field intensity at given locations will vary from these plots due to the following effects:

- Ferrous materials used in building construction that will become permanently magnetized when in close proximity to the MR generated magnetic field.
- Earth's magnetic field - about 0.5 gauss in strength and unidirectional.

The 5 gauss line can expand to 22.96 ft (7 m) axially and 16.4 ft (5 m) radially for up to 2 seconds in the rare event of a magnet quench.

These plots are only approximations of actual field intensities found at points surrounding the magnet. These plots should be used as an aid in reviewing the location of MR and hospital equipment and services (i.e., elevators, vehicular traffic, computer monitors, etc.) Refer to [Chapter 3, Proximity Limits](#) for the sensitivities of various equipment within the magnetic field.

Illustration 4-1: CxK4 (1.5T) Magnetic Isogauss Line Plot - Top View

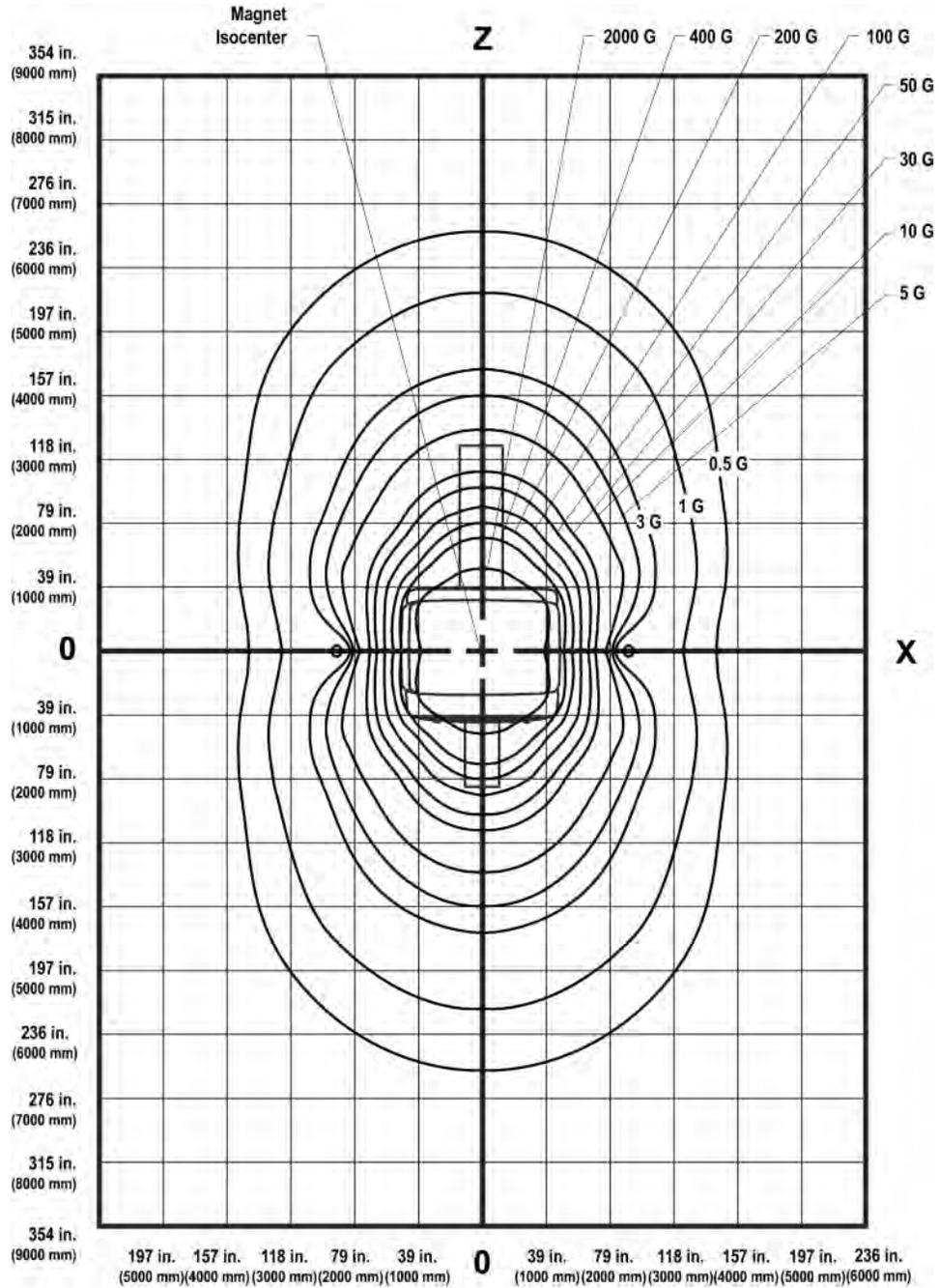


Illustration 4-2: CxK4 (1.5T) Magnetic Isogauss Line Plot - Front View

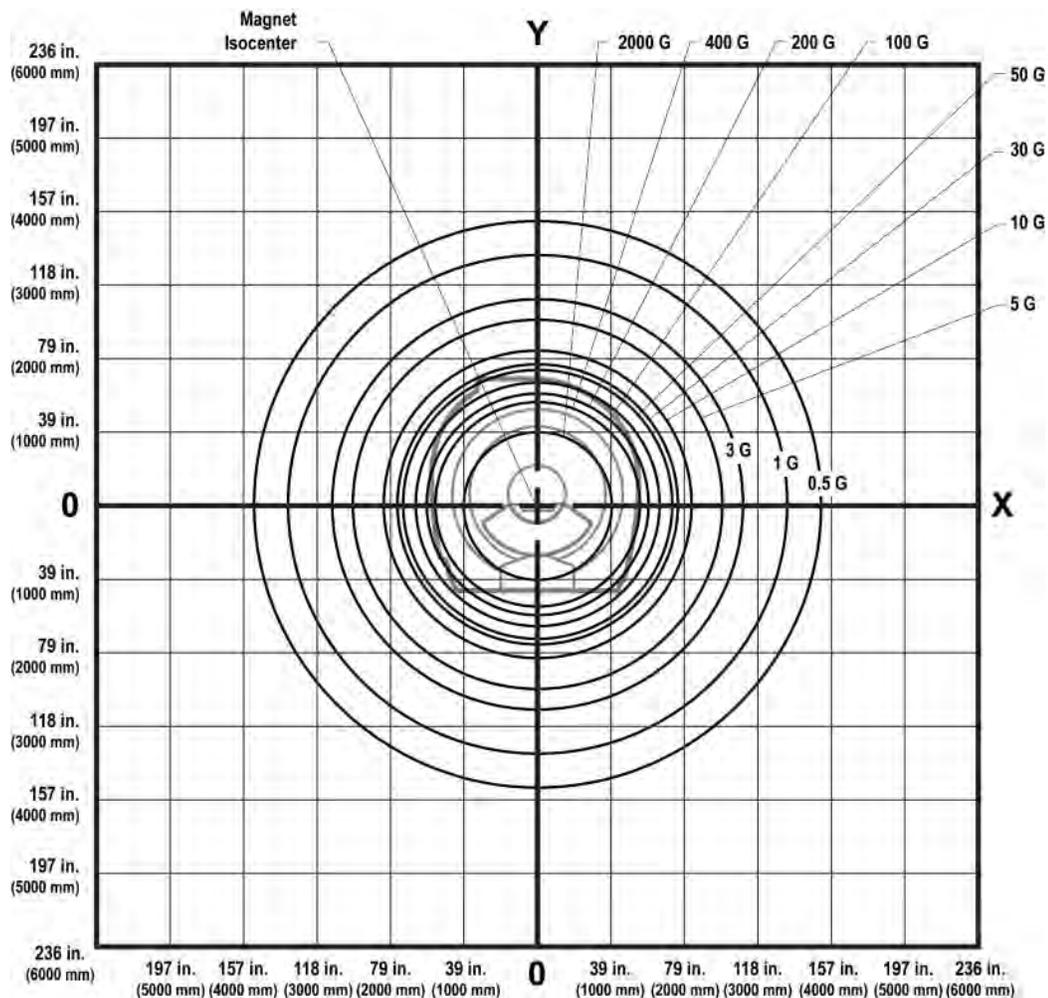
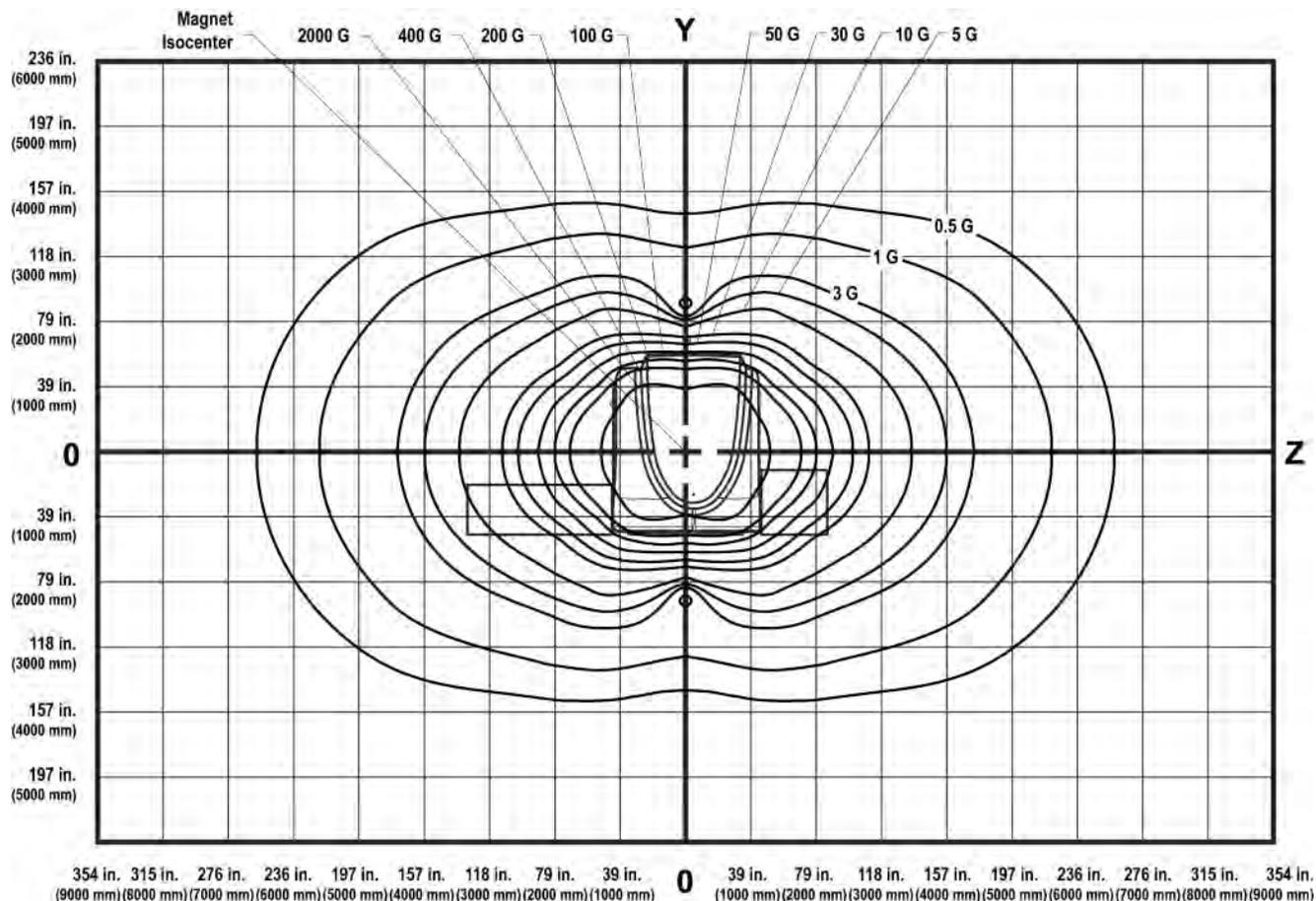


Illustration 4-3: CxK4 (1.5T) Magnetic Iso-gauss Line Plot - Side View



6 Exclusion Zone

The 5 Gauss exclusion zone for cardiac pacemakers, neurostimulators, and other biostimulation devices is shown in the iso-Gauss line plot illustrations in [Magnetic Field](#) for the CxK4 Magnet.

The 5 gauss field can expand in the rare event of a magnet quench. See [Magnetic Field Definition](#) for details.

It is recommended that every site consider the event of a quench and plan accordingly (such as placing 5 Gauss (0.5mT) warning signs at the expanded locations).

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Chapter 5 Site Environment

1 Introduction



Equipment Failure

Failure to maintain the required temperature or humidity at all times (i.e., both working and non-working hours) may result in equipment failure, scanning failure, or warranty void.

Ensure the HVAC system has the correct capacity for the room size, equipment heat output, and environmental conditions to maintain proper temperature and humidity.

The magnet, equipment room and operators rooms must be designed to maintain specific environmental limits for proper use of the MR System.

2 IEC EMC Compliance

Per IEC 60601-1-2 Edition 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. Full declaration is stored on-site in the user manual delivered with the system.

The MR system is designed and tested to the following standards:

Table 5-1: Guidance And Manufacturer’s Declaration – Electromagnetic Emissions

Emissions Test	Type of Test	Compliance Level
CISPR 11	Conducted Emissions	Class A Group 2
	Radiated Emissions	Class A Group 2
IEC 61000-4-3	E-Field RF Immunity	80-2500 MHz, 5 V/m with AM 80% @ 1kHz or 2 Hz

Table 5-2: Guidance And Manufacturer’s Declaration – Electromagnetic Immunity

Immunity test	IEC 60601 test level	Compliance Level
Electrostatic discharge (ESD) IEC 61000-4-2	±8 kV air	Air 2, 4, 6, 8, 10kV
	±6 kV contact	Contact 2, 4, 6, 8kV
		Coupling Plane 2, 4, 6, 8kV
Electrical fast transient / burst IEC 61000-4-4	±2 kV for power supply lines	Power Lines 3kV
	±1 kV for input/output lines	Interconnect Cables 1.5kV
Surge IEC 61000-4-5	±2 kV common mode	Common Mode ±2 kV
	±1 kV differential mode	Differential ±1 kV
Power Frequency (50/60Hz) magnetic field IEC 61000-4-8	3 A/m	4.5A/m at 50 Hz. and 60 Hz.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5 % UT (>95 % dip in UT) for 5 sec	5 sec @ >-95%, Each phase individually
Conducted RF IEC 61000-4-6	V1 = 3 Vrms 150 kHz to 80 MHz	0.15-80 MHz @5 VRMS with AM 80% @ 1kHz 1% Frequency steps
Radiated RF IEC 61000-4-3	E1 = 3 V/m 80 MHz to 2,5 GHz	80-2500 MHz, 5 V/m with AM 80% @ 1kHz or 2 Hz

3 Temperature and Humidity Specifications

This section lists the temperature and humidity specifications for the MR suite. Refer to [Air Cooling](#) for heat load specifications.

3.1 System Suite



CAUTION

Equipment Failure

Failure to maintain the required temperature or humidity at all times (i.e., both working and non-working hours) may result in equipment failure, scanning failure, or warranty void.

Ensure the HVAC system has the correct capacity for the room size, equipment heat output, and environmental conditions to maintain proper temperature and humidity.

Use the specifications listed in [Table 5-3](#) for designing your HVAC (heating, ventilation, and air conditioning) system. Proper insulation and moisture barrier should be installed within the environmental controlled space (e.g. area above drop ceiling) for humidity, condensation, and temperature control.

Table 5-3: Temperature And Humidity Specifications

Area	Temperature		Humidity		Max. Room Gradient °F (°C)
	Range °F (°C)	Change °F/Hr (°C/Hr)	Range %	Change %/Hr	
Equipment Room at Inlet to Equipment	59-89.6* (15-32)*	5 (3)	30-75*	5	5 (3)**
Magnet Room	59-69.8 (15-21)	5 (3)	30-60*	5	5 (3)
Operator's Control Room	59-89.6* (15-32)*	5 (3)	30-75*	5	5 (3)
Note					
* Non-condensing humidity with 50% nominal at 65°F (18.3°C).					
** Room temperature gradient specification applies from floor to height of top discharge of equipment cabinets.					

3.2 MRCC Operating Environment

The MRCC is designed to be located external to the building and operate in environments meeting the following specifications.

- Operating Ambient Temperature: -22°F (-30°C) to 110°F (43°C)
- Operating Humidity: 5-100%

4 Air Cooling Specifications

The following table contains the heat output of the equipment listed in the typical site location. These values do not include people, lights and non-MR equipment. Actual site average values will vary depending on system use (e.g., protocols used, patient load, etc.). Note any variations of equipment location for your site when calculating your cooling requirements for each room.

Table 5-4: CxK4 System Maximum Heat Output For Air Cooling *

MR Component	Magnet Room		Equipment Room		Operator/Control Room	
	See Note 1 listed below		See Note 2 listed below			
	BTU/hr	Watt	BTU/hr	Watt	BTU/hr	Watt
RF/Gradient (BRM) Body Coil Assembly, LCC Magnet Enclosure Equipment	8189	2400				
Patient Blower Box	3415	1000				
Penetration Panel			324	95		
1.5T RFS Cabinet			27,806	8142		
HFD/PDU Cabinet			34,120	10,000		
Water Chiller for Gradient Coil			14,000	4100		
Magnet Monitor			205	60		
Water-Cooled Cryocooler Compressor			See Note 4			
Air-Cooled Cryocooler Compressor			28,320	8300		
External Transformer			820	240		
Operator Workspace with LCD Color Display (See Note 3)					4950	1450
GE Main Disconnect Panel **			900	264		
1.5T MNS Amp Cabinet**			5120	1500		
MRCC** option for providing Shield/Cryo Cooler Compressor water cooling (See Note 4)			52,550	15,400		
BrainWave HW Lite Cabinet** (see Note 5)			2337	685		
DC Lighting Controller Panel **			1024	300		
DC Lighting Controller Autotransformer **			171	50		
1.5T 32 Channel Cabinet **			4269	1250		

MR Component	Magnet Room		Equipment Room		Operator/Control Room	
	See Note 1 listed below		See Note 2 listed below			
	BTU/hr	Watt	BTU/hr	Watt	BTU/hr	Watt
Notes						
* Maximum heat output is defined for temperature and humidity as defined in Temperature and Humidity Specifications .						
** Optional equipment						
1. Magnet Room must be an individual temperature zone controlled by a separate thermostat to allow for adjustments to meet room specifications as listed in Temperature and Humidity Specifications . It is recommended that cool inlet air be directed towards the Blower Box intake which contain a patient cooling fan.						
2. FOR EQUIPMENT ROOM ONLY: Although the air cooling load averaged over a 12 hour working day is approximately 1/2 of the maximum value, the Equipment Room HVAC system must be sized such that Maximum Room Gradient, Temperature Range, Temperature Change per Hour, and Humidity specifications per Temperature and Humidity Specifications are not exceeded at any point during the working day. Actual heat output is site specific and dependent on the specific MR system configuration and customer usage of the MR system and options.						
3. Operator Workspace equipment includes the following: LCD Color Monitor, GOC Computer Cabinet, Workspace Cabinet, Mouse and Mouse Pad, LCD Panel, and Keyboard.						
4. Shield/Cryo Cooler Compressor requires water cooling to dissipate heat output. Heat dissipation to air is negligible. The Shield/Cryo Cooler Compressor water cooling can be provided by an MRCC or by customer provided facility water cooling. MRCC can be located outdoor or indoor. Refer to Shield/Cryo Cooler Requirements For Site Provided Water Cooling .						
5. Addition of 3rd party provided audio-visual equipment to the BrainWave HW Lite Cabinet may increase cabinet heat maximum output to 2781 BTU/Hr (815 Watts).						

4.1 Requirements

The Magnet Room must be an individual temperature zone controlled by a separate thermostat to allow for adjustments to meet room temperature specification as listed in [Temperature and Humidity Specifications](#). It is recommended that cool inlet air be directed towards the Enclosure Rear Pedestal and Blower Box air intake for patient cooling.

4.2 Recommendations

A dedicated air conditioner with a dual compressor is preferred to avert shutdowns during repair of the primary air conditioner. Due to the large variation in heat loads, the compressors should be equipped with unloaders or hot gas bypass to prevent moisture stripping of the evaporator coils.

It is recommended that a temperature and humidity recorder be used during preinstallation and during actual installation and placed near the Gradient Cabinet air inlets to establish the true criteria. Refer to cooling table calculator in this section for each room's cooling requirements.

GE recommends the use of a 12 inch high raised flooring system for the equipment room (10 inch minimum clearance from floor slab to underside of access flooring). Care must be taken in locating the air conditioning supply vents in the floor. The air conditioning supply vents should be located directly in front of the cabinet inlets

5 Water Cooling

5.1 Gradient Coil Water Cooling

The BRM Gradient Coil is air and water cooled. A water-to-air Water Chiller (WC1) is provided with the fixed site system. De-ionized water and anti-freeze mixture is supplied with the MR system for use in the closed loop system.

NOTE: The Water Chiller is a dedicated closed loop unit for BRM Gradient Coil water cooling only and not to be shared with other equipment.

NOTE: The BRM Gradient Coil has GE provided flexible hose (0.5 in. (12.7 mm) inside diameter) and adjustable compression clamps for connections.

For Mobile systems (True Mobile, Transportable, Relocatable), the BRM Gradient Coil water cooling will be provided by the Water-to-Water Heat Exchanger, the Van chilled water system will provide chilled water for the Heat Exchanger operation.

5.2 Gradient Coil Temporary Backup Water Cooling

There are no options available to support temporary backup water cooling for the Gradient Coil.



NOTICE

The WC1 must be used to provide water cooling to the gradient coil. In addition to the cooling, the WC1 prevents contamination/damage to the coil.

5.3 Shield/Cryo Cooler Temporary Backup Water Cooling

Customer provided temporary backup water cooling is recommended for the Shield/Cryo Cooler Compressor Cabinet (MS5). The backup cooling design can utilize open loop city water only as temporary backup during loss of the closed loop water cooling from the MRCC or customer provided water cooling to the Shield/Cryo Cooler Compressor. Long term open loop systems will not allow a chemical equilibrium to be established resulting in continual build up or etching that can take place which will eventually contribute to failure. Water system capacity must be selected to make sure adequate reserve for overcoming all pressure drops and still maintain the required flow rate for the Shield/Cryo Cooler Compressor Cabinet, for water cooling specifications refer to [Shield/Cryo Cooler Water Cooling For Site Provided Water Cooling](#).

NOTE: These water cooling specifications are the requirements at the water entry to the equipment. The backup cooling system design must have allowances for pressure/temperature changes due to distance located from the Shield/Cryo Cooler Compressor.



CAUTION

Switching the Shield/Cryo Cooler Compressor inlet/outlet cooling from the MRCC to a temporary water backup supply will result in approximately 1.5 gallons (5.5 liters) of 50% mixture of Dowfrost HD and de-ionized water being discharged. This discharge may have site impacts due to local regulatory codes. Make sure to understand and follow local regulatory requirements when designing and implementing a temporary backup water system. The design of the change over equipment from MRCC to city water and vice-a-versa must not allow contamination of the closed loop system in the MRCC.



NOTICE

Continuous water cooling is critical for the Shield/Cryo Cooler Compressor and therefore **MUST** be available 24 hours per day / 7 days per week to maximize proper uninterrupted magnet operation. Water cooling is required immediately upon magnet arrival, temporary water cooling must be provided if permanent site water cooling is not available.

5.4 Water-Cooled Cryocooler Compressor Requirements

Either an air- or water-cooled cryocooler compressor may be used. This section lists the requirements for a water-cooled cryocooler compressor. For air-cooled cryocooler specifications and requirements, refer to the air-cooled cryocooler compressor drawing and interconnect sections.

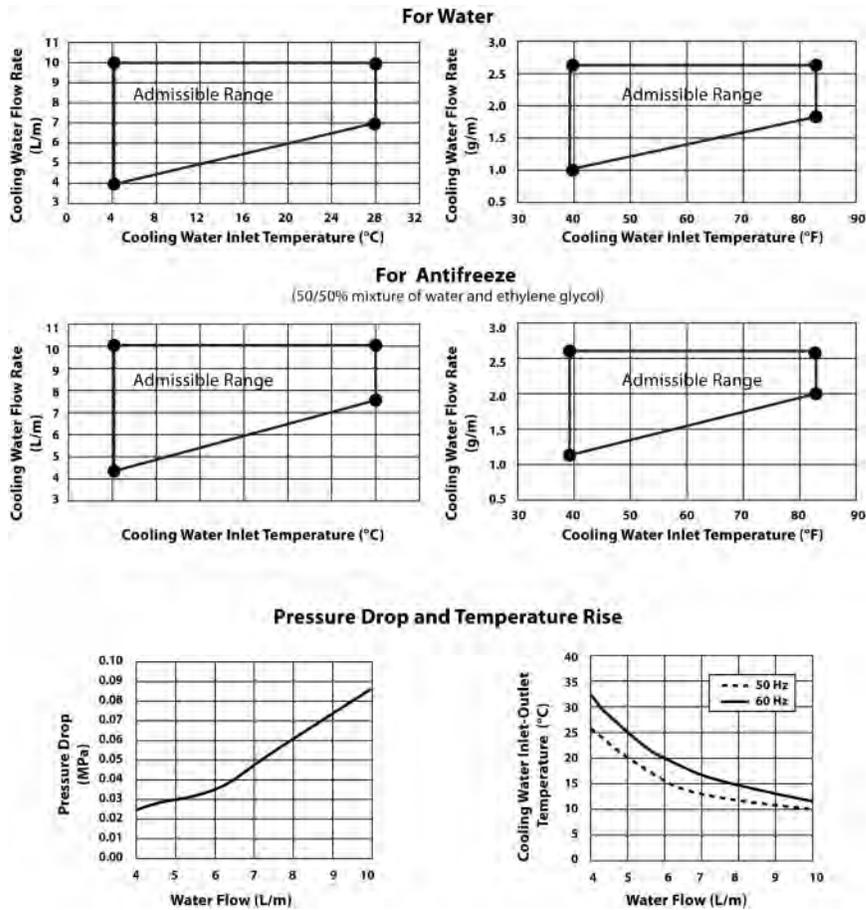
1. An uninterrupted supply of liquid coolant is required at magnet delivery and continuously thereafter.
2. The Shield/Cryo Cooler Compressor must be a closed loop coolant system.
3. A temporary open loop system using city water may be used as a backup if the requirements in [Table 5-5](#) are met
4. The Shield/Cryo Cooler Compressor closed loop system may be shared with other equipment in the MR suite. Flow gauges and valves are recommended at all branch lines to control distribution and allow servicing of equipment.
5. The Shield/Cryo Cooler Compressor requires customer supplied 0.5 in. (12.7 mm) inside diameter flexible hose and 1.0 in. (25.4 mm) adjustable compression clamps.

Table 5-5: Shield/Cryo Cooler Compressor Water Quality Requirements

Parameter	Requirement	Notes
pH level	6.5-8.2	GE Healthcare recommends de-ionized water
Hardness	Less than 200 ppm of calcium carbonate	Hard water will produce calcium deposits in the Gradient Coil and Shield/Cryo Cooler Compressor resulting in decrease of cooling efficiency.
Suspended matter	Less than 10 mg per liter, less than 150 micron particle size	To meet the specification for suspended matter it is necessary to install a 100-150 micron filter. Install Shield/Cryo Cooler Compressor Cabinet filter at cabinet inlet.
Antifreeze	Preferred minimum 25% by Volume, maximum 50% by volume	Either laboratory grade Ethylene Glycol or Propylene Glycol antifreeze may be used (do not mix Ethylene Glycol with Propylene Glycol). 65% water and 35% Glycol is recommended to minimize organic growth. Concentration of 50/50 is acceptable with a derate of 0.8 in specific heat calculations and a 20% increase in flow with a resultant internal pressure increase of 40%
Inlet Temperature Range °F (°C)	39.2 - 82.4 (4 - 28)	
Inlet Pressure psi (KPa)	See Illustration 5-1	
Note: Inlet to the first GE supplied part. Pressure drop is across all GE supplied parts.		
Minimum Flow Rate	1.8 gpm (7 L/m)	Minimum flow rate is for 100% water at 28 degrees C refer to Illustration 5-1
Maximum Flow Rate	2.6 gpm (10 L/m)	Maximum flow rate is for any mixture of water/antifreeze

Parameter	Requirement	Notes
Pressure Drop	0.085 MPa (12.1 psig) at the flow rate of 10 liter/min (2.6 gal./min). The maximum inlet pressure must be less than 0.69 MPa (99 psig)	Pressure drop is when operating with water and no antifreeze. Operating with antifreeze (50/50% mixture of water and ethylene glycol), the flow rate must be 10% larger than water flow rate and the pressure drop through the cooling water line will be 40% larger. The larger circulating pump will be required for the Antifreeze.
Temperature Rise □°F (□°C)	48.4 (26.9) for 60 Hz operation; 39.4 (21.9) for 50 Hz operation	
Temperature Rise □°F (□°C) at Maximum Flow	19.4 (10.8) for 60 Hz operation; 15.7 (8.7) for 50 Hz operation	
Typical Heat Output BTU/hr (Watts)	25,590 (7500) for 60 Hz operation 20,728 (6100) for 50 Hz operation	
Maximum Heat Output BTU/hr (Watts)	28,320 (8300) for 60 Hz operation 23222 (6700) for 50 Hz operation	

Illustration 5-1: Shield/Cryo Cooler Compressor Requirements



5.5 Air-Cooled Cryocooler Compressor Requirements and Specifications

Either an air- or water-cooled cryocooler compressor may be used. This section lists the requirements for an air-cooled cryocooler compressor. For water-cooled cryocooler requirements, refer to the water-cooled cryocooler compressor section (see [Water-Cooled Cryocooler Compressor Requirements](#)).

1. The air-cooled cryocooler compressor consists of the compressor and an optional external transformer (see [Chapter 8, Cryocooler Compressor Cabinet](#)). The external transformer is required if using a GE Healthcare supplied MDP (or a customer supplied MDP with 380-480 VAC). The external transformer is not required for 200VAC operation
2. Customer supplied cooling water or additional MRCC (MRCC #2) and associated cabling or water hose is not used
3. The air-cooled cryocooler compressor may be powered from a GE Healthcare supplied MDP or customer supplied MDP
 - a. If using a GE Healthcare supplied MDP (or a customer supplied MDP with 380-480 VAC), the power requirements are the same for either the air- or water- cooled cryocooler compressor (see [Chapter 6, Facility Power Requirements](#)) with the exception of the additional external transformer. For customer supplied MDP with 380-480VAC, the customer is required to provide overcurrent protection for the primary side of the transformer at no more than 50A @ 480VAC and 60A at 380VAC
 - b. If using a customer supplied MDP (with 200 VAC), a 35A-60A circuit breaker is required for the cryocooler compressor circuit
 - c. All other power requirements are the same for both the air- or water-cooled cryocooler compressor
4. The air-cooled cryocooler adds a significant heat load for Equipment room air cooling (see [Air Cooling Specifications](#))
5. If the optional external transformer is used, the customer must supply a power cable from the MDP to external transformer
6. A 393 in. (10 m) cable is provided for power from the external transformer to the air-cooled cryocooler compressor (or non-GE Healthcare supplied MDP if the external transformer is not used)

6 Lighting

Magnet Room Lighting requirements are listed in [Table 5-6](#)

Table 5-6: Magnet Room Direct DC Lighting Requirements

Requirements	
	<div style="background-color: #0056b3; color: white; padding: 5px; text-align: center; font-weight: bold; font-size: 1.2em;">NOTICE</div> <p>Fluorescent lighting is not allowed in the Magnet Room due to the RF noise generated by the fluorescent light tubes.</p>
<ol style="list-style-type: none"> 1. Direct Current (DC) lighting is required in the magnet room to avoid RF broadband noise impacts to image quality. 2. Illumination of 300 lux around the front of the magnet for patient access. 3. Need to provide 300 lux above the magnet service work (non-magnetic, portable lighting is acceptable). 4. The AC ripple from the DC power should be not greater than 5%. 5. Discrete switch or variable lighting level DC Lighting Controller (GE option available refer to Chapter 6, DC Lighting Controller (Facility Option)) must be used for selectable light levels. Dimmers (i.e. SCR, rheostats, etc.) are not allowed. 6. Lighting fixtures selection and installation must comply with requirements in Chapter 11, RF Shielded Room Requirements to minimize the possibilities of electrical discharge. 7. Light fixtures must have a ground wire from its power source and be grounded to the RF Shielded Room at the RF Common Ground Stud as shown in illustration in Chapter 6, Grounding System Ground subsection. 8. Light Emitting Diode (LED) lighting, if used, must meet the following: <ol style="list-style-type: none"> a. Power source must be located external to the Magnet Room RF Shield. b. All wiring, filters, and ground requirements must be met, refer to Chapter 6, Grounding System Ground subsection. 9. Battery chargers (e.g. emergency lighting) are required to be located outside the Magnet Room. 	
Comments	
	<ul style="list-style-type: none"> • Short filament length is recommended, linear lamps are not recommended because of the filament length and high incidence of filament failure. • Track lighting fixtures do not comply with light fixtures requirement listed above.

7 MR Suite Acoustic Specifications

7.1 Acoustic Specifications

Acoustic information is only provided as a guide. The actual room noise level may vary based on room design, optional equipment, and usage.

Table 5-7: Acoustic Specifications

	GE Equipment Acoustic Output	Notes
Control Room	55 dBA	
Equipment Room	75 dBA	The 75 dBA level is for GE equipment only. The Equipment room acoustic level must not exceed 85 dBA
Magnet Room	127 dBA	

Refer to acoustic guidelines in [Chapter 14, Acoustic Design Guidelines](#)

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

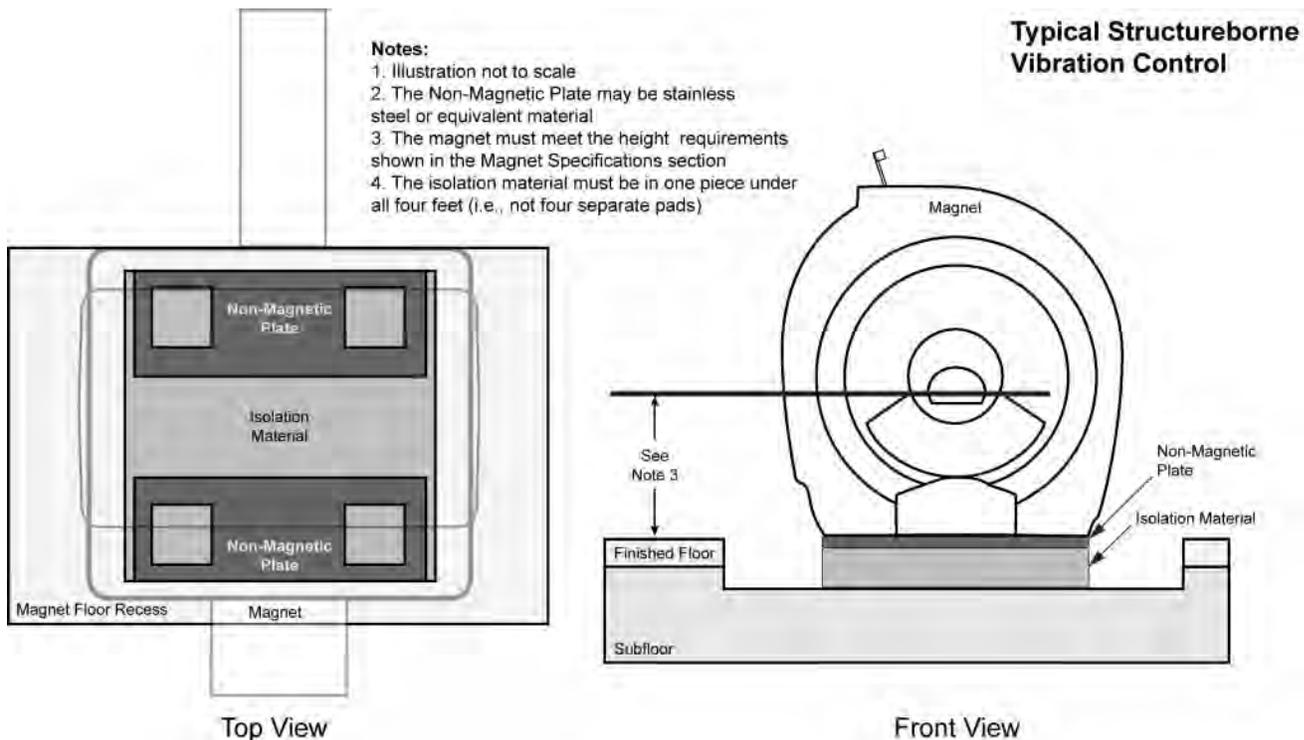
7.2 Structureborne Vibration Control Specifications

Structureborne acoustic issues tend to occur at MR installations above the ground floor of the facility. Two options to mitigate structureborne acoustic transmission are:

- GE Healthcare provides an available VibroAcoustic Damping Option. Contact the GE Healthcare Project Manager of Installation for information
- The customer may design and implement a custom solution. See [Illustration 5-2](#) for a typical example

NOTE: The amount of vibration attenuation provided by the VibroAcoustic Damping Option will be site dependent.

Illustration 5-2: Customer Designed Structureborne Vibration Control Example



8 Room Ventilation Requirements

1. Sufficient air ventilation in the Magnet Room must be maintained for patient comfort during scans and to maintain proper oxygen level during cryogen replenishment.
2. An exhaust fan to be placed above RF shielding with appropriate wave guide filtering for quick removal of helium gas if large amounts of helium disperse into magnet room. Inert gas containers, such as dewars, are not air tight.
3. The Magnet Room exhaust fan intake vent must be located at the highest ceiling point near the magnet cryogen vent.
4. The Magnet Room exhaust fan to exhaust to safe outside area and be independent of cryogenic venting.
5. The Magnet Room exhaust fan and air inlet must be sized for a minimum of 1200 CFM (34 m³/minute) and minimum of room 12 air exchanges per hour. See [Illustration 5-3](#) and [Illustration 5-4](#)
6. Two manual exhaust fan controls connected parallel, one to be located near the Operator Workspace and second control located in the Magnet Room.
 - a. The Magnet Room ventilation switch should be mounted near the Magnet Room door and is the responsibility of the architect and mechanical contractor.
 - b. Refer to the illustrations below for exhaust fan recommended set-up or recommended set-up with optional Oxygen Monitor.
7. Exhaust fan (customer supplied) to be installed and operating before magnet is moved into room.
8. Annual customer inspection and cleaning / maintenance of the exhaust fan system (fan, inlet grill/filter, ducts, etc.) is needed to meet the minimum airflow requirement to an outside area.
9. Provide minimum 2 ft x 2 ft (0.61 m x 0.61 m) or 576 sq in. (372,100 sq mm) pressure equalizing waveguide vent in the magnet room ceiling or in the wall (with waveguide top edge located at ceiling) to prevent positive or negative pressures from interfering with opening of the magnet room door
10. Minimum 5-7% of outside makeup air to be vented into the Magnet Room. For example, with an air input rate of 1200 cubic feet per minute (CFM) (34 cubic meters per minute), there must be a minimum of 60 CFM (1.7 cubic meters per minute) (5%) of outside makeup air..

Illustration 5-3: Exhaust Fan Set-Up

NOTE:
All items shown are supplied and installed by Customer or Contractor.

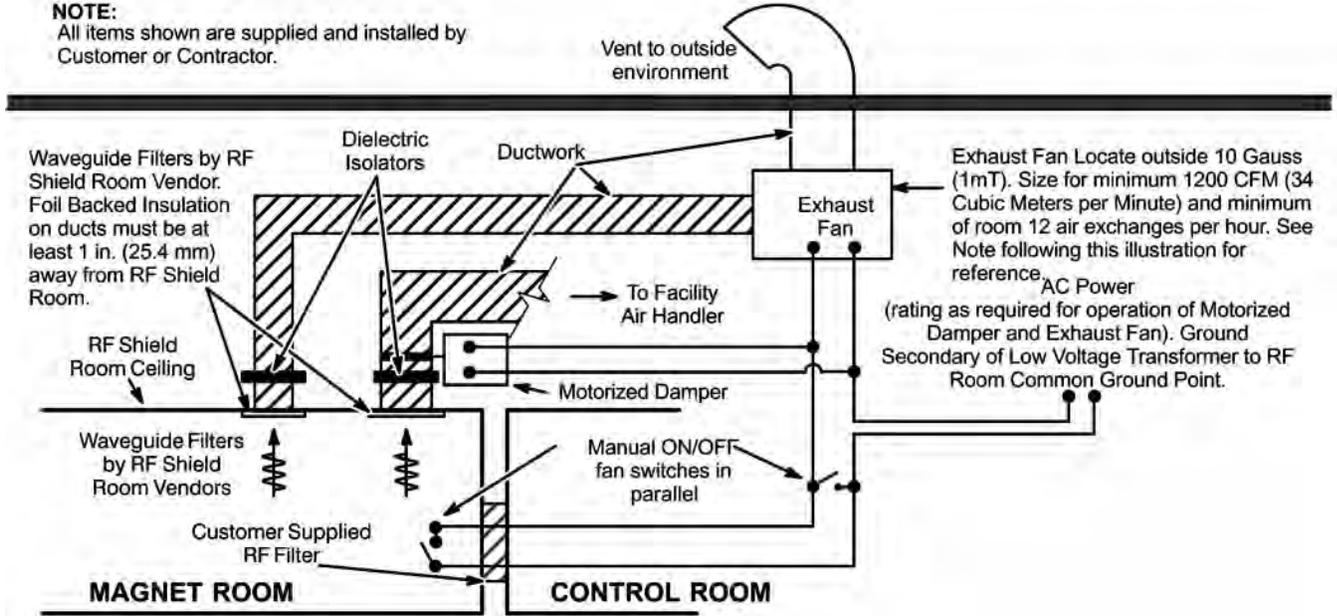
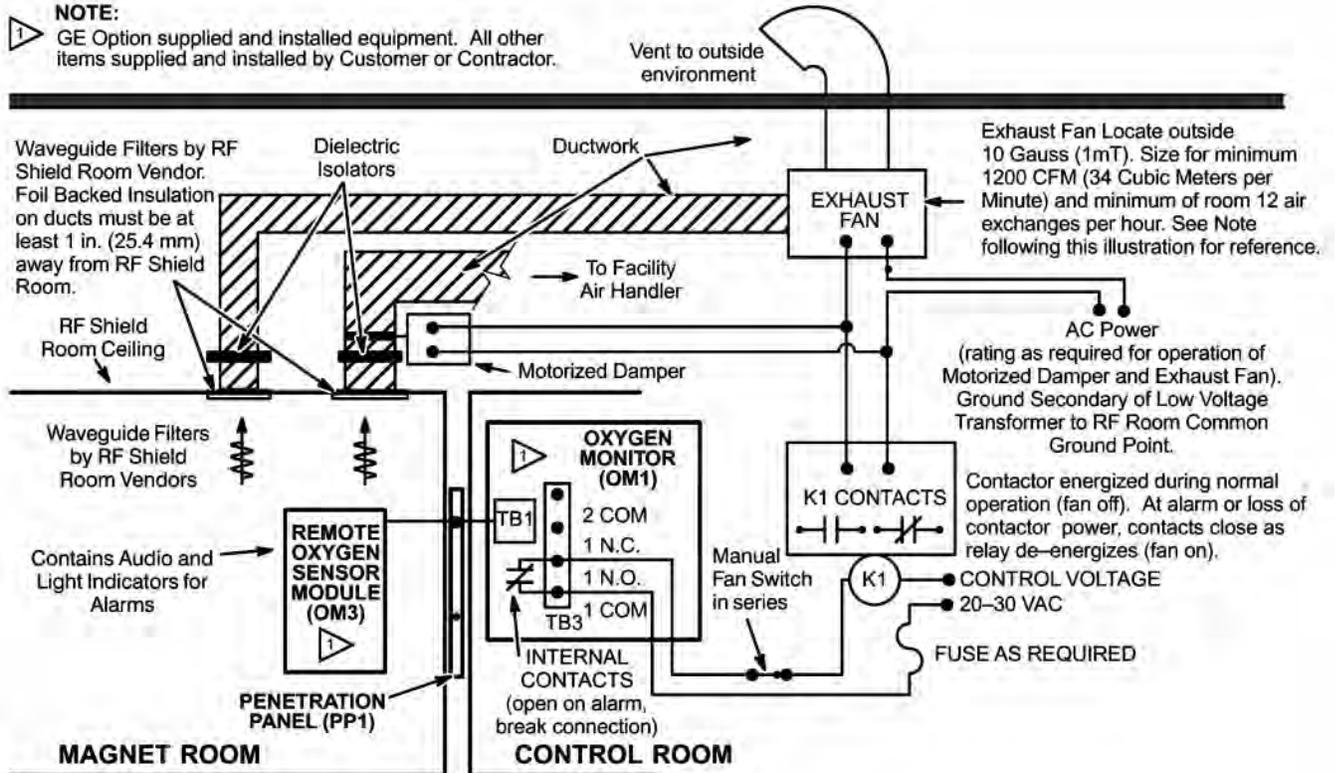


Illustration 5-4: Exhaust Fan Set-Up With Optional Oxygen Monitor

NOTE:
GE Option supplied and installed equipment. All other items supplied and installed by Customer or Contractor.



9 Cryogenic Venting

9.1 Cryogenic Venting Introduction

9.1.1 General Requirements



NOTICE

All venting system components must be accessible for customer inspection, cleaning, and maintenance.

1. The MR System requires an outside vent to allow helium gas to escape during magnet quench. The vent must be properly installed to ensure the gas does not escape into the building
2. The term tube or pipe may be used interchangeably in this document
3. The vent must be connected to the magnet within 24 hours of installation in the magnet room
4. The entire vent system must be accessible for regular inspection and maintenance
5. RF shielded room contractor is to provide one straight pipe with maximum 0.125 in. (3.175 mm) wall thickness for the cryogenic vent pipe/waveguide.
6. The vent pipe/waveguide must extend inside and outside of the RF shielded room
7. Refer to [Chapter 11, Waveguide](#) for additional waveguide requirements

NOTE: All pipe or tube dimensions specified in this document are outside diameters.

NOTE: Some requirements in this document may not be applicable to Mobile, Transportable, or Relocatable configurations.

Table 5-8: Magnet Cryogen Specifications

Magnet Types	Helium Volume gallons (liters)	Peak Helium Flow During Quench ft ³ per min (m ³ per min)	Magnet Vent Pipe OD inches (mm)
1.5T Magnet	520 (1970)	2737 (77.50)	8 (203.2)

9.1.2 Vent Size - Pressure Drop

- The vent must be routed as directly as possible to the outside. If used, elbows must be standard or long sweep.
- The total pressure drop of the cryogenic vent system (from the magnet vent interface to the termination point outside the building) must be less than 17 psi (117.2 kPa). The pressure drop of the RF shield waveguide must be included in the overall calculation.

NOTE: Refer to [Chapter 14, Magnet Cryogenic Venting Pressure Drop Reference Tables](#) to calculate the pressure drop.

9.2 Outside Magnet Room Requirements

The waveguide inside the magnet room must be connected to a final exit outside the building. The customer is responsible for design and installation of the venting system.

9.2.1 Vent Support

- The vent support assemblies must be able to support the entire vent system and 1850 lbs (8229 N) helium flow reaction force at vent elbows.
- The Ventglass joint must not be used as a vent system support.

9.2.2 Vent Construction

- Expansion/contraction joints must be provided for temperature decrease from ambient to 4.5 K (-451°F or -268°C)
- A Ventglas isolation joint must be installed at the waveguide. The joint gap must be 1.0 ± 0.25 inch (25 ± 6 mm)
- The Ventglas joint must be accessible for inspection or maintenance
- 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)
- Electro-mechanical fire dampers must not be used. Fusible link fire dampers may be used (with annual inspection)
- Exit of vent must prevent ingress of weather elements (i.e., rain, snow, hail, sand, etc.) and foreign material debris (i.e., leaves, bird nests, etc.)
- Condensate must be prevented from pooling inside any section of the venting system

9.2.3 Vent Exit



WARNING

**CRYO-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.**

**ENSURE ACCESS TO CRYOGEN VENT EXHAUST AREA IS RESTRICTED AND
THE RELEASED GAS DOES NOT REENTER THE BUILDING. REFER TO THE
SPECIFICATIONS BELOW.**

- The vent exhaust area 20 feet (6.1 m) long by 15 feet (4.6 meters) wide:
 - Must be restricted and labeled with appropriate warning signs.
 - Must not include air intake vents
 - Must not include any personnel, building components, or objects (movable or stationary)
- For a roof-top exit:
 - Use either a horizontal exhaust vent with a 90° elbow and minimal pressure drop or other low pressure drop, high flow rate roof cap
 - The bottom of the 90° elbow must be at least 3 feet (0.9 meters) above the roof deck (or higher if at risk of being blocked by drifting snow, sand, etc.)
 - The outlet must be covered with a 0.5 inch (12.7 mm) square screen mesh

- The exhaust vent must be included in the pressure drop calculation
- For a side-wall exit:
 - Use an exhaust vent with a 45° elbow (with a deflector rated for the helium reaction force) and no restriction in gas flow
 - The exhaust exit must be at least 12 feet (3.66 meters) above the ground
 - The outlet must prevent foreign material from entering the opening (using mesh screen, louvers, etc.)
 - The exhaust vent must be included in the pressure drop calculation

9.3 Inside Magnet Room Requirements

The magnet must be connected to the waveguide inside the magnet room. The customer is responsible for design and installation of the venting system.

9.3.1 General Configuration

- Do not remove or modify the vent adaptor bolted to the magnet
- The GE Healthcare supplied vent tube must be bolted directly to the magnet vent adaptor bolt flange
- The vent tube may be cut to a minimum of 4 inches (10.6 cm) from the top of the magnet flange

9.3.2 Vent Material

- The vent material must be one of the following materials with the wall thickness indicated:
 - SS 304: Minimum 0.035 in. (0.89 mm); Maximum 0.125 in. (3.18 mm)
 - AL 6061-T6: Minimum 0.083 in. (2.11 mm); Maximum 0.125 in. (3.18mm)
 - CU DWV, M or L: Minimum 0.083 in. (2.11 mm); Maximum 0.140 in. (3.56 mm)
- Either tubes or pipes may be used and must be seamless or have welded seams
- Corrugated pipe must not be used
- A bellows pipe less than 1 ft (30 cm) may be used as a thermal expansion joint
- The vent pipe must withstand a maximum pressure of 35 psi (241.4 kPa)
- Waveguide vent material must match the outside diameter of the magnet vent

9.3.3 Vent Support

- The vent support assemblies must be able to support the entire vent system and 1850 lbs (8229 N) helium flow reaction force at vent elbows
- Any vent support must not compromise the integrity of the RF shield
- The Ventglas joint must not be used as a vent system support

9.3.4 Vent Construction

- One dielectric break in the vent system (using Ventglas) is required in the Magnet Room to ensure the integrity of the RF shield for the Magnet Room (it may also serve as a thermal expansion joint)
 - Ensure the gap between the pipes is 1.0 ±0.25 inch (25.4 ±6 mm) using a continuous wrap technique
 - The Ventglas joint must be accessible for annual inspection or maintenance by GE Healthcare
- The customer supplied vent (except the Ventglas joints) must be welded or brazed. No clamped, sealed flanges are permitted
- All isolation/thermal expansion joints (except the Ventglass joint) must be rated to 4.5 K (-451° F or -268° C) and 35 psi (241.4 kPa)
- The vent system must be insulated with 1.5 inch (38 mm) thick flexible unicellular insulation to prevent condensation during magnet ramping. Exposed insulation must be covered with a white PVC jacket

- The installation of the vent pipe section between the waveguide and the supplied magnet vent pipe must not result in any vertical or side load to the waveguide and the magnet vent pipe

10 Alarm Devices, Water Sensors and Thermostats

10.1 RFS Cabinet

10.2 Water Sensor Alarm and Floor Drain

It is recommended that customer supplied water sensor alarms and floor drain be located on floors where water cooled cabinets are positioned, especially under raised flooring.

10.3 Pneumatic Patient Alert

The Pneumatic Patient Alert Control Box provides an audible and visual alarm near the operator when the patient depresses the hand held squeeze bulb. The control box is to be mounted with consideration for ease of use by operator, remaining in sight of operator, and remaining within 5 ft (1.5 m) of an electrical outlet. Note, an outlet on the Operator Workspace may be used. Options for control box location include mounting box vertically (on a wall or other vertical surface), horizontally (place box on a counter top, desk top, or other horizontal surface), or under a shelf within sight of operator.

11 Ambient Radio Frequency Interference (RFI)

The MR System utilizes spatially encoded radio frequency information to create the MR image. Therefore, it is sensitive to ambient RFI. To protect the MR from ambient RFI (as well as the local environment from Magnetic Resonance RF), all sites require a 100 dB RF Shield, refer to [Chapter 11, RF Shielded Room Requirements](#) for exact requirements. It is very unlikely that local signals will affect an MR System with a properly designed and installed RF Shield. During the site evaluation visit, GE notes the location of nearby sources of RFI and will advise if further information or on-site testing is required. Most sites do not require on-site testing. Listed in [Table 5-9](#) are the recommended centerband and bandwidth frequencies to be used when measuring radio frequency interference. This table includes those frequency bands which are important for both proton imaging and spectroscopy.

Table 5-9: 1.5T System Radio Frequency Survey Specifications

Isotope	Bandcenter MHz	Bandwidth Hz
¹ H	63.86	916,138
¹⁹ F	60.12	981,882
³¹ P	25.88	390,296
²³ Na	16.90	242,773
¹³ C	16.06	233,925

When required, RFI site surveys are to be performed by cycling through the preceding frequency bands and a broad band range of 100MHz ± 10MHz. 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, that the RFI noise at the site will not exceed the 100 db attenuation provided by the RF shielded room. Note that any RFI site survey no matter how thorough, will not preclude the possibility of future or unmeasured RFI caused by new or intermittent sources.

The ambient RF noise measured should be less than 100 millivolt per meter (100 dB microvolt per meter). When a RFI site survey is required, it must be completed before the purchase and installation of the RF shielded room.

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

$$BW \text{ (resolution)} = f_0 / 50$$

where: BW = Bandwidth (resolution)

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

12 Pollution

The site must be clean prior to delivery of the equipment. Although individual components have filters for optimum air filtration, care should be taken to keep air pollution to a minimum.

When cleaning tile floors, do not use steel wool which could enter cabinet enclosures and cause internal shorts.

The computer/equipment area requires that the air be filtered to remove 90 percent of all particles down to 10 microns and 80 percent of all particles from 10 to 5 microns in size.

13 Changing Magnetic Environment Specifications

The main field of the MR magnet can be negatively impacted when installed in areas where dynamically changing magnetic fields exist. Two possible sources of changing magnetic fields include

- Moving Metal
- AC Power Lines, Transformers and Motors.

NOTE: Also refer to [Chapter 3, Proximity Limits](#) for additional proximity limitations.

13.1 Definition Of Moving Metal

Metal objects moving within the magnet sensitivity lines can produce a negative impact during clinical scanning. The moving metal object will cut flux lines distorting the main field. As an example, cars driven inside the moving metal line will impact the magnets main field. The same vehicle may park within the moving metal line and remain parked during clinical scanning without impact to the main field.

13.2 Magnet Steel Objects Categories And Requirements

Table 5-10: CxK4 Magnet Moving Metal Requirements

Steel Objects Category	Definition Of Distance Location	Minimum Distance Radial X Axial ft (m) See Note 1
Objects 100 - 400 lbs	distance from isocenter radial x axial (See Note 1)	3 Gauss line
Cars, Minivans, Vans, Pickup Trucks, Ambulances	distance from isocenter measured to center of driving or parking lane radial x axial (See Note 1)	15.5 x 21 (4.72 x 6.40)
Bus, Trucks (Utility, Dump, Semi)	distance from isocenter measured to center of driving or parking lane radial x axial (See Note 1)	18.1 x 24.5 (5.52 x 7.47)
Objects > 400 lbs, Elevators, Trains, Subways	Place a directional probe (e.g. flux gate sensor) at isocenter of proposed magnet location aligned along the Z-axis. Measure p-p magnetic field change (dc).	See Illustration 5-5 and see Example in Note 2
Notes		
1. Radial distances are magnet X and Y axis. Axial distances are magnet Z axis. 2. EXAMPLE: For Moving Metal Requirements of objects > 400 lbs category you can use the time history of the occurrence to determine what milligauss level to use. <ol style="list-style-type: none"> If the site has elevators/counter weights near the magnet and the elevator can stop on the floors for longer than 20 seconds (which is usually the case), peak-to-peak milligauss reading must be less than 4.43. If the site has a subway nearby and the field disturbance is less than 5 seconds, the peak-to-peak milligauss reading must be less than 8.39. Use 4.43 milligauss peak-to-peak. 		

Illustration 5-5: Actual Axial Shielding Performance

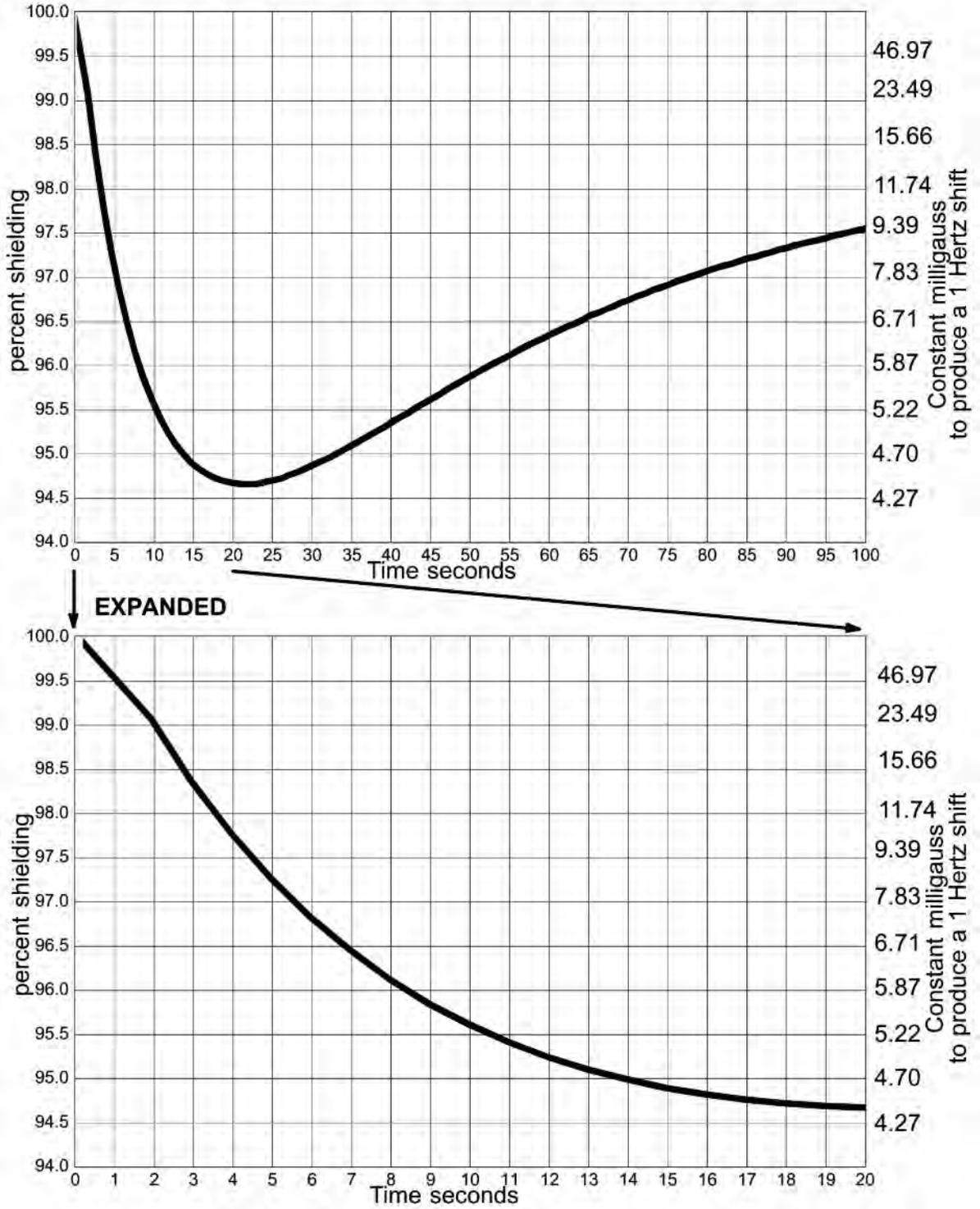


Illustration 5-6: Magnet Moving Metal Sensitivity Line Plot (MR Center Level)

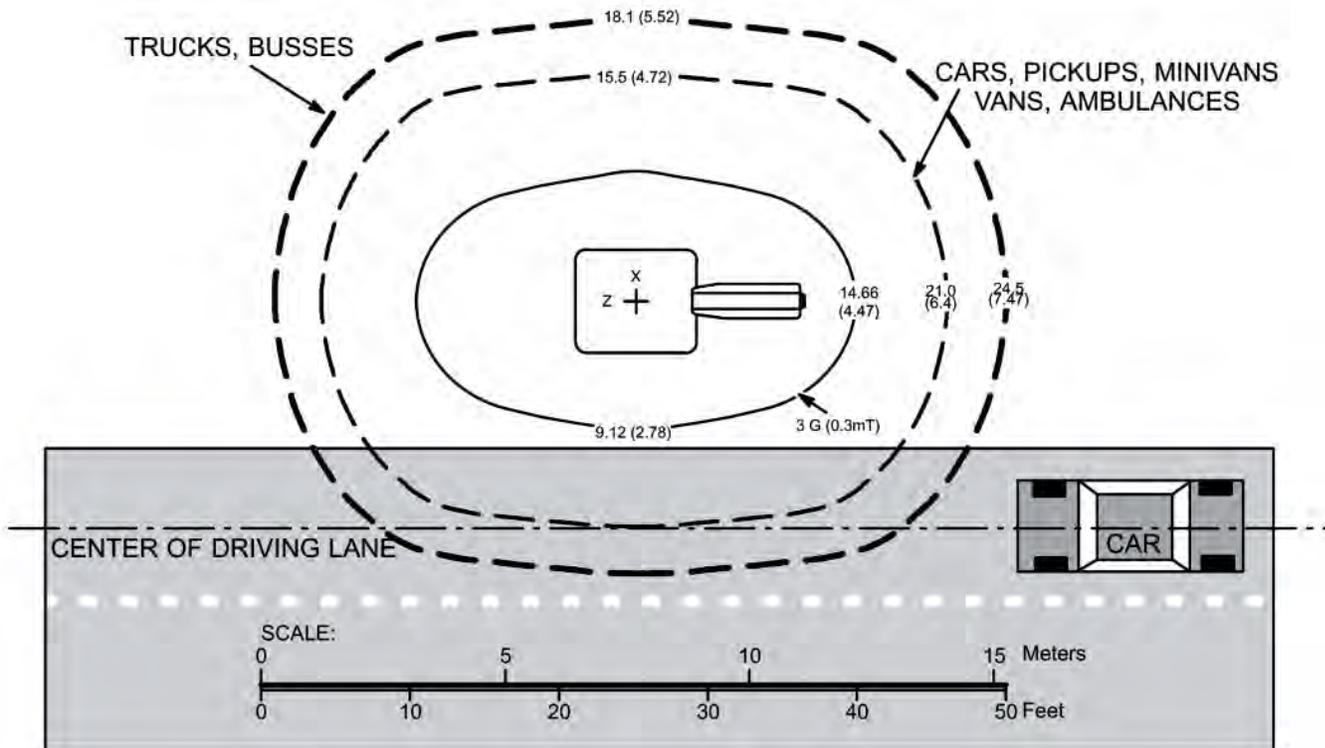
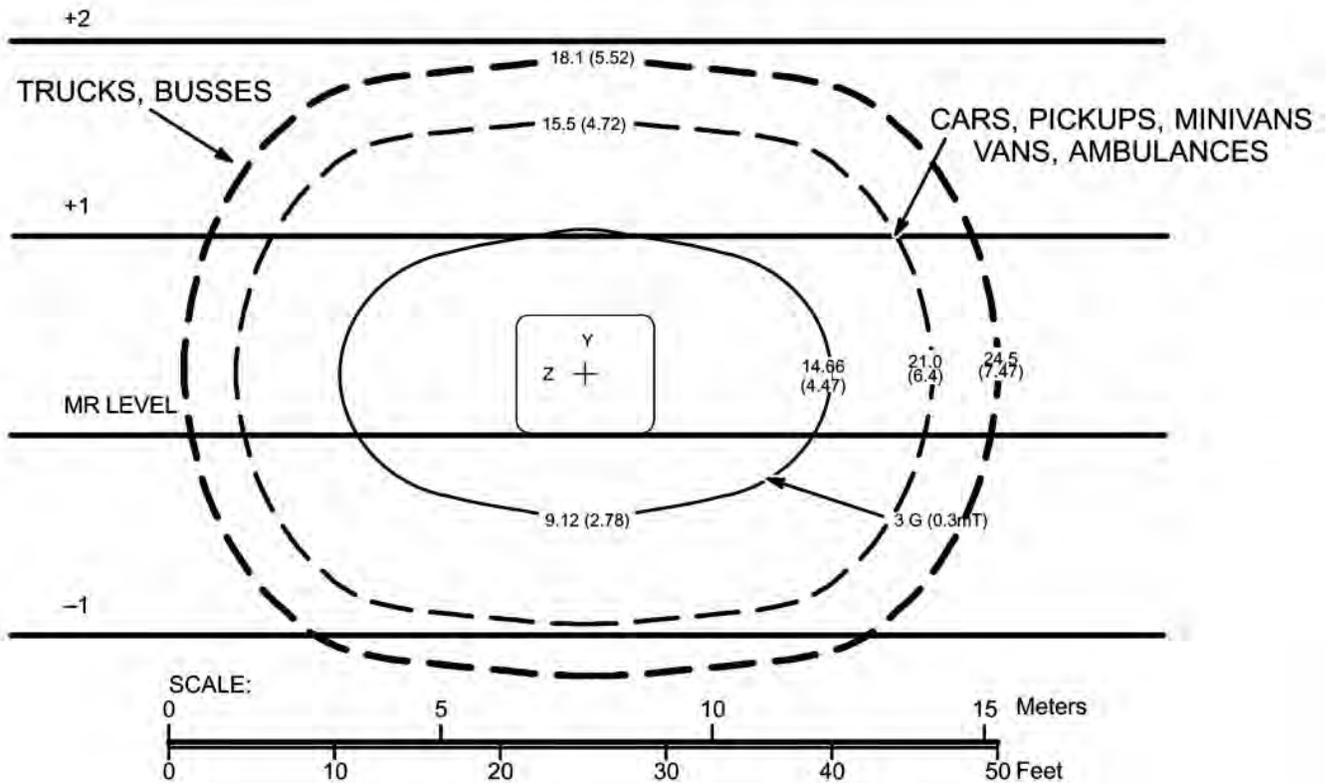


Illustration 5-7: Magnet Moving Metal Sensitivity Line Plot (Vertical View)



13.3 Distances For AC Power Lines, Transformers And Electric Motors

Electrical currents flowing in high voltage power lines, transformers, and large generators or motors near the magnet can affect the magnetic field homogeneity that is essential to the proper performance of the MR System.

Magnetic field interference at 50 or 60 Hz must not exceed 40 milligauss RMS respectively at the magnet location, refer to [Illustration 5-8](#). 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.

$$I = (20X^2)/S$$

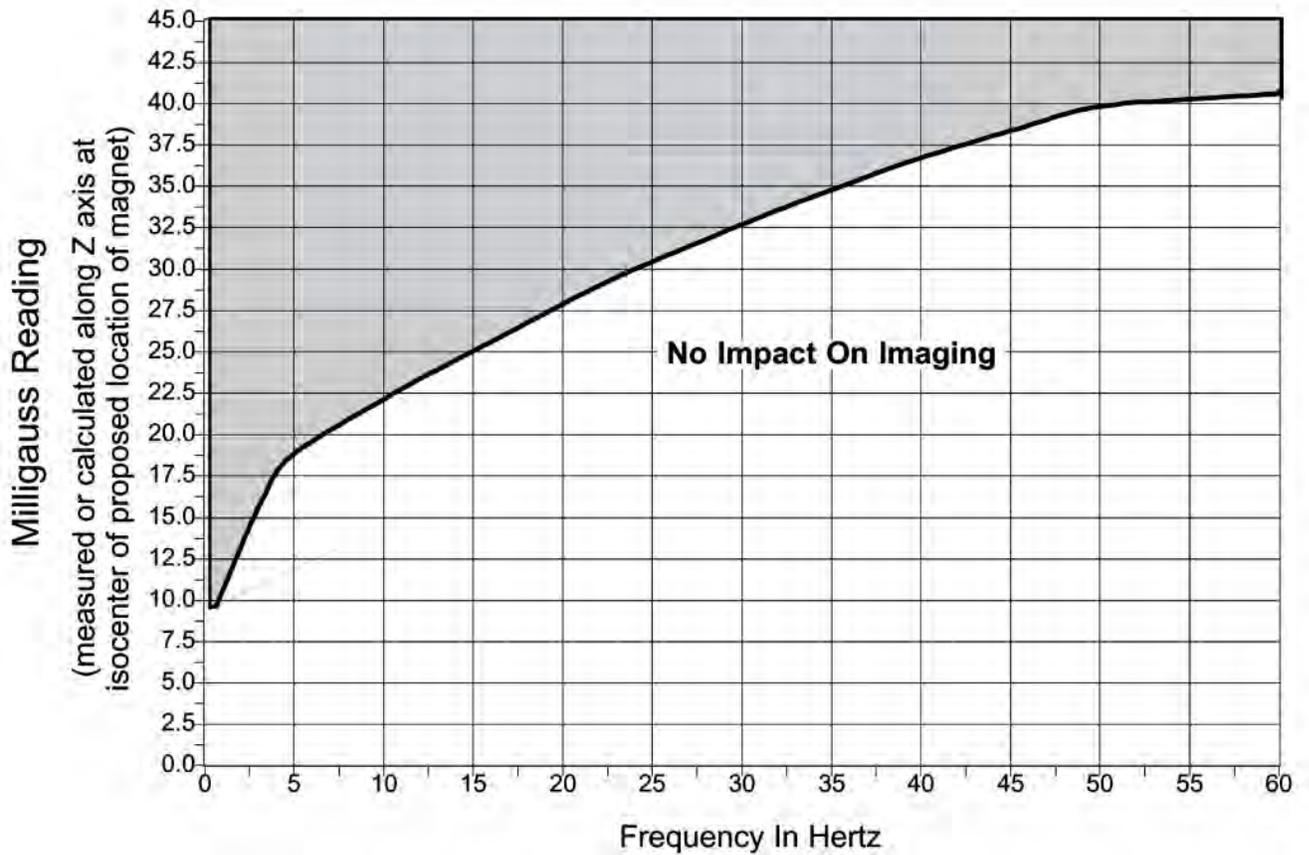
where:

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

X = Minimum distance (in meters) from the feeder lines to isocenter of the magnet

Illustration 5-8: Allowable Milligauss VS Line Frequency For AC Equipment



13.4 Sample Calculation Determine Minimum Distance From AC Power Lines, Transformers, And Electric Motors

This is a sample calculation to determine minimum distance from a feeder, transformer, or other AC electrical source, using the Formula found in [Section 13.3 Distances For AC Power Lines, Transformers And Electric Motors](#).

$$I \text{ (amps)} = 20X^2 \text{ (meters)} \div S \text{ (meters)}$$

Note that the formula has 3 variables, if you have 2 of them, you can calculate the 3rd. 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 5 inch conduit.

$$X^2 \text{ (meters)} = [I \text{ (amps)} \times S \text{ (meters)}] \div 20$$

$$X = \sqrt{\left\{ \frac{[I \text{ (amps)} \times S \text{ (meters)}]}{20} \right\}}$$

Rearranging:

Note that 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



$$X = \sqrt{\left\{ \frac{|450(\text{amps}) \times 0.127(\text{meters})|}{20} \right\}}$$

X = 1.69meters = 5.4feet

So in this example, the conduit should be 1.69 meters or 5.54 feet or farther from the magnet's isocenter.

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.

What if it is too close? Keep in mind that 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 worse 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.

14 Construction Materials

The following requirements are for maintaining field homogeneity of the magnet. All construction must comply with local and national building codes.

14.1 Magnet Room Floors Magnetic Properties

Table 5-11 information must be used to evaluate site steel in close proximity of the magnet isocenter.

Table 5-11: Steel Mass Proximity To Magnet Isocenter Requirements

Limits Of Steel Mass lbs/ft2 (kg/m2)	Distance From Magnet Isocenter in. (mm)	Distance Below Top Surface Of Floor in. (mm)
0 (0)	0-42 (1067)	0 (0)
2 (9.8)	42-45 (1143)	0-3 (76)
3 (14.7)	45-47 (1194)	3-5 (127)
8 (39.2)	47-52 (1321)	5-10 (254)
20 (98.0)	52-55 (1397)	10-13 (330)

Note

- Limited site materials include steel rebars and other steel building components within a 10 foot by 10 foot (3.1 meter by 3.1 meter) area directly below the magnet.
- If non-uniform steel is present or if these mass proximity limits are exceeded then the steel must be analyzed by the MR Siting and Shielding Team. Refer to *Magnetic Field Consideration Chapter 4, Introduction, Chapter 4, Structural Steel Evaluation Of Proposed Sites*, and *Chapter 4, Magnetic Field*. It is highly recommended to use non-magnetic structural components in the floor below the Magnet.
If the MR Siting and Shielding Team analysis of the site steel determines the steel cannot be shimmed by normal methods, the customer will be required to alter the structural design using non-magnetic materials and/or more favorable geometry. If changes cannot be made, on-site factory shimming at extra cost and extended calibration cycle may be necessary. Also, the GE Field Service Engineer must arrange for delivery of the necessary shim tools and a 1000 amp Power Supply. .

14.2 Walls, Ceilings, and Fixtures

All electrical and mechanical connections and fasteners including screws, nails, nuts, bolts, clips, clamps, etc. must be sufficiently tightened and secured so as not to become a potential broadband noise source, refer to [Chapter 11, RF Shielded Room Requirements](#) for requirements. Standard steel nails, screws, and other hardware are acceptable if properly secured. Any loose steel objects can be violently accelerated into the bore of the magnet.

Careful thought should be given to the selection of light fixtures, cabinets, wall decoration, etc. to minimize this potential hazard. For safety, all **removable** items within the magnet room such as switch box cover plates, light fixture components, mounting screws, etc. must be non-magnetic. If you have a specific question about material, bring it to the attention of your GE Healthcare Project Manager, Installations.

Non-movable steel such as wall studs or HVAC components will produce negligible effect on the magnet.

14.3 Electrical conduits

All electrical and mechanical connections and fasteners including screws, nails, nuts, bolts, clips, clamps, etc. must be sufficiently tightened and secured so as not to become a potential broadband noise source, refer to [Chapter 11, RF Shielded Room Requirements](#) for requirement. Electrical conduit within the magnet room may be steel provided it is inside walls and ceilings. Note, conduit for a receptacle must be metallic. Ferromagnetic material inside the magnet room could inadvertently become a projectile.

14.4 Plumbing pipes and drains

Pipes and drains within the magnet room may be iron, if desired, without significant effect on the magnet homogeneity. For safety, any removable items such as faucet handles, drain covers, etc. must be non-magnetic material such as PVC, copper, or brass. Any magnetic material inside the magnet room could inadvertently become a projectile.

Refer to [Cryogenic Venting, Requirements For Outside Magnet Room](#), and [Requirements for Inside Magnet Room](#) for cryogenic vent materials requirements.

15 Vibration

15.1 Types of Vibration Image Quality Issues

MR image quality can be impacted by either steady state or transient vibration. Steady state vibration typically refers to disturbances caused by rotating machinery. Examples of machinery known to have previously generated vibration image quality problems are exhaust fans, air conditioning blower units, compressors, pumps (air and water), etc. Transient vibrations are typically a function of the building structure or the building foundation and are associated with vehicular traffic, pedestrian motion, patient transport, door slamming, etc. A transient event would typically decay from a high vibration amplitude to lower levels in short periods of time.

15.2 Site Planning Vibration Requirements

Magnet Room vibration testing and site planning requirements are listed in [Table 5-12](#).

Table 5-12: Magnet Room Site Vibration Testing And Requirements

Requirements	
1.	The customer is responsible for contracting a vibration consultant or qualified engineer to implement design modifications to meet the vibration specifications as stated in Section 15.3 .
2.	<p>The vibration tests outlined in Chapter 14, MR Site Vibration Test Guidelines must be used to assess the vibration environment. The vibration effects on image quality can be minimized early in the site planning of the MR suite.</p> <ul style="list-style-type: none"> a. Sites which meet the vibration criteria may proceed with the installation planning. b. Sites which fail to meet the vibration requirements will be required to have the customer architect/project engineer provide recommendation to isolate the vibration source(s) and/or recommend structural modifications. <ul style="list-style-type: none"> i. Resolution/solution of measured issue(s) must be communicated to customer/architect, local GE Healthcare Field Service, and GE Project Manager, Installations. ii. A formal report defining the measured issue(s) and resolution/solution to be provided to customer/architect, GE Healthcare Field Service, and GE Project Manager, Installations. c. Sites building a new complex to house the MR suite must use MR Site Vibration Test Guidelines information in the design of the facility.
3.	Air conditioning unit(s) installed for the purpose of cooling the MR Suite must be vibration isolation.
4.	Magnet vibration isolation is not an acceptable solution for environmental vibration issue(s). The magnet must be bolted rigid to a structure or to VibroAcoustic Damping Option mats which set on the finished floor.

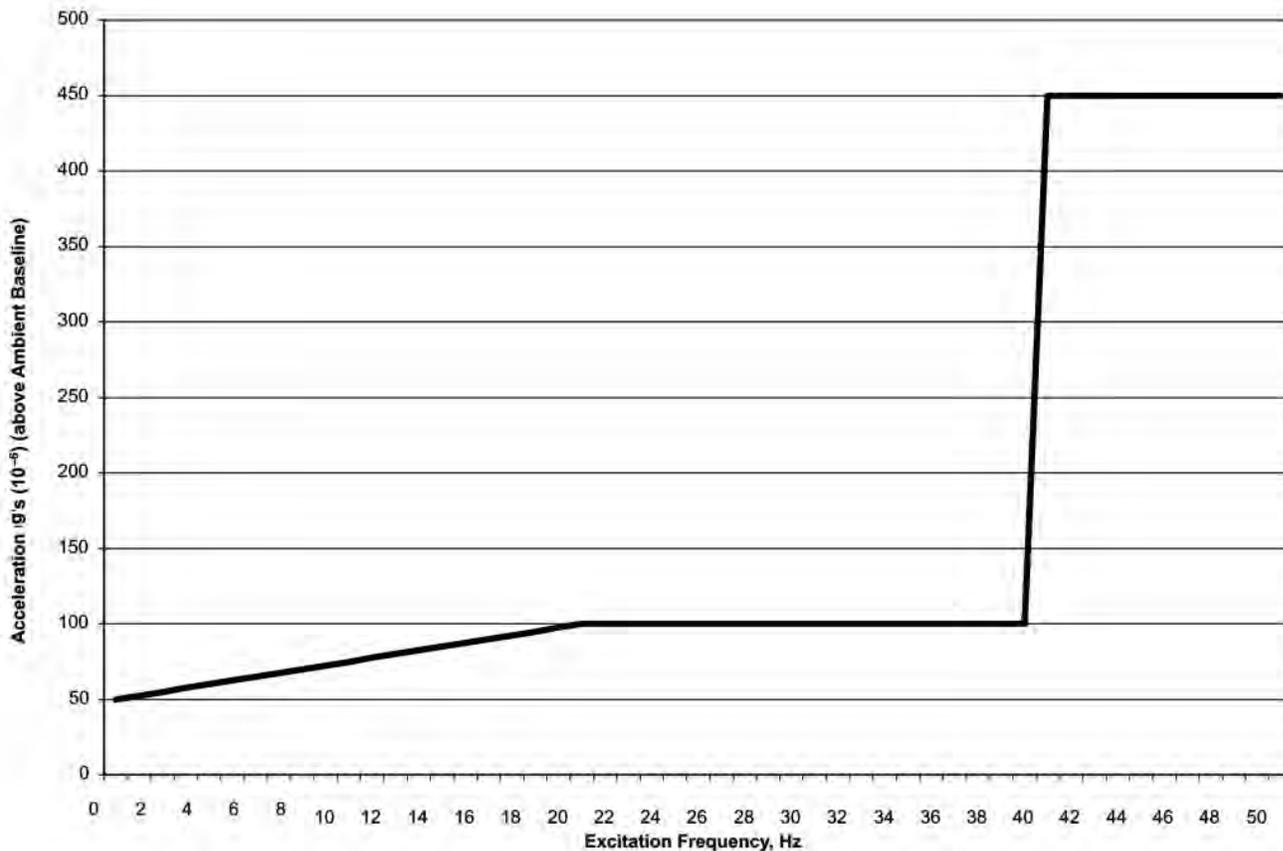
15.3 Vibration Specifications

NOTE: Refer to Appendix [Chapter 14, MR Site Vibration Test Guidelines](#) for definition of ambient baseline.

15.3.1 Steady State Vibration Specifications

The maximum steady state vibration transmitted through the floor must not exceed the maximum single frequency components above ambient baseline listed in [Illustration 5-9](#).

Illustration 5-9: 1.5T LCC Magnet Steady State Vibration Specifications



Refer to [Chapter 14, MR Site Vibration Test Guidelines](#) for an example applying the steady state specifications with ambient baseline and zoomed in for analysis purposes.

Discrete signal must represent a real mechanical vibration source, that is the signal must have a bandwidth that typifies dynamic system response.

15.3.2 Transient Vibration Specifications

NOTE: Transient vibration analysis requires the elimination of all steady state vibration so as not to mask the transient signal. I.E. Variations in acceleration amplitudes due to rotating equipment must not be confused with transient vibration.

1. Time history transient levels exceeding 500 micro-g, zero to peak must be fully analyzed to assess impact to the building structure.
2. The building (spectral) response immediately following the 500 micro-g trigger level must not cause the site environment to exceed the Steady State Vibration levels defined in [Section 15.3.1](#).
 - a. The vibration consultant must measure and report the transient disturbance of concern.
 - b. The consultant must determine (assess) the frequency, amplitude, and duration of the transient.

- c. The consultant must determine whether the disturbance will vibrate the building structure, MR RF Shielded Room, plus the magnet to amplitudes that would exceed the Steady State Vibration specifications, refer to [Section 15.3.1](#).

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Chapter 6 Power Requirements

1 Facility Power Requirements

1. The facility is responsible for supplying system power and cabling to the Main Disconnect Panel (MDP). Associated transformers and cables must be correctly sized for system power requirements
2. Facility power is required at Magnet delivery and continuously thereafter
3. If a customer supplied Main Disconnect Panel (MDP) is used, it must have correctly sized wires and rated components to meet the MR system power requirements
4. If an uninterruptible power supply (UPS) is used, it must meet system power requirements

Table 6-1: Required Customer Power

MR Component	Voltage (VAC)	Frequency	Phase	Max. Amps	Comments
Main Disconnect Panel (MDP) See Notes 1, 2, 4, & 5	480Y/277 VAC ± 10% or	60 Hz	(3+GND) See Comments	See Note 3	Recommend input configuration: 3 phase Grounded WYE with Neutral and Ground (5 wire system). Note, Neutral must be terminated prior to PDU or inside the Main Disconnect Panel and not brought to the HFD/ PDU Cabinet. Optional input configuration: 3 phase DELTA with Ground (4 wire) input, recommend corner Grounded Delta configuration.
	400Y/230 VAC ± 10%	50 Hz			
Shield/Cryo Cooler Cabinet	460, 480	60 Hz	3+GND	9 KVA	Hard wired in unit and at facility power (no power connector). Shield/Cryo Cooler Compressor power and water cooling must be available 24 hours per day / 7 days per week to maximize proper uninterrupted magnet operation. Also see Note 2, 6.
	380, 400, 415	50 Hz			
Magnet Rundown Unit	100-120 or 200-240	50/60 Hz	1	1.0	Hard wired in unit. Power must be available 24 hours per day / 7 days per week.
Magnet Monitor	100/120 or 200/220	50/60 Hz	1	0.75	Receptacle required. Power must be available 24 hours per day / 7 days per week. Also see Note 3.
Service Receptacle in Magnet Room	110-120 See Comments	50/60 Hz	1	2.0	Receptacle required for small power tools. Local voltage and portable transformers for voltages values.
* MR Common Chiller (MRCC) See Note 2	460/480 ± 10%	60 Hz	3	6.2	15 Amp minimum circuit required, customer supplied power wire, 6 AWG (16 mm ²) maximum wire size.
	380/400 ± 10%	50 Hz			
* Remote Magnet Rundown Unit	100-120 or 200-240	50/60 Hz	1	1.0	Hard wired in unit.
* O ₂ Monitor	110-120 or 200-240	50/60 Hz	1	3.0	Hard wired in monitor

MR Component	Voltage (VAC)	Frequency	Phase	Max. Amps	Comments
Notes					
* Optional equipment.					
1. Power phase conductors, neutral (if present), and ground conductor must be routed inside the same raceway, cable tray, trench cable, or cord					
2. GE Healthcare MDP (E4502SP) option controls power to the MR system Power Distribution Unit and Shield/Cryo Cooler Compressor. GE MDP option does not support the MRCC option. Customer is responsible for the power requirements for MRCC (M3088TL).					
3. Maximum amps dependent on voltage selected. Refer to Critical Power Requirements for configuration.					
4. Shield/Cryo Cooler Cabinet power and water cooling are required immediately upon magnet arrival. If permanent site power is not ready, temporary drop line must be made available. If site voltage is not any of the voltages listed above, customer must provide transformer and secondary circuit breaker to provide correct voltage and/or configuration.					
5. The complete MR System Digital Energy SG Series UPS 100 KVA (E4502FB) option requires 480 VAC, 3-phase, 4 wire + ground, 60 Hz input power.					
6. If the air-cooled cryocooler compressor option is selected, refer to Chapter 5, Air-Cooled Cryocooler Compressor Requirements and Specifications					

2 Critical Power Requirements

The facility shall provide a Main Disconnect Panel with Low Voltage Low Energy local and multi-point remote control capability in the feeder lines that supply input power to the Shield Cooler Compressor Cabinet and the Power Distribution Unit (PD1).

Table 6-2: Critical Power Requirements

Parameter	Requirements
Configuration	<ul style="list-style-type: none"> Recommend input configuration 3 phase solidly Grounded WYE with Neutral and Ground (5 wire system). Note: Neutral must be terminated prior to or inside the Main Disconnect Panel Optional input configuration 3 phase DELTA with Ground (4 wire) input, recommend corner Grounded Delta configuration.
Frequency	50 ± 3 Hz or 60 ± 3 Hz
Regulation	4% maximum at system maximum power demand (averaged over 5 seconds) from source to PDU (i.e. includes all feeders and transformer to utility)
Phase Balance	Difference between the highest phase line-to-line voltage and the lowest phase line-to-line voltage must not exceed 2%
Daily Voltage Variation	10% from nominal under worst case line and load regulation
PDU Voltage	200/208/380/400/415/480 VAC 10%
Shield/Cryo Cooler Compressor Voltage	380/400/415 VAC 50 Hz or 460/480 VAC 60Hz
Coldhead MRCC Voltage	380/400 VAC 10% 50 Hz or 460/480 VAC 10% 60Hz
Magnet Monitor equipment Voltage	100/120 or 200/220 VAC
Voltage Transients	Phase-to-phase voltages must be within 2% of the lowest phase-to-phase voltage. Maximum allowable transient voltage above or below nominal waveshape not to exceed 200 V at a maximum duration of 1 cycle and frequency of 10 times per hour.
Facility Zero Voltage Reference Ground	<ul style="list-style-type: none"> Main facility ground conductor to Main Disconnect Panel (MDP) must be copper Main facility ground wire must be insulated Ground impedance to earth at power source must be 2 ohms or less Main facility ground wire must be bonded at every distribution box in an approved grounding block
Maximum Momentary Demand	<p>The power demands specified as a function of the duration of the power demand. Table 6-3 lists peak power demands.</p> <p>The power system feeding the Signa system must be designed to meet the specifications of less than 4% regulation when loaded at the 5.0 second allowable consumption. For short intervals the Signa system power demands can exceed the 5.0 second value and the line voltage delivered to the system will sag below the 4% regulation. The Signa system is designed to tolerate these short voltage sags.</p>
Average (while scanning) Power Demand	57.1 kVA consisting of 48.1 kVA for PDU and 9kVA (continuous operation) for Shield/Cryo Cooler Cabinet.
Standby (no scan) Power Demand	13.4 kVA at 0.9 lagging Power Factor including 4.4 kVA for PDU and 9kVA (continuous operation) for Shield/Cryo Cooler Cabinet.

Table 6-3: System With BRM Coil Peak Power Demand

System Equipment (See Note 1)	Power Demand
PDU draw for 5.0 sec	~61.2 kVA

System Equipment (See Note 1)	Power Demand
PDU draw for 1.0 sec or less See Note 2	~65 kVA
Shield/Cryo Cooler Compressor	9 kVA
TOTAL for 5.0 sec	~70.2 kVA
TOTAL for 1.0 sec or less	~74 kVA
Notes	
1. MRCC option for Shield/Cryo Cooler Compressor water cooling or Customer provided water cooling equipment power demands are not included in the values in this table. The GE pre-engineered MDP option (E4502SP) option does not support the MRCC. Customer is responsible for the power requirements of water cooling equipment power demands.	
2. The PDU draw on the line will not exceed list values. The HFD Power Supply may provide up to 170 kVA for 0.003 seconds from supply internal capacitance but the supply will recharge capacitors at a power level less than 65 kVA.	

3 Power Distribution System

3.1 Main Disconnect Panel (MDP) Requirements

**WARNING**

PERSONNEL INJURY OR EQUIPMENT DAMAGE
CUSTOMER SUPPLIED MAIN DISCONNECT PANEL DESIGN MUST HAVE
CORRECTLY SIZED WIRES AND RATED COMPONENTS TO MEET THE MR
SYSTEM POWER REQUIREMENTS.

**WARNING**

IF AN UNINTERRUPTIBLE POWER SUPPLY (UPS) PROVIDES POWER TO THE
ENTIRE MR SYSTEM THEN THERE IS A NEED TO MAKE SURE THE UPS
OPERATION PARAMETERS ARE COMPATIBLE WITH THE SIGNA SYSTEM
POWER AND REGULATION DEMANDS.

**WARNING**

THE MDP CIRCUIT FOR THE SHIELD COOLER COMPRESSOR CABINET
AUTO RESTART FUNCTION MUST BE CONTROLLED BY THE EMERGENCY
OFF FUNCTION.

3.1.1 System MDP

1. Required Main Disconnect Panel shall consist of two three-pole, 600 VAC circuit breakers trip rated for the appropriate current. The short-circuit current interrupting rating of the breaker must be sized to accommodate fault current available.
2. The MDP circuit breaker for lines providing power to Shield/Cryo Cooler Compressor and PDU must be capable of handling the magnetizing inrush current of the Shield/Cryo Cooler Compressor and transformer of the PDU module (PD1) in the HFD/PDU Cabinet (MR3).
3. The MDP circuit for the PDU shall have an undervoltage device that automatically trips the breaker when the applied coil voltage drops to a specific percent of the rated value.
4. The MDP circuit for the Shield Cooler Compressor Cabinet shall provide auto restart upon return of normal power to maximize proper uninterrupted magnet operation and to minimize cryogen consumption of the system.
5. If the air-cooled cryocooler compressor option is selected, refer to [Chapter 5, Air-Cooled Cryocooler Compressor Requirements and Specifications](#)
6. Main Disconnect Panel is to be located so the panel is visible to Power Distribution Unit (PD1) service personnel. Panel position above the floor must be per National Electric Code (NEC) 2005 or 2002 Article 404.8 or other national or local code.
7. A recommended method for providing a Main Disconnect Panel with multi-point remote control capability is shown in [Illustration 6-1](#).
8. Time delay fuses are recommended on the lines providing power to the protective disconnect device and must be rated according to the cable size. The circuit breaker ahead of the fuses

- must be capable of handling the magnetizing inrush current values of the Shield Cryo Cooler Compressor and transformer of the PDU module (PD1) in the HFD/PDU Cabinet (MR3).
9. Check local and national codes to determine if an interlock to the air-conditioning unit in the Equipment Room is required in the protective disconnect setup.
 10. The GE Healthcare MDP option provides two Emergency Off buttons to be connected to the MDP to disable the power to all system equipment in emergency situations. Two Emergency Off buttons must be provided by the customer if GE Healthcare MDP Option is not used. The Emergency Off buttons are to be mounted near each exit in the Magnet Room and Equipment Room at a height specified by local/national codes and connected to the protective disconnect device in order to disable the power to all MR system equipment in emergency situations. The Emergency Off buttons are to be clearly labeled "Emergency Off" and visible to personnel. It is important the buttons are labeled "off" and not "stop" since there exists an "Emergency Stop" button in the Signa system which powers down only a portion of system equipment for patient safety.
 11. Customer supplied MDP must be lockable to meet OSHA requirements for power Lockout/ Tagout requirements. The optional GE Healthcare MDP provides for the disconnect of the facility power to the PDU, including the emergency off buttons, contacts for an interlock to the air-conditioning units in the Equipment Room, and the Shield Cooler Compressor Cabinet power circuit with auto restart and emergency off functions.
 12. The MDP must be listed and labeled by a Nationally Recognized Testing Lab (NRTL) such as Underwriters Laboratory (UL) in accordance with NEC 2005 or 2002 Article 110.2. The GE Healthcare MDP option is UL labeled in accordance with NEC 2005 or 2002 Article 110.2 and is cUL and CE labelled. A customer designed and manufactured MDP labeling must bear the appropriate markings per local/national regulations.
 13. The maximum conductor the GE Healthcare MDP can accept is #3/0 AWG (83 mm²). For feeders larger than 3/0 AWG (83 mm²) the wires must be reduced (ie. splice, junction box, etc.) to 3/0 AWG (83 mm²) within 10 feet (3 meters) of MDP. It is important to note the maximum cable wire from the MDP to the PDU must not be larger than 2/0 AWG (70 mm²).

3.2 Power Distribution Unit (PDU) Requirements

The Power Distribution Unit (PDU) is located in the lower section of the HDF/PDU cabinet (MR3) and has the following requirements:

1. The largest allowable phase conductor the PDU will accept is 3/0 AWG (83 mm²). Larger feeder wires can be connected to the MDP with 3/0 AWG (83 mm²) between the MDP and PDU
2. The ground conductor between the MDP and PDU must be at least 1/0 AWG copper (or the same size as the feeder wire) whichever is larger. Lug connector for the ground wire must be provided by the contractor (recommended Amp Inc. number 36919 lug)
3. The resistance between any two grounded devices in the MR system (e.g., PDU and MDP) must not exceed 0.1 ohm
4. Neutral, if present, must be terminated prior to or inside the Main Disconnect Panel (MDP) and not brought to the PDU Module in the HFD/PDU Cabinet (MR3)
5. When the full MR system UPS option [Signature 5000 Series 3 UPS 100KVA (E4502FB)] is installed, the feeder wiring from the UPS to the PDU Module must be sized to maintain voltage regulation of <5% at 100KVA.

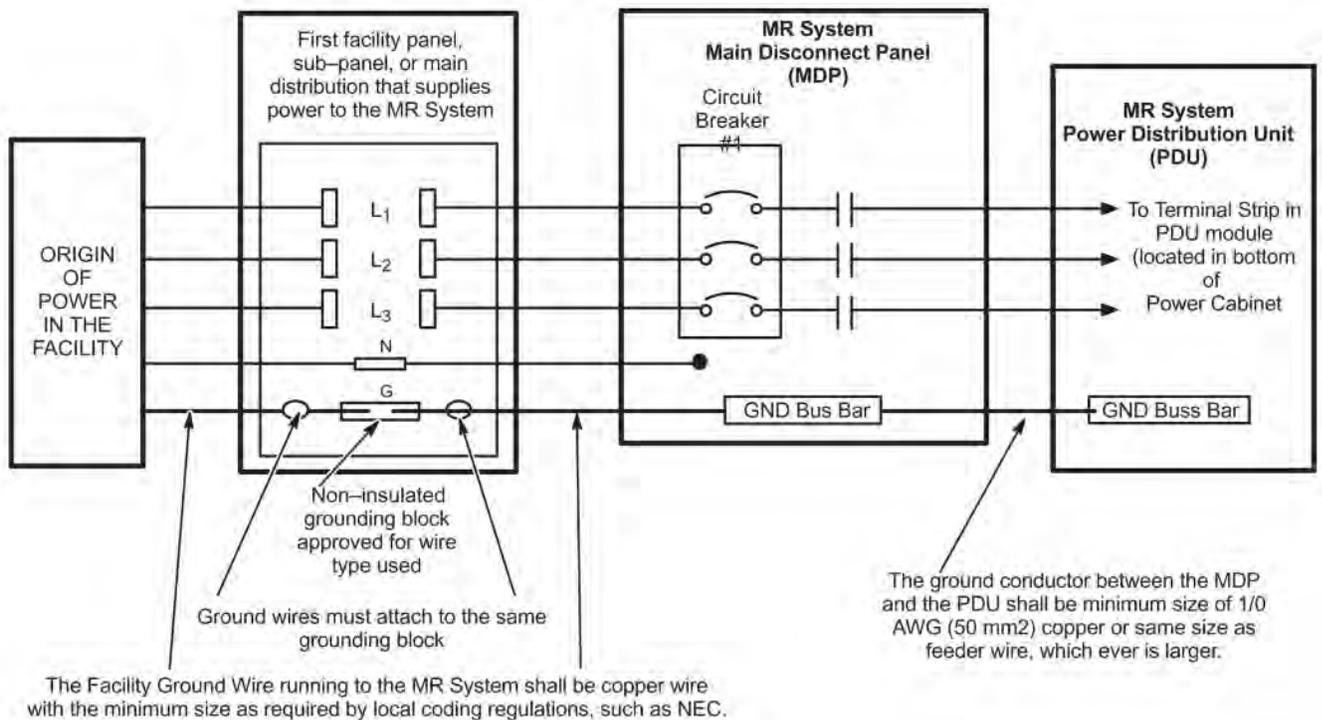
4 Grounding

4.1 Facility Ground

The ground for the MR system shall originate at the system power source, ie. transformer or first access point of power into the facility, and be continuous to the MR system Main Disconnect Panel (MDP) in the room. This ground can be spliced with "High Compression Fittings" and should be terminated at each distribution panel it passes through. When it is broken for a connection to a panel, it shall be connected into an approved non-insulated grounding block with the incoming and outgoing ground in this same grounding block, which is then connected to the steel panel, never using the steel or other material of the panel as the block. See [Illustration 6-2](#).

The connection at the power source shall be at the grounding point of the "Neutral - Ground" if a "Wye" transformer is used, or typical grounding points of separately derived system. In the case of an external facility, it shall be bonded to the facility ground point at the service entrance.

Illustration 6-2: Ground Wire To MR System & Ground Connection At Distribution Panel



Ground Wire

The main facility ground conductor to the MDP shall be copper wire and the minimum size as required by the local coding regulations, such as the NEC. A dedicated copper ground wire the same size as the feed wires or 1/0 AWG (which ever is larger) must be run from the MR system MDP to the PDU. See [Illustration 6-2](#). The ground wire impedance from the MR system disconnect, including the ground rod, shall not have an impedance greater than 2 ohms to earth as measured by one of the applicable techniques described in Section 4 of ANSI/IEEE Standard 142 - 1982 which can be accomplished using 3-point Fall Of Potential (3 point measurement) method or

Clamp-On Ground Resistance measurement which requires a ground measurement device such as AEMC 3730.

4.2 System Ground

The MR system is designed with minimum ground loops to prevent noise currents and natural disturbances from flowing through the low-level signal reference path.

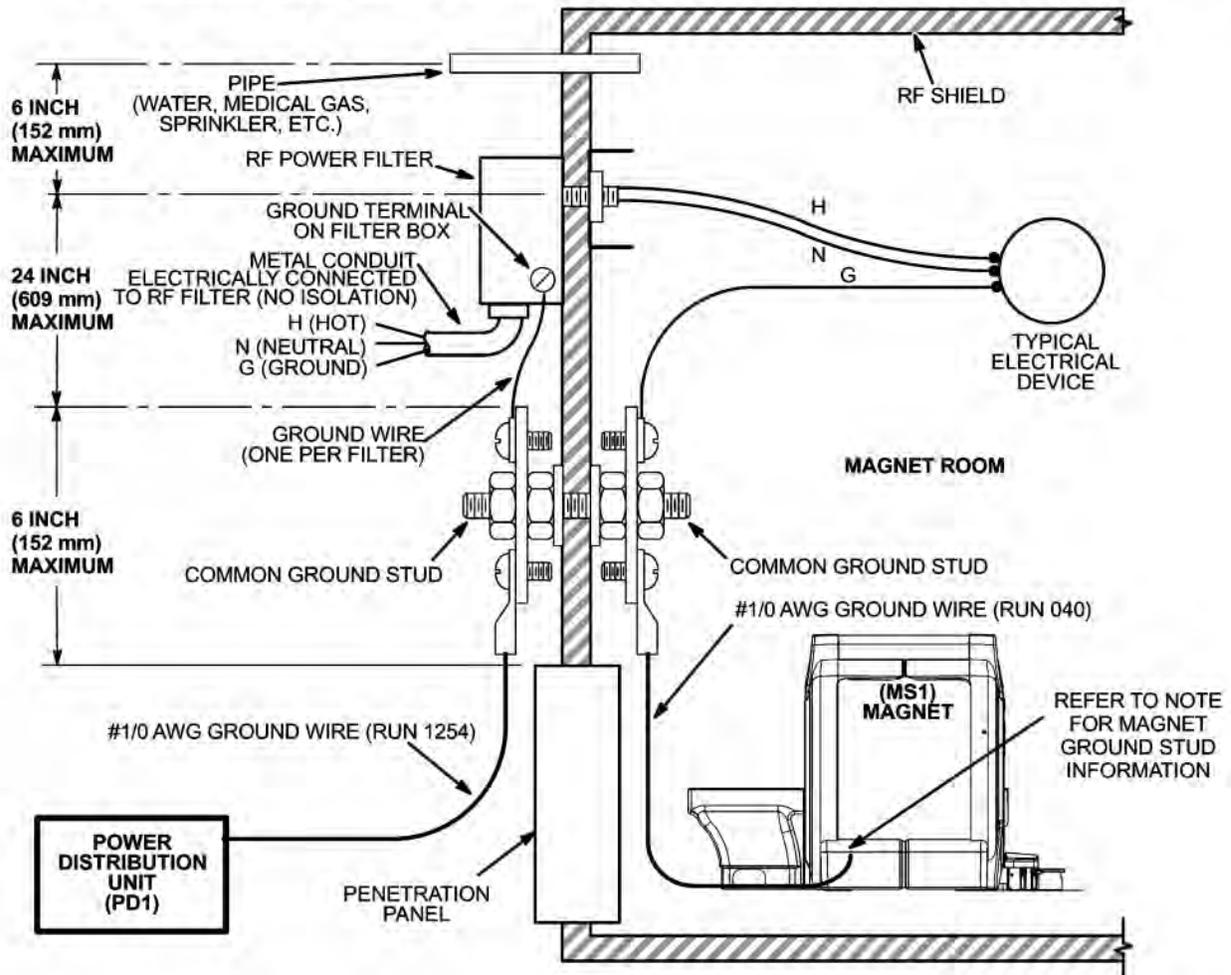
The three major grounding points in the MR system are: the system ground point (bus) in the System PDU (PD1), the enclosure ground points (ground studs located in each cabinet or enclosure), and the RF shielded room common ground point. This RF shielded room common ground point is to be located within 6 in. (152 mm) of the GE supplied Penetration Panel. Refer to [Chapter 11, Electrical](#) for a further description of the RF shielded room common ground point.

To ensure patient safety and system performance, the conditions defined in [Illustration 6-3](#) must be met when running power lines into the Magnet Room.

Any modifications or non-MR equipment grounds added to the MR ground system must be approved by your GE Service Representative in order to ensure safety and performance.

Illustration 6-3: MR Magnet Room Grounding Requirements And Typical Diagram

- NOTE:**
- ALL ITEMS SHOWN ARE CUSTOMER SUPPLIED EXCEPT POWER DISTRIBUTION UNIT, MAGNET, AND ONE #1/0 AWG GROUND WIRE BETWEEN MAGNET GROUND STUD AND RF COMMON GROUND POINT AND ONE #1/0 AWG GROUND WIRE BETWEEN PD1 AND RF COMMON GROUND POINT.
 - **RESISTANCE BETWEEN ANY TWO GROUNDED DEVICES MUST NOT EXCEED 0.1 OHM TO ENSURE EQUAL POTENTIAL GROUND SYSTEM WITHIN MAGNET ROOM.**
 - **LOCATE FILTERS WITHIN 2 FEET (600 mm) OF RF COMMON GROUND STUD WHICH MUST BE LOCATED WITHIN 6 INCHES (152 mm) OF PENETRATION PANEL.**
 - ALL EXTERNAL CONDUIT MUST BE **METAL AND ELECTRICALLY CONNECTED** TO THE RF POWER FILTERS (REGARDLESS OF FILTER VOLTAGE) PER NEC 2005 OR 2002 ARTICLE 250.110.
 - RF POWER FILTERS OF 30 VOLTS OR LESS MAY BE LOCATED ANYWHERE ON THE RF SHIELD **PROVIDED THE INCOMING CONDUIT IS METALLIC** PER NEC 2005 OR 2002 ARTICLE 725.21, **THESE FILTERS MUST ALSO BE LOCATED WITHIN 24 INCHES (609 mm) OF THE RF COMMON GROUND STUD .**
 - ALL CONDUITS IN THE RF ROOM MUST BE **METAL**. STEEL IS ACCEPTABLE PROVIDED IT IS ADEQUATELY ANCHORED PER NEC 2005 ACTICLE 517.13 (A) & (B).
 - ALL ELECTRICAL DEVICES (IE. OUTLETS, LIGHT FIXTURES, ETC.) MUST HAVE A GROUND WIRE FROM ITS POWER SOURCE AND BE GROUNDED TO RF ROOM SHIELD AT THE RF COMMON GROUND STUD AS SHOWN BELOW.
 - ALL METALLIC PIPES ENTERING THE RF ROOM, EXCLUDING CRYOGENIC VENT AND FLOOR DRAINS, MUST BE LOCATED WITHIN 30 INCHES (762 MM) OF THE RF COMMON GROUND.
 - LCC MAGNET HAS 4 GROUND STUDS, ONE ON EACH FOOT. HOWEVER, THERE IS ONLY ONE #1/0 AWG GROUND WIRE TO BE CONNECTED TO ONLY ONE OF THE GROUND STUDS.



5 Ground Fault Protection

MR suites and radiology departments are considered health care facilities pursuant to National Electric Code (NEC) 2005 or 2002 Article 517.2 definitions and as such must be powered from sources that comply with the ground fault requirements of NEC Article 517.17. NEC 2005 Article 517.17 (B) or NEC 2002 Article 517.17 (A) states "Where ground fault is required for the operation of the service disconnecting means or feeder disconnecting means as specified in NEC 2002 Article 230.95 or 215.10, an additional step of ground fault protection shall be provided in the next level of feeder disconnecting means downstream towards the load."

NEC 2005 or 2002 Article 230.95 or 215.10 requires ground fault protection on service disconnecting means rated 1000 Amps or more on solidly grounded WYE services over 150 volts to ground but not over 600 volts phase to phase.

The two or more levels of ground fault shall be coordinated to provide selectivity between each level of ground fault such that a ground fault on the load side of the feeder would cause the feeder and not the service disconnect to open on a ground fault. Six cycles of separation between the different levels of ground fault tripping is required for the system to be considered selective in accordance with NEC 2005 Article 517.17 (B) or NEC 2002 Article 517.17(B).

Check national and local electrical codes.

6 Power Source Monitoring

The facility input power for the proposed system should be checked using a power line disturbance monitor for average line voltage, surges-sags, impulses, and frequency. Some of the recommended line analyzers which are designed for unattended monitoring are the Dranetz Models 656A or 658 and RPM Models 1651, 1656, or 1658.

Analysis should span a period to include two weekends so as to cover several days of normal use. The possibility of "brown-out" conditions which may be experienced in summer must be considered. Any existing power problems with large power consuming systems (x-ray units, CT scanners, etc.) or other computer installations at the proposed site should be reviewed as they may affect the MR system. Results of this analysis should be reviewed with your GE representative to determine if line conditioning is needed.

7 Emergency Power

Primary power should be distributed from the customer's emergency life-safety power branch to an emergency lighting source in the Magnet Room. All input power lines must be filtered upon entrance into the RF shielded room (Magnet Room) and grounded according to the requirements listed under System Grounding heading in [Grounding](#). Always check national and local codes for other emergency power requirements.

8 DC Lighting Controller (Facility Option) Requirements

Direct current (DC) powered lighting is required in the Magnet Room per [Chapter 5, Lighting](#). A constant lighting level DC Light Controller is available from GE as well as a variable DC lighting controller system. The wiring diagrams for these units are shown in [Illustration 6-4](#) and [Illustration 6-5](#). The input power, interconnect cabling, RF shielded room filters, lighting fixtures, and conduit are customer furnished.

The DC lighting systems output is rated nominally 115 VDC. Determining whether the 20 or 28 Amp system is required can be calculated by: $I = \frac{\text{Total Lamp Wattage}}{115V}$. If $I \leq 20$ then a 20 Amp system can be used. If $I \geq 20$ but < 28 then use the 28 Amp system.

Illustration 6-4: DC Lighting Controller (Facility Option) Wiring Diagram

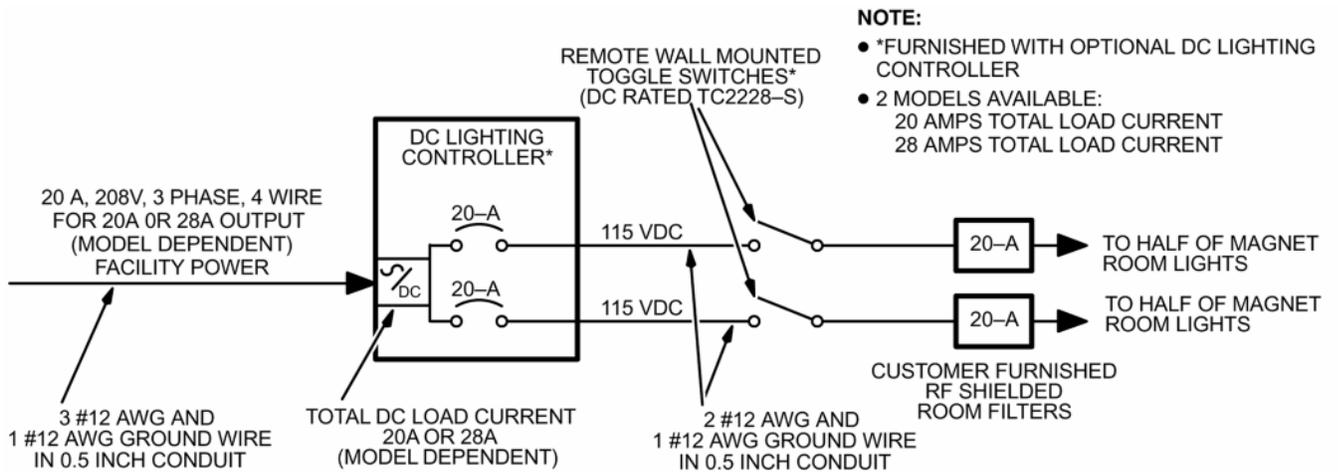
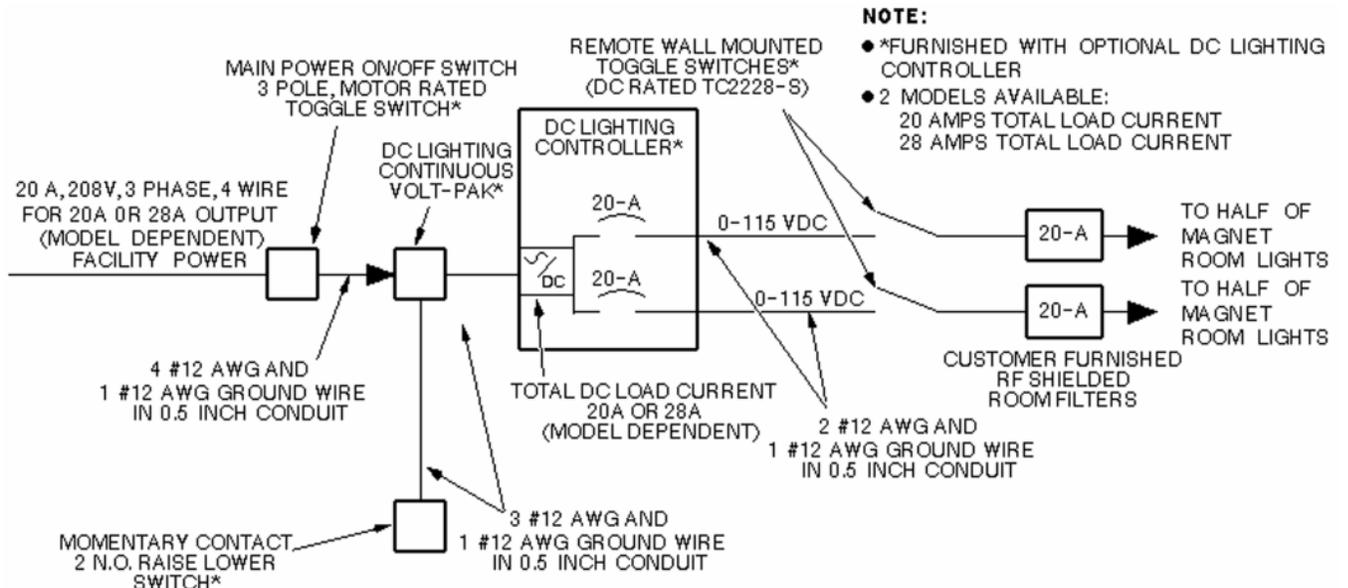


Illustration 6-5: Variable DC Lighting Controller (Facility Option) Wiring Diagram



See [Chapter 8, DC Lighting Controller Option](#) for equipment specifications.

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Chapter 7 Magnet Room

1 Magnet and Enclosure

Illustration 7-1: Magnet Enclosure Front and Rear Views

Note 1

Center of gravity is approximate and includes the GE Healthcare supplied VibroAcoustic Damping option, but does not include cryogenics, gradient assembly, side-mount electronics, or enclosures.

Center of gravity without the GE Healthcare supplied VibroAcoustic Damping option is 41.61 (1067)

Magnet and Rear Pedestal

All Dimensions are in inches
Bracketed dimensions are in millimeters

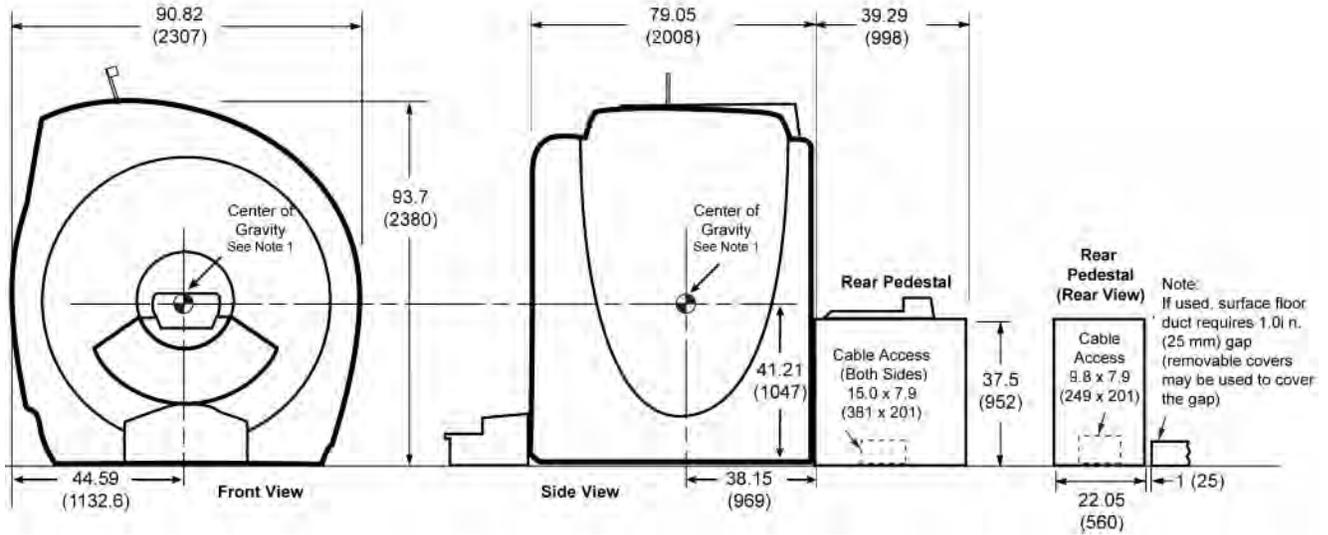
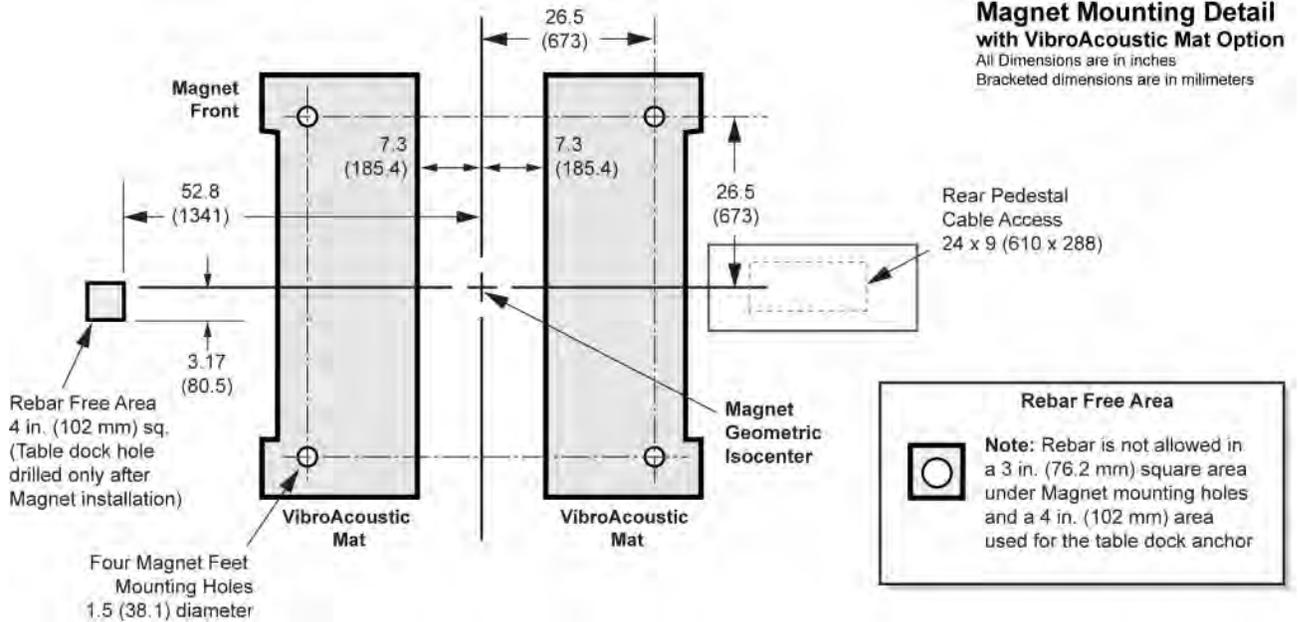


Illustration 7-2: Magnet Mounting Detail



2 Patient Transport Table

Illustration 7-3: Patient Transport Table

NOTE:

- ALL DIMENSIONS ARE IN INCHES
 ALL BRACKETED () DIMENSIONS
 ARE IN MILLIMETERS.
- APPROX. WEIGHT: 280 lbs (127 kg)
 630 lbs (286 kg) WITH 350 lbs (159 kg)
 PATIENT

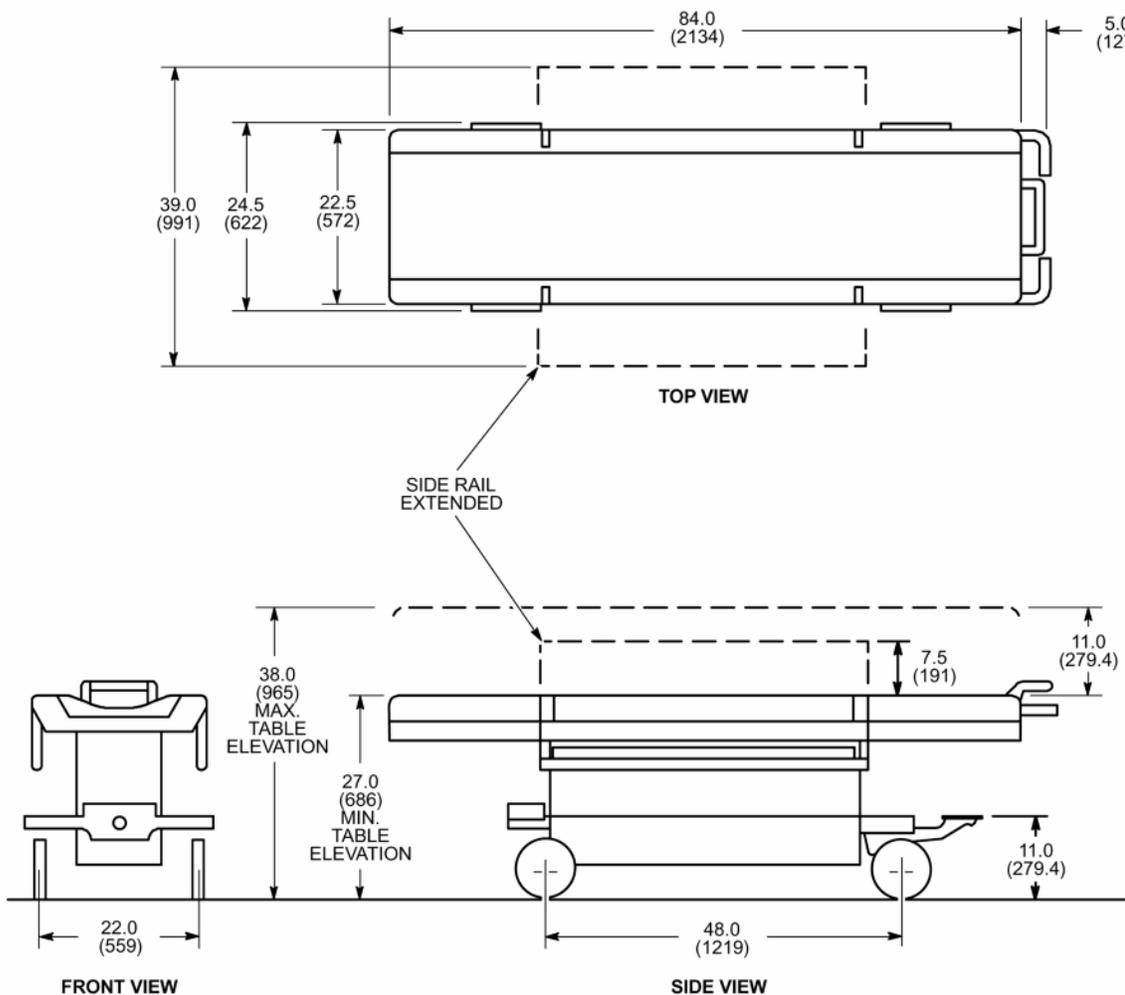
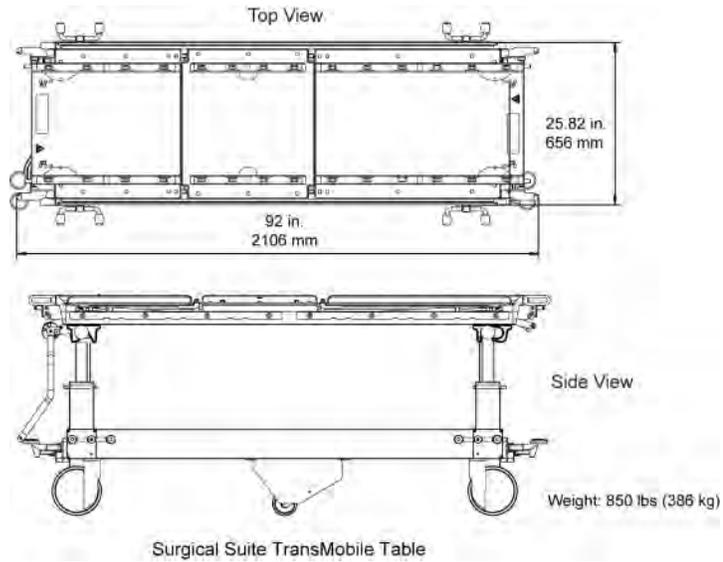


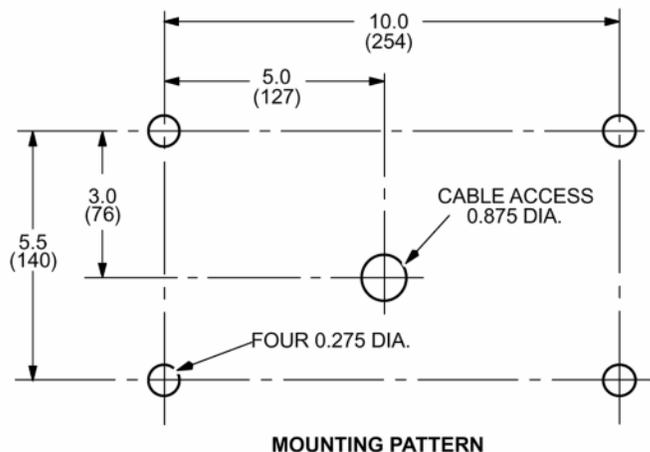
Illustration 7-4: Optional Surgical Suite TransMobile Table



3 Magnet Rundown Unit

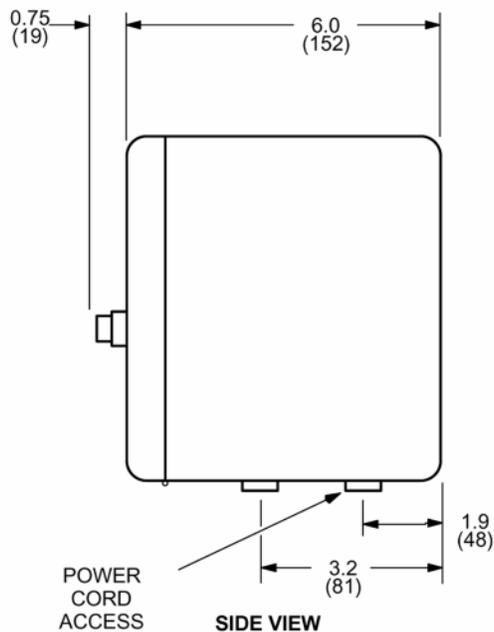
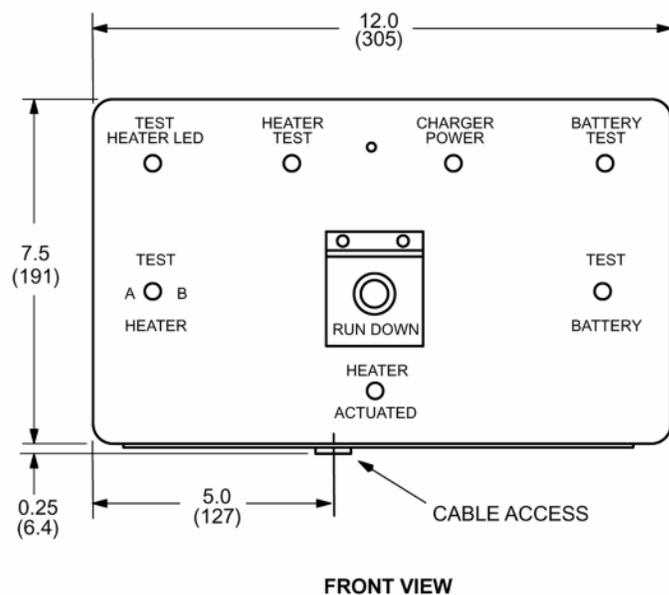
Magnetic Field Limit: 200 Gauss (20 mT)

Illustration 7-5: Magnet Rundown Unit (MS4)



NOTE:

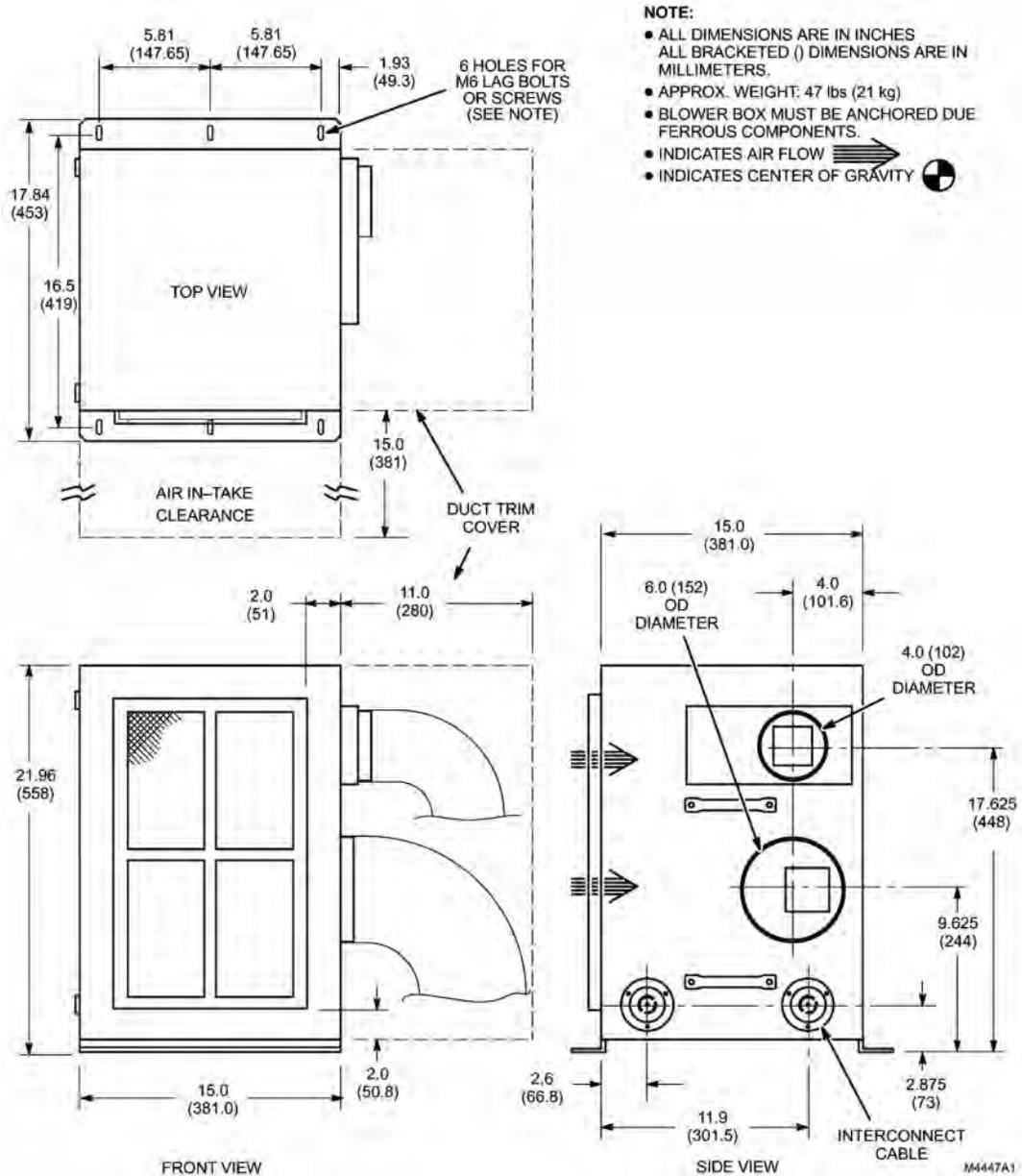
- ALL DIMENSIONS ARE IN INCHES. ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.
- APPROX. WEIGHT: 8.8 lbs. (4kg)



4 Blower Box

Magnetic Field Limit: 200 Gauss (20 mT)

Illustration 7-6: Blower Box (MG6)



5 Oxygen Monitor Option

1. Oxygen Monitor: Magnetic Field Limit: 100 Gauss (10 mT)
2. Remote Oxygen Monitor Sensor: Magnetic Field Limit: 200 Gauss (20 mT)

Illustration 7-7: Oxygen Monitor (OM1)

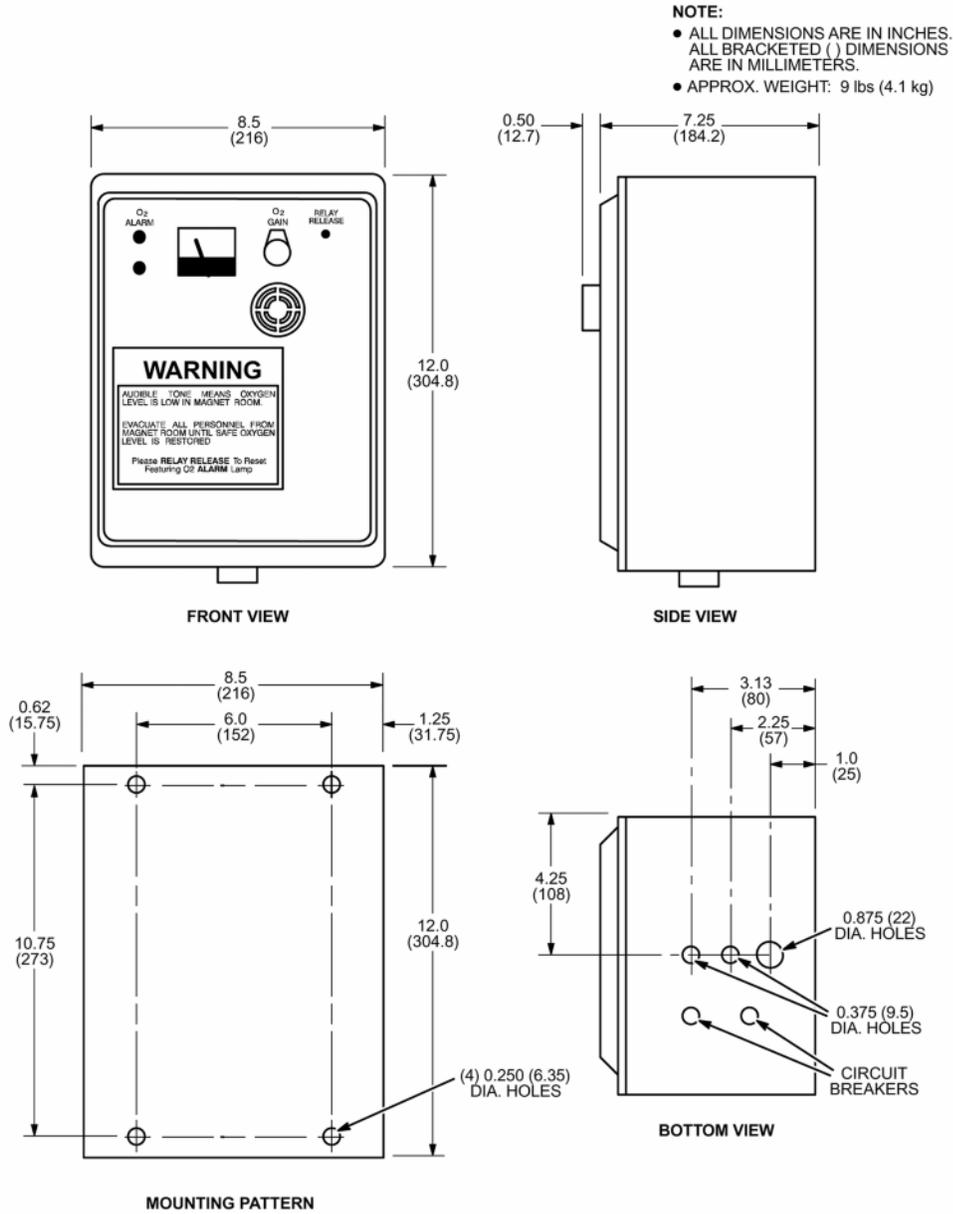
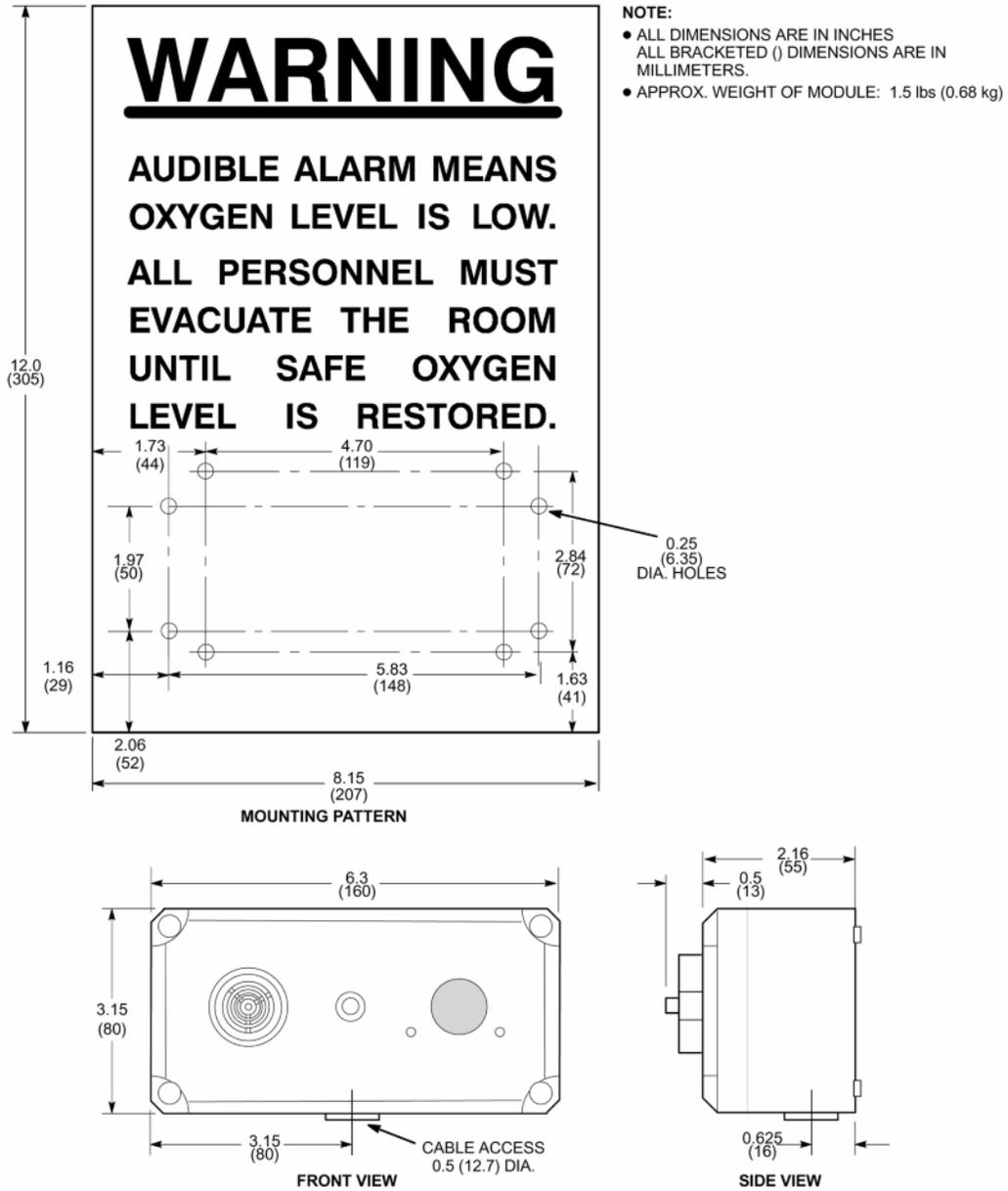


Illustration 7-8: Remote Oxygen Sensor Module (OM3)



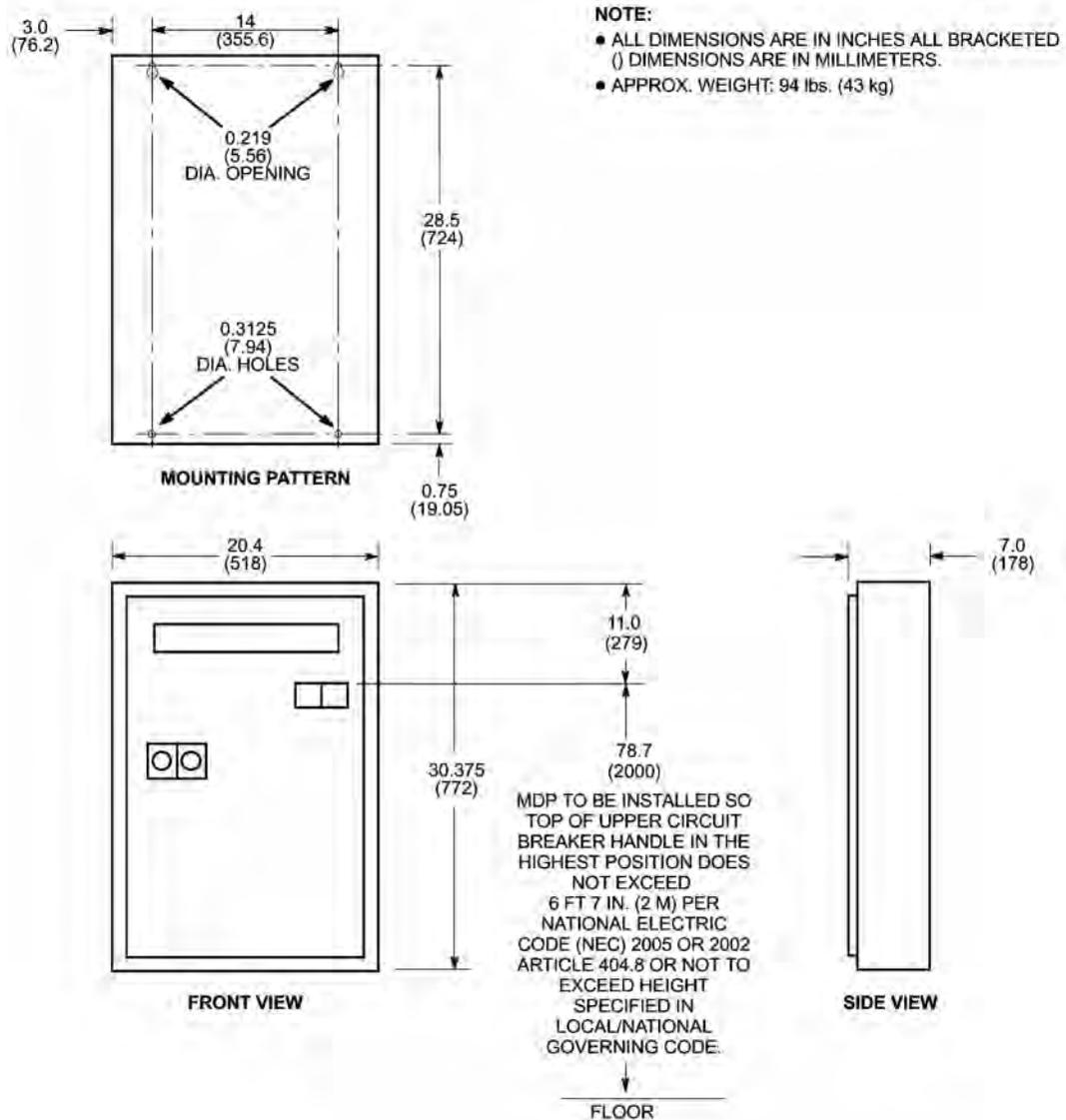
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Chapter 8 Equipment Room

1 Main Disconnect Panel

Magnetic Field Limit: 50 Gauss (5 mT)

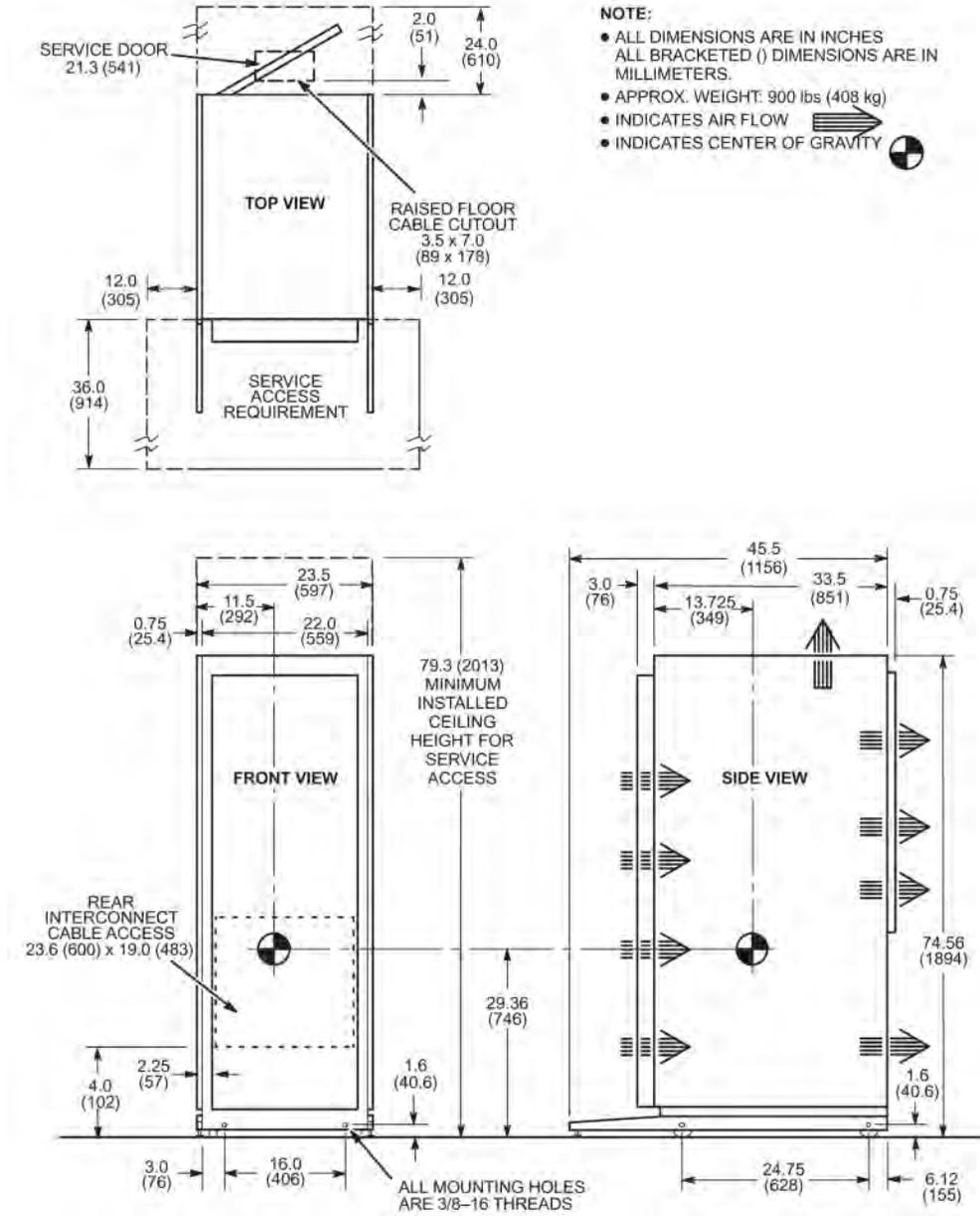
Illustration 8-1: Signa Main Disconnect Panel E4502SP Option



2 RFS Cabinet (MR2)

Magnetic Field Limit: 30 Gauss (3 mT)

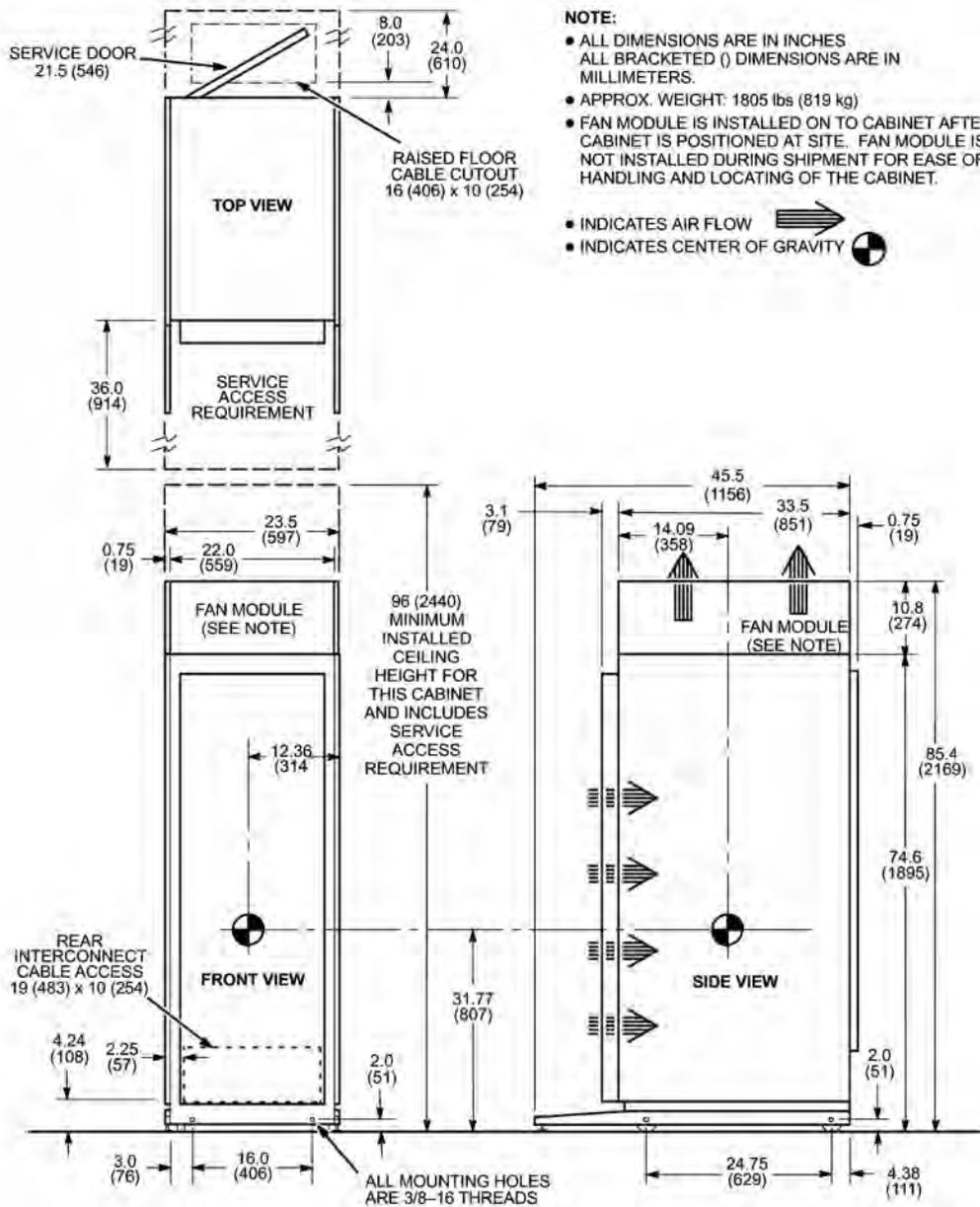
Illustration 8-2: HDxt 1.5T RFS Cabinet



3 HFD/PDU Cabinet (MR3)

Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 8-3: HFD/PDU Cabinet (MR3)



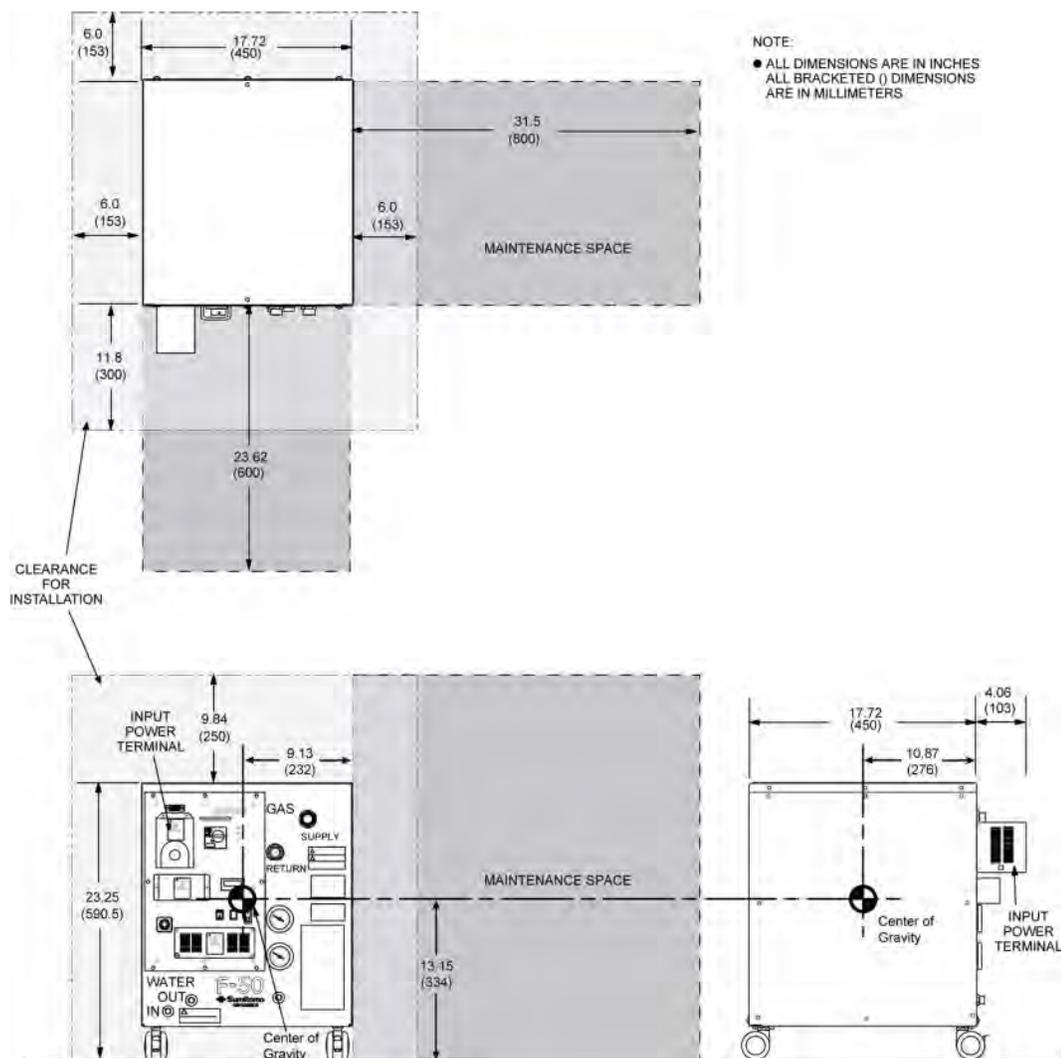
4 Cryocooler Compressor Cabinet

4.1 Water-Cooled Cryocooler Compressor

For water-cooling specifications and requirements, refer to [Chapter 5, Shield/Cryo Cooler Water Cooling For Site Provided Water Cooling](#).

1. Weight: 264 lbs (120 kg)
2. Magnetic Field Limit: 100 Gauss (10 mT)

Illustration 8-4: Water-Cooled Cryocooler Compressor



4.2 Air-Cooled Cryocooler Compressor

For additional air-cooled cryocooler specifications and requirements, refer to [Chapter 5, Air-Cooled Cryocooler Compressor Requirements and Specifications](#).

1. Weight:

- a. Cryocooler compressor: 309 lbs (140 kg)
 - b. Optional External Transformer : 225 (102 kg)
2. Magnetic Field Limit:
- a. Cryocooler compressor: 150 Gauss
 - b. Optional External Transformer : 100 Gauss

Illustration 8-5: Air-Cooled Cryocooler Compressor

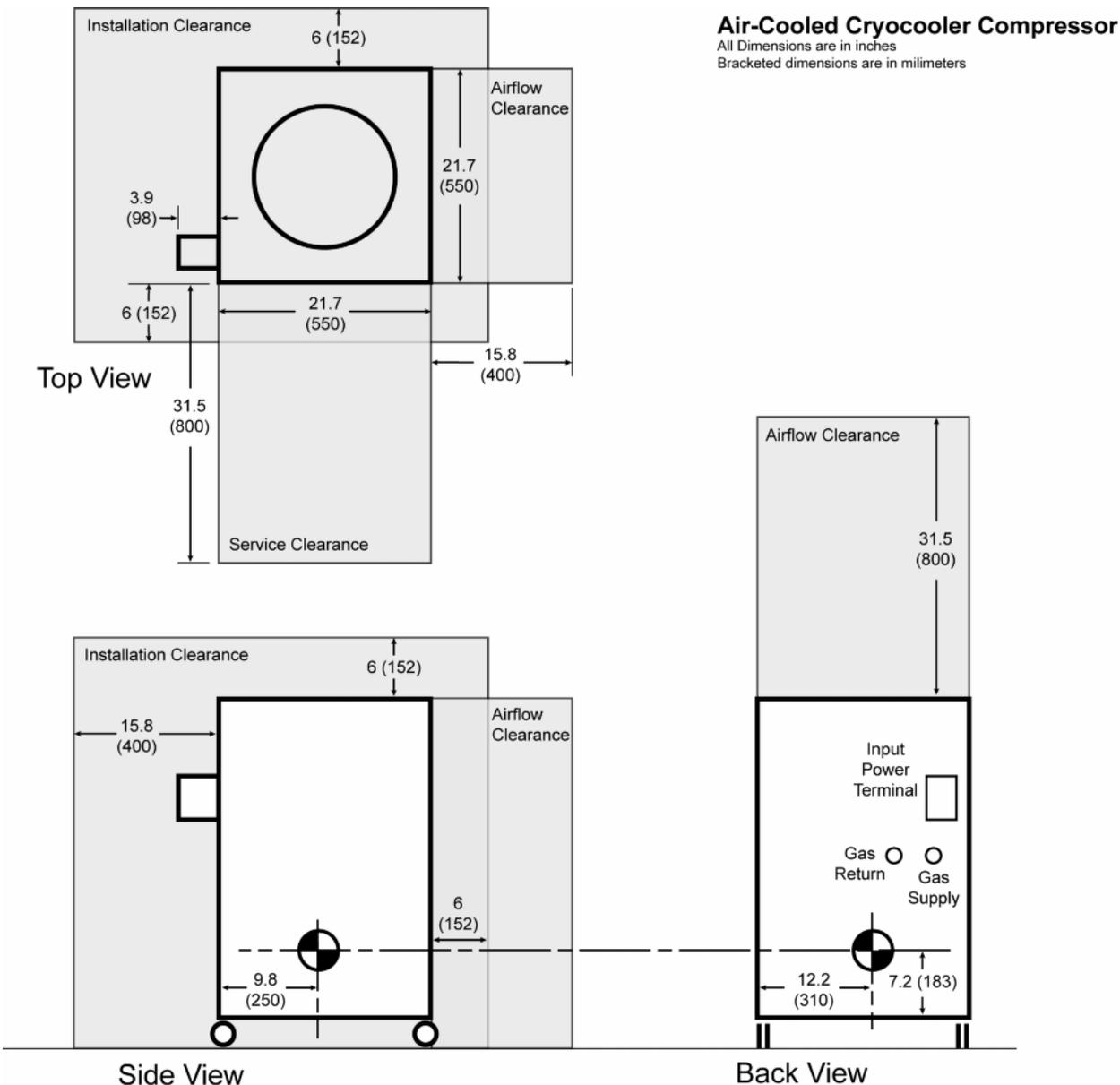
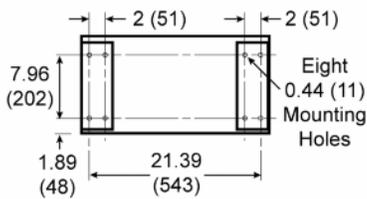
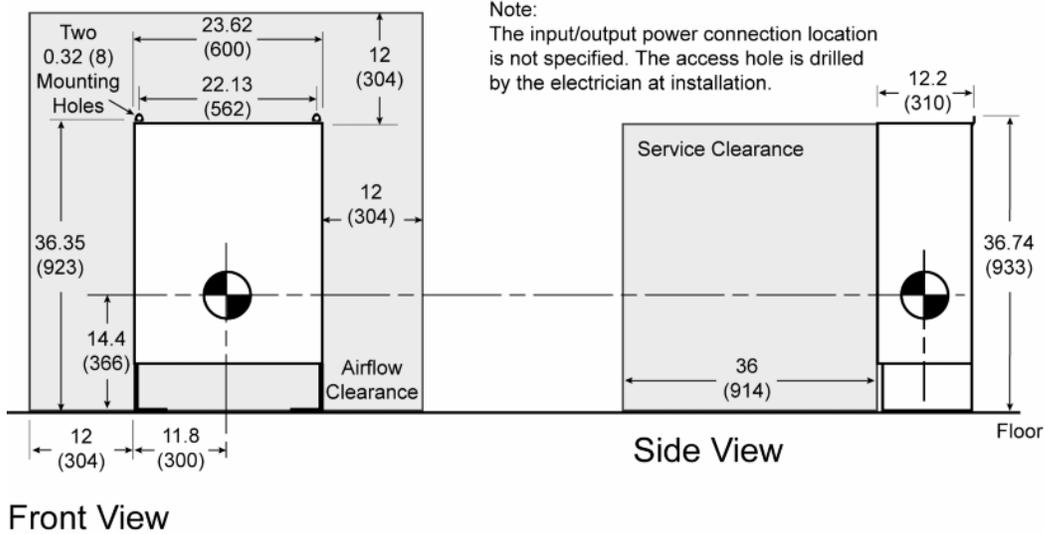


Illustration 8-6: Optional External Transformer

Air-Cooled Cryocooler Compressor Transformer

All Dimensions are in inches
 Bracketed dimensions are in millimeters



5 MR Common Chiller (MRCC)

Magnetic Field Limit: 30 Gauss (3 mT)

Illustration 8-7: MR Common Chiller

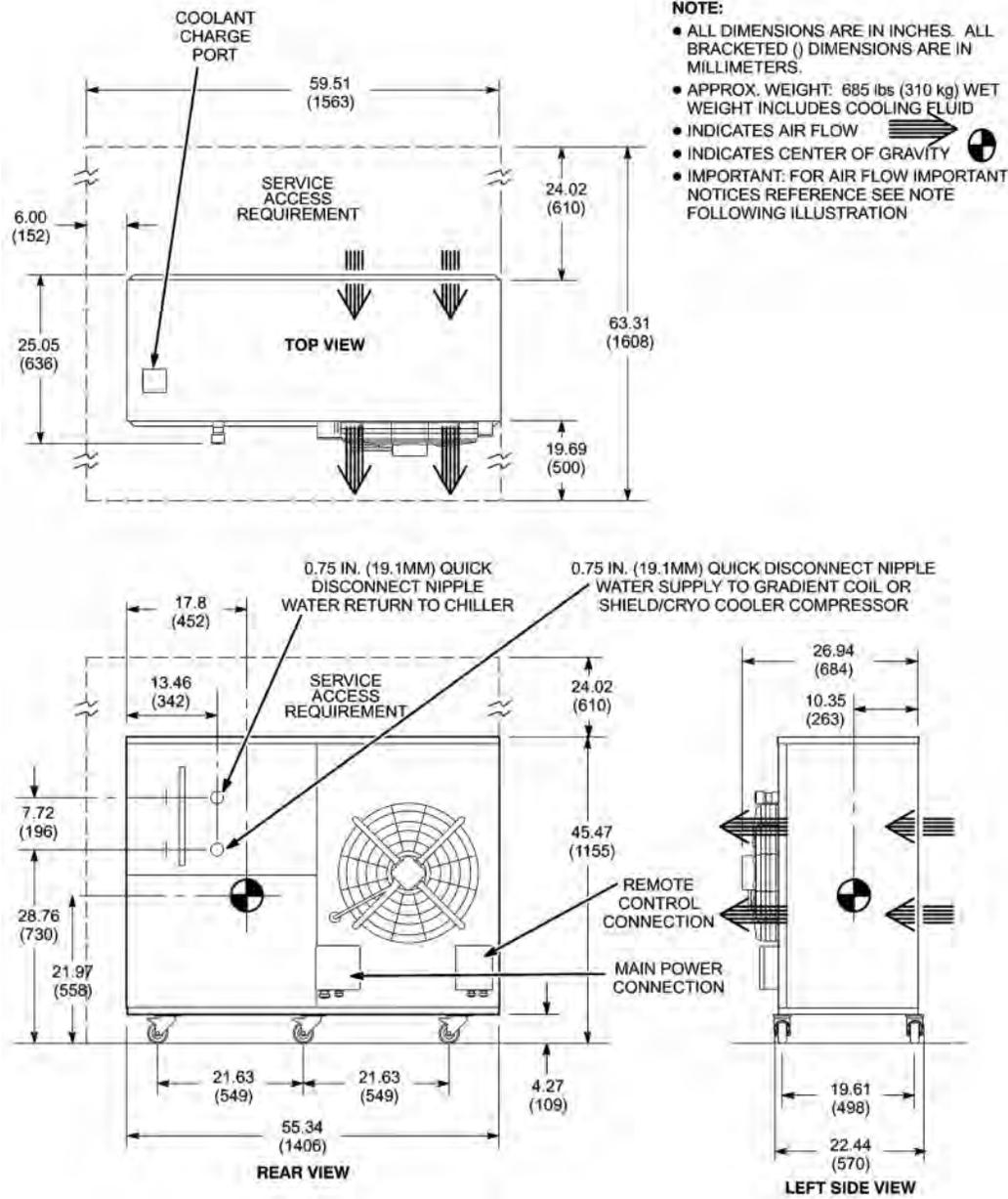
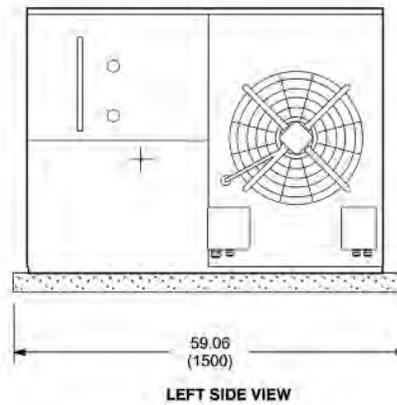
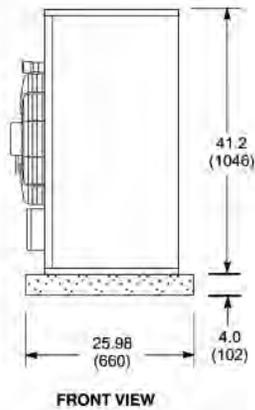
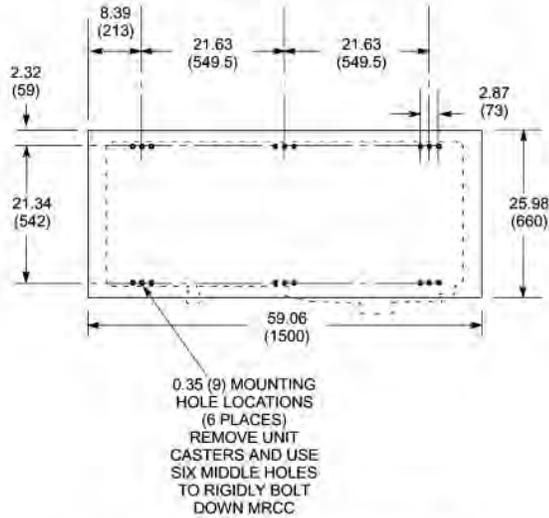


Illustration 8-8: MRCC Outdoor Mounting

NOTE:

- ALL DIMENSIONS ARE IN INCHES. ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.
- GROUND INSTALLATION: REMOVE UNIT CASTERS AND USE SIX MIDDLE HOLES TO RIGIDLY BOLT DOWN ON CONCRETE PAD. CONCRETE PAD MUST HAVE LEVEL SURFACE (1 CM OVER 300 CM) AND PROPERLY SUPPORTED TO PREVENT SETTLING, MINIMUM 4 INCH (101.6 MM) DEEP CONCRETE PAD OF 2500 PSI CONCRETE REQUIRED. THE CONCRETE FOOTING SHOULD MEET OR EXCEED LOCAL CODE REQUIREMENTS.
- ROOF INSTALLATION: REMOVE UNIT CASTERS AND USE SIX MIDDLE HOLES TO RIGIDLY BOLT DOWN THE MRCC ON LEVEL SURFACE 0.4 INCHES OVER 118 INCHES (1 CM OVER 300 CM) ON ROOF.



Restricting airflow into or out of the MRCC will affect performance. Ensure multiple MRCCs are configured with the minimum distances as shown below. Insufficient ventilation may increase condensing temperature and cause the pressure switch to trip. High winds may cause high pressure alarms. Units installed in extremely windy areas may require customer provided anti-wind shields.

Illustration 8-9: Required Configurations and Separation Distances for Multiple MRCCs

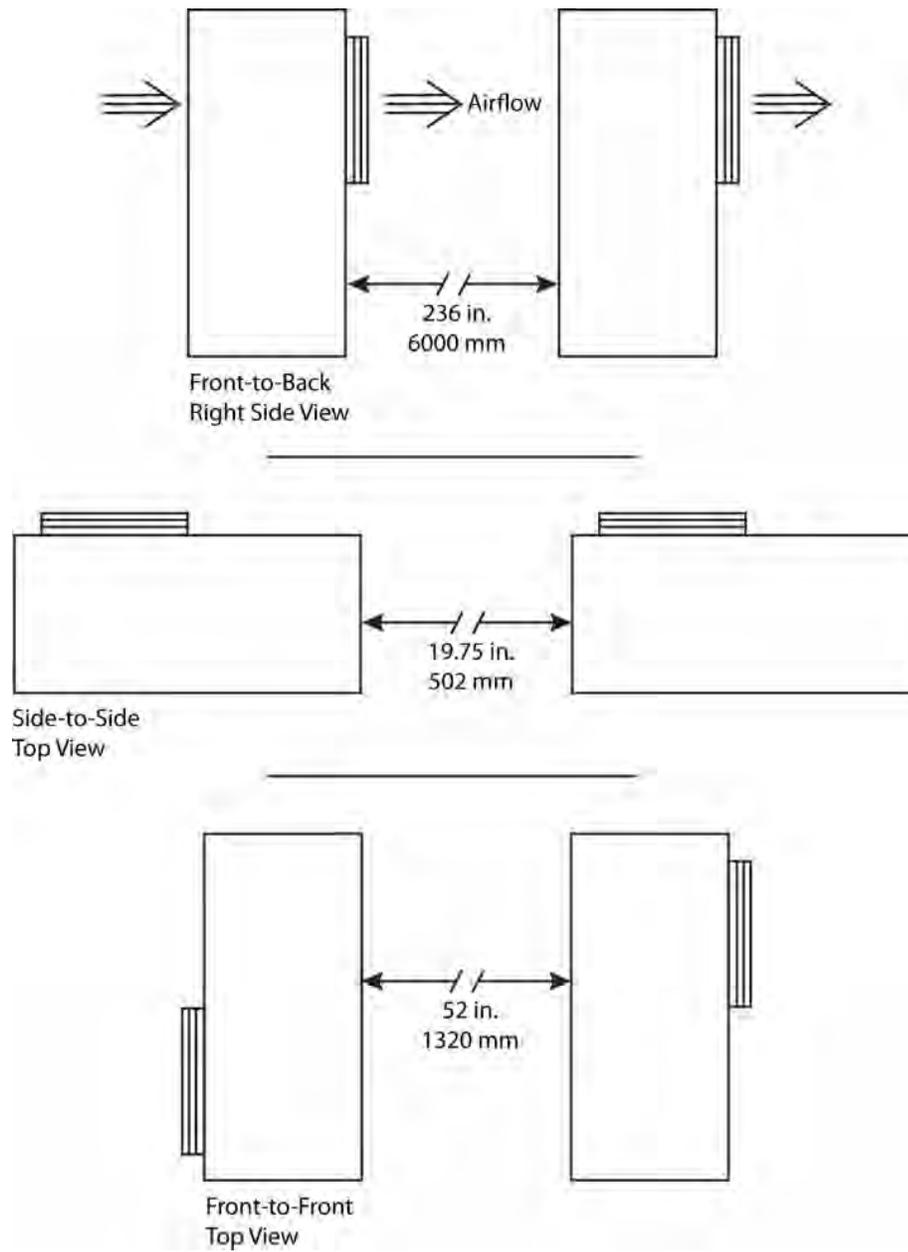
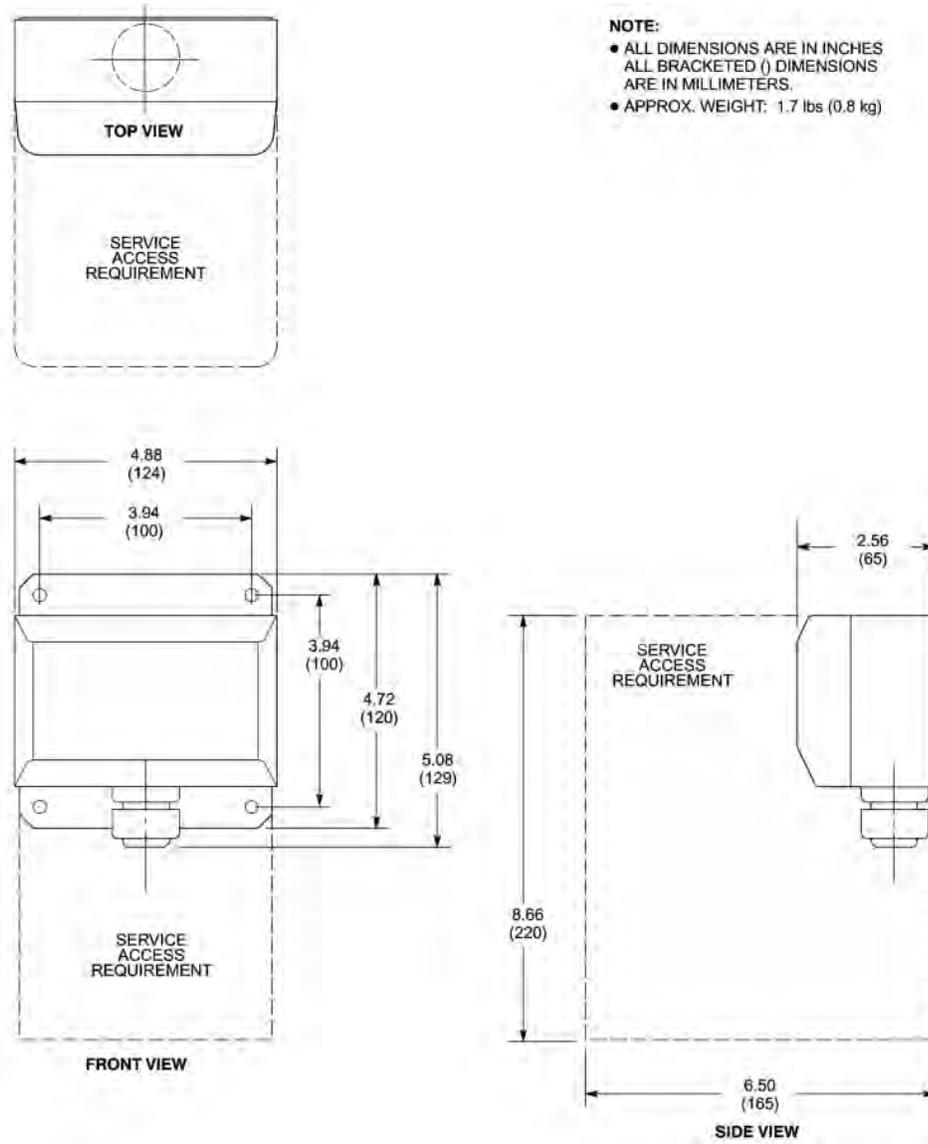


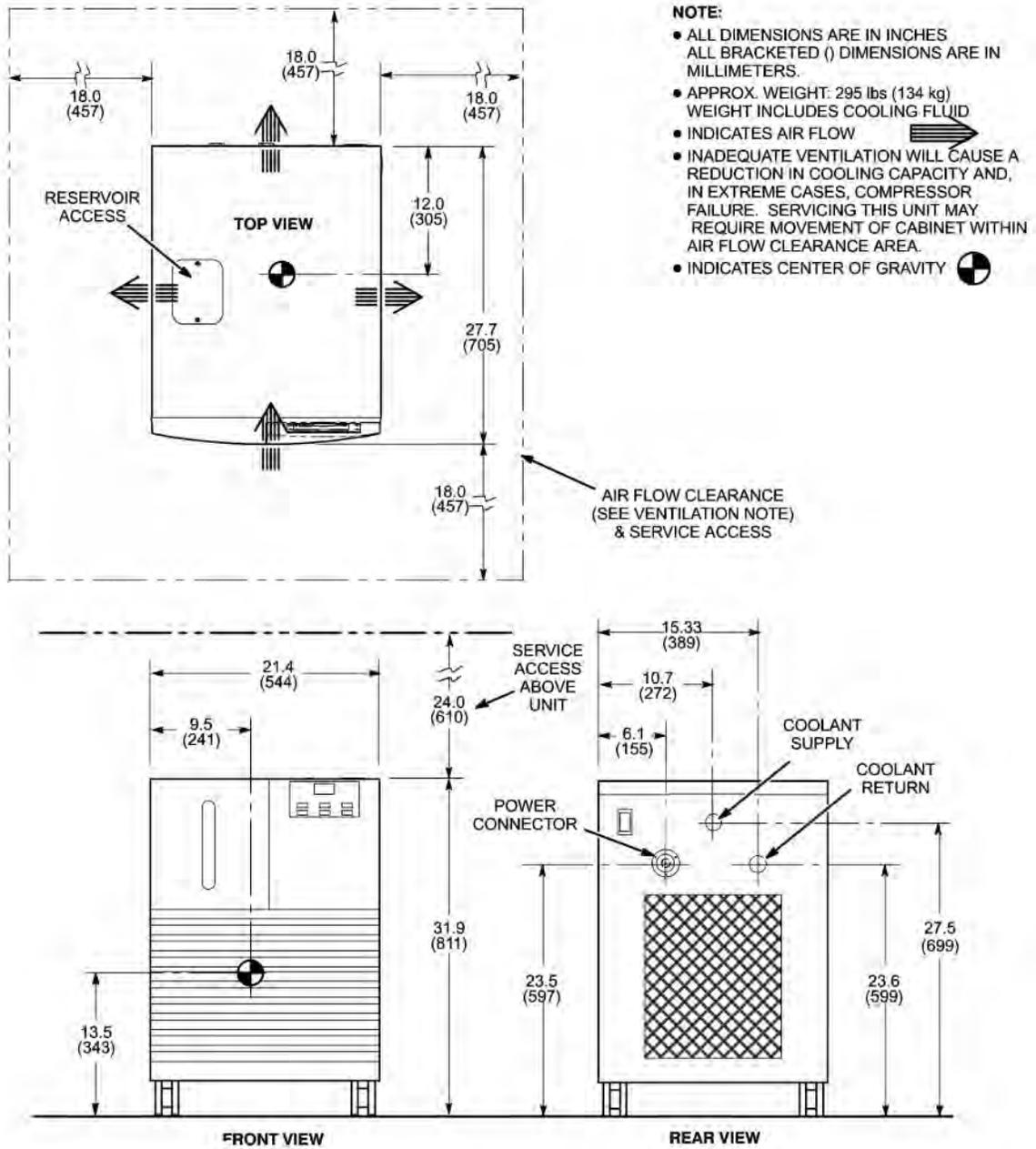
Illustration 8-10: Remote Control Panel (RCP) For MRCC



6 Water Chiller For BRM Gradient Coil Cooling Water

Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 8-11: Water Chiller (WC1) For BRM Gradient Coil Cooling Water



7 Penetration Panel

Magnetic Field Limit: 200 Gauss (20 mT)

NOTE: The entire Penetration Panel must be outside the 200 Gauss (20 mT) line.

Illustration 8-12: Penetration Panel (PP1)

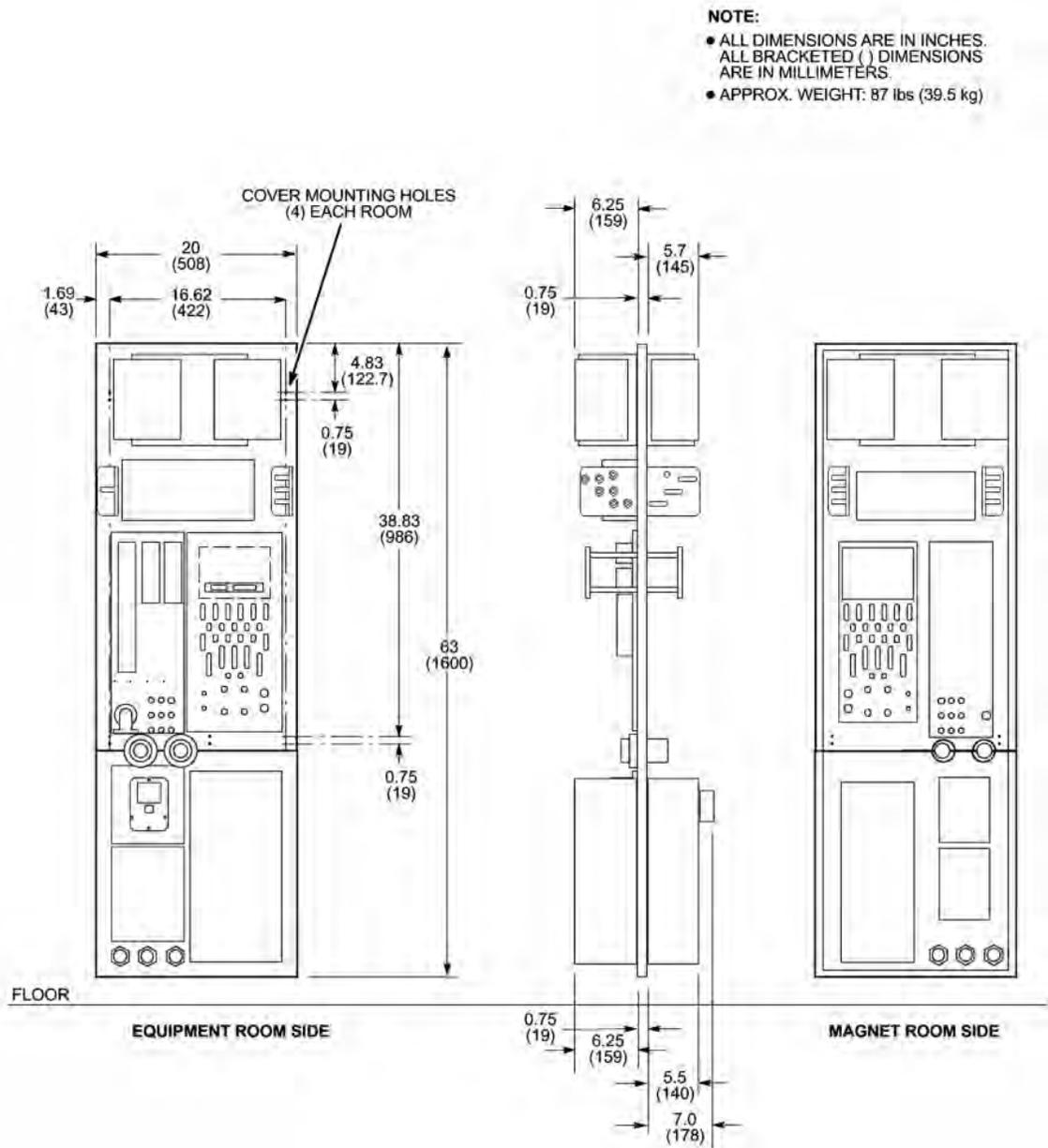
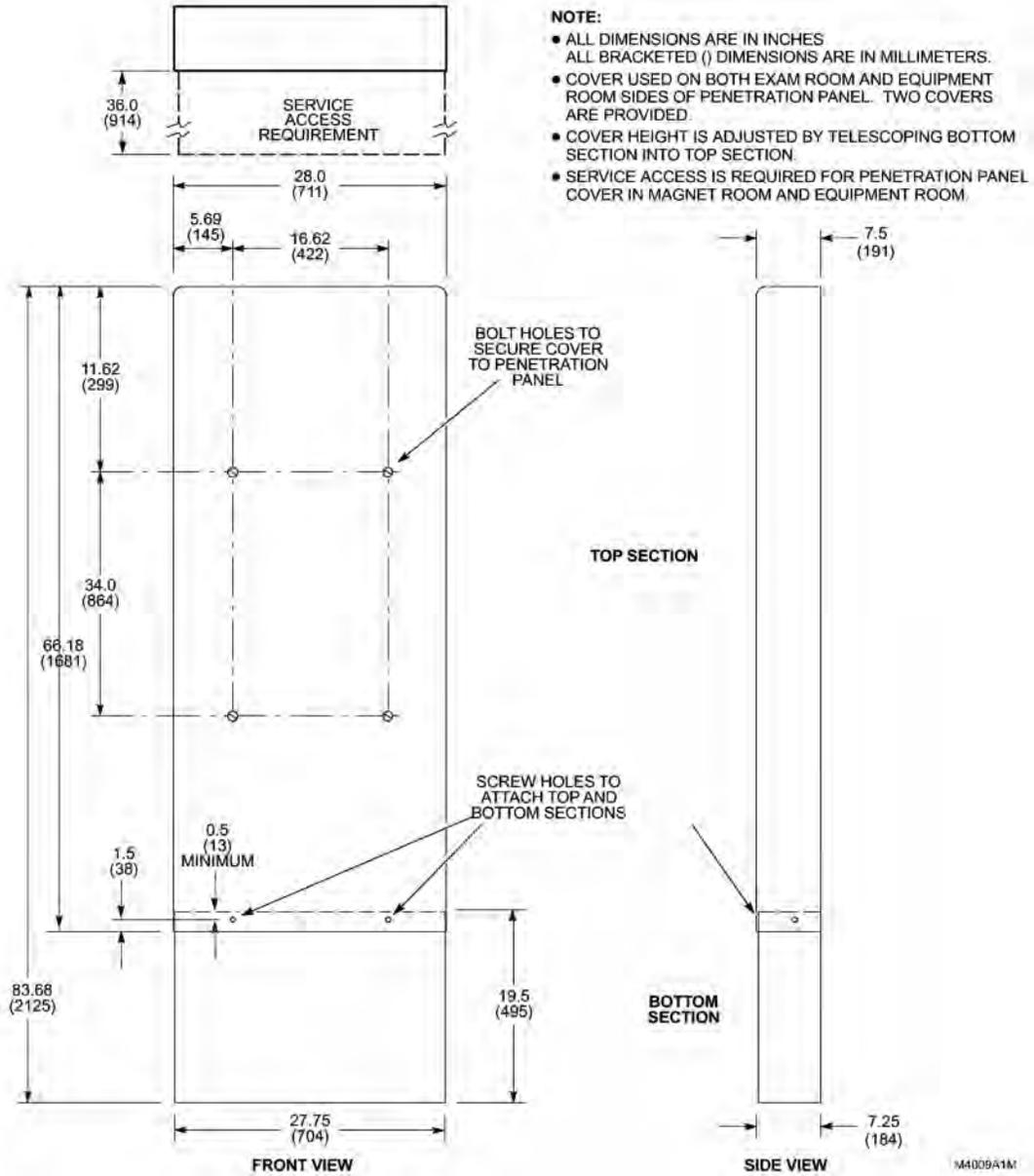


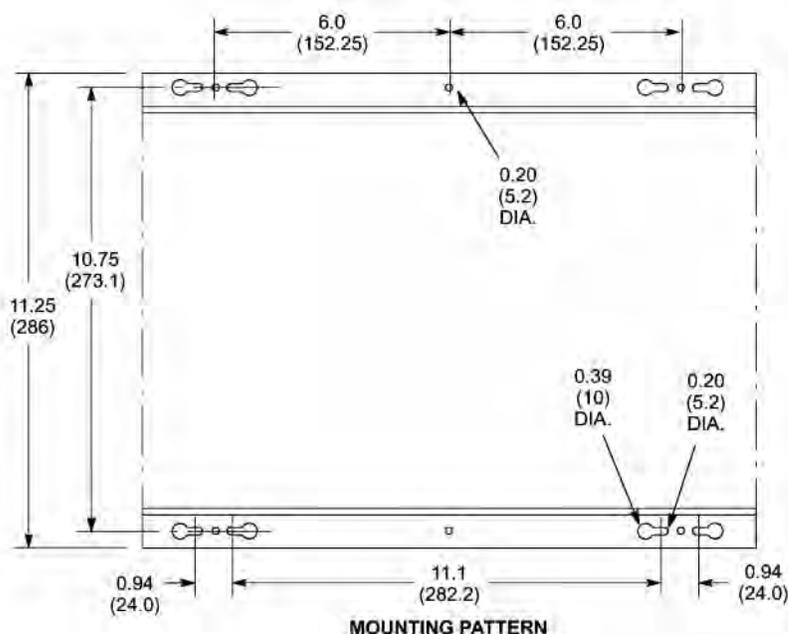
Illustration 8-13: Penetration Panel Cover



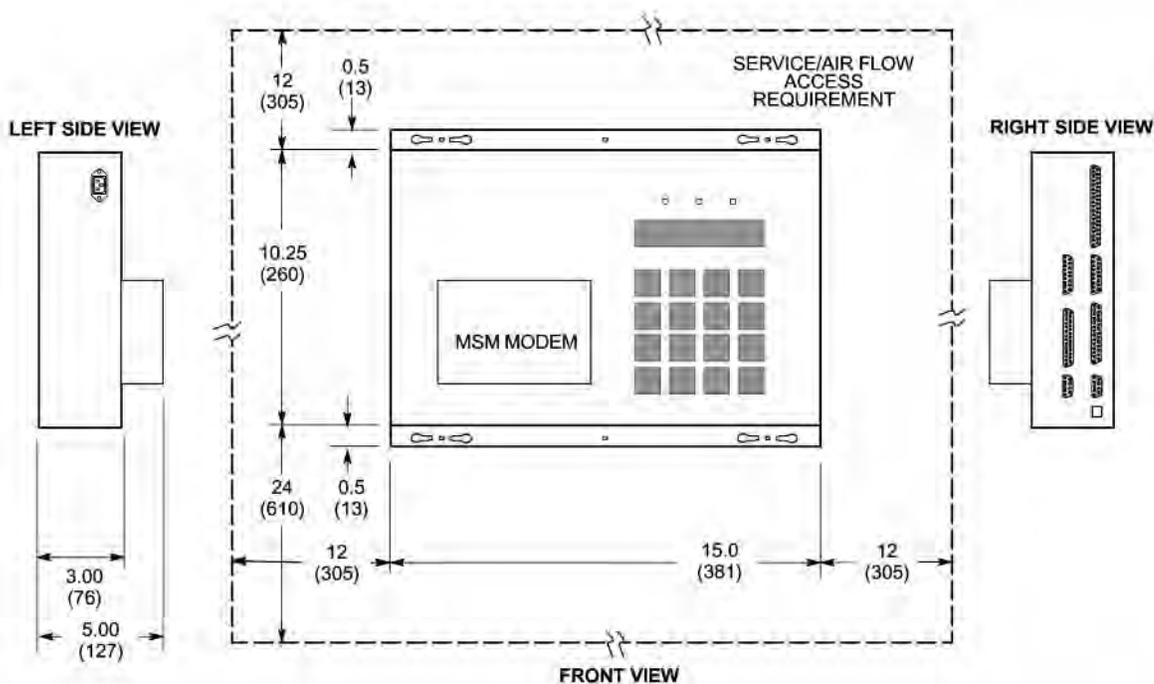
8 Magnet Monitor

Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 8-14: Magnet Monitor (MSM1)



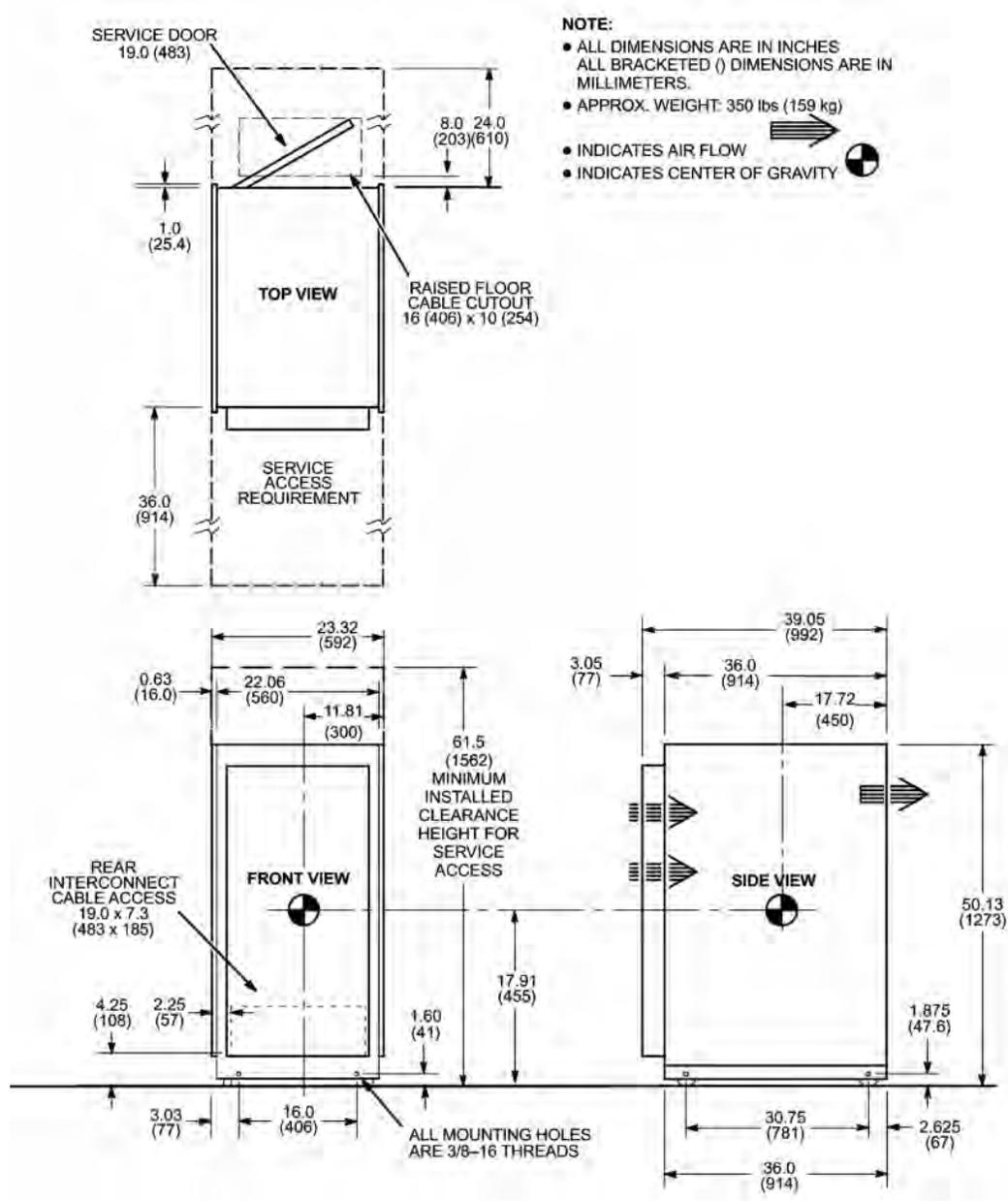
- NOTE:**
- ALL DIMENSIONS ARE IN INCHES
 ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.
 - APPROX. WEIGHT: 22 lbs (10 kg)



9 MNS Amp Cabinet

Magnetic Field Limit: 50 Gauss (5 mT)

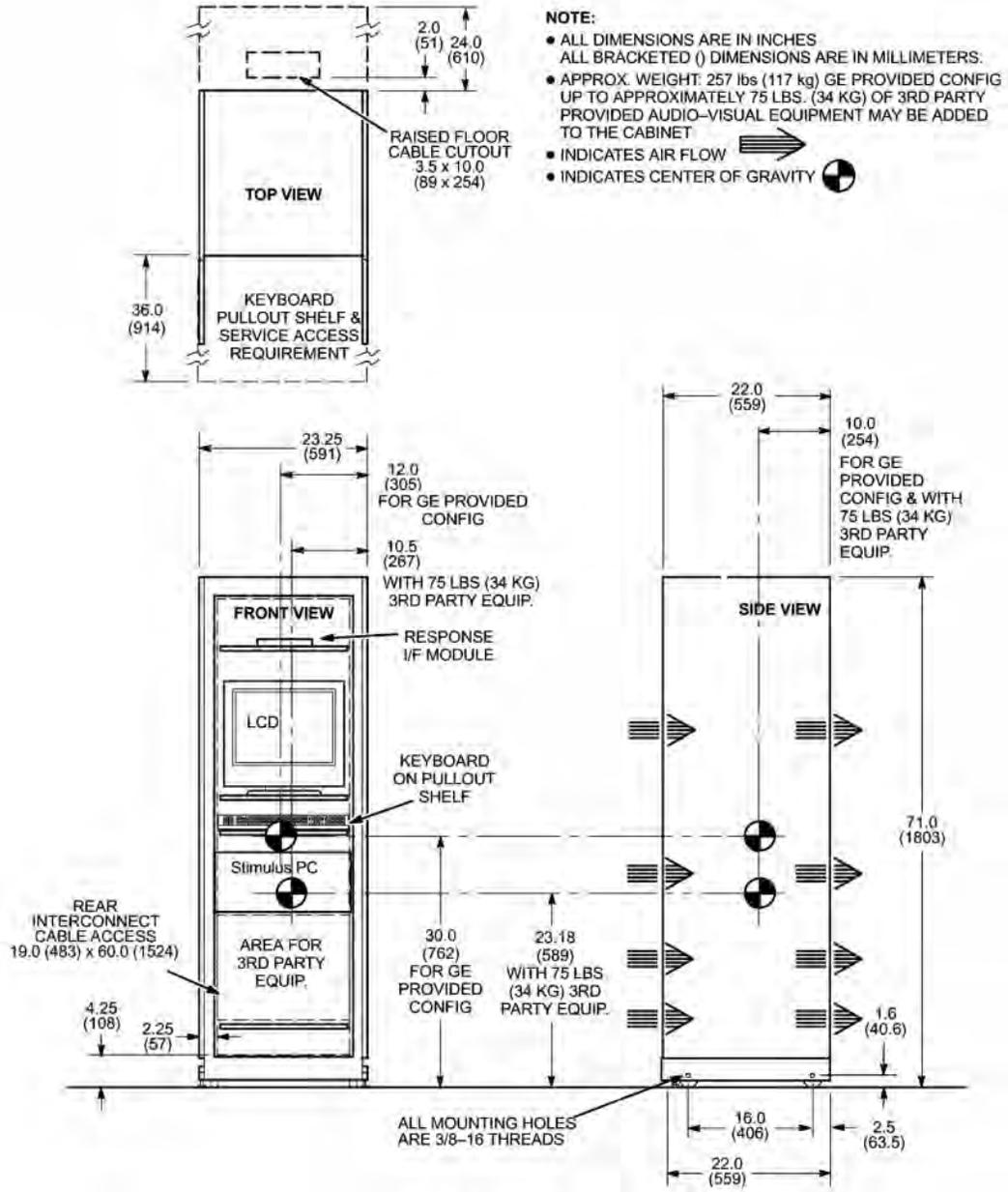
Illustration 8-15: 1.5T MNS Cabinet (MR10) for 2 KW MNS Option



10 BrainWave HW Lite Cabinet Option

Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 8-16: Brainwave HW Lite Cabinet

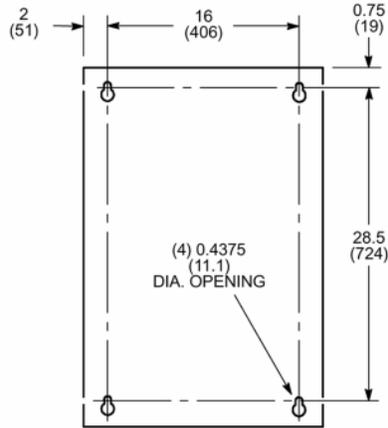


11 DC Lighting Controller Option

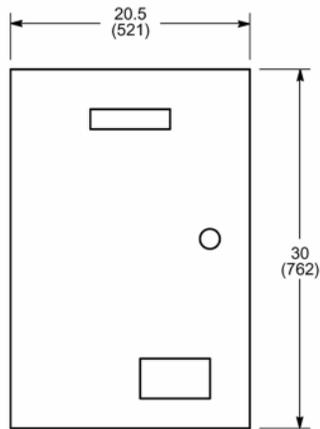
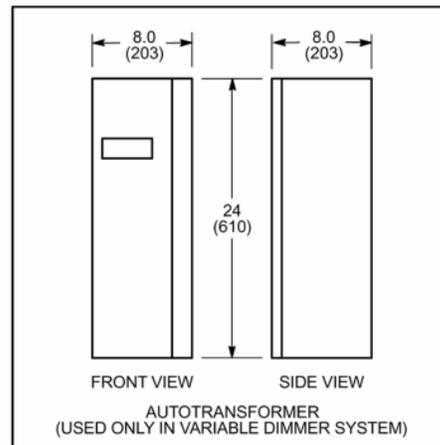
Illustration 8-17: DC Lighting Controller Option

NOTE:

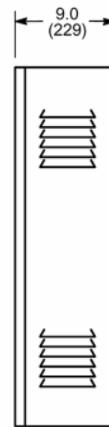
- ALL DIMENSIONS ARE IN INCHES.
 ALL BRACKETED () DIMENSIONS
 ARE IN MILLIMETERS.
- APPROX. WEIGHTS:
 CONTROL PANEL: 155 lbs (70 kg)
 AUTOTRANSFORMER: 60 lbs (27 kg)



MOUNTING PATTERN
 (CONTROL PANEL)



FRONT VIEW
 (CONTROL PANEL)

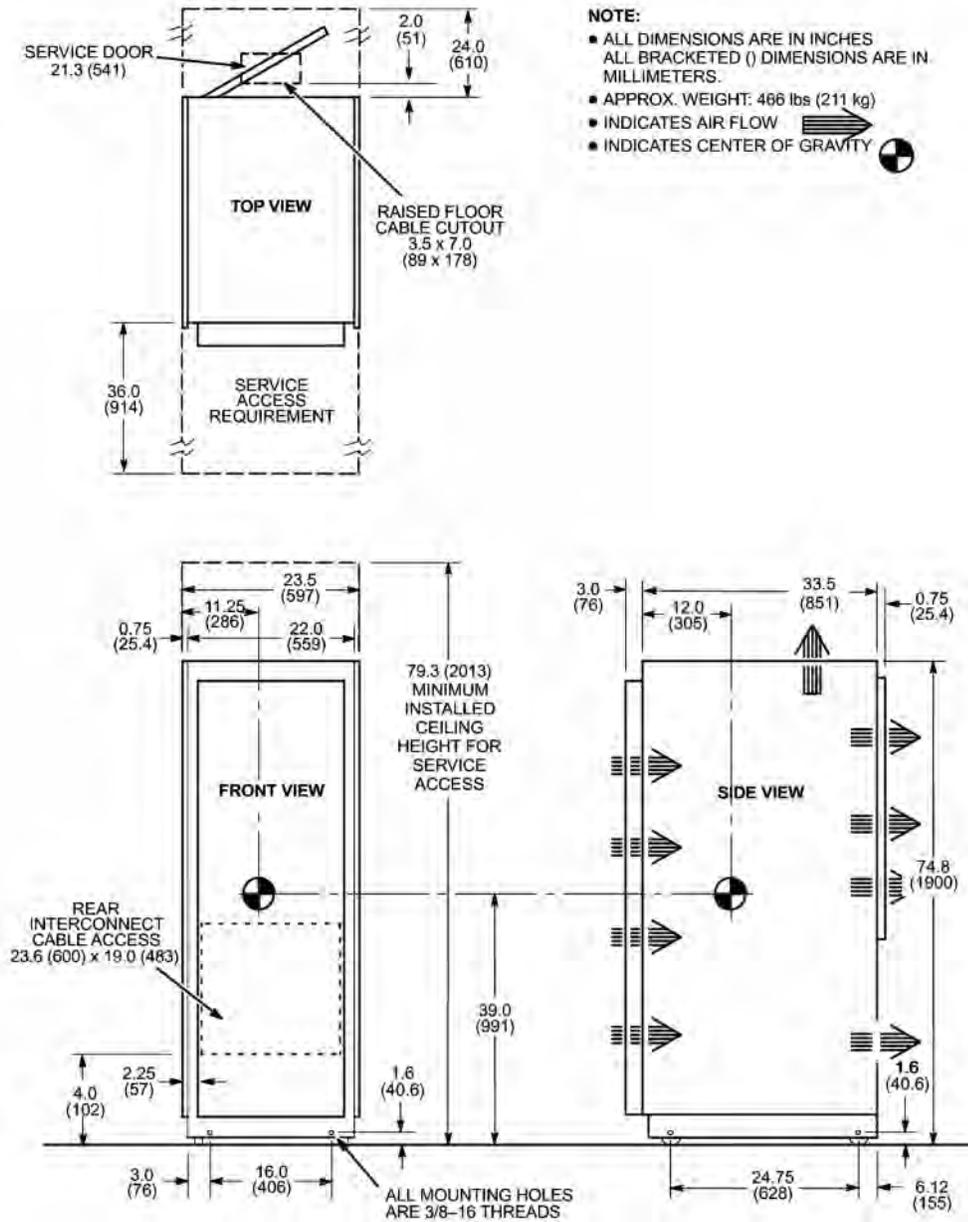


SIDE VIEW
 (CONTROL PANEL)

12 32 Channel Cabinet Option

Magnetic Field Limit: 30 Gauss (3 mT)

Illustration 8-18: 1.5T 32 Channel Cabinet



Chapter 9 Control Room

1 Operator Workspace

Magnetic Field Limit: 50 Gauss (5 mT)

Illustration 9-1: Operator Workspace (OW1) Overall Dimensions

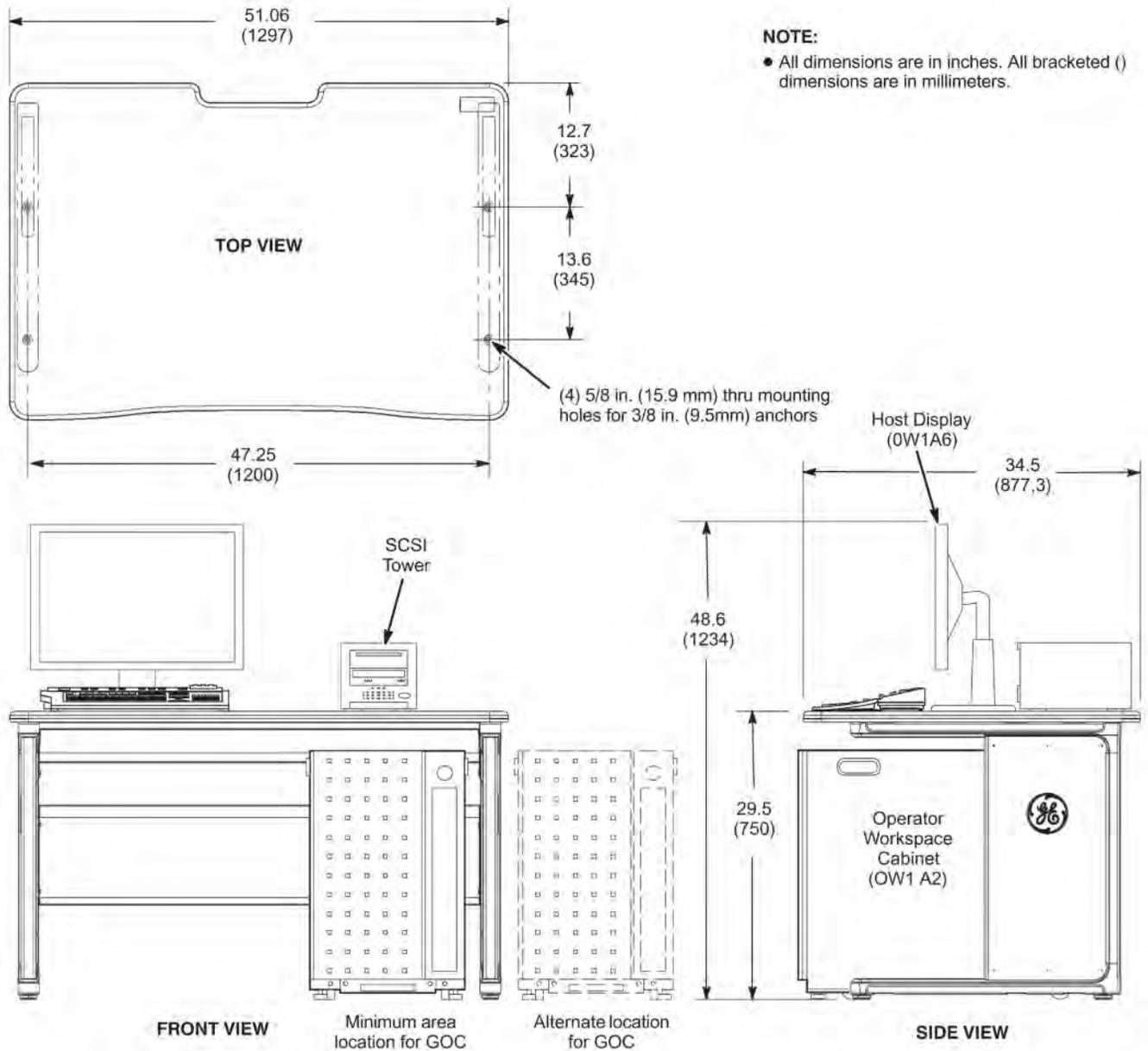


Illustration 9-2: GOC Computer Cabinet (OW1 A2)

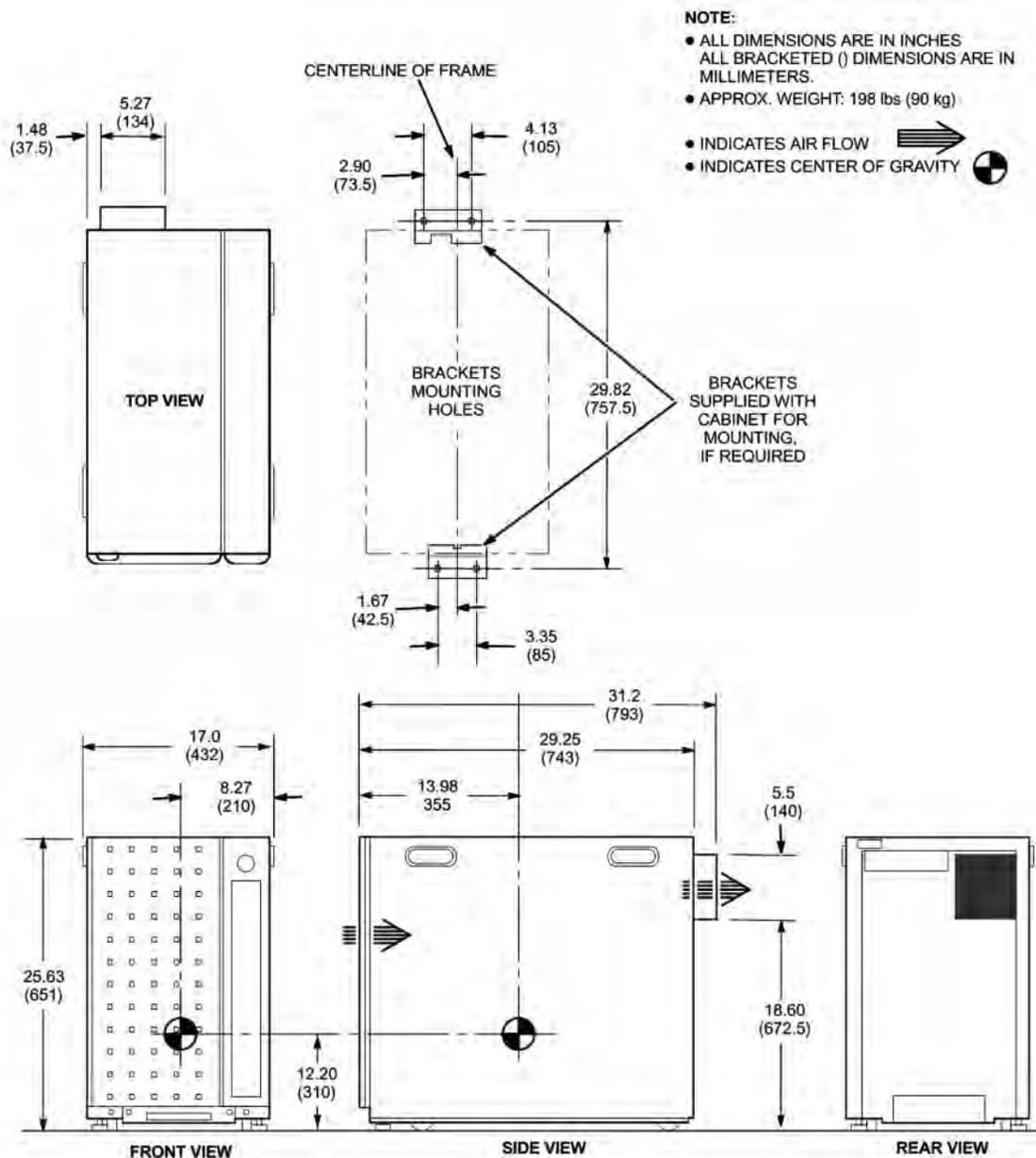


Illustration 9-3: Operator Workspace Components Position on Table Top - Host Display

NOTE:

- ALL DIMENSIONS ARE IN INCHES
 ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.
- APPROX. WEIGHT – WITH STAND: 19.8 lbs (9 kg)
- APPROX. WEIGHT – WITHOUT STAND: 13.2lbs (6 kg)

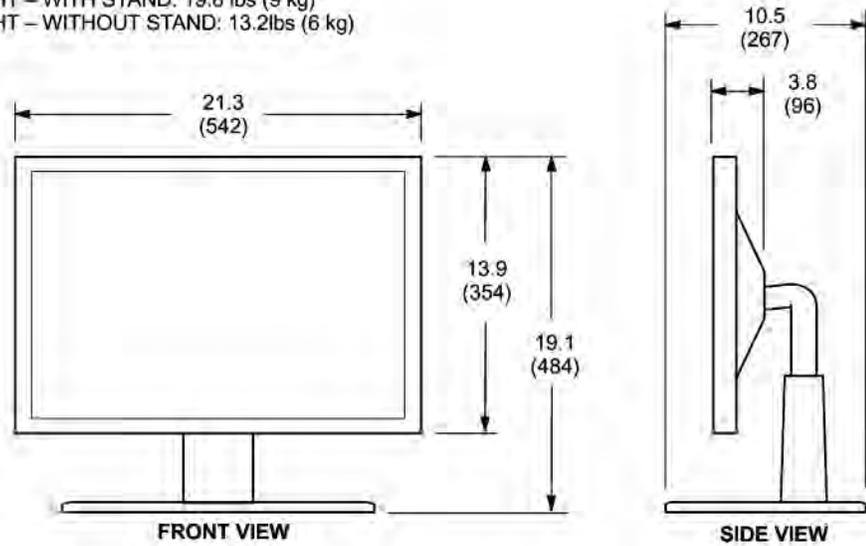
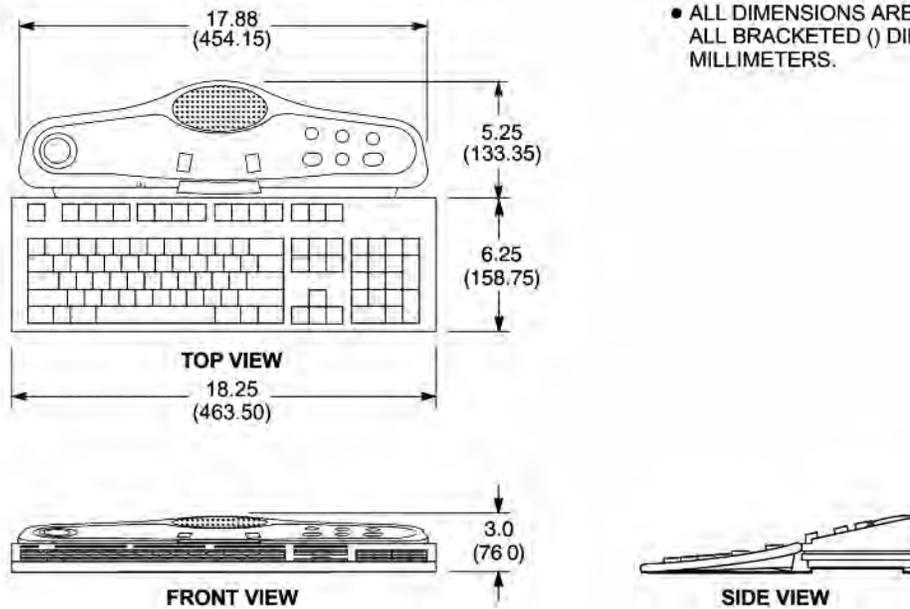


Illustration 9-4: Operator Workspace Components Position on Table Top - Keyboard

NOTE:

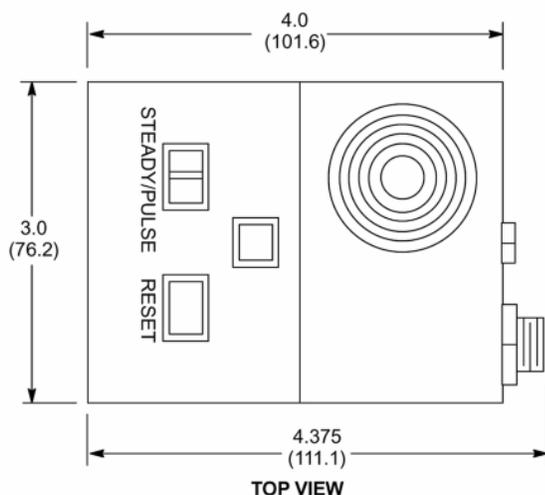
- ALL DIMENSIONS ARE IN INCHES
 ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.



2 Pneumatic Patient Alert

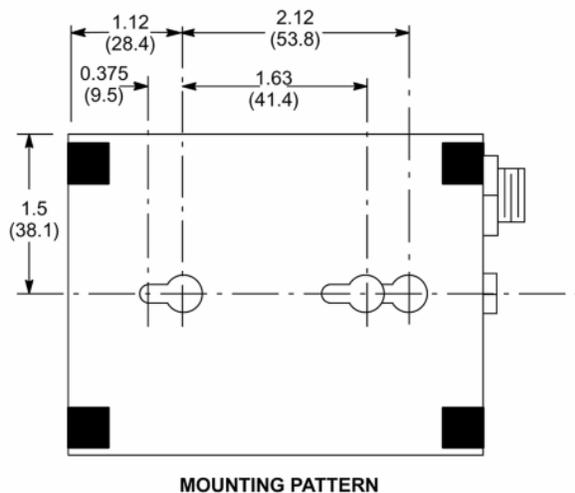
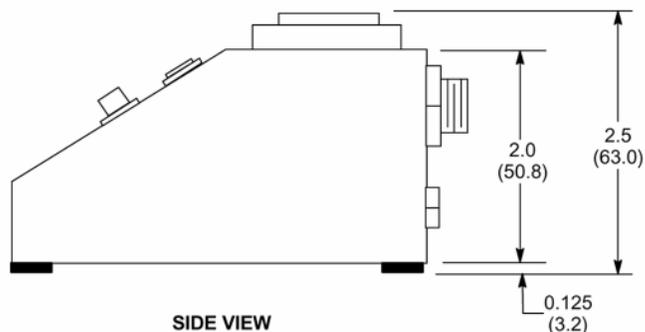
Magnetic Field Limit: 100 Gauss (10 mT)

Illustration 9-5: Pneumatic Patient Alert Control Box (PA1)



NOTE:

- ALL DIMENSIONS ARE IN INCHES. ALL BRACKETED () DIMENSIONS ARE IN MILLIMETERS.
- APPROX. WEIGHT: 0.5 lbs (0.2 kg)



Chapter 10 Interconnects

1 MR System Interconnects Specifications

1.1 Introduction

The sections in the Interconnect Data Chapter contain details of GE supplied MR system interconnections and customer supplied components for the MR system install.

1.2 Component Designators

GE uses a Component Designator System to identify system components. All subsystem cabinets and other components are referred to by their component designators in the diagrams and tables of the Interconnect Data sections.

Table 10-1: MR System Component Designations

Basic System Or Option	Component Designator	Description
Basic System	EO1/EO2	Emergency Off Buttons
	MDP	Main Disconnect Panel
	MG2	Magnet Enclosure
	MG3	Magnet Rear Pedestal
	MG6	Blower Box
	MR2	RFS Cabinet
	MR3	HFD/PDU Cabinet has PD1 in lower portion cabinet
	MS1	Superconducting Magnet
	MS4	Magnet Rundown Unit
	MS5	Shield/Cryo Cooler Compressor Cabinet (may be either air- or water-water cooled)
	MSM1	Magnet Monitor
	OW1	Operator Workspace
	PD1	Power Distribution Unit (PDU) is a module in lower portion of HFD/PDU Cabinet
	PA1	Pneumatic Patient Alert Control Box
	PP1	Penetration Panel
	PT1	Patient Transport Table
WC1	Water Chiller	
System Options	BW	BrainWave HW Lite Cabinet
	MR10	1.5T MNS Amp Cabinet
	MR11	32 Channel Option
	MRCC	MR Common Chiller
	RCP	Remote Control Box for MRCC located outdoors or indoors
	OM1	Oxygen Monitor
	OM3	Remote Oxygen Sensor Module

1.3 Definition of Terms

The definition of terms used in the interconnects details tables throughout this chapter are:

L1 (Location 1)

Location of interconnects between Penetration Panel (PP1) and components in Magnet Room and Within Magnet Room between components.

L2 (Location 2)

Location of interconnects between Penetration Panel (PP1) and components in Equipment Room.

L1/L2 (Location 1 / Location 2)

Location of interconnects between Magnet Room and Equipment Room components, includes interconnects routed through PP1 waveguides and interconnects; which length provided is cut at site and shared between Magnet and Equipment Rooms.

L3 (Location 3)

Location of interconnects between components within Equipment Room.

L4 (Location 4)

Location of interconnects between Operator Workspace (OW) and PP1.

L5 (Location 5)

Location of interconnects between OW and components in Equipment Room.

1.4 Usable Cable Lengths

Table 10-2: Interconnects Location and Relative Length Provided

Location	Relative Length Provided By Catalog		
	M3335NJ (16 ch)	M3335NK (16 ch)	M3335NL (16 ch)
	M3335AA (8 ch)	M3335AB (8 ch)	M3335AC (8 ch)
L1	Short	Short	Long
L2	Short	Long	Short
L1/L2	Short	Long	Long
L3	Same length for all catalogs.		
L4	Same length for all catalogs.		
L5	Same length for all catalogs.		

Usable Length

Amount of cable/wire/hose/etc. available for site routing point to point of the FROM and TO equipment. The interconnect cable/wire/hose total length MINUS any required takeup at or within both the FROM and TO equipment determines the usable length.

Group Number

Identifying number referenced to bundles (i.e. groups) of cables.

Area

Cross-sectional area of the combined cables in a group.

NOTE: The group area was found by adding up the circular cross-sectional areas of all individual cables within a group. It does not take any fill factors or space between cables into account. Adhere to applicable electrical codes for fill factors.

Between Units (From/To)

Component Designators as found in interconnects list tables throughout this section.

Run Number

Unique number assigned to each GE-supplied cable.

NOTE: The Run Number must be used when making special cable order inquiries.

Cable Diameter

Diameter of an individual cable

Plug Pulling Diameter x Length

Cable plug dimensions (e.g., 2.0 x 3.25 indicates a plug with dimensions of 2.0 in. diameter and 3.25 in. length). If a cable has more than one connector on an end, the number of connectors is indicated at after the dimensions (e.g., 2.0 x 3.25 x 2).

1.5 Cable Group Lengths Provided

The table below lists the specific usable length provided for each interconnect Group to determine the fixed site cable catalog that will best meet the specific site layout requirements.

Table 10-3: Length Provided by Fixed Site Catalogs

Location	Group	Between Units		Usable Length		
		From	To	M3335NJ M3335AA ft (m)	M3335NK M3335AB ft (m)	M3335NL M3335AC ft (m)
L1	42	PP1	EO1	68 (20.7) allows EO1 take-up of 15 ft (4.57 m)		
	45	PP1	MG2/3	19 (5.79)	19 (5.79)	40 (12.2)
	48	MS4	MS1	81 (24.7) - See Note 3.		
	78	RF Common Ground Stud	MS1	19 (5.79)	19 (5.79)	40 (12.2)
				Minus take-up at RF Common Ground Stud		
	87	PP1	MG6	16 (4.88)	16 (4.88)	37 (11.3)
88	MG6	MG3	16 (4.88) allows 2 ft (0.6 m) take-up at MG6. See Note 4.			
L2	23	MR2	PP1	25 (7.62)	55 (16.8)	25 (7.62)
	30	PD1	PP1	59 (17.98)		
	31	MR3	PP1	25 (7.62)	61 (18.59)	25 (7.62)
	75	MS5	PP1	42 (12.8) - See Note 3.		
	77	PD1	RF Common Ground Stud	83 (25.3)		
	81	EO2	PP1	30 (9.14)	50 (15.24)	30 (9.14)
	95	MSM1	PP1	67 (20.42) allows 8 ft (2.44 m) take-up at MSM1. See Note 1.		
L1/L2	27	MR3	MG2/3	38 (11.58)	74 (22.56)	74 (22.56)
				Runs in this Group are cut to length and connected via PP1 at the site. Usable length provided is for routing in both the Equipment Room and the Magnet Room. These cables have a minimum bend radius of 8 in. (203.2 mm)		
	71	MS5	MS1	43 (13.11) runs are routed through waveguides in PP1. Runs have 8 in. (203.2 mm) bend radius. See Note 3.		
	72	MR2	MG2/3	46 (14.0)	88 (26.8)	88 (26.8)
L3	6	PD1	MR2	16 (4.88)		
	20	MR2	MR3	16 (4.88)		
	69	MDP	MS5	27 (8.23) allows 3 ft (0.91 m) take-up at MDP. See Note 7		
	89	PD1	WC1	33 (10.0)		
	94	MSM1	MS5	49 (14.94) allows 8 ft (2.44 m) take-up at MSM1. See Note 1.		
	96	MSM1	MR2	50 (15.24) allows 8 ft (2.44 m) take-up at MSM1. See Note 1.		
L4	79	OW1	PA1	5 (1.5) minus take-up at PA1		
	80	PA1	MG2	72 (21.9.5) allows 5 ft (1.52 m) take-up at PA1. See Note 5.		
				Pneumatic tubing is continuously routed from PA1 through PP1 and MG3 to MG2.		
92	PP1	OW1	80 (24.4)			
L5	43	MR2	RF Door Switch	83 (25.3) allows 15 ft (4.57 m) take-up at RF Door Switch		

Location	Group	Between Units		Usable Length		
		From	To	M3335NJ M3335AA ft (m)	M3335NK M3335AB ft (m)	M3335NL M3335AC ft (m)
	90	PD1	OW1	80 (24.4)		
	91	MR2	OW1	80 (24.4)		

Notes

1. 1.5T Magnet Catalog (M3335PB) provides Magnet Monitor interconnects and Shield/Cryo Cooler Compressor to Magnet interconnects included in this Group.
2. 1.5T Magnet Catalog (M3335PB) provides some Penetration Panel to Magnet Enclosure interconnects included in this Group.
3. Shield/Cryo Cooler Compressor Catalog (M1060JW) provides Shield/Cryo Cooler Compressor to Magnet interconnects in this Group.
4. 8 or 16 Channel Fixed Site Collector Catalog (M3335NA or M3335ND) provides Group 88 interconnect.
5. If installation requires pneumatic tubing that is greater than listed between the squeeze bulb, located on the front of the Magnet Enclosure, and the Patient Alert Control Box (PA1), located near the Operator Workspace, an Extender Kit (46-317758P2) must be ordered. The Extender Kit consists of a small Extender Box (to be mounted in Equipment Room) and 95 feet (29.0 meter) of pneumatic tubing.
6. If the air-cooled cryocooler compressor option is selected, see [Chapter 5, Air-Cooled Cryocooler Compressor Requirements and Specifications](#).

2 Customer Supplied Interconnects

Illustration 10-1 shows the cable Groups which are customer supplied.

Table 10-4 contains the list of customer supplied interconnects for the MR system and references to location of detail information for the specific interconnects.

Illustration 10-1: System Customer Supplied Interconnects Diagram

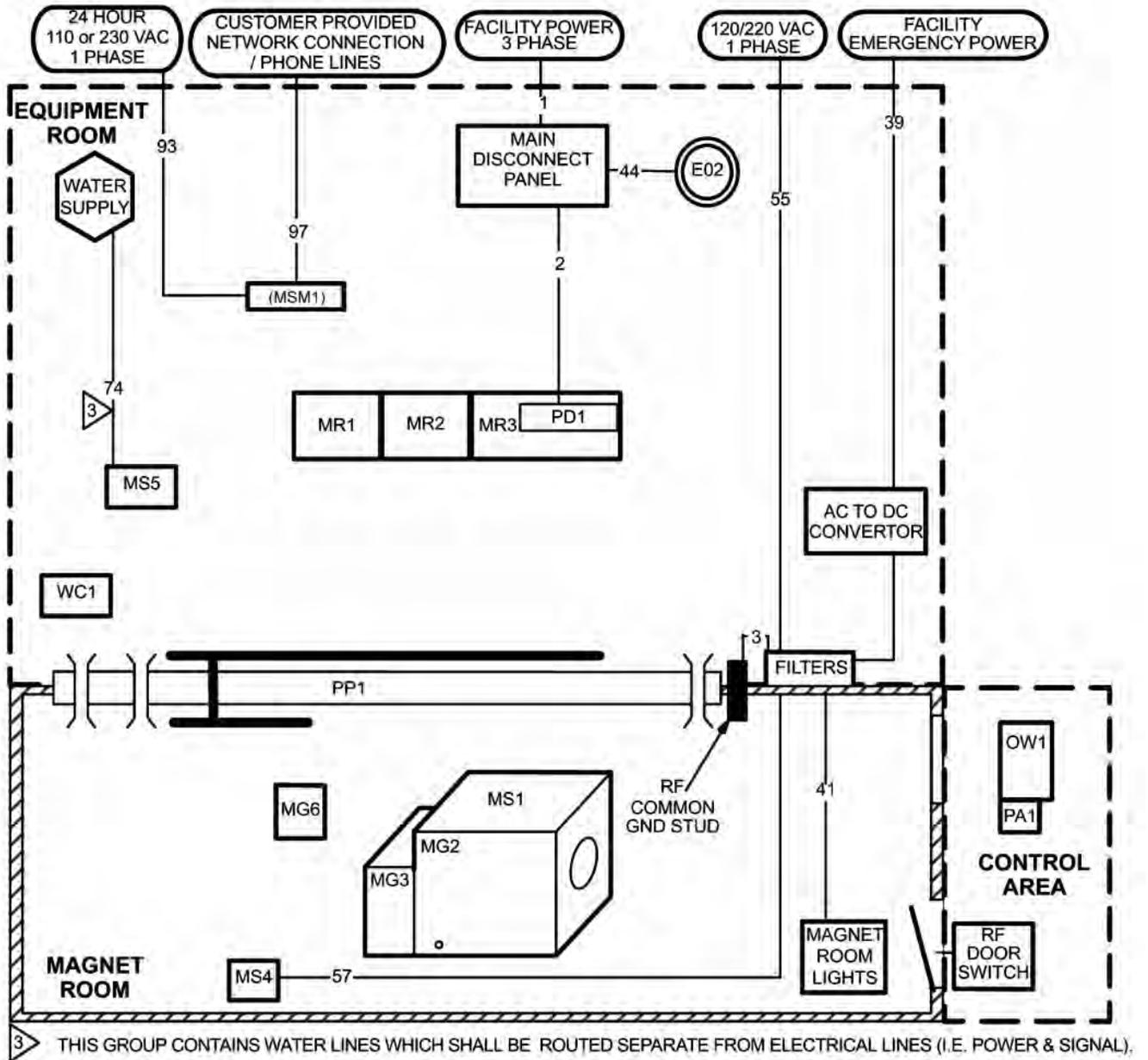


Table 10-4: Customer Supplied Interconnects

Group #	Between Units	
	From	To
1	Facility Power	MDP
2	MDP	PD1 (See Note 2)
3	Facility Emerg Power Filter	PP1
39	Facility Emergency Power	Filter
41	Filter	Magnet Room Lights
44	MDP	EO2
55	Facility Power	Filter
57	Filter	MS4
74	Facility Water Supply	MS5
See Notes 3 and 4		
97	Network &/or Phone Line Connection	MSM1 or MSM4 (Option)

Notes

1. If low Voltage Step-Up Transformer Option (R4500AW or R4500BE) is used then customer supplied interconnects are required between facility power, transformer and MDP.
2. The PDU is a module (PD1) in the lower portion of the HFD/PDU Cabinet (MR3).
3. This Group contains water lines which shall be routed separate from electrical lines (i.e. power & signal).
4. If the air-cooled cryocooler compressor option is selected, see [Air-Cooled Cryocooler Compressor Requirements and Specifications](#).

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Chapter 11 RF Shielded Room

1 RF Shielded Room Requirements

Improvements in MR imaging technology have increased imaging capabilities. MR procedures require a stable RF environment to achieve high resolution image quality. RF sources both inside and outside the Magnet Room have the potential to adversely affect image quality. Therefore the Magnet Room must be properly RF shielded to prevent external RF sources from entering the room. In addition, the selection of materials and construction methods of the RF Shield must be designed and installed to minimize the generation of adverse signals within the RF Shield and Magnet Room.

1.1 RF Shielding Background

RF sources which can adversely affect image quality may be generated by discrete frequency or broadband noise (RF) sources.

1.1.1 Discrete Frequency

Discrete RF interferences are narrowband and are fixed frequency in nature. The Magnet Room must be RF shielded from RF sources so external RF energy does not degrade the MR system RF receivers at the system imaging frequencies, refer to [Chapter 5, Ambient Radio Frequency Interference \(RFI\)](#). Some potential sources for discrete frequency signals are radio station transmitters, mobile or hand-held RF transmitting devices, etc.

1.1.2 Broadband RF Noise

Broadband RF noise is a single transient or continuous series of transient disturbances caused by an electrical discharge, for system imaging frequencies refer to [Chapter 5, Ambient Radio Frequency Interference \(RFI\)](#). Low humidity environmental conditions will have higher probability of electrical discharge, refer to [Chapter 5, Temperature and Humidity Specifications](#). 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:

- loose hardware/fasteners vibration or movement (electrical continuity must always be maintained)
- flooring material including raised access flooring (panels & support hardware) and carpeting
- electrical fixtures
 - lighting fixtures
 - track lighting
 - emergency lighting
 - battery chargers
 - outlets
- ducting for HVAC and cable routing
- RF Shield seals (walls, doors, windows, etc.).

1.2 RF Shielded Room Requirements

The Magnet Room RF Shield must meet the requirements defined in [Table 11-1](#) for the system to produce high quality MR images.

NOTE: The RF Attenuation and Ground Isolation are intended to control discrete RF signals and RF interference sources. The remaining parameters contained in [Table 11-1](#) are intended to minimize potential broadband noise sources.

Table 11-1: RF Shielded Room Requirements

Parameter (See Note *)	Requirements (See Note *)
RF Attenuation	100dB (100MHz ± 10MHz) planewave, refer to Chapter 14, RF Shielded Enclosure Test Guideline Frequency Range subsection.
Ground	<ol style="list-style-type: none"> 1. Ground Isolation: 1,000 ohms or greater 2. Primary Ground: All RF Shield components (walls, floor, ceiling, etc) must be electrically bonded together to form one common ground plane which is connected to the Facility Grounding Conductor. The RF Shield must be grounded back to the facility ground via the RF Common Ground Stud connection to the MR system PDU. NOTE: Introduction of facility power into the RF Shielded Room must not compromise the RF Shield Primary Ground. 3. Secondary Ground (Other grounds that connect the outside of the RF Shield Room to earth grounds are called secondary grounds): Secondary grounds must not compromise Ground Isolation of 1,000 ohms or greater. 4. Refer to Electrical Isolation for additional information on electrical isolation requirement.
Materials	<ol style="list-style-type: none"> 1. The choice of RF Shield material including fasteners is the responsibility of the customer's architect and RF vendor. 2. The choice of material must not affect magnet homogeneity (i.e. copper, brass or treated aluminum are non-magnetic and will not affect Magnet homogeneity). NOTE: Any steel RF Shield will affect the magnet's homogeneity and must be reviewed by GE Healthcare MR Siting and Shielding Group. 3. The floor under the Magnet in a 10 ft x 10 ft (3.048 m x 3.048 m) area must not be fabricated from magnetic materials, per Magnet Room Floors Magnetic Properties in Chapter 5, Construction Materials. 4. The Magnet Room floor materials must meet the requirements in Magnet Room Floors. 5. The door or any other moving or non-rigid parts must not be fabricated from magnetic materials. 6. The RF Shield integrity (attenuation) must not be compromised by corrosion for the anticipated duration of usage for MR imaging. The following items are critical: <ol style="list-style-type: none"> a. Avoid direct contact of materials of different solution potential (e.g. dissimilar metals galvanic corrosion) when selecting fastens to secure the RF screen material to the RF supporting structure. b. Ensure the RF shield seams/joints have overlaps that are properly dressed selecting proper material to avoid galvanic corrosion. c. Introduce sacrificial anodes to prevent corrosion of critical RF shield components. NOTE: Typically the RF Shield surrounds the Magnet Room finished walls, ceiling, and floor. Therefore the RF Shield may not be in a temperature and humidity controlled environment. d. RF Screen Room including all openings (i.e. windows, doors, vents, etc.) need acoustic properties to meet local regulations and customer requirements. NOTE: RF Screen Room doors with <55 db acoustic attenuation have caused customer acoustics issues.

Parameter (See Note *)	Requirements (See Note *)
Construction	<ol style="list-style-type: none"> 1. The design of the shield support system is the responsibility of the customer's architect and RF vendor. 2. RF Shield construction methods must not compromise RF Shield integrity (attenuation) for the anticipated duration of usage for MR imaging. <ol style="list-style-type: none"> a. When RF shield seams/joints are sealed with solder: all solder drips, cold solder joints, and cracked solder joints must be cleaned and repaired. b. RF Shield movement can cause micro electrical arcs (static discharge or broadband RF noise) that will cause MR image artifact known as White Pixel. c. Physical fluctuation of the RF Shield material can result in RF leaks due to seam openings, cracks, enlarged holes at fasteners. Physical fluctuation of the RF Shield can be generated by cyclic air pressure changes and door closures/openings. d. All electrical and mechanical connections and fasteners including screws, nails, nuts, bolts, clips clamps, concrete anchors, seismic anchors, etc. must be tightened and secured to supplier specifications so as not to become a potential broadband noise source. e. All fasteners must be solid locking devices such as t-nuts, PEM nuts or welded nuts; no self tapping screws allowed. f. The Magnet Room floor design and construction must meet the requirements in Floors. g. It is the customer's responsibility to coordinate mounting methods for equipment in the Magnet Room with the RF Shielded Room vendor to prevent RF leaks and secondary grounding problems. For additional information refer to Anchor Hardware For MR Equipment Inside RF Shield, Physical Characteristics, Anchor Location And Installation, Clamping Force (Tension) and Pull Test, RF Shield Integrity, Electrical Isolation, and Magnet Room Equipment Mounting. It is the customer's responsibility to coordinate mounting methods for equipment in the Magnet Room with the RF Shielded Room vendor to prevent RF leaks and secondary grounding problems. <div style="display: flex; align-items: center; margin-top: 10px;">  <div style="border: 1px solid black; padding: 2px; background-color: yellow; text-align: center;">  CAUTION </div> </div> <p style="margin-top: 5px;">For safety reasons, magnetic materials must be secured to ensure magnetic components do not become projectiles.</p> <p style="margin-top: 10px;">Methods of securing must not loosen due to repeated use, some options include (but not limited to) redundant restrains straps or anchors/bolts with locking nuts.</p>
Testing	<ol style="list-style-type: none"> 1. The customer's architect and RF vendor are responsible for conducting testing to verify compliance with the requirements for RF attenuation and ground isolation. 2. The RF shielded room verification test is to be performed in the presence of a GE representative. 3. The FINAL RF Shielded room acceptance test shall be performed in accordance with Chapter 14, RF Shielded Enclosure Test Guideline.
Maintenance	<ol style="list-style-type: none"> 1. The customer is responsible for maintaining the RF Shield service life integrity for the anticipated duration of usage for MR imaging per the RF vendor's recommended maintenance. 2. The customer is responsible to notify the GE Service Representative of any RF shielded Room maintenance issues since there may be system performance impacts.
NOTE:	* The RF Shielded Room design, materials, construction, and installation shall be such to meet the requirements for the anticipated duration of usage for MR imaging.

2 Vents

2.1 Cryogenic Vent Location

The cryogenic vent location on the magnet is shown below. The waveguide in the RF Shield must be within 0.25 in. (6.25 mm) of the center point of the vent.

Illustration 11-1: 1.5T Cryogen Vent Location

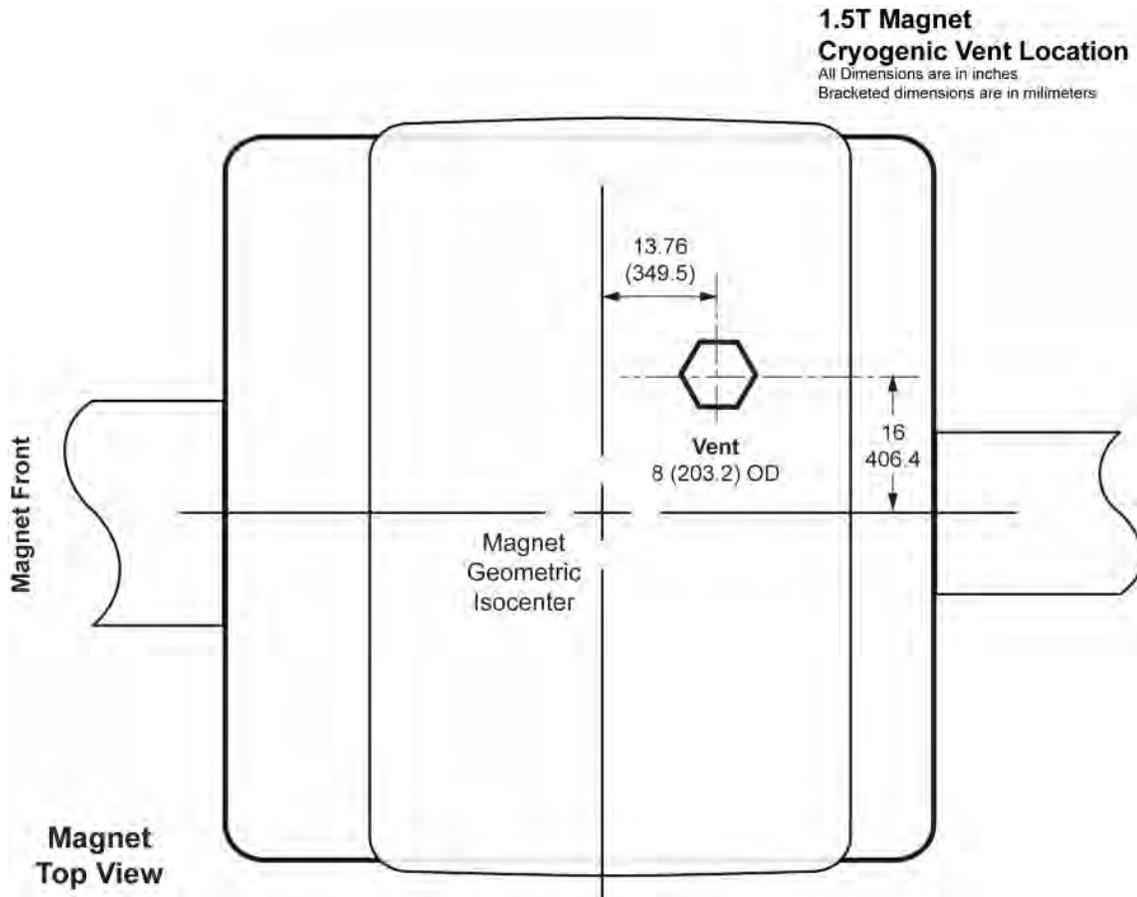
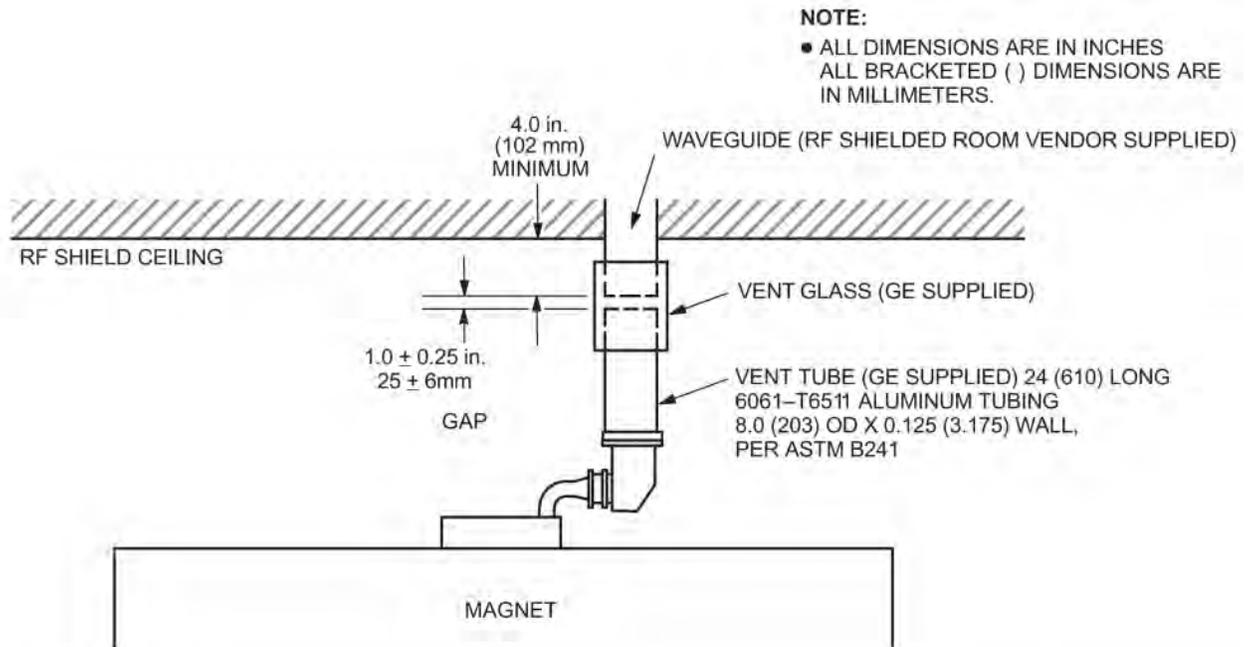


Illustration 11-2: Typical Cryogenic Vent Routing



Refer to [Chapter 5, Cryogenic Venting](#), [Chapter 5, Requirements For Outside Magnet Room](#), and [Chapter 5, Requirements for Inside Magnet Room](#) for vent requirements.

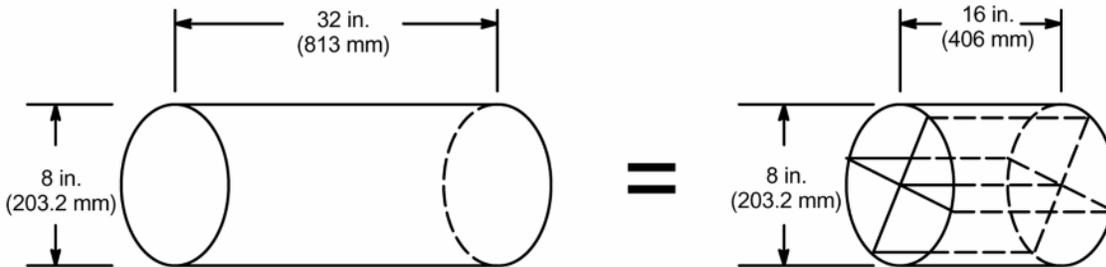
2.2 Waveguide

RF shield room contractor/designer is responsible for choosing and installing a RF shield waveguide for the cryogen vent and customer specific cables/MR compatible system interconnects. Refer to [Table 11-2](#) for list of GE requirements for the waveguide.

Table 11-2: Waveguide Requirements

Parameter	Requirements
Waveguide Size	The generally accepted length of the waveguide is four times the inside diameter of the tube (e.g., to match the 8 in. diameter GE Healthcare supplied cryogen vent adaptor, the waveguide must be a minimum of 32 in. long)
Waveguide Material	<ul style="list-style-type: none"> The Waveguide must be constructed from one of the GE accepted non-magnetic materials (i.e., stainless steel, aluminium, or copper). The waveguide must be made from the same material as the RF shielded enclosure to avoid dissimilar metal interfaces (i.e., galvanic reaction)
Waveguide Construction	<ul style="list-style-type: none"> The customer must work with the RF shield vendor to install any non-GE Healthcare penetration points The waveguide does not have to be positioned equally on either side of the RF shield Waveguides do not have to be completely straight (e.g., 90 degree elbows may be part of the waveguide). Shorter waveguide can be fabricated by dividing the inside volume into no more than four chambers (e.g., an 8 in. (203.2 mm) OD waveguide can be divided into four equal chambers, as shown in Illustration 11-3, the length of the waveguide may be decreased from 32 in. (813 mm) to 16 in. (406 mm). (Refer to <i>Site Environment chapter sections: Chapter 5, Cryogenic Venting, Chapter 5, Requirements For Outside Magnet Room, Chapter 5, Requirements for Inside Magnet Room.</i>) 1 psig must be added to the pressure drop calculation to account for the pressure drop of the four chambered waveguide for cryogen vents Flat, honeycomb type waveguide is not acceptable.

Illustration 11-3: 4 Chamber Waveguide



NOTE:

- 1 psig MUST BE ADDED TO THE PRESSURE DROP CALCULATION TO ACCOUNT FOR THE PRESSURE DROP OF THE FOUR CHAMBERED WAVEGUIDE.
- IN A CASE OF WAVEGUIDE LENGTH RESTRICTION, A HALF LENGTH WAVEGUIDE WITH FOUR CHAMBERS MAY BE USED.

2.3 Guide for Outside RF Room Isolation Joint

The RF shielded room contractor/designer is responsible for choosing and installing an isolation joint outside of the RF shielded room as shown in [Chapter 5, Requirements For Outside Magnet Room](#). This isolation joint is required to maintain the single point ground concept for the RF shielded room. [Table 11-3](#) contains suggestions for the RF room isolation joint.

NOTE: GE supplies Ventglass and clamps which can be used for 8 in. (203 mm) diameter pipe ONLY. These materials may be used for isolation joint outside RF room at the contractor's option if the material meets the contractor's design requirements.

Table 11-3: Outside RF Room Isolation Joint Suggestions

Parameter	Isolation Joint Suggestions
Isolation Joint Material	<ul style="list-style-type: none"> • PVC, rubber or soil pipes must not be used to construct the isolation joint. • Ventglass and Lorenz clamp is a GE recommended method of achieving the isolation.
Isolation Joint Construction	<ul style="list-style-type: none"> • Ventglass: If the connection diameter is 8 in. (203.2 mm), a Ventglass connection is recommended. • Lorenz clamp: If the connection diameter is 8 in. (203.2 mm), a Lorenz clamp connection is recommended. • The mating diameters must match within ± 0.125 in. (3 mm). • The Ventglass must not be used for structural support.
Suppliers	<p>Ventglass information may be obtained from:</p> <p>Industrial Machine & Fabricating Inc. 2808 E. Sammy's Lane Florence, SC 29506-3841 USA (843) 667-4582 indmachfab@aol.com</p> <p>Vent Fabric Inc. 5520 N. Lynch Avenue Chicago, IL 60630-1418 USA (800) 621-1207 or (773) 775-4477 www.ventfabrics.com</p> <p>Lorenz clamp information may be obtained from:</p> <p>Lorenz and Son Mfg. Co. LTD. P.O. Box 1002 Cobourg, Ontario, Canada K9A4W4 (905) 372-2240, fax (905) 372-4456</p>

2.4 HVAC

RF shielded room contractor is to install HVAC waveguides (open pipes or honeycomb-type) which penetrate room and to ensure waveguides are non-magnetic and electrically isolated. HVAC contractor is to determine size and number of vents, consistent with local codes.

Honeycomb-type waveguides must be accessible for annual customer inspection and cleaning / maintenance.

An exhaust fan placed outside the RF shielding with appropriate wave guide filtering is required for quick removal of helium gas in the event large amounts of helium disperse into the Magnet Room. The exhaust fan can be connected to the output relay of the optional oxygen monitor. The fan will then be activated in the event the room oxygen level is less than 18%. Refer to [Chapter 5, Room Ventilation](#) for other exhaust fan requirements.

3 Plumbing

All metallic pipes entering the RF Room, excluding cryogenic vent and floor drains, must be located within 30 inches (762 mm) of the RF common ground.



NOTICE

Mounting and support of all metallic pipes must comply with requirements in [RF Shielded Room Requirements](#) to minimize the possibilities of electrical discharge which can cause RF broadband noise.

NOTE: When welding in an MR room with system equipment installed, the return path for the welding must be in very close proximity to the welding. The close proximity is needed to make sure the welding currents do not cause damage to the system. Never use the building structure as a return path for welding.

3.1 Water

All pipe waveguides must comply with requirements in [RF Shielded Room Requirements](#) to minimize the possibilities of electrical discharge which can cause RF broadband noise. All plumbing must be in accordance with local and national codes.

3.2 Medical Gases

The customer should consider if medical gases are to be piped into the Magnet Room along with suction service for patient life support. Remember, all non-electrical entries into the Magnet Room must use appropriate waveguide. Special precaution must be taken to ensure that ferromagnetic medical gas cylinders are not brought into the Magnet Room.

3.3 Sprinklers

If using sprinklers in the Magnet Room, dry pipe systems have the advantage of reducing ground problems. However, all decisions regarding fire protection systems are the customer's responsibility. If wet-type sprinkler system is used, pipe penetration should be limited to one location.

4 Electrical

4.1 Electrical Lines and Filters

The entry of any electrical lines into the RF Shielded Room must be filtered to ensure compliance with the RF Shielded Room attenuation requirements. The RF Shielded Room vendor must supply filters for all penetrations of the RF shielding excluding the lines entering through the GE supplied RF penetration panel. All filters (for electrical lines) must be located outside the 200 gauss line.

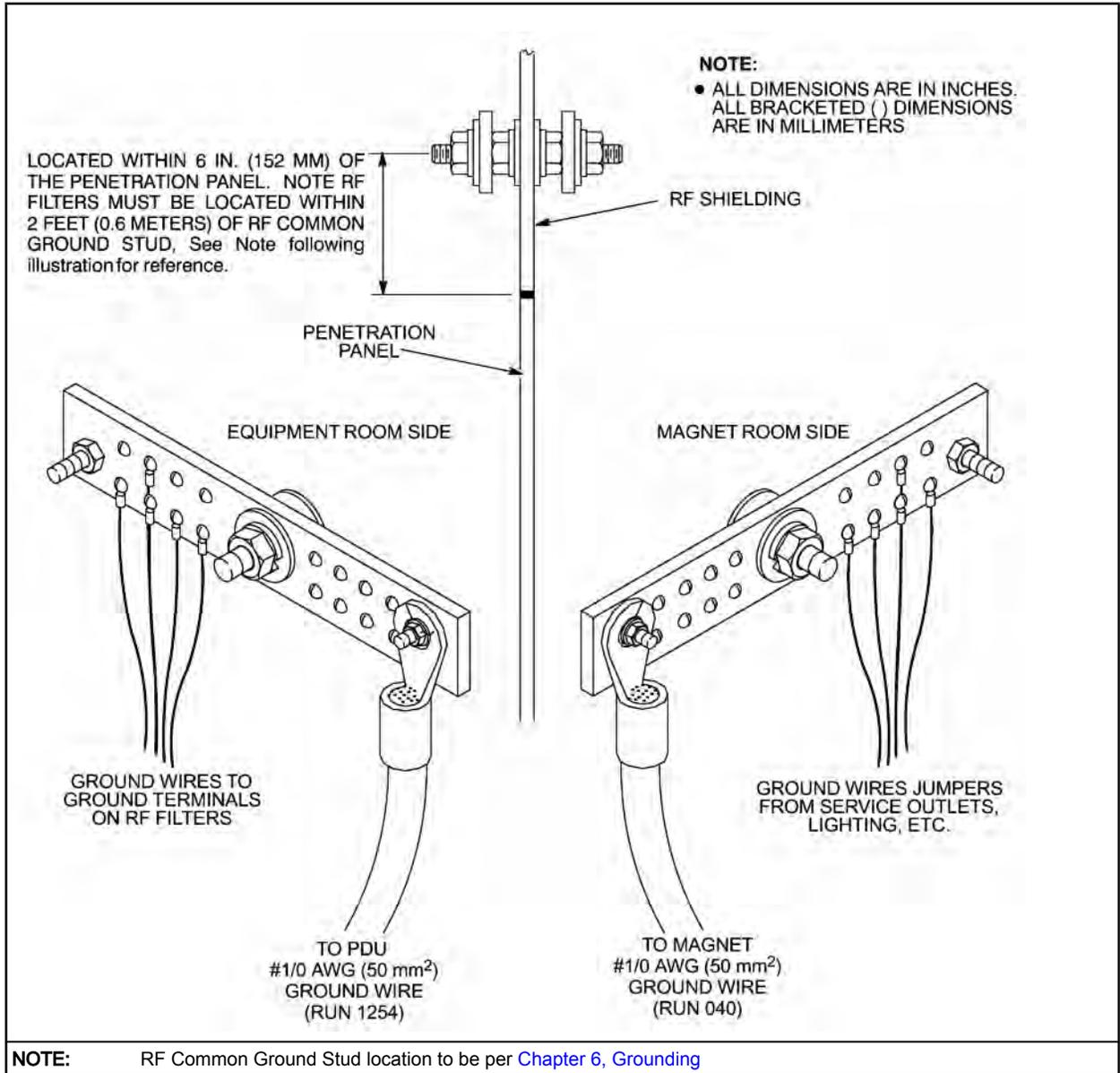
NOTE: All electricals lines and filters must comply with requirements in [RF Shielded Room Requirements](#) to minimize the possibility of electrical discharge which can cause RF broadband noise.

RF Shielded Room vendor must review with the electrical contractor the number of incoming power lines to the Magnet Room to determine the number of filters needed for electrical requirements.

Grounding from customer supplied power filters to the RF Shield Common Ground Stud, see [Chapter 6, Critical Power Requirements](#) and [Chapter 6, Grounding](#) for power and grounding requirements of all incoming power lines to the RF shielded room.

Common ground connection for shielded room must be located within 6 in. (152 mm) of the RF shielded room Penetration Panel with RF filters located within 2 feet (0.6 meters) of the RF Common Ground Stud. RF shielded room vendor to provide this common ground connection on both sides of shielded room by means of a stud extending through the shielded room (see [Table 11-4](#)). The RF Common Ground Stud and terminal bars must be accessible for servicing purposes on both sides of shield room. It is recommended that the RF Common Ground Stud be positioned above the Penetration Panel so it is concealed behind the Penetration Panel Covers ([see RF Penetration Panel](#)).

Table 11-4: RF Common Ground Penetration Stud



4.2 Room Lighting



NOTICE

Installation and selection of lighting fixtures must comply with requirements in [RF Shielded Room Specifications](#) to minimize the possibility of electrical discharge which can cause RF broadband noise.

Fluorescent lighting is not allowed in the Magnet Room due to the RF noise generated by the fluorescent light tubes. Dimmer switches must not be used; however, a selectable switch may be used to change the light intensity.

For additional Magnet Room lighting information refer to [Chapter 5, Lighting](#), [Chapter 6, Grounding](#), [Chapter 6, Emergency Power](#), [Chapter 6, DC Lighting Controller \(Facility Option\)](#).

Also refer to [Chapter 10, Customer Supplied Interconnects](#).

5 RF Penetration Panel

The RF Shielded Room Vendor must provide the opening in the RF shielding and appropriate mounting hardware for the GE Penetration Panel.

The entire Penetration Panel must be located outside 200 Gauss.



NOTICE

Penetration Panel electrical and mechanical connections, mounting hardware, and installation must comply with requirements in [RF Shielded Room Requirements](#) to minimize the possibilities of electrical discharge can cause RF broadband noise.



NOTICE

The Penetration Panel mounting hardware must not loosen over time to maintain RF attenuation requirement in [RF Shielded Room Requirements](#) for the anticipated duration of usage for MR imaging. Some of the design parameter that can contribute to loosen of the Penetration Panel mounting hardware are: wall material compression over time, insufficient fasteners quantity or spacing, over or under tightness of mounting fasteners, insufficient locking mechanism (i.e. Locktight, double/locking nuts), etc.

The RF shielded room acceptance test must be performed after the opening is cut in the RF shielding for the GE Penetration Panel. This acceptance test must be conducted with vendor supplied blank panel and the same mounting hardware to be used with the GE Penetration Panel. It is the facility's responsibility to ensure that the RF Shielded Room Vendor testing meets the attenuation specifications listed in [RF Shielded Room Specifications](#).

The Penetration Panel must be covered on both sides for safety. If GE supplied adjustable covers are not used, customer must furnish covers or enclosures with key or tool required for opening to limit access to the panel. The mounting and clearance dimensions for the Penetration Panel GE covering are shown in Penetration Panel/Covering Mounting Requirements illustration in [Table 11-5](#).

[Illustration 11-4](#) and [Illustration 11-5](#) show two possible methods for mounting the GE MR Penetration Panel. Either method may be used depending on RF shielded room wall thickness. Make sure if the mounting method in [Illustration 11-4](#) is used then the RF wall thickness must be 0.75 in. (19 mm) 0.0625 in. (1.6 mm). Refer to the two preceding Notices. Check with RF Shielded Room Vendor to determine appropriate mounting method.

The Penetration Panel is to be mounted above the finished floor on the Equipment Room side of the RF shielded room. GE supplies only the Penetration Panel as shown in [Illustration 11-4](#) and [Illustration 11-5](#).

NOTE: The following illustrations are examples only and they remain responsible for this RF integrity detail. The connection is dependent upon the thickness and flexibility of the RF shield. The RF vendor is responsible for these details, not GEHC.

Illustration 11-4: Penetration Panel Cut Out For 0.75 Inch (19 MM) Thick RF Wall

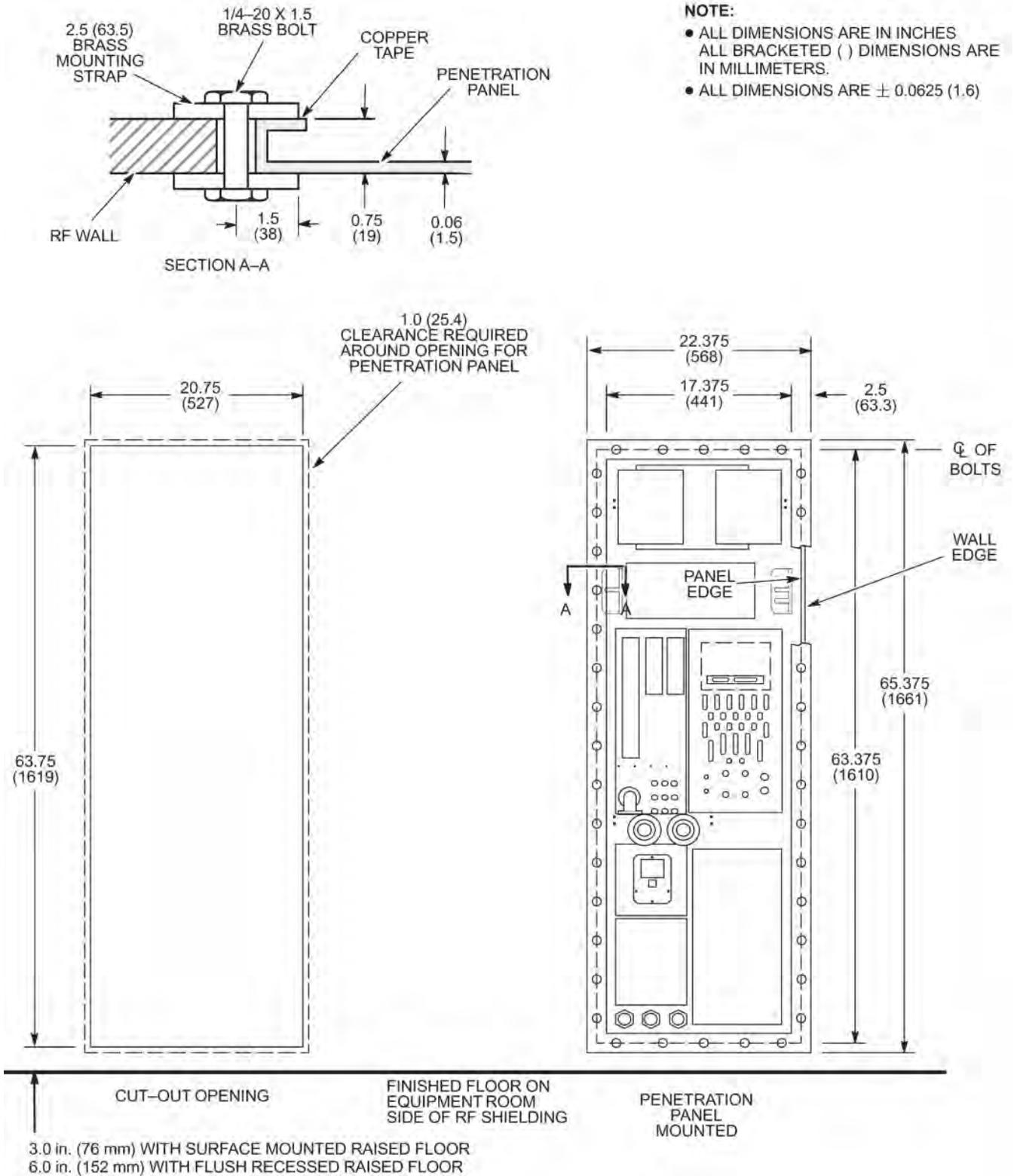


Illustration 11-5: Penetration Panel Cut Out For RF Wall Thickness Varying From Small To Large

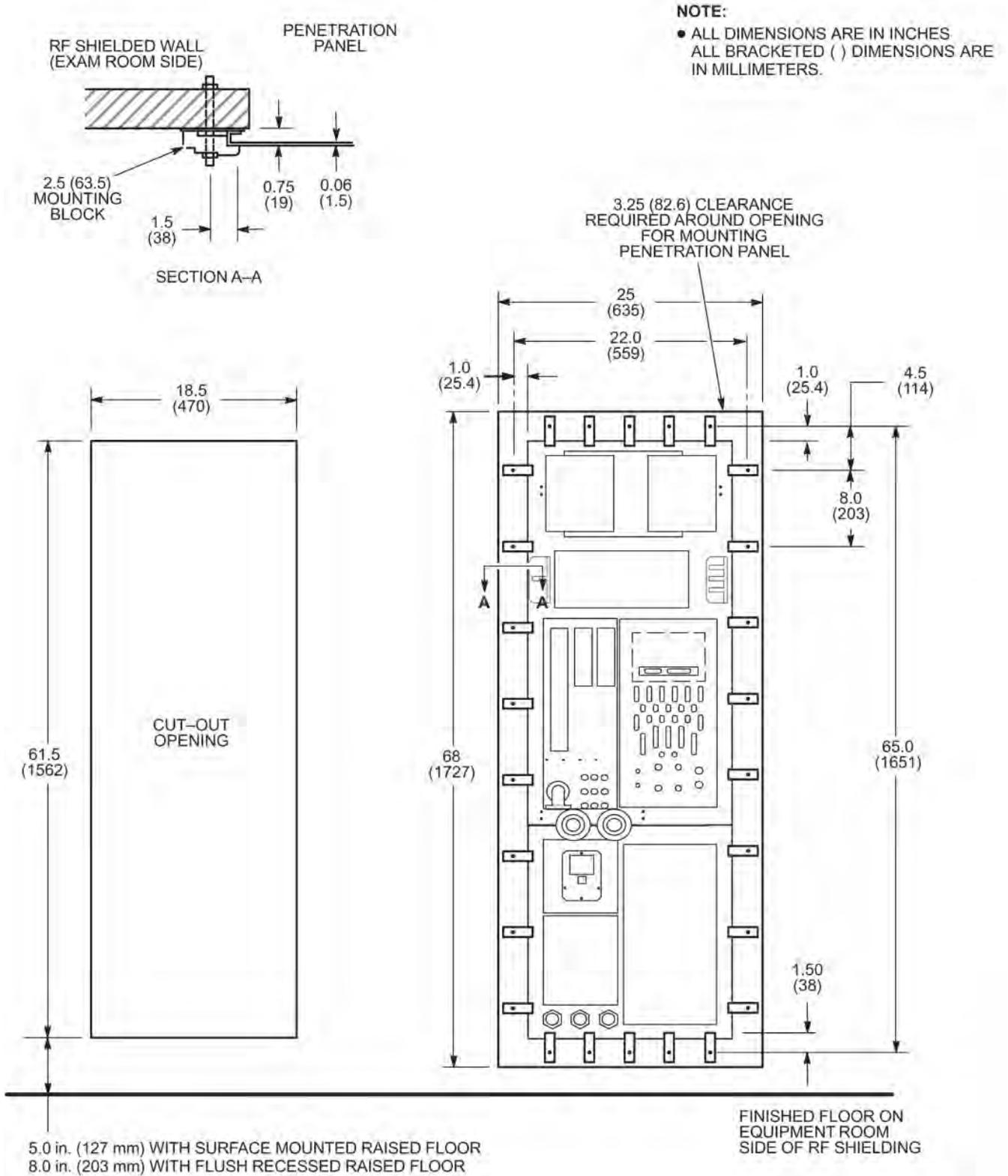
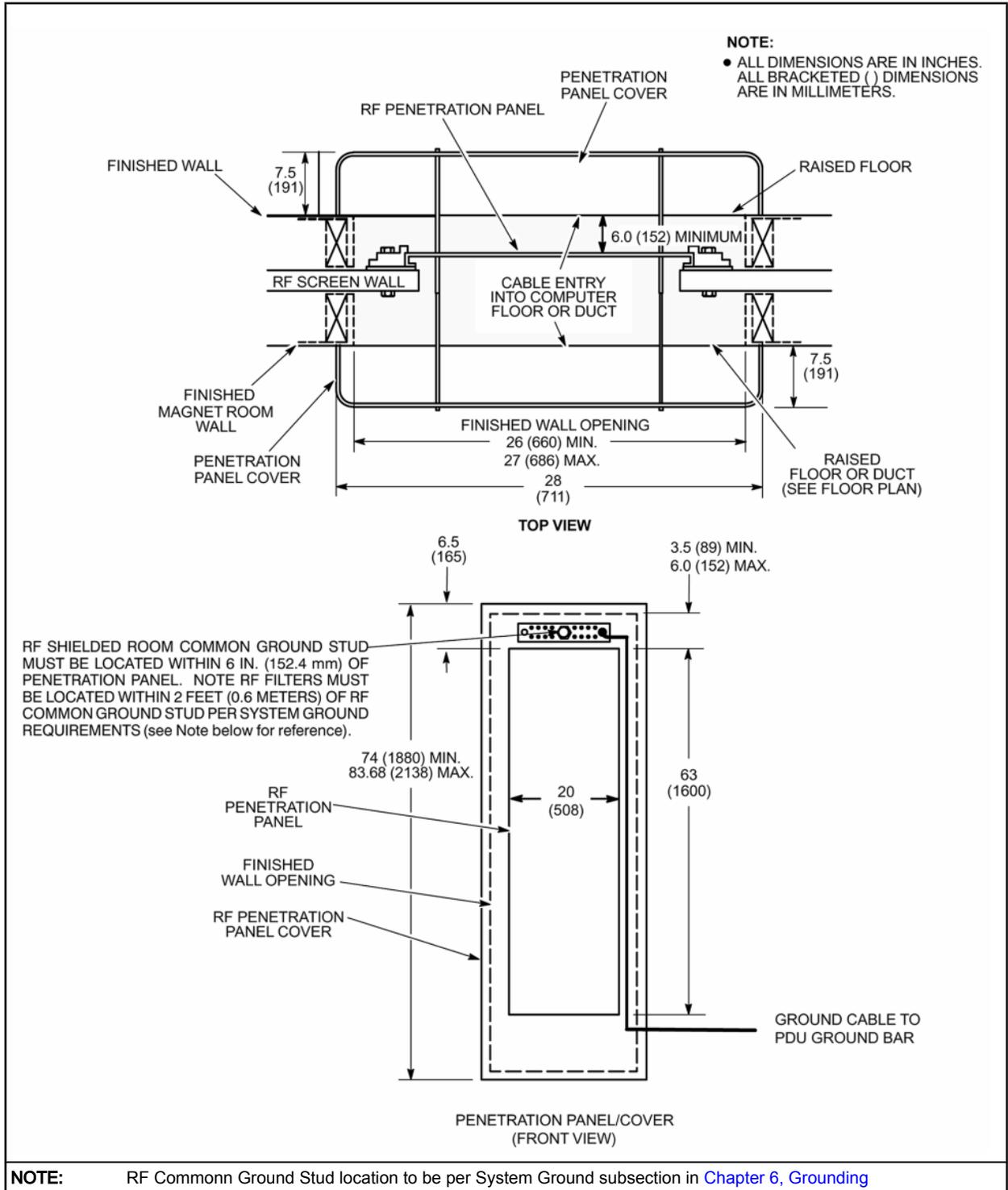


Table 11-5: Penetration Panel/Covering Mounting Requirements



6 Physical Considerations

6.1 Introduction

The RF shielded room can be either a free standing shielded structure or a shielded room within an existing room. All styles of RF Shielded Rooms must be electrically isolated from earth ground complying with requirements in [RF Shielded Room Requirements](#).

NOTE: All physical considerations must comply with requirements in [RF Shielded Room Requirements](#) to minimize the possibilities of electrical discharge that can cause RF broadband noise.

6.2 Doors and Other Openings

Shielded room doors are a major source of RFI leaks and must comply with requirements in [RF Shielded Room Requirements](#).

The door requires a minimum finished opening of 43 in. (1092 mm) to allow for helium dewars and patient tables to pass through the opening. However, a 48 in. (1219 mm) wide door is recommended for easy maneuvering of the Patient Table. Maximum door sill height is 1 in. (25 mm) with a 10 degree maximum threshold inclination.

The magnet delivery into the Magnet/RF Shielded Room requires an access opening into the room which meets the following:

- Wall or ceiling opening to allow sufficient clearance of magnet with rigging equipment, refer to [Chapter 12, Magnet Shipping Considerations](#) for magnet shipping dimensions and consult with customer provided/arranged riggers to determine clearances required for their equipment.

NOTE: Consideration for clear opening dimensions is especially important for sites requiring magnetic shielding.

NOTE: A typical 9 ft (2.74 m) wide by 9 ft (2.74 m) high removable wall panel or 9 ft (2.74 m) by 10 ft (3.05 m) ceiling hatch may require a larger opening in the RF Shield wall or ceiling to accommodate panel or hatch mounting hardware.

- Removable panels/hatch mounting and installation must comply with requirements in [RF Shielded Room Requirements](#) for RF Shield integrity and to minimize the possibilities of electrical discharge can cause RF broadband noise.

6.3 Minimum Ceiling Height

See [Chapter 3, Minimum Room Sizes](#) for minimum ceiling height requirements.

6.4 Walls

It is recommended that walls be covered to protect RF material and to add to the aesthetics of the room. Fire retarding material must be used per building codes. Consult RF shield room vendor for RF shielding service requirements prior to covering RF walls. Removable wall covering may be needed if periodic RF shield servicing is required to maintain RF integrity.

NOTE: Walls materials and installation including all electrical and mechanical connections, mounting hardware, and installation must comply with the requirements in [RF Shielded Room Requirements](#) to minimize the possibilities of electrical discharge can cause RF broadband noise.

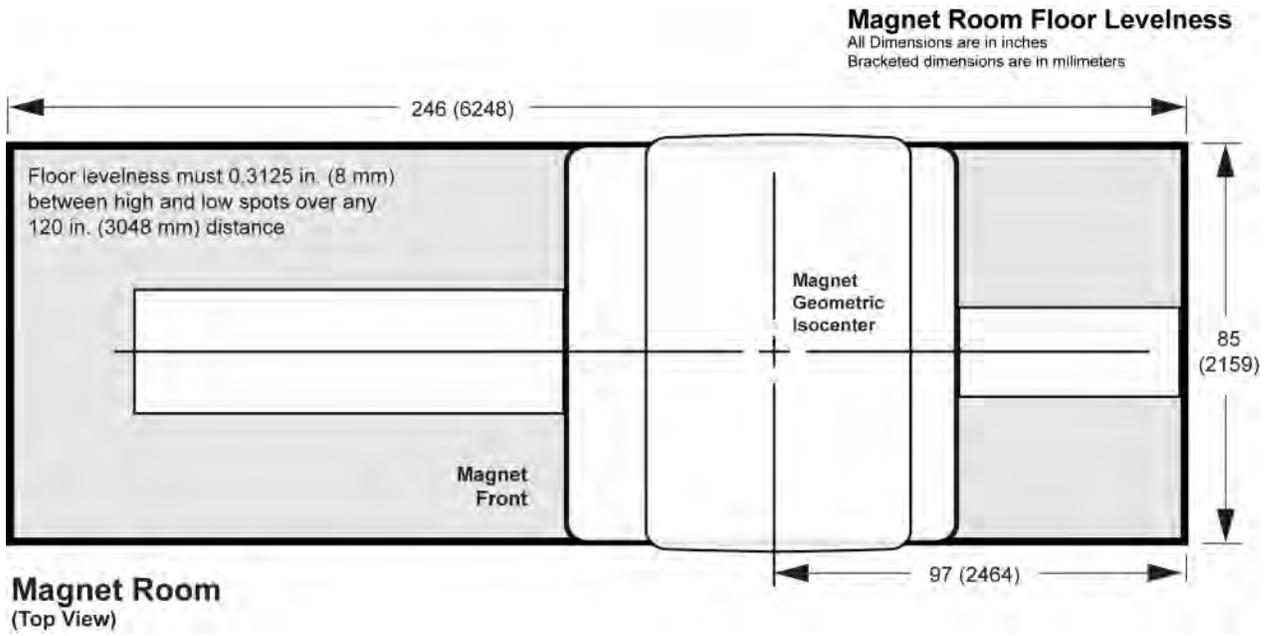
The recommended patient viewing window dimensions are 48 in. wide by 42 in. high (1219 mm x 1067 mm). The location of the window is dependent on the position of Operator Workspace position.

NOTE: The operator at the Operator Workspace must be able to view the patient during a scan.

6.5 Magnet Room Floor Requirements

1. The floor/flooring (i.e. structural, sub-floor and finished flooring) must meet local and national codes.
2. The floor under the Magnet in a 10 ft x 10 ft (3.048 m x 3.048 m) area must not be fabricated from magnetic materials per Magnet Room Floors Magnetic Properties in [Chapter 5, Construction Materials](#).
3. Floor/flooring must support the weight of equipment during system installation and throughout the operation and Service life.
4. Magnet, Enclosure, and Patient Table areas (shown below) must be level to 0.3125 in. (8 mm) between high and low spots over any 120 in. (3048 mm) distance
5. For non-VibroAcoustic Damping Option sites: RF Shield Vendor to provide Aluminum, Brass or Stainless Steel plates to support the Magnet feet (non-compressible material to maintain the depth and level requirements stated in preceding requirements).
6. Metal access floor tiles are not allowed anywhere in the Magnet Room.
7. Rear Pedestal floor support:
 - a. The floor under the Rear Pedestal must support 550 lbs (250 kg) distributed across the 4 leveling feet (1.2 meter).
 - b. The Rear Pedestal leveling feet must be positioned on one solid floor member, no joints or seams are allowed.
8. Electrically conductive materials utilized must comply with requirements in [RF Shielded Room Requirements](#) to minimize the possibilities of electrical discharge which can cause RF broadband noise.
9. The finished floor needs to be water resistant and protect the RF/Magnetic Shield and subfloor from possible water damage.
10. MR System Interconnection cables are FT4 or equivalent rated; not plenum rated.
11. The flooring grounding device and fastener/securing equipment are supplied by the customer or customer contractor and must be installed as the manufacturer defines.

Illustration 11-6: Magnet Room Floor Levelness Area



7 Anchor Hardware Requirements

7.1 Anchor Hardware for MR Equipment Inside RF Shield

7.1.1 Introduction

The following components must be anchored to the floor:

- Blower Box
- Dock
- Magnet (without Vibro-Acoustic dampening option)

An RF Shielded Room is required per [RF Shielded Room Requirements](#) and the mounting of MR equipment located inside the RF Shield must comply with the RF Shield requirements.

Anchors are installed into the Magnet Room floor to provide a connection point to securely mount equipment. Improper installation of anchors can introduce RF issues (discrete and/or broadband) as well as secondary ground issues. Refer to [RF Shielded Room Requirements](#) for potential RF issues and RF Shielded Room requirements.

When the anchors penetrate the RF shield then the installation of the anchors must meet the requirements of [RF Shielded Room Requirements](#). Refer to [RF Shield Integrity](#) and [Electrical Isolation](#) for additional information.



NOTICE

Customers choosing to install the Magnet using the VibroAcoustic Damping Option (M1060MA) are not required to set anchors into the structural floor directly under the magnet feet. However, other system equipment anchors defined in the following sections are still required.

7.1.2 Customer Responsibilities

The Customer is responsible for the following tasks:

- Contract with RF Shield Room vendor, structural engineer, and architect to design the equipment anchor hardware to meet the GE specifications, refer to [RF Shielded Room Requirements](#) requirements table, [Physical Characteristics](#), and [Anchor Location And Installation](#).

NOTE: The need for Blower Box anchors must be planned in advance to allow the RF Shield vendor to include the cost in their bid.

- Obtain any and all approvals necessary for the construction of equipment support and seismic anchoring. The customer needs to obtain a copy of building inspector's (inspection) report and approval of the anchor method, maintain these documents with the site documentation.
- Coordinate equipment anchor methods and anchor locations with the contracted RF Shield Room vendor, structural engineer, and architect to prevent RF leaks and secondary grounding problems.

7.1.3 RF Shield Room Vendor Responsibilities

The RF Shield Room vendor is responsible for the following tasks:

- Design the equipment anchor hardware to meet the GE specifications, refer to [RF Shielded Room Requirements](#) requirements table, [Physical Characteristics](#), and [Anchor Location And Installation](#).
- Procurement of commercially available anchors, bolts / removable rods, and fastening hardware required for equipment listed in [Physical Characteristics](#).



NOTICE

The RF Shield Room vendor **MUST** supply torque specifications for all procured two part type anchors, BOLTS / REMOVABLE RODS, and fastening hardware to meet the clamping force specified for each piece of equipment listed in [Physical Characteristics](#).

- Define the anchor torque/method required to achieve the specified clamping force (tension), refer to [Physical Characteristics](#). The torque requirement to be provided to the customer for use during magnet installation.
- Layout and installation of the equipment anchors (create own template from GE supplied information) Coordination with Building Contractor/Architect may be necessary to prevent interference with rebar or structural steel that would cause a secondary ground path through the anchor.
 - Coordinate with GE Service to locate magnet isocenter and equipment mounting. RF Shield Room vendor must be present when GE Service identifies magnet isocenter location (to maximize the accuracy of the location).
 - Coordinate with GE Service to make sure site requires Magnet anchor bolts (i.e VibroAcoustic Damping Option (M1060MA) not planned to be installed).
 - If VibroAcoustic Damping Option (M1060MA) not planned to be installed then anchors for Magnet shall be installed prior to magnet installation to allow time to address any issues that may arise.
 - Dock Assembly Anchor shall be installed at the anchor location determined by GE Service using the Dock Assembly aligned to the Magnet. Anchor location is determined by GE Service temporarily installing the dock assembly – use dock as a template.
 - If the Blower Box is secured to the finished floor and the anchor hardware penetrates the RF shield then the RF Shield Vendor must install the anchors prior to system equipment delivery.
- Perform pull test on all anchors to confirm the specified clamping force (tension) can be meet, refer to [Clamping Force \(Tension\) and Pull Test](#). A copy of the test results must be provided to the customer (customer to maintain copy with the site documentation).
- Perform ground impedance (electrical isolation) test on installed anchors, refer to [Electrical Isolation](#).
- Perform RF integrity test per [Chapter 14, RF Shielded Enclosure Test Guideline](#).
- Provide copy of ground impedance and RF room integrity tests to the customer to be maintained with the site documentation.

7.1.4 GE Healthcare Responsibilities

GE Healthcare is responsible for the following tasks:

- GE Project Manager, Installations to provide equipment dimensions drawings showing equipment mounting locations to the RF Shield Room vendor and review the anchor method prior to anchor installation.
- GE Service to assist RF Shield Room vendor by locating magnet isocenter during layout of equipment anchors. RF Shield Room vendor to be present when GE Service identifies magnet isocenter location to maximize the accuracy of the location.
- GE Service to inspect and verify the anchor location is correct and obtain the anchoring hardware from the RF Shield Room vendor prior to equipment delivery.
- GE Service to carefully inspect the RF seal (electrical connectivity) of the anchor and bolts/ rods to the RF Shield (i.e. the fibrous washer or equivalent device is in place).
- GE Service to work with riggers to secure Magnet to anchors at time of delivery and installation.
- The Dock Assembly anchor location is determined by GE Service using the Dock Assembly aligned to the Magnet. (RF Shield Room Vendor is responsible for installing the two part anchor.)

Refer to [Physical Characteristics](#) for equipment type and seismic anchor characteristics.

7.2 Anchor Hardware Physical Requirements

7.2.1 Anchor Hardware Requirements

Anchor hardware must meet the following requirements:

- Two part type anchor assembly (female and male)
 - The female anchor can be expansion or epoxy type (must be compliant with local and national code and regulation)
 - The male anchor can be either a bolt or threaded rod with appropriate sized nut (rod must be completely removable, not epoxyed or cemented in place)
- Able to achieve clamping force (tension) requirement for the equipment to be anchored, refer to [Table 11-6](#).
- Non-magnetic and electrically conductive (to allow it to be electrically connected to the Room's RF Shield at the point of penetration)
- Compatible with the material properties of the RF Shield and not produce galvanic corrosion due to dis-similar metals
- Be completely removable for the life of the product (with possible multiple removals)
- Be commercially procured
- Is approved by the local building inspector.

7.2.2 Design of Anchor Assembly

The following factors contribute to the anchor selection:

- Embedment depth (affects the length of the bolt/removable rod) and properties of material in which the anchor will be embedded
- Floor thickness including RF Shield floor and Magnet Room finished floor
- Equipment base thickness and any spacers required under the base
- Equipment base clearance for protrusion of bolt/rod inside the base
- Anchor diameter:
 - Magnet anchor bolt/removable rod diameter: minimum 0.625 in. (M16) and maximum 1.25 in. (M32)
 - Dock and Blower Box: refer to [Table 11-6](#)
- Size of the hole in the equipment base (affects the diameter of the bolt/removable rod)
- Clamping force (tension) requirement for the equipment, refer to [Table 11-6](#)
- Seismic codes (affect the length and diameter of the bolt/removable rod and anchor size)

Refer to [Table 11-7](#) for Equipment Characteristics.

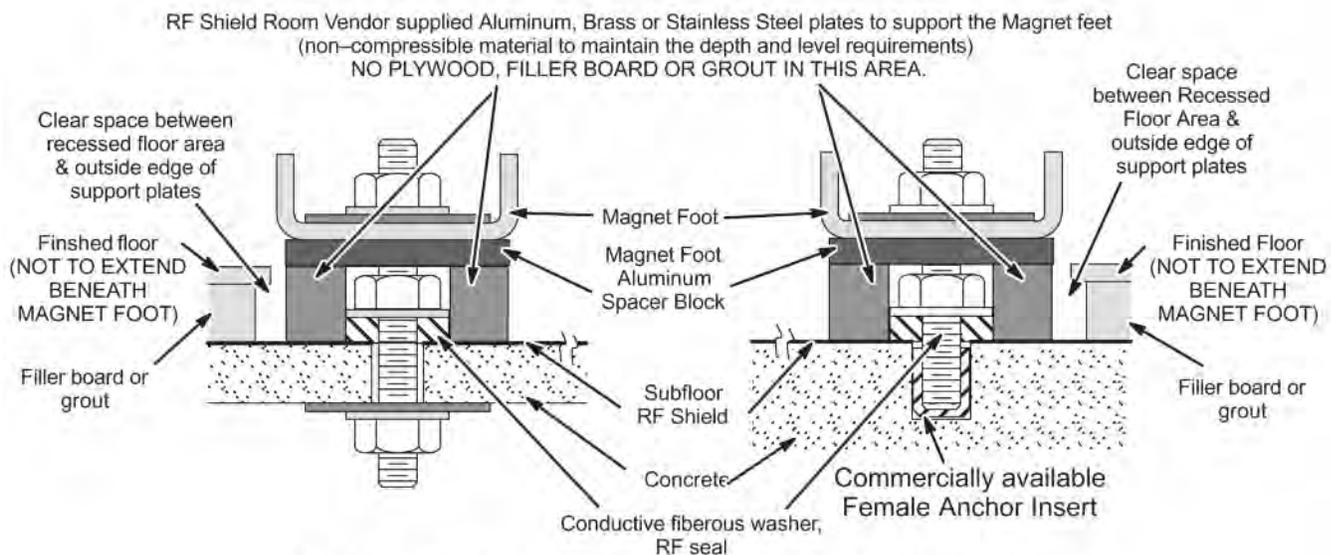
Table 11-6: Equipment Clamping Force (Tension) Requirements

Equipment Type	Clamping Force (Tension) To The Floor Applied To Each Anchor	
	See Note 1	
	lbs	N
CxK4 Magnet without VibroAcoustic Damping Option (See Note 2 & 3)	2,500 ± 200	11,100 ± 900
Dock Assembly for CxK4 Magnet	600 ± 100	2700 ± 450
Blower Box (See Note 4)	100 ± 10	450 ± 45

Note

1. The RF Shield Room Vendor must perform a pull test on each anchor, equal to the clamping force (tension) required for the equipment, prior to equipment delivery. A copy of the pull test results, anchor ground impedance measurements and building inspection certification must be given to the customer to be maintained with the site documentation.
2. Compressible material must not be present in the recessed floor area under the Magnet, refer to [Illustration 11-7](#). The clamping force (tension) must be maintained for the equipment over the life of the product.
3. All four feet of the magnet must be anchored to the floor. The anchor hole openings in the magnet base are to be used to anchor the magnet.
4. The Blower Box must be securely mounted to the solid floor in the Magnet Room or a support shelf on the Magnet Room wall or ceiling with support provided under the Blower Box. The Blower Box **must not** be on a raised floor section within the Magnet Room. If the Blower Box is secured to the finished floor and the anchor hardware penetrates the RF shield then the RF Shield Vendor must install the anchors prior to system equipment delivery. The need for Blower Box anchors must be planned in advance to allow the RF Shield vendor to include the cost in their bid.

Illustration 11-7: RF Shield Room Anchor Details



Note: For sites with RF Shield on top of subfloor, the RF Shield needs to be recessed to the concrete level to provide a proper RF Seal.

NOTE: For VibroAcoustic Damping Option mounting in seismic zones refer to seismic drawings available on request from your local GE Healthcare Project Manager Installations.

Table 11-7: Equipment Characteristics (See Note 1 in this Table)

Equipment Type	Equipment Mounting Base Thickness in. (mm)	Clearance Hole In Equipment Base in. (mm)	Maximum Clearance Above Equipment Base in. (mm) See Note 2	Seismic Requirement Pre-Approved By OSHPD For Bolt Or Stud Diameter in. (mm) See Note 3	Equipment Mounting Illustration
CxK4 Magnet without VibroAcoustic Damping Option See Note 4	1.75 (44) See Note 5	1.5 (38)	2.5 (64)	1.0 (M24)	& Illustration 11-7
Magnet Dock Assembly	0.75 (20)	0.43 (11)	2.0 (50)	Pre-approval not required. Select anchor/stud to clamping force (tension).	
Blower Box See Note 5	0.25 (6)	0.25 (6)	0.5 (13)	Pre-approval not required. Select anchor/stud to clamping force (tension).	Chapter 7, Blower Box

Notes

- All equipment mounting methods and installation must meet requirements in [RF Shielded Room Requirements](#).
- Maximum Clearance Above Equipment Base is the dimension for protrusion of the bolt or rod inside the equipment base including clearance for tools to tighten hardware to meet specifications in [Table 11-6](#).
- When the VibroAcoustic Damping Option is not installed then all four feet of the Magnet must be bolted to the floor. The bolt hole openings in the Magnet base are to be used to anchor the Magnet.
- Magnet mounting base thickness includes the 1 inch (25 mm) foot block required to maintain the Magnet Center Line Height dimension as defined in [Chapter 7, Magnet and Enclosure Magnet Enclosure Front And Rear Views illustration](#).
- The Blower Box must be securely mounted to the solid floor in the Magnet Room or a support shelf on the Magnet Room wall or ceiling with support provided under the Blower Box. The Blower Box must not be mounted on a raised floor section within the Magnet Room. If the Blower Box is secured to the finished floor and the anchor hardware penetrates the RF shield then the RF Shield Vendor must install the anchors prior to system equipment delivery.

7.3 Anchor Location And Installation



NOTICE

Anchor hardware must avoid direct contact with rebar or wire mesh located in the building or Magnet Room floor to avoid secondary ground planes and/or RF issues (discrete and/or broadband), refer to Ground requirements in RF Shielded Room Requirements table in [RF Shielded Room Requirements](#).

The exact location for installing the Magnet anchors is determined by dimensional footprint drawings for the MR equipment to be installed. The Design Center group at GE Healthcare will provide to the RF Shield Room Vendor the dimensional drawing showing all anchor locations. The drawing can be issued in either hard copy or electronic format. The RF Shield Room Vendor is responsible for supplying their own template to precisely mark the Magnet anchor locations within the room.

Dock Assembly Anchor shall be installed at the anchor location determined by GE Service using the Dock Assembly aligned to the Magnet. RF Shield Room Vendor is responsible for installing the two part anchor.

Coordination between the RF Shield Room Vendor and Building Contractor/Architect may be necessary to mark the location of the Magnet anchors to prevent interference with rebar or structural steel. A re-arrangement of the room may be necessary to ensure ground isolation, refer to Ground requirements in RF Shielded Room Requirements table [RF Shielded Room Requirements](#).

Refer to equipment dimensional illustration references in the Equipment Characteristics table in [Physical Characteristics](#).

7.4 Clamping Force (Tension) and Pull Test

1. Anchors which meet requirements in [Physical Characteristics](#) must be installed per [Anchor Location And Installation](#).
2. Each anchor must meet the clamping force (tension) requirement defined in [Physical Characteristics](#).

NOTE: The equipment must be clamped directly to the floor and the entire equipment base must maintain full contact to the floor per [Physical Characteristics](#) requirements.

3. A pull test equal to the clamping force (tension) must be performed by the RF Shield Room Vendor prior to the equipment installation. The test results indicating the torque required to achieve the specified clamping force (tension) must be recorded by RF Shield Room Vendor and the customer to maintain a copy of this report with the site documentation.

7.5 RF Shield Integrity

The anchor hardware must maintain RF shield integrity. This is accomplished by electrically sealing the stud at the penetration point on the RF shield. The method by which the electrical contact is made must take into account any stretch in the stud resulting from the applied clamping force (tension). A fibrous washer or equivalent will provide a proper RF seal where a solid flat washer could produce an RF leak and introduce artifacts into the MR images. The RF room test should result in a specific attenuation at the operating frequency of the system under the following conditions:

1. Blank Penetration Panel installed
2. Anchor hardware installed
3. Electrical connection made between the anchor stud and the RF shield.

Refer to Appendix [Chapter 14, RF Shielded Enclosure Test Guideline](#).

7.6 Electrical Isolation

The anchor hardware must not provide a secondary ground path for the RF Shield Room, refer to [Table 11-8](#) for anchor hardware electrical isolation requirements and recommendations.

Table 11-8: Anchor Hardware Electrical Isolation Requirements & Recommendations

Requirements	
<ol style="list-style-type: none"> 1. Ground Isolation: 1,000 ohms or greater (refer to RF Shielded Room Requirements requirements table) 2. Secondary Ground (Other grounds that connect the outside of the RF Shield Room to earth grounds are called secondary grounds.): Secondary grounds must not compromise Ground Isolation of 1,000 ohms or greater. (Refer to RF Shielded Room Requirements requirements table) NOTE: If the result is less than 100 ohms then it is very likely the anchor has made contact to steel rebar or wire mesh. In this case the steel in the floor will need to be removed or the anchors will need to be relocated. In either case GE Healthcare must be notified and a retest performed after the corrective action is taken. 3. The electrical isolation test results must be recorded by RF Shield Room Vendor and the information forwarded to the customer to be maintained with the site documentation. 	
Comments	
Electrical isolation test of each anchor and bolt/rod should be performed prior to Magnet placement.	

8 Magnet Room Equipment Mounting

8.1 Magnet Rundown Unit (MS4)

The Magnet Rundown Unit should be mounted 60 in. (1524 mm) above the Magnet Room floor near the front of the magnet enclosure but outside the 200 gauss zone.

8.2 Emergency Off Buttons

Customer supplied emergency off buttons to be located near each room exit including magnet and equipment rooms. These buttons must be clearly labeled, "Emergency Off". Refer to [Chapter 6, Emergency Power](#).

8.3 Remote Oxygen Sensor Module (OM3) - Optional

The Remote Oxygen Sensor Module (if option ordered) must be mounted approximately 60 in. (1524 mm) above the Magnet Room floor near the front of the magnet enclosure.

9 RF Door Switch

RF shielded room vendor must supply and install RF door switches on all RF shielded doors. These switches must be wired in series and a GE supplied cable (two loose lead conductors) will attach to one door switch. RF switches must be rated for 24 volts at 750 milliamperes maximum and the switches must be in the open position when the doors are open (switch contacts close when the doors are completely closed).

10 Emergency Exit

Emergency exiting from the Magnet Room is to be specified by the customer's architect and contractor. Such measures as an out swinging door, emergency door latch release, easily removed window, or other measures must be designed into the room. Emergency exit instructions must be permanently and prominently mounted near the door and/or window.

11 Room Ventilation Switch

Placement of the room ventilation switch should be near the Magnet Room door and is the responsibility of the architect and mechanical contractor.

Chapter 12 Shipping and Delivery

1 MR System Shipping and Receiving



NOTICE

All shipping dimensions and weights are approximate and may vary based on ship-to location, required rigging, or other requirements. Some shipping or access routes may have requirements in addition to those listed in this section. Contact the GE Healthcare Project Manager of Installation (PMI) to verify magnet shipping, rigging, and access.

1. The customer must provide an area for unloading system components

NOTE: Contact the GE Healthcare Project Manager of Installation (PMI) for a list of experienced rigging companies.

2. At delivery, the customer is responsible for ensuring:
 - a. All floors along the route will support the weight of the magnet (GE Healthcare recommends a structural analysis)
 - b. Doors or other openings are sufficiently wide to allow passage
 - c. Sufficient room is provided for any required dollies or rigging

Table 12-1: 1.5T MR System Shipping Data

MR Component	Approximate WxDxH		Approximate Weight		Method Of Shipment
	in.	mm	lbs	kg	
1.5T LCC Magnet with cryogenics, partial Quiet Technology Enclosure installed	93 x 144 x 107	2362 x 3658 x 2718	See Note 1		Domestic - Tarpred International - crate/pallet
Magnet Accessory Equipment	48 x 48 x 28	1219 x 1219 x 711	400	182	crate
Shield/Cryo Cooler Compressor Cabinet	26 x 28 x 42	660 x 711 x 1067	240	109	skid with box cover
Rear Pedestal Assembly with Rear Split Bridge Assembly, Low Profile Carriage Cover	34 x 58 x 48	864 x 1473 x 1219	310	132	box on pallet
Enclosure Top	48 x 36 x 36	1219 x 914 x 914	30	14	box
Enclosure Skirts	40 x 24 x 24	1016 x 610 x 610	30	14	box
Fixed Site Water Chiller for Gradient Coil Cooling	29 x 42 x 33	737 x 1067 x 838	320 dry weight	154 dry weight	crate
Patient Table	94 x 29 x 38	2377 x 772 x 952	474	215	pallet
Patient Blower Box	24 x 30 x 24	610 x 762 x 610	30	14	box
HFD/PDU Cabinet without Fan Module installed	24 x 37 x 75	610 x 940 x 1905	1810	823	on cabinet casters, wrapped with plastic
Fan Module for HFD/PDU Cabinet	28 x 38 x 15	711 x 965 x 381	160	73	on pallet

MR Component	Approximate WxDxH		Approximate Weight		Method Of Shipment
	in.	mm	lbs	kg	
RFS Cabinet	24 x 36 x 77	610 x 914 x 1956	905	411	on cabinet casters, wrapped with plastic
SPT Phantom Set	34 x 32.5 x 60	864 x 826 x 1524	350	159	on cart casters with box cover
Operator Workspace Cabinet	24 x 35 x 31	600 x 900 x 780	243	110	wood pallet with cardboard cover
Operator Workspace LCD Panel	27 x 33 x 27	686 x 838 x 686	125	57	skid
Operator Workspace equipment	32 x 32 x 23	813 x 813 x 584	100	45	box
Operator Workspace Table	45 x 54 x 37	1143 x 1372 x 940	180	82	box
1.5T MNS Amp Cabinet*	23 x 39 x 50	584 x 991 x 1270	600	272	on cabinet casters, wrapped with plastic
BrainWaveHW Lite Cabinet *	24 x 23 x 72	610 x 584 x 320	320	147	on cabinet casters, wrapped with plastic
VibroAcoustic Damping Option *	36 x 65 x 12	914 x 1651 x 305	575	261	box on pallet
32 Channel Cabinet *	24 x 36 x 77	610 x 914 x 1956	471	214	on cabinet casters, wrapped with plastic
Outdoor/Indoor Air Cooled MRCC Unit					
MRCC unit	63.8 x 34.3 x 59.1	1620 x 870 x 1500	750	340	crate
Ship loose items	31.5 x 31.5 x 36	800 x 800 x 920	394	178.5	box
Notes					
* Optional Equipment					
1. Approximate magnet shipping weight of magnet with cryogenics, BRM Gradient & RF coils, Enclosure parts installed on magnet, and lifting beams (i.e. minus packaging material): 11,700 lbs (5320 kg).					
International shipments must add shipping crate/pallet of 2,200 lbs (998 kg).					

2 Magnet Shipping Considerations

For domestic, the magnet is shipped covered with plastic (no shipping pallet). For export, the magnet is crated for shipment on a special shipping pallet. Refer to table titled Shipping Date in [Shipment](#) for the weight and dimensions of the magnet in its cold ship configuration (i.e. with liquid cryogen in vessel within the cryostat) and with the RF/Gradient Coil inside the magnet bore.

The magnet moving dimensions are shown in [Illustration 12-1](#).

Consideration must be given to the delivery route of the magnet to ensure that the floor can support the magnet and any rigging equipment required to move it. A structural analysis should be performed by a professional structural engineer. The magnet must not be tilted more than 30° in any direction when being moved into position.

The customer is to provide and arrange for riggers to move the magnet from the delivery truck to the final site location. Contact local GE Service for a list of recommended rigger companies. The customer's riggers should have an adequate amount of liability insurance to cover any damage to property or MR system that may occur during delivery of the magnet. The GE Sales Representative or Project Manager, Installations can provide customer riggers with the replacement value of the MR system for insurance purpose.

The magnet is shipped with liquid helium in the vessel within the cryostat. Thus, when these magnets arrive at site, a cryogen delivery route must be available for moving cryogen dewars to the magnet for periodic replenishment of liquid helium.



NOTICE

Power and cooling water for the Shield/Cryo Cooler Compressor Cabinet must be available when the Magnet is delivered to minimize cryogen usage. For specifications see Site Environment chapter sections:

- [Chapter 5, Shield/Cryo Cooler Temporary Backup Water Cooling](#) for temporary backup water specifications
- [Chapter 5, Air Cooling](#) for sites using air cooled MRCC unit
- [Chapter 5, Shield/Cryo Cooler Water Cooling For Site Provided Water Cooling](#) for details of Shield/Cryo Cooler Compressor Cabinet requirements

and Power Requirements chapter sections:

- [Chapter 6, System Power Introduction](#)
- [Chapter 6, Critical Power Requirements](#)
- [Chapter 6, Main Disconnect Panel \(MDP\) Requirements](#)

Means must be provided for venting of the cryogenic gases, refer to specifications in [Chapter 5, Cryogenic Venting Introduction](#), [Chapter 5, Requirements For Outside Magnet Room](#) and [Chapter 5, Requirements For Inside Magnet Room](#).

Illustration 12-1: Magnet Moving Dimensions

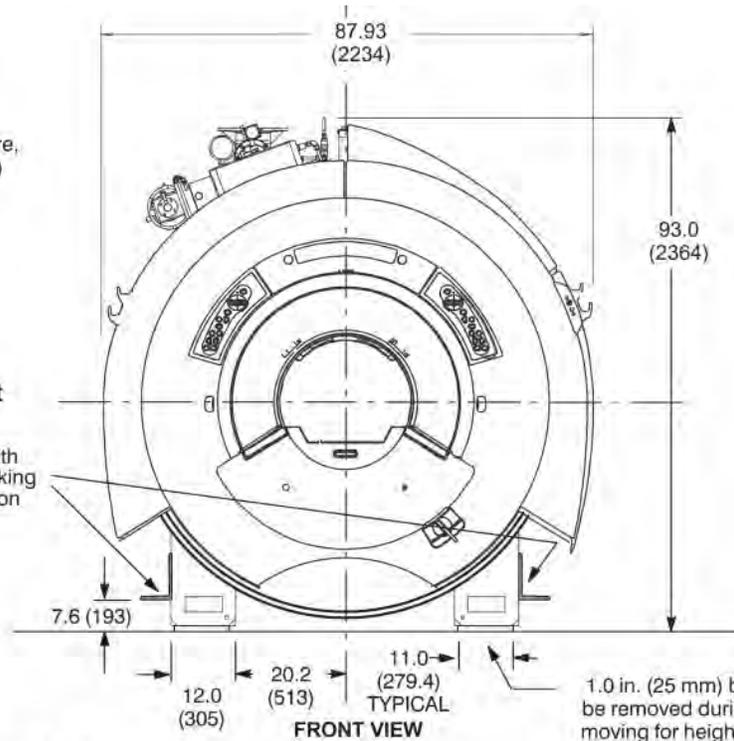
NOTE:

- All dimensions are inches, all bracketed () dimensions are in millimeters.
- 1.5T LCC Magnet with cryogenics, partial Enclosure, BRM-F Gradient & RF Coils in bore, and lifting beams weight: 11,600 lbs (5320 kg)

CAUTION

Final magnet moving dimensions are dependent on rigger equipment requirements.

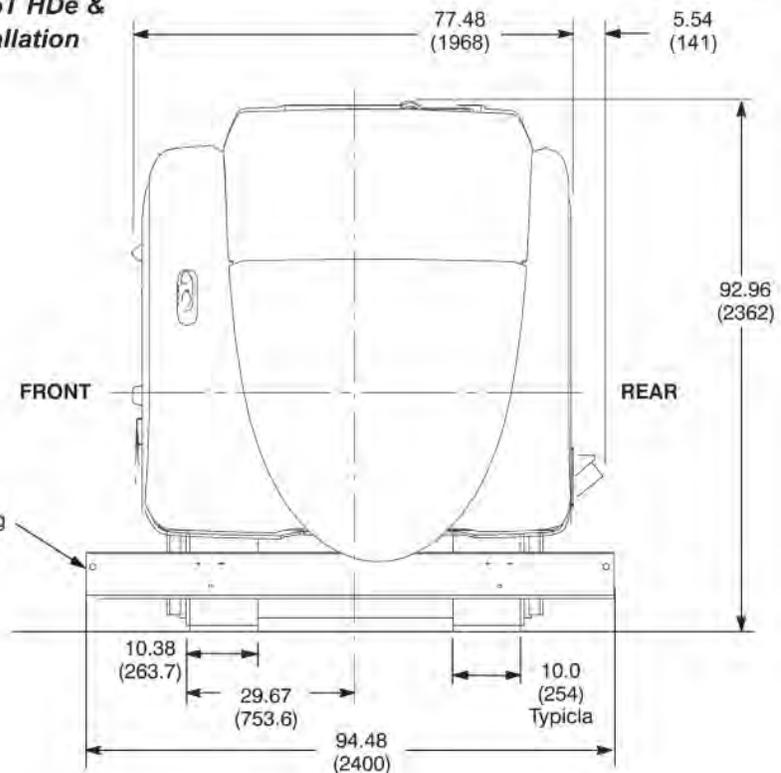
Magnet ships with bolt-on lifting/jacking beam mounted on each side



CAUTION

Refer to *Direction 5154839 GE 1.5T HDe & HDx LCC Magnet Delivery & Installation* for magnet moving and lifting requirements and details.

Magnet ships with bolt-on lifting/jacking beam mounted on each side



Chapter 13 Site Planning Reminders

1 General Pre-Installation Reminders

The following Reminders define absolute minimum site planning issues that must be completed prior to equipment delivery, installation and calibration. Tables below are organized to identify site planning design requirements, safety requirements, then a list of tasks that must be completed prior to delivery of the magnet or electronics into the MR site. The final group defines tasks that must be completed prior to ramping the magnet to field.

The customer’s site planner/architect is expected to use this guide when performing final site completion inspections. The items in the following tables assist subsequent inspections. This does not relieve the customer’s site planner/architect from meeting any other requirement in this manual.

All work must be in compliance with national and local codes.

Table 13-1: Design/Engineering Requirements Review & Final Inspection

Step	Requirement
1	The customer’s site planner/architect must review customer supplied site planning construction drawings to ensure the plans are in compliance with the requirements defines in the Pre-Installation Manual and the MR Typical Drawings
2	Site Planner/architect to present a vibration study confirming the site meets the product requirements. The site construction plans must identify solutions to any site detail that failed to meet the vibration specification. Refer to: Chapter 5, Vibration
3	Site construction plans identify means to contain the magnetic field and that the site design complies with the external magnetic field requirements. Refer to: <ul style="list-style-type: none"> • Chapter 3, Magnetic Field Proximity Limits • Chapter 4, Introduction • Chapter 4, Homogeneity Requirements • Chapter 4, Structural Steel Evaluation of Proposed Site • Chapter 4, Magnetic Shielding • Chapter 4, Magnetic Field Definition • Chapter 4, Exclusion Zone • Chapter 5, Construction Materials
4	Building facility steel and iron materials must be limited so as not to influence the main magnetic field. Refer to: Chapter 4, Structural Steel Evaluation of Proposed Site
5	Magnet Room floor level, locations (relative to magnetic shield, cryogenic vent), service area, and VibroAcoustic Damping Kit, etc. meet site planning requirements. Refer to: <ul style="list-style-type: none"> • Chapter 3, Minimum Room Sizes • Magnetic Field Considerations (Refer to sections in Item 3) • Chapter 5, Construction Materials • Chapter 11, Cryogenic Vent Location • Chapter 11, Magnet Room Floors • Chapter 11, Physical Considerations – Anchors

6	<p>Site walls, RF doors and windows have been selected to contain acoustic noise. Refer to:</p> <ul style="list-style-type: none"> • System Acoustic Noise Levels • Chapter 14, Acoustic Design Guidelines
7	<p>The site main power details meet the power quality requirements. Refer to:</p> <ul style="list-style-type: none"> • Chapter 6, System Power Introduction • Chapter 6, Critical Power Requirements
8	<p>Magnet Room lighting design, material and construction techniques comply with RF Shielded Room Requirements, specifically broadband noise requirements. Refer to:</p> <p>Chapter 11, RF Shield Room Requirements</p>
9	<p>Magnet and equipment room design will meet requirements should multiple MR scanners share common rooms, areas. Refer to:</p> <ul style="list-style-type: none"> • Chapter 3, Two Magnet Site Layout • Chapter 3, Equipment Room Shared By Multiple MR Systems



WARNING

GASEOUS HELIUM IS AN INVISIBLE, ODORLESS GAS THAT CAN CAUSE ASPHYXIATION WHEN OXYGEN IS DEPLETED. HELIUM GAS, WHICH IS LIGHTER THEN AIR, WILL RISE TO THE CEILING. THE MAGNET WILL EXHAUST HELIUM GAS DURING MAGNET DELIVERY & INSTALLATION.

THE FOLLOWING SAFETY ITEMS MUST BE STRICTLY ADHERED TO PRIOR TO MOVING THE MAGNET FROM THE TRUCK INTO THE ROOM.

Table 13-2: Site Safety Readiness

Step	Requirement
1	<p>The entire customer supplied cryogenic venting system has been inspected from within the magnet room to the final exit to outside the building. Refer to:</p> <ul style="list-style-type: none"> • Chapter 5, Cryogenic Venting Introduction • Chapter 5, Requirements for Outside Magnet Room • Chapter 5, Requirements for Inside Magnet Room
2	<p>Broadband Network Connection & Telephone: Communications are primarily for human Safety (dial out phone line) but also to protect the magnet operation (broadband connection).</p>
3	<p>Magnet room ventilation must be installed and fully tested to ensure required air ventilation is available when equipment delivers. Exhaust fans, fan controllers must be installed and functioning. Refer to:</p> <p>Chapter 5, Room Ventilation</p>
4	<p>Cryogenic Vent system is designed for connectivity from the magnet to the outside world within 24 hours of magnet delivery into magnet room. Refer to item 1 above.</p>

Table 13-3: Actions to Be Completed Prior To Magnet Delivery (to site) and Move Into Magnet Room

Step	Requirement
1	<p>Room Ventilation completely installed and functioning. Refer to Safety Site Readiness, item 3 above.</p>

2	Water cooling is available 24 hours/day, 7 days a week for immediate operation of the Shield/Cryo Cooler. Refer to: Chapter 5, Shield/Cryo Cooler Water Cooling for Site Provided Water Cooling
3	Magnet Room anchors have been installed and tested to ensure proper location and pull test confirm anchors are properly designed and installed. Magnet anchors, blower box, etc. when required. Refer to: Chapter 11, Clamping Force (Tension) and Pull Test
4	Magnet Room Anchors have been measured to meet the ground impedance. Refer to: Chapter 11, Electrical Isolation
5	The MDP has been installed (by certified electrician) and the MDP is fully operational with power available for 24 hour/day, 7 day/week to cool the Shield/Cryo Cool Compressor cabinet. Power must also support the Magnet Monitor and the Coldhead Compressor Chiller – if customer provided. Refer to: <ul style="list-style-type: none"> • Chapter 6, System Power Introduction • Critical Power Requirements
6	The magnet delivery route is clear and ready for the magnet installation. Refer to: Chapter 6, Minimum Delivery Route Sizes and Capacity
7	Rigger has made provisions to have necessary equipment available to move the magnet into the magnet at the time the magnet arrives. Refer to: Chapter 3, Magnet Shipping Considerations
8	Site construction has been completed or suspended, the magnet room is dust free and the magnet room environment has been cleared to provide riggers space to deliver the magnet to final installed location. Refer to: Chapter 12, Magnet Shipping Considerations

Table 13-4: Actions to Be Completed Prior To System Delivery (to site) and Installation

Step	Requirement
1	All areas in the MR Magnet Room, Equipment Room and the Control Room are dust-free. Final room construction, after magnet delivery, needs to protect the equipment from dust. Refer to: Chapter 5, Pollution
2	Environmental systems and controls are fully functioning to provide the required site environment for all MR System equipment. Refer to: <ul style="list-style-type: none"> • Chapter 5, Temperature and Humidity Specification • Chapter 5, Air Cooling • Chapter 5, Gradient Coil Water Cooling • Chapter 5, Gradient Coil Temporary Backup Water Cooling • Chapter 5, Shield/Cryo Cooler Temporary Backup Water Cooling • Chapter 5, Shield/Cryo Cooler Water Cooling for Site Provided Water Cooling
3	MR System Interconnects routing has been installed. Refer to: Chapter 3, MR System Interconnections Routing
4	The magnet delivery route has been planned to protect the building structure and flooring material Refer to: Chapter 3, Minimum Delivery Route Sizes and Capacity
5	The PDU power is ready for connection to the Main Disconnect Panel (MDP). Refer to: <ul style="list-style-type: none"> • Chapter 6, Main Disconnect Panel (MDP) Requirements • Chapter 6, System Power Distribution Unit



WARNING

GASEOUS HELIUM IS AN INVISIBLE, ODORLESS GAS THAT CAN CAUSE ASPHYXIATION WHEN OXYGEN IS DEPLETED. HELIUM GAS, WHICH IS LIGHTER THEN AIR, WILL RISE TO THE CEILING. THE MAGNET WILL EXHAUST HELIUM GAS DURING MAGNET DELIVERY & INSTALLATION.

THE FOLLOWING SAFETY ITEMS MUST BE STRICTLY ADHERED TO PRIOR TO MOVING THE MAGNET FROM THE TRUCK INTO THE ROOM.

Table 13-5: Actions to Be Completed Before Magnet Ramp-up

Step	Requirement
1	The Magnet Room RF Shield has been fully installed, including magnet dock anchor and tested to meet the RF attenuation and room isolation requirements. Refer to: Chapter 11, RF Shielded Room Specifications
2	The Magnet Room construction has been completed and all ferrous metal objects have been removed from the room.
3	Safety and Exclusion signs have been posted to warn personnel of the danger of the magnetic field. Refer to: Chapter 4, Exclusion Zone
4	Facility personnel, local fire departments, and police departments have been informed of the unique temporary conditions that will be observed when the magnet ramp follows normal magnet safety procedures and corrective precautions are in place in the event of unforeseen emergencies. That is, strong magnetic field, cryogen exhaust, etc.) Refer to Direction 2381696 MR Safety Guide that is provided with the MR Systems Operator's manual.
5	Power has been connected from the Main Disconnect Panel to the Power Distribution Unit. Refer to: <ul style="list-style-type: none"> • Chapter 6, Main Disconnect Panel (MDP) Requirements • Chapter 6, System Power Distribution Unit
6	The Penetration Panel has been installed. Refer to: Chapter 11, RF Penetration Panel
7	The site environment has been inspected in areas where large metal objects will impact the magnet main field. Large objects within the Moving Metal lines, including contractor construction equipment, must be removed. Refer to: Chapter 5, Changing Magnetic Environment Specifications

Chapter 14 Appendices

1 Glossary

BB

Abbreviation for Broadband

Cryogen

A substance for producing low temperatures. Liquid helium is the cryogen used to cool the magnet to approximately 4 Kelvin (-269°C or -452°F).

Cryostat

An apparatus maintaining a very low constant temperature. The cryostat consists of one concentric, cylindrical container housed in an outer vacuum tight vessel. The magnet and shim coils are mounted in the inner container. The container is filled with liquid helium. The shields surrounding the inner container are kept cold by a refrigeration device.

Dewar

A container with an evacuated space between two highly reflective walls used to keep low temperature substances at near-constant temperatures. Liquid helium is usually stored and shipped in dewars.

Exclusion Zone

Area where the magnetic flux density is greater than five gauss. Personnel with cardiac pacemakers, neurostimulators and other biostimulation devices must NOT enter this zone. Signs are posted outside the five gauss line alerting personnel of this requirement. Since the magnetic field is three-dimensional, signs are also posted on floors above and below the Magnet Room in which the five gauss line exists.

Ferrous Material

Any substance containing iron which is strongly attracted by a magnetic field.

Gauss (G)

A unit of magnetic flux density. The earth's magnetic field strength is approximately one half gauss to one gauss depending on location. The internationally accepted unit is the tesla (1 Tesla = 10,000G and 1 milli Tesla = 10G).

Gradient

The amount and direction of the rate of change in space of the magnetic field strength. In the magnetic resonance system, gradient amplifiers and coils are used to vary the magnetic field strength in the x, y, and z planes.

GWHX

Gradient Water Heat Exchanger

HFD

Abbreviation for High Fidelity Drivers

Homogeneity

Uniformity. The homogeneity of the static magnetic field is an important quality of the magnet.

Isocenter

Center of the imaging volume ideally located at the magnet center.

Isogauss Line

An imaginary line or a line on a field plot connecting identical magnetic field strength points.

Magnetic Field (B)

A condition in a region of space established by the presence of a magnet and characterized by the presence of a detectable magnetic force at every point in the region. A magnetic field exists in the space around a magnet (or current carrying conductor) and can produce a magnetizing force on a body within it.

Magnetic Resonance (MR)

The absorption or emission of electromagnetic energy by nuclei in a static magnetic field, after excitation by a suitable radio frequency field.

Magnetic Shielding

Using material (e.g. steel) to redistribute a magnetic field , usually to reduce fringe fields.

MGD Chassis

Abbreviation for Multi Generational Data Acquisition Chassis

MRCC

Abbreviation for MR Common Chiller

NB

Abbreviation for Narrow Band

Quench

Condition when a superconducting magnet becomes resistive and rapidly boils off liquid helium. The magnetic field first expands then reduces rapidly after a quench.

Radio Frequency (RF)

Frequency intermediate between audio frequency and infrared frequencies. Used in magnetic resonance systems to excite nuclei to resonance. Typical frequency range for magnetic resonance systems is 5-130 Mhz.

Radio Frequency Shielding

Using material (e.g. copper, aluminium, or steel) to reduce interference from external radio frequencies. A radio frequency shielded room usually encloses the entire magnet room.

Resonance

A large amplitude vibration caused by a relative small periodic stimulus of the same or nearly the same period as the natural vibration period of the system. In magnetic resonance imaging, the radio frequency pulses are the periodic stimuli which are at the same vibration period as the hydrogen nuclei being imaged.

RRF Chassis

Abbreviation for Remote Radio Frequency Chassis

Security Zone

Area within the Magnet Room where the magnet is located. Signs are posted outside the Magnet Room warning personnel of the high magnetic field existing in the Magnet Room and the possibility of ferrous objects becoming dangerous projectiles within this zone.

Shield Cooler Coldhead

An external refrigeration device which maintains the shields inside the cryostat at a constant temperature.

Shim Coils

Shim coils are used to provide auxiliary magnetic fields in order to compensate for inhomogeneities in the main magnetic field due to imperfections in the manufacturing of the magnet or affects of steel in the surrounding environment.

Shimming

Correction of inhomogeneity of the main magnetic field due to imperfections in the magnet or to the presence of external ferromagnetic objects.

Superconducting Magnet

A magnet whose magnetic field originates from current flowing through a superconductor. Such a magnet is enclosed in a cryostat.

Superconductor

A substance whose electrical resistance essentially disappears at temperatures near zero Kelvin. A commonly used superconductor in magnetic resonance imaging system magnets is niobium-titanium embedded in a copper matrix.

Tesla

The internationally accepted unit of magnetic flux density. One tesla is equal to 10,000 gauss. One milli Tesla is equal to 10 gauss.

TGWC

Abbreviation for Twin Gradient Water Chiller

TSCC

Abbreviation for TwinSpeed Combined Chiller

2 MR Site Vibration Test Guidelines

2.1 Test Measurements

- Vibration measurements must be in the range of 10^{-6} g. Test equipment must have the required sensitivity to these levels.
- Instrumentation must have a low tolerance to temperature effects since many times the low frequency thermal drift may influence the measurements.
- All measured data must be acquired real time. Recording of vibration data will not allow for a proper site survey, specifically when studying transient vibration and when searching for specific vibration sources.
- All analyses must be narrow-band Fast Fourier Transforms (FFT) over the frequency bands listed in [Table 14-1](#).
- 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 14-1: Frequency Bands for FFT

Frequency Band	Frequency Resolution
0.2 to 50 Hz	$\Delta f = 0.125$ Hz

2.2 Equipment (Spectral Analyzer) Set-Up

- Frequency average should be a minimum of 20 linear averages. (Do not use peak hold or 1/3 octave analysis.)
- Average and store should be a minimum of 10 plots to support the consistency of the site vibrations.
- Hanning windows must be applied to the entire spectra.

Spectrum analyzers capable of these measurements are readily available for purchase or rental. 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.

NOTE: 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.

2.3 Data Collection

2.3.1 Ambient Baseline Condition

All of the measurements defined in [Section 2.1](#) and [Section 2.2](#) must be made in a **quiet** environment--areas where excessive traffic, subway trains, etc. 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.

The source of any steady state vibration, whose level exceeds the magnet specifications found in [Chapter 5, Vibration](#), 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.

2.3.2 Normal Condition

All of the vibration measurements listed above must be repeated during periods of **normal** environmental conditions, including the 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.

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. If the source of any transient vibration is not locatable, it is recommended that the customer have an alternate location identified and the vibration studied.

Transient vibration can be difficult to assess if the details are not understood. The **0.0005g, 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.

The test consultant must provide site data to show the design recommendations for all sites/building structures meet the LCC Magnet specifications found in [Chapter 5, Vibration](#).

2.4 Presentation/Interpretation of Results

The recommended format for site vibration data collection, presentation, and analysis is demonstrated in the examples in [Illustration 14-1](#), [Illustration 14-2](#), [Illustration 14-3](#), and [Illustration 14-4](#). 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.

All plots must be properly annotated with:

- Instrumentation set-up including number of averages, frequency resolution, etc.
- Test location
- Test conditions
 - Steady state
 - Transient

- Heal drop
- Normal environment
- Typical traffic

NOTE: Other conditions not listed could also be conditions necessary to demonstrate understanding of potential sources of vibration.

It is the responsibility of the customer's vibration testing service to interpret the results and determine if that site meets GE Healthcare's specifications. [Illustration 14-1](#) and [Illustration 14-2](#) are examples provided to assist a test consultant in the use of GE Healthcare Steady State specifications (vibration specifications above ambient baseline). If the vibration levels are too high, additional data acquisition may be necessary.

- determine the source of the vibration,
- propose a solution to the problem,
- find an alternate site location.

[Illustration 14-1](#), [Illustration 14-2](#), [Illustration 14-3](#), and [Illustration 14-4](#) are examples provided to assist a test consultant in the use of GE Healthcare transient specifications. The 500 micro-g, zero-to-peak trigger level identifies data collection to begin assessment of the site vibration analysis. The response of the transient must be assessed relative to the 1.5T LCC Magnet Steady State vibration specifications found in [Chapter 5, Vibration](#).

Any questions regarding test equipment requirements, test parameters, or general questions should be discussed with your GE Project Manager of Installation.

Illustration 14-1: Example of Site Environmental Vibration Levels

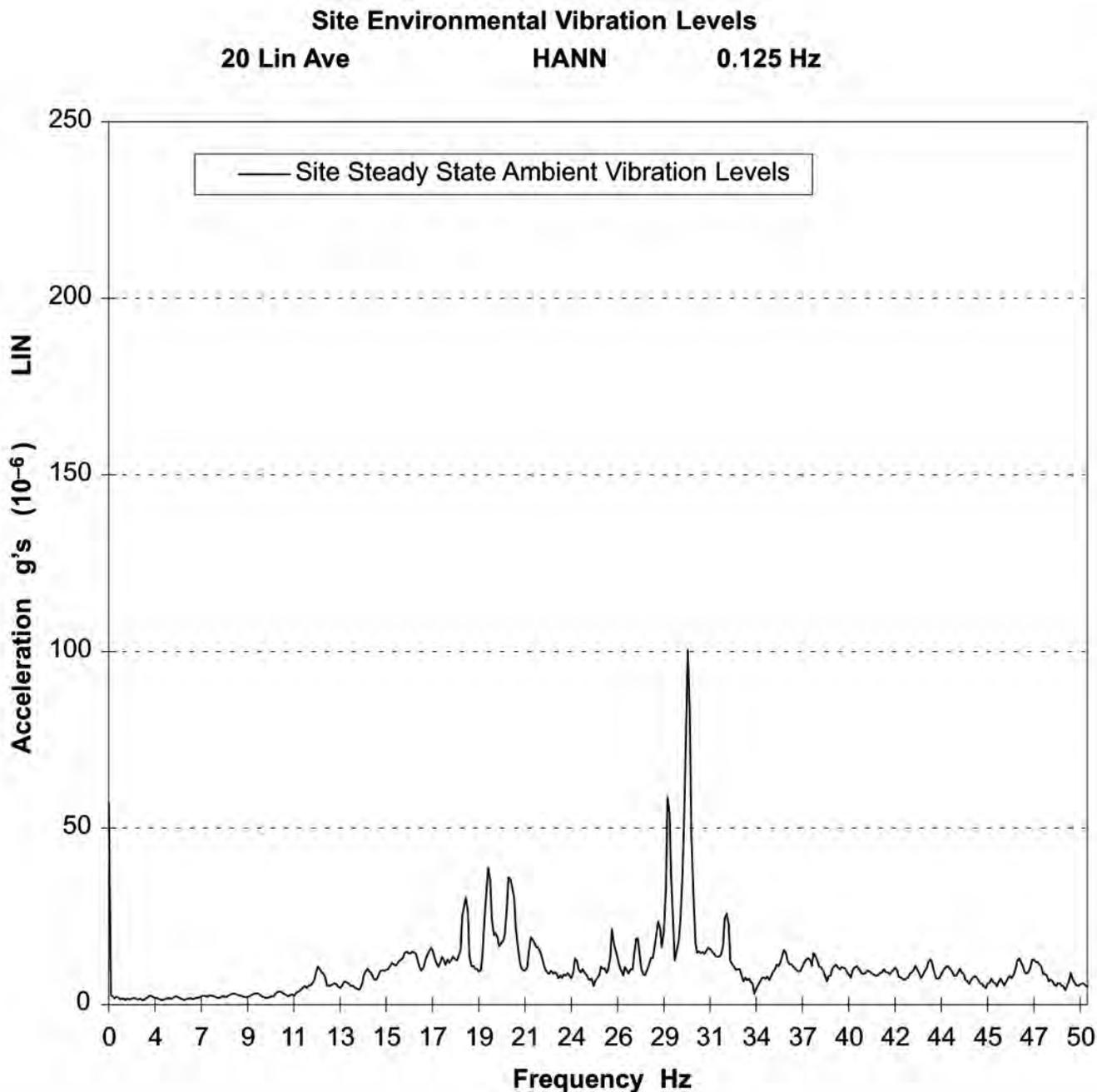


Illustration 14-2: Example Site Environmental Vibration

EXAMPLE: Site Environmental Vibration vs. GE Spec. for 1.5T K4 Magnet
 20 Lin Ave Hann 0.125Hz

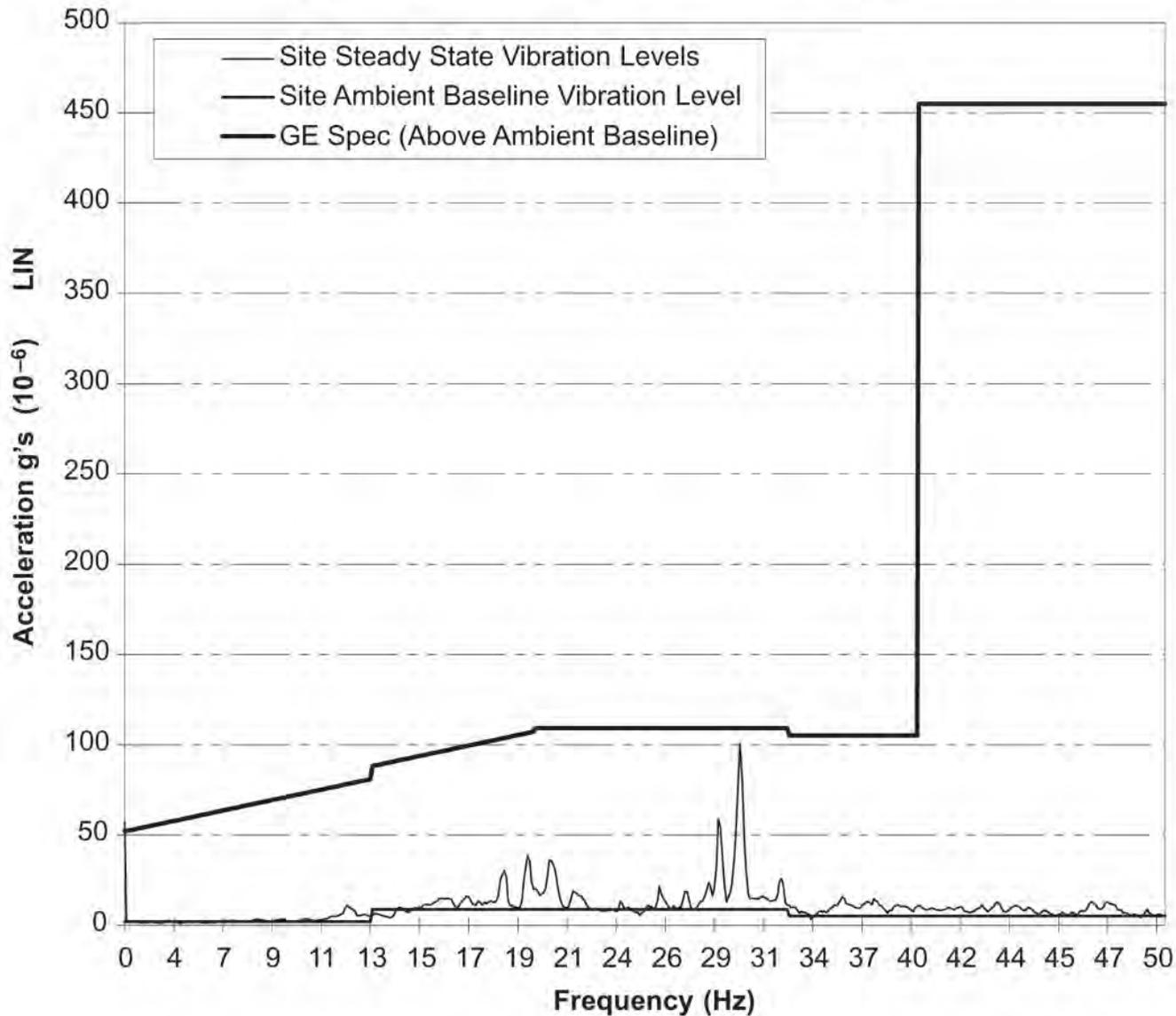


Illustration 14-3: Acceleration Time History

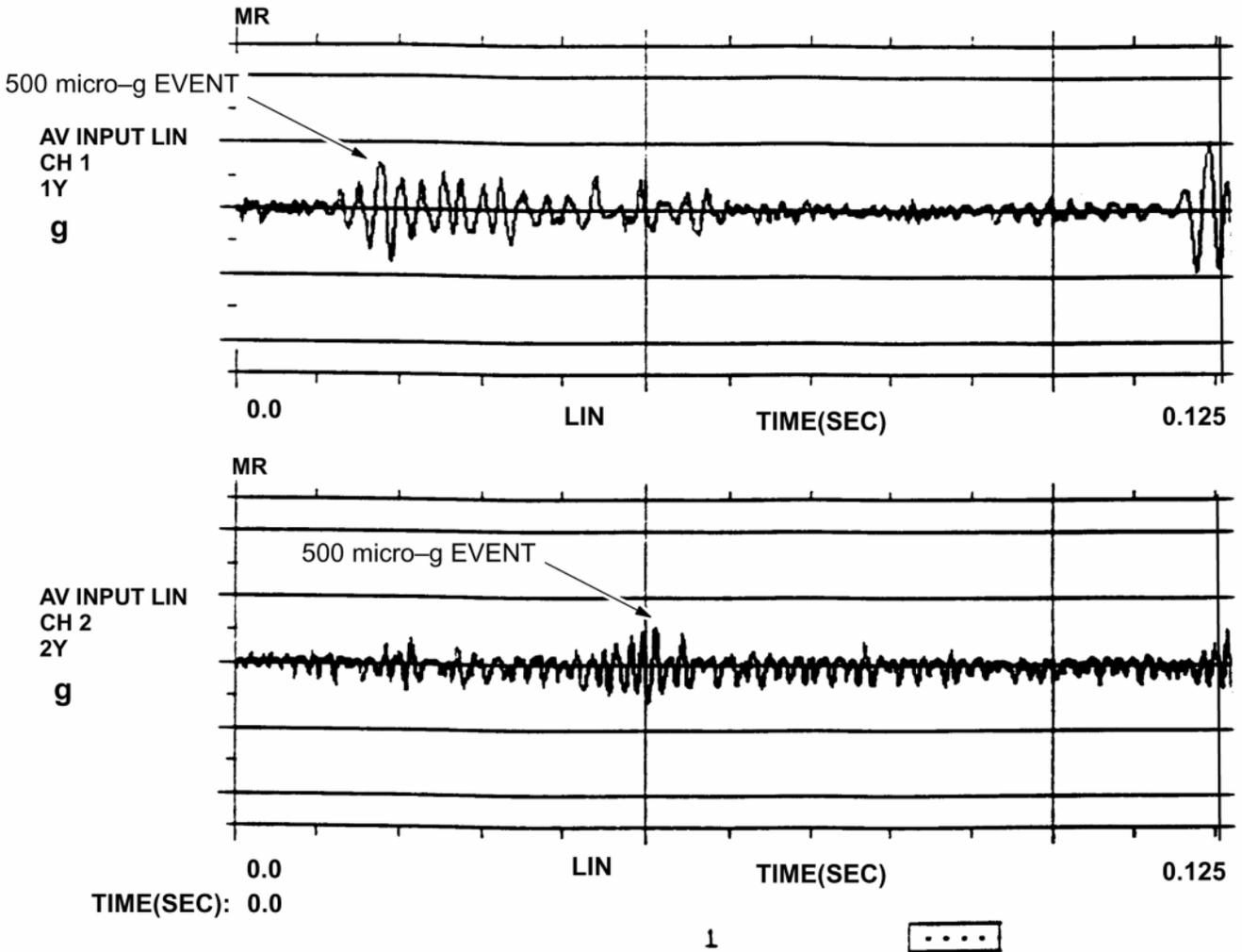
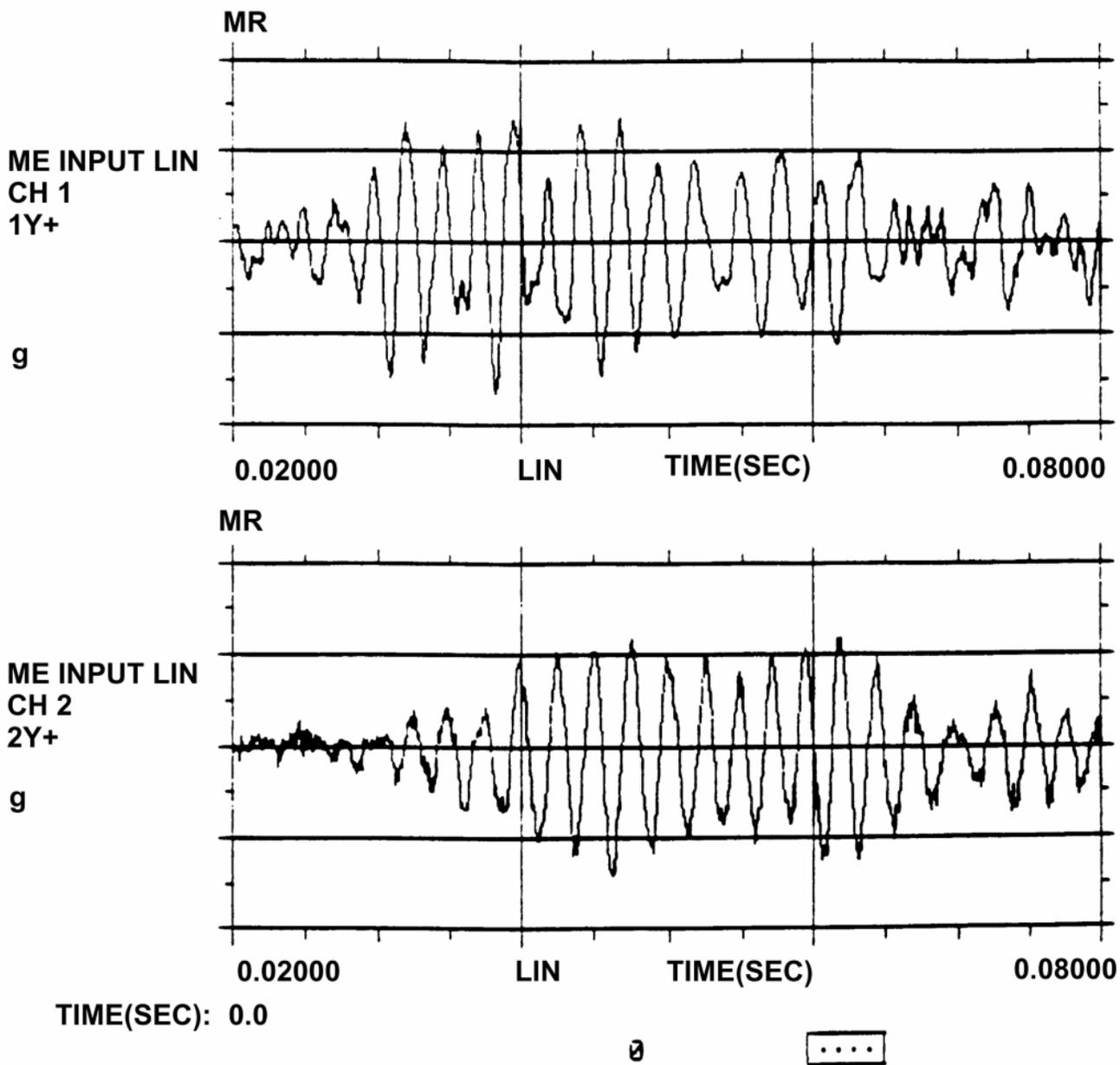


Illustration 14-4: Acceleration Time History (Zoomed In on Transient Event)



3 RF Shielding Background and Guidelines

3.1 RF Shielding Background

RF sources which can adversely affect image quality may be generated by discrete frequency or broadband noise (RF) sources.

3.1.1 Discrete Frequency

Discrete RF interferences are narrowband and are fixed frequency in nature. The Magnet Room must be RF shielded from RF 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, etc.

3.1.2 Broadband RF Noise

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:

- Loose hardware/fasteners vibration or movement (electrical continuity must always be maintained)
- Flooring material including raised access flooring (panels & support hardware) and carpeting
- Electrical fixtures
 - Lighting fixtures
 - Track lighting
 - Emergency lighting
 - Battery chargers
 - Outlets
- Ducting for HVAC and cable routing
- RF Shield seals (walls, doors, windows, etc.).

3.2 RF Shielded Room Grounding

- Primary Ground: All RF Shield components (walls, floor, ceiling, etc) 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 Shield Room to earth grounds are called secondary grounds): Secondary grounds must not compromise Ground Isolation of 1,000 ohms or greater.

4 RF Shielded Enclosure Test Guidelines

4.1 Introduction

This document describes the procedure and methodology of performing an RF shielding effectiveness verification testing on enclosures that will house GE Healthcare Magnetic Resonance Imaging (MRI) equipment. MRI equipment is sensitive to RF energy from sources outside of the shielded enclosure. To ensure proper operation of the MRI equipment, the shielded enclosure must attenuate local RF signals to levels that do not cause interference.

NOTE: RF Shielding Performance is based on plane-wave measurements. *H* and *F* field tests are not required, but are allowed as needed for diagnostic purposes.

4.1.1 Purpose of Test Plan

The purpose of this test plan is to describe a series of RF shielding effectiveness tests to demonstrate compliance of an MRI shielded enclosure to the requirements of GE Healthcare.

The test procedure described in this guideline is a modification of MIL-STD-285 and IEEE Std 299-1991. This procedure provides a thorough evaluation of the shield integrity at the upper end of the frequency range of interest showing any RF leakage that may cause imaging problems. These testing guidelines ensure that the electromagnetic environment inside of the enclosure will meet the requirements of GE Healthcare.

4.1.2 Not used

4.2 Applicable Documents

MIL-STD-285	MILITARY STANDARD ATTENUATION MEASUREMENTS FOR ENCLOSURES, ELECTRO-MAGNETIC SHIELDING, FOR ELECTRONIC TEST PURPOSES, METHOD OF; 25 June 1956
IEEE Std 299-1991	IEEE STANDARD FOR MEASURING THE EFFECTIVENESS OF ELECTROMAGNETIC SHIELDING ENCLOSURES; 2 July 1991

4.3 Test Sample Set-Up

The shielded enclosure under testing will be set up in a normal configuration that consists of:

- Magnet installed including all floor mounting bolts
- RF shielded door(s)
- Waveguide penetrations, HVAC, vents, medical gas lines, etc.
- AC power supplied through low-pass filters
- Patient view window, skylights, windows, hatches, etc.
- Blank penetration panel installed, dimensionally equivalent to the GE panel and the same mounting hardware to be used with the GE penetration panel.

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 certification report.

4.4 Shielding Effectiveness

This test procedure determines the worst case shielding effectiveness based on the lowest test point reading obtained. The lowest reading obtained will be the reading of the room.

4.5 Measurement Procedure

To simulate the effects of external RF sources, the transmitting antenna will be located outside the enclosure on a plane parallel to the face of the enclosure wall at a distance of 6 ft. (1.8 m) unless physically constrained to a lesser separation. The areas of least effectiveness are located by searching the inside of the enclosure with the antenna connected to the spectrum analyzer.

4.5.1 Test Position

The transmitting antenna will be positioned in front of all critical areas (doors, windows, filters, penetration areas, etc.) at a minimum of every 20 ft. (6.1 m) of the wall. The receiving antenna is scanned over all panel section joints (where accessible) at the floor, wall, and ceiling for a minimum of 10 ft. (3.05 m) in all directions from the location of transmitting antenna. The receiving antenna will be at a minimum of 1 ft. (0.3 m) from the shield. For areas that are inaccessible for direct location of the transmitting antenna, the inside of that area will still be scanned using the receiving antenna with the transmitting antenna positioned in front of the adjacent wall or test position.

4.5.2 Frequency Range

The standard frequency for shielding measurements will be 100 MHz \pm 10 MHz (150 MHz \pm 10 MHz for 3T). This allows the frequency to be adjusted slightly to avoid interference from local active transmitters and/or RF noise from other sources. Test frequency utilized will be noted in the certification report.

4.5.3 Free Field Calibration

The incident field (free field) is measured by the following procedure:

Position the transmitting antenna parallel to the exterior wall of the enclosure at a distance of 6 ft. (1.8 m) using horizontal polarization, unless physically constrained to a lesser separation, in which case a separate reference will be established and documented at the new test distance. The receiving antenna will be placed between the transmitting antenna and 1 ft. (0.3 m) from the exterior wall of the enclosure. The receiving antenna will be moved vertically and horizontally to achieve maximum signal strength. The receiving antenna will be placed no closer than 2 in. (51 mm) from the exterior wall of the enclosure and in line with the transmitting antenna. The maximum received voltage at the test frequency will be recorded.

4.6 Enclosure Power Reference Isolation



NOTICE

This section does not apply to upgrades.

To prevent personal hazard, it is necessary for the enclosure to be properly grounded.

To minimize common mode currents, the ungrounded enclosure should be isolated from the ground with a minimum of 1000 ohms of DC resistance. The isolation measurement is performed by the following procedure:

- All power to the enclosure is removed. For safety reasons, an AC voltage measurement will be made to verify that no power is connected.
- With electrical power and intentional ground disconnected, connect the test instrument between the shielded enclosure and AC power ground.
- Take a reading and record the value.

NOTE: This test must be made using either an isolated, current limited, high-voltage (>150 VDC) DC source and DMM to read 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 will not be used.

4.7 Test Equipment

Test equipment will be selected to provide measuring capabilities as described in these testing guidelines. The signal source, amplifier, antennas, and receiver or spectrum analyzer will be such that the difference between the induced reference voltage and the receiver sensitivity is at least 6 dB greater than the required attenuation specification.

The signal source and power amplifier will output a CW signal for a nominal test frequency of 100 mHz (150 mHz for 3T). The receiver or spectrum analyzer and preamplifier (if required) will provide adequate sensitivity to permit attenuation measurements to be made at the specified limits. Dipole antennas and other miscellaneous equipment required to transmit and receive the proper RF fields will be used.

The absolute performance calibration of the equipment requiring calibration will be performed on an as-needed basis in accordance with MIL-STD-45662. The calibration period will not exceed one year. The test equipment tolerances of at least $\pm 2\%$ frequency and ± 2 dB amplitude will be met. Equipment certifications will be traceable to the National Institute of Standards and Technology (NIST). All equipment will be verified for proper operation between and after each series of tests by repeating the reference readings at the specified frequency(s).

4.8 Data Recording and Verification

Measurements will be performed by qualified responsible EMC test personnel. The test must be performed in the presence of a GE Healthcare representative unless other arrangements were made by GE Healthcare. All data collected during the course of the tests will be recorded on standardized data sheets. The data sheets will include the test location, frequency, reference level, measured enclosure level, and attenuation level.

4.9 Test Report

A final certification report will be provided after the test is performed. This report will include all recorded data necessary for the evaluation of the shielded enclosure test results and will list any changes pertinent to the test set-up or shielding effectiveness. The certification report will also include the test procedures and a list of the actual equipment used during the test. Along with the

data sheet, there will be a presentable drawing showing the shape of the enclosure, all test point locations, doors, filters, windows, and existing building walls.

5 Acoustic Design Guidelines

5.1 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. The measured sound levels via a sound level meter will not change. However, the measured sound levels can be reduced only when the sound level generated by the MR System is reduced.

Sound quality improvements can be achieved by the following:

- Use ceiling tiles with fiberglass panels having a 2 inch (51mm) 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 4ft x 6ft (1.2m x 1.8m) with a thickness of 4 inches (102mm) or equivalent. Panels shape could vary to produce mosaic effects to meet the customer preference. 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 breath 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.

5.2 Inter-Spatial 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 via 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 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.

5.2.1 Wall Construction

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

- The preferred wall would have an ASTM STC 50 construction which entails the use of standard wall construction of steel studs (typically 3-5/8 inch (92 mm)) with 2 layers of Type X drywall (typically 5/8 (16 mm)) on each side totaling 4 layers and fiberglass batt in the stud cavity. All drywall must be overlapped by 6 inches (152 mm) 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 examples of wall construction shown in and .

- The top of the wall must join the ceiling/floor above so that no cracks or gaps occur. If metal pan is used on the ceiling/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.

Illustration 14-5: Example Of Wall Construction For Airborne Noise Control - Option 1

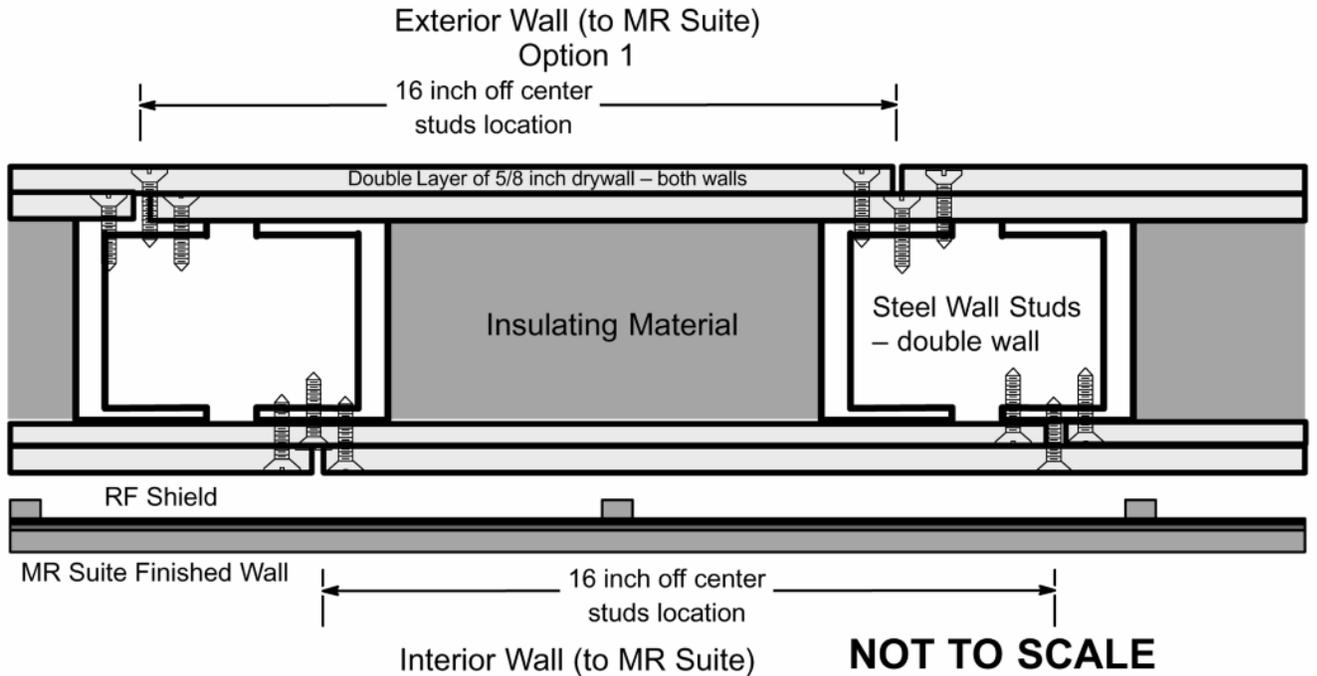
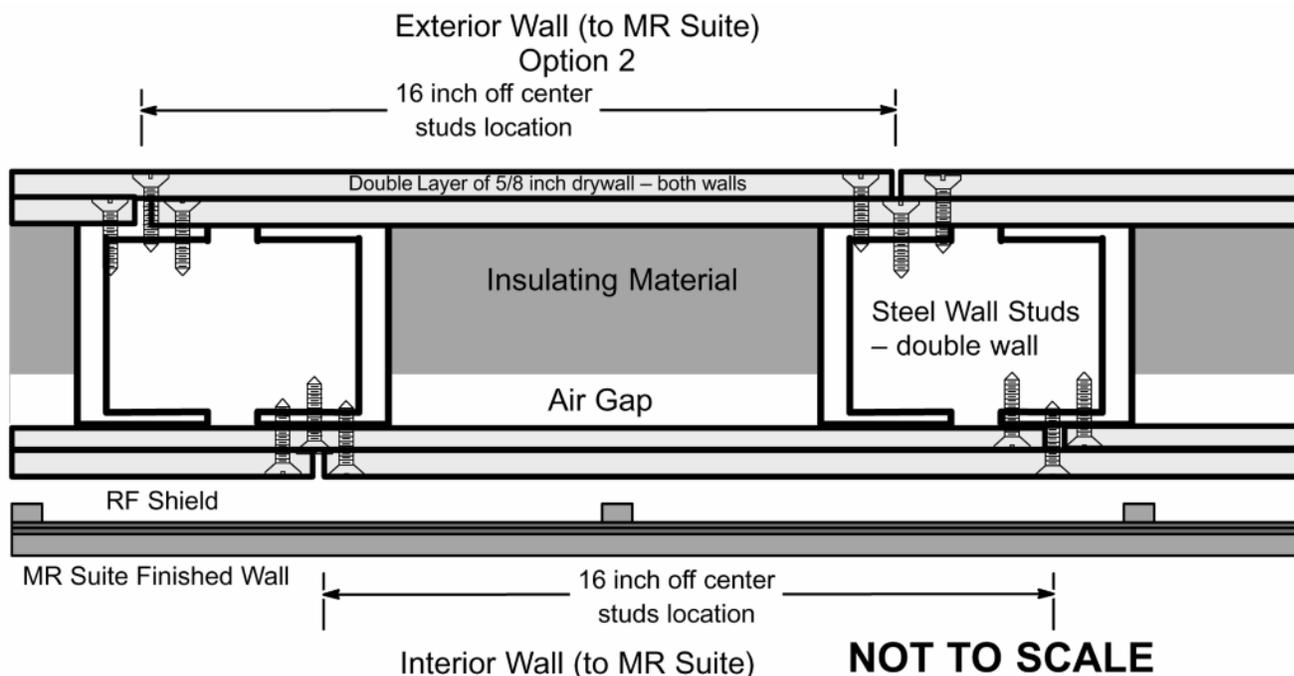


Illustration 14-6: Example Of Wall Construction For Airborne Noise Control - Option 2



5.2.2 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 (total of 4 layers) with fiberglass batt in the cavity.
- Penetrations should be avoided via 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".

5.2.3 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/frame units with an STC rating obtained from laboratory testing per ASTM standards. STC 50 to 60 windows are needed. The installation must include proper sealing to avoid sound leaks.
- RF doors should be selected to provide an STC 50 to 60 to quell the noise. Contact 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.

6 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 MR Suite Magnetic Field Specifications Electrical Current subsection to determine minimum distance from a feeder, transformer, or other AC electrical source.

Note that the formula has 3 variables, if you have 2 of them, you can calculate the 3rd. 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 5 inch conduit.

Note that 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.

$$S = 5 \text{ inches} = 0.127 \text{ meters}$$



$$X = 1.69 \text{ meters} = 5.4 \text{ feet}$$

So in this example, the conduit should be 2.58 meters or 8.5 feet or farther from the magnet's isocenter.

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.

What if it is too close? Keep in mind that 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 worse 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 Example - Select Magnet Anchor Size

The following is an example to illustration the selection of proper anchors to install a Magnet into a building structure with 2000 psi (13.8 MPa) concrete. For this example the area is not under seismic requirements.

- Determine magnet clamping force (tension) by referring to requirements in [Chapter 11, Clamping Force \(Tension\) and Pull Test](#).
2500 lbs + 200 lbs = 2700 lbs or 11,100 N + 900 N = 12,000 N
- Refer to [Illustration 14-7](#) or [Illustration 14-8](#) (examples of anchor vendor catalogs) to select anchor diameter and embedment which meets the clamping force (tension) determined in Step 1.
Diameter : Min. 0.625 inch Max. 1.25 inch
For 8 inch embedment select 3/4 inch diameter
For 4.5 inch embedment select 1 inch diameter
or
Diameter : Min. M16 Max. M32
For 130 mm embedment select M20 diameter
For 114 mm embedment select M24 diameter
- The vendor instructions and torque to the maximum recommended level for the anchor selected in Step 2 must be provided to the RF Shield Room vendor for proper installation of the anchor and equipment.

Illustration 14-7: EXAMPLE OF ENGLISH UNITS STAINLESS STEEL ANCHOR ALLOWABLE LOADS IN CONCRETE

ANCHOR DIAMETER in. (mm) See Note 1	EMBEDMENT DEPTH in. (mm)	2000 psi (13.8 MPa)		3000 psi (20.7 MPa)		4000 psi (27.6 MPa)		6000 psi (41.4 MPa)	
		TENSION lb (kN)	SHEAR lb (kN)	TENSION lb (kN)	SHEAR lb (kN)	TENSION lb (kN)	SHEAR lb (kN)	TENSION lb (kN)	SHEAR lb (kN)
5/8 (15.9)	2 3/4 (70)	1250 (5.6)	2800 (12.5)	1600 (7.1)	3070 (13.7)	1810 (8.1)	3330 (14.8)	1920 (8.5)	3330 (12.5)
	4 (102)	1870 (8.3)	3330 (14.8)	2400 (10.7)	3330 (14.8)	2930 (13.0)	3330 (14.8)	3200 (14.2)	3330 (12.5)
	7 (178)	2500 (11.2)	3330 (14.8)	3010 (13.4)	3330 (14.8)	3650 (16.2)	3330 (14.8)	3650 (16.2)	3330 (12.5)
3/4 (19.1)	3 1/4 (83)	1550 (6.9)	2880 (12.8)	1950 (8.7)	3310 (14.7)	2350 (10.5)	3730 (16.6)	2610 (11.6)	4800 (21.4)
	4 3/4 (121)	2510 (11.2)	4510 (20.1)	3250 (14.5)	4650 (20.7)	3870 (17.2)	4800 (21.4)	4670 (20.8)	4800 (21.4)
	8 (203)	2930 (13.0)	4800 (21.4)	3870 (17.2)	4800 (21.4)	4530 (20.2)	4800 (21.4)	5120 (22.8)	4800 (21.4)
1 (25.4)	4 1/2 (114)	3120 (13.9)	6080 (27.0)	3870 (17.2)	6770 (30.1)	4610 (20.5)	7470 (33.2)	4800 (21.4)	7470 (33.2)
	6 (152)	4400 (19.6)	7470 (33.2)	6400 (28.5)	7470 (33.2)	7200 (32.0)	7470 (33.2)	7330 (32.6)	7470 (33.2)
	9 (229)	5600 (24.9)	7470 (33.2)	8000 (35.59)	7470 (33.2)	9390 (41.77)	7470 (33.2)	9390 (41.8)	7470 (33.2)

Note 1 All shaded values fail to meet the clamping force (tension), therefore are not acceptable anchors.

Illustration 14-8: EXAMPLE OF METRIC STAINLESS STEEL ANCHOR ALLOWABLE LOADS IN CONCRETE

ANCHOR DIAMETER See Note 1	EMBEDMENT 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)
M16	105 (4 1/8)	11.2 (2500)	25.1 (5650)	20.9 (4705)	39.9 (8965)	24.2 (5450)	10125 (45.0)	6900 (30.7)	10550 (46.9)
M20	130 (5 1/8)	25.1 (5650)	52.9 (11900)	30.7 (6910)	58.7 (13195)	36.4 (8175)	14490 (64.5)	10005 (44.5)	14490 (64.5)
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 1 All shaded values fail to meet the clamping force (tension), therefore are not acceptable anchors.

8 Magnet Cryogenic Venting

Enter descriptive content here.

Table 14-2: 1.5T CxK4 Magnet Cryogenic Vent System Pressure Drop Matrix

Inside dia. of vent pipe (D)	Distance of vent system component from magnet		Pressure drop for straight pipe with smooth inside surface		Pressure Drop Per Elbow Used Anywhere Within A 20 Ft (6.1 M) Vent Segment							
					Standard Sweep				Long Sweep			
					Std sweep 45° elbow (K = 15 Ft)		Std sweep 90° elbow (K = 30Ft)		Long sweep 45° elbow (K = 7.5Ft)		Long sweep 90° elbow (K = 15 Ft)	
	ft	m	psi/ft	kPa/m	psi	kPa	psi	kPa	psi	kPa	psi	kPa
8 in. (203.2 mm)	00-20	0 -6.1	0.10	2.26	1.10	7.58	2.06	14.20	0.55	3.79	1.03	7.10
	20-40	6.1 -12.2	0.21	4.75	2.10	14.48	3.70	25.51	1.03	7.10	1.85	12.76
	40-60	12.2 -18.3	0.30	6.79	2.88	19.86	5.21	35.92	1.44	9.93	2.60	17.92
	60-80	18.3 -24.4	0.38	8.60	3.70	25.51	6.71	46.27	1.85	12.76	3.36	23.17
	80-100	24.4 -30.5	0.47	10.63	4.52	31.17	8.22	56.68	2.26	15.58	4.11	28.34
10 in. (250 mm)	0-20	0 - 6.1	0.03	0.68	0.55	3.79	0.82	5.65	0.27	1.86	0.41	2.83
	20-40	6.1 -12.2	0.07	1.58	0.82	5.65	1.51	10.41	0.41	2.83	0.75	5.17
	40-60	12.2 -18.3	0.10	2.26	1.23	8.48	2.19	15.10	0.62	4.27	1.10	7.58
	60-80	18.3 -24.4	0.12	2.71	1.51	10.41	2.74	18.89	0.75	5.17	1.37	9.45
	80-100	24.4 -30.5	0.16	3.62	1.92	13.24	3.43	23.65	0.96	6.62	1.71	11.79
12 in. (300 mm)	0-20	0 - 6.1	0.013	0.29	0.27	1.86	0.41	2.83	0.14	0.97	0.21	1.45
	20-40	6.1 -12.2	0.027	0.61	0.41	2.83	0.82	5.65	0.21	1.45	0.41	2.83
	40-60	12.2 -18.3	0.041	0.93	0.55	3.79	1.10	7.58	0.27	1.86	0.55	3.79
	60-80	18.3 -24.4	0.054	1.22	0.69	4.76	1.37	9.45	0.34	2.34	0.69	4.76
	80-100	24.4 -30.5	0.069	1.56	0.96	6.62	1.51	10.41	0.48	3.31	0.75	5.17
	100-120	30.5 -36.6	0.08	1.81	1.09	7.52	1.77	12.20	0.55	3.79	0.88	6.07
	120-140	36.6 -42.7	0.10	2.26	1.27	8.76	2.07	14.30	0.63	4.34	1.04	7.17
	140-160	42.7 -48.8	0.11	2.49	1.43	9.86	2.36	16.30	0.72	4.96	1.19	8.21
	160-180	48.8 -54.9	0.12	2.71	1.60	11.00	2.53	17.40	0.80	5.52	1.27	8.76
180-200	54.9 -61.0	0.17	3.85	1.75	12.10	2.93	20.20	0.88	6.07	1.47	10.14	
14 in. (350 mm)	0-20	0 - 6.1	0.008	0.055	0.20	1.38	0.301	2.08	0.102	0.70	0.15	1.03
	20-40	6.1 -12.2	0.017	0.12	0.30	2.07	0.602	4.15	0.154	1.06	0.30	2.07
	40-60	12.2 -18.3	0.026	0.18	0.40	2.76	0.808	5.57	0.198	1.37	0.40	2.76
	60-80	18.3 -24.4	0.034	0.23	0.51	3.52	1.01	6.96	0.250	1.72	0.51	3.52
	80-100	24.4 -30.5	0.043	0.30	0.71	4.90	1.11	7.65	0.353	2.43	0.55	3.79
	100-120	30.5 -36.6	0.050	0.34	0.80	5.52	1.30	8.96	0.40	2.76	0.64	4.41
	120-140	36.6 -42.7	0.063	0.43	0.933	6.43	1.52	10.48	0.46	3.17	0.76	5.24
	140-160	42.7 -48.8	0.069	0.48	1.05	7.24	1.73	11.93	0.52	3.59	0.87	6.00
	160-180	48.8 -54.9	0.076	0.52	1.18	8.14	1.85	12.76	0.59	4.07	0.93	6.41
180-200	54.9 -61.0	0.11	0.76	1.29	8.89	2.15	14.82	0.64	4.41	1.08	7.45	
16 in. (400 mm)	0-20	0 - 6.1	0.0053	0.037	0.153	1.05	0.230	1.59	0.078	0.54	0.115	0.79
	20-40	6.1 -12.2	0.013	0.09	0.229	1.58	0.460	3.17	0.118	0.81	0.229	1.58
	40-60	12.2 - 18.3	0.020	0.14	0.306	2.11	0.618	4.26	0.152	1.05	0.306	2.11
	60-80	18.3 -24.4	0.026	0.18	0.390	2.69	0.773	5.33	0.191	1.32	0.390	2.69

Inside dia. of vent pipe (D)	Distance of vent system component from magnet		Pressure drop for straight pipe with smooth inside surface		Pressure Drop Per Elbow Used Anywhere Within A 20 Ft (6.1 M) Vent Segment							
					Standard Sweep				Long Sweep			
					Std sweep 45° elbow (K = 15 Ft)		Std sweep 90° elbow (K = 30Ft)		Long sweep 45° elbow (K = 7.5Ft)		Long sweep 90° elbow (K = 15 Ft)	
ft	m	psi/ft	kPa/m	psi	kPa	psi	kPa	psi	kPa	psi	kPa	
	80- 100	24.4 -30.5	0.033	0.23	0.543	3.74	0.850	5.86	0.270	1.86	0.421	2.90
	100-120	30.5-36.6	0.038	0.26	0.613	4.23	0.995	6.86	0.310	2.14	0.490	3.38
	120-140	36.6-42.7	0.048	0.33	0.714	4.92	1.16	8.00	0.352	2.43	0.581	4.01
	140-160	42.7-48.8	0.052	0.36	0.803	5.54	1.32	9.10	0.398	2.74	0.666	4.59
	160-180	48.8-54.9	0.058	0.40	0.903	6.23	1.42	9.79	0.451	3.11	0.712	4.91
	180-200	54.9-60.1	0.084	0.56	0.987	6.81	1.64	11.31	0.490	3.38	0.826	5.70

- Notes**
1. Elbows with angles greater than 90° must not be used.
 2. The table data is based on the followings:
 - a. Initial flow conditions at magnet interface
 - b. Gas temperature starting at 4.5 Kelvin (-452° F or -268°C).
 - c. Helium gas flow rate of 2,737 cubic feet per minute (77.5 cubic meters per minute)
 - d. 45° standard sweep elbow K = 15 Ft
 - e. 90° standard sweep elbow K = 30 Ft
 - f. 45° long sweep elbow K = 7.5 Ft
 - g. 90° long sweep elbow K = 15 Ft

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