

# Optima MR360 / Brivo MR355

## Pre-Installation



OPERATING DOCUMENTATION

5433834-1EN  
Revision 7



# WARNING



## STRONG MAGNETIC FIELD



**NO PACEMAKERS\***  
**NO NEUROSTIMULATORS\***  
**NO CONDUCTIVE/METALLIC IMPLANTS\***



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

\* In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. For patients with implants that are labeled as 'MR Safe' or 'MR Conditional', consult the implant device manufacturer's documentation.

\* WARNING: Only use quadrature transmit for 'MR Conditional' devices.

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# Important Information

## LANGUAGE

### ПРЕДУПРЕЖДЕНИЕ (BG)

Това упътване за работа е налично само на английски език.

- 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。

- 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电击、机械伤害或其他形式的伤害。

### 警告 (ZH-HK)

本服務手冊僅提供英文版本。

- 倘若客戶的服務供應商需要英文以外之服務手冊，客戶有責任提供翻譯服務。
- 除非已參閱本服務手冊及明白其內容，否則切勿嘗試維修設備。
- 不遵從本警告或會令服務供應商、網絡供應商或病人受到觸電、機械性或其他危險。

### 警告 (ZH-TW)

本維修手冊僅有英文版。

- 若客戶的維修廠商需要英文版以外的語言，應由客戶自行提供翻譯服務。
- 請勿試圖維修本設備，除非 您已查閱並瞭解本維修手冊。
- 若未留意本警告，可能導致維修廠商、操作員或病患因觸電、機械或其他危險而受傷。

### UPOZORENJE (HR)

Ovaj servisni priručnik dostupan je na engleskom jeziku.

- Ako davatelj usluge klijenta treba neki drugi jezik, klijent je dužan osigurati prijevod.
- Ne pokušavajte servisirati opremu ako niste u potpunosti pročitali i razumjeli ovaj servisni priručnik.
- Zanimarite li ovo upozorenje, može doći do ozljede davatelja usluge, operatera ili pacijenta uslijed strujnog udara, mehaničkih ili drugih rizika.

**VÝSTRAHA  
(CS)**

Tento provozní návod existuje pouze v anglickém jazyce.

- 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.

- 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.

- 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.

- 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 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.

- 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, laitteen käyttäjän tai potilaan vahingoittuminen sähköiskun, mekaanisen vian tai muun vaaratilanteen vuoksi.

**ATTENTION  
(FR)**

Ce manuel d'installation et de maintenance est disponible uniquement 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.

- 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 Kundendienst-technikers, des Bedieners oder des Patienten durch Stromschläge, mechanische oder sonstige Gefahren kommen.

**ΠΡΟΕΙΔΟΠΟΙΗΣΗ  
(EL)**

Το παρόν εγχειρίδιο σέρβις διατίθεται μόνο στα αγγλικά.

- 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.

- 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 aðeins fáanleg á ensku.

- 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 aðvörun 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 lingua inglese.

- 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。

- 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)**

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 apkopes rokasgrāmata ir pieejama tikai angļu valodā.

- Ja klienta apkopes sniedzējam nepieciešama informācija citā valodā, klienta pienākums ir nodrošināt tulkojumu.
- Neveiciet aprikojuma apkopi bez apkopes rokasgrāmatas izlasīšanas un saprašanas.
- Šī brīdinājuma neievērošanas rezultātā var rasties elektriskās strāvas trieciena, mehānisku vai citu faktoru izraisītu traumu risks apkopes sniedzējam, operatoram vai pacientam.

**[SPĖJIMAS  
(LT)]**

Šis eksploatavimo vadovas yra tik anglų kalba.

- 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.

- Hvis kundens serviceleverandør har bruk for 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.

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

**ATENÇÃO  
(PT-BR)**

Este manual de assistência técnica encontra-se disponível unicamente em inglês.

- 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.

- Se qualquer outro serviço de assistência técnica solicitar este manual noutro idioma, 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.

**ATENȚIE  
(RO)**

Acest manual de service este disponibil doar în limba engleză.

- 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 представлено только на английском языке.

- 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.

**UPOZORENJE  
(SR)**

Ovo servisno uputstvo je dostupno samo na engleskom jeziku.

- 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.

**UPOZORNENIE  
(SK)**

Tento návod na obsluhu je k dispozícii len v angličtine.

- Ak zákazník 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.

- 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 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.

**OPOZORILO  
(SL)**

Ta servisni priročnik je na voljo samo v angleškem jeziku.

- Če ponudnik storitve stranke potrebuje priročnik v drugem jeziku, mora stranka zagotoviti prevod.
- Ne poskušajte servisirati opreme, če tega priročnika niste v celoti prebrali in razumeli.
- Če tega opozorila ne upoštevate, se lahko zaradi električnega udara, mehanskih ali drugih nevarnosti poškoduje ponudnik storitev, operater ali bolnik.

**DİKKAT  
(TR)**

Bu servis kılavuzunun sadece ingilizcesi mevcuttur.

- Eğer müşteri teknisyeni bu kılavuzu ingilizce 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.

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## Revision History

| Optima MR360 / Brivo MR355 Pre-Installation |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rev                                         | Date         | Reason For Change                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 1                                           | Jul 18, 2012 | Initial Release                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 2                                           | Feb 20, 2013 | Update hallway dimension in magnet room in <a href="#">Chapter 1, MR System Shipping and Receiving</a><br>Update the minimum height of Fixed Table and Standard Table in <a href="#">Chapter 2, Basic System</a><br>Update Magnet Rundown Unit in <a href="#">Chapter 2, Magnet Rundown Unit</a><br>Add Maximum Heat Output of Step Down Transformer, update power requirement about MRU in <a href="#">Chapter 4, Heat Output</a><br>Update Minimum Service Area in <a href="#">Chapter 2, Room Layouts</a><br>Add <a href="#">Chapter 2, SV VibroAcoustic Kit</a><br>Update Hose nipple for F-50 Cryogen compressor in Water Chiller Siting Considerations |
| 3                                           | Sept 9, 2013 | Add the power of Step Down Transformer, Update System With BRM Coil Peak Power Demand in <a href="#">Chapter 5, Critical Power Requirements</a> .<br>Update MDP and Step Down Transformer connection in <a href="#">Chapter 5, Main Disconnect Panel (MDP) Requirements</a><br>Update Acoustic Specifications in <a href="#">Chapter 2, Acoustic Room Specifications</a> .                                                                                                                                                                                                                                                                                   |
| 4                                           | Jan 27, 2014 | Add Mobile Info in <a href="#">Chapter 2, Basic System</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 5                                           | Mar 12, 2014 | Updated Emergency Exhaust Vent Requirements in Cryogenic Venting                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 6                                           | Jan 26, 2015 | Update the description of Section 3.3.1.Magnet Mounting Requirements Step 4 under <a href="#">Chapter 2, Finished Room Requirements</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 7                                           | Oct 11, 2016 | Update Chapter 4 Section 6 <a href="#">Chapter 4, Magnet Venting Room Requirements</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

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# Chapter 1 General Requirements

## 1 Objectives & Overview



### **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. Equipment Requirements
3. Special Construction
4. Environmental Requirements (HVAC)
5. Electrical Requirements
6. Communications Requirements

## 2 Customer Responsibilities

### 2.1 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 list 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.

Mobile configuration can be installed in GE qualified trailers. Listed below is contact information for GE qualified trailer vendors.

- SMIT Mobile Equipment B. V.

Buyts Ballotstraat 6

3261 LA

Oud-Beijerland

The Netherlands

Tel: +31 (0) 186 614 322

Email: [info@smit.eu](mailto:info@smit.eu)

- Lamboo Specials Sales B.V.

Koperstraat 44

2718 RE

Zoetermeer

The Netherlands

Tel: +31 (0) 79 363 8383

Email: [info@mobile-medical.eu](mailto:info@mobile-medical.eu)

**NOTE:** GE qualified trailer vendor is expected to provide a trailer in which MR system can still comply with IEC 60601-1 and IEC 60601-2-33.

## 2.2 Site Planning Reminders

### 2.2.1 Site Safety Readiness

**Table 1-1: Site Safety Readiness**

| Step | Title                                               | Requirements                                                                                                                                                                                                                                                                                                                                         |
|------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <b>Cryogenic Vent</b>                               | The cryogenic vent has been installed complete and inspected from the Magnet Room RF to the final exit outside of the building. The customer needs to maintain a copy of the Vent Inspection Report with the site documentation. Refer to Cryogenic Venting.                                                                                         |
| 2    | <b>Magnetic Room Ventilation</b>                    | All of the required Magnet Room ventilation items have been installed and tested to make sure sufficient ventilation is available. The exhaust fan and fan controls are installed and functional. The customer needs to maintain a copy of the Exhaust Fan System test reports with the site documentation. Refer to Refer to HVAC Vent Requirements |
| 3    | <b>Broadband Network Connection &amp; Telephone</b> | Functioning Broadband (network) connections and telephone are available at the site for the duration of the installation and system operation. Broadband is needed for Magnet Monitor and MR System computer access. Telephone is needed to dial out in case of an emergency. Refer to <a href="#">Chapter 6, Communications Requirements</a> .      |

### 2.2.2 Actions to Be Completed Prior to Magnet Delivery (to site) and Moved into Magnet Room

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

**Table 1-2: Actions to Be Completed Prior to Magnet Delivery (to site) and Moved into Magnet Room**

| Step | Title                                                                                 | Requirements                                                                                                                                                                                                                                                                                                                                                                          |
|------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <b>Vibration Study</b>                                                                | The vibration study has been completed and vibration sources have been identified and addressed to comply with the specifications. (It is Customer's responsibility to contract a vibration consultant or qualified engineer to implement design modifications to meet the specified limits.) Refer to <a href="#">Chapter 2, Magnet Field Consideration/Vibration Requirements</a> . |
| 2    | <b>Magnetic Field</b>                                                                 | The site design contains the magnetic field and site design complies with the moving metal requirements. Refer to: <ul style="list-style-type: none"> <li><a href="#">Chapter 3, Section 1.2.2, Non-MR System Equipment Sensitivity to Magnetic Fields</a></li> <li>For magnetic field containment refer to <a href="#">Chapter 3, Magnetic Field Consideration</a></li> </ul>        |
| 3    | <b>Structural Steel</b>                                                               | The site steel and iron materials comply with the requirements. Refer to <a href="#">Chapter 2, 3.2.2 Environmental Steel Limits</a>                                                                                                                                                                                                                                                  |
| 4    | <b>Acoustics</b>                                                                      | The site has been designed and constructed to contain the MR System acoustic levels to meet local regulations and Customer requirements. Refer to <a href="#">Chapter 7, Acoustic Background and Design Guidelines</a> .                                                                                                                                                              |
| 5    | <b>Exclusion Zone</b>                                                                 | Please refer to <a href="#">Chapter 3, Section 1.2.3, Exclusion Zone</a>                                                                                                                                                                                                                                                                                                              |
| 6    | <b>RF Shield Room Special Construction Requirement for Brivo MR355 / Optima MR360</b> | <a href="#">Chapter 3, RF Shield Consideration for System Cabinet and Penetration Panel</a>                                                                                                                                                                                                                                                                                           |
| 7    | <b>Magnetic Room Layout</b>                                                           | For magnetic room layouts and minimal room size with service area please refer to Room Layout                                                                                                                                                                                                                                                                                         |

|    |                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                |
|----|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8  | <b>Magnet Room Floor</b>                                                        | The Magnet Room floor and Magnet mounting area has been properly design/constructed (location, size, levelness, etc.) relative to the cryogenic vent location, finished floor to center of Magnet opening dimension, Rear Pedestal support, flooring and sub-flooring materials and construction. Refer to Cryogenic Venting/Magnet Cryogenic Vent Location and Finished Room Requirements/Magnet Room Floors. |
| 9  | <b>Magnet Room Lighting</b>                                                     | The Magnet Room lighting installed and designed to comply with the requirements so as to not to generate RF noise, which would be detrimental to the ability of the MR System to produce images of good quality. Refer to <a href="#">Chapter 5, Lighting Specifications</a> .                                                                                                                                 |
| 10 | <b>Magnet Room Anchors</b>                                                      | All Magnet Room anchors have been installed, with ground impedance test performed to meet requirements. Installed and test results recorded by RF Shield Room Vendor and information forwarded to the customer to be maintained with the site documentation. Refer to Finished Room Requirements.                                                                                                              |
| 11 | <b>Cryogenic Venting System(Customer portion, installation within 24 hours)</b> | All of the required Magnet Room ventilation items have been installed and tested to make sure sufficient ventilation is available. The exhaust fan and fan controls are installed and functional. The customer needs to maintain a copy of the Exhaust Fan System test reports with the site documentation. For Cryogenic Venting System please refer toCryogenic Venting                                      |
| 12 | <b>Environment Controls(HVAC, Cooling, Dust Free)</b>                           | All of the areas in the MR System Equipment Room and Control Room are complete, so a dust-free environment is available for the installation of the equipment. Refer to <a href="#">Chapter 4, Air Quality</a> .                                                                                                                                                                                               |
| 13 | <b>Facility Power(for Magnet Monitor, Cool head)</b>                            | For Facility Power requirements please refer to Power Requirements                                                                                                                                                                                                                                                                                                                                             |
| 14 | <b>Magnet Delivery Route</b>                                                    | For Magnet Delivery Route please refer to Minimum Delivery Route Sizes and Capability                                                                                                                                                                                                                                                                                                                          |
| 15 | <b>Multiple MR System Site</b>                                                  | The site design complies with the requirements for sites with more than one magnet in the magnetic field area or the Equipment Room is shared by more than one MR system of the same field strength. Refer to Room Layout.                                                                                                                                                                                     |

### 2.2.3 Actions to Be Completed Prior to System Delivery (to site) and Installation

Table 1-3: Actions to Be Completed Prior to System Delivery (to site) and Installation

| Step | Title                                                  | Requirements                                                                                                                                                                                                               |
|------|--------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Environment Controls(HVAC, Cooling, Dust Free)         | All of the areas in the MR System Equipment Room and Control Room are complete, so a dust-free environment is available for the installation of the equipment. Refer to <a href="#">Chapter 4, Air Quality</a> .           |
| 2    | Equipment and Operator Room Layout (Minimal Room Size) | Room Layout                                                                                                                                                                                                                |
| 3    | System Cabinet Anchor                                  | For System Cabinet Anchor, please refer to <a href="#">Chapter 2, Section 3.6, System Cabinet Special Consideration</a>                                                                                                    |
| 4    | RF Shield Requirement                                  | Please refer to <a href="#">Chapter 3, RF Shield Requirement</a>                                                                                                                                                           |
| 5    | Equipment Delivery Route                               | For Equipment Delivery Route please refer to MR System Delivery Route Requirements                                                                                                                                         |
| 6    | Multiple MR System Site                                | The site design complies with the requirements for sites with more than one magnet in the magnetic field area or the Equipment Room is shared by more than one MR system of the same field strength. Refer to Room Layout. |

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

### 2.2.4 Actions to Be Completed Prior to Magnet Ramp-up RF Shielding (Attenuation and isolation for full installation, Dock Anchor )

1. Magnet Room Construction Completed and no Ferrous Metal
2. Safety and Exclusion Sign Posted
3. Facility Personnel and Departments Informed
4. Power Readiness (for Ramp up)
5. Penetration Panel Installed
6. Site Environment Inspection (Moving Metal)

## 3 Delivery Requirements

### 3.1 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.

#### 3.1.1 MR System Shipping Requirements



#### NOTICE

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.



#### NOTICE

At delivery, the customer is responsible for ensuring:

1. All floors along the route will support the weight of the magnet (GE Healthcare recommends a structural analysis)
2. Doors or other openings are sufficiently wide to allow passage
3. Sufficient room is provided for any required dollies or rigging

#### 3.1.2 Minimum Delivery Route Sizes and Capability

[Table 1-4](#) lists minimum actual clearance opening dimensions for doors and hallways required by the MR system equipment.

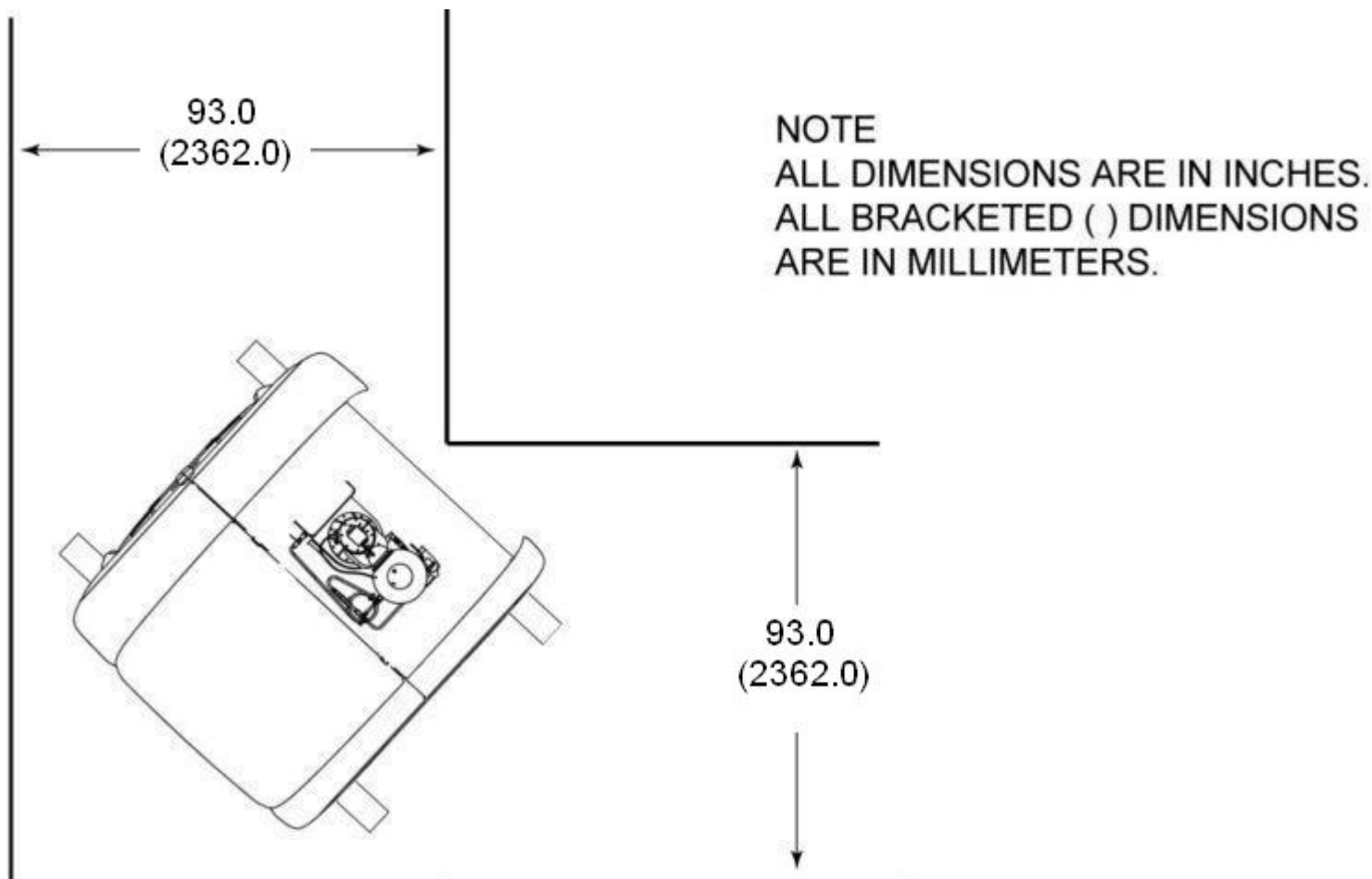
Installation or replacement of components listed in [Table 1-5](#) must be taken into consideration when determining hallway and door dimensions.

Clearance for maneuvering around corners or turns must also be taken into consideration. Refer to [Table 1-6](#), Shipment for Component shipping dimensions.

Table 1-4: Minimum Hallway/Door Dimensions

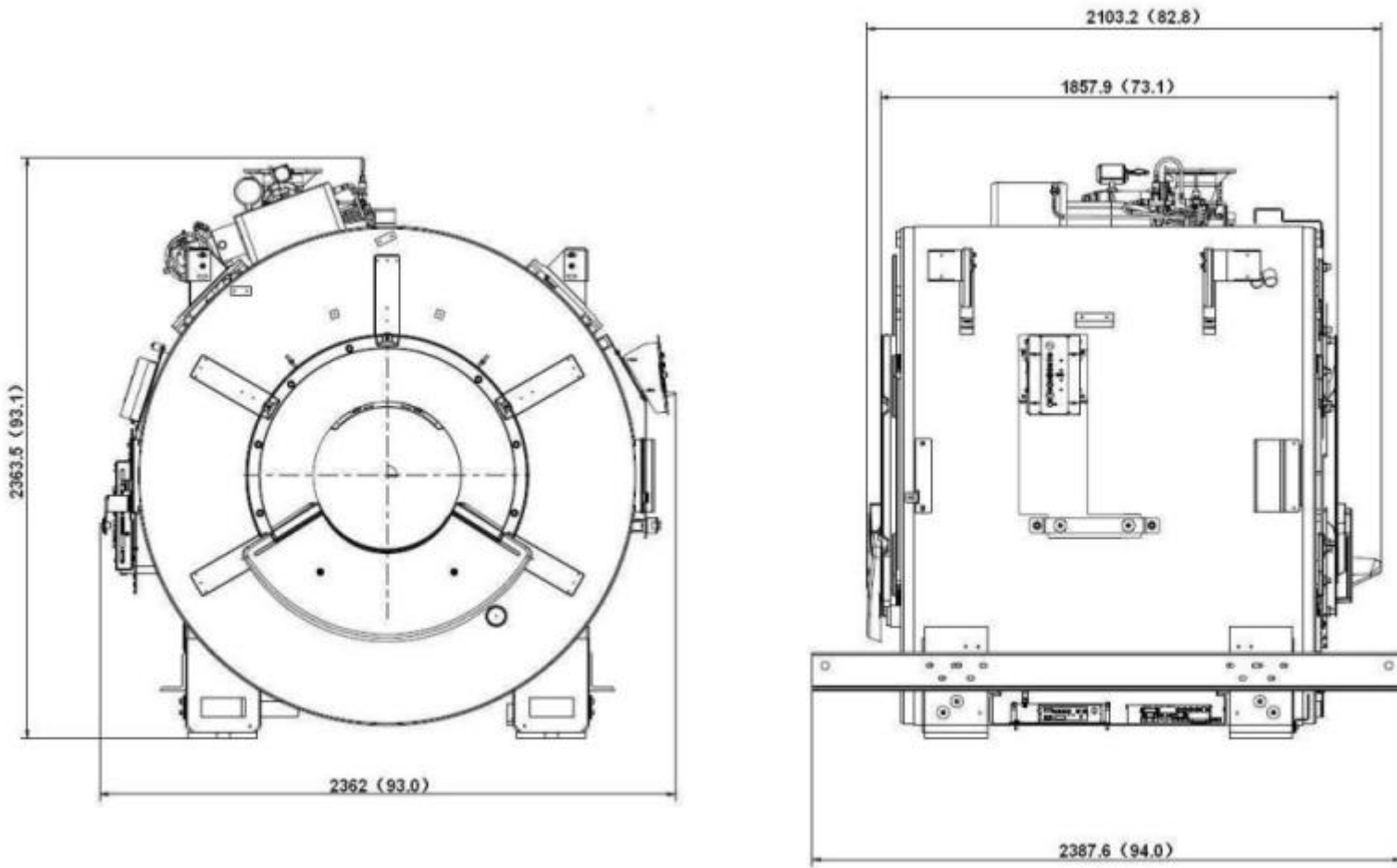
| Component                                                                                                                                                                                                                                                                                                                                                      | Minimum Hallway/<br>Door Width* |      | Minimum Hallway/<br>Door Height* |      | Comments                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------|----------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                | in.                             | mm   | in.                              | mm   |                                                                                                                                                   |
| Operator Workspace Table                                                                                                                                                                                                                                                                                                                                       | 32                              | 813  | 80                               | 2032 |                                                                                                                                                   |
| System Cabinet                                                                                                                                                                                                                                                                                                                                                 | 39                              | 1000 | 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 <a href="#">Illustration 1-2</a>                                                                                                         |
| 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. <a href="#">Illustration 1-1</a> shows dimensions for 90° turn. |                                 |      |                                  |      |                                                                                                                                                   |
| 2. Final dimension is dependent on rigger equipment used.                                                                                                                                                                                                                                                                                                      |                                 |      |                                  |      |                                                                                                                                                   |

Illustration 1-1: LCC Magnet Minimum Door/Hallway Dimensions 90° Turn





**Illustration 1-2: Magnet Size for Transportation**



**Table 1-5: Component Dimensions For Installation/Replacement**

| Component                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Approximate Weight lbs (kg) | Overall Dimensions W x D x H in. (mm)                 | Comments                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Magnet (uncrated)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Refer to comments.          | Refer to comments.                                    | Refer to 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 x 96.09 x 55.88 (889 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 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.                                                                                                                                                                                                                 |
| System Cabinet                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2206 (1000)                 | 40 x 31 x 79 (1000 x 800 x 1995)                      |                                                                                                                                                                                                                             |
| <p><b>Note</b></p> <ol style="list-style-type: none"> <li>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 <a href="#">Section 3.1.3</a>.</li> <li>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).</li> <li>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. Utilization of Gradient Coil Replacement Tool requires 107.75 in. (2737 mm) clear space in front of magnet.</li> </ol> |                             |                                                       |                                                                                                                                                                                                                             |

**Table 1-6: Optima MR360 / Brivo MR355 1.5T 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 - Tarped<br>International - crate/pallet |
| Magnet Accessory Equipment                                                    | 48 x 48 x 28      | 1219 x 1219 x 711  | 400                | 182 | crate                                             |
| Shield/Cryo Cooler Compressor Cabinet for Type A, B, C, E                     | 26 x 28 x 42      | 660 x 711 x 1067   | 240                | 109 | skid with box cover                               |
| Air Cooled Compressor for Type D                                              | 32 x 26 x 45      | 800 x 660 x 1140   | 366                | 166 | crate/pallet                                      |

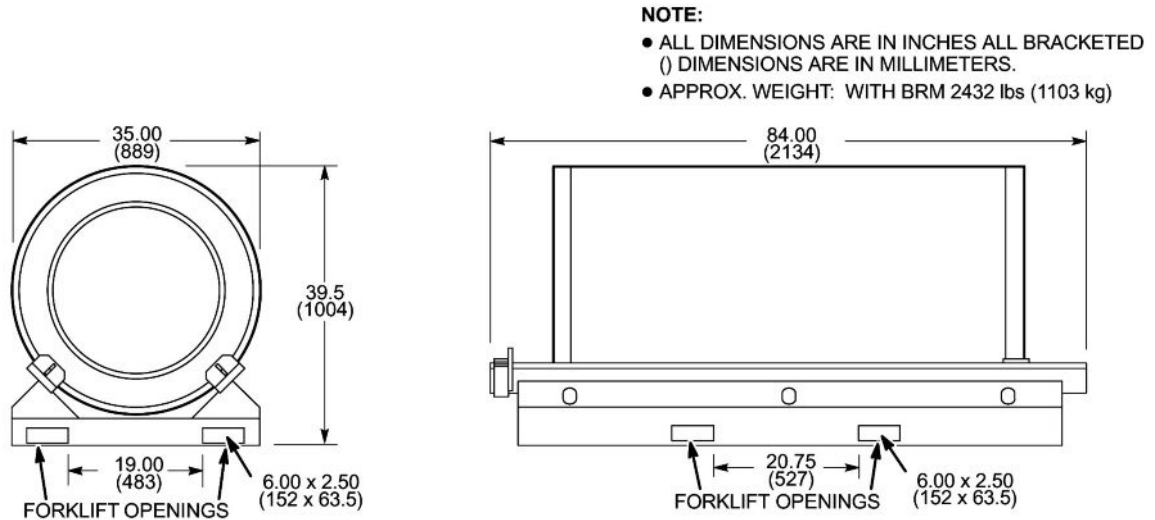
| MR Component                                                                                                                                                                                                                                                                                                                     | Approximate WxDxH  |                    | Approximate Weight |                 | Method Of Shipment               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|--------------------|-----------------|----------------------------------|
|                                                                                                                                                                                                                                                                                                                                  | in.                | mm                 | lbs                | kg              |                                  |
| 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 Skirts                                                                                                                                                                                                                                                                                                                 | 40 x 24 x 24       | 1016 x 610 x 610   | 30                 | 14              | box                              |
| Fixed Site Water Chiller for Gradient Coil Cooling for Type D, E                                                                                                                                                                                                                                                                 | 29 x 42 x 33       | 737 x 1067 x 838   | 320 dry weight     | 154 dry weight  | crate                            |
| Water Chiller (LCS 4KW) for Type B, B'                                                                                                                                                                                                                                                                                           | 19.7 x 39.3 x 29.5 | 500 x 1000 x 750   | 86                 | 33 dry weight   |                                  |
| Water Chiller (LCS 8KW) for Type A, B, B'                                                                                                                                                                                                                                                                                        | 19.7 x 39.3 x 29.5 | 500 x 1000 x 750   | 107                | 48.5 dry weight |                                  |
| Water Chiller (MCS) for Type C, D, E                                                                                                                                                                                                                                                                                             | 27.5 x 39.5 x 31.5 | 700 x 1000 x 850   | 220                | 100 dry weight  |                                  |
| 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                              |
| System Cabinet                                                                                                                                                                                                                                                                                                                   | 52 x 42 x 90.5     | 1310 x 1060 x 2300 | 2070               | 950             | crate                            |
| SPT Phantom Set                                                                                                                                                                                                                                                                                                                  | 52 x 42 x 90.5     | 1310 x 1060 x 2300 | 2400               | 1100            | crate                            |
| 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                              |
| VibroAcoustic Damping Option *                                                                                                                                                                                                                                                                                                   | 36 x 65 x 12       | 914 x 1651 x 305   | 575                | 261             | box on pallet                    |
| Air Cooled 11KW Airsys Chiller for Type A,C                                                                                                                                                                                                                                                                                      |                    |                    |                    |                 |                                  |
| Air Cooled 11KW Airsys Chiller                                                                                                                                                                                                                                                                                                   | 46 x 33.5 x 58     | 1180 x 860 x 1490  | 782                | 355             | crate                            |
| Ship loose items                                                                                                                                                                                                                                                                                                                 | 31.5 x 31.5 x 36   | 800 x 800 x 920    | 394                | 178.5           | box                              |
| <b>Notes</b><br>* Optional Equipment<br>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).<br>International shipments must add shipping crate/pallet of 2,200 lbs (998 kg). |                    |                    |                    |                 |                                  |

### **3.1.3 BRM Gradient Coil Assembly, Cradle and Cart Delivery**

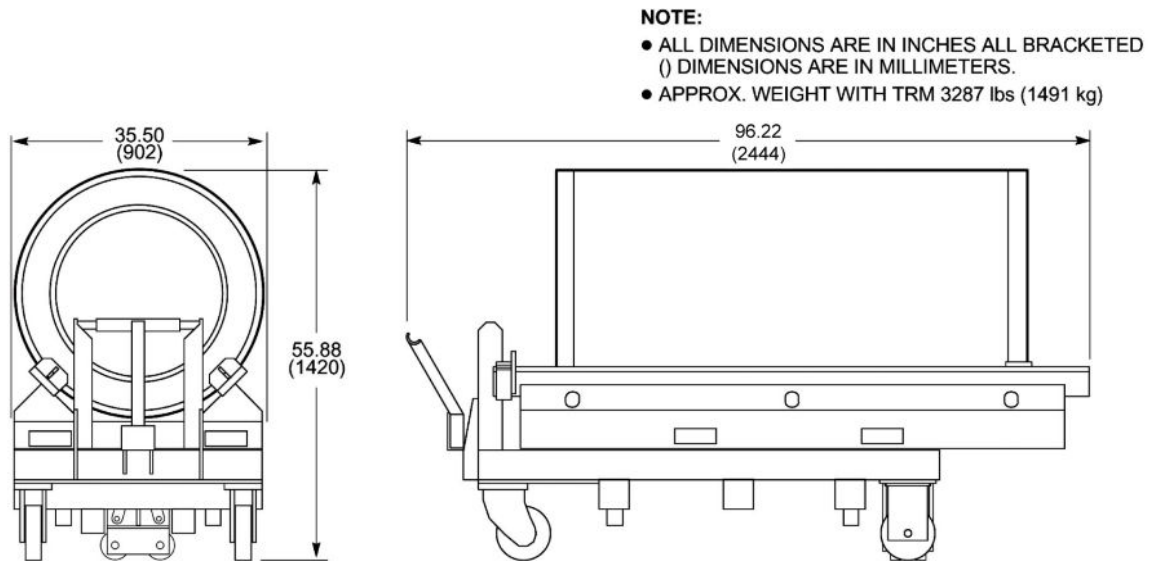
Initial BRM Gradient Coil Assembly is shipped installed in the Magnet. Shipping/installation cart is required to be used to install replacement coil assembly. The Gradient Coil Assembly will be delivered on an aluminium (re-useable) cradle. A forklift or crane/hoist rated for 4000 lbs (1818

kg) may be required to position the coil/cradle assembly onto the cart for installing the coil into the magnet, see and .

**Illustration 1-3: Replacement BRM Gradient Coil Assembly & Cradle**



**Illustration 1-4: Short Room Replacement BRM Gradient Coil Assembly & Cradle On Cart**



## 4 Product Storage and Handling Requirements

### 4.1 Storage Requirements

#### 4.1.1 Transportation and Storage Environmental Conditions

Refer to [Table 1-7](#) for transportation and storage environmental conditions.

**Table 1-7: Transportation and Storage Environmental Conditions**

| System Equipment                                  | Temperature Range<br>°F (°C) | Temperature<br>Change °F/Hr<br>(°C/Hr) | Relative Humidity %      | Humidity Change<br>%/Hr | Atmospheric Pres-<br>sure hPa |
|---------------------------------------------------|------------------------------|----------------------------------------|--------------------------|-------------------------|-------------------------------|
| Electronics Cabinets<br>& equipment except<br>GOC | -30 to 140<br>(-34 to 60)    | 68 (20)                                | 0-90 non-condens-<br>ing | 30                      | 1012 to 525                   |
| Simple OC                                         | -22 to 140<br>(-30 to 60)    | 68 (20)                                | 8-90 non-condens-<br>ing | 30                      | 1060 to 500                   |
| Magnet                                            | -31 to 122<br>(-35 to 50)    | 176 (80)                               | 0-90 non-condens-<br>ing | 30                      | 1012 to 525                   |

The GE LCC Magnet utilizes a Shield/Cryo Cooler System to maintain a reduced helium boil-off. However, the Shield Cooler System is not operational during transportation. Therefore the magnet will require liquid helium replenishment if transportation time exceeds two weeks. Contact GE Service for magnet servicing.

The Magnet is filled with liquid helium at initial shipment but can be allowed to warm up during transportation without damage to the support structure.

#### 4.1.2 Construction-Site Storage

When storing the MR system at a construction site be sure to adhere to the following storage requirements:

- Do not damage or puncture the shipping crate.
- Protect the MR system from weather, dirt, and dust.

### 4.2 Handling Requirements

The design of the system does not tolerate dropping, shock, vibration, or tipping. Be sure to communicate these handling requirements to all parties involved in transporting, moving, and handling system components.

#### 4.2.1 Avoid Dropping

Never drop the magnet, cabinet, console, or table. A drop may cause structural damage to the frame or other major components. Damage resulting from a drop (e.g., bent frame, misalignment) may not become apparent until after the system is installed

#### ***4.2.2 Avoid Shocks and Vibrations***

The design of the system, including the Magnet, cabinet, console, and table, does not tolerate excessive shock or vibration, which may occur during unloading. For example, rolling the cabinet across a “washboard” style ramp may vibrate components, causing loose or broken connections. Damage resulting from shock or vibration may not become evident until after the system is installed.

## Chapter 2 Equipment Requirements

### 1 System Components

#### 1.1 Basic System

The basic Optima MR360 / Brivo MR355 system for fixed site operation consists of the following major equipments.

##### **Basic System**

- 1.5T LCC Magnet with Magnet Enclosure and Magnet Accessories (MAG)
- Body Gradient (BRM) and RF body coils
- Blower Box provides Body Coil cooling air and air to the Patient Comfort Module in the Magnet Enclosure (MG6)
- Magnet Rundown Unit (MRU)
- Magnet Monitor (MSM)
- System Cabinet (MR2)
- Penetration Panel (PP1)
- Operator Workspace equipment (OW)
- Pneumatic Patient Alert System (PA)
- Patient accessories such as a phantom kit, patient log book, head cushion and sponges, chin and forehead straps, body wedges, knee cushions, and security/restraint straps
- Gating accessories which include patient cardiac leads, peripheral gating probe, and respiratory bellows

##### **System Option**

- The VibroAcoustic Damping Option
- Patient Transport Table and cradle (Fixed/Standard/Lite)  
Refer to [Illustration 2-4](#)
- Main Distribution Panel(MDP)
- Shield/Cryo Cooler Compressor Cabinet(Air Cooled/Water Cooled)
- 11KW Airsys Chiller
- 4KW LCS (WC1) for TypeB
- 8KW LCS (WC2) for Type A, B
- MCS(WC1) for Type C, D, E

- Water Chiller for BRM for Type D, E
- Advantage Workstation
- 

**NOTE:** Refer to [Illustration 2-1](#) and [Illustration 2-3](#) for system configuration types.



### Facility Option

- System Seismic Anchorage Service (R4390JA).
- 
- Direct current (DC) lighting controller for the magnet room:
  - E4502SC 20 Amp Maximum Constant Lighting Level System, surface/semi-flush mount
  - E4502SD 20 Amp Maximum Variable Lighting Level System, surface/semi-flush mount
  - E4502SE 28 Amp Maximum Constant Lighting Level System, surface/semi-flush mount
  - E4502SF 28 Amp Maximum Variable Lighting Level System, surface/semi-flush mount.
- Oxygen Monitor Kit (M1060KM) which includes Oxygen Monitor and Remote Oxygen Monitor Module.

**NOTE:** The Oxygen Monitor does not bear a CE monogram and therefore may not be acceptable in all European countries.

- Magnet Monitor(MON) Weight: 10 lbs (4.5 kg).

[Illustration 2-1](#) shows a typical MR suite layout without Equipment Room. [Illustration 2-3](#) shows a typical MR suite layout with Equipment Room. Not all components listed above are shown.

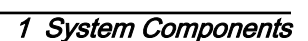
Actual room layout, equipment placement, system configuration, and options may vary based on site requirements and system specifications. Refer to the appropriate section in this manual for detailed layout requirements and specifications.

### ***Without Equipment Room***

- Water Cooled Shield Cooler Compressor with 11kw chiller
- LCS(8KW) for Cabinet Cooling
- 11 KW Chiller for BRM and LCS Cooling



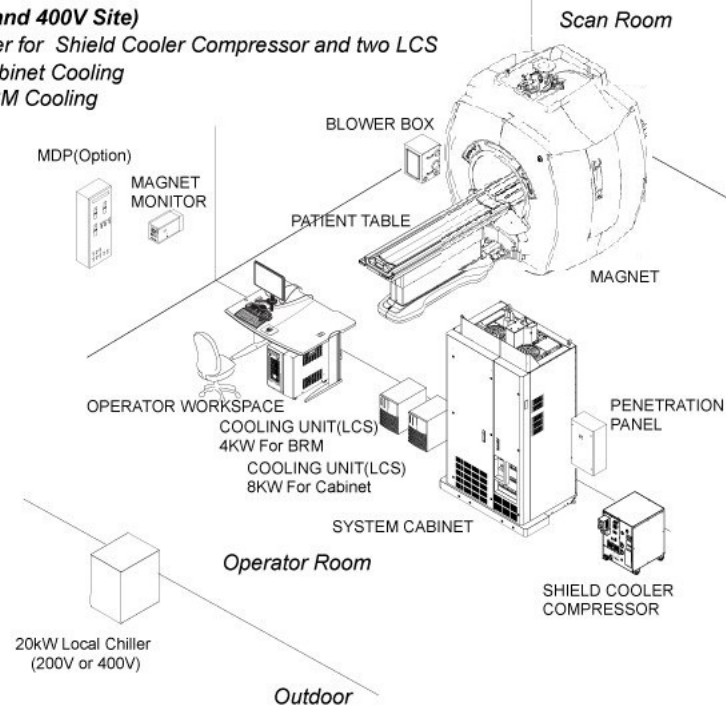
- Note:**  
Mobile site will use  
Type B System configuration.



**Illustration 2-2: Optima MR360 / Brivo MR355 System without Equipment Room (continued)**

**Type B' (For 200V and 400V Site)**

- 20kW Local Chiller for Shield Cooler Compressor and two LCS
- LCS(8KW) for Cabinet Cooling
- LCS(4KW) for BRM Cooling

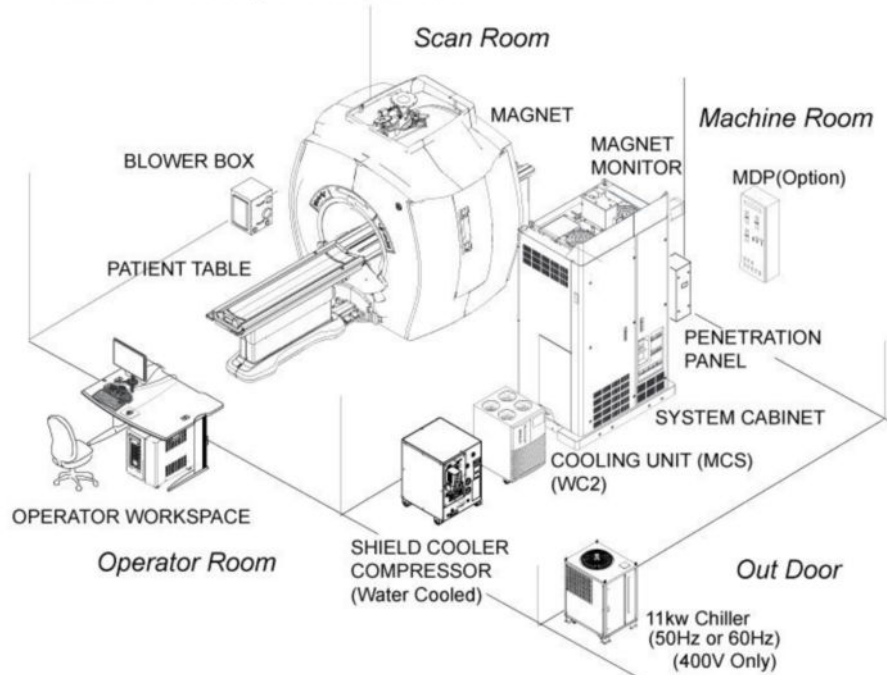


## Illustration 2-3: Optima MR360 / Brivo MR355 System with Equipment Room

### With Equipment Room

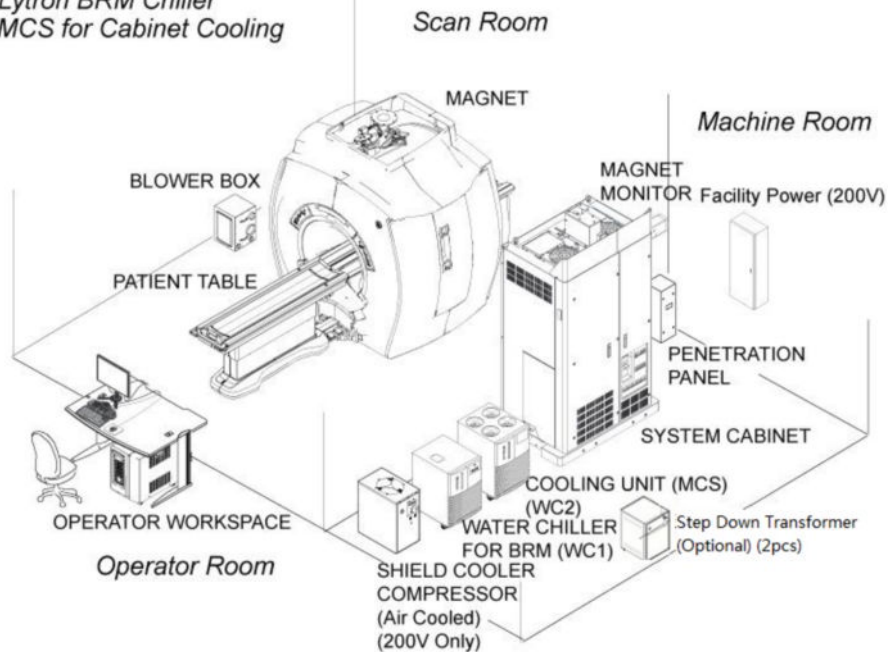
#### Type C (400V Site Only)

- Water Cooled Shield Cooler Compressor
- MCS for Cabinet Cooling
- 11kw chiller for Compressor and BRM



#### Type D (200V Site Only)

- Air Cooled Shield Cooler Compressor
- Lytron BRM Chiller
- MCS for Cabinet Cooling



Note : Type C cooling is not supported in EAGM.

Illustration 2-4: Type E with Equipment Room

### With Equipment Room

#### Type E (Europe and EAGM)

- Water Cooled Shield Cooler Compressor
- Lytron BRM Chiller
- MCS for Cabinet Cooling

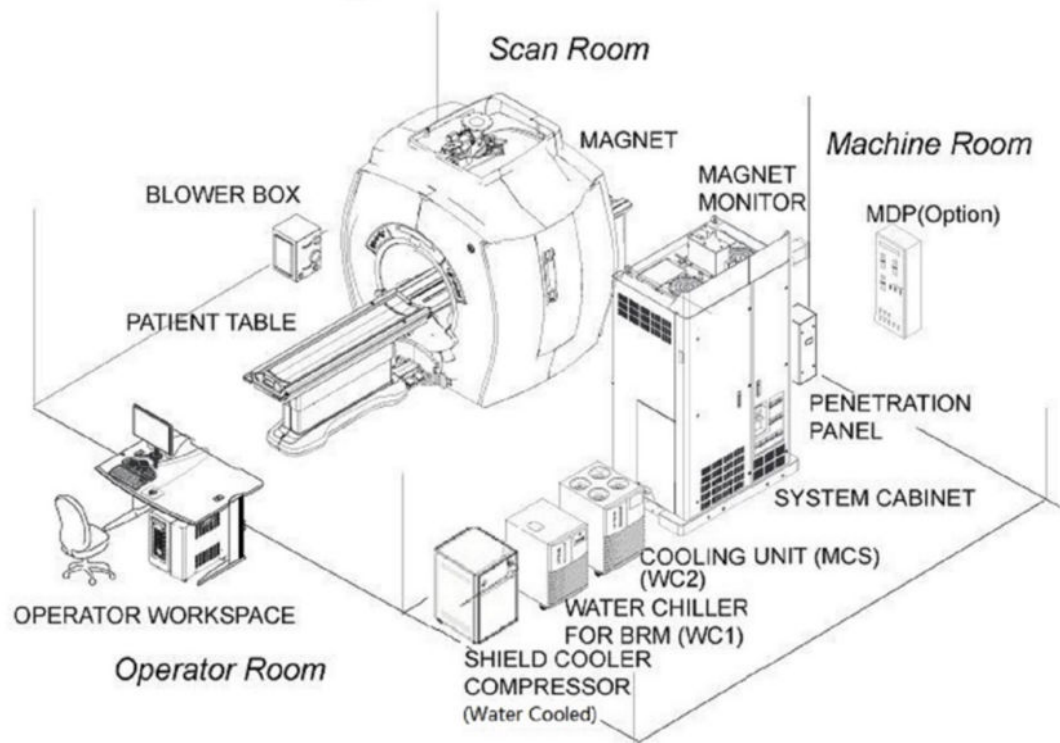
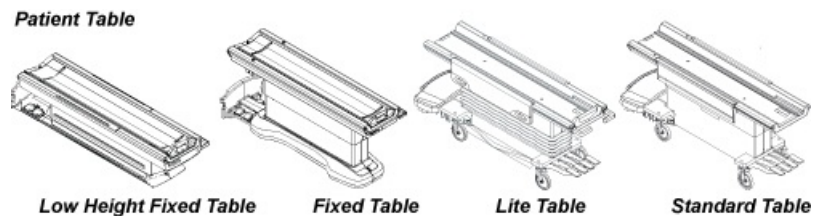


Illustration 2-5: Patient Table



**NOTE:** The minimum height of Low Height Fixed Table is 19.3 inch (490mm) whereas the minimum height of Fixed Table is 27 inch (680mm)

- NOTE:**
- For Brivo MR355 system, only Fixed Table or Low Height Fixed Table can be selected.
  - For Optima MR360 system, one Table can be selected from four selection.
  - Fixed Table or Low Height Fixed table includes the PA Express coil embedded in the cradle for simple operation.
  - Lite Table and Standard Table are both detachable. The lowest height is different. (490mm for Lite Table, 686mm for Standard Table)

## 1.2 Component Dimensions

To assist in completing your room layout, refer to [Table 2-1](#) for list of component Illustrations.

**Table 2-1: Optima MR360 / Brivo MR355 System Component Illustrations List**

|                                                                                                                     | Illustration Name                                                                                                                                                                                                                                                                                        | Illustration Location                                                                    |
|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| <b>Magnet Room</b>                                                                                                  | <ul style="list-style-type: none"> <li>Optima MR360 / Brivo MR355 LCC Magnet (Minimum Service Area)</li> <li>Optima MR360 / Brivo MR355 LCC Magnet Enclosure Front And Rear Views</li> <li>Optima MR360 / Brivo MR355 LCC Magnet Enclosure Cable Access</li> <li>1.5T LCC Magnet Load Pattern</li> </ul> | Magnet room equipment specification                                                      |
|                                                                                                                     | Patient Transport Table (PT1)                                                                                                                                                                                                                                                                            | Patient Transport Table                                                                  |
|                                                                                                                     | Magnet Rundown Unit (MS4)                                                                                                                                                                                                                                                                                | Magnet Rundown Unit                                                                      |
|                                                                                                                     | Remote Oxygen Sensor Module (OM3)                                                                                                                                                                                                                                                                        | <a href="#">Oxygen Monitor Option</a>                                                    |
|                                                                                                                     | Blower Box (MG6)                                                                                                                                                                                                                                                                                         | <a href="#">Blower Box</a>                                                               |
| <b>Equipment Room</b><br><b>NOTE:</b> For Non-Equipment Room System, please put these components into Control Room. | System Cabinet and Penetration Panel                                                                                                                                                                                                                                                                     | <a href="#">System Cabinet</a>                                                           |
|                                                                                                                     | Mesh Shield and System Cabinet Cover                                                                                                                                                                                                                                                                     | <a href="#">Mesh Shield and System Cabinet Cover</a>                                     |
|                                                                                                                     | Main Disconnect Control                                                                                                                                                                                                                                                                                  | <a href="#">Main Disconnect Panel</a>                                                    |
|                                                                                                                     | Magnet Monitor (MSM1)                                                                                                                                                                                                                                                                                    | Magnet Monitor                                                                           |
|                                                                                                                     | Penetration Panel                                                                                                                                                                                                                                                                                        | <a href="#">Penetration Panel</a>                                                        |
|                                                                                                                     | DC Lighting Controller Option                                                                                                                                                                                                                                                                            | <a href="#">DC Lighting Controller Option</a>                                            |
|                                                                                                                     | Shield/Cryo Cooler Compressor Cabinet (MS5) for Type D                                                                                                                                                                                                                                                   | <a href="#">Shield/Cryo Cooler Compressor (Air Cooled Type)</a>                          |
|                                                                                                                     | Shield/Cryo Cooler Compressor Cabinet For Type A, B, B', C and E (Water Cooled Type) (MS5)                                                                                                                                                                                                               | <a href="#">Shield/Cryo Cooler Compressor (Water Cooled Type)</a>                        |
|                                                                                                                     | Remote Control Panel (RCP) of 11kw Chiller for Type A, C                                                                                                                                                                                                                                                 | Remote Control Panel (RCP) For 11kW Chiller in <a href="#">11KW Airsys Water Chiller</a> |
|                                                                                                                     | <ul style="list-style-type: none"> <li>8 KW LCS for Cabinet (WC2) (Type A, B, B')</li> <li>4 KW LCS for BRM (WC1) (Type B, B')</li> </ul>                                                                                                                                                                | <a href="#">4 KW LCS and 8kW LCS</a>                                                     |
|                                                                                                                     | MCS for Cabinet (Type C, D, E) (WC2)                                                                                                                                                                                                                                                                     | <a href="#">MCS</a>                                                                      |
|                                                                                                                     | Water Chiller For BRM (Type D, E) (WC1)                                                                                                                                                                                                                                                                  | <a href="#">BRM Chiller</a>                                                              |



|                         | Illustration Name                                                                                                                                                                                                                                                                    | Illustration Location     |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Control Room            | <ul style="list-style-type: none"> <li>Operator Workspace (OW1) Overall Dimensions</li> <li>Simple OC Computer Cabinet</li> <li>Operator Workspace Components Position on Table Top - 23 Inch LCD</li> <li>Operator Workspace Components Position on Table Top - Keyboard</li> </ul> | Operator Workspace        |
|                         | Pneumatic Patient Alert Control Box (PA1)                                                                                                                                                                                                                                            | Pneumatic Patient Alert   |
|                         | Oxygen Monitor (OM1)                                                                                                                                                                                                                                                                 | Oxygen Monitor            |
| Outdoor (For Type A, C) | <p><b>NOTE:</b> 11kw Chiller can be used to provide BRM and LCS cooling.</p> <ul style="list-style-type: none"> <li>11kw Airsys Water Chiller (11kw Chiller)</li> <li>11kw Chiller Outdoor Mounting</li> </ul>                                                                       | 11KW Airsys Water Chiller |

### **1.2.1 Magnet room equipment specification**

- 1.5T LCC Magnet (including VibroAcoustic Damping option)
- 3 types of Patient Table (Selectable)
- MRU
- Oxygen Sensor
- Blower Box

### **1.2.2 Equipment Room equipment specification**

- MDP
- System Cabinet (For Type C, D)
- 2nd Penetration Panel
- Magnet Monitor
- MCS (For Type C, D, E)
- BRM Chiller (For Type D, E)
- Shield cooled compressor



### ***1.2.3 Control Room equipment specification***

- Operator Workspace
- Simplified Operator Cabinet
- Host Display
- Host Keyboard
- Pneumatic Patient Alert
- Oxygen Monitor
- System Cabinet (For Type A, B, B')
- LCS(4kW) (For Type B, B')
- LCS(8kW) (For Type A, B, B')

### ***1.2.4 Outdoor***

- 11 kW Airsys Chiller (For Type A, C)

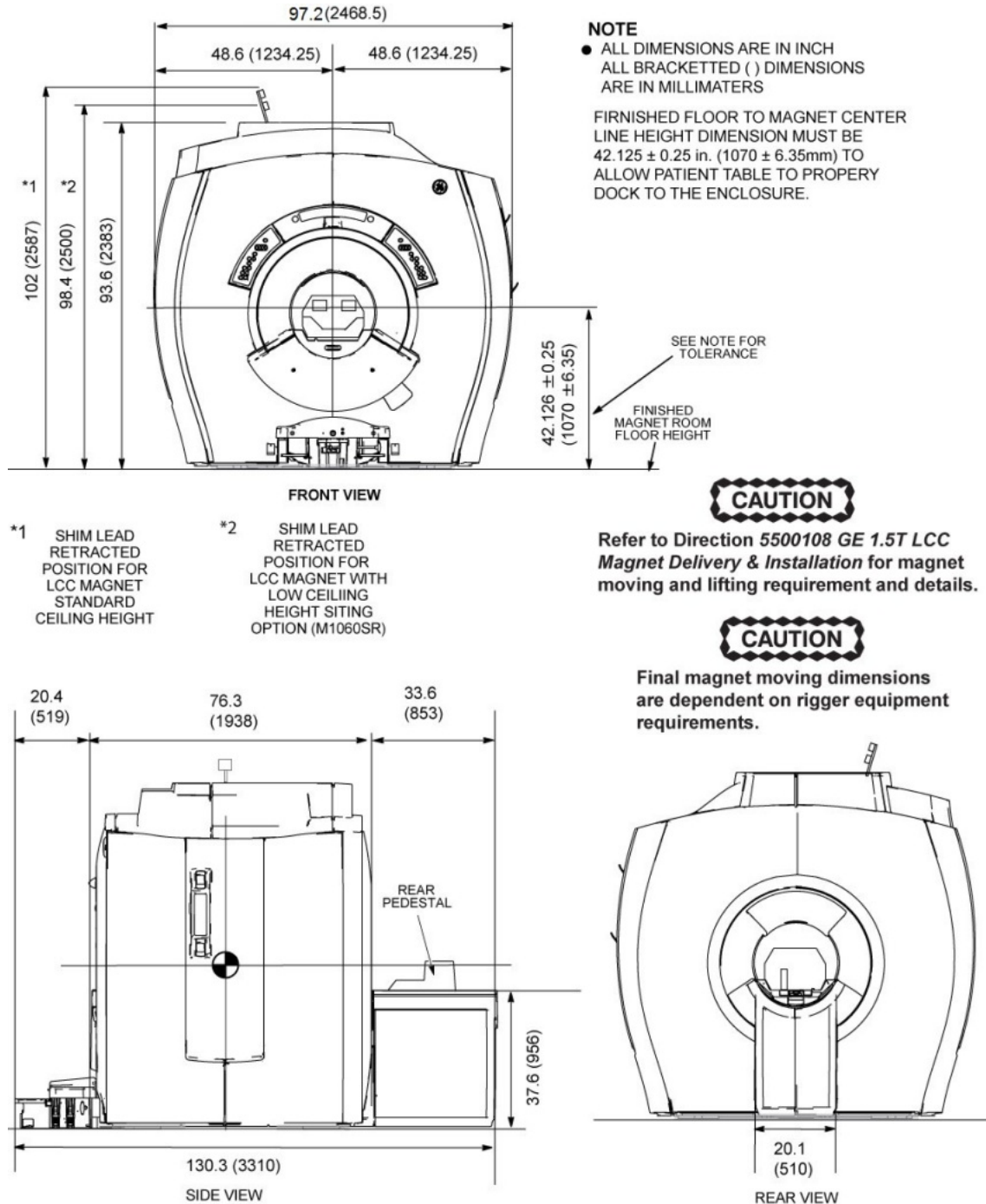
## 1.3 Magnet Room Equipment Specification

### 1.3.1 Magnet room equipment specification

1.5T LCC Magnet (including VibroAcoustic Damping option)

Weight: 11,700 lbs (5320 kg) with cryogenics, partial Quiet Technology Enclosure installed

**Illustration 2-6: Magnet Enclosure Dimensions**



## Illustration 2-7: Recommended duct example if there is enough room

Recommended Duct Example if there is enough room:

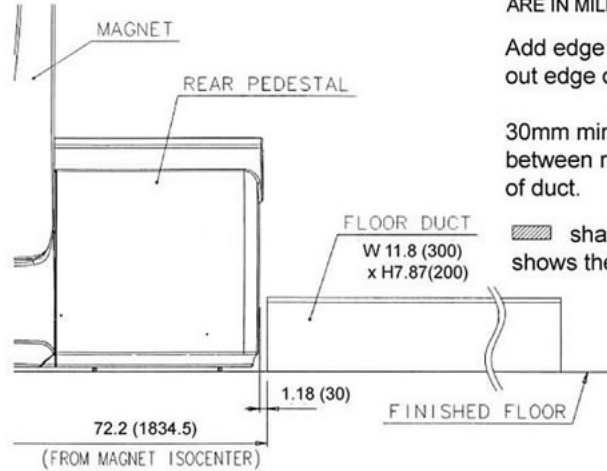
### NOTE

ALL DIMENSIONS ARE IN INCH  
ALL BRACKETTED ( ) DIMENSIONS  
ARE IN MILLIMETERS

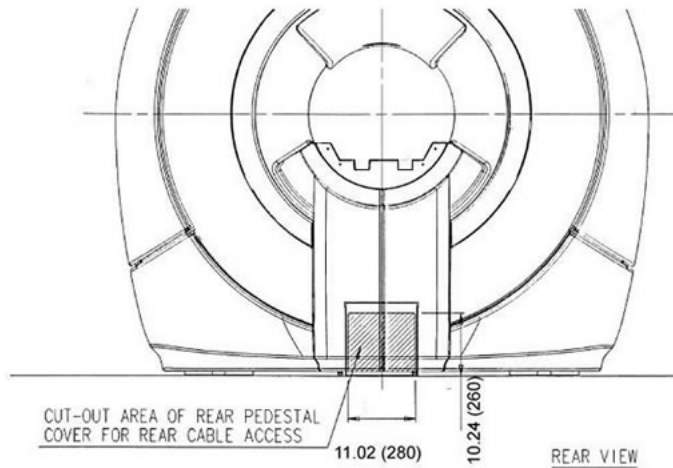
Add edge guards or tapes to the cutted  
out edge of rear pedestal covers.

30mm minimum clearance is required  
between rear pedestal and surface  
of duct.

shaded area of rear pedestal  
shows the cut out area.



Side View

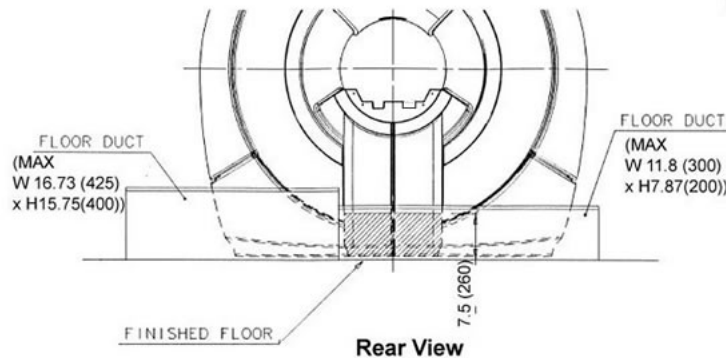


Rear View

## Illustration 2-8: Limitation of Duct size for minimum Room layout

### Limitation of Duct Size for Minimum Room Layout:

The following drawing shows the limitation of Duct size.  
Do not exceed the following specification.  
Otherwise, it will affect for servicing(replacement or maintenance).



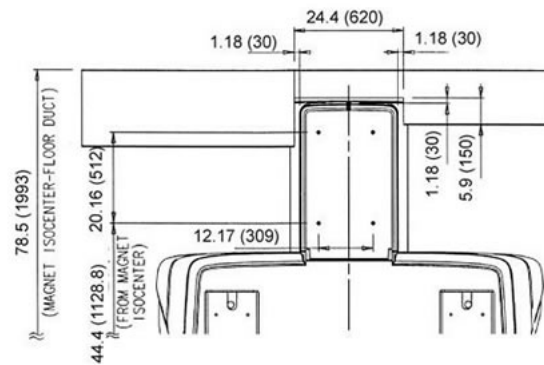
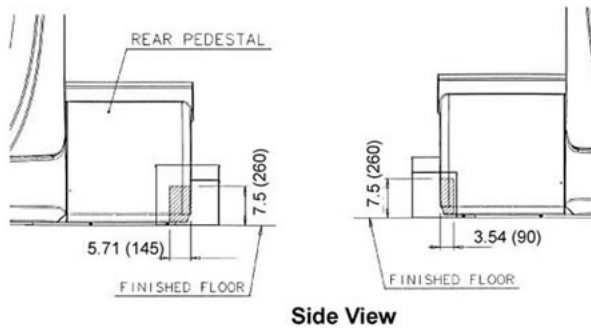
#### NOTE

ALL DIMENSIONS ARE IN INCH  
ALL BRACKETTED ( ) DIMENSIONS  
ARE IN MILLIMETERS

Add edge guards or tapes to the cutted  
out edge of rear pedestal covers.

30mm minimum clearance is required  
between rear pedestal and surface  
of duct (for all covers).

shaded area of rear pedestal  
shows the cut out area.

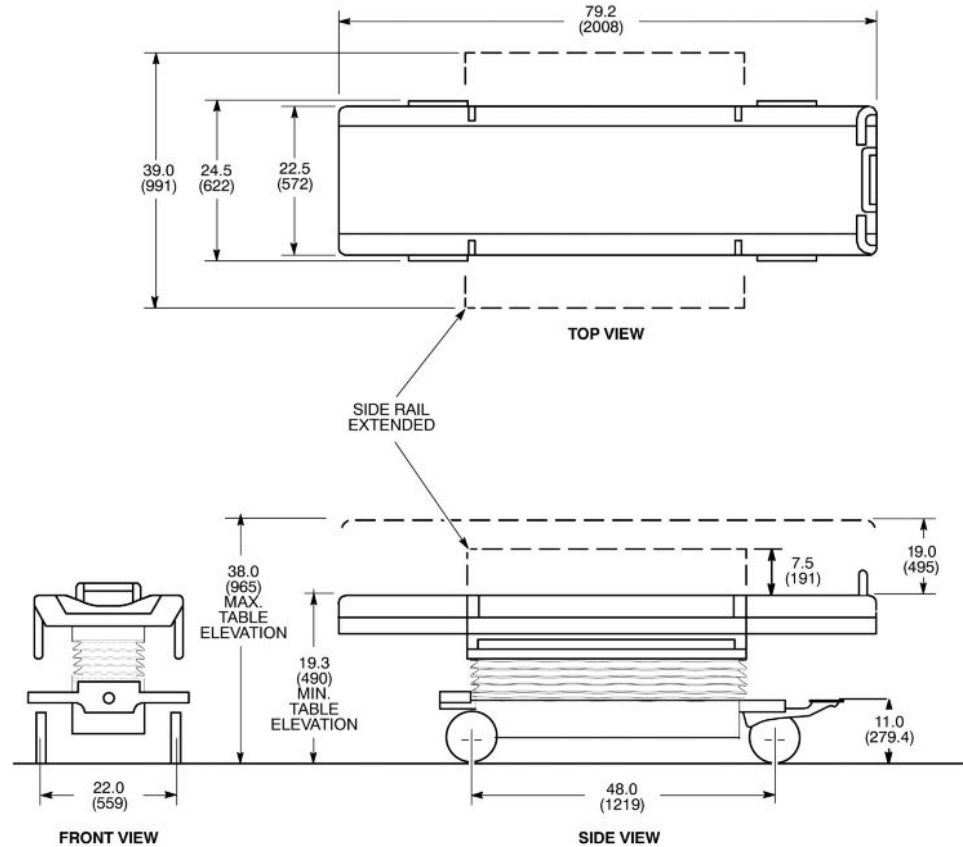


### 1.3.2 Patient Transport Table

NOTE: \*: Detachable Patient Transport Table is selectable in Asia Pole.

Illustration 2-9: Patient Transport Table (Lite Table) for Asia\*

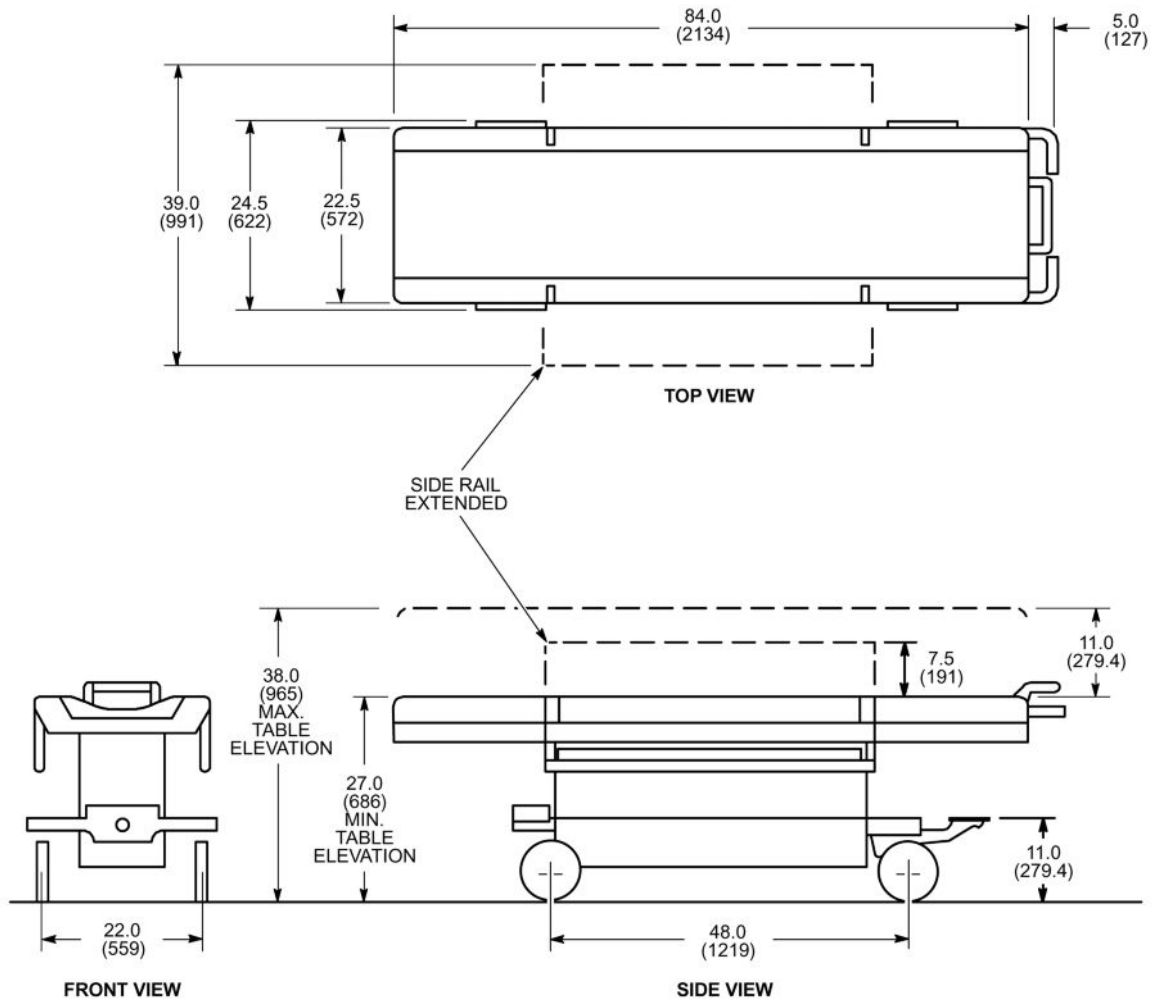
NOTE:  
ALL DIMENSIONS ARE IN INCHES.  
ALL BRACKETED ( ) DIMENSIONS  
ARE IN MILLIMETERS.  
WEIGHT: 330 lbs (150 kg)



**Illustration 2-10: Patient Transport Table for Americas, Europe, and Asia\***

**NOTE:**

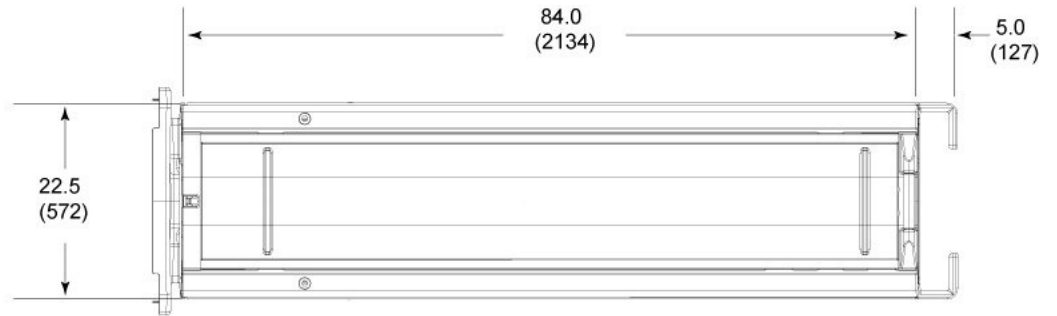
- ALL DIMENSIONS ARE IN INCHES  
ALL BRACKETED ( ) DIMENSIONS  
ARE IN MILLIMETERS.
- APPROX. WEIGHT: 280 lbs (127 kg)  
630 lbs (286 kg) WITH 350 lbs (159 kg)  
PATIENT



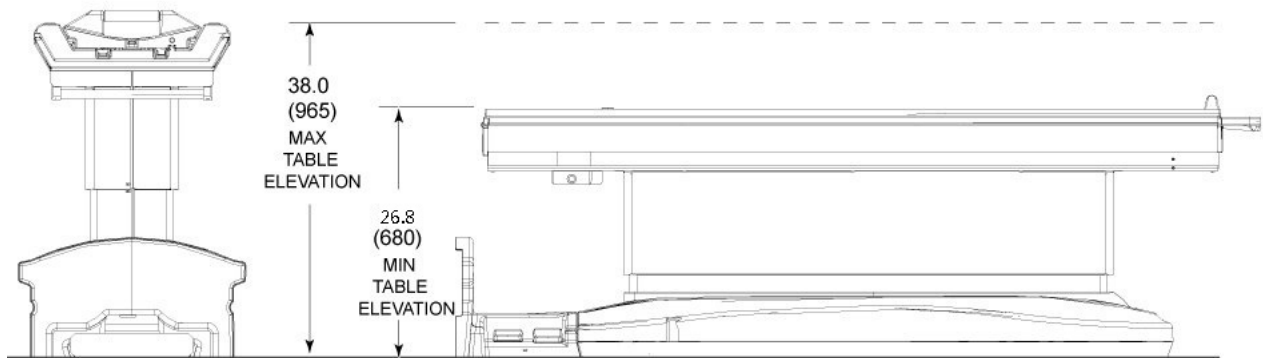
**Illustration 2-11: Fixed Table**

**NOTE**

- ALL DIMENSIONS ARE IN INCHES.  
ALL BRACKETED ( ) DIMENSIONS  
ARE IN MILLIMETERS.
- APPROX. WEIGHT: 265 lbs (120 kg)



**TOP VIEW**



**FRONT VIEW**

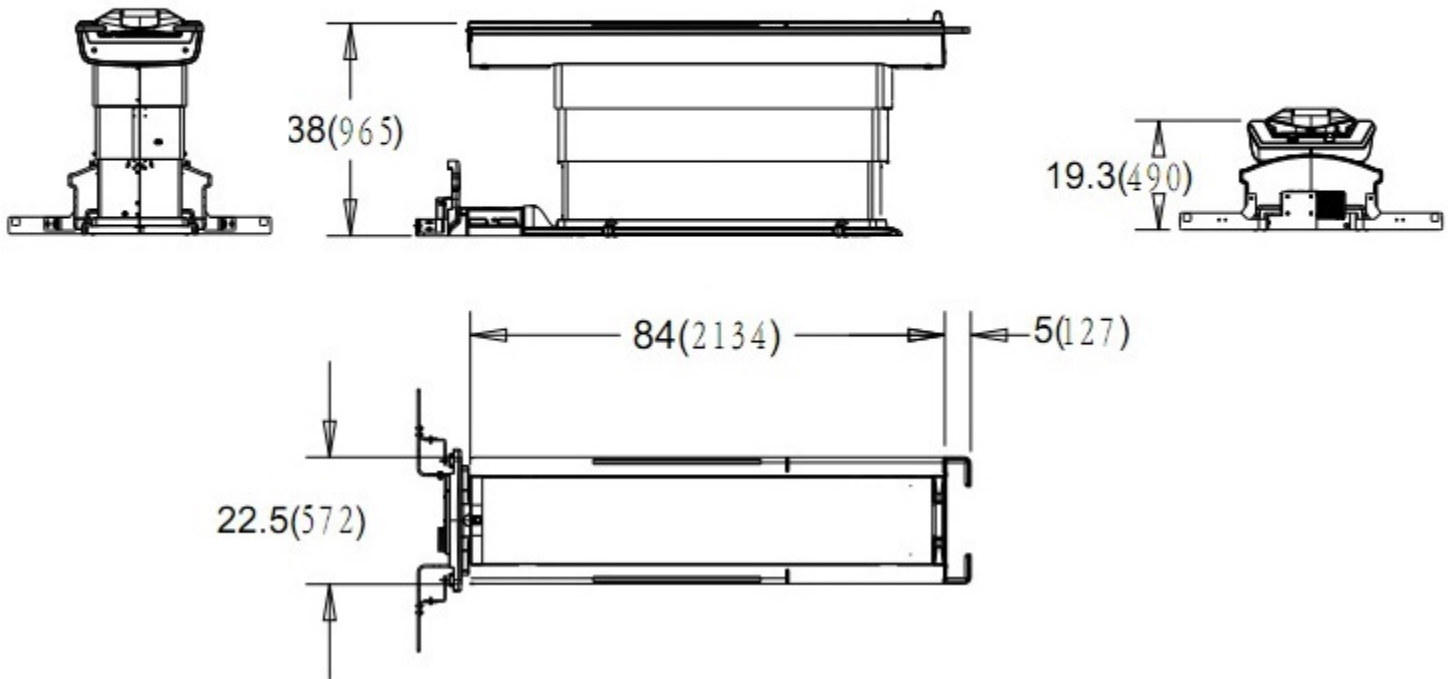
**SIDE VIEW**

Illustration 2-12: Low Height Fixed Table

**NOTE:**

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

WEIGHT: 300 lbs(136 kg)





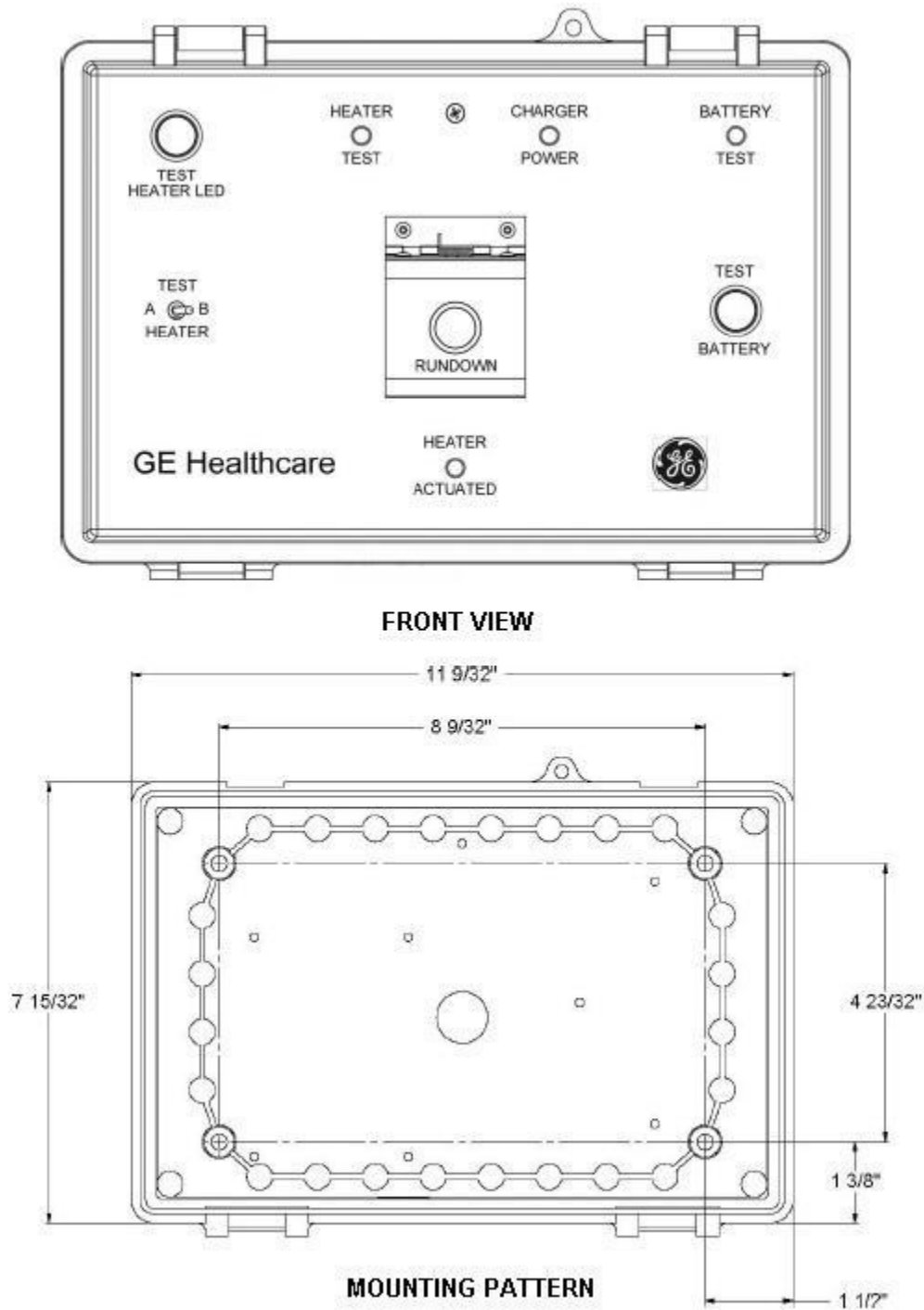
### 1.3.3 Magnet Rundown Unit

1. Location: The bottom edge of the MRU must be mounted 60 in. (1524 mm) above the Magnet room floor near the front of the magnet enclosure
2. Weight: 7 lbs (3.2 kg)
3. Magnetic field limit: 200 gauss (20 mT)
4. The MRU is installed by the facility contractor
5. The MRU requires the following facility supplied power:

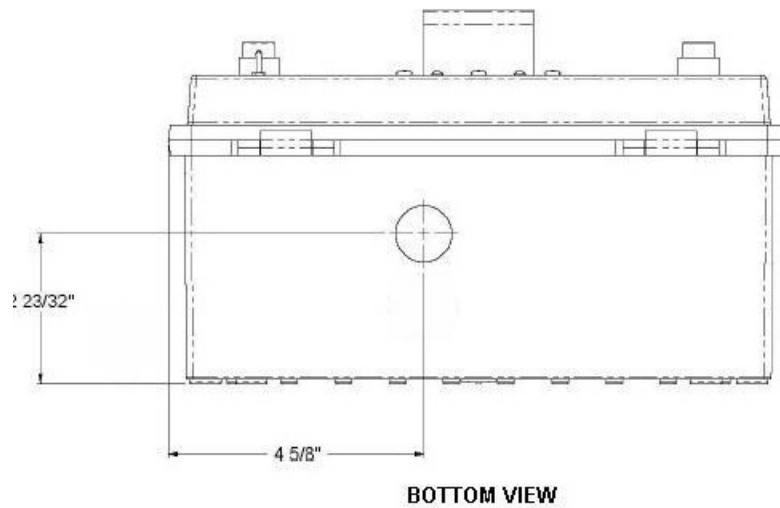
**Table 2-2:**

| Parameter           | Requirements                             |          |
|---------------------|------------------------------------------|----------|
| Voltage / Frequency | 100-120 VAC                              | 50/60 Hz |
|                     | 200-220 VAC                              | 50/60 Hz |
| Phase               | 1                                        |          |
| Maximum Amps        | 1.0                                      |          |
| Connection type     | Hard wired in unit and at facility power |          |
| Availability        | Continuous                               |          |

Illustration 2-13: Front View and Mounting Pattern



**Illustration 2-14: Bottom View**



**NOTE:**  
1. ALL DIMENSION  
ARE IN INCHES  
2. ALL DIMENSIONS  
BRACKETED ( ) ARE IN  
MILLIMETERS  
3. APPROX. WEIGHT 6  
lbs (2.7kg)

#### 1.3.4 Blower Box



#### 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 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. Therefore 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.

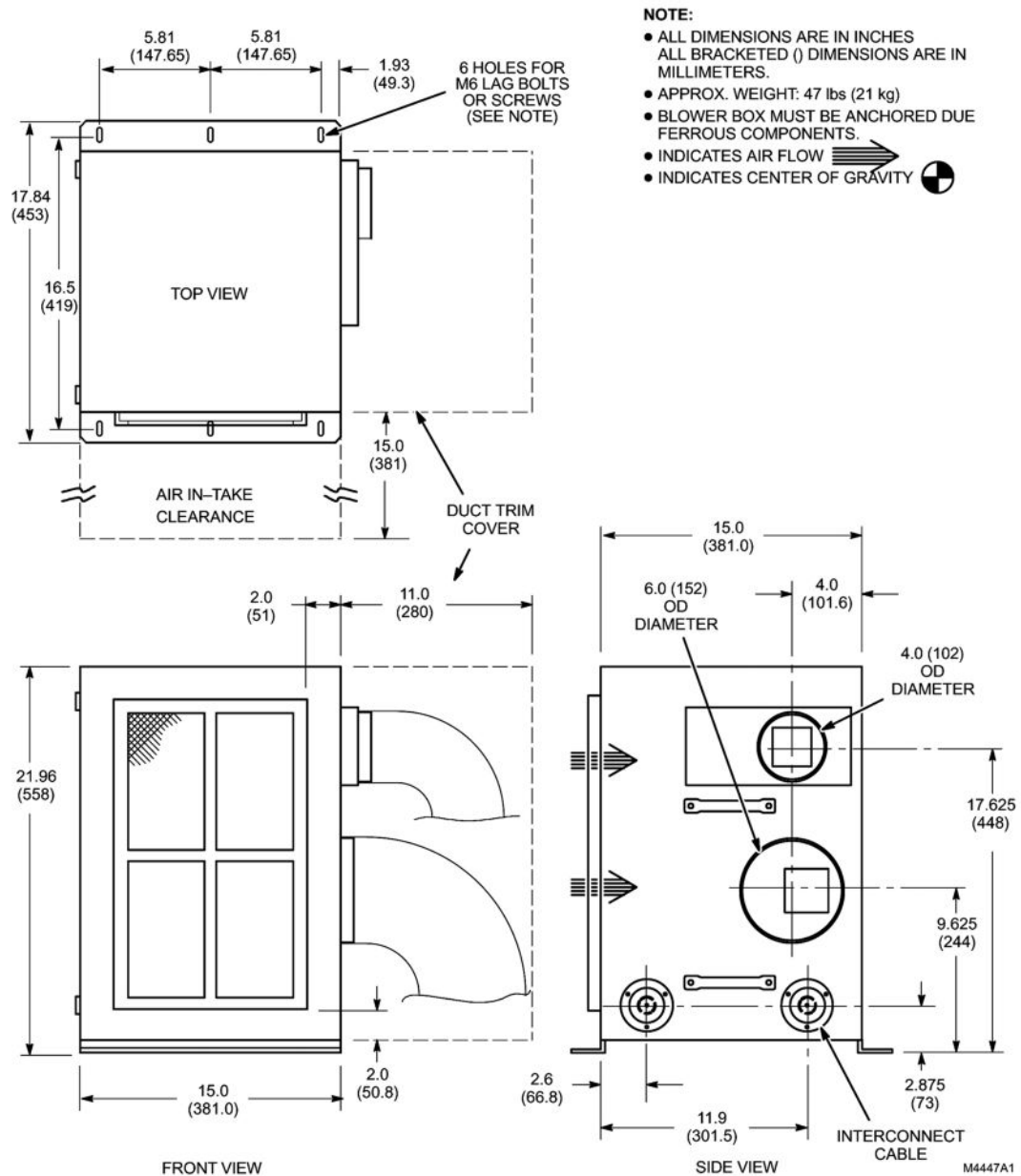
**NOTE:** Blower Box mounting requires customer supplied hardware (ie. lag bolts, screws, etc.) appropriate for the surface on which the box will be mounted.

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 [Illustration 2-15](#),

Weight: 47lbs (21kg)

Magnetic Field Limit: 200 Gauss (20 mT)

Illustration 2-15: Blower Box (MG6)



## 1.4 Equipment Room Equipment Specification

### 1.4.1 System Cabinet

Weight: 1960lbs (890kg)

Magnetic Field Limit: 50 gauss (5mT) (Penetration Panel (Back Panel) side)

Contact Area: 2461.76 mm<sup>2</sup> for each adjuster. Totally there are 6 adjuster as showing in [Illustration 2-16](#).

**Illustration 2-16: System Cabinet Floor Support**

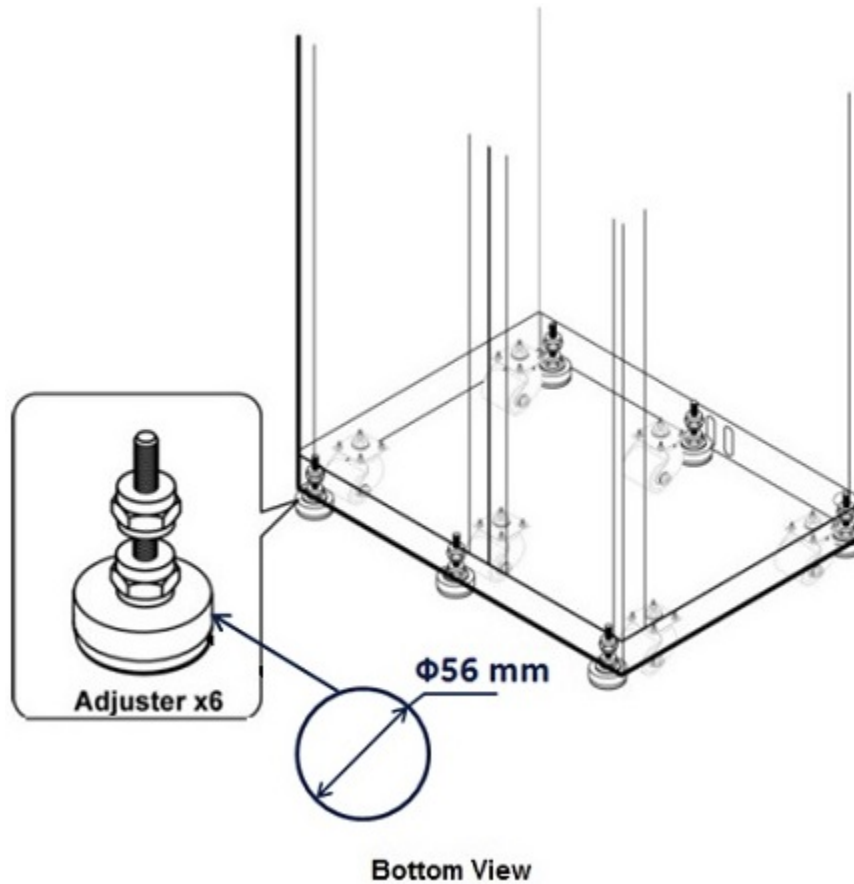


Illustration 2-17: System Cabinet

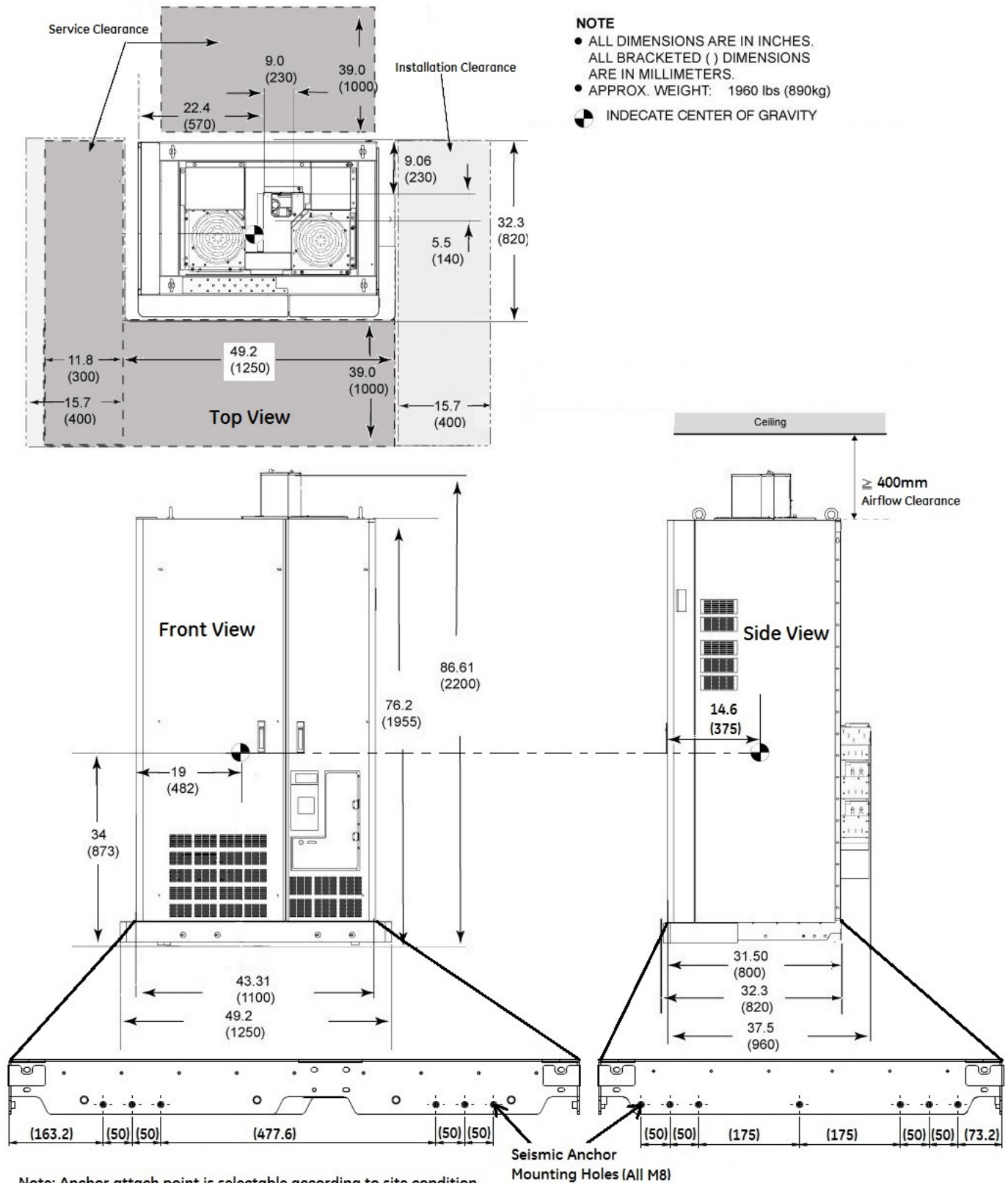


Illustration 2-18 shows the area that must be leveled.

**Illustration 2-18: Area to be leveled**

**NOTE:** Shaded area must be leveled.

**Specification of Floor**

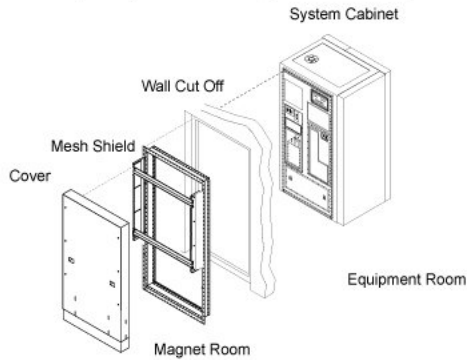
1. Floor slope:  $< \pm 0.5$  deg
2. Floor surface:  $< \pm 5$ mm
3. Non-compressible flooring material only, for example, no carpet allowed.



## 1.4.2 Mesh Shield and System Cabinet Cover

**Illustration 2-19: Mesh Shield and System Cabinet Cover**

Relationship of System Cabinet, RF shield wall, Mesh Shield, and cover.



**NOTE**

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

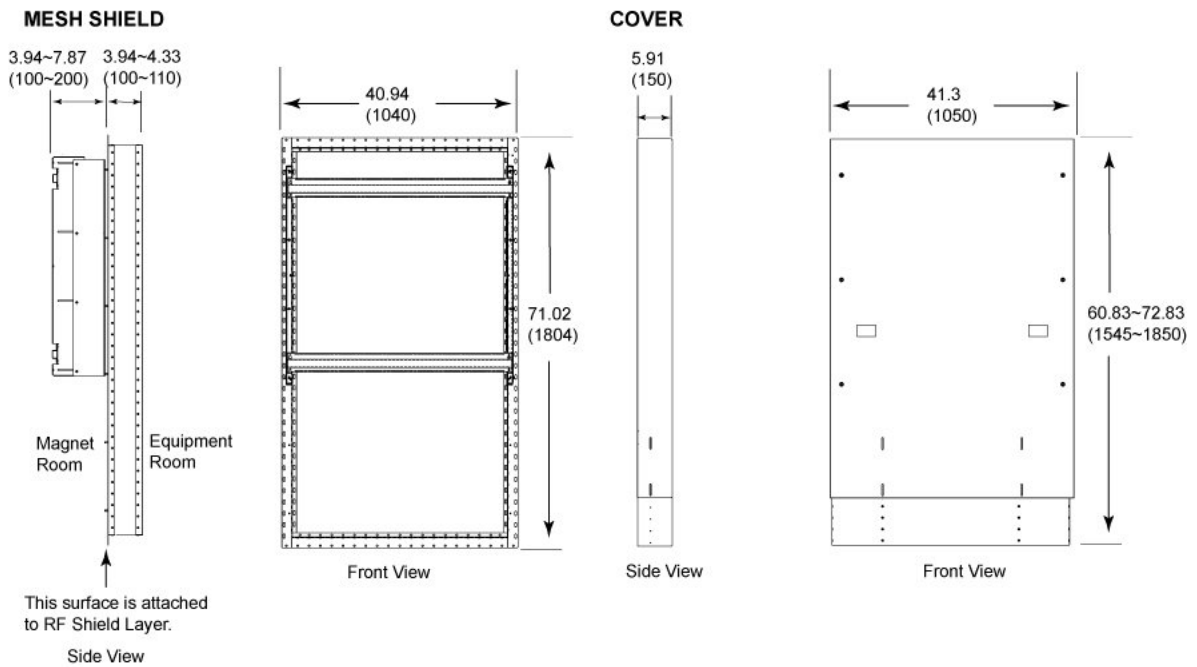
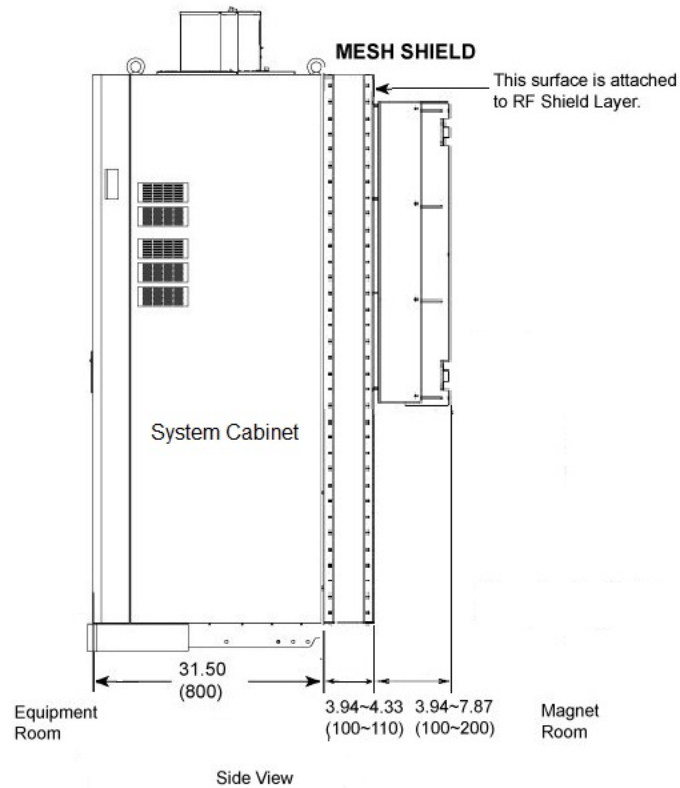


Illustration 2-20 shows the dimensions that mesh shield installed together with System Cabinet.

**Illustration 2-20: Mesh shield with System Cabinet Dimensions**

**NOTE**

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



### 1.4.3 Main Disconnect Panel

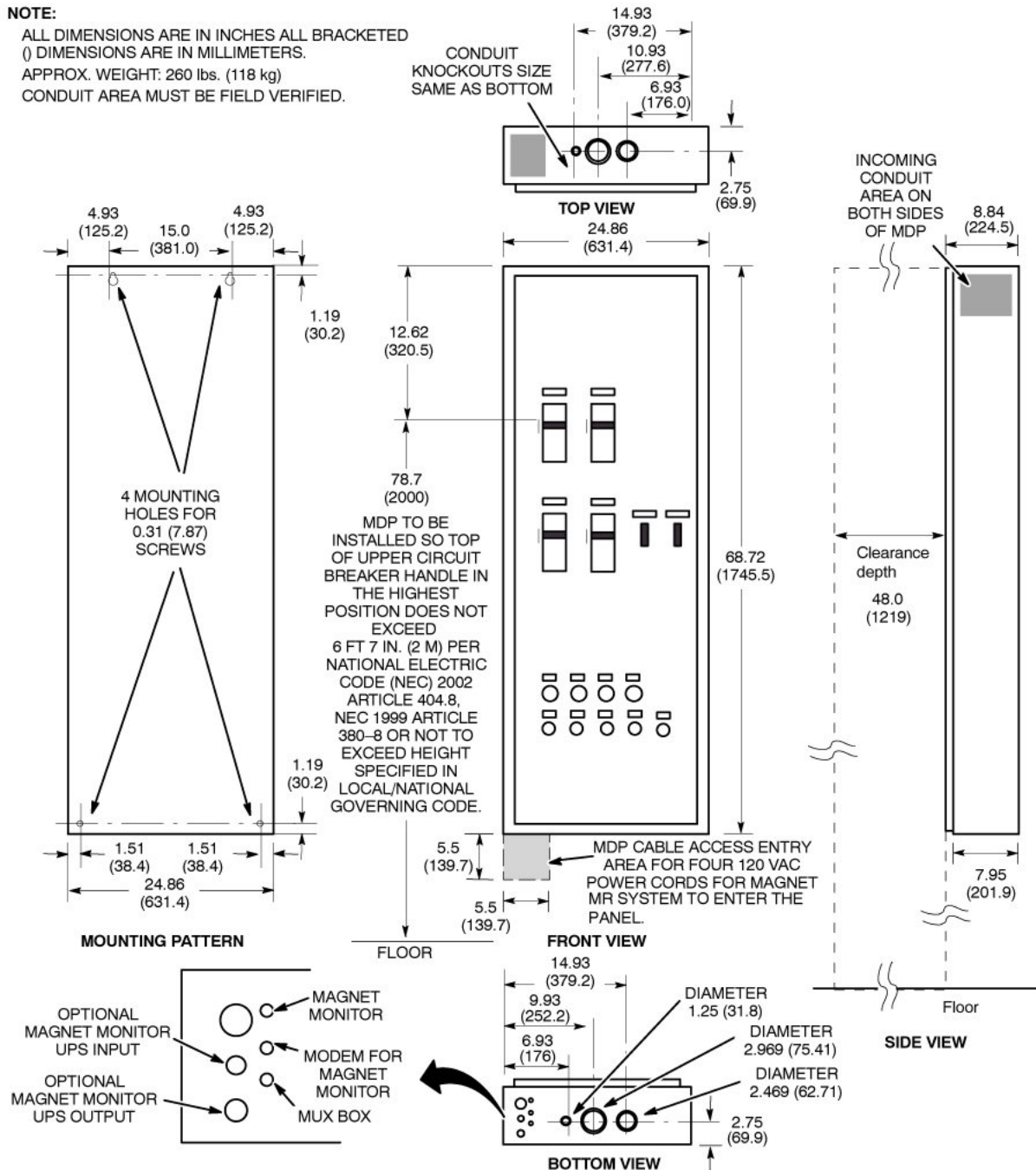
Weight: 350 lbs(158 Kg)

Magnetic Field Limit: 50 gauss (5mT)

Illustration 2-21: Main Disconnect Panel (MDP) M3088TM Option

**NOTE:**

ALL DIMENSIONS ARE IN INCHES ALL BRACKETED  
( ) DIMENSIONS ARE IN MILLIMETERS.  
APPROX. WEIGHT: 260 lbs. (118 kg)  
CONDUIT AREA MUST BE FIELD VERIFIED.



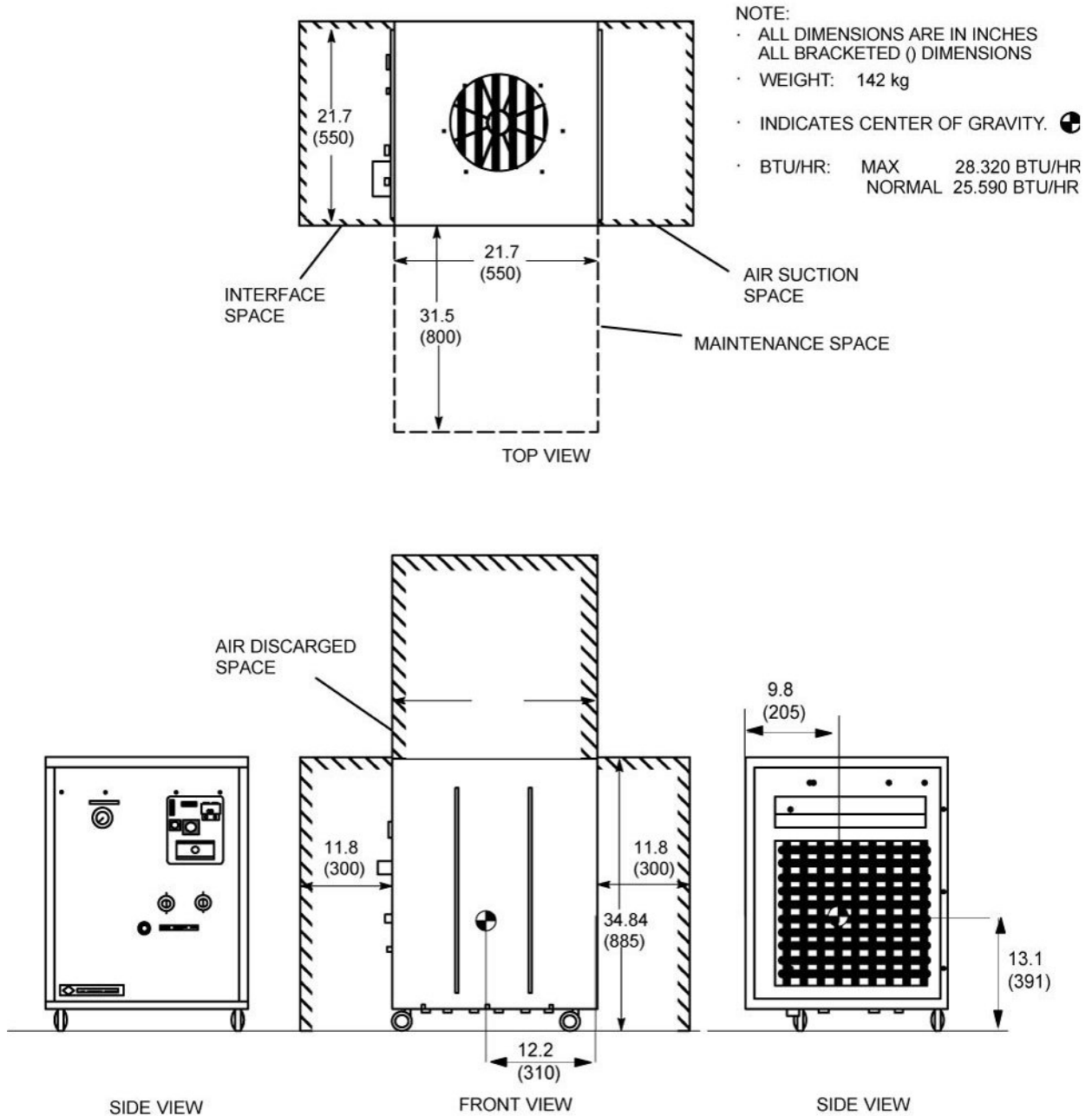


#### 1.4.5 Shield/Cryo Cooler Compressor (Air Cooled) for 200V Site

Weight: 313 lbs(142 Kg)

Magnetic Field Limit: 100 Gauss(10 mT)

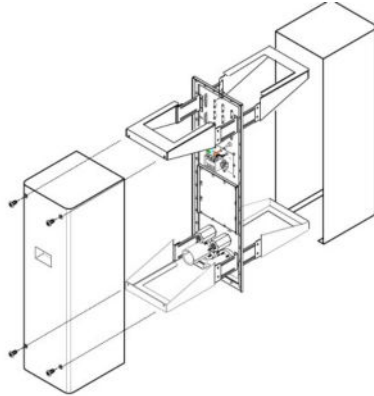
Illustration 2-23: CSA-71A COMPRESSOR UNIT for 200V Site Only



## 1.4.6 Penetration Panel

Magnetic Field Limit: 200 gauss (20mT)

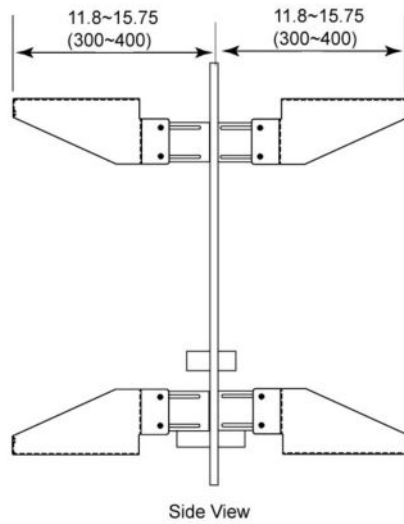
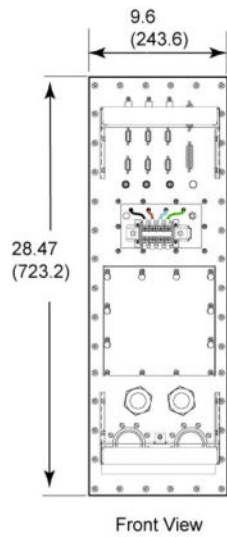
Illustration 2-24: Penetration Panel (PP)



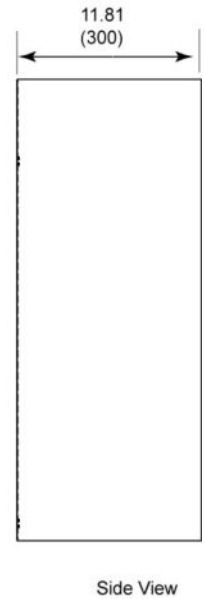
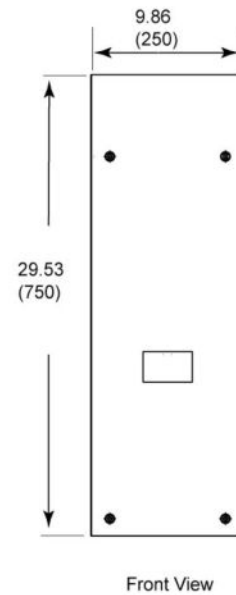
### NOTE

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

Penetration Panel



Cover



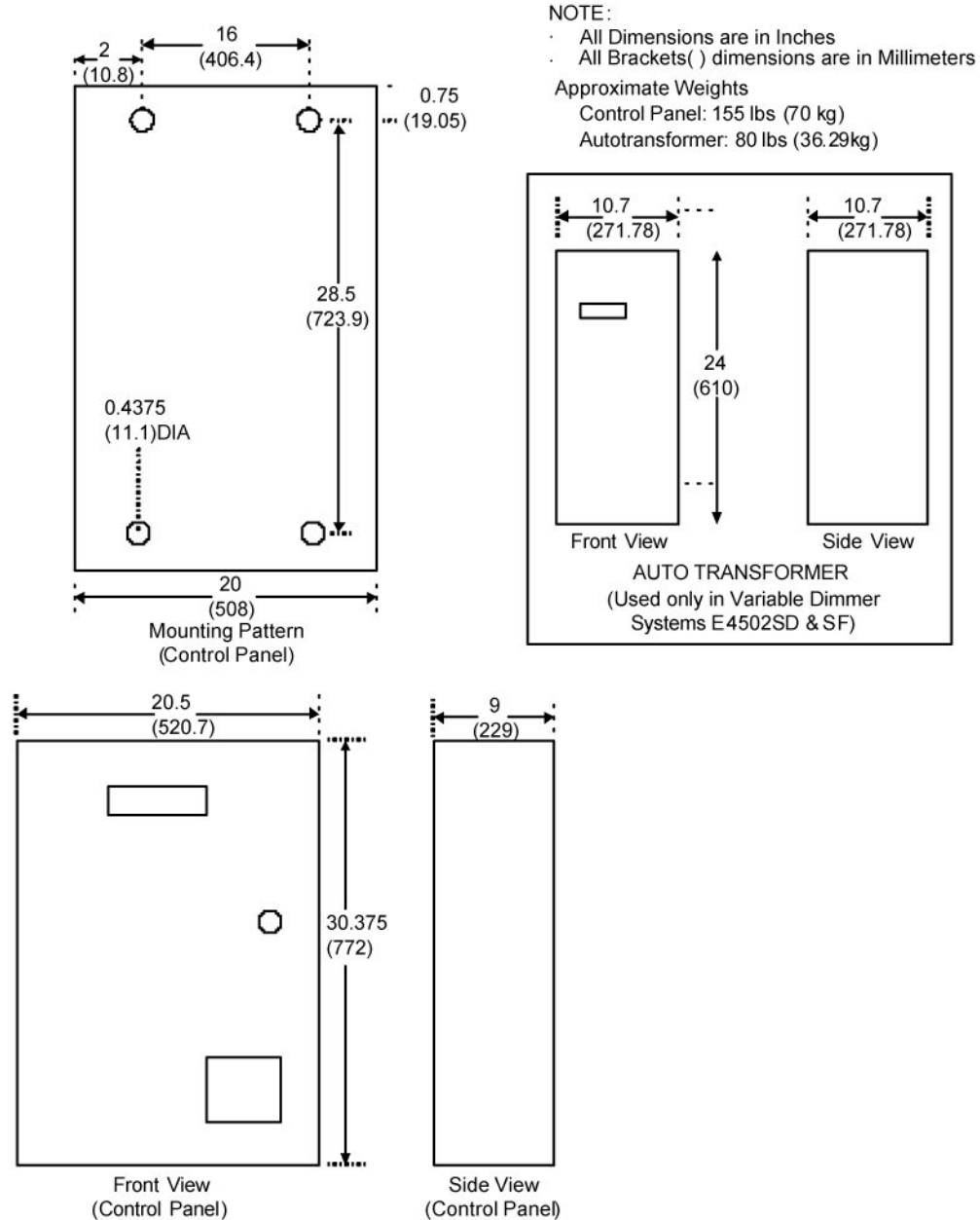
### 1.4.7 DC Lighting Controller Option

Control Panel Weight: 155 lbs(70 Kg)

Autotransformer Weight: 60 lbs(27 Kg)

**Illustration 2-25: DC Lighting Controller Option**

DC Lighting Controller (E4502SC, E4502SD, E4502SE, E4502SC)



#### 1.4.8 4 kW LCS (LCS7594G1) and 8 kW LCS (LCS7593G1)



### NOTICE

Keep 18 inches (457mm) from at least two sides of water chiller for Air flow.

For 8 kW CHILLER:

Weight: 107 lbs (48.5 Kg)

Magnetic Field Limit: 50 gauss (5mT)

For 4 kW CHILLER:

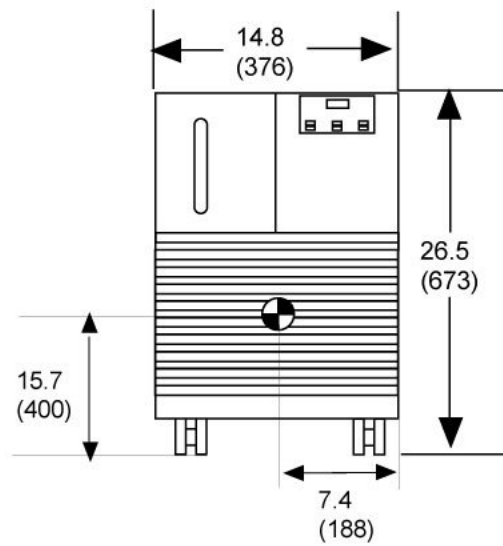
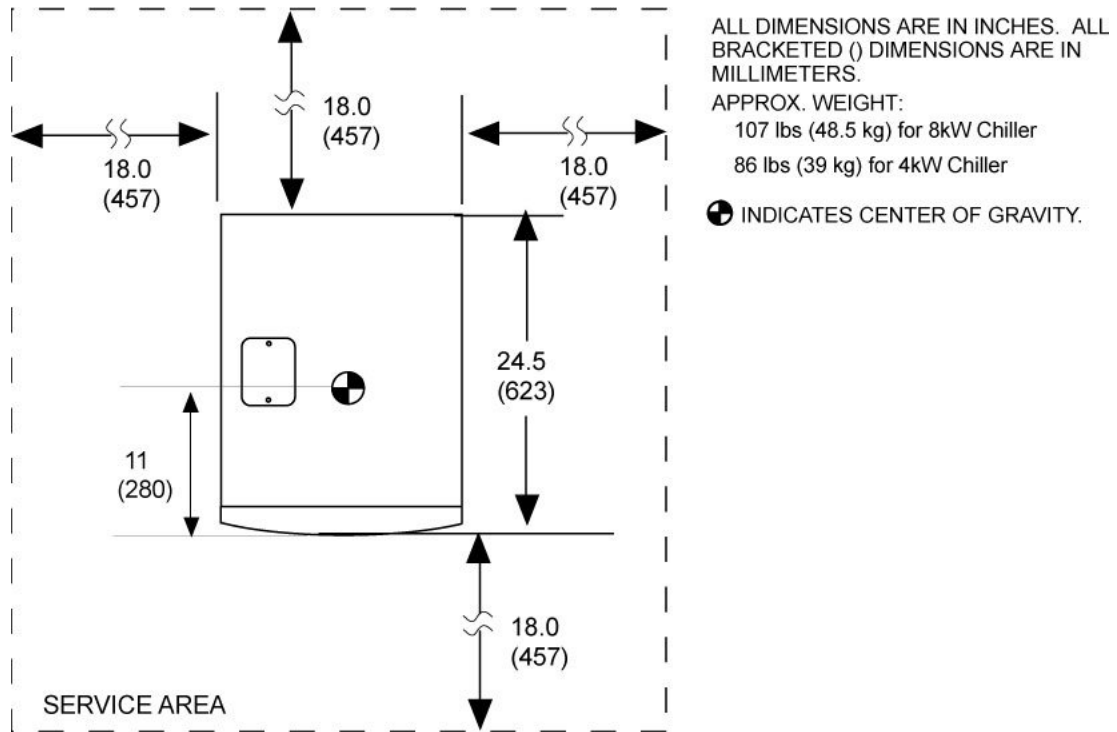
Weight: 86 lbs (39 Kg)

Magnetic Field Limit: 50 gauss (5mT)

**NOTE:** 4 kW and 8 kW chiller are shown in the same illustration because they share same size.



**Illustration 2-26: Water Chiller For System Cabinet**



#### 1.4.9 MCS



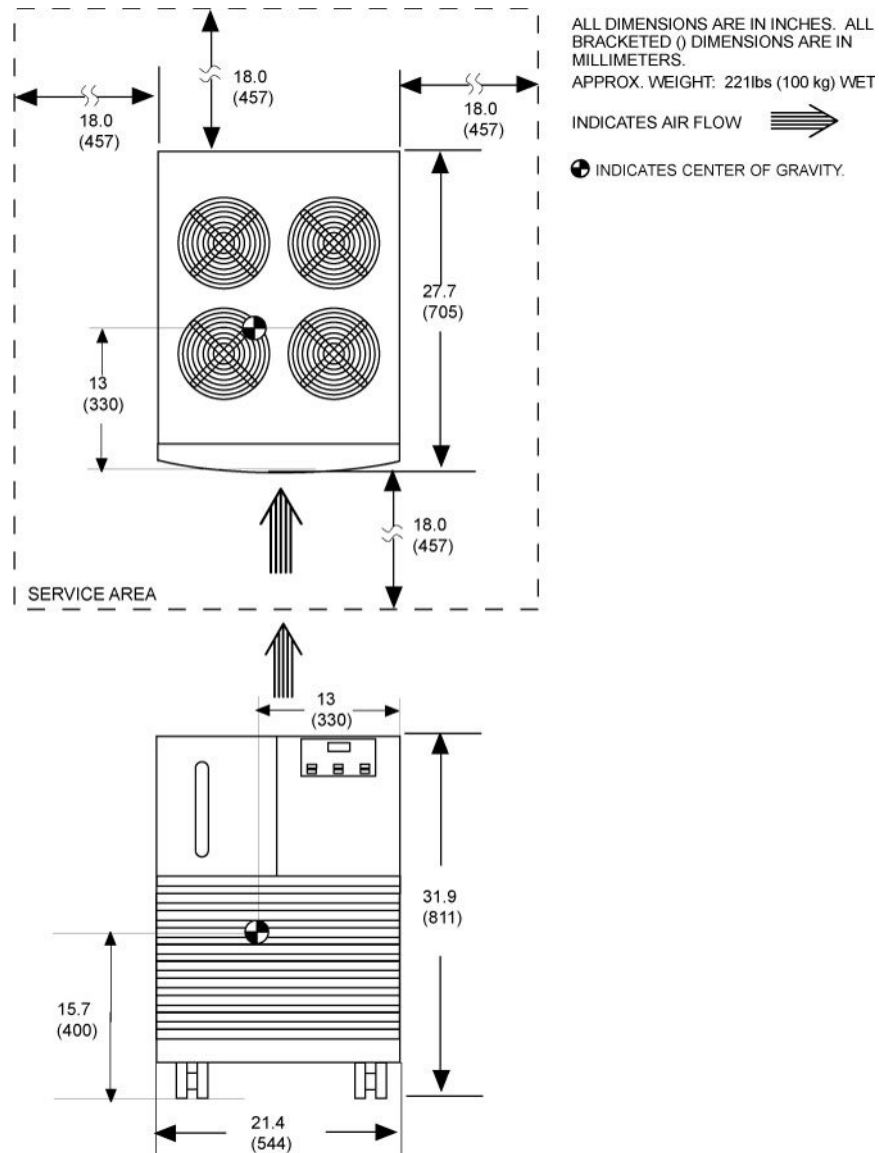
### NOTICE

Keep 18 inches (457mm) from at least two sides of water chiller for Air flow.

Weight: 221 lbs (100 Kg)

Magnetic Field Limit: 50 gauss (5mT)

Illustration 2-27: Water Chiller (WC2) For System Cabinet

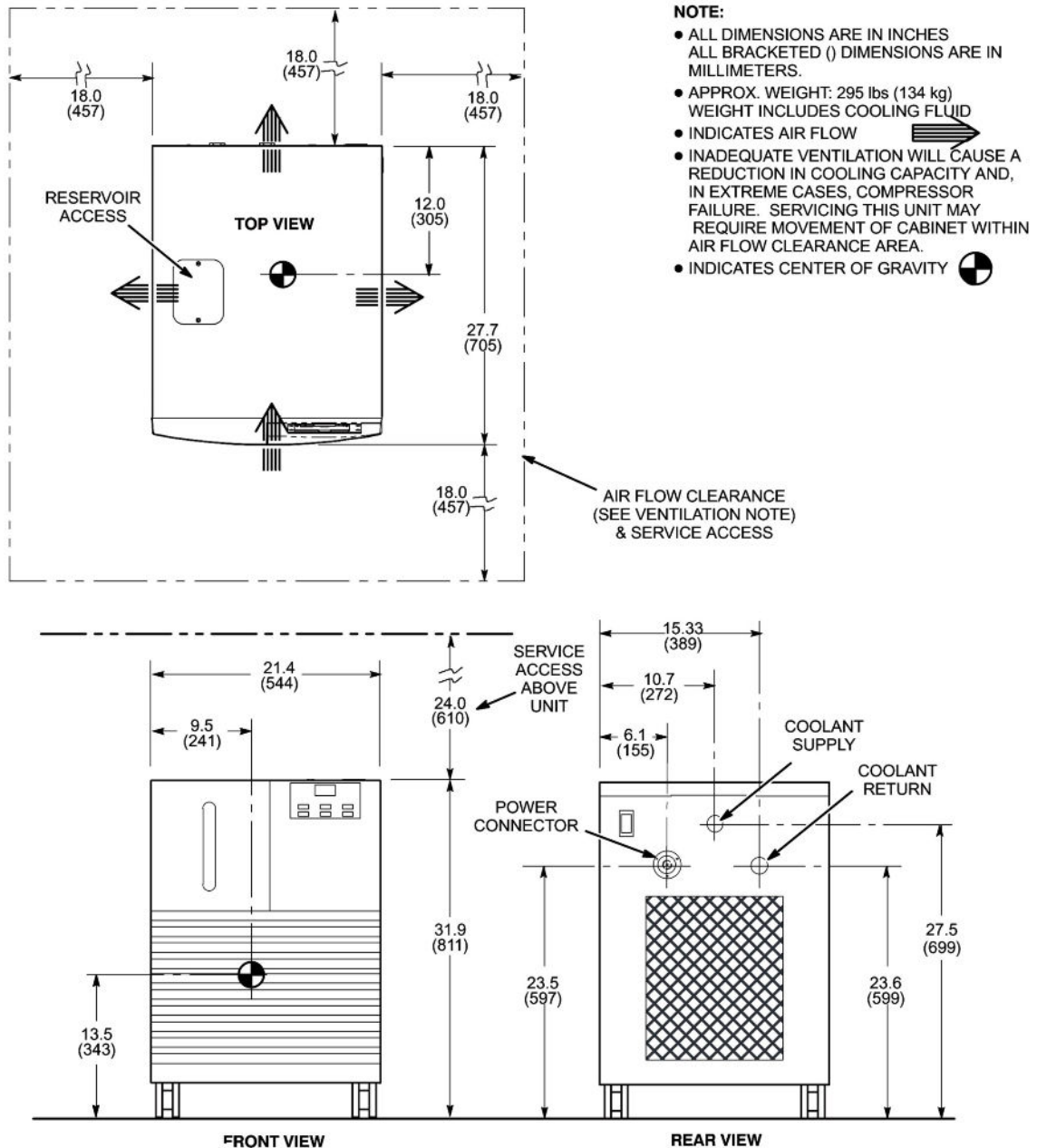


#### 1.4.10 BRM Chiller

Weight: 295 lbs (134 Kg)

Magnetic Field Limit: 50 gauss (5mT)

Illustration 2-28: Water Chiller (WC1) For BRM Gradient Coil Cooling Water



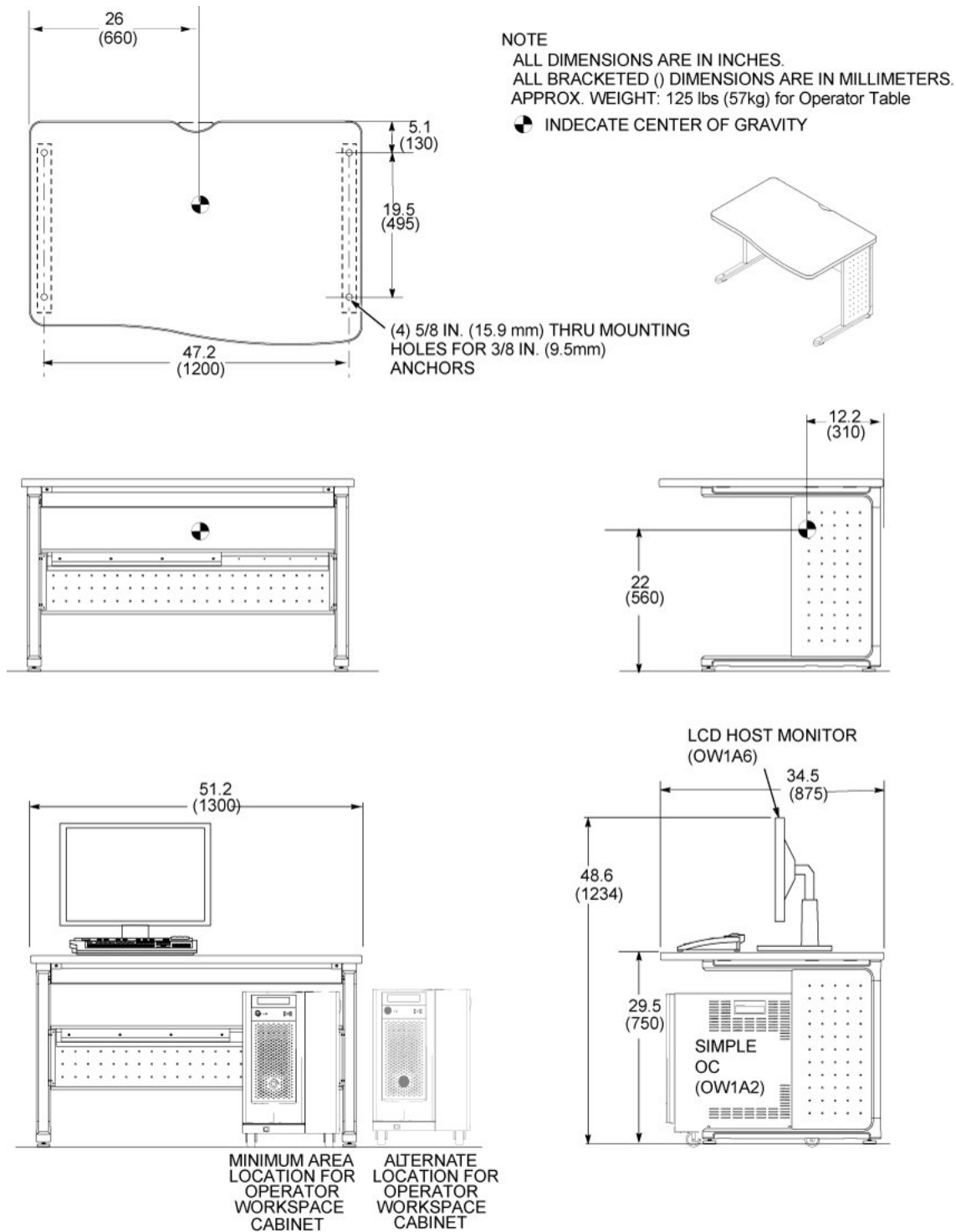
## **1.5 Control Room Equipment Specification**

### **1.5.1 Operator Workspace**

Weight: 125 lbs(57 Kg)

Magnetic Field Limit: 50 gauss (5mT)

Illustration 2-29: Operator Workspace (OW1) Overall Dimensions

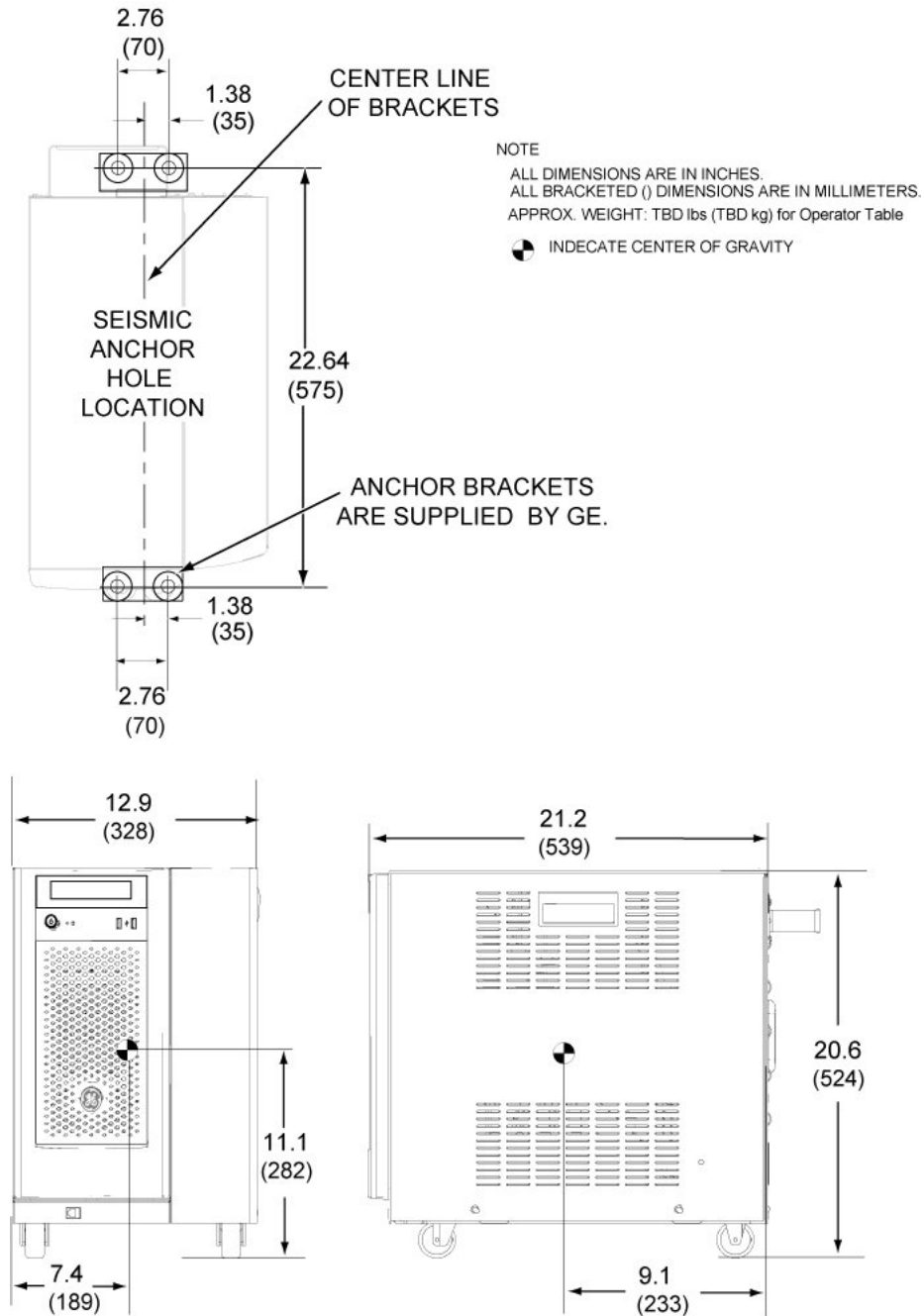


### Simple OC Computer Cabinet

Weight: 84.9 lbs (38.5 Kg).

Magnetic Field Limit: 50 gauss (5mT)

Illustration 2-30: Simple OC Computer Cabinet (OW1 A2)



Weight - with stand: 19.8 lbs (9 Kg).

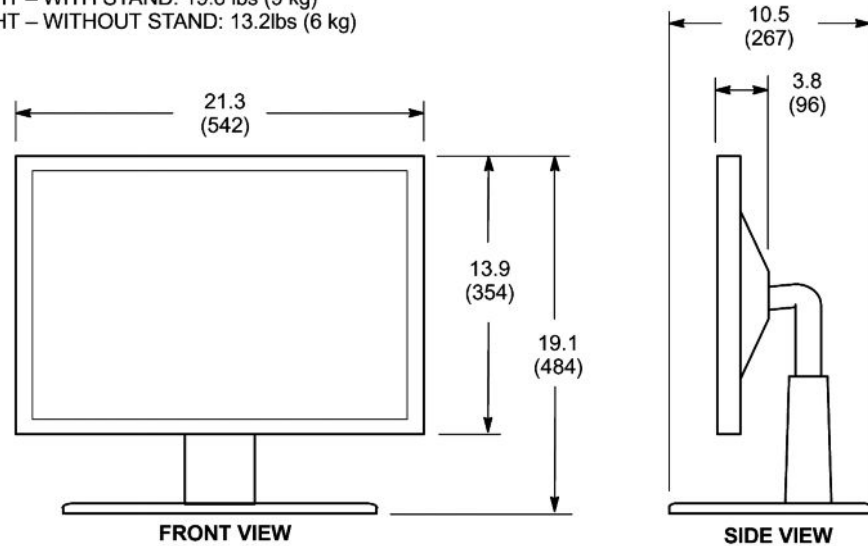
Weight - without stand: 13.2 lbs (6 Kg).

Magnetic Field Limit: 50 gauss (5mT)

**Illustration 2-31: Operator Workspace Components Position on Table Top - Host LCD**

**NOTE:**

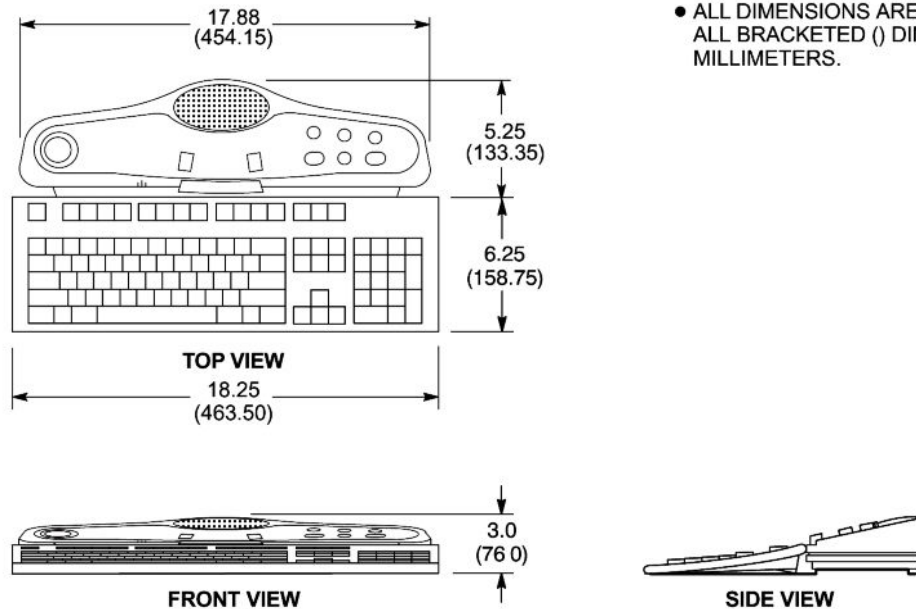
- ALL DIMENSIONS ARE IN INCHES  
ALL BRACKETED ( ) DIMENSIONS ARE IN MILLIMETERS.
- APPROX. WEIGHT – WITH STAND: 19.8 lbs (9 kg)  
APPROX. WEIGHT – WITHOUT STAND: 13.2lbs (6 kg)



**Illustration 2-32: Operator Workspace Components Position on Table Top - Keyboard**

**NOTE:**

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

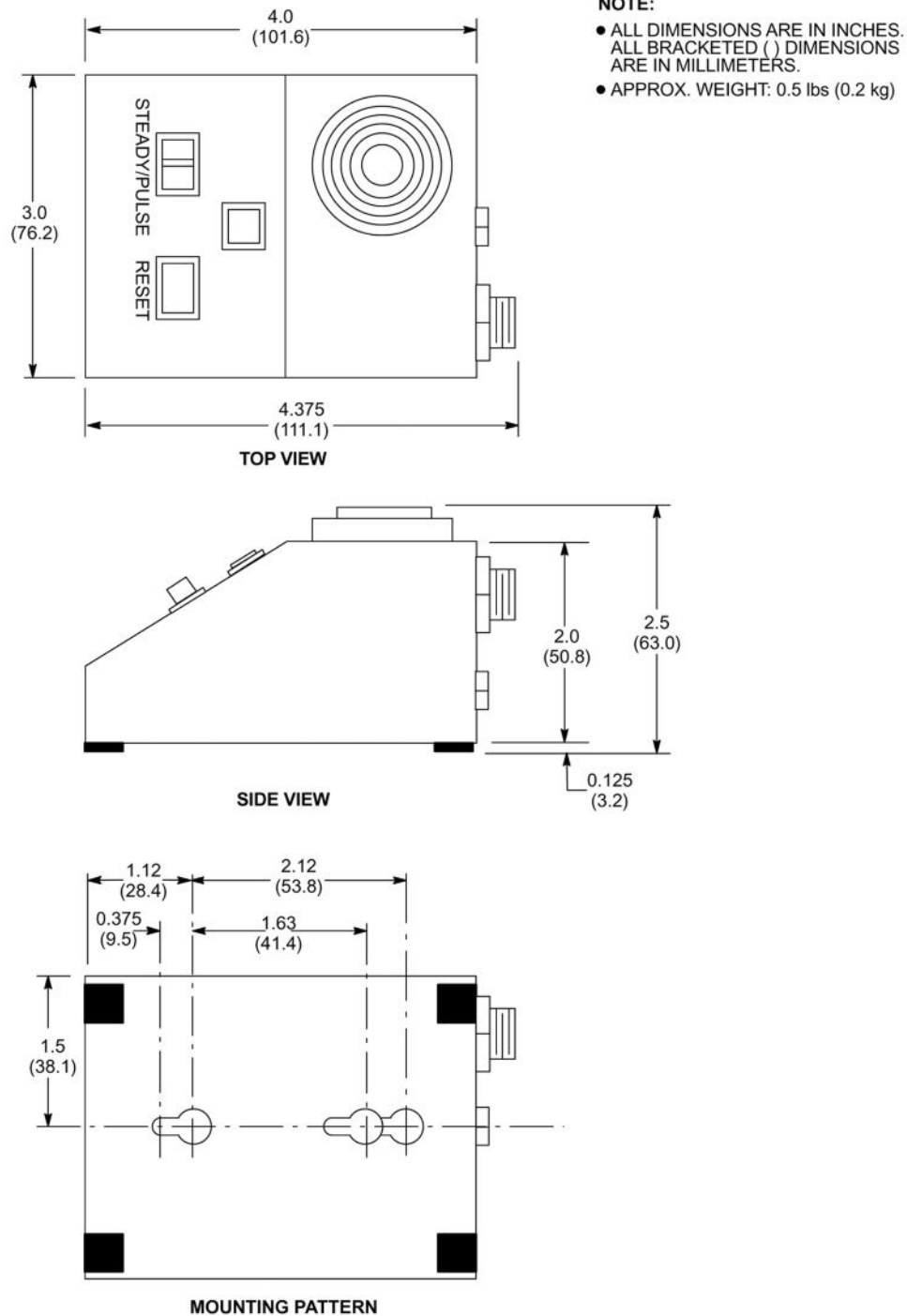


## 1.5.2 Pneumatic Patient Alert

Weight: 0.5 lbs (0.2 Kg).

Magnetic Field Limit: 100 gauss (10mT)

**Illustration 2-33: Pneumatic Patient Alert Control Box (PA1)**





### 1.5.3 Oxygen Monitor Option

Table 2-3: Oxygen Monitor Option List of Illustrations

| Illustration Name                                            | Illustration Number               |
|--------------------------------------------------------------|-----------------------------------|
| Oxygen Monitor (OM1) :<br>Located in Operator Room           | <a href="#">Illustration 2-34</a> |
| Remote Oxygen Sensor Module (OM3):<br>Located in Magnet Room | <a href="#">Illustration 2-35</a> |

Weight: 9 lbs (4.1 Kg)

Magnetic Field Limit: 100 Gauss (10 mT)

Illustration 2-34: Oxygen Monitor (OM1)

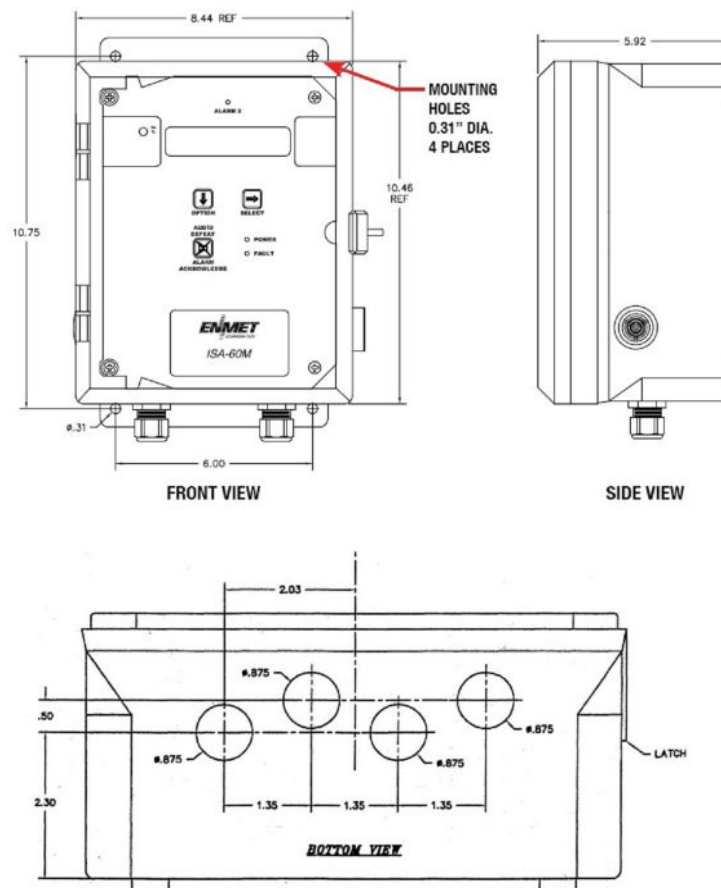
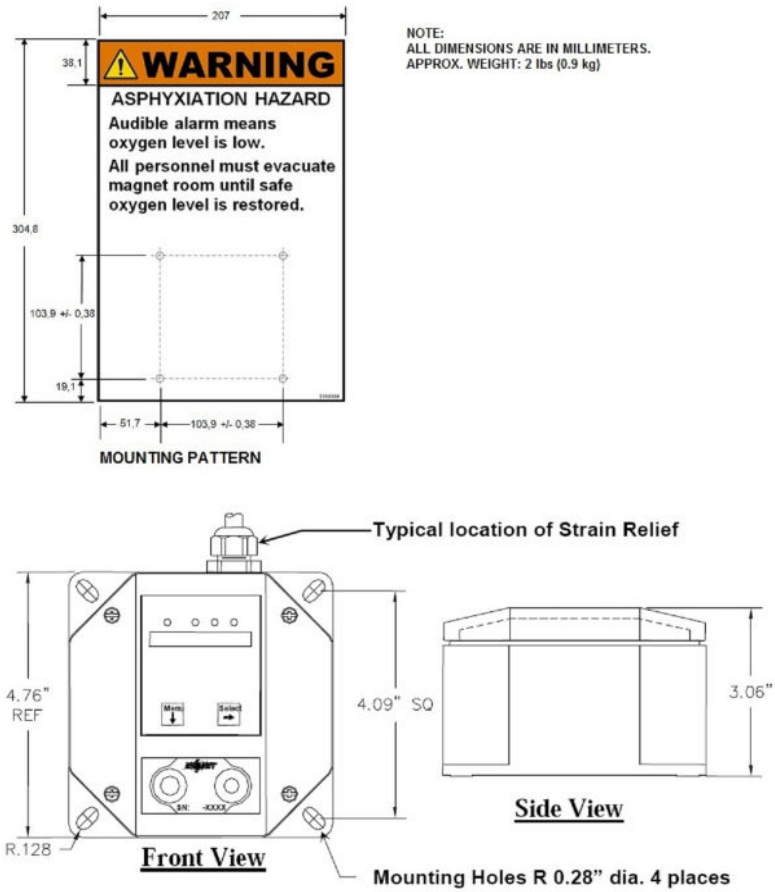


Illustration 2-35: Remote Oxygen Sensor Module (OM3)



## 1.6 Outdoor Equipment Specification

### 1.6.1 11kW Airsys Water Chiller (11kW Chiller) for Type A,C Configuration

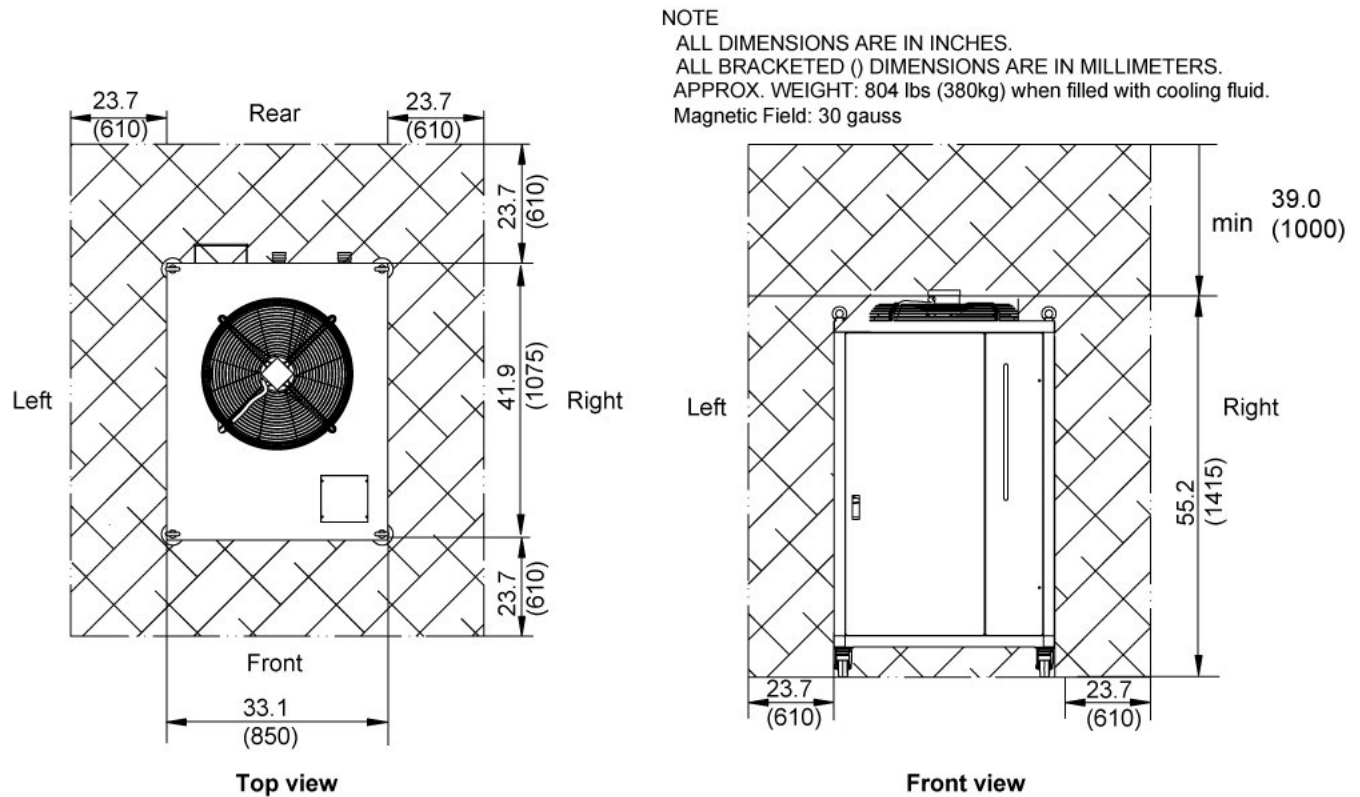
Table 2-4: 11kw Chiller List of Illustrations

| Illustration Name                           | Illustration Number                                                                                           |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| 11kW Chiller                                | <a href="#">Illustration 2-36</a> , <a href="#">Illustration 2-37</a> , and <a href="#">Illustration 2-38</a> |
| 11kW Chiller Outdoor Mounting               | <a href="#">Illustration 2-39</a>                                                                             |
| Remote Control Panel (RCP) For 11kW Chiller | <a href="#">Illustration 2-40</a>                                                                             |

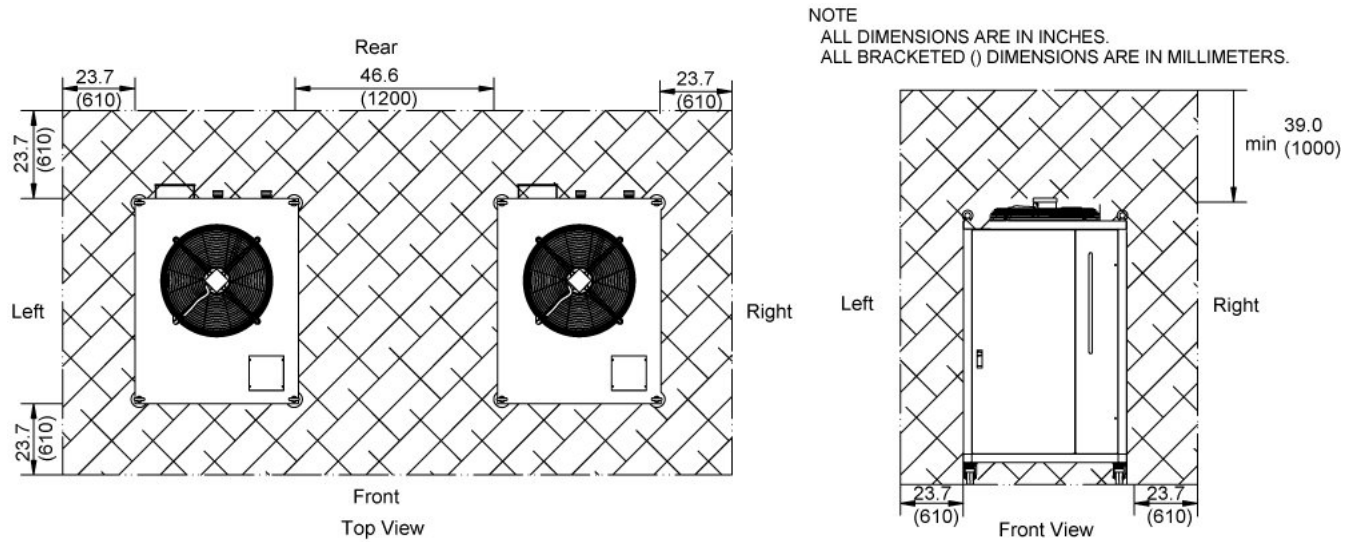
Weight: 804 lbs (360 kg) when filled with cooling fluid

Magnetic field limit: 30 Gauss

Illustration 2-36: 11kW Airsys Water Chiller Dimensions and Service Clearance for single unit



**Illustration 2-37: Service Clearances for two or more units 1 (recommended)**



**Illustration 2-38: Service Clearances for two or more units 2**

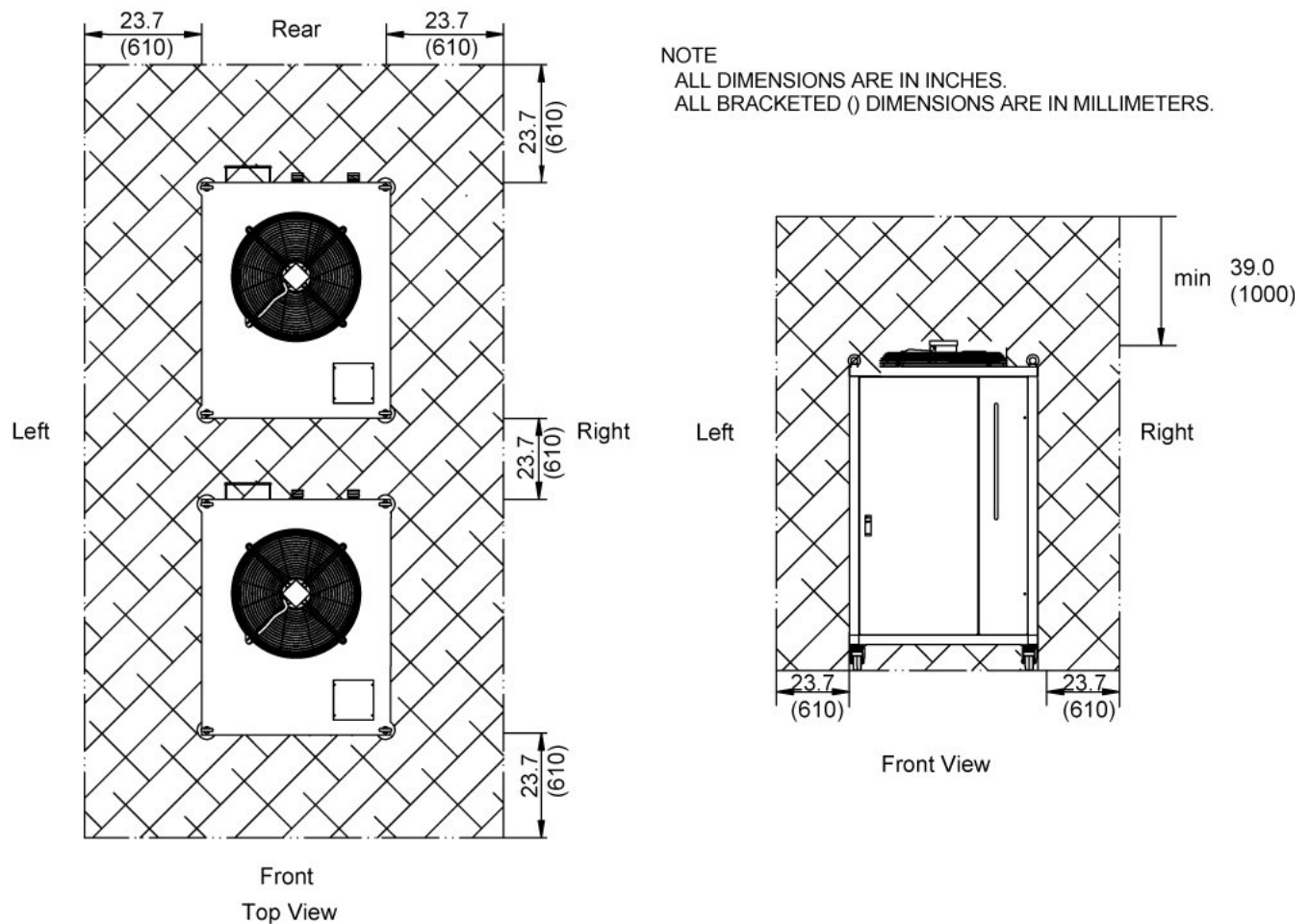


Illustration 2-39: 11kW Chiller Outdoor Mounting

#### GROUND INSTALLATION

Loosen bolts between support brackets and bottom of crate and mount the unit on the concrete pad.

#### Soil requirements below concrete pad:

Soil below concrete pad used for mounting the unit should be a level surface, which is 1/300 cm max allowed and be properly supported to prevent sedimentation. A concrete pad area of 50.0cm (59 in) x66.0cm (26 in) at strength of 17.23MPa (2500 psi) min (4 inches thickness recommended) is needed to place the chiller.

NOTE: The concrete pad should meet or exceed the local code requirements.

#### ROOFTOP INSTALLATION:

Loosen bolts between support brackets and bottom of crate and use the bracket to firmly fix the chiller on a level surface on rooftop, which is 1/300 cm max allowed. Local code should be followed.

NOTE: In case of extremely bad weather, like snowstorm, snow and ice may influence the proper working of the fan. So it is recommended to shelter unit to protect the fan against bad weather.

NOTE: Be careful of the elevation requirements, -3m< height <30m, ensure no circumfluence of coolant to the system.

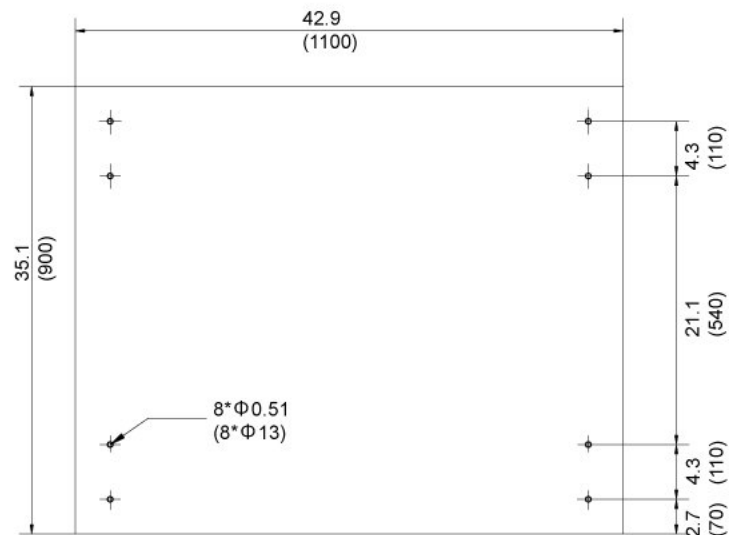
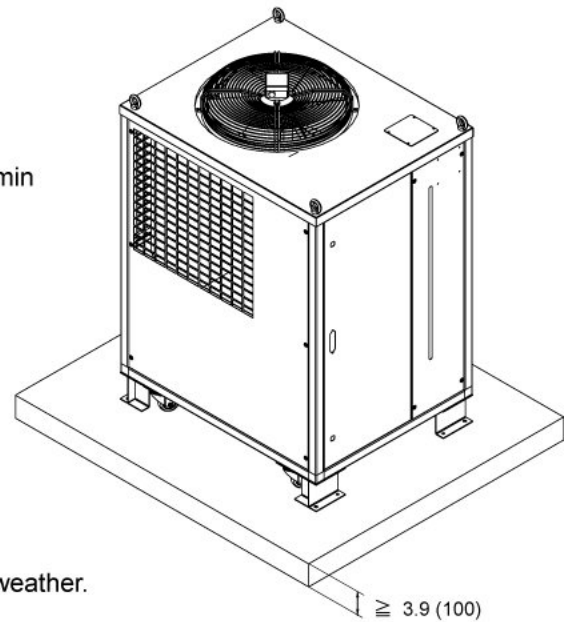
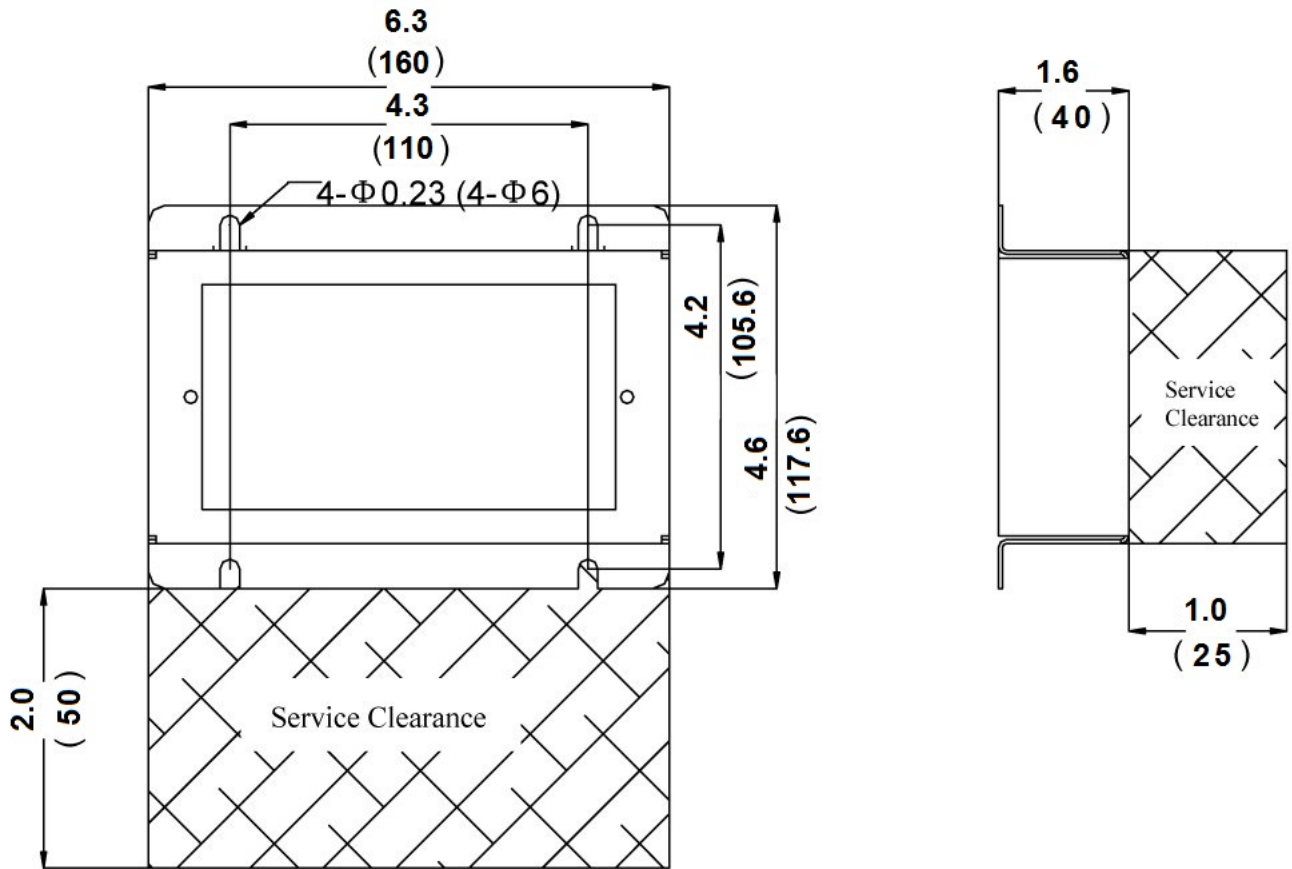


Illustration 2-40: Remote Control Panel (RCP) For 11kW Chiller



## 1.7 MR Touch Specification

### 1.7.1 Magnetic Resonance Elastography (MRE) Specifications

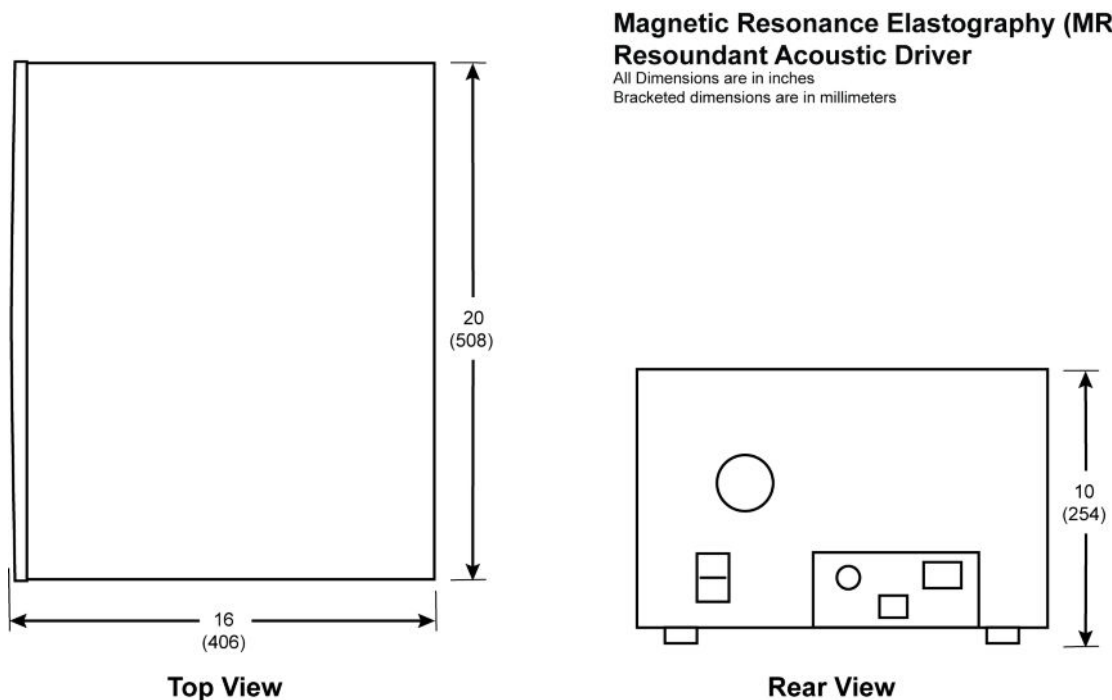
#### 1.7.1.1 Requirements

1. Customer must work with the RF shield vendor to provide a waveguide for the 1 in. (25.4 mm)
2. MRE Resoundant Acoustic Driver location is limited to the length of the 1 in. (25.4 mm) tube (see the usable cable lengths in Magnetic Resonance Elastography (MRE) Option)
3. The MRE Resoundant Acoustic Driver module requires a 110/220 VAC, 50/60 Hz, 2.0 A facility supplied outlet. Power at the outlet must be continuously available

#### 1.7.1.2 Specifications

1. Weight: 53.4 lbs (24.22 kg)
2. Gauss Limit: 50 gauss
3. Power Cord Length:
  - 60 Hz: 240 in. (6096 mm)
  - 50 Hz: 300 in. (7620 mm)

**Illustration 2-41: Magnetic Resonance Elastography (MRE) Resoundant Acoustic Driver**



**NOTE:** Refer to the MRE Service Manual for seismic anchor placement specifications.

The power outlet shall be compatible with either US power cord with round earth pin or Europe power cord with female earth contact.

## 2 Room Layouts

**NOTE:** Customer is responsible for complying with all national, state, or local regulatory requirements for the country in which the installation occurs.

The illustration below shows a typical Equipment room layout.

For Multiple MR Systems Site Layout, please refer to Multiple MR Systems Site

Table 2-5 contains minimum room dimensions necessary for an MR suite and issues which are created by reduction in service access, operator access, and equipment space.

**NOTE:** These values do not include space for cabinetry or storage.

**Table 2-5: System Minimum Room Inside Clear Space Dimensions**

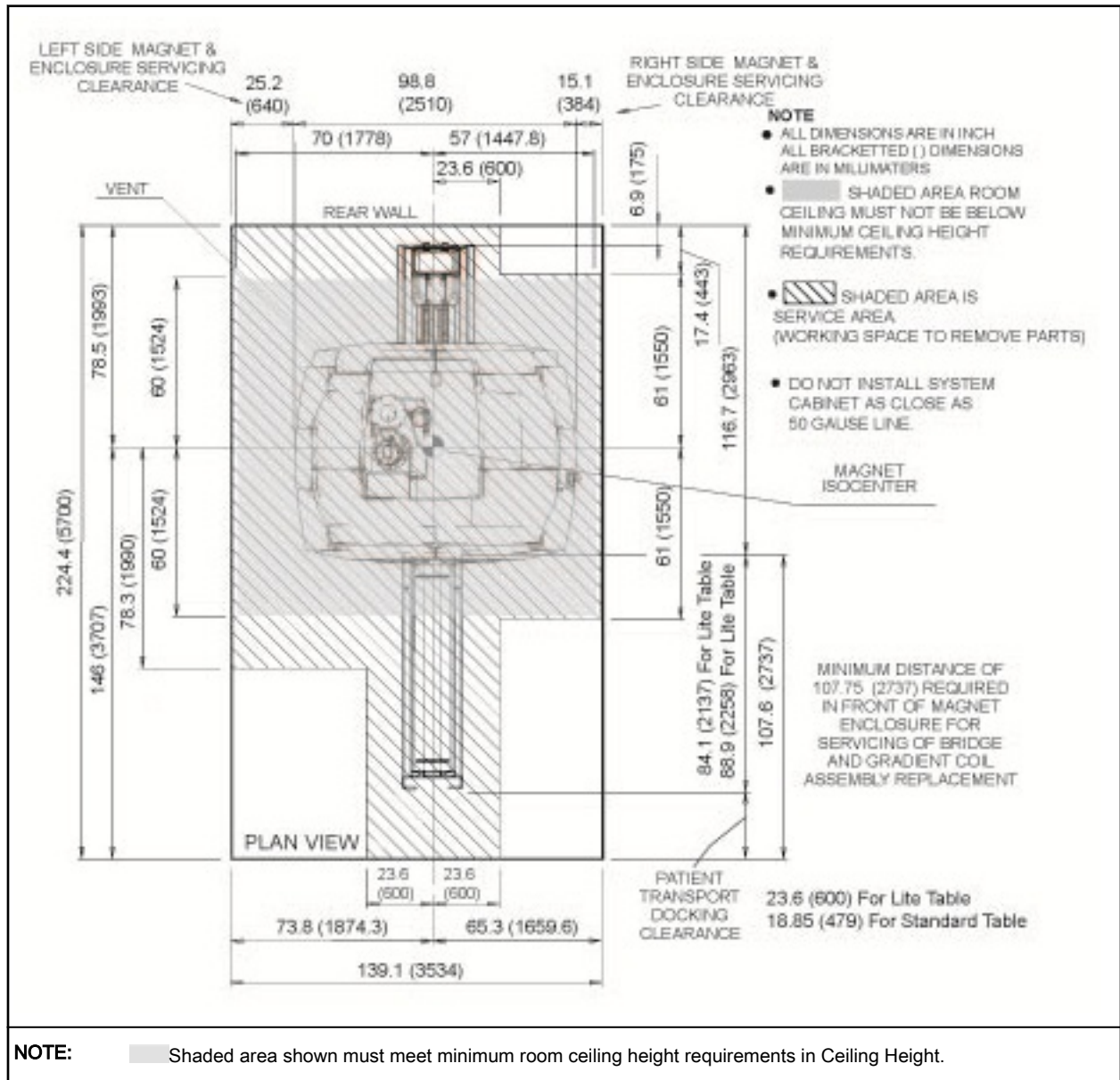
| <div>  <div> <b>NOTICE</b><br/> Room design must provide exit routes for evacuation in the event of an emergency. Local, national, and safety codes must be met. For example, USA regulation (29 CFR 1910.36) require an exit route to be at least 28 inches (711 mm) wide at all points. The dimensions below do not include exit route. </div> </div> |                                                          |                                           |                                                               |                                           |                              |                                                    |                                           |                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------|-------------------------------------------|------------------------------|----------------------------------------------------|-------------------------------------------|--------------------------------------------------------|
| System Configuration                                                                                                                                                                                                                                                                                                                                                                                                                     | Equipment Room Finished Minimum Values<br>See Note 6 & 7 |                                           | Magnet Room Finished Minimum Values<br>See Note 4             |                                           |                              | Control Room Finished Minimum Values<br>See Note 7 |                                           | Total System Area<br>ft <sup>2</sup> (m <sup>2</sup> ) |
|                                                                                                                                                                                                                                                                                                                                                                                                                                          | W x D<br>ft-in. (m)                                      | Area<br>ft <sup>2</sup> (m <sup>2</sup> ) | W x D<br>ft-in. (m)                                           | Area<br>ft <sup>2</sup> (m <sup>2</sup> ) | Ceiling Height<br>ft-in. (m) | W x D<br>ft-in. (m)                                | Area<br>ft <sup>2</sup> (m <sup>2</sup> ) |                                                        |
| System without Equipment Room (Type A, B)                                                                                                                                                                                                                                                                                                                                                                                                | N/A                                                      | N/A                                       | 11.7X 18.7<br>(3.53 x 5.7)<br>See Note 1, 2, 3, 5, 10, 11, 12 | 232.5<br>(21.6)                           | 8-9 (2.67)<br>See Note 8     | 11.0 x 6.23<br>(3.334 x 1.9)                       | 68.53<br>(6.335)                          | 300.63<br>(27.93)                                      |
| System with Equipment Room (Type C, D, E)                                                                                                                                                                                                                                                                                                                                                                                                | 8.9 x 8.2(2.7 x 2.5)                                     | 73.0 (6.75)                               |                                                               |                                           |                              | 5.0 x 7.0<br>(1.52 x 2.13)                         | 35 (3.252)                                | 340.14<br>(31.60)                                      |



**NOTE:** \* Width is dependent on Magnet Room door location and customer's approval of limited space available for operator.

1. Must locate center of the magnet to keep minimum service area described in [Table 2-6](#).
2. Minimum dimensions dependent on the magnetic field containment requested and dimensions of magnetic shield design.
3. Room dimensions in front of LCC Magnet MUST allow for Gradient Coil Assembly and split bridge installation/servicing. The LCC Magnet MUST USE special Gradient Coil Replacement Tool Kit for replacing the Gradient Coil Assembly. The Gradient Coil Replacement Tool Kit is shipped in a wooden crate on casters. Utilization of Gradient Coil Replacement Tool requires 107.75 in. (2737 mm) clear space in front of magnet. Note split bridge servicing requires 77.5 in. (1969 mm) clear space in front of the magnet.
4. Absolute Minimum Magnet Room dimensions will result in limited operator clearances and increased Magnet Service time. [Table 2-6](#) shows only 18.85 inch (0.48 m) clearance at end of Standard Patient Transport. (23.85 inch (0.6 m) clearance at end of Standard Patient Transport)
5. Minimum Magnet Room dimensions do not contain 5 gauss line to room.
6. Equipment Room contents for the listed dimensions include System Cabinet, Shield/Cryo Cooler Compressor Cabinet, MDP, Magnet Monitor. The minimum room dimensions do not permit space for any optional equipment such as Laser Camera, etc.
7. Minimum Equipment Room and Control Room dimensions do not permit placement of air conditioning units in the room.
8. Magnet Room minimum ceiling height is 8 ft 2.5 in. (2.50 meter) when Low Ceiling Height Siting Option (M1060SR) is installed. Refer to Ceiling Height.
9. System Cabinet must be placed farther than 50 gauss line from the magnet.
10. RF extension cable M50002DF should be ordered if the usable cable length between rear-pedestal and the system cabinet is more than 10 meter.
11. Short cable M50002LW should be ordered if the usable cable length between rear-pedestal and the electronics cabinet is 6 meter or less.
12. Long cable M50002LT should be ordered if the usable cable length between rear-pedestal and the electronics cabinet is 6-9.2 meters.

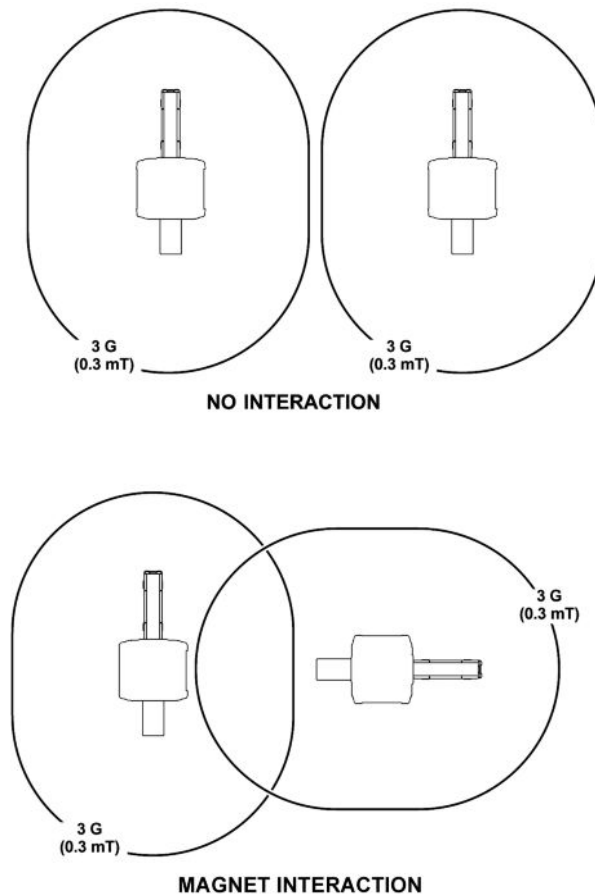
Table 2-6: Brivo MR355 / Optima MR360 (Minimum Service Area)



## 2.1 Two Magnet Site Layout

For two magnet installations interaction can occur between the magnetic fields. For 2 magnets not to interact at all (including when bringing magnet to field) the 3 gauss lines of each magnet must not intersect, see [Illustration 2-42](#). If the 3 gauss lines intersect but remain outside each magnet's cryostat there will be interaction between the magnets when bringing to field, see [Illustration 2-42](#). The orientation of the magnets is irrelevant. Consult the GE Healthcare MR Siting & Shielding group for closer proximity of magnets.

**Illustration 2-42: Two Magnet Installation**



## 2.2 Equipment Room Shared By Multiple MR Systems

### 2.2.1 Introduction

When the 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 resulting in a cross-talk scenario.

**NOTE:** The potential for cross-talk exists for RF transmit cables and equipment that produces RF that are part of a non-GE MR System of the same field strength.



#### **NOTICE**

The RF Screen of the Magnet Room for each system needs to meet the RF Attenuation specifications in [Chapter 3, RF Shielded Room Requirement](#).

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

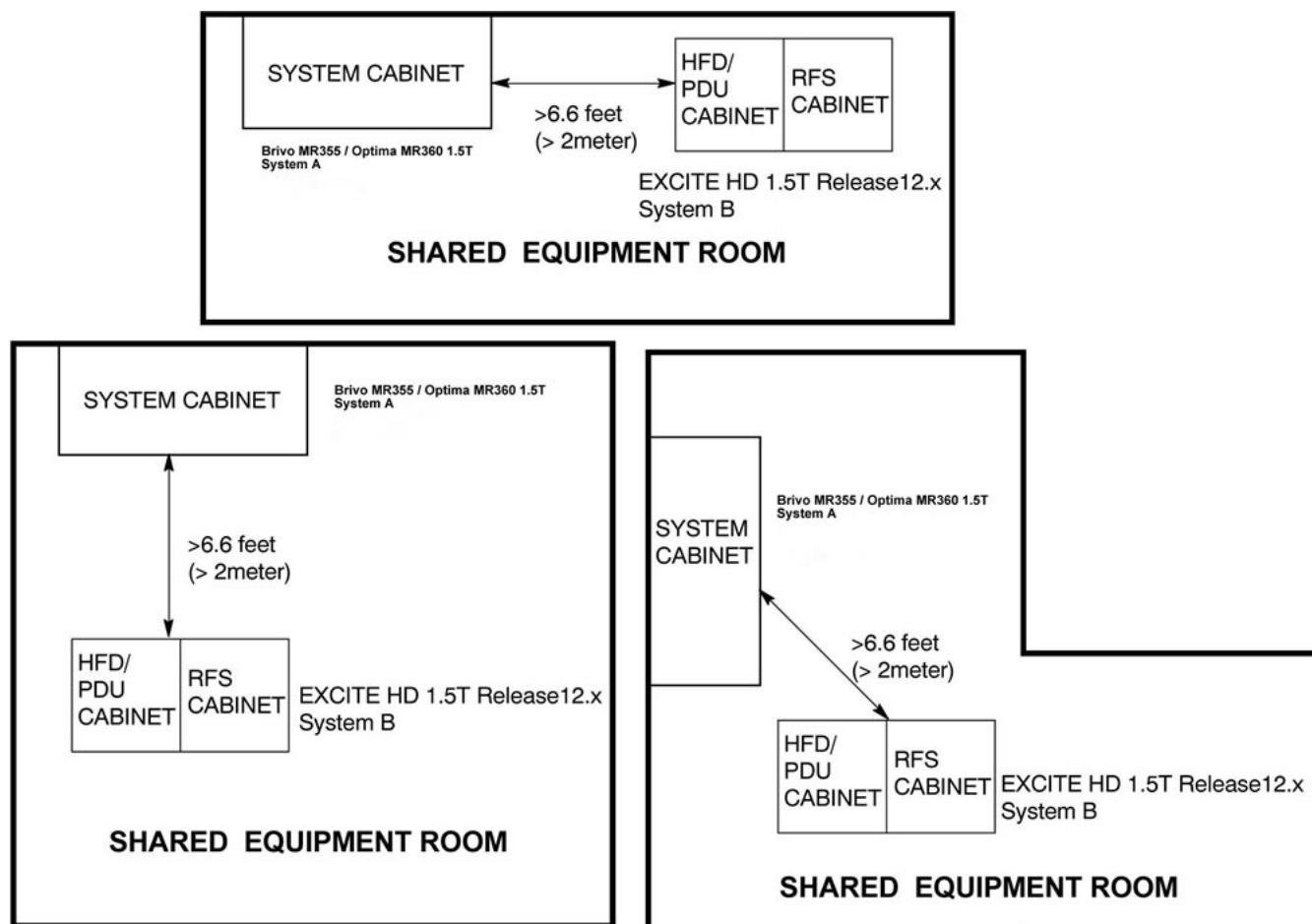
## 2.2.2 Equipment Cabinets Relative Locations

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 of the other MR system of the same field strength.
- The RF transmitter (RF Amplifier) of one MR system and the RF receiver 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 2-43](#).
- Brivo MR355 / Optima MR360 RF Amplifier is located in the System Cabinet.

**NOTE:** Relative placement should not be an issue for chillers, compressors, and other non-RF Transmit/Receiver MR System equipment.

**Illustration 2-43: Brivo MR355 / Optima MR360 & Excite(Release 12.x) Systems Electronics Cabinets Spacing**

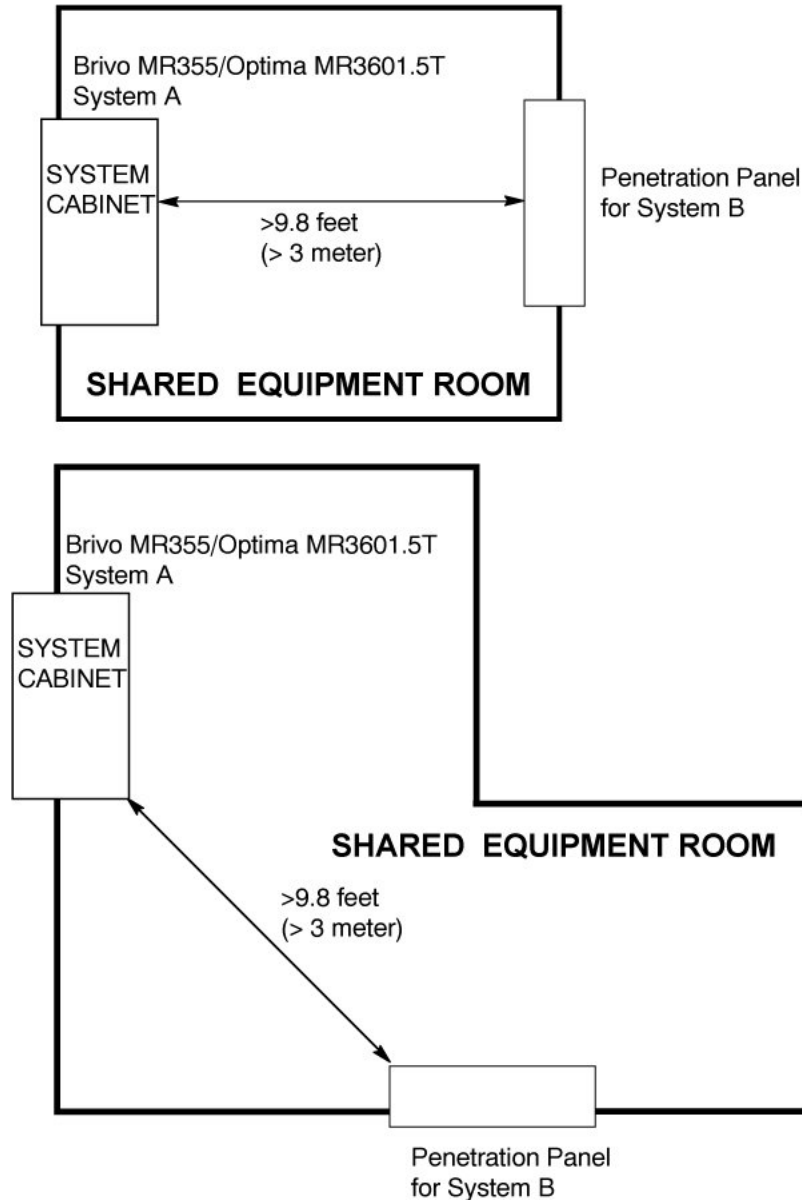


### 2.2.3 Penetration Panels Locations

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

There must be > 9.8 feet (3 meters) separation between the Penetration Panels and System Cabinet of each system sharing the Equipment Room space, see [Illustration 2-44](#).

**Illustration 2-44: Multiple MR Systems Penetration Panel Spacing**

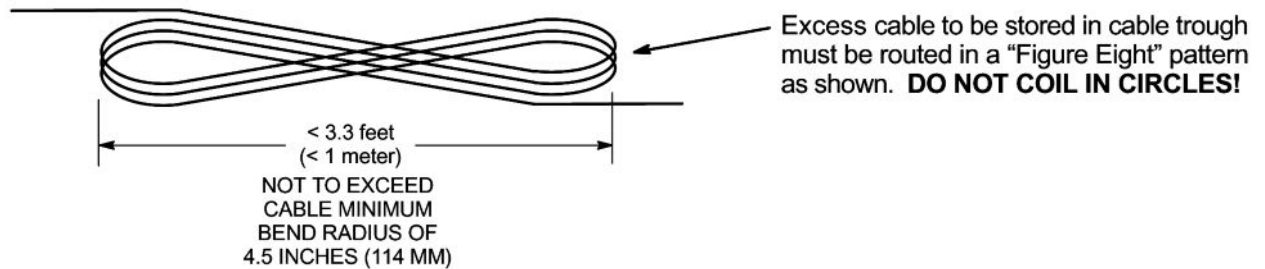


### **2.2.4 System Cables Requirements**

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.
- Receive cables excess length must be stored in a “figure 8” with overall dimension of <3.3 feet (<1 meter), see [Illustration 2-45](#).

**Illustration 2-45: Proper Storage Of Excess Receive Cables**



## **3 Room Structural Requirements**

### **3.1 Magnet Room Structural Requirements**

When preparing a building plan or evaluating a potential site for an MR system, care should be taken to minimize the interaction with building materials or magnetic or RF fields. This section lists the structural requirements that must be considered when performing site evaluation and planning of the Magnet room.

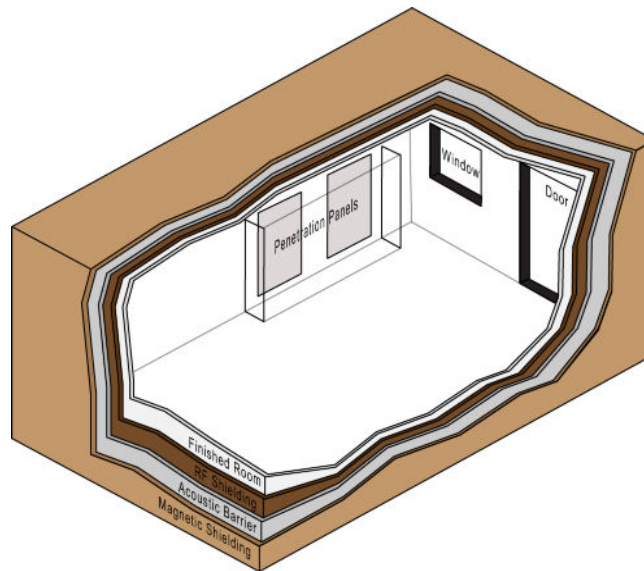
#### **3.1.1 Magnet Room Introduction**

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

1. The outer layer is the building superstructure. This may be a preexisting space in an existing building or a new structure built to specification. This section lists the overall structural requirements that must be considered when performing site evaluation and planning.
2. Inside the building superstructure is the Magnetic Shield room. Magnetic shielding prevents interaction between the magnet and external magnetic sources. A site survey is required to determine magnet shield requirements (not all sites require magnetic shielding). Because of the added cost of magnetic shielding, room location should be carefully considered.
3. The Acoustic room is a layer used to help minimize the noise produced during a scan. A careful assessment by an acoustic engineer is strongly recommended when the magnet room shares common walls, floors, or ceilings with adjacent occupied rooms.
4. The RF Shielded room is critical to the proper MR system operation. RF shielding prevents interaction of external RF radiation with MR system operation and minimizes the generation of RF interference within the room (it also prevents MR system RF radiation from interfering with external systems, such as aircraft control). Special care must be used when installing all fixtures penetrating the RF shield (e.g., vents, electrical conduit, penetration panels) to ensure the integrity of the RF shield is maintained.
5. The Finished room includes the wall coverings, ceiling tile, other fixtures, Magnet (MAG) and Patient Table (PT). When planning the finished room, ensure all building codes (such as maintaining egress routes) are met, items which may cause RF interference, or magnetic items (which could become projectiles when the magnet is installed) are not used.



**Illustration 2-46: Magnet Room Layers**



### ***3.1.2 Physical Requirements***

1. The customer is responsible for any testing required to verify suitability of a proposed site. All test results and any questions regarding testing, results, or analysis must be forwarded to the GE Healthcare Project Manager of Installation (PMI)
2. The Magnet room must be sized so that when finished, it meets the minimum room size requirements and all building and safety codes
3. Floor must support the weight of equipment during system installation and throughout the operation and service life

### 3.1.3 Environmental Steel Limits



#### CAUTION

#### Personnel Injury or Equipment Damage

Metallic structural or construction materials may become projectiles if not properly secured.

Properly secure any loose building materials or materials that could loosen due to vibration.

A static magnetic field extends in a three-dimensional space around the magnet isocenter. Environmental steel within the static magnetic field affects the uniformity (or homogeneity) of the field. Field uniformity is critical to both image quality and chemical shift analysis (spectroscopy). An analysis of the environmental steel is required in within a 9.84 feet (3 meters) spherical radius of the magnet isocenter. Environmental steel includes pipes, beams, concrete rebar, or any other structural steel in the floors, walls, or ceiling.

1. Non-movable steel construction material such as wall studs or HVAC components may be used
2. Metallic electrical conduit inside walls and ceilings may be used. Conduit for receptacles must be metallic
3. Metallic pipes and drains may be used
4. Steel in the floor under the Magnet (MAG) must be limited per the table below:

**Table 2-7: Steel Mass Limits to Magnet Isocenter**

| 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 rebar and other steel building materials within an area 9.84 feet (3 meters) directly below the Magnet

### 3.2 Magnetic Shielded Room Requirements



#### **NOTICE**

All sites, including upgrade sites, must be evaluated for magnetic shielding requirements. Existing magnetic shielding at an upgrade site may not be sufficient for the new system. Contact the GE Healthcare Project Manager of Installation (PMI) to request a site evaluation.

Magnetic shielding prevents interaction between the magnet and nearby sensitive devices. Because of the added cost of magnetic shielding, room location should be carefully considered (not all sites require magnetic shielding). See Magnetic Field Consideration for detailed magnetic proximity limit information.

1. The GE Healthcare Project Manager of Installation (PMI) works with the customer to coordinate the magnetic shielding site evaluation
2. If required, the GE Healthcare Project Manager of Installation (PMI) coordinates the delivery of the magnetic shielding design
3. The customer is responsible for installation of all magnetic shielding

### 3.3 Finished Room Requirements

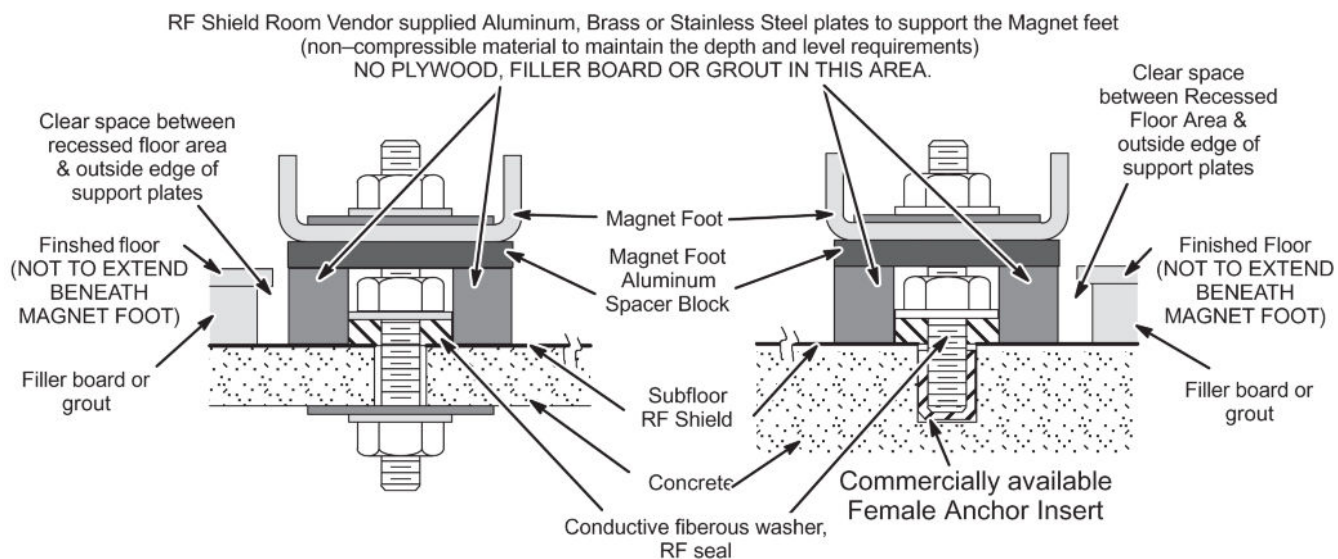
#### 3.3.1 Magnet Mounting Requirements

The following requirements are applicable only if the VibroAcoustic dampening option is not included with the MR system.

1. Before planning for or installing any Magnet anchors verify with the GE Healthcare Project Manager of Installation (PMI) that the VibroAcoustic dampening option is not included with the MR system order
2. The customer must coordinate magnet mounting with the RF Shield vendor
3. Any Magnet anchor plan must be submitted to the GE Healthcare Project Manager of Installation (PMI)
4. All four magnet feet must be anchored to the floor or VibroAcoustic mat. Anchoring is not performed when using the SV VibroAcoustic Kit.. (refer to [Illustration 2-47](#))
5. Magnet anchors must be installed before the Magnet is delivered
6. Refer to [Vibration Requirement](#) for Magnet Feet mounting hole locations
7. Magnet anchors must not contact floor rebar or other structural steel
8. Magnet anchors must electrically contact the RF shield at point of entry
9. Magnet anchors must have the following properties:
  - a. Anchors must be two-part assembly (male/female)
  - b. Female side must be expansion- or epoxy-type
  - c. Male side must be a bolt or threaded rod with appropriate-sized nut (bolt or rod must be removable--not epoxied or cemented in place)
  - d. Anchors must be electrically conductive
  - e. Anchors must be non-magnetic
  - f. Anchors must not induce galvanic corrosion with the RF shield
  - g. Anchors must be commercially procured
  - h. Anchors must meet all building codes, including seismic codes if required
  - i. Anchor rods diameter must be between 0.625 in (M16) and 1.25 in (M32)
  - j. Anchors must meet the following clamping force: 2,500 ± 200 lbs (11,100 ± 900 N)
10. Refer to [Chapter 7, Selecting Magnet Anchor Size](#) for an example of how to properly size the Magnet anchor
11. The RF shield vendor must perform the following tests before installation. Results must be provided to the GE Healthcare Project Manager of Installation (PMI)
  - a. A pull test on each anchor (equal to the clamping force)
  - b. RF integrity test

c. Ground impedance test

**Illustration 2-47: Magnet 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.

### **3.3.2 Dock Anchor Mounting Requirements**

1. The customer must coordinate dock anchor mounting with the RF Shield vendor
2. The dock anchor hole must be drilled after the Magnet is installed. Refer to Dock Anchor Hole.
3. The dock anchor must not contact floor rebar or other structural steel
4. The dock anchor must electrically contact the RF shield at point of entry
5. The dock anchors must have the following properties:
  - a. Anchors must be two-part assembly (male/female)
  - b. Female side must be expansion- or epoxy-type
  - c. Male side must be a bolt or threaded rod with appropriate-sized nut (bolt or rod must be removable--not epoxied or cemented in place)
  - d. Anchors must be electrically conductive
  - e. Anchors must be non-magnetic
  - f. Anchors must not induce galvanic corrosion with the RF shield
  - g. Anchors must be commercially procured
  - h. Anchors must meet all building codes, including seismic codes if required
  - i. The anchor rod hole clearance in the dock anchor base is 0.43 in (11). The anchor rod diameter must be sized appropriately

- j. Anchors must meet the following clamping force: 600 lbs (2669 N)
  - k. The anchoring bolt for dock should stand 0.337 Kilo Newton(KN) shear force and 0.118 KN tension force.
6. The RF shield vendor must perform the following tests. Results must be provided to the GE Healthcare Project Manager of Installation (PMI)
- a. A pull test on each another (equal to the clamping force)
  - b. RF integrity test
  - c. Ground impedance test

### **3.3.3 Blower Box Mounting Requirements**

Please refer to [Blower Box](#)

**NOTE:** The blower box should be anchored with M6 bolts which can stand 0.217 Kilo Newton shear force and 0.076 Kilo Newton tension force.

### **3.3.4 MRU Mounting Requirements**

Please refer to 1.5 Magnet Rundown Unit

### **3.3.5 Oxygen Monitor Mounting Requirement**

Please refer to [1.22 Oxygen Monitor Option](#)

### **3.3.6 Walls**

GE Healthcare recommends wall coverings to protect the RF shielding (wall coverings may be removable, if required, to access the RF shield)

### **3.3.7 Doors and Magnet Access Openings**

- 1. The finished opening of the main door must be at least 43 in. (1092 mm) to allow for helium dewars and patient tables
- 2. The finished opening of the main door must be positioned to allow the Gradient Cart to move into the room
- 3. Maximum door sill height is 1 in. (25 mm) with a maximum 10 degree threshold inclination
- 4. GE Healthcare recommends a patient viewing window 48 in. wide by 42 in. high (1219 mm x 1067 mm) and 72 in. (1829 mm) above the finished floor

**NOTE:** IEC requires the patient, while in the bore, be in full view of the operator. GE Healthcare recommends using a window, although other means (e.g., camera and video display) may be used as long as all IEC requirements are met

- 5. The magnet delivery requires opening into the room to allow access for the magnet and any rigging

### **3.3.8 Finished Ceiling**

[Table 2-8](#) lists the Magnet Room absolute minimum ceiling height required for servicing the listed magnets. This height is required for the area directly above the magnet. GE Healthcare

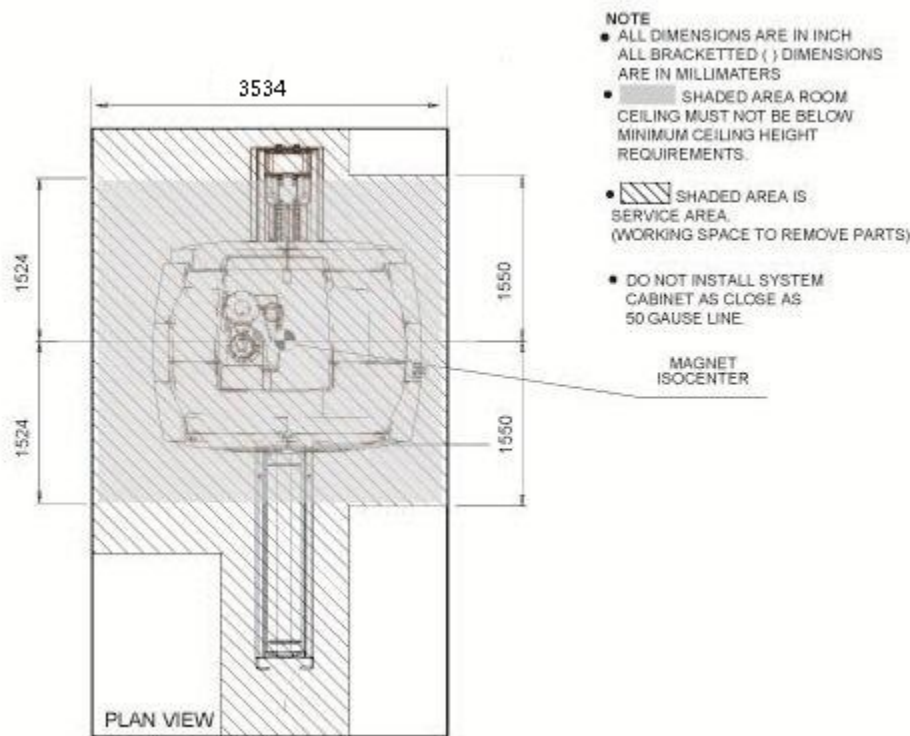
PMI must be notified of any ceiling dimensions less than ceiling heights stated in [Table 2-8](#) and shown in [Illustration 2-48](#).

**Table 2-8: Magnet Servicing Ceiling Height Requirements**

| Magnet Type                                                                                                                                                                                                                                                                                                                    | Absolute Minimum Ceiling Height * |      | Comments                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                | in.                               | mm   |                                                                                                                                                                                                                     |
| 1.5T LCC                                                                                                                                                                                                                                                                                                                       | 105                               | 2667 | Magnet servicing is performed from a platform ladder which is positioned at the Coldhead side of the Magnet. Ceiling height allows for clearance for fill line stinger insertion.                                   |
| 1.5T LCC with Low Ceiling Height Siting Option (M1060SR) installed                                                                                                                                                                                                                                                             | 98.5                              | 2500 | Magnet servicing is performed from a platform ladder which is positioned at the Coldhead side of the Magnet. Ceiling height allows for clearance for insertion of fill line with 7 inch (178 mm) stinger insertion. |
| <b>Note</b> * Absolute minimum ceiling height values are from magnet room finished floor to fixed ceiling. Minimum Ceiling Height 2500 mm is only possible if Quench pipe is leaving the room vertically. In case quench pipe exists from side walls using new 90° vent adaptor then required ceiling height should be 2652mm. |                                   |      |                                                                                                                                                                                                                     |

**NOTE:** Minimum ceiling height except the shaded area in [Illustration 2-48](#) is 98.5 inch (2500mm).

**Illustration 2-48: Minimum Ceiling Height for Magnet Servicing**



Use of a standard valved helium transfill line and a 250 liter dewar (not more than 70 in. (1778 mm) high) requires a ceiling height of 135.5 in. (3442 mm) for inserting transfill line into the dewar. Note that this need only be a 24 in. (610 mm) square ceiling recess located either in the Magnet Room or in an accessible area near the Magnet Room where the transfill line can be



inserted into the dewar. A 500 liter dewar (not more than 73 in. (1854 mm) high) requires a ceiling height of 138 in. (3505 mm) for the same process.

If the helium transfill requirements cannot be satisfied in or near the Magnet Room, consider a location outside the building or on a loading dock. The standard valved transfill line, after insertion into either a 500 or 250 liter dewar, will fit through 79 in. (2007 mm) high doorways and hallways. Provide free access from the dewar location to the magnet. 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).

### **3.3.9 Magnet Room Floors**

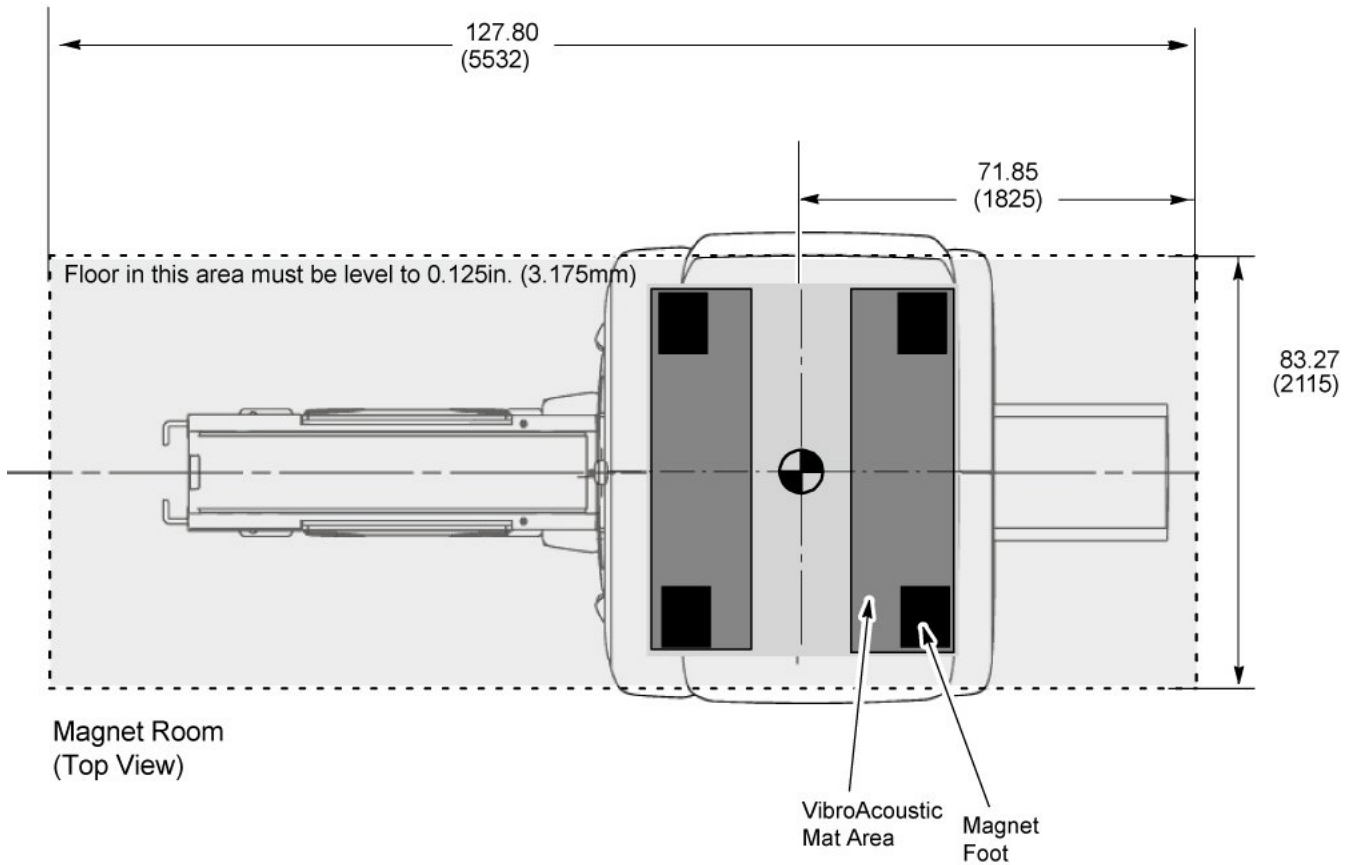
1. The finished floor must be water resistant to protect the subfloor and shielding from water damage
2. The customer is responsible for providing flooring to meet the maximum 8 kV ESD resistance requirement for GE Healthcare equipment
3. Magnet, Enclosure, and Patient Table areas (shown below) must be level to 0.125in. (3.175mm) between high and low spots over any 120 in. (3048 mm) distance
4. If the Magnet is mounted directly to the floor, see [Chapter 3, RF Shielded Room Requirements](#) for mounting bolt requirements



**Illustration 2-49: Magnet Room Floor Levelness Area**

**Note**

All dimensions are in inches. All bracket ( ) dimensions are in millimeters.



### 3.4 System Cabinet Special Consideration

This section describes the special consideration of System Cabinet and Penetration Panel.

Refer to [System Cabinet](#) for dimensions of System Cabinet.

For RF Shield Consideration for System Cabinet and Penetration Panel, refer to [Chapter 3, RF Shield Consideration for System Cabinet and Penetration Panel](#).



#### NOTICE

Specification of Floor under System Cabinet:

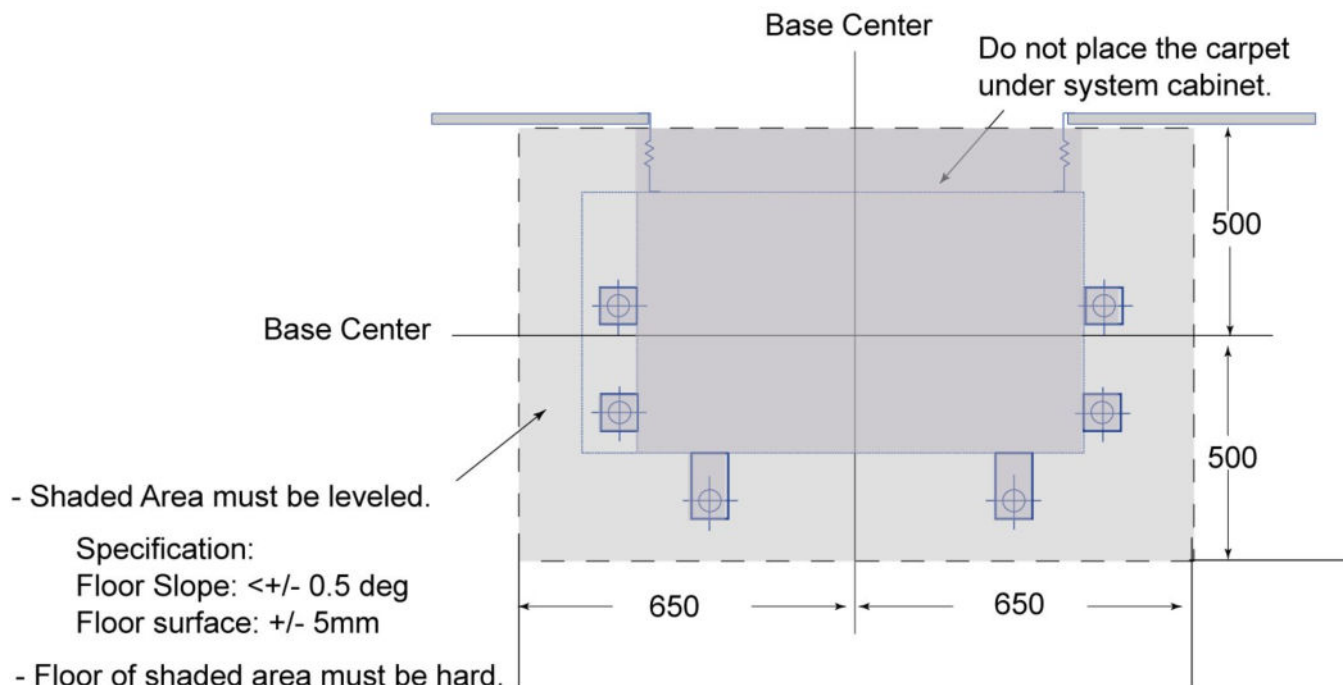
- Floor slope:  $< \pm 0.5$  deg
- Floor surface:  $< \pm 5$ mm in Cabinet installation area
- Installed Cabinet tilt:  $< \pm 0.5$ deg (Installed Cabinet level will be measured during mechanical installation)
- The System Cabinet should be installed on concrete slab.

**NOTE:** Use precision levels ('Block Type' or 'Square Frame Type') 150mm or longer to measure the level of floor.

Specification of precision levels: JIS B7510 (A Grade, Sensitivity 1~3) or equivalent.

[Illustration 2-50](#) shows the area that must be leveled.

Illustration 2-50: Area to be leveled

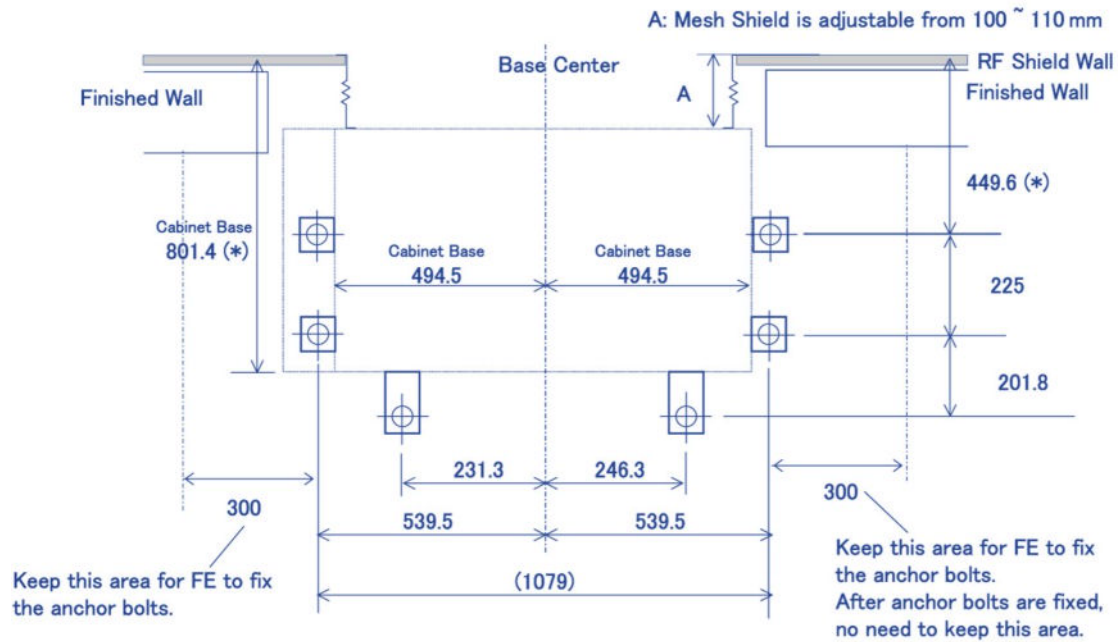


[Illustration 2-51](#) shows anchor location of System Cabinet for seismic area (1st floor or lower). For Seismic Area (2nd Floor or higher), refer to [Illustration 2-52](#).

**NOTE:** It is recommended to extend Mesh Shield in between 100mm and 110mm. However, Mesh Shield can be extended to 180mm without any slack. In case there is any reason that the System Cabinet cannot be located closely enough to the RF shield, it is local site engineer's responsibility to extend Mesh Shield more than 110mm. Consider floor level under System Cabinet severely when extending the Mesh Shield more than 110mm.

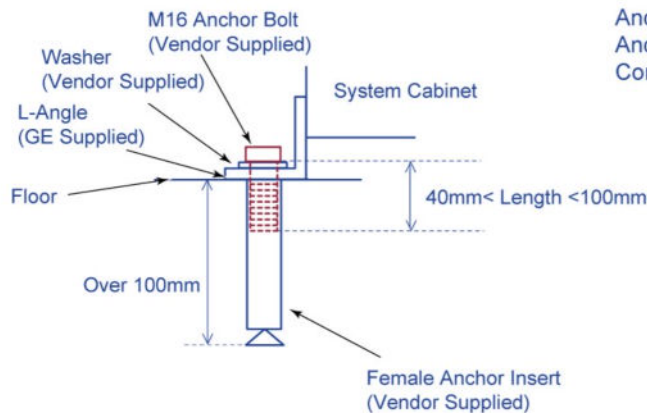
Illustration 2-51: System Cabinet Anchor Location (for seismic area (1st floor or lower ))

## Anchor Location



Note: The value (\*) is a recommended value.  
This value is flexible within specification of Mesh Shield (A).

## Anchor Side View



Anchor Bolt : M16  
Anchor Length : 100mm over  
Concrete tensile strength : 17.6MPa(1760N/cm<sup>2</sup>) over

### Important!!:

M16 anchor bolts will be used to fix the system cabinet.  
It is vendor's responsibility to prepare M16 bolts, female anchor inserts, and washer (6 pieces).  
Anchor holes must be drilled and female anchor inserts are installed before System Installation.

[Illustration 2-52](#) shows anchor location of System Cabinet for seismic area (2nd Floor or higher). For seismic area (1st floor or lower), refer to [Illustration 2-51](#).

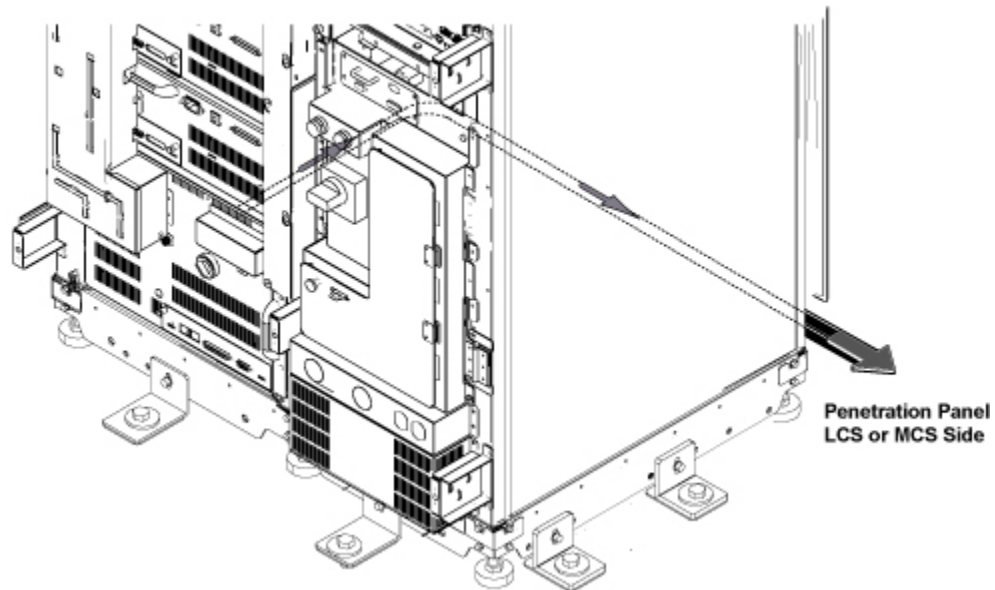
**NOTE:** It is recommended to extend Mesh Shield in between 100mm and 110mm. However, Mesh Shield can be extended to 180mm without any slack. In case there is any reason that the System Cabinet cannot be located closely enough to the RF shield, it is local site engineer's responsibility to extend Mesh Shield more than 110mm. Consider floor level under System Cabinet severely when extending the Mesh Shield more than 110mm.



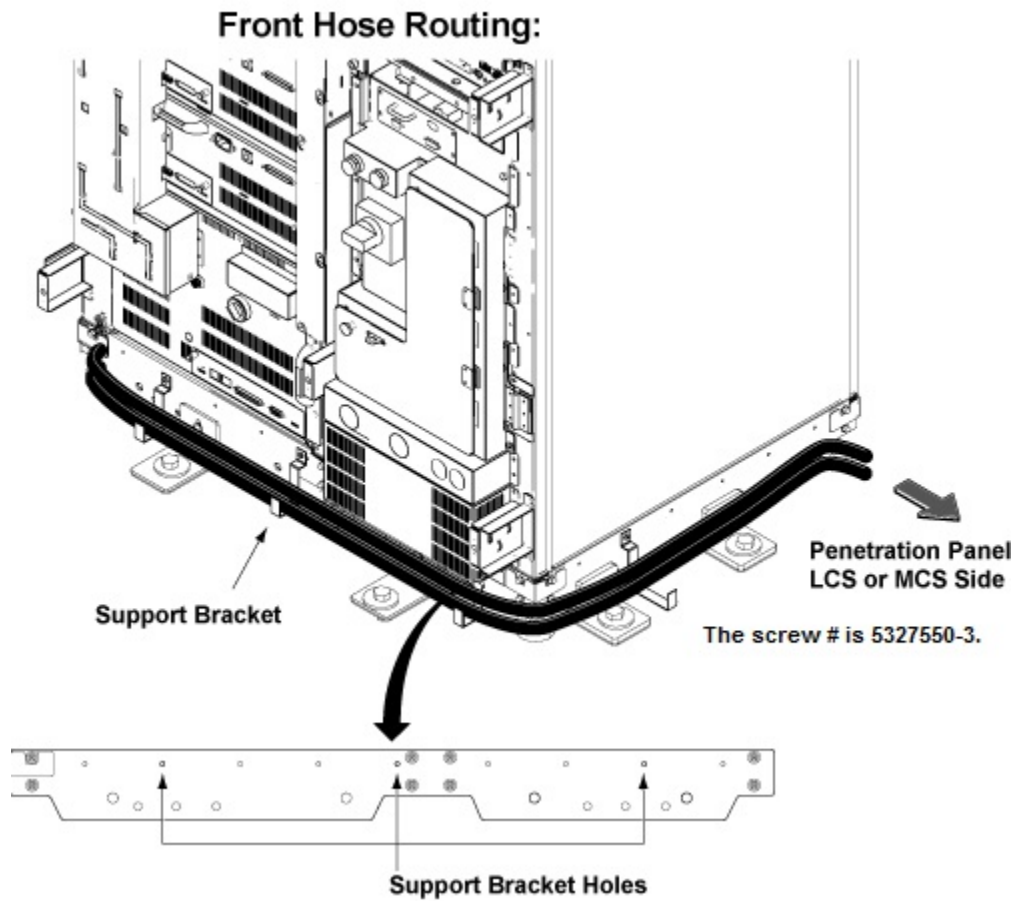
[Illustration 2-53](#) and [Illustration 2-54](#) show different System Cabinet Water hose routing output according to the site condition.

**Illustration 2-53: Rear Hose Routing**

**Rear Hose Routing:**



**Illustration 2-54: Front Hose Routing**

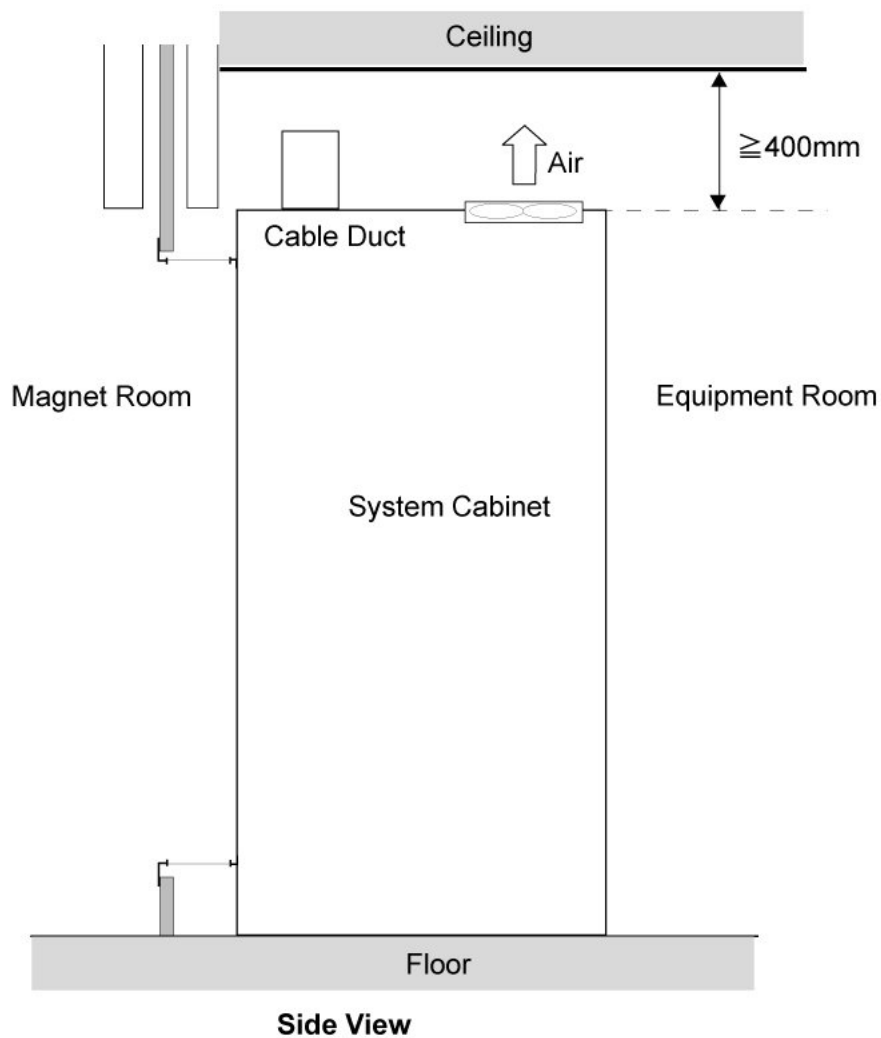




[Illustration 2-55](#) shows minimum ceiling height of Equipment (or Operator) Room by considering the air flow of System Cabinet.

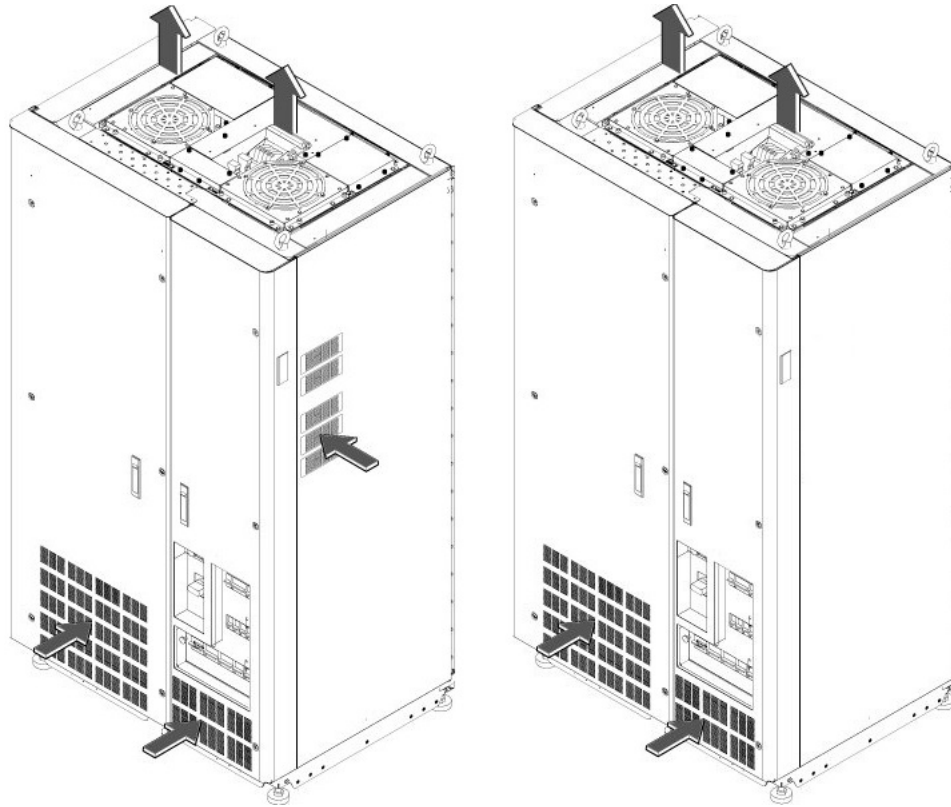
**Illustration 2-55: Minimum Ceiling Height Specification of Equipment (or Operator) Room**

**Notice:** Keep the gap between top of System Cabinet and Ceiling more than 400mm for air flow from System Cabinet.



**Illustration 2-56** shows two types of air flow of System Cabinet. When the System Cabinet is equipped with ICE, there is no airvent on the right side of the System Cabinet.

**Illustration 2-56: System Cabinet Air Flow**



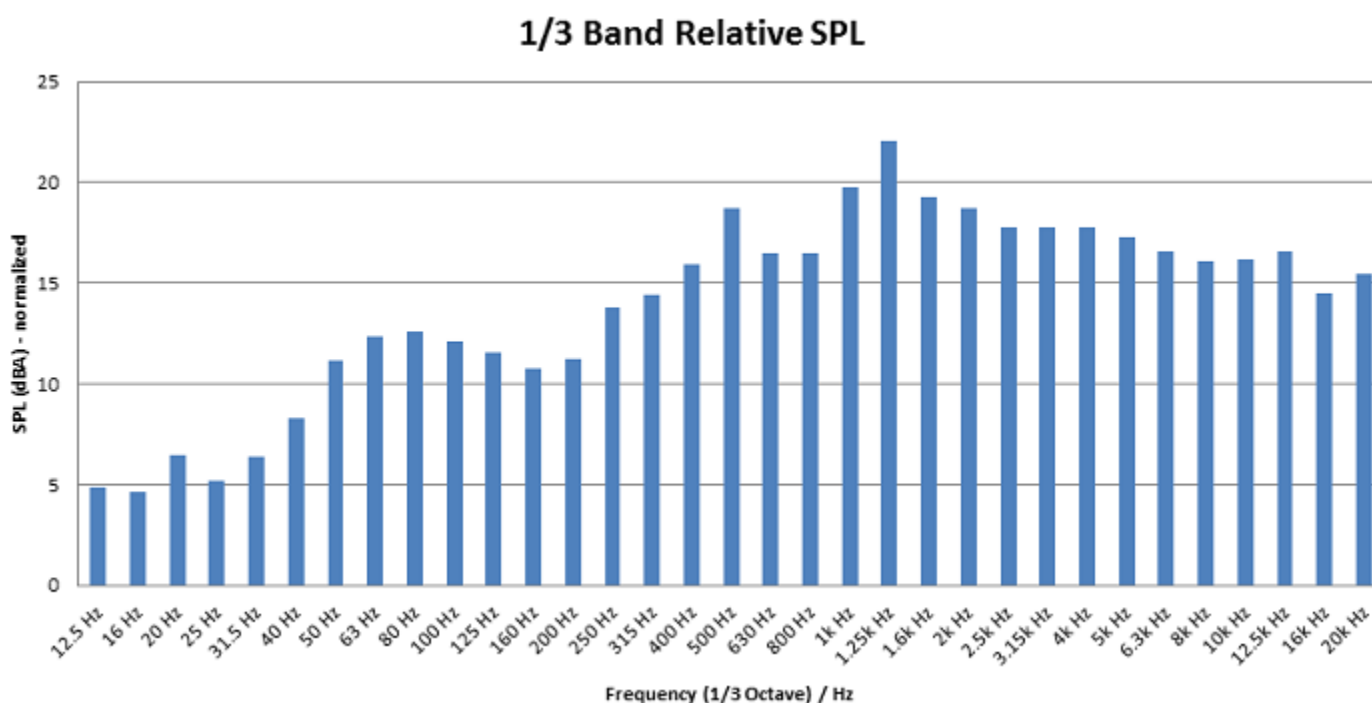
### 3.5 Acoustic Room Specifications

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

**Table 2-9: Acoustic Specifications**

|                                                                                                                                                                                                                                     | Maximum Sound Pressure Level <sup>1</sup> | Frequency Range                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------|
| Magnet Bore Isocenter                                                                                                                                                                                                               | 127 dBA <sup>2</sup>                      | See <a href="#">Illustration 2-57</a> |
| Front of Magnet - 800 mm from bore measurement                                                                                                                                                                                      | 120 dBA                                   |                                       |
| Notes:                                                                                                                                                                                                                              |                                           |                                       |
| 1. Maximum Sound Pressure Levels is defined as the maximum allowable level any MR scanner can produce while protecting the patient to the IEC 60601-2-33 code.                                                                      |                                           |                                       |
| 2. The total energy, SPL, is derived through the log sum of each 1/3 band octave totaling the 127 dBA. That is, the maximum single 1/3 band is lower than the published values at both the isocenter and at the front of the magnet |                                           |                                       |

**Illustration 2-57: Sound Pressure Spectral Distribution (1/3 Band Relative SPL)**



**NOTE:** The MR product clinical operation will generate sound pressure proportional to the specific clinical application. The entire spectra (envelope) shown above ([Illustration 2-57](#)) represents the relative 1/3 band octave sound pressure the MR scanner may transmit into the air. The acoustic room will best suit the customer when the 127 dBA proportionally distributed as defined by the Illustration.

Refer to [Chapter 7, Acoustic Background and Design Guidelines](#) for acoustic design information.

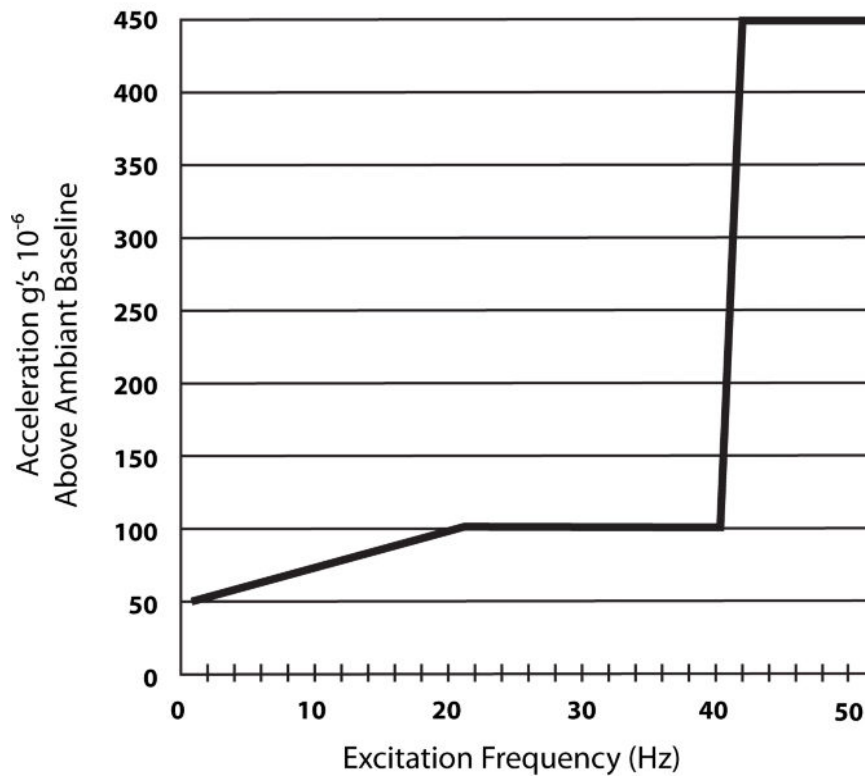
### **3.6 Vibration Requirements**

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

1. The Magnet (MAG) cannot be directly isolated from vibration. Any vibration issue must be resolved at the source
2. MR Suite HVAC must have vibration isolation
3. A vibration analysis must be performed at the proposed site with the results (and any mitigation) forwarded to the GE Healthcare Project Manager of Installation (PMI). See the MR Site Vibration Test Guidelines
4. A transient vibration test must only be performed after a steady-state test has been performed and all steady-state sources of vibration have been mitigated
5. Transient vibration levels above the specified limits in the MR Site Vibration Test Guidelines must be analyzed
6. Any transient vibration that causes vibration to exceed the steady-state level must be mitigated

Illustration 2-58: Magnet Steady State Vibration Specifications

Magnet Steady-State  
Vibration Specifications



### 3.7 SV VibroAcoustic Kit(M50002LP)



#### NOTICE

The Surface Mounted VibroAcoustic Damping Mats must be installed on the floor before moving the magnet into the magnet room.



#### NOTICE

Tasks in this section are to be performed by riggers, not by GE Service personnel.

**NOTE:** The SV VibroAcoustic Mats may arrive in a cold state preventing compression. The SV VibroAcoustic Mats should be placed in the magnet room prior to moving magnet to MR suite to allow for temperature stabilization. If the magnet exceeds the installation height specification, allow the magnet to settle on the SV VibroAcoustic Mats for 24 hours, then remeasure the magnet height.

1. Verify that the SV VibroAcoustic Kit contains the parts listed in table [Table 2-10](#).
2. Remove any debris from the magnet room floor where the Mats will be positioned.
3. Verify that there are no RF seams under the SV VibroAcoustic Mats.
4. The SV VibroAcoustic Kit consists of two sets of two identical plates. Identify the magnet geometric center based upon vent stack location as shown in [Illustration 2-59](#). Place the SV VibroAcoustic Mats spaced according to [Illustration 2-60](#), with the aluminum plate down against the floor and the dampener (rubber) up against the magnet foot as shown in [Illustration 2-61](#) and [Illustration 2-62](#).

**Table 2-10: SV VibroAcoustic Kit**

| Quantity | Part Number | Description |
|----------|-------------|-------------|
| 2        | 5420414     | Vibro Pad   |
| 2        | 5420414-2   | Vibro Pad   |

Illustration 2-59: 1.5T LCC Magnet Geometry, R Series

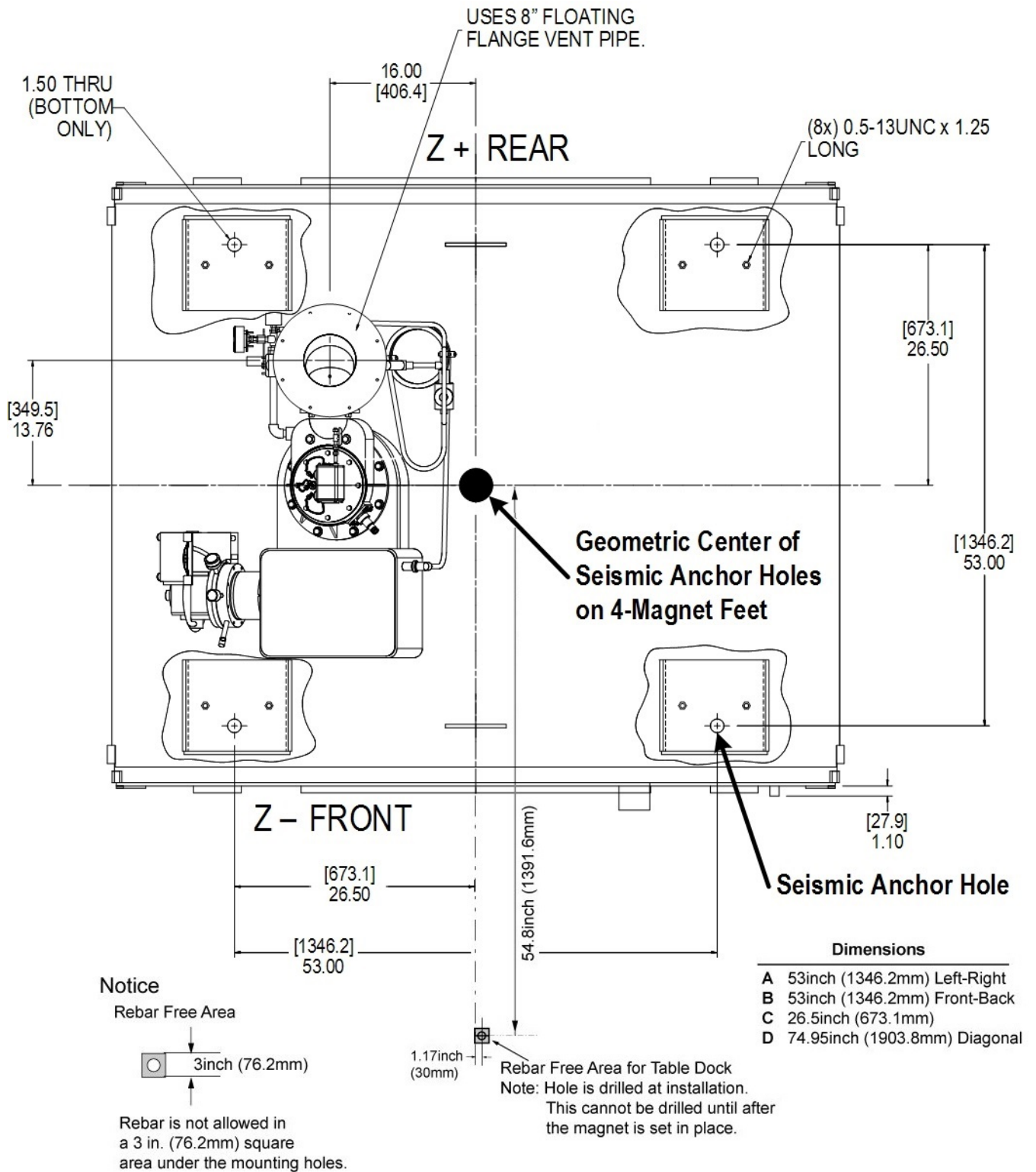


Illustration 2-60: Positioning SV VibroAcoustic Mats

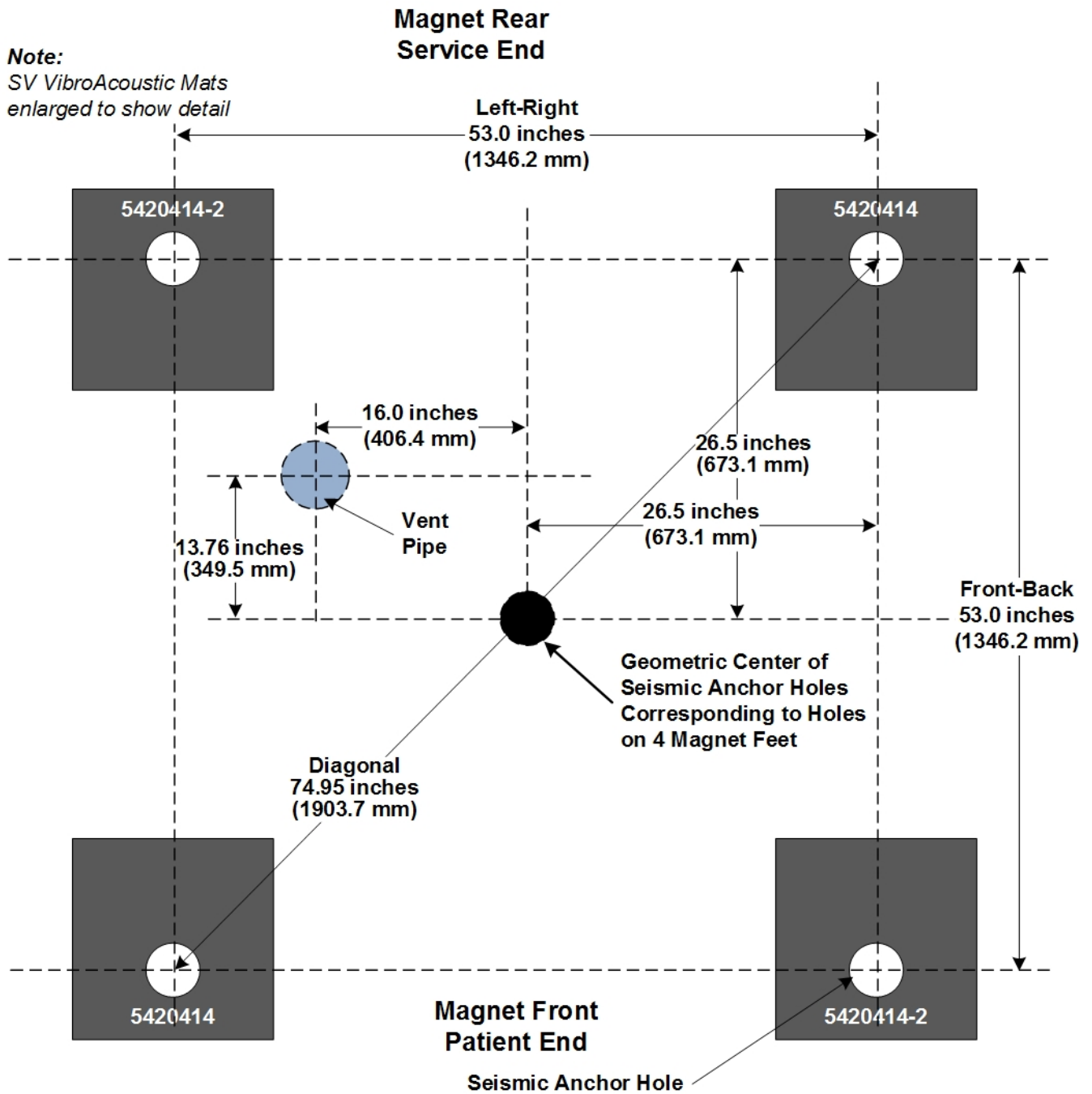
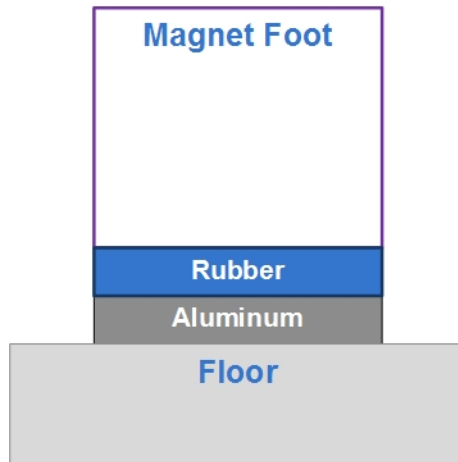




Illustration 2-61: Placement of SV VibroAcoustic Mat

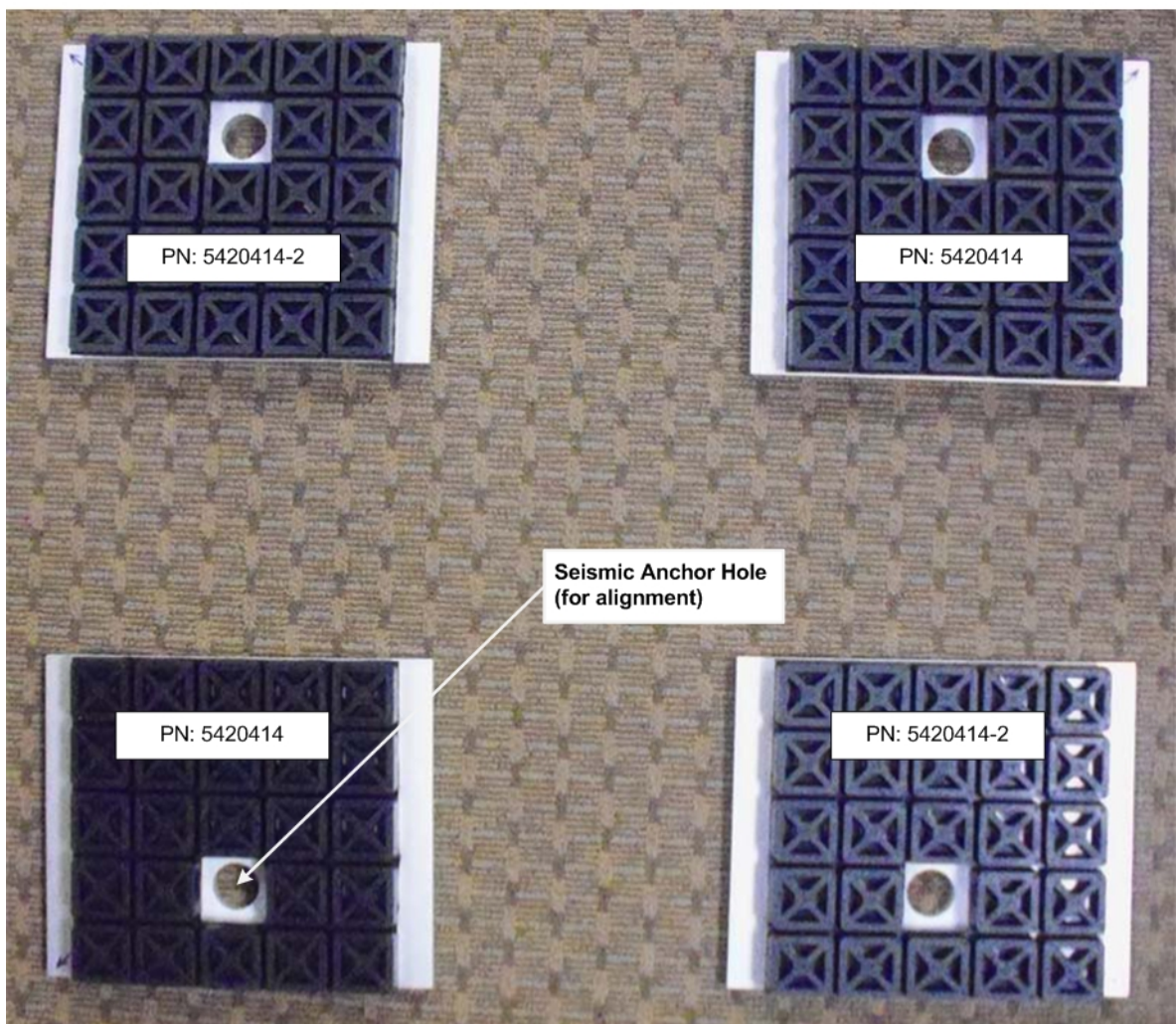


**Note:**

Rubber pad **MUST** be installed facing upwards against the magnet foot.

Illustration 2-62: SV VibroAcoustic Mats

MAGNET REAR (SERVICE)



MAGNET FRONT (PATIENT)

## **4 Seismic**

Contact the Project Manager of Installation for any questions regarding MR system seismic requirements or specifications.

1. The customer is responsible for seismic anchoring of GE components
2. Center of gravity, weight, and physical dimensions are provided for seismic calculations
3. The customer must work with the RF shield vendor to ensure any seismic anchoring complies with all RF shield requirements

## Chapter 3 Special Construction

### 1 Magnetic Field Consideration

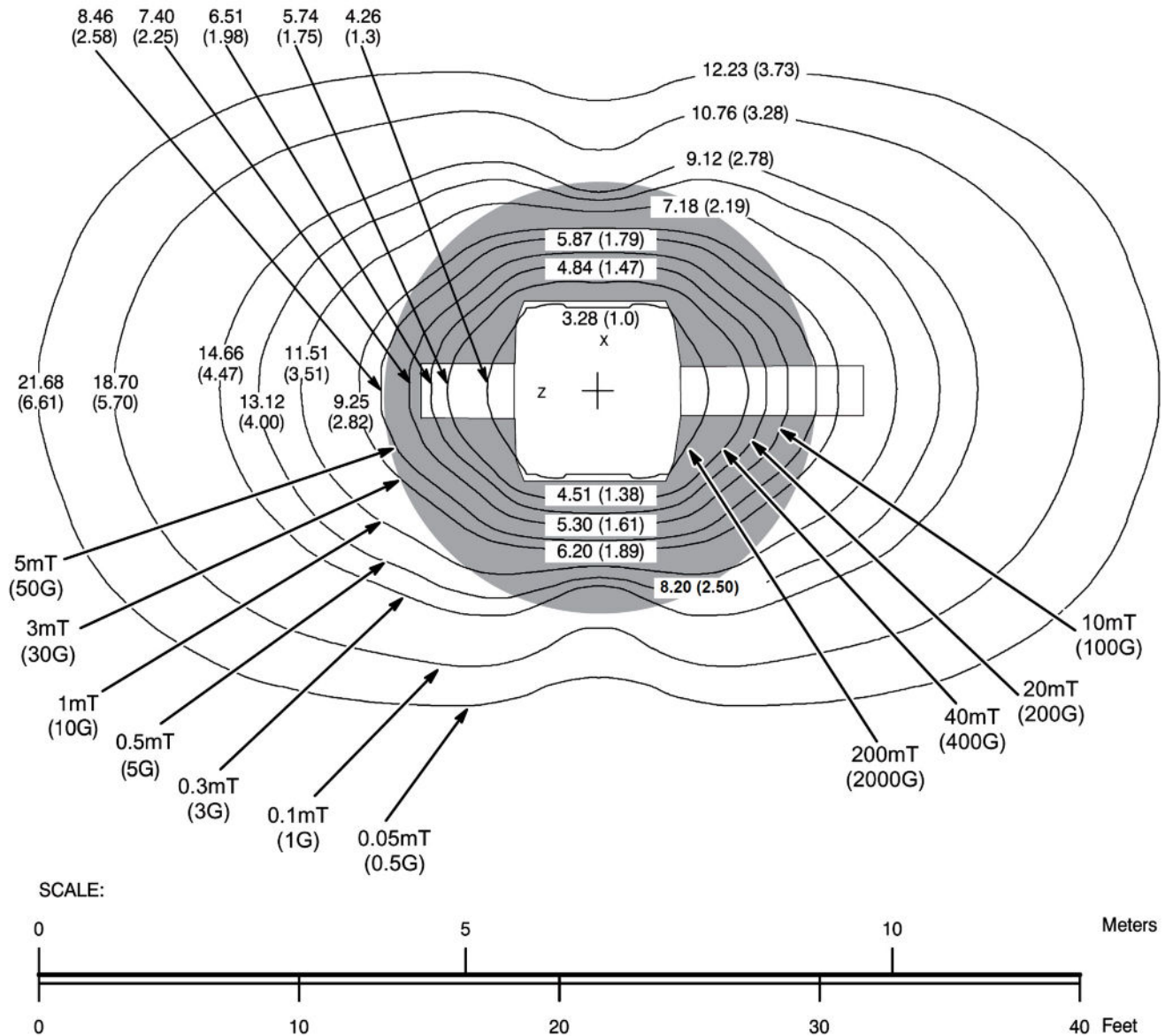
#### 1.1 Fringe Field

[Illustration 3-1](#), [Illustration 3-2](#), and [Illustration 3-3](#) are the fringe field plots for the 1.5T LCC/LCCw 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 which 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.

Therefore, 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 Proximity Limits for the sensitivities of various equipment within the magnetic field.

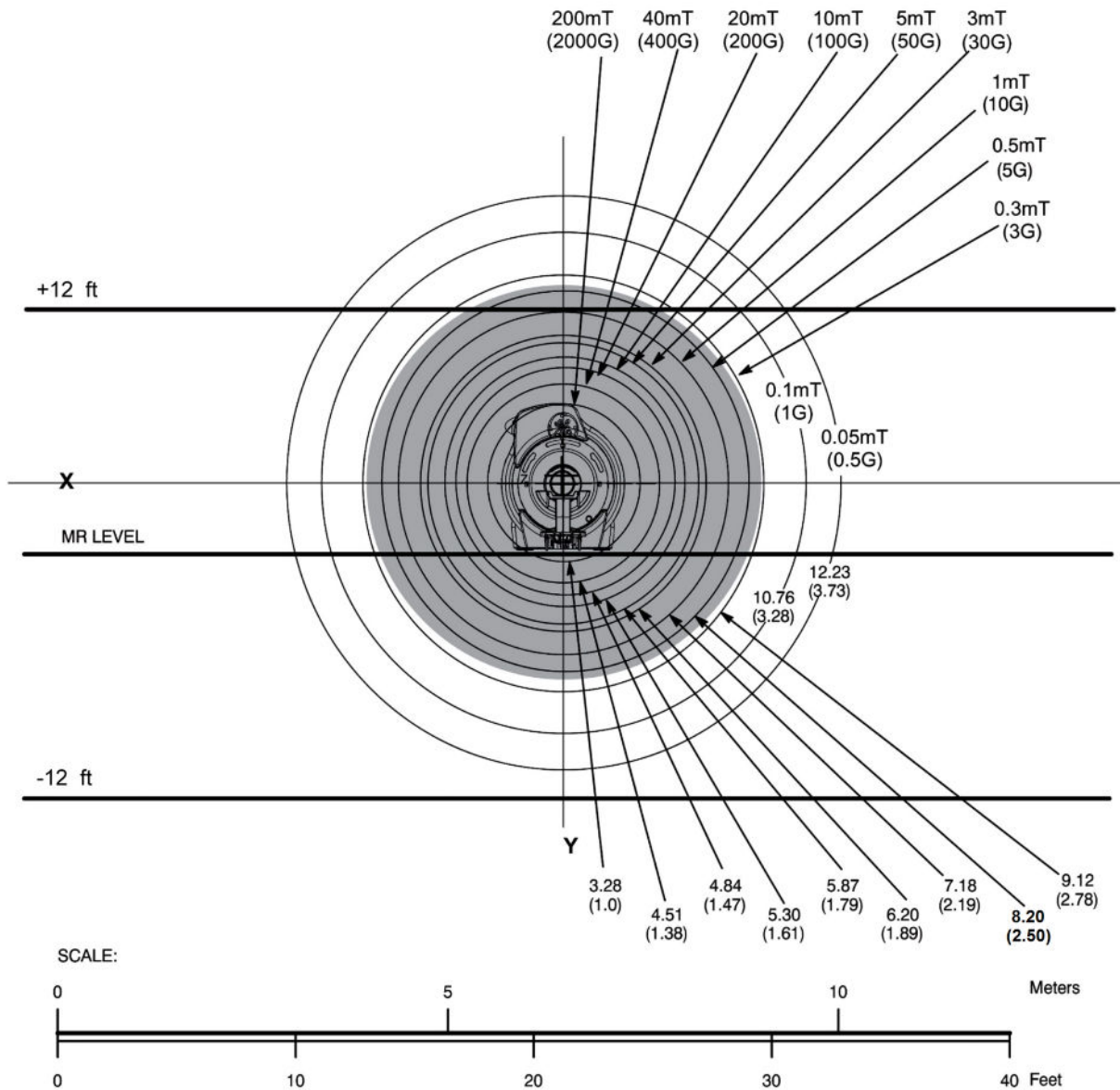
Illustration 3-1: 1.5 Tesla LCC Magnetic Isogauss Line Plot - Top View



**NOTE:**

- MEASURED MAGNETIC FLUX DENSITY WILL VARY FROM PLOT DUE TO FACTORS SUCH AS CONCENTRATING EFFECTS OF NEARBY FERROUS OBJECTS AND AMBIENT FIELDS, INCLUDING EARTH'S MAGNETIC FIELD.
- POTENTIAL EXISTS UNDER FAULT CONDITIONS THAT THE 5 GAUSS LINE MAY EXPAND TO 16.40 ft (5.0 m) RADIALLY AND 22.96 ft (7.0 m) AXIALLY FOR 2 SECONDS OR LESS.

Illustration 3-2: 1.5 Tesla LCC Magnetic Isogauss Line Plot - Front View

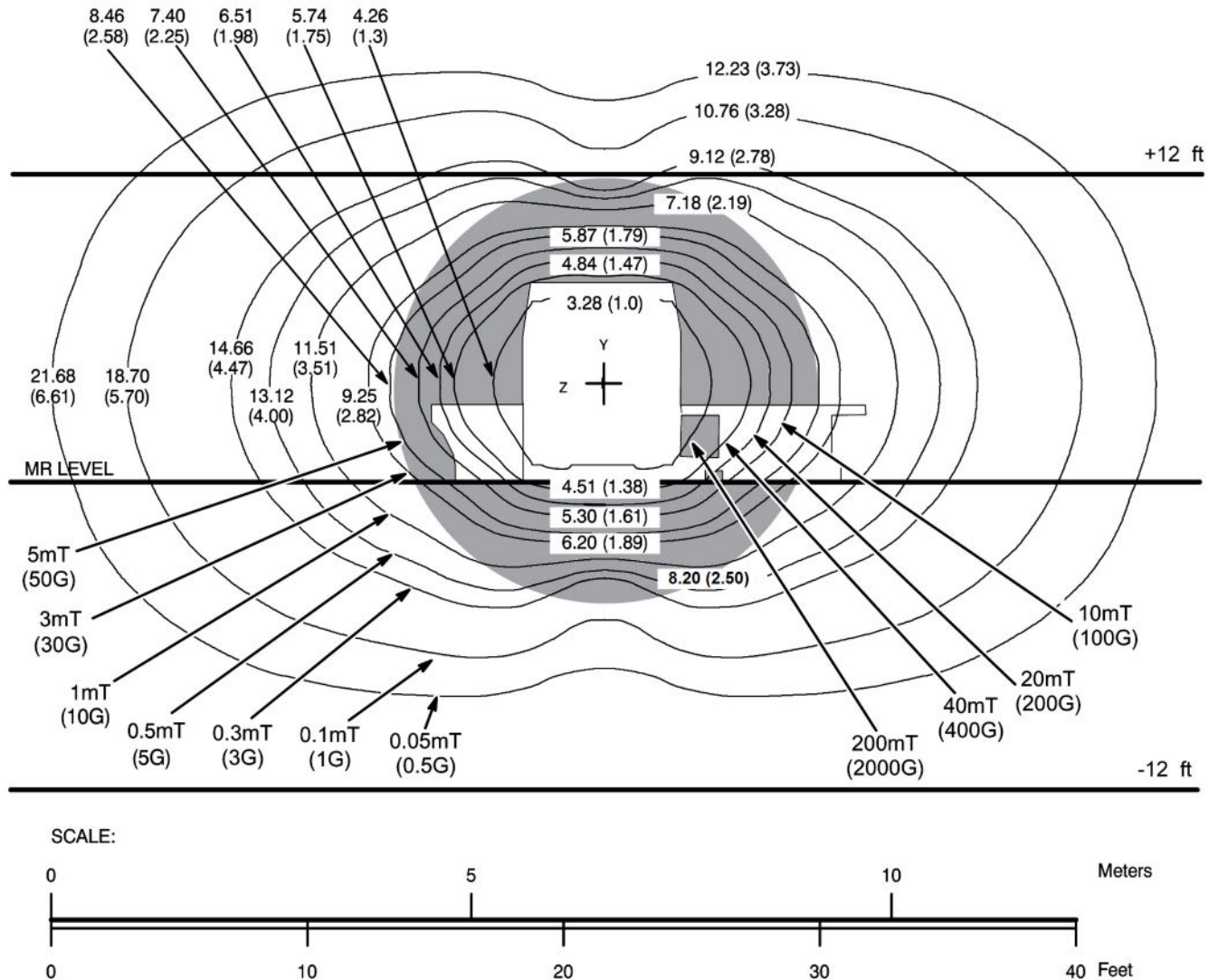


**NOTE:**

- MEASURED MAGNETIC FLUX DENSITY WILL VARY FROM PLOT DUE TO FACTORS SUCH AS CONCENTRATING EFFECTS OF NEARBY FERROUS OBJECTS AND AMBIENT FIELDS, INCLUDING EARTH'S MAGNETIC FIELD.
- POTENTIAL EXISTS UNDER FAULT CONDITIONS THAT THE 5 GAUSS LINE MAY EXPAND TO 16.40 ft (5.0 m) RADIALLY FOR 2 SECONDS OR LESS.



Illustration 3-3: 1.5 Tesla LCC Magnetic Isogauss Line Plot - Side View



**NOTE:**

- 12 ft (3.66 m) BETWEEN FLOORS.
- MEASURED MAGNETIC FLUX DENSITY WILL VARY FROM PLOT DUE TO FACTORS SUCH AS CONCENTRATING EFFECTS OF NEARBY FERROUS OBJECTS AND AMBIENT FIELDS, INCLUDING EARTH'S MAGNETIC FIELD.
- POTENTIAL EXISTS UNDER FAULT CONDITIONS THAT THE 5 GAUSS LINE MAY EXPAND TO 16.40 ft (5.0 m) RADIALLY AND 22.96 ft (7.0 m) AXIALLY FOR 2 SECONDS OR LESS.

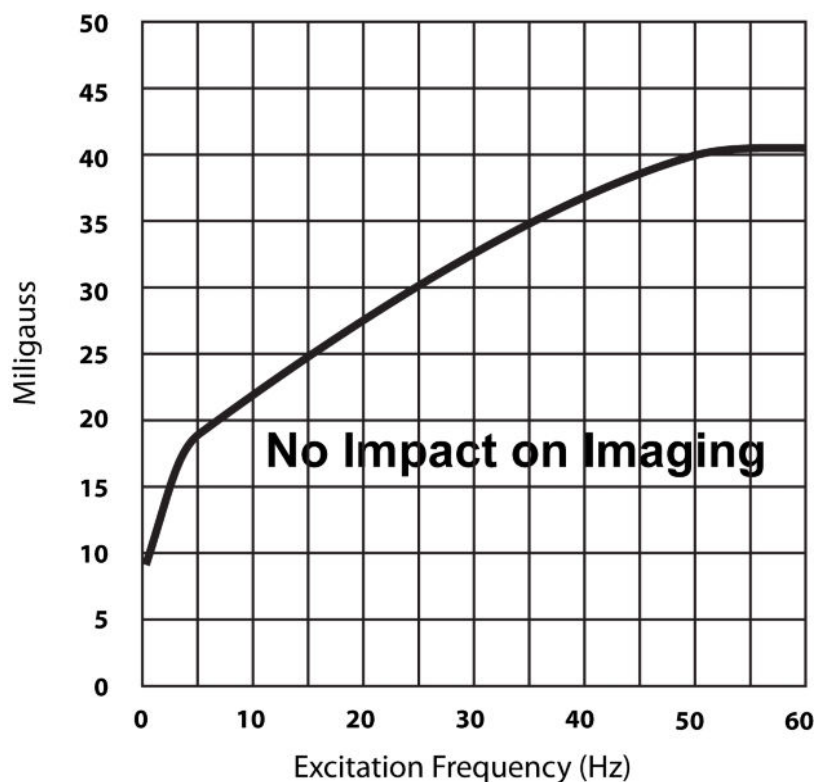
## 1.2 MR Suite Magnetic Field Specifications

### 1.2.1 Electrical Current

1. Electrical current in high voltage power lines, transformers, motors, or generators near the magnet may affect magnetic field homogeneity
2. Magnetic field interference at 50 or 60 Hz must not exceed 40 milligauss RMS respectively at the magnet location (refer to [Illustration 3-4](#))
3. The following equation can be used as a general guide in determining allowable current in feeder lines at a given distance from the magnet isocenter:
  - a. For 1.5T LCC RD Magnet:  $I = (20X^2)/S$
  - b. I = Maximum allowable RMS single phase current (in amps) or maximum allowable RMS line current (in amps) in three phase feeder lines
  - c. S = Separation (in meters) between single phase conductors or greatest separation between three phase conductors
  - d. X = Minimum distance (in meters) from the feeder lines to isocenter of the magnet

**Illustration 3-4: Magnet Allowable Milligauss vs. Line Frequency for AC Equipment**

AC Field EMI Limits



Refer to Sample Calculation AC Power Equipment Minimum Distance for additional examples.

### **1.2.2 Non-MR System Equipment Sensitivity to Magnetic Fields**

This section lists equipment known to be sensitive to high magnetic fields. Recommended limits given 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.

The table is provided as a guide only. Actual Gauss limits are equipment specific (refer to the OEM manuals). Site plans must include consideration for magnetic field interaction with customer equipment.

**NOTE:** Gauss limits for MR system equipment is provided with the specifications for each component.



**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                       | Digital X-Ray                             |
| 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          |
| 30 gauss (3mT)     | 11 kW Airsys Chiller                     |                                           |
| 50 gauss (5mT)     | System Cabinet (Penetration Side)        | Main Disconnect Panel                     |
|                    | Simple OC                                | Magnet Monitor                            |
|                    | LCD panels                               | Telephones                                |
|                    | Water Chiller (LCS, MCS, or BRM Chiller) | Metal detector for screening              |
| 100 gauss (10mT)   | Shield/Cryo Cooler Compressor Cabinet    | Oxygen Monitor                            |
|                    | Magnet Power Supply Cabinet              | Pneumatic Patent Alert Control Box        |
|                    | Shim Power Supply Cabinet                |                                           |
| 200 gauss (20mT)   | Penetration Panel                        | Magnet Run Down Unit                      |
|                    | Blower Box                               | Remote Oxygen Sensor                      |
| No Limit           | Digital Detectors                        |                                           |

### 1.2.3 Exclusion Zone

The 5 gauss exclusion zone for cardiac pacemakers, neurostimulators, and other biostimulation devices is shown in above isogauss line plot illustrations for 1.5T LCC RD Magnet. It should be noted the vertical views for the various magnetic field plots show 12 ft (3.66 m) between floors for reference. If the distance between floors is other than 12 ft (3.66 m), appropriate corrections must be made.

The interaction of the main magnet coils and the cancellation coils results in the effective shielding for the active shield magnet. Magnet quenches can actually cause a very short magnetic field transient resulting in the 5 gauss (0.5mT) field expanding for 2 seconds or less as noted in the above isogauss line plot illustrations for 1.5T LCC RD (Active Shield) magnet.

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

#### **1.2.4 Magnet Shield**



### **NOTICE**

**If a site has an existing magnetic shield and an upgrade to the LCC RD magnet is being performed, 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 for the fringe field plots for the Magnet.

Magnetic shielding can also be used to reduce the magnetic field disturbance from moving metal objects which can improve the moving metal capability.

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 which 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. The GE Healthcare MR Siting & Shielding Group has the capability to design magnetic shields which meet a broad range of site requirements.

## 2 RF Shielding

### 2.1 RF Shielded Room Requirements



#### Projectile Hazard

Improperly secured magnetic material may become a projectile hazard when the magnet is installed.

Ensure all magnetic material is properly secured.

The RF Shielded room is critical to the proper MR system operation. RF shielding prevents interaction of external RF radiation with MR system operation (it also prevents MR system RF radiation from interfering with external RF systems, such as aircraft control). Special care must be used when installing all fixtures penetrating the RF shield (e.g., vents, electrical conduit, penetration panels, etc.) to ensure the integrity of the RF shield is maintained.

The RF shielded room can be either a free standing shielded structure or a shielded room within an existing room.

#### 2.1.1 RF Noise Definitions

##### Discrete Interference

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

##### Broadband Interference

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

#### 2.1.2 RF Shield Requirements

1. The customer is responsible for contracting with an RF Shield vendor to design, install, test, the RF shield (on request, the GE Healthcare Project Manager of Installation (PMI) can supply a list of RF Shield vendors)

**NOTE:** The RF shield may not be in a temperature or humidity controlled environment. Shielding, shield support, and associated components must be installed to prevent degradation over the life of the MR system

2. The customer is responsible for maintenance and repair of RF shielding, including shielding support and associated components for the life of the MR System
3. All RF shield designs must be provided to the GE Healthcare Project Manager of Installation (PMI)
4. The customer must notify the GE Healthcare Project Manager of Installation (PMI) immediately with any changes to the shielding design or other installation issues
5. The RF shielded room must provide a minimum of 100 dB of shielding effectiveness (SE) for the entire room at the following frequencies:

- 63.86 MHz +/- 0.5 MHz
- 51.00 +/- 0.5 MHz
- 76.60 +/- 0.5 MHz

**NOTE:** Additional testing of 100 dB SE at 102.20, 127.72, and 153.30 MHz is recommended for all new construction to accommodate future upgrades.

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

6. The customer must work with the RF shield vendor to install any non-GE Healthcare penetration points
7. The RF shield must be isolated from ground by more than 1000 ohms
8. The RF shielding must be grounded to the RF common ground stud (which is grounded back to the Power Distribution Unit in the Power, Gradient, RF cabinet)
9. Facility power to the Magnet room must not compromise the RF Shield primary ground
10. RF shield materials must not affect magnetic homogeneity
11. Any moving part (such as doors) must not contain magnetic materials
12. RF shield RF attenuation and ground testing is performed by the customer with a report provided to the GE Healthcare Project Manager of Installation (PMI)

### ***2.1.3 Broadband Interference Avoidance Requirements***

1. Ensure all joints and mechanical connections remain secure:
  - a. All solder joints must be clean and properly prepared
  - b. All mechanical fasteners must be sufficiently tightened and secured
  - c. Do not use rivets or self-tapping screws (as these tend to loosen over time due to vibration)
2. Doors and door frames must be structurally stiff to prevent physical changes to the RF shield

### ***2.1.4 Ambient Radio Frequency Interference (RFI) Requirements***

The MR System uses 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. 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, the GE Healthcare representative 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 the table below 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 imaging and spectroscopy.

**Table 3-2: Radio Frequency Survey Specifications**

| Isotope          | Bandcenter MHz | Bandwidth Hz |
|------------------|----------------|--------------|
| <sup>1</sup> H   | 63.86          | 916,138      |
| <sup>19</sup> F  | 60.12          | 981,882      |
| <sup>31</sup> P  | 25.88          | 390,296      |
| <sup>23</sup> Na | 16.90          | 242,773      |
| <sup>13</sup> 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  $\pm$  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)

### **2.1.5 Magnet Mounting and Dock Anchor Mounting Requirements**

**NOTE:** Magnet mouting and dock anchor mounting need to be consistent, please refer to [Chapter 2, Section 3.3.1, Magnet Mounting Requirements](#)

## 2.2 RF Shield Consideration for System Cabinet and Penetration Panel

This section describes method for mounting the GE MR System Cabinet and Penetration Panel. The penetration panel and System Cabinet 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.

Refer to following section for dimensions of System Cabinet and Penetration Panel.

- [Chapter 2, System Cabinet](#)
- [Chapter 2, Mesh Shield and System Cabinet Cover](#)
- [Chapter 2, Penetration Panel](#)



### 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.

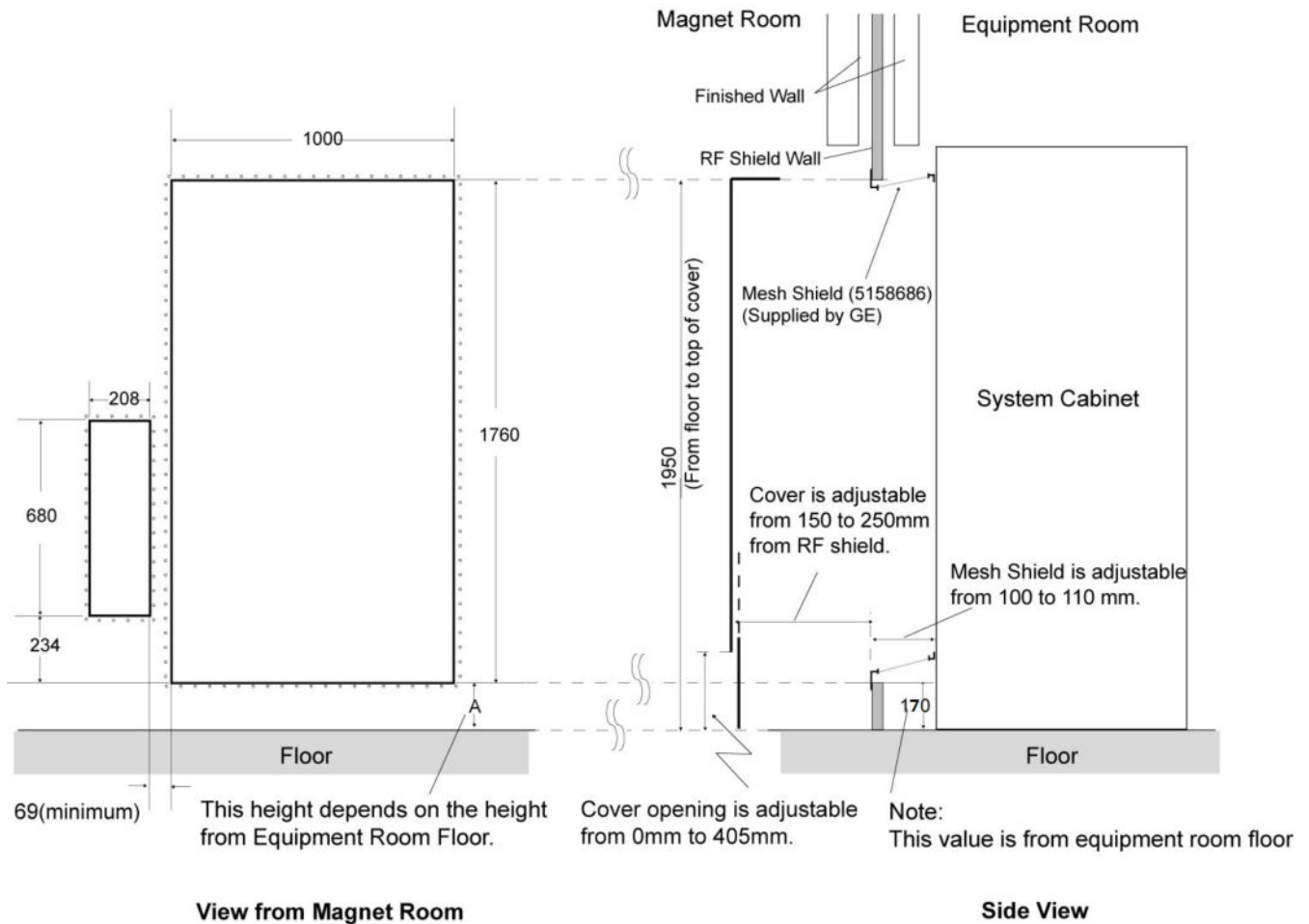
The RF shielded room acceptance test must be performed after the opening is cut in the RF shielding for the GE Penetration Panel and Mesh Shield Tunnel. This acceptance test must be conducted with vendor supplied blank panel and the same mounting hardware to be used with the GE Penetration Panel and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

The Penetration Panel and System Cabinet 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 and the System Cabinet are shown in this section.

[Illustration 3-5](#) shows the wall opening for System Cabinet and Penetration Panel.

### Illustration 3-5: RF Shield Opening

System Cabinet and Penetration Panel Opening specification Note: All Dimensions are in millimeters



**Notice 1:**

If the Penetration Panel is placed at the opposite side of system cabinet, keep **169mm** or more between System Cabinet Opening and Penetration Panel Opening.

**Notice 2:**

Penetration Panel and System Cabinet must be placed on the same wall plane and they must not be placed further than 7m. If the condition above cannot be satisfied, it is necessary to consider the ground line and cooling water hose routing.

**Notice 3:**

System Cabinet Cover (Magnet Room Side) is supplied by GE.

**NOTE:** If single-point ground bar is prepared by customer, locate it according to the information in [Chapter 5, Section 2.1.2, System Ground](#).

**Illustration 3-6** shows the equipment room side view of the wall opening. The dotted line shows the out line of the System Cabinet. make sure that the wall cutoff is not symmetric with System Cabinet center.

**Illustration 3-6: Notice about System Cabinet Cut Off**

Note that the system cabinet is placed as following illustration.(View from Equipment Room)  
Right edge of the system cabinet is aligned to the right edge of the opening.

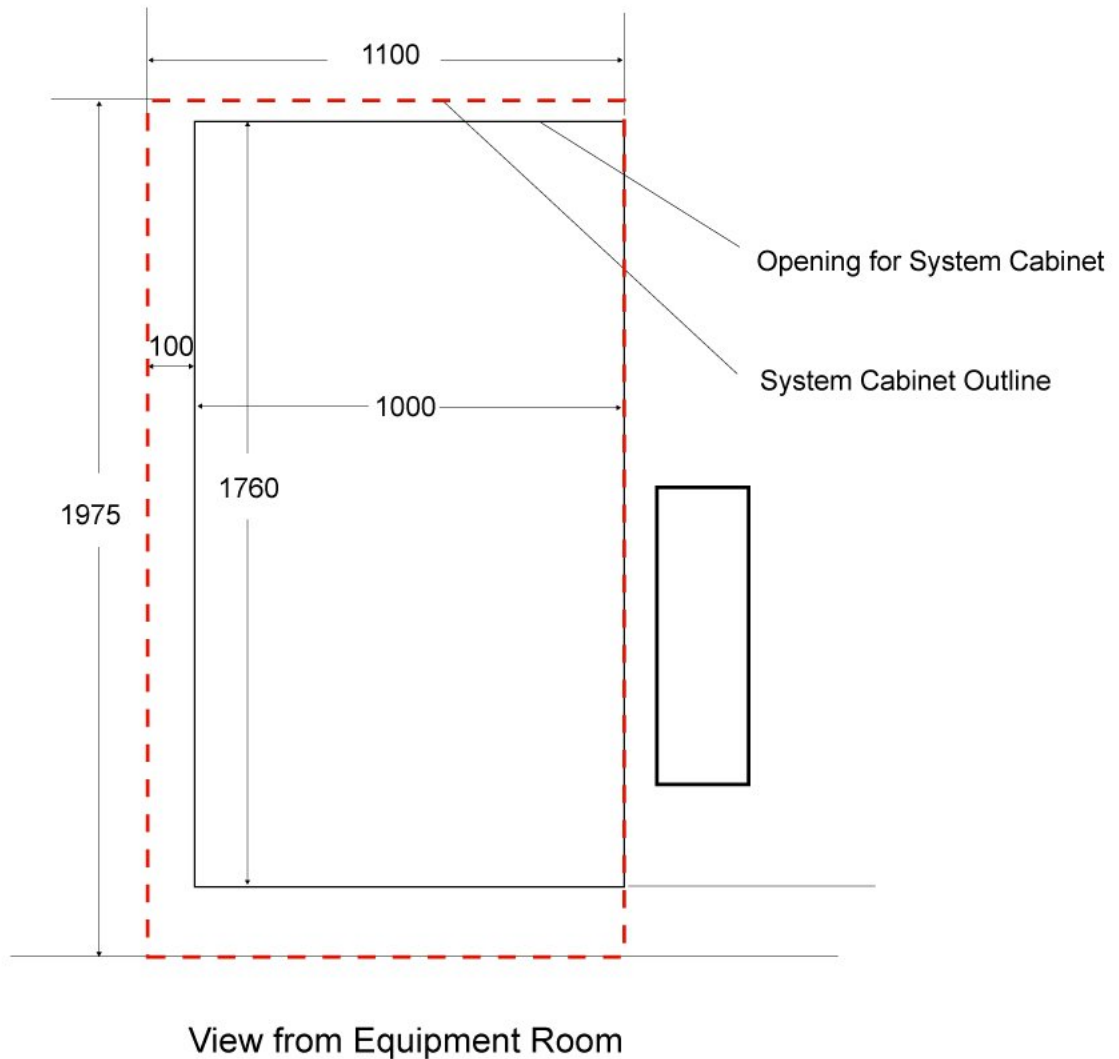




Illustration 3-7 shows wall cutoff detail for System Cabinet (Magnet Room Side).

Illustration 3-7: Wall for System Cabinet Detail (Magnet Room Side)

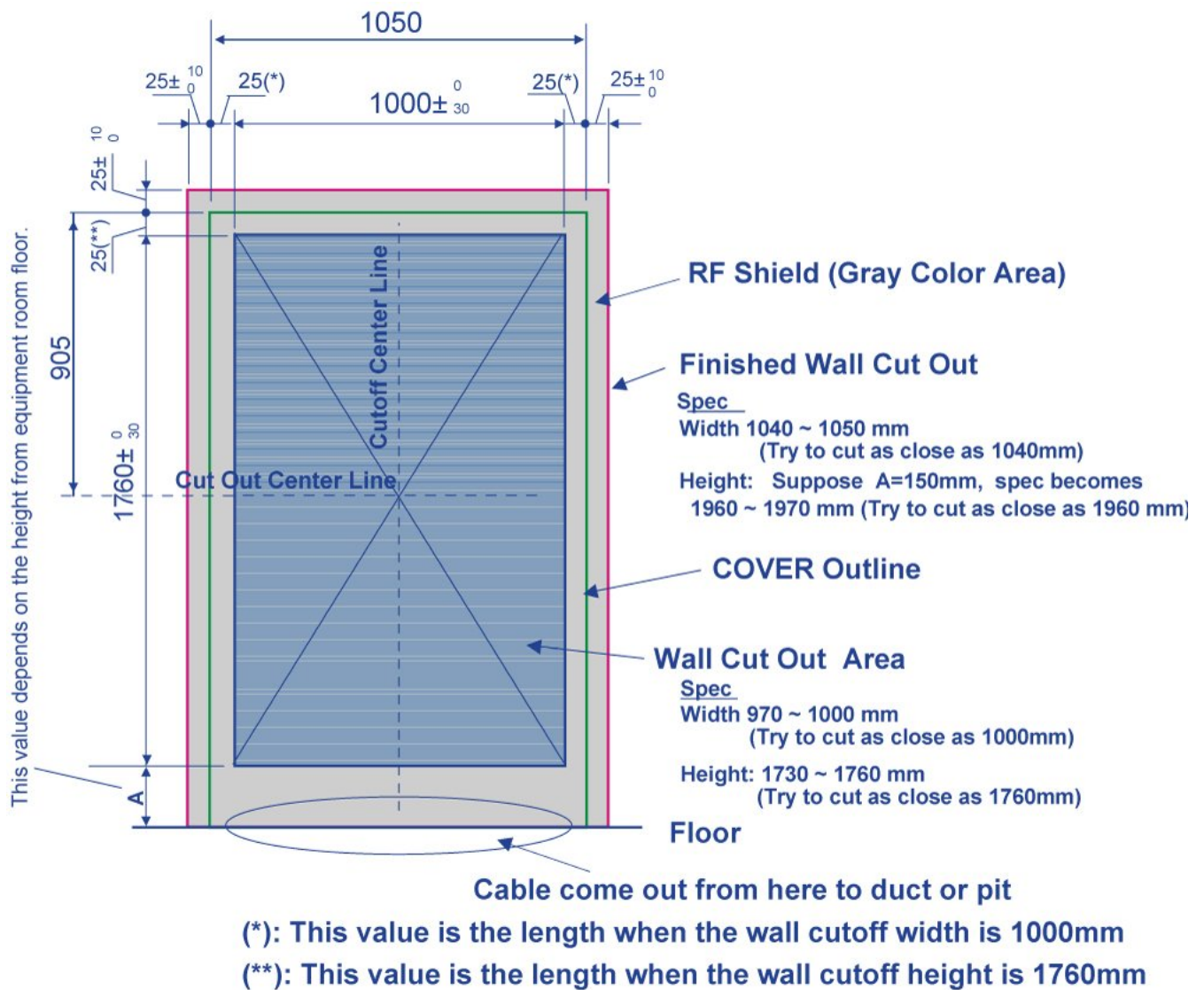
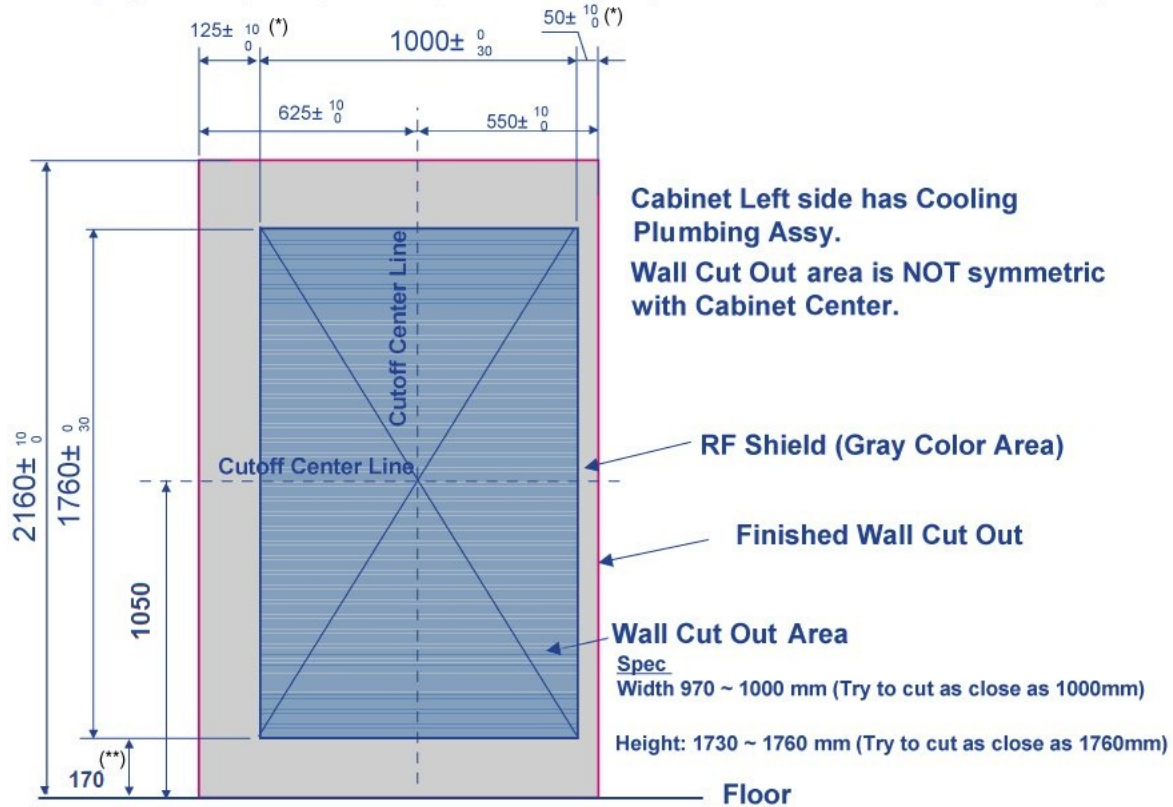


Illustration 3-8 shows wall cutoff detail for System Cabinet (Equipment (or Operator) Room Side).

Illustration 3-8: Wall for System Cabinet Detail (Equipment (or Operator) Room Side)

### Equipment(or Operator) Room Side (Wall for Mesh Shield Detail)

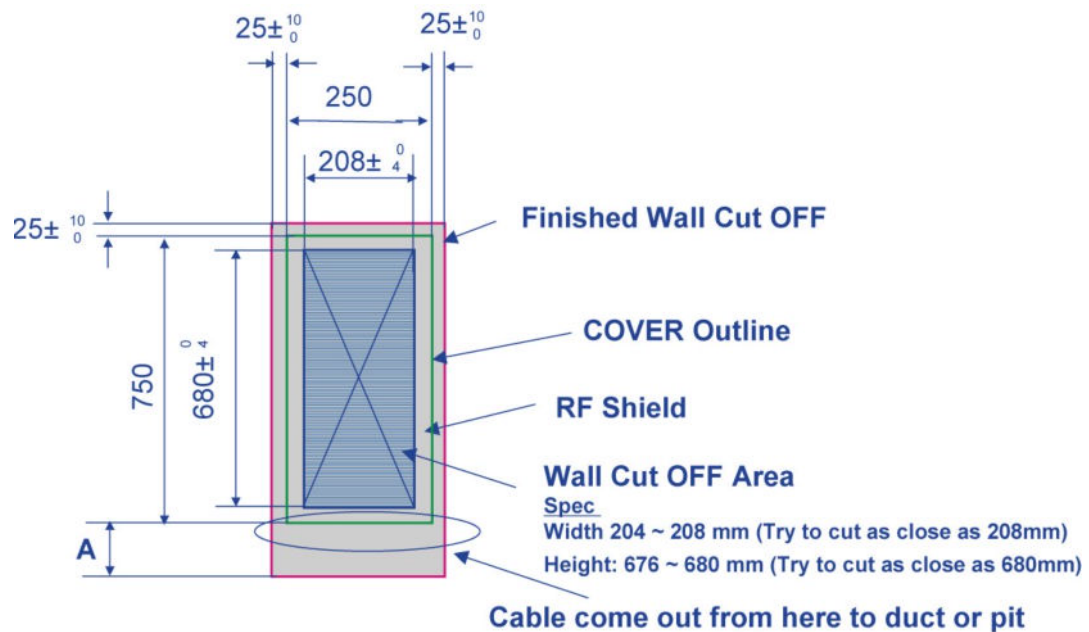


(\*): This value is the length when the wall cutoff width is 1000mm

(\*\*): This value is the length when the wall cutoff height is 1760mm

Illustration 3-9 shows wall cutoff detail for Penetration Panel (Magnet Room Side and Equipment (or Operator) Room Side).

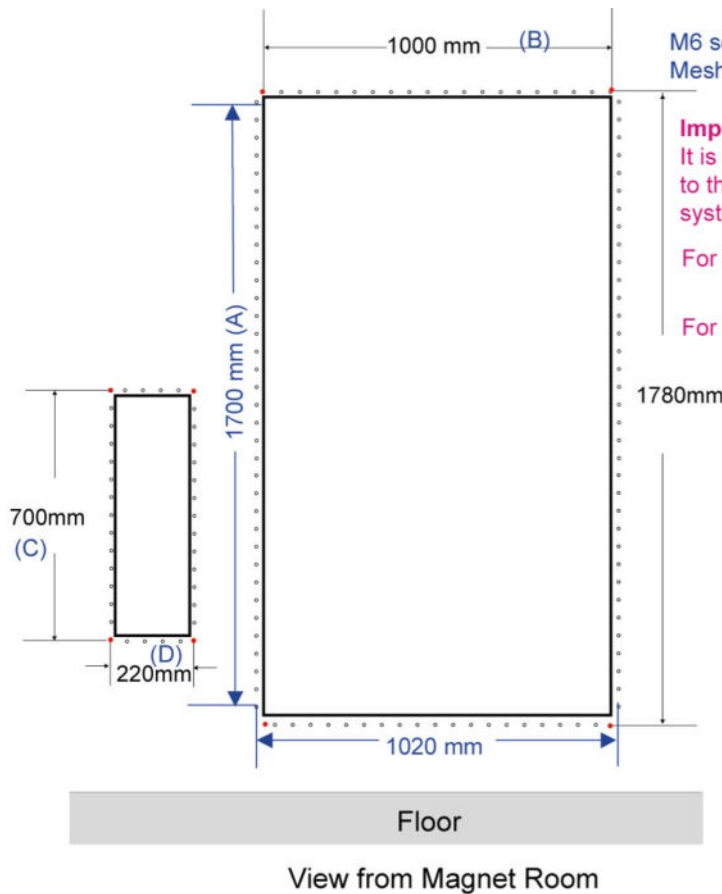
Illustration 3-9: Wall for PP Detail (Magnet Room Side and Equipment (or Operator) Room Side)



A: This value is decided according to the site layout.

Illustration 3-10 shows screw location for Mesh Shield and Penetration Panel.

**Illustration 3-10: Screw Information Of Mesh Shield and PP**



M6 screws are used to fix Mesh Shield and PP.  
Mesh shield and PP will be screwed from Magnet Room Side.

**Important!!**

It is RF vendor's responsibility to prepare M6 screws according to the site condition. Mesh shield and PP will be installed during system installation by mechanical Installer.

For Wooden RF shield wall:

M6 wood screws.

For RF shield wall which has holes for screw:

M6 screws and M6 nuts

A: 35 screws  
Pitch 50mm x 34 = 1700mm

B: 21 screws  
Pitch 50mm x 20 = 1000mm

C: 15 screws  
Pitch 50mm x 14 = 700mm

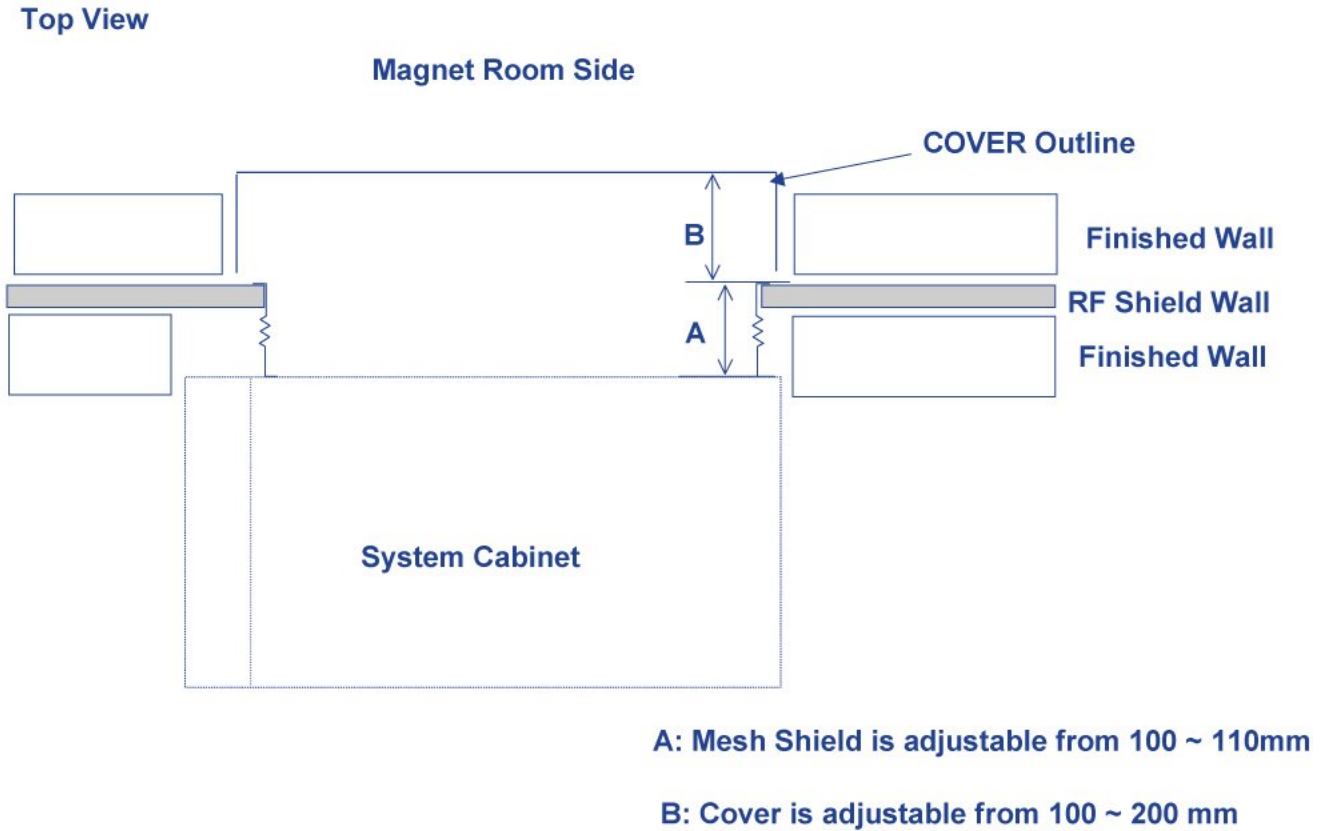
D: 6 screws  
Pitch 44 mm x 5 = 220mm

Total screw number =  
 $A \times 2 + B \times 2 + C \times 2 + D \times 2 - 4 =$   
 $70 + 42 + 30 + 12 - 4 = 150$

(=> Prepare 170 screws to fix PP and Mesh Shield)

Illustration 3-11 shows Top View of System Cabinet and Wall.

Illustration 3-11: System Cabinet Cover Top View



**NOTE:** It is recommended to extend Mesh Shield in between 100mm and 110mm. However, Mesh Shield can be extended to 180mm without any slack. In case there is any reason that the System Cabinet cannot be located closely enough to the RF shield, it is local site engineer's responsibility to extend Mesh Shield more than 110mm. Consider floor level under System Cabinet severely when extending the Mesh Shield more than 110mm.

Illustration 3-12 shows Top View of duct or pit.

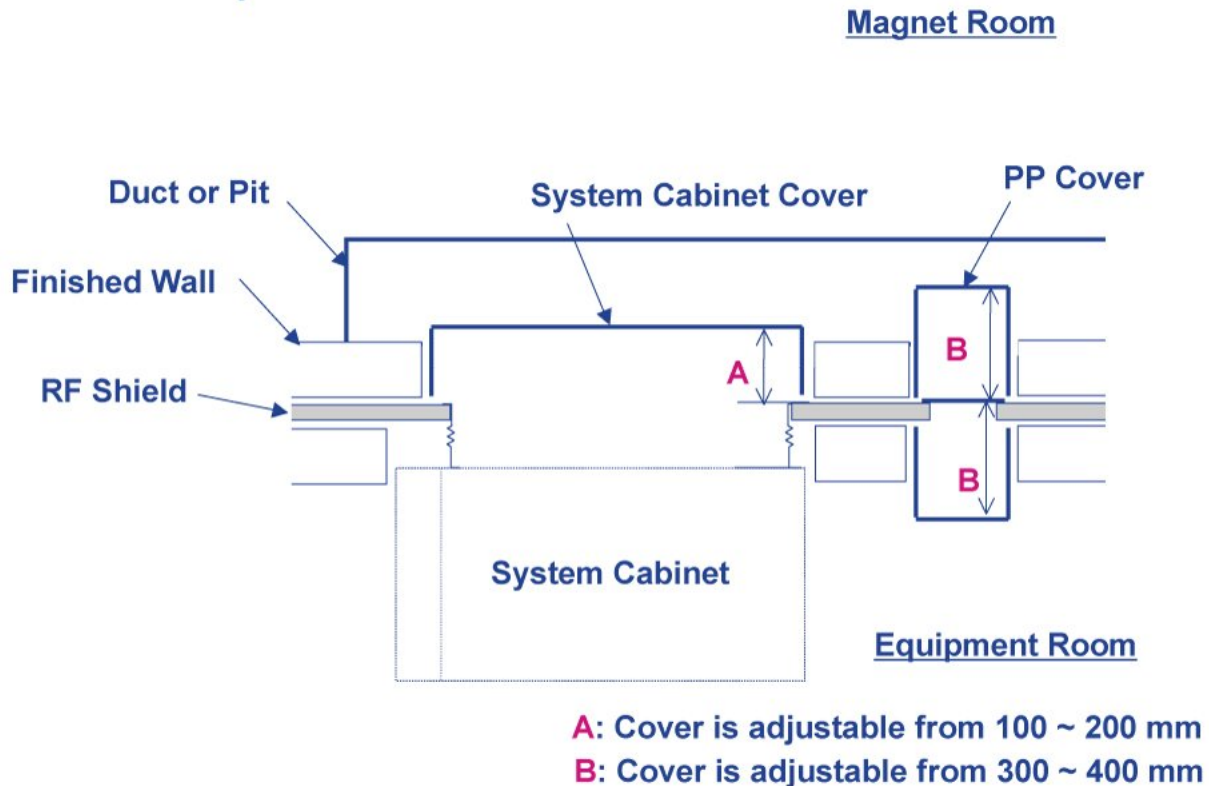


## NOTICE

When cutting the duct or pit for cable routing, make sure the System Cabinet Cover can cover the cutoff for the cable.

Illustration 3-12: Duct or Pit Top View

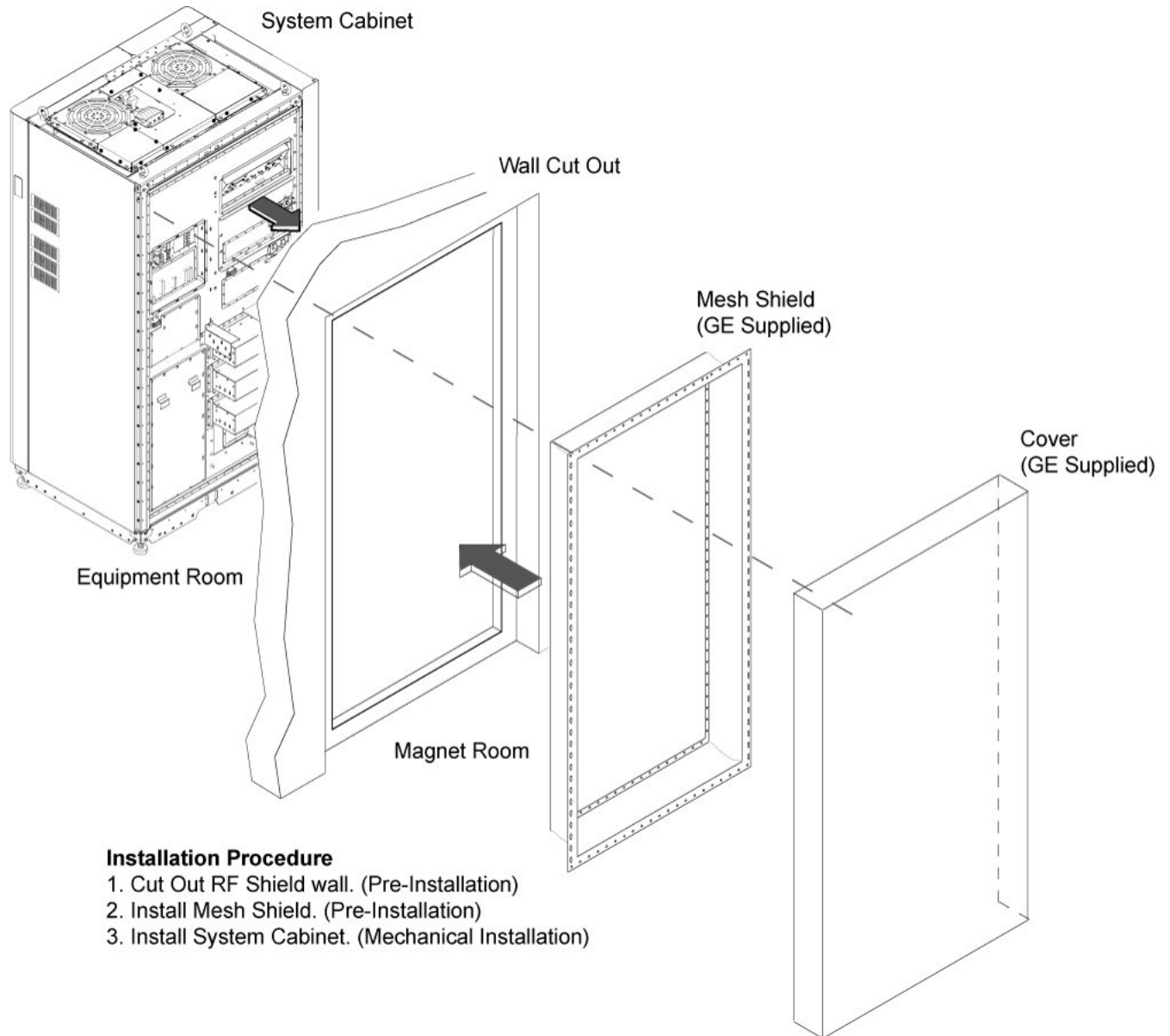
### Duct or Pit Top View



#### Notice:

When cutting the Duct or Pit for cable routing, make sure the System Cabinet Cover can cover the cut out for the cable.

**Illustration 3-13: Relationship of Mesh Shield and System Cabinet**



## **2.3 Electrical**

Ground Line of Filter for Facility Electrical Devices (Exam Room Lights, etc) must be connected to the equal level to the RF Shield.



## **2.4 RF Door Switch**

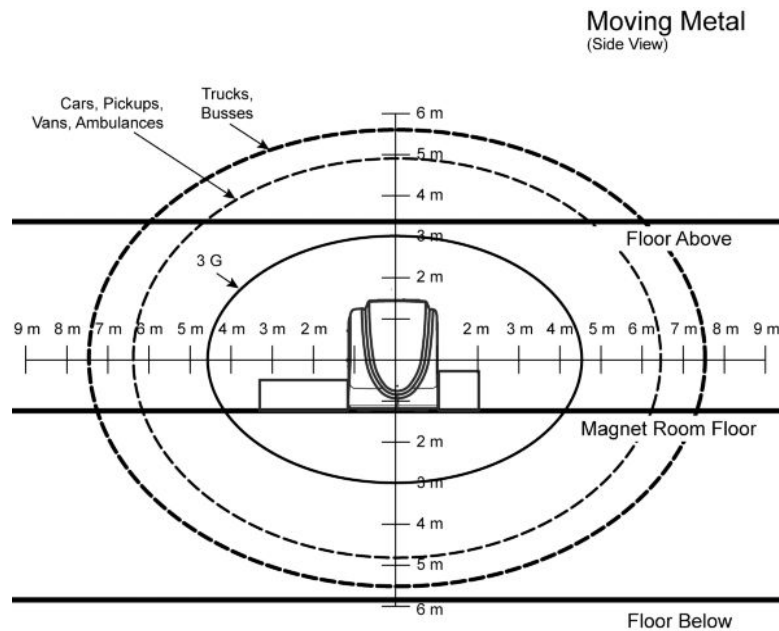
RF shielded room vendor must supply and install RF door switches on all RF shielded doors. These switches must be wired in series and a GE supplied cable (two loose lead conductors) will attach to one door switch. RF switches must be rated for 24 volts at 750 milliamperes maximum and the switches must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

### 3 EMI Consideration

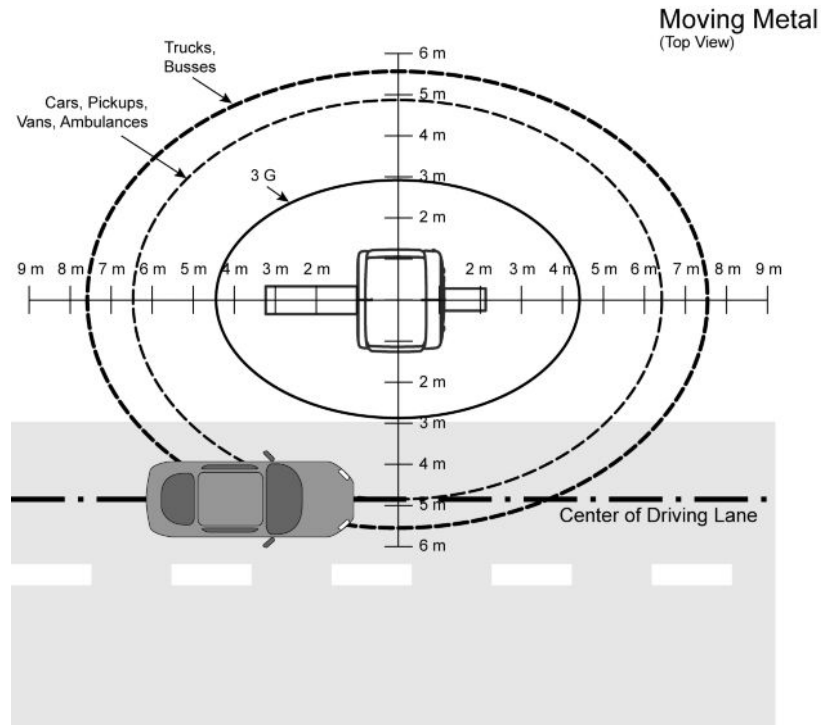
#### 3.1 Interference from Changing Magnetic Fields

Metal objects moving within the magnet sensitivity lines can produce a field disturbance during clinical imaging. If the metal object is moving it will produce a fluctuating dipole type of field which cause image artifacts. As an example, a car driven inside the moving metal line will act as a dipole and produce a time varying field which change the magnet's main field during the imaging time. The same vehicle may park within the moving metal line and remain parked during clinical scanning without impact to the main field. See [Illustration 3-14](#) and [Illustration 3-15](#).

**Illustration 3-14: Magnet Moving Metal Sensitivity Line Plot (Side View)**



**Illustration 3-15: Magnet Moving Metal Sensitivity Line Plot (Top View)**



**Table 3-3: Magnet Moving Metal Requirements**

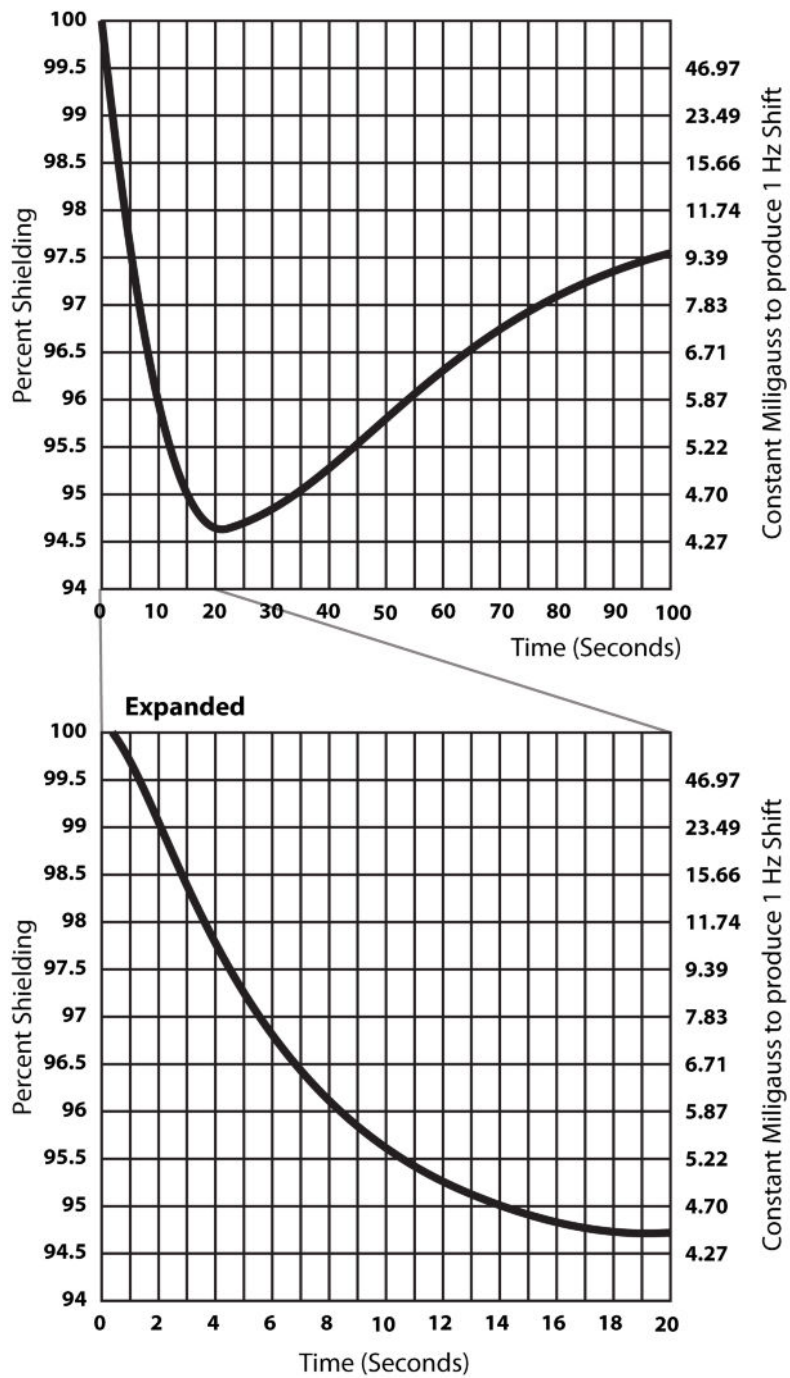
| Steel Objects Category                          | Definition Of Distance Location                                                                                                                              | Minimum Distance Radial X Axial ft (m)<br>See Note 1            |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| 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 <a href="#">Illustration 3-16</a> 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.
  - a. 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.
  - b. 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.
  - c. Use 4.43 milligauss peak-to-peak.

Illustration 3-16: Actual Axial Shielding Performance

Actual Axial  
Shielding Performance



## Chapter 4 Environmental Requirements (HVAC)

### 1 Relative Humidity and Temperature

#### 1.1 System Suite



#### NOTICE

If these temperature and humidity specifications are not strictly adhered to, failures of the Gradient Amplifier Module of the System Cabinet may occur.

Use the specifications listed in [Table 4-1](#) or [Table 4-2](#) according to the system configuration 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.

**NOTE:** To help prevent a patient from feeling uncomfortably warm during a scan, make sure the magnet room temperature does not exceed 69.8°F (21°C) maximum.

**Table 4-1: Temperature And Humidity Specifications for System with Equipment Room**

| Area                                                                                                                                                                                                                                                                          | Temperature                                                                                                                                                                                                                                                           |                      | Humidity |             | Max. Room Gradient °F (°C) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|-------------|----------------------------|
|                                                                                                                                                                                                                                                                               | Range °F (°C)                                                                                                                                                                                                                                                         | Change °F/Hr (°C/Hr) | Range %  | Change %/Hr |                            |
| Equipment Room at In-let to Equipment                                                                                                                                                                                                                                         | 59-82.4* (15-28)* @ -30.5m to 800m<br>59-80.6* (15-27)* @ 800m to 1100m<br>59-78.8* (15-26)* @ 1100m to 1400m<br>59-77.0* (15-25)* @ 1400m to 1700m<br>59-75.2* (15-24)* @ 1700m to 2000m<br>59-73.4* (15-23)* @ 2000m to 2300m<br>59-71.6* (15-22)* @ 2300m to 2438m | 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)                      |
| <b>Note</b><br>* Non-condensing humidity with 50% nominal at 65°F (18.3°C).<br>** Room temperature gradient specification applies from floor to height of top discharge of equipment cabinets.<br>Maximum ambient temperature is derated by 1 degree C per 300 m above 2000m. |                                                                                                                                                                                                                                                                       |                      |          |             |                            |



## NOTICE

For the system without equipment room, the temperature of Operator Room needs to be set under 82.4°F (28°C) .

Communication with customer is needed before site planning.

Table 4-2: Temperature And Humidity Specifications for System without Equipment Room

| Area                                                                                                                                                                                                                                                                          | Temperature                                                                                                                                                                                                                                                           |                      | Humidity |             | Max. Room Gradient °F (°C) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------|-------------|----------------------------|
|                                                                                                                                                                                                                                                                               | Range °F (°C)                                                                                                                                                                                                                                                         | Change °F/Hr (°C/Hr) | Range %  | Change %/Hr |                            |
| Magnet Room                                                                                                                                                                                                                                                                   | 59-69.8 (15-21)                                                                                                                                                                                                                                                       | 5 (3)                | 30-60*   | 5           | 5 (3)                      |
| Operator's Control Room                                                                                                                                                                                                                                                       | 59-82.4* (15-28)* @ -30.5m to 800m<br>59-80.6* (15-27)* @ 800m to 1100m<br>59-78.8* (15-26)* @ 1100m to 1400m<br>59-77.0* (15-25)* @ 1400m to 1700m<br>59-75.2* (15-24)* @ 1700m to 2000m<br>59-73.4* (15-23)* @ 2000m to 2300m<br>59-71.6* (15-22)* @ 2300m to 2438m | 5 (3)                | 30-75*   | 5           | 5 (3)                      |
| <b>Note</b><br>* Non-condensing humidity with 50% nominal at 65°F (18.3°C).<br>** Room temperature gradient specification applies from floor to height of top discharge of equipment cabinets.<br>Maximum ambient temperature is derated by 1 degree C per 300 m above 2000m. |                                                                                                                                                                                                                                                                       |                      |          |             |                            |

## 1.2 11Kw Airsys Chiller Operating Environment

The 11kw Airsys Chiller is designed to be located external to the building and operate in environments meeting the following specifications.

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

## **2 Altitude**

100 ft (30.5 m) below sea level to 7992 ft (2438 m) above sea level.

### 3 Heat Output

Table 4-3 and Table 4-4 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 (i.e. protocols used, patient load, etc.). Note any variations of equipment location for your site when calculating your cooling requirements for each room.



#### **NOTICE**

For Type A, C, D and E system configuration, BRM is cooled by coolant during night time even though System Cabinet PDU is turned off by night mode. To prevent condensation of BRM, it is required to operate air conditioner in Magnet Room for 24 hours/day, 7 days/week for Type A, C, D and E system configuration.



**Table 4-3: Optima MR360 / Brivo MR355 System Maximum Heat Output For Air Cooling for Type A, B (B')**

| MR Component                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Magnet Room<br>See Note 1 listed below |      | Operator/Control Room<br>See Note 2 listed below |         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------|--------------------------------------------------|---------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | BTU/hr                                 | Watt | BTU/hr                                           | Watt    |
| RF/Gradient Body Coil Assembly, Magnet Enclosure Equipment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 8189                                   | 2400 |                                                  |         |
| Patient Blower Box                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3415                                   | 1000 |                                                  |         |
| MRE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 682                                    | 200  |                                                  |         |
| System Cabinet                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        |      | 17,000                                           | 5,000   |
| Water Chiller for BRM (4kW LCS) for Type B (B') Only                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                        |      | * 5,695                                          | * 1,670 |
| Water Chiller for SC (8kW LCS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        |      | 5,695                                            | 1,670   |
| Magnet Monitor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        |      | 205                                              | 60      |
| Shield/Cryo Cooler Compressor -Water Cooled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                        |      | 1,706                                            | 500     |
| Operator Workspace with LCD Color Display (See Note 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                        |      | 4950                                             | 1450    |
| GE pre-engineered Main Disconnect Panel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                        |      | 900                                              | 264     |
| <b>Notes</b><br>* This value is for Type B (B') Configuration Only.<br>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 <a href="#">Relative Humidity and Temperature</a> . It is recommended that cool inlet air be directed towards the Blower Box intake which contain a patient cooling fan.<br>2. FOR OPERATOR ROOM ONLY: Although the air cooling load averaged over a 12 hour working day is approximately 1/2 of the maximum value, the Operator Room HVAC system must be sized such that Maximum Room Gradient, Temperature Range, Temperature Change per Hour, and Humidity specifications per <a href="#">Relative Humidity and Temperature</a> 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.<br>3. Operator Workspace equipment includes the following: LCD Color Monitor, Simple OC Computer Cabinet, Mouse and Mouse Pad, and SCIM Keyboard. |                                        |      |                                                  |         |

**Table 4-4: Optima MR360 / Brivo MR355 System Maximum Heat Output For Air Cooling for Type C, D, E**

| MR Component                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Magnet Room<br>See Note 1 listed below |      | Equipment Room<br>See Note 2 listed below |           | Operator/Control Room |      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------|-------------------------------------------|-----------|-----------------------|------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | BTU/hr                                 | Watt | BTU/hr                                    | Watt      | BTU/hr                | Watt |
| RF/Gradient Body Coil Assembly, Magnet Enclosure Equipment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8189                                   | 2400 |                                           |           |                       |      |
| Patient Blower Box                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3415                                   | 1000 |                                           |           |                       |      |
| MRE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 682                                    | 200  |                                           |           |                       |      |
| System Cabinet                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                        |      | 17,000                                    | 5,000     |                       |      |
| Water Chiller for BRM (Lytron Chiller) For Type D, E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                        |      | * 14,000                                  | * 4100    |                       |      |
| Water Chiller for SC (MCS) – For Type C,D,E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                        |      | ** 19,613                                 | ** 5,740  |                       |      |
| Magnet Monitor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                        |      | 205                                       | 60        |                       |      |
| Shield/Cryo Cooler Compressor -Air Cooled For Type D                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                        |      | *** 28,100                                | *** 8,240 |                       |      |
| Shield/Cryo Cooler Compressor -Water Cooled For Type C, E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                        |      | **** 1,706                                | **** 500  |                       |      |
| Operator Workspace with LCD Color Display (See Note 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                        |      |                                           |           | 4950                  | 1450 |
| GE pre-engineered Main Disconnect Panel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        |      | 900                                       | 264       |                       |      |
| Heat Dissipated of Step Down Transformer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                        |      | 760                                       | 223       |                       |      |
| <b>Notes</b><br>* For Type D, E Configuration Only<br>** For Type C, D, E Configuration Only<br>*** For Type D Configuration Only<br>**** For Type C, E Configuration Only<br>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 <a href="#">Relative Humidity and Temperature</a> . It is recommended that cool inlet air be directed towards the Blower Box intake which contain a patient cooling fan.<br>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 <a href="#">Relative Humidity and Temperature</a> 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.<br>3. Operator Workspace equipment includes the following: LCD Color Monitor, Simple OC Computer Cabinet, Mouse and Mouse Pad, and SCIM Keyboard. |                                        |      |                                           |           |                       |      |

### 11 Kw Airsys Chiller

The 11kW Chiller is designed to locate external to the building. The following is heat output information of 11 Kw Airsys Chiller.

11 Kw Airsys Chiller: 50,500 BTU/hr (15,400 Watt)

## **4 Air Quality**

### **4.1 Air Quality**

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.

Since static discharge can cause system failures or affect its operation, carpeting should be of the anti-static type or treated with an anti-static solution.

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

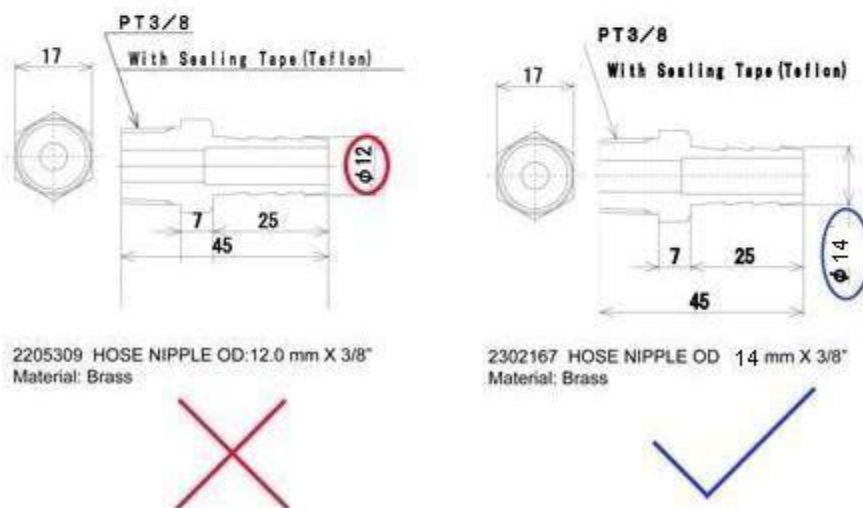
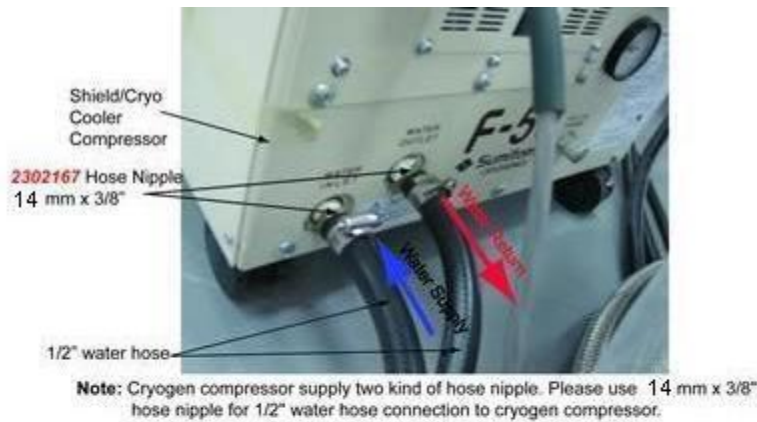
The computer/equipment area requires that the air be filtered to remove 90 percent of all particles down to 10 microns and 80 percent of all particles from 10 to 5 microns in size.

## 5 Water Cooling

### 5.1 Water Chiller Siting Considerations

Cryogen compressor supply two kind of hose nipple. There are two steps between the connection of 1/2" hose to cryogen compressor: 3/8" side of hose nipple to cryogen compressor; 14mm side of hose nipple to 1/2" water hose.

Illustration 4-1: Hose Nipple



#### 5.1.1 Type A Configuration

This configuration consists of two 11kW Chillers. The one 11kW Chiller (WC1) provides water for 8kW LCS (WC2) and BRM.

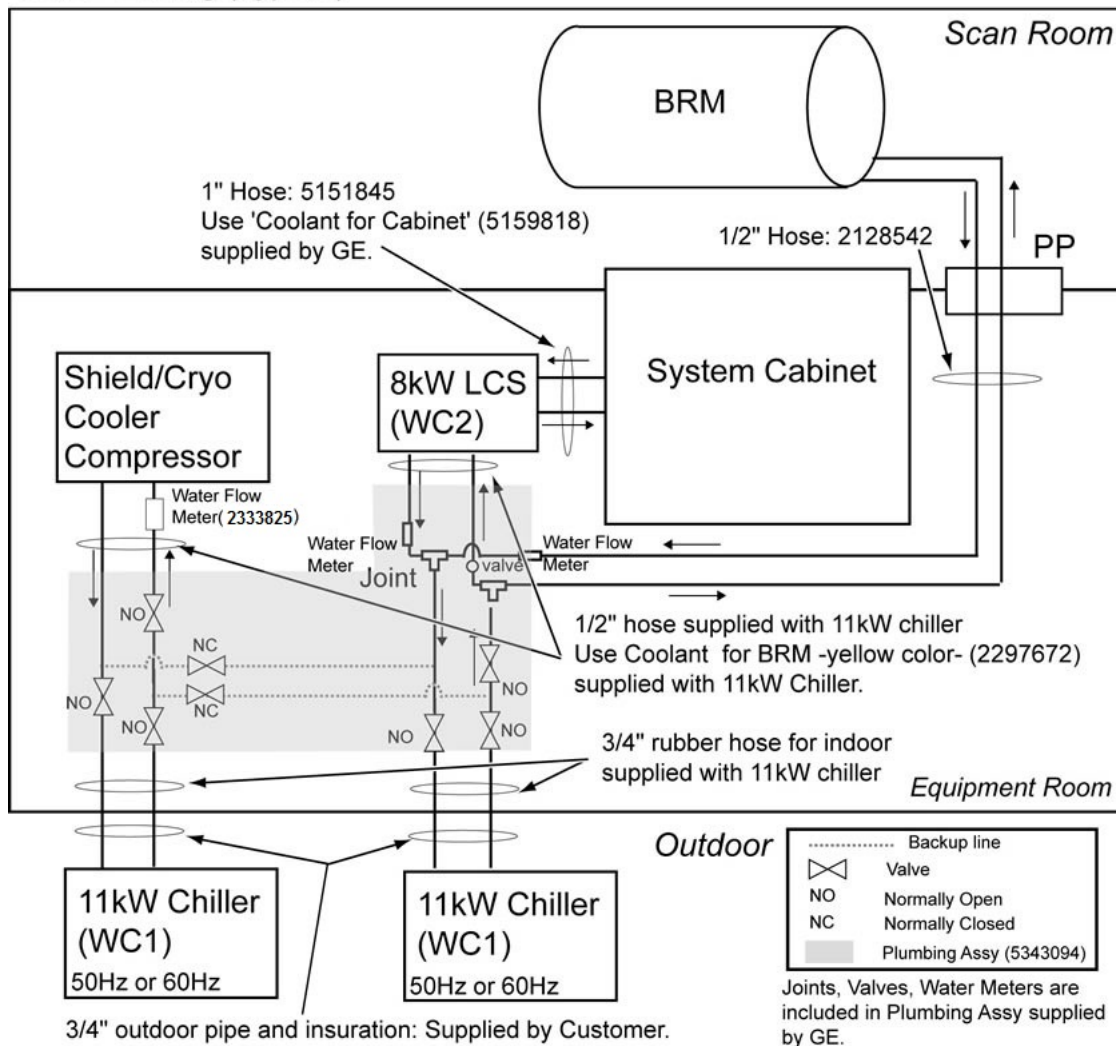
The other 11kW Chiller provide water for Shield/Cryo Cooler Compressor. The supply and return lines of Both 11kW Chillers are connected and normally closed by water valves as backup line.

The 8kW LCS (WC2) is an indoor dedicated, closed loop, chilled water is provided for the System Cabinet.

Regarding 11kW Chiller for 8kW LCS and BRM, the two hoses (supply and return) are routed from the 11kW Chiller (WC1). Each hoses are separated into two hoses by T-Shape Joint. One hose set (supply and return lines) is connected to 8kW LCS (WC2) for System Cabinet. The other hose set (supply and return lines) is routed through waveguides in the Penetration Panel, through the Rear Pedestal (MG3), and connect to the rear of the Gradient Coil with supplied adjustable compression clamps. The 8kW LCS (WC2) for System Cabinet must be located at the same level of System Cabinet.

Illustration 4-2: Type A Chiller Configuration

Water Cooling (Type A)



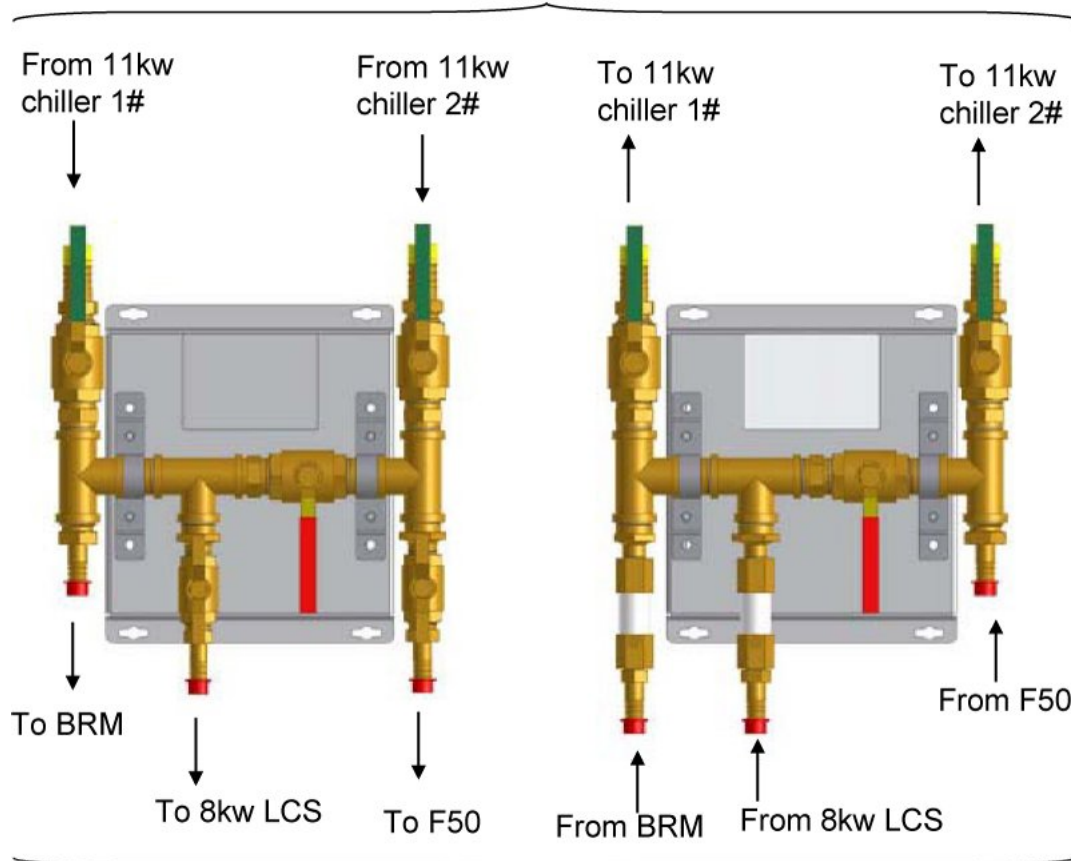
For outdoor, copper or PP-R pipe/joint/valve is recommended which satisfies the following requirement.

- Working temperature:  $-30^{\circ}\text{C} \sim 90^{\circ}\text{C}$
- Working pressure:  $\geq 1.6\text{MPa}$
- Material should be propylene glycol (50%) resistant.
- All pipes installed outdoor should be insulated.

**Note:** Only use 12.7mm x 3/8" hose nipple for 1/2" water hose connection to cryogen compressor.

Illustration 4-3: Plumbing Assy for Type A

Hose Inner Diameter = 3/4"



Hose Inner Diameter = 1/2"

### **5.1.2 Type B Configuration**

This configuration uses the water provided by Facility. This water must meet the specification described in [Requirements For Site Provided Facility Chilled Water or Local Chiller for Type B \(B'\) Configuration](#).

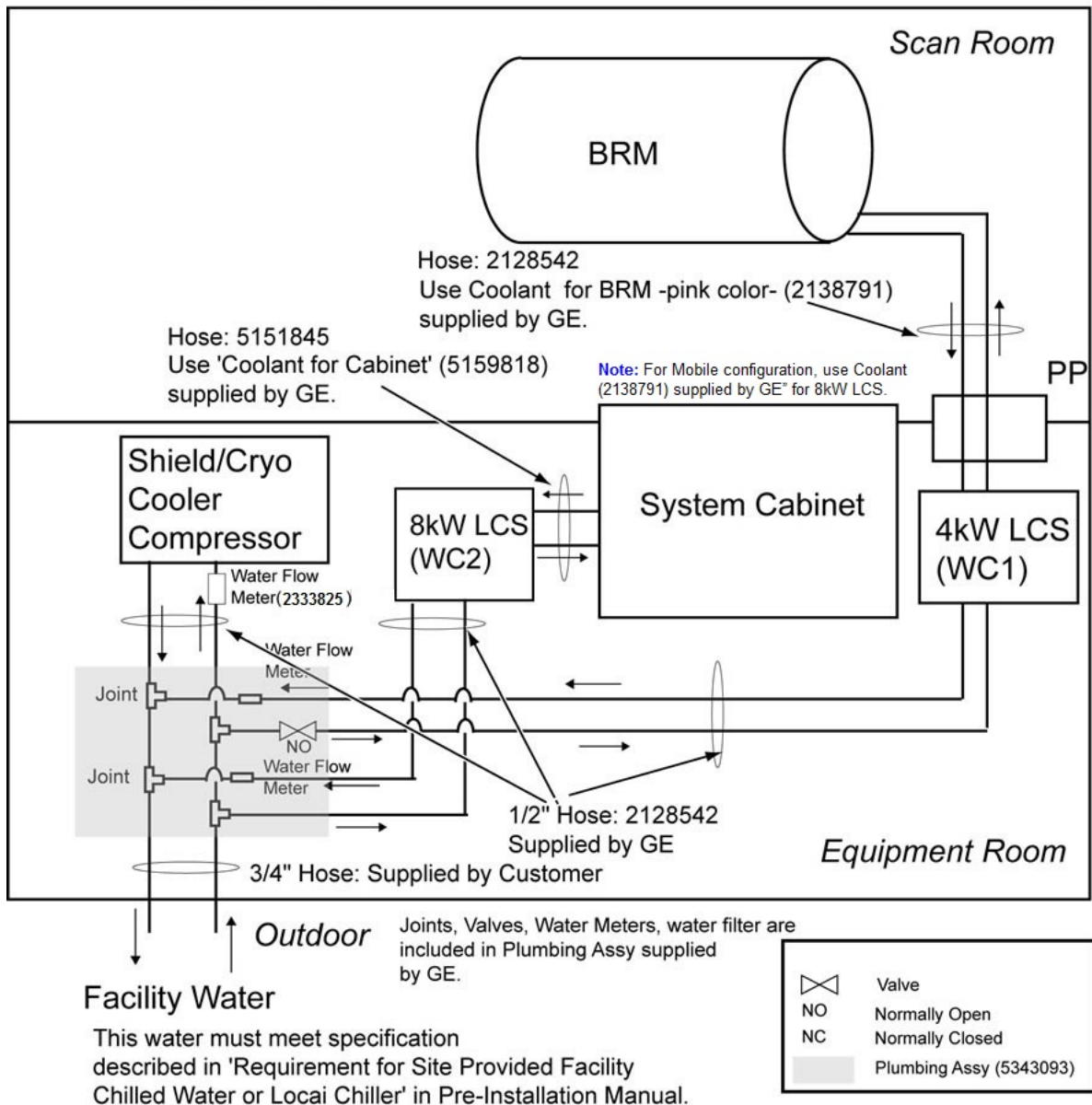
The facility water provides water for Shield/Cryo Cooler Compressor, 8kW LCS, and 4kW LCS. The 8kW LCS (WC2) and 4kW LCS (WC1) are an indoor dedicated.

The two flexible hoses (supply and return) are to be routed from the Facility Water. Each hoses are separated into three hoses by T-Shape Joint. One hose set (supply and return lines) is connected to Shield/Cryo Cooler Compressor. The other hose set (supply and return lines) is connected to 8kW LCS (WC2) for System Cabinet. And The other hose set (supply and return lines) is connected to 4kW LCS (WC1) for BRM. 4kW LCS (WC1) provide water routed through waveguides in the Penetration Panel, through the Rear Pedestal (MG3), and connect to the rear of the Gradient Coil with supplied adjustable compression clamps.

The 8kW LCS (WC2) and 4kW LCS (WC1) must be located at the same level of System Cabinet.

Illustration 4-4: Type B Chiller Configuration

Water Cooling (Type B)



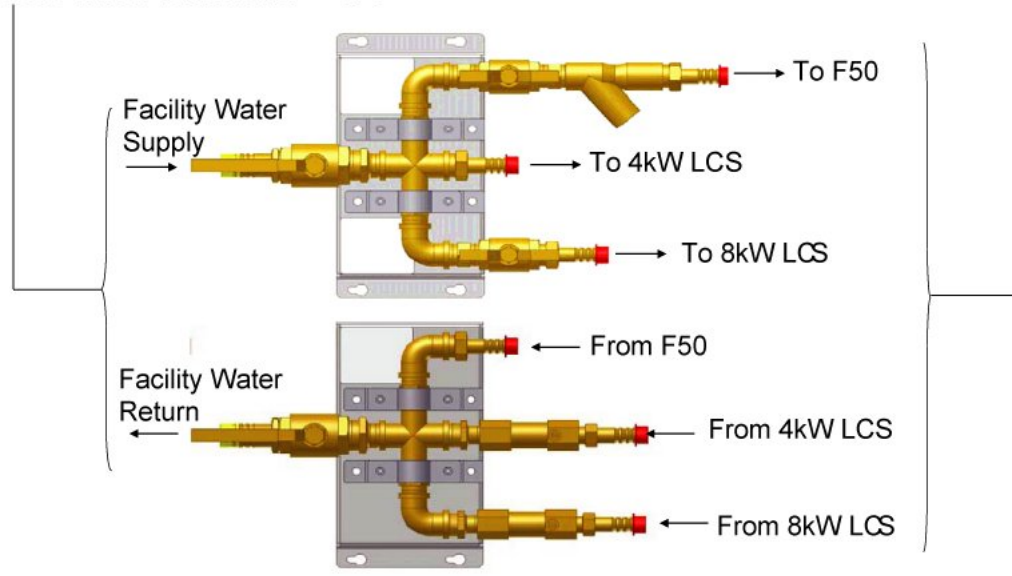
This water must meet specification described in 'Requirement for Site Provided Facility Chilled Water or Locai Chiller' in Pre-Installation Manual.

**Note:** Only use 12.7mm x 3/8" hose nipple for 1/2" water hose connection to cryogen compressor.



Illustration 4-5: Plumbing Assy for Type B and B'

Hose Inner Diameter = 3/4"



Hose Inner Diameter = 1/2"

### **5.1.3 Type B' Configuration**

This configuration uses Customer supplied 20kW Local Chiller. The Local 20kW Chiller must meet the specification described in [Requirements For Site Provided Facility Chilled Water or Local Chiller for Type B \(B'\) Configuration](#).

The one 20kW Local Chiller provides water for Shield/Cryo Cooler Compressor, 8kW LCS, and 4kW LCS.

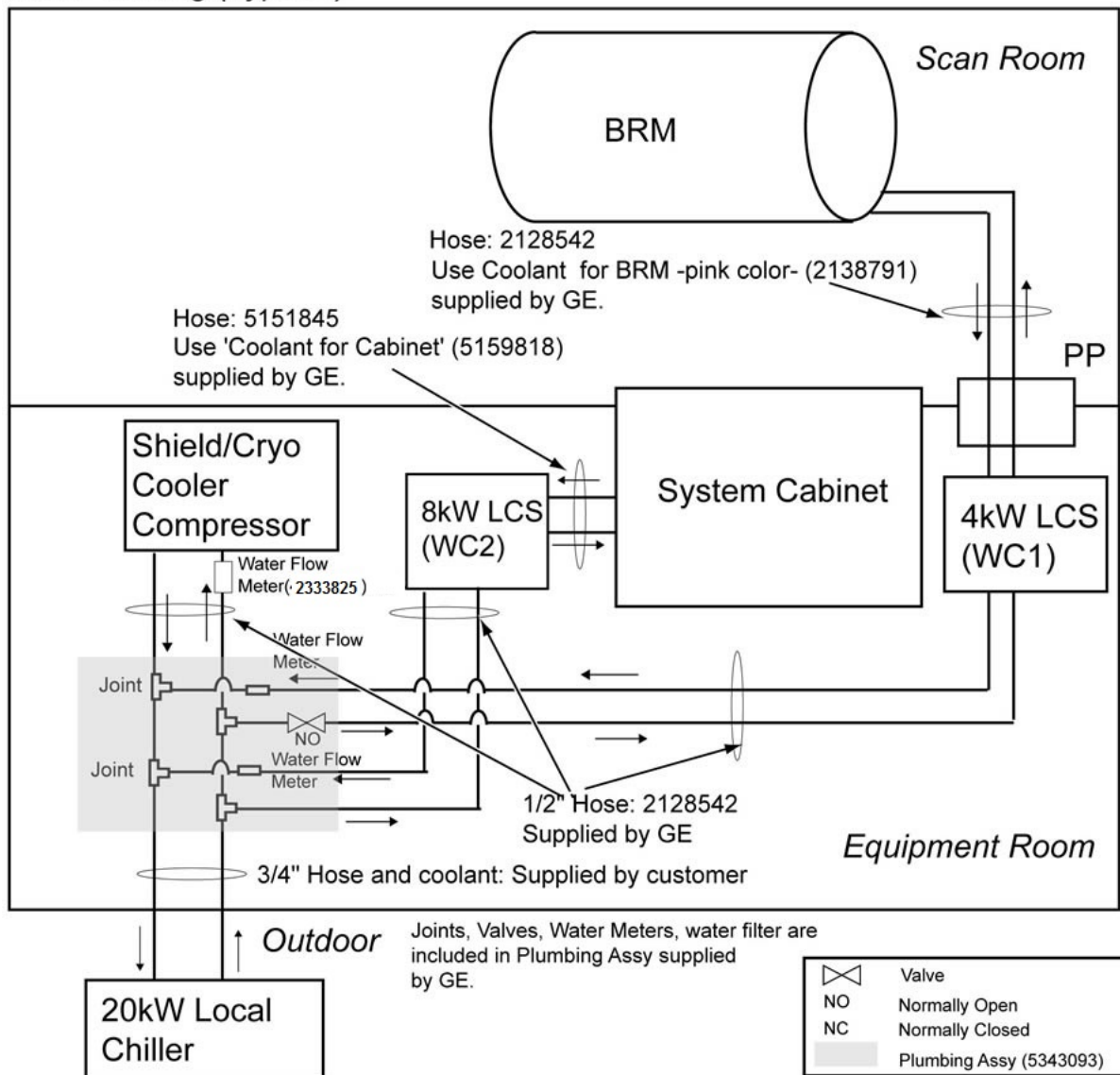
The 8kW LCS (WC2) and 4kW LCS (WC1) are an indoor dedicated.

The two flexible hoses (supply and return) are to be routed from the Facility Water. Each hoses are separated into three hoses by T-Shape Joint. One hose set (supply and return lines) is connected to Shield/Cryo Cooler Compressor. The other hose set (supply and return lines) is connected to 8kW LCS (WC2) for System Cabinet. And The other hose set (supply and return lines) is connected to 4kW LCS (WC1) for BRM. 4kW LCS (WC1) provide water routed through waveguides in the Penetration Panel, through the Rear Pedestal (MG3), and connect to the rear of the Gradient Coil with supplied adjustable compression clamps.

The 8kW LCS (WC2) and 4kW LCS (WC1) must be located at the same level of System Cabinet.

Illustration 4-6: Type B' Chiller Configuration

Water Cooling (Type B')



The 20kw local chiller must meet specification described in 'Requirement for Site Provided Facility Chilled Water or Local Chiller'

**Note:** Only use 12.7mm x 3/8" hose nipple for 1/2" water hose connection to cryogen compressor.

For the detail of Plumbing Assy for Type B', refer to [Illustration 4-5](#).

#### **5.1.4 Type C**

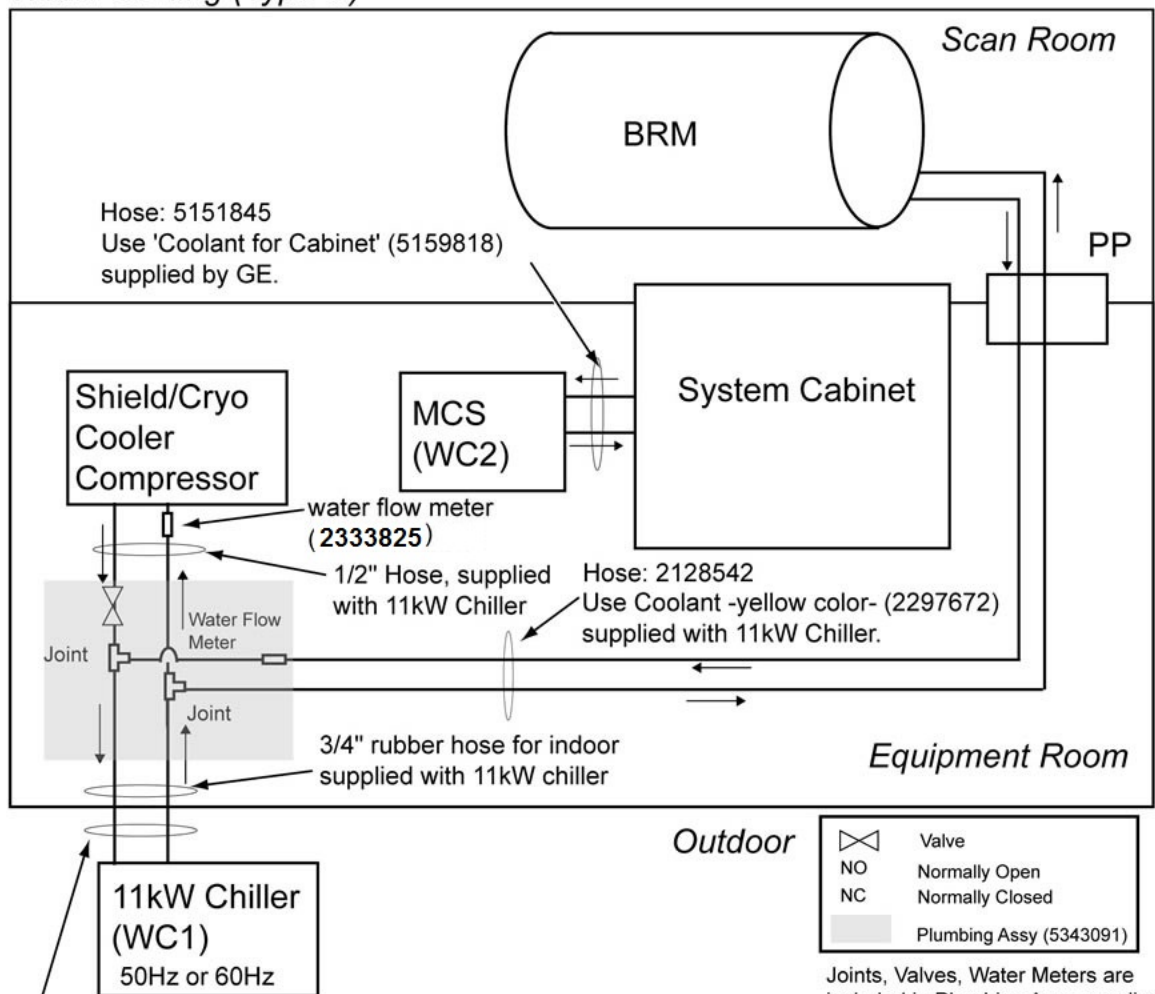
The 11kW Chiller (WC1) provides water for Shield/Cryo Cooler Compressor and BRM.

The supply and return lines of 11kW Chillers are separated into two hoses by T-Shape Joint. One hose set (supply and return lines) is connected to Shield/Cryo Cooler compressor. The other hose set (supply and return lines) is routed through waveguides in the Penetration Panel, through the Rear Pedestal (MG3), and connect to the rear of the Gradient Coil with supplied adjustable compression clamps.

The two flexible hoses (supply and return) are to be connected from the MCS (WC2) to System Cabinet.

Illustration 4-7: Type C Chiller Configuration

Water Cooling (Type C)



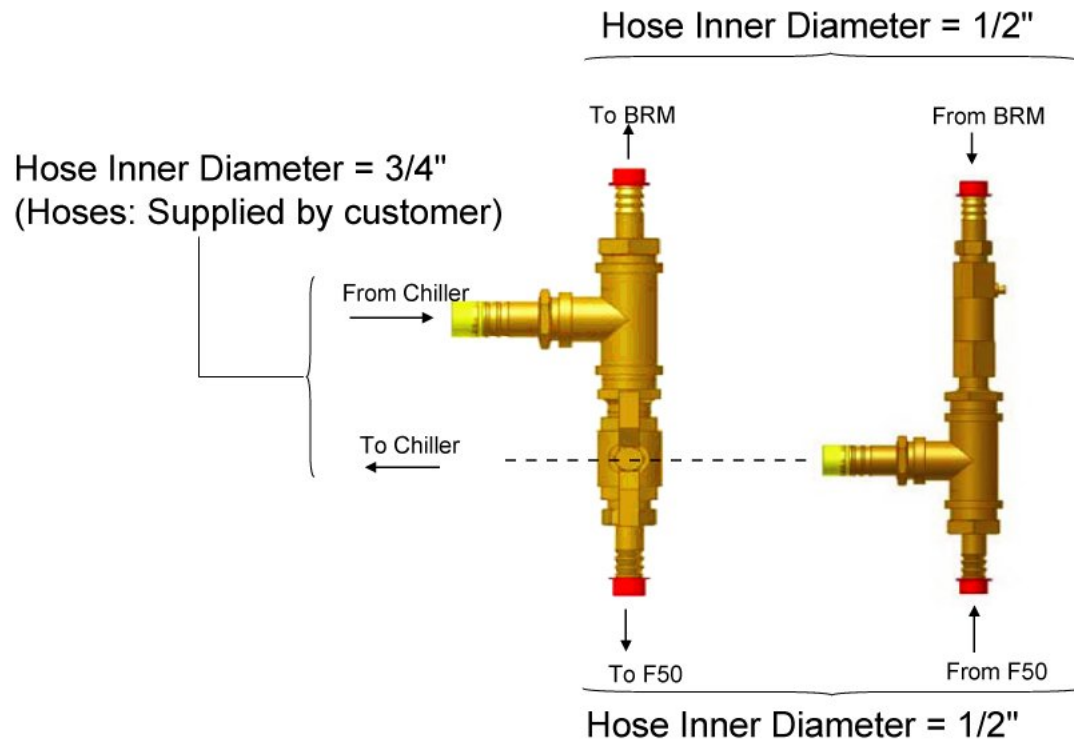
3/4" outdoor pipe and insulation: Supplied by Customer.

For outdoor, copper or PP-R pipe/joint/valve is recommended which satisfies the following requirement.

- Working temperature:  $-30^{\circ}\text{C} \sim 90^{\circ}\text{C}$
- Working pressure:  $\geq 1.6\text{MPa}$
- Material should be propylene glycol (50%) resistant.
- All pipes installed outdoor should be insulated.

**Note:** Only use 12.7mm x 3/8" hose nipple for 1/2" water hose connection to cryogen compressor.

Illustration 4-8: Plumbing Assy for Type C



### 5.1.5 Type D

The two flexible hoses (supply and return) are to be routed from the BRM Water Chiller (WC1) through waveguides in the Penetration Panel (PP1), through the Rear Pedestal (MG3), and connect to the rear of the Gradient Coil with supplied adjustable compression clamps.

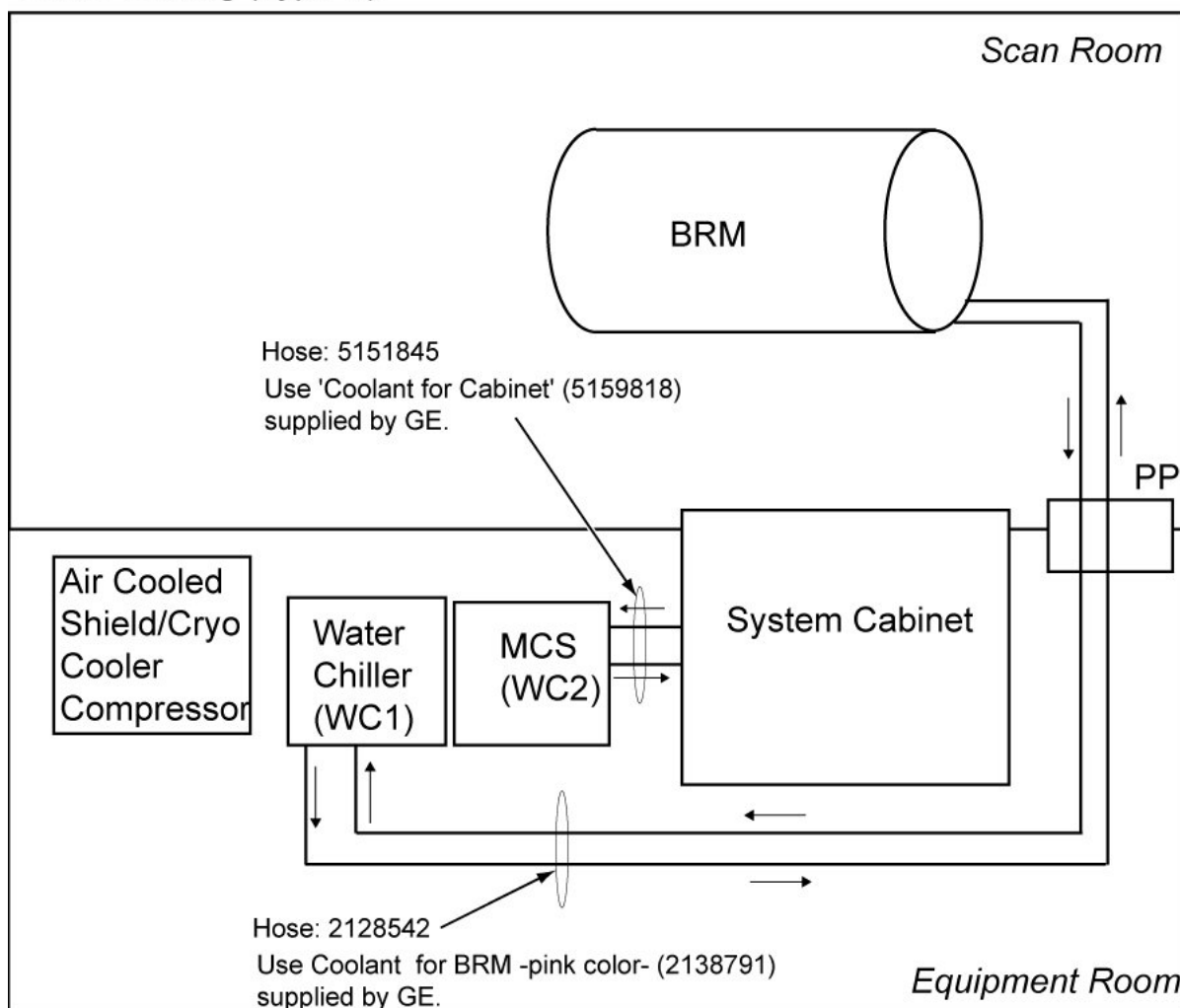
The two hoses (supply and return) are connected from the MCS (WC2) to System Cabinet.

The Water Chiller (WC1) for Gradient Coil Cooling must not be located below the Magnet Room floor level. The Water Chiller reservoir tank has a low pressure vent plug which relieves pressure from thermal expansion of water and activates when tank pressure reaches 3-5 psi (0.2-0.3 bar). The vent plug could allow fluid to leak if located below the MR system level. The reservoir tank vented plug can not be replaced with a non-vented type, damage to the tank may occur.

The Water Chiller (WC2) for System Cabinet must be located at the same level of System Cabinet.

Illustration 4-9: Type D Chiller Configuration

#### Water Cooling (Type D)



### 5.1.6 Type E

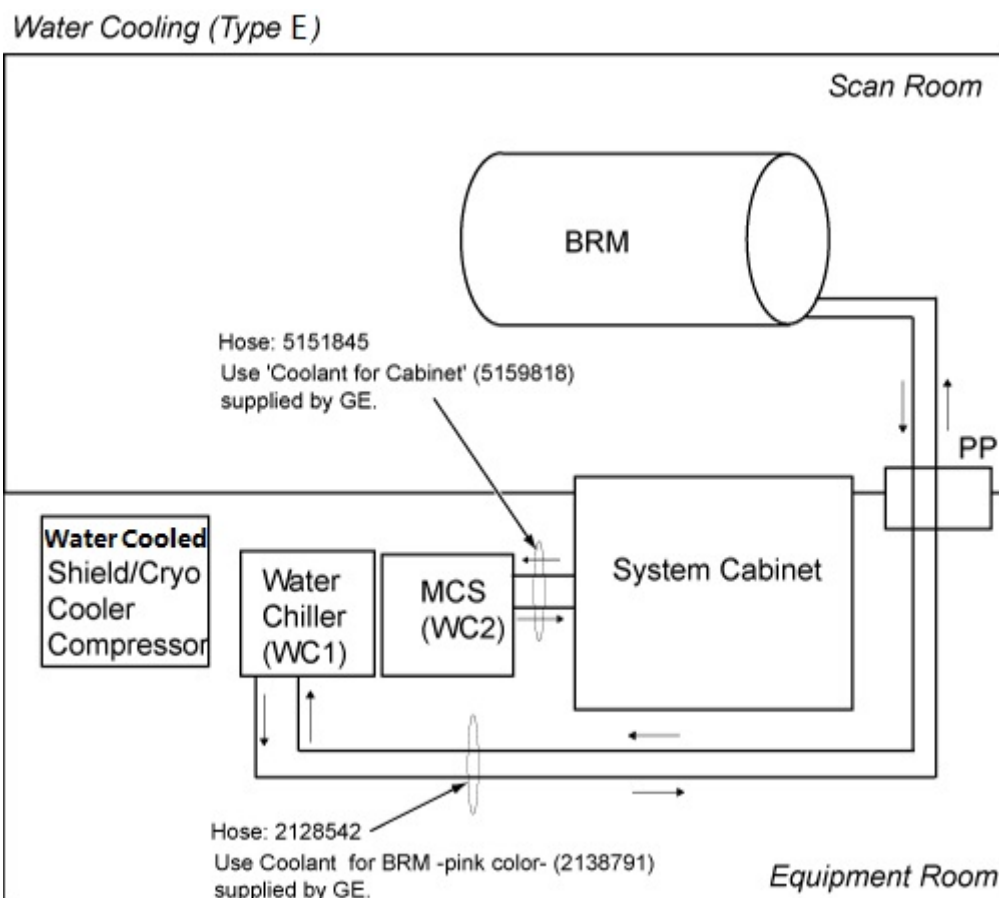
The two flexible hoses (supply and return) are to be routed from the BRM Water Chiller (WC1) through waveguides in the Penetration Panel (PP1), through the Rear Pedestal (MG3), and connect to the rear of the Gradient Coil with supplied adjustable compression clamps.

The two hoses (supply and return) are connected from the MCS (WC2) to System Cabinet.

The Water Chiller (WC1) for Gradient Coil Cooling must not be located below the Magnet Room floor level. The Water Chiller reservoir tank has a low pressure vent plug which relieves pressure from thermal expansion of water and activates when tank pressure reaches 3-5 psi (0.2-0.3 bar). The vent plug could allow fluid to leak if located below the MR system level. The reservoir tank vented plug can not be replaced with a non-vented type, damage to the tank may occur.

The Water Chiller (WC2) for System Cabinet must be located at the same level of System Cabinet.

Illustration 4-10: Type E Chiller Configuration



### 5.1.7 Notification Coolant Lines Through The Wall

Illustration 4-11 shows the Notification Of Coolant Lines Through The Wall.

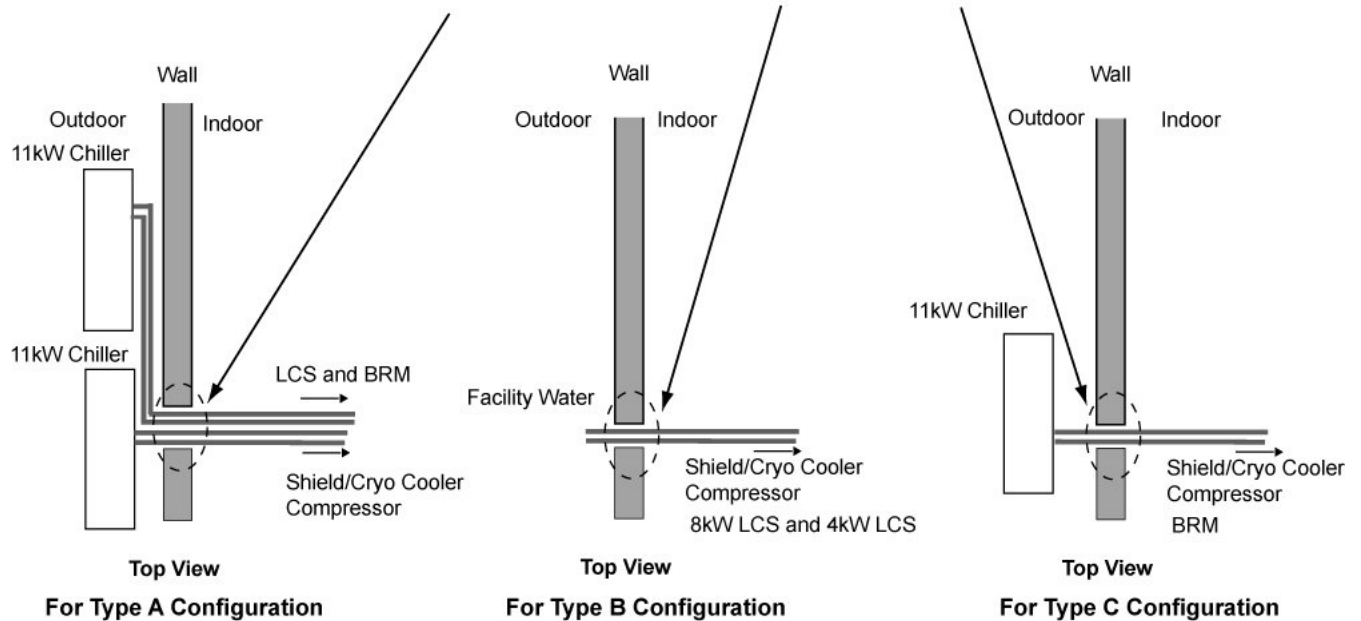


#### Illustration 4-11: Notification Of Coolant Lines Through The Wall

### Important!!

Wall opening for coolant line must be closed and thermally shielded from outdoor.

Consider coolant line can be replaced in case of trouble.



## 5.2 Gradient Coil Water Cooling

The BRM Gradient Coil is air and water cooled. A Water Chiller (WC1) (11kW Chiller, 4kW LCS, or BRM Water Chiller) is provided with site system. De-ionized water and anti-freeze mixture is supplied with the MR system for use in the closed loop system.

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

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



### NOTICE

Water cooling must be provided by the system cooling equipment (a 11kW Chiller, 4kW LCS, or a BRM Water Chiller) ordered with the system to prevent contamination/damage to the coil and for proper image quality.

### 5.3 Requirements For Site Provided Facility Chilled Water or Local Chiller for Type B (B') Configuration

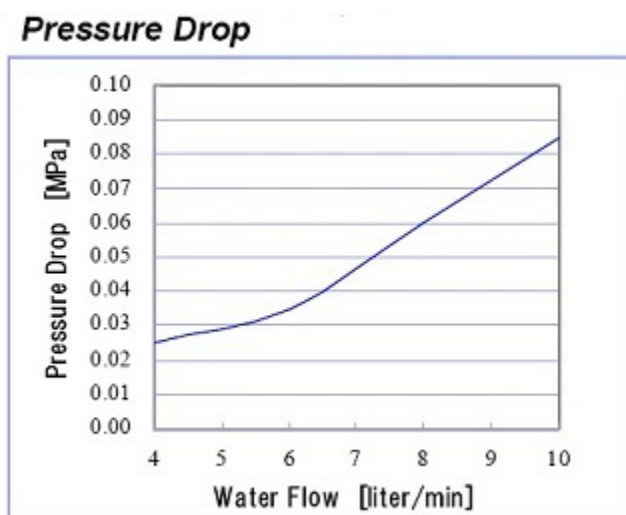
The customer provided water cooling system must be closed loop design. The water cooling design can utilize open loop city water, with required filtering, only as temporary backup during loss of closed loop water cooling system. Open loop systems will not allow a chemical equilibrium to be established resulting in continual build up or etching to take place which will eventually contribute to failure. Water system capacity must be selected to insure adequate reserve for overcoming all pressure drops and still maintain the required flow rate.

**NOTE:** Continuous water cooling is critical for the System and therefore **MUST** be available 24 hours per day / 7 days per week / 365 days per year 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.

The closed loop system may be shared with other equipment in the MR suite. The number of sharing systems should be kept to as low as possible in order to minimize contamination and reliability problems. Flow gauges and valves are recommended at all branch lines to control distribution and allow servicing of equipment.

For Type B (B'), the local 8kW/4kW LCS/Cryogen compressor should meet the requirement as shown in [Illustration 4-12](#)

Illustration 4-12: Cooling Water Typical Flow Characteristics



1 Mpa = 10 Bar = 145 PSI

**Table 4-5: Facility Chilled Water or Local Chiller Requirement**

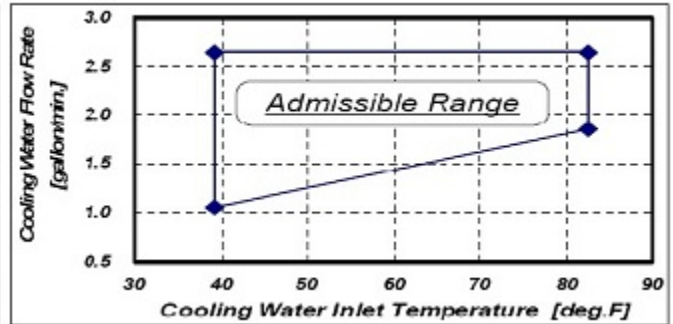
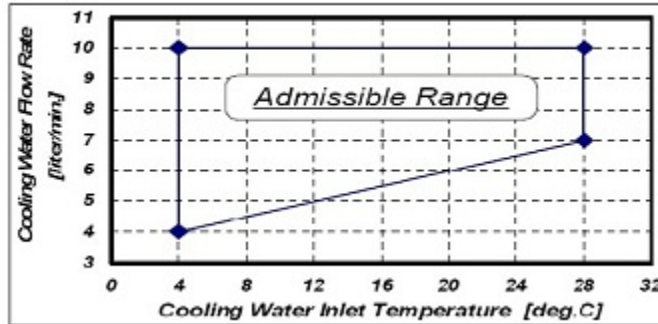
| Parameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Requirements                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Availability                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Continuous                                                                                                               |
| Cooling capacity (See Note1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Minimum 20 KW                                                                                                            |
| Minimum Continuous Heat Load                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 7.5 KW                                                                                                                   |
| Inlet Temperature to LCS/Cryo Compressor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 44.6 to 59°F (7 to 15°C) measured at the inlet to the LCS/Cryogen compressor (See Note9)                                 |
| Inlet Pressure of LCS/Cryo Compressor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Minimum 29 psi (200 kpa), Maximum 100 psi (690 kpa)                                                                      |
| Maximum Flow (See Note2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 18.5 gpm (70 L/min)                                                                                                      |
| Minimum Flow (See Note2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 8 gpm (30 L/min)                                                                                                         |
| Temperature rise at Maximum Flow                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 40.1°F (4.5°C) with 40% propylene glycol-water; 3730 J/(kg K) specific heat; 1021 kg/m <sup>3</sup> density; 20 kW heat  |
| Temperature rise at Minimum Flow                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 50.9°F (10.5°C) with 40% propylene glycol-water; 3730 J/(kg K) specific heat; 1021 kg/m <sup>3</sup> density; 20 kW heat |
| Antifreeze (See Note3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0-40% propylene glycol                                                                                                   |
| pH level (See Note4)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 6.5 to 8.2                                                                                                               |
| Hardness (See Note5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Less than 200 ppm of calcium carbonate                                                                                   |
| Suspended Matter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Less than 10 mg per liter and less than 150 micron particle size                                                         |
| Facility Filter (See Note6)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 150 micron or smaller with a field-changeable filter                                                                     |
| Customer supplied hose connections to the LCS/Cryogen compressor (See Note7)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 3/4 inch                                                                                                                 |
| Condensation Protection (See Note8)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Condensation must be managed to prevent equipment damage or safety hazards.                                              |
| <b>Notes</b><br>1. Minimum 20 KW should be based on local max. environment temperature.<br>2. Recommend a flowmeter be permanently installed in system by customer.<br>3. See below. <ul style="list-style-type: none"> <li>○ This requirement is only applied for the area where the water in pipe/hose freezes during winter season.</li> <li>○ Laboratory grade Ethylene Glycol or Propylene Glycol antifreeze may be used (do not mix Ethylene Glycol with Propylene Glycol). Preferred concentration is 65% de-ionized water and 35% Glycol 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%.</li> </ul> 4. GE recommends the use of de-ionized water to ensure longest life with fewest problems.<br>5. Hard water will produce calcium deposits in the LCS and Shield/Cryogen compressor resulting in decrease of cooling efficiency.<br>6. To meet the specification for suspended matter, it is necessary to install a 100-150 micron filter at facility water supply side by customer.<br>7. Hose between facility water and facility plumbing 5343093, will be supplied by customer<br>8. Hose insulation between facility water and 8kW/4kW LCS/Cryogen compressor, will be supplied by customer.<br>9. It is recommended to set the supply water temperature of facility water/local 20kW chiller to close to the upper limit specification (15°C) to save energy. |                                                                                                                          |

## 5.4 Requirements For Local Chiller for Type E

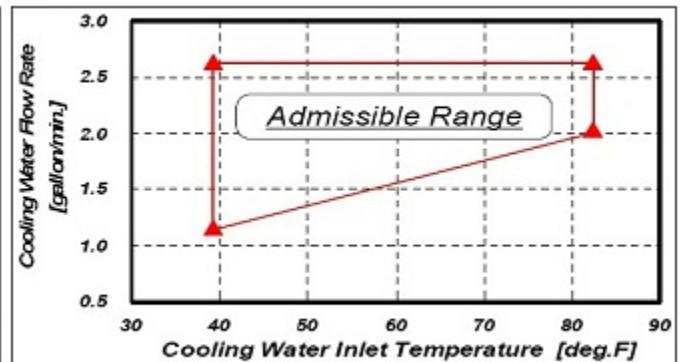
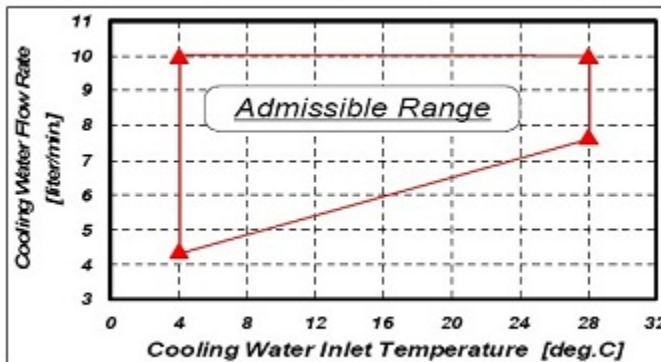
For Type E, local chiller should meet the requirement as shown in [Illustration 4-13](#) and [Table 4-6](#) :

Illustration 4-13: Cooling Water Typical Flow Characteristics

**For Water**

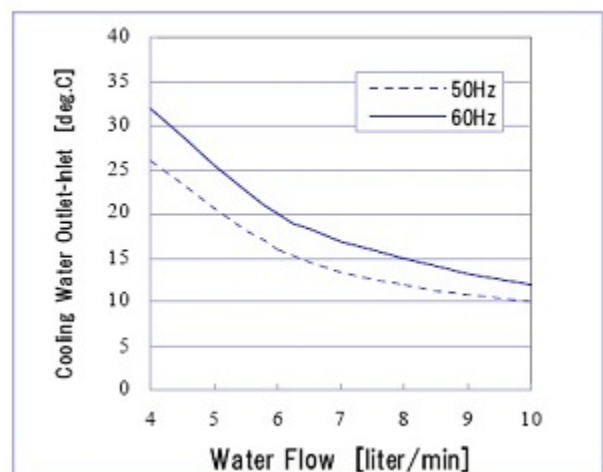
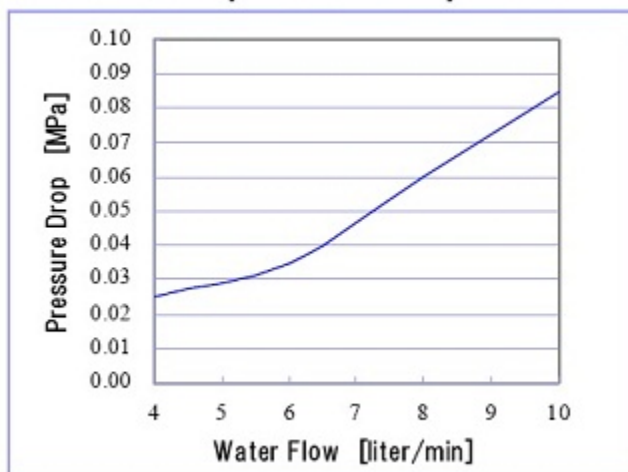


**For Antifreeze (50/50 % mixture of water and ethylene glycol)**



The larger circulating pump will be required for the Antifreeze.

### Pressure Drop and Temperature Rise



1 Mpa = 10 Bar = 145 PSI

**Table 4-6: COOLING WATER SPECIFICATIONS**

|                 |                                                                                                                                                                                                    |                                                                                                                                                                                                                                     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CHARACTERISTICS | Inlet Temperature Range [deg.C] (deg.F)                                                                                                                                                            | [4.0 ~ 28.0] (39.2 ~ 82.4)                                                                                                                                                                                                          |
|                 | Inlet Pressure Range [MPa] (psig)                                                                                                                                                                  | [0.20 ~ 0.69] (29 ~ 100)                                                                                                                                                                                                            |
|                 | Flow Rate [liter/min.] (gallon/min.)                                                                                                                                                               | [4.0 ~ 10.0] (1.1 ~ 2.6)                                                                                                                                                                                                            |
|                 | Pressure Drop [MPa] (psig)                                                                                                                                                                         | [0.025 ~ 0.085] (3.55 ~ 12.1)                                                                                                                                                                                                       |
|                 | Heat Output [kW] (BTU/Hr)                                                                                                                                                                          | <b>Steady State</b><br>[< 6.5] (< 22180) for 50Hz<br>[< 7.5] (< 25590) for 60Hz<br><b>Maximum</b><br>[< 7.2] (< 24570) for 50Hz<br>[< 8.3] (< 28320) for 60Hz                                                                       |
| QUALITY         | pH Value<br>Electrical Conductivity<br>Alkaline<br>Total Hardness<br>Chloride<br>Sulfide<br>Iron<br>Sulfur<br>Ammonium<br>Silica<br>Aggressive Carbon Dioxide<br>Suspended Matter<br>Particle Size | 6.5 to 8.2 at 25 deg.C (77 deg.F)<br>< 800 uS/cm at 25 deg.C<br>< 100 PPM<br>< 200 PPM<br>< 200 PPM<br>< 200 PPM<br>< 1.0 PPM<br>None, Not detectable<br>< 1.0 PPM<br>< 50 PPM<br>None, Not detectable<br>< 10 mg/liter<br>< 100 um |

## 5.5 Shield/Cryo Cooler Temporary Backup Water Cooling for Cooling type B,C,E

**NOTE:** THIS SECTION APPLIES TO INDOOR SHIELD COOLER COMPRESSOR FOR COOLING TYPE B, C, E.

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 11Kw AirSys chiller 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 [Water Cooling For Site Provided Water Cooling](#).

**NOTE:** These water cooling specifications are the requirements at 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 11kw AirSys chiller 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 11kw AirSys chiller to city water and vice-a-versa must not allow contamination of the closed loop system in the 11kw AirSys chiller.



### **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.

**NOTE:** Connections to the Shield/Cryo Cooler Compressor requires 0.5 in. (12.7 mm) inside diameter flexible hose and 1.0 in. (25.4 mm) adjustable compression clamps.

## 5.6 11kW Chiller Siting Considerations

### 5.6.1 11kW Chiller Interconnects/Separation Limitations

Location of the 11kW Chiller must meet the following limitations for the water lines:

- Outdoor water line (pipe) must be thermal insulated.
- Maximum vertical separation is not to exceed 98 ft (30 m) with the 11kW Chiller above the MR system or 9.8 ft (3.0 m) with the 11kW Chiller below the MR system.
- 11kW Chiller and the Remote Control Panel (RCP) must not be separated by a distance greater than 100 ft (30.5 m) total interconnect length.
- Distance should be less than 30m between chiller and operating room, if use 3/4" piping between outdoor chiller and indoor unit.
- Distance between chiller and operating room can be >30m, if use >3/4" piping between outdoor chiller and indoor unit. Please consult GE or Airsys for details.
- If the length between remote controller and chiller is longer than 30m, order 100m cable from option list.

The 11kW Chiller is powered from customer supplied power. Use GE MDP M3088TM option for 11kW Chiller.

### 5.6.2 11kW Chiller Access & Air Considerations

Ensure there is easy access to the top cover of the unit. The air inlet and outlet are located on the unit front and rear respectively. Restricting airflow into or out of the 11kW Chiller will impair performance. The minimum clearances shown in [Chapter 2, 11kW Chiller](#) are required on each side and top to ensure adequate airflow.

An 11kW Chiller unit installed in a high airflow area may be affected by the seasonal winds. In such environments it is recommended to install wind breaks for the 11kW Chiller.

### 5.6.3 11kW Chiller Outdoor Installation Mounting

The 11kW Chiller must be located on a strong, level surface, see [Chapter 2, 11kW Chiller](#) for concrete pad requirements for one 11kW Chiller unit. A chiller mounted on a slab on grade or rooftop will have the casters removed and be bolted down using the six middle holes shown in 11kW Chiller Outdoor Mounting illustration in [Chapter 2, 11kW Chiller](#) to rigidly mount the unit.

### 5.6.4 Responsibility For Installation Tasks For 11kW Chiller Equipment

The 11kW Chiller subsystem equipment installation requires specific tasks to be performed by the Customer Contractor, GE Service, and Service Provider (dependent on site location Service provider, refer to [Table 4-8](#)). [Table 4-7](#) lists the responsibility for the specific tasks. Refer to vendor manual for additional information concerning tasks.



**Table 4-7: 11kW Chiller Equipment Installation Tasks Responsibility**

| 11kW Chiller Equipment Responsibility For Installation Tasks When Used For Shield/Cryo Cooler Compressor Prior To Magnet Delivery & When Magnet Is Delivered/Installed |                             |    |                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----|------------------------------------|
| Task                                                                                                                                                                   | Responsible To Perform Task |    |                                    |
|                                                                                                                                                                        | Customer                    | GE | Service Provider<br>See Table Note |
| Unload chiller from truck                                                                                                                                              | X                           |    |                                    |
| Move chiller to Equipment Room or Outdoor concrete pad and mount in accordance with local codes.                                                                       | X                           |    |                                    |
| Connect customer supplied power cable from facility power supply or MDP to Chiller                                                                                     | X                           |    |                                    |
| Install water lines to chiller, and no leaks                                                                                                                           | X                           |    |                                    |
| Install Remote Control and cable in Operation Room, and connect remote controller cable to chiller.                                                                    | X                           |    |                                    |
| Fill chiller with glycol                                                                                                                                               |                             |    | X                                  |
| Start chiller, verify proper phase rotation and no leaks found                                                                                                         |                             |    | X                                  |
| Perform final Inspection of chiller and verify proper operation.                                                                                                       |                             |    | X                                  |
| Attach labels                                                                                                                                                          |                             |    | X                                  |
| Fullfill Start-up report                                                                                                                                               |                             |    | X                                  |
| Installation Verification                                                                                                                                              |                             | X  | X                                  |
| Note<br>* The Service Providers are listed in <a href="#">Table 4-8</a> .                                                                                              |                             |    |                                    |

**Table 4-8: 11kW Chiller Service Providers**

| Location                     | Service Provider Address                                                 | Telephone                               | Fax/Email                                |
|------------------------------|--------------------------------------------------------------------------|-----------------------------------------|------------------------------------------|
| U.S, Canada, & Latin America | GE Healthcare, 3200N Grandview Blvd, Waukesha, WI 53188                  | +1 800 437 1171                         |                                          |
| Europe & other countries     | The Competitive Advantage, Italy 27100 Pavia Via Sacco 7                 | +39 382 303 990                         | Roberto@caciolli.191.it                  |
| India                        | India Service Center                                                     | +91 33 2251 7220                        | +91 22 6645 9287<br>cc-india@air-sys.com |
| Asia and all other countries | AIRSYS, No.28, East LuGu St, Shijingshan Dist. Beijing P.R. China 100040 | +86 10 400 820 5515<br>+86 10 6865 6161 | 86-10-68652453                           |

## 6 Magnet Room Venting Requirements

### 6.1 Venting System Requirements

The Magnet Room requires the following venting systems:

1. HVAC
2. Emergency Exhaust
3. Pressure Equalization
4. Cryogenic venting

### 6.2 HVAC Vent Requirements

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

### 6.3 Emergency Exhaust Vent Requirements

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

**NOTE:** If used, vent diffusers must not extend beyond the vent opening to prevent helium from pooling between the edge of the diffuser and the ceiling.

7. The Magnet room exhaust fan and exhaust intake vent must have a capacity of at least 1200 CFM (34 m<sup>3</sup>/minute) with a minimum 12 room air exchanges per hour
8. The exhaust fan must be installed outside of the RF shield and must remain fully functional in the magnetic field per the fan specification sheet
9. The exhaust fan must have appropriate waveguides and di-electric break to maintain the RF shield requirements (see *RF Shielded Room Requirements*)

10. The system must have a manual exhaust fan switch near the Operator Workspace (OW) and in the Magnet room near the door (the switches must be connected in parallel)

**NOTE:** If the Magnet room contains an optional oxygen monitor, the Magnet room switch is not required.

11. All system components must be accessible for customer inspection, cleaning, and maintenance
12. Electromechanical fire dampers must not be used. Fusible link fire dampers may be used (with annual inspection)

**Illustration 4-14: Magnet Room Exhaust Fan Schematic**

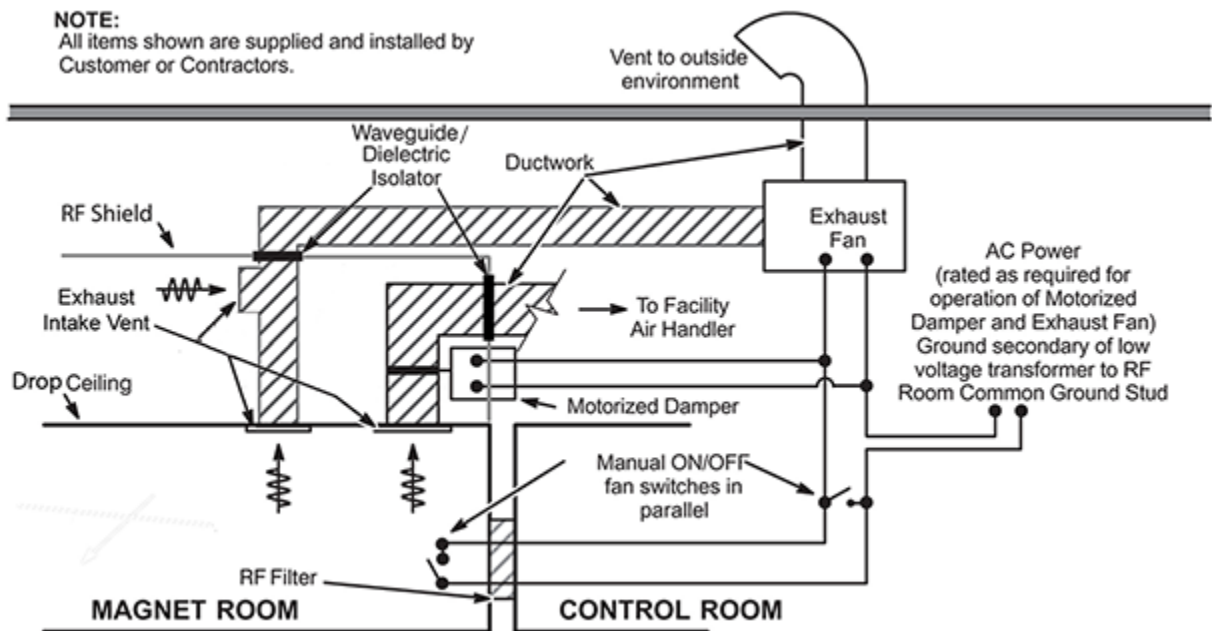
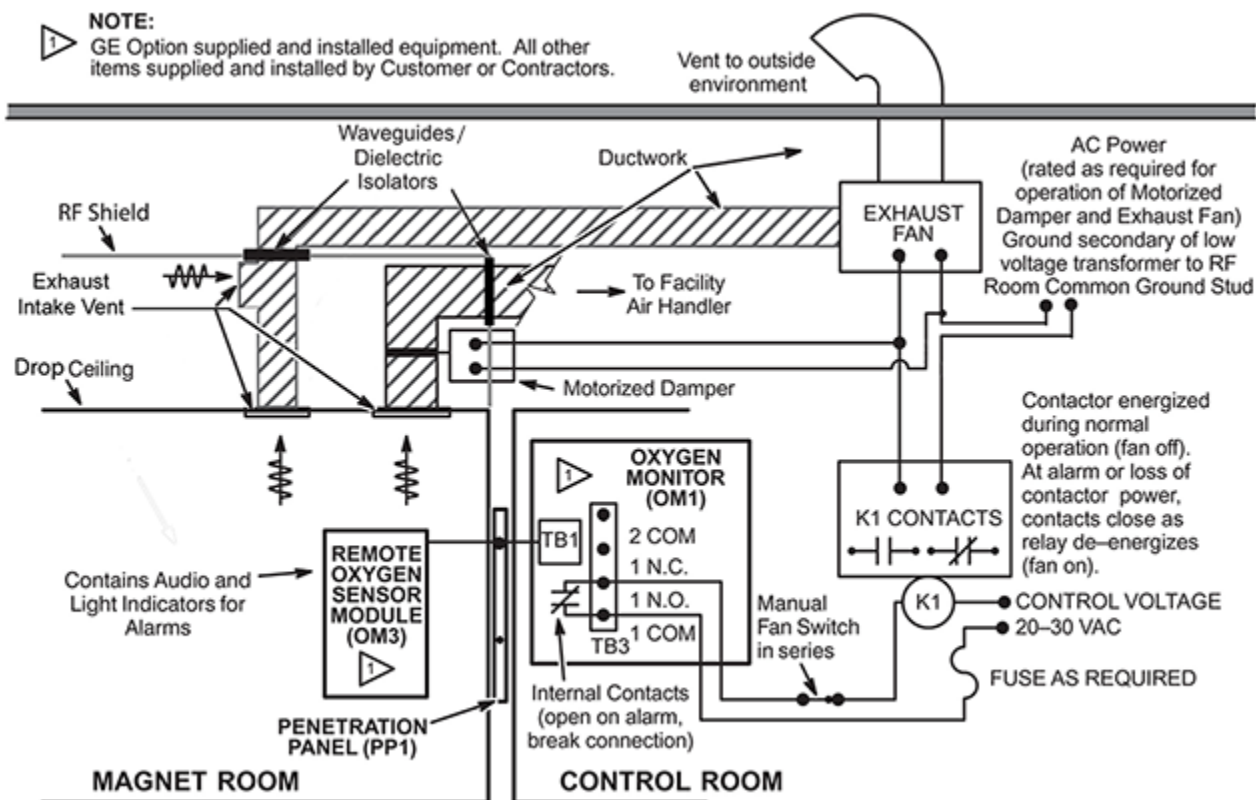


Illustration 4-15: Magnet Room Exhaust Fan Schematic with Optional Oxygen Monitor



## 6.4 Pressure Equalization Vent Requirement

1. A pressure equalizing vent is required in the magnet room ceiling or in the wall, at the highest point possible
2. The vent minimum size must be 24 in. x 24 in. (610 mm x 610 mm) or equivalent area
3. The pressure equalization vent must be located so any Helium gas is not vented into occupied areas

**NOTE:** Location may affect acoustic noise transmission into occupied spaces.

## 6.5 Cryogenic Venting



### **WARNING**

**CRYOGENIC BURNS OR ASPHYXIATION**  
FAILURE OF THE CRYOGENIC VENT MAY CAUSE EXTREMELY COLD HELIUM GAS TO ENTER THE MAGNET ROOM OR OTHER OCCUPIED BUILDING SPACE. DIRECT CONTACT COULD CAUSE CRYOGENIC BURNS AND ASPHYXIATION COULD RESULT FROM OXYGEN DISPLACEMENT. THE CUSTOMER IS RESPONSIBLE CRYOGENIC VENTING. DESIGNERS AND INSTALLERS OF THE VENT MUST BE FAMILIAR WITH INDUSTRIAL PIPING SYSTEMS.

The MR System (magnet) requires a cryogenic venting system to direct helium gas to an unoccupied space if the magnet quenches. The cryogen venting system must direct all the helium gas outside the facility, and it must keep all helium out of all facilities. The helium in the magnet is a cold gas, which rapidly expands as it becomes warmer. The cryogen vent designer must adhere to the following requirements for the material, construction and maintenance of the vent. The customer is responsible for all of the cryogenic venting system.

Note the following:

1. All pipe or tube dimensions specified in this document are outside diameters unless otherwise noted
2. Some requirements in this document may not be applicable to Mobile, Transportable, or Relocatable configurations.
3. See Magnet Cryogenic Venting Pressure Drop Reference Tables to calculate pressure drop for a specific system

**Table 4-9: Magnet Cryogen Specifications**

| Magnet Types    | Helium Volume gallons (liters) | Peak Helium Flow During Quench ft <sup>3</sup> per min (m <sup>3</sup> per min) | Magnet Vent Pipe OD inches (mm) |
|-----------------|--------------------------------|---------------------------------------------------------------------------------|---------------------------------|
| 1.5T LCC Magnet | 520 (1970)                     | 2737 (77.5) [Gas]                                                               | 8 (203.2)                       |

## 6.6 Vent Requirements Inside the Magnet Room

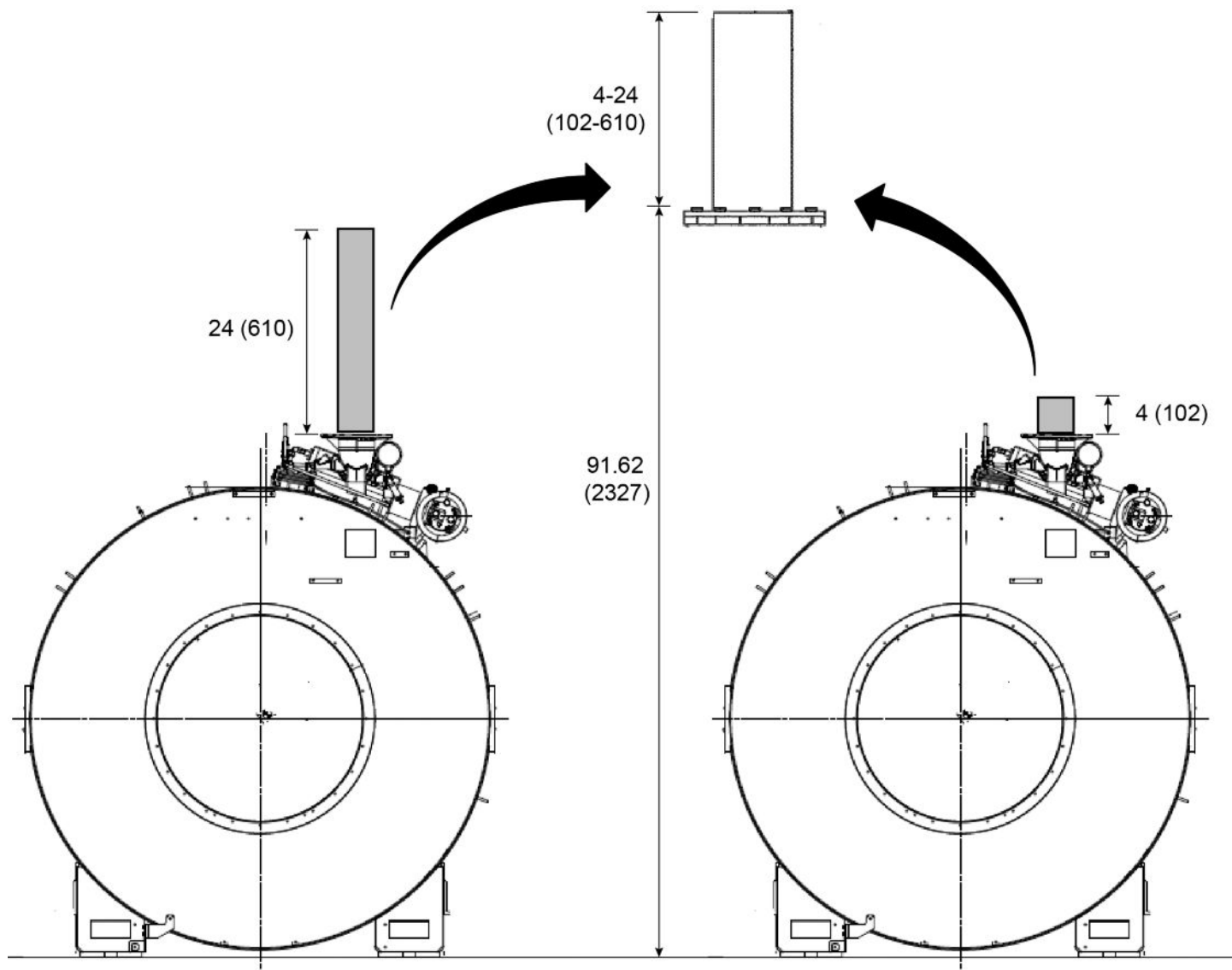
### 6.6.1 General

1. The customer is responsible for design, installation, and maintenance of all cryogenic venting materials inside the Magnet room
  - a. The cryogenic vent must be connected to the magnet within 24 hours of magnet delivery
  - b. Appropriate ventilation must be provided to evacuate the helium gas in the case of a quench before the magnet is connected to the cryogenic vent. See [Section 6.3](#)
2. The cryogenic vent must not transfer load to the magnet adaptor
3. GE Healthcare provides a flanged vent adapter that is 8 in. (203 mm) OD and 24 in. (610 mm) long. GE installs it straight up from the magnet (inline with the waveguide in the RF shield). The vent tube can be cut as short as 4 in. (102 mm). See [Illustration 4-16](#).
4. The customer must provide any additional vent tube (above the 1.0 ±0.25 in.gap) beyond the 24 in. (610 mm) provided
5. Other cryogenic venting systems are allowable (e.g., sidewall, ceiling offset) as long as all other cryogenic venting requirements are met
6. Do not remove or modify the vent adaptor bolted to the magnet
 

**NOTE:** The GE Healthcare supplied flanged adapter must be bolted directly to the magnet vent adaptor bolt flange
7. The vent must be located within 0.25 in (6.35 mm) of the location (in relation to isocenter) shown in [Illustration 4-21](#)

8. A  $1.0 \pm 0.25$  inch ( $25.4 \pm 6$  mm) isolation gap must be included at the top of the GE Healthcare supplied vent tube

Illustration 4-16: Flanged Magnet Vent Adapter



### 6.6.2 Vent Size

The total pressure drop of the cryogenic vent system (from the magnet vent interface to, and including, the vent cap) must be less than 17 psi (117.2 kPa). The pressure drop of the RF shield waveguide must be included in the overall calculation.

Refer to Magnet Cryogenic Venting Pressure Drop Reference Tables

### 6.6.3 Vent Materials

1. The 8 in. (203 mm) OD vent material must be one of the following materials with the wall thickness indicated:
  - a. SS 304: Minimum 0.035 in. (0.89 mm); Maximum 0.125 in. (3.18 mm)

- b. AL 6061-T6: Minimum 0.083 in. (2.11 mm); Maximum 0.125 in. (3.18 mm)
- c. CU DWV, M or L: Minimum 0.083 in. (2.11 mm); Maximum 0.140 in. (3.56 mm)
- 2. Either tubes or pipes may be used and must be seamless or have welded seams
- 3. Corrugated pipe or spiral duct must not be used
- 4. If required, bellows pipe less than 1 ft (30 cm) in length may be used as a thermal expansion joint
- 5. The vent pipe must withstand a maximum pressure of 35 psi (241.4 kPa)
- 6. Waveguide vent material must match the outside diameter of the magnet flanged vent adapter

#### **6.6.4 Cryogen Vent Support**

- 1. The venting system (including supports) must be sized to withstand 1850 lbs (8229 N) helium flow reaction force at vent elbows
- 2. Any vent support connected to the RF shield must have a dielectric break
- 3. The Ventglas joint (GEHC-supplied) must not be used as a vent system support

#### **6.6.5 Construction**

- 1. A single dielectric break (i.e., Ventglas connection) in the vent system is required in the Magnet room
  - a. Gap between the RF waveguide and GEHC-supplied vent tube must be 1.0 ±0.25 inch (25.4 ±6 mm)
  - b. The outside diameter of the waveguide must match the outside diameter of the GE vent tube within ± 0.125 in. (3 mm)
  - c. The Ventglas connection inside the scan room must be accessible for maintenance and annual inspection
  - d. The distance between the bottom of the RF waveguide and the magnet room floor cannot be more than 116.9 in. (2969 mm)
- 2. The Ventglas connection may also serve as a thermal expansion joint
- 3. All pipe section connections must be welded or brazed
- 4. All isolation/thermal expansion elements (except the Ventglas joint) must be rated to 4.5 K (-451°F or -268°C) and 35 psi (241.4 kPa)
- 5. 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

Illustration 4-17: Waveguide

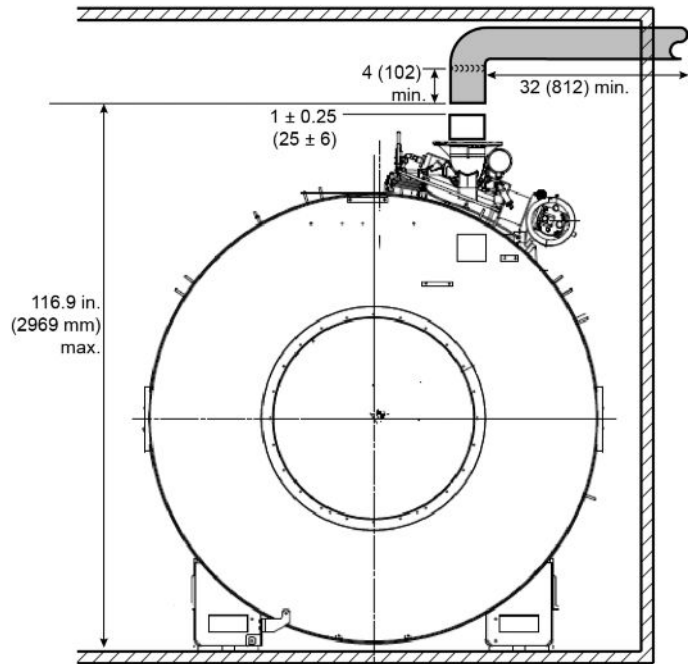
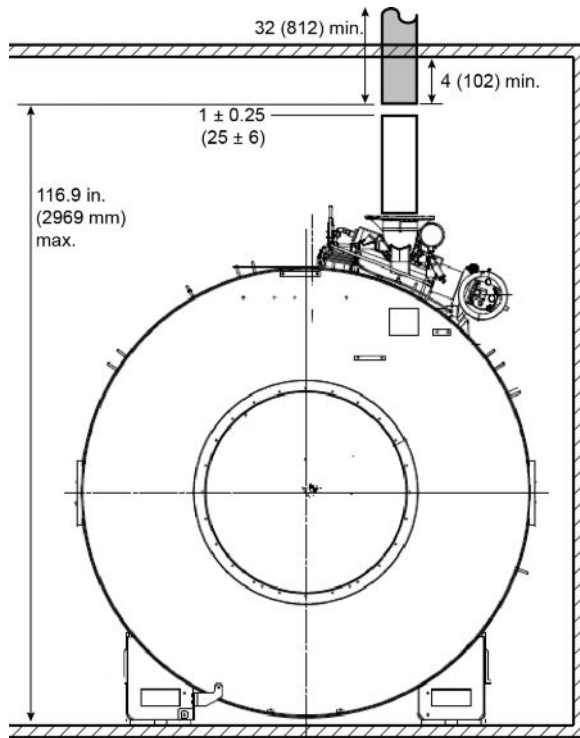
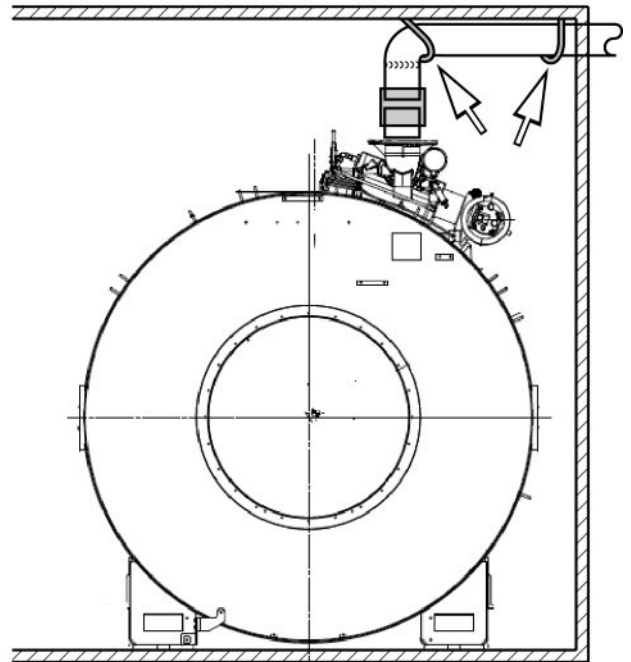
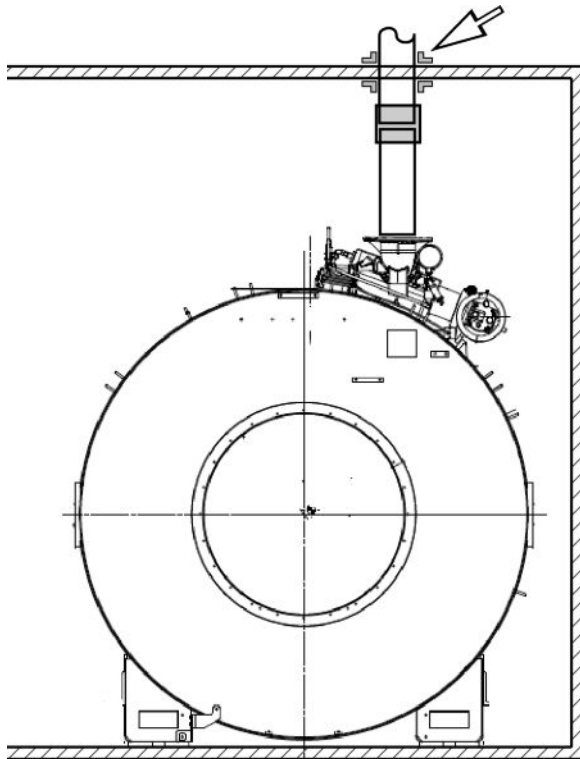


Illustration 4-18: Pipe Supports to Remove Vent Load from Ventglas Connection





## **6.7 Vent Requirements Outside the Magnet Room**

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

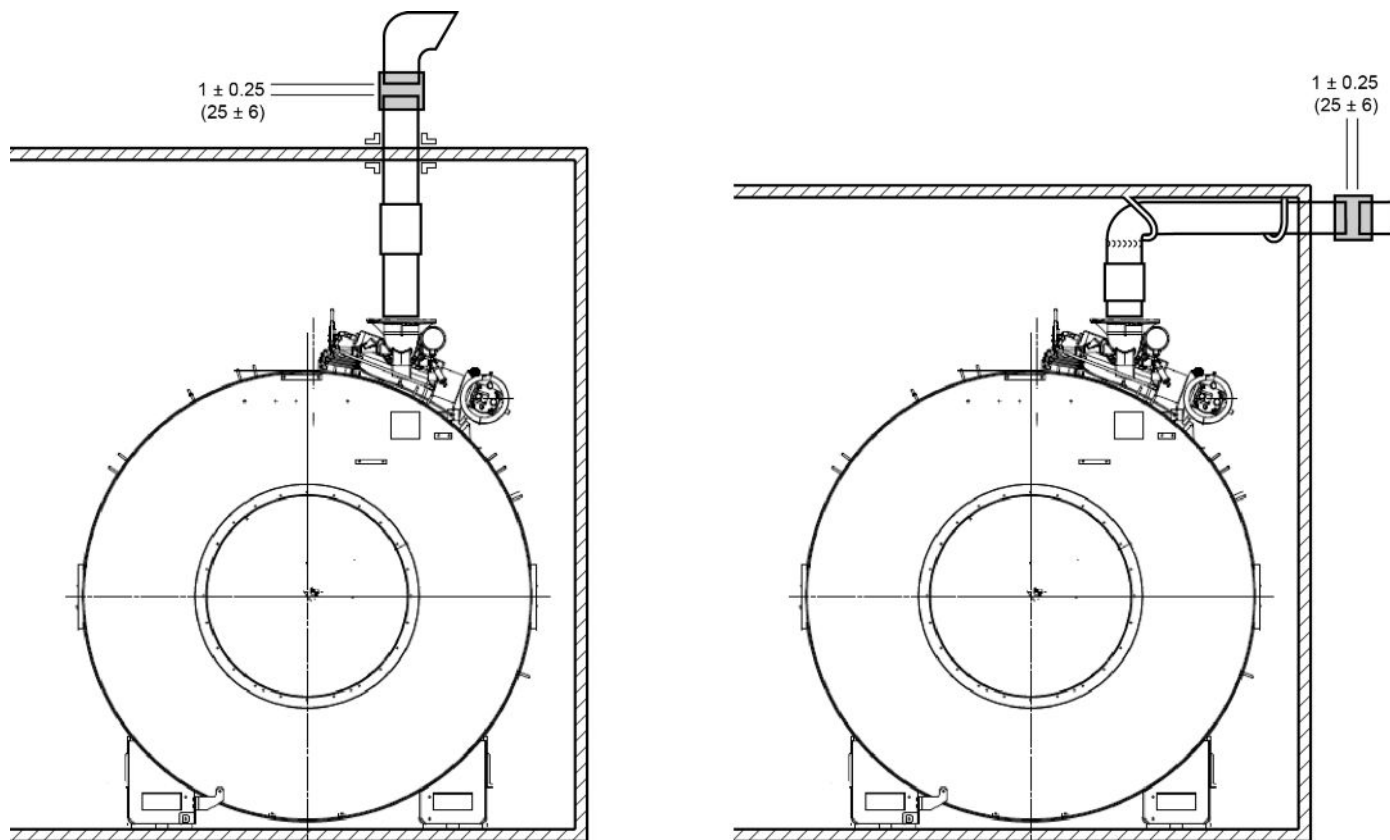
### **6.7.1 Cryogen Vent Support**

1. The venting system (including supports) must be sized to withstand 1850 lbs (8229 N) helium flow reaction force at vent elbows
2. The customer supplied dielectric break must not be used to support the outside cryogenic vent pipe

### **6.7.2 Vent Construction**

1. GE Engineering recommends that the cryogen vent be constructed to the same specification as required inside the Magnet Room.
2. The vent must be routed as directly as possible to the vent cap (i.e., venting system external protective cover)
3. Expansion/contraction elements must be provided for temperature decrease from ambient to 4.5 K (-451°F or -268 °C)
4. A dielectric break must be installed adjacent to the waveguide
  - a. The dielectric break gap must be  $1.0 \pm 0.25$  inch ( $25 \pm 6$  mm)
  - b. A customer supplied clamp may be used to connect the dielectric break
  - c. The dielectric break must be accessible for inspection or maintenance
5. All components must be rated to withstand the helium flow reaction force at temperatures from ambient to 4.5 K (-451°F or -268°C)
6. Electromechanical fire dampers must not be used. Fusible link fire dampers may be used (with annual inspection)
7. Vent cap must prevent ingress of weather elements (e.g., rain, snow, hail, sand, etc.) and foreign material debris (e.g., leaves, bird nests, etc.)
8. Condensate must be prevented from pooling inside any section of the venting system (e.g., downward tilted vent system or local minima with weephole)

Illustration 4-19: Outside Dielectric Break (Customer-supplied)



### 6.7.3 Vent Exit



#### **WARNING**

CRYOGENIC BURNS OR ASPHYXIATION  
DURING A QUENCH, EXTREMELY COLD GAS OR PARTICLES ARE  
RELEASED FROM THE CRYOGENIC VENTING SYSTEM. A QUENCH MAY  
OCCUR AT ANY TIME.  
ENSURE ACCESS TO CRYOGEN VENT EXHAUST AREA IS RESTRICTED  
AND THE RELEASED GAS DOES NOT REENTER THE BUILDING. REFER TO  
THE SPECIFICATIONS BELOW.

1. An exhaust area in front of the vent 20 feet (6.1 m) long by 15 feet (4.6 meters) wide ([Illustration 4-20](#)):
  - a. The facility is responsible for any exhaust area barriers, restrictions, and warning signs
  - b. Must not include air intake vents to prevent cryogen exhaust from reentering the facility
  - c. Must not include any personnel, building components, or objects (movable or stationary)
2. For a rooftop exit:
  - a. Use either a horizontal exhaust vent with a 90° elbow and minimal pressure drop or other low pressure drop, high flow rate roof cap

- b. 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.)
  - c. The outlet must be covered with a 0.5 inch (12.7 mm) square screen mesh
  - d. The exhaust vent must be included in the pressure drop calculation
3. For a sidewall exit:
- a. You can use an exhaust vent with a 45° elbow (with a deflector rated for the helium reaction force) or vent cap with no restriction in gas flow
  - b. The exhaust exit must be at least 12 feet (3.66 meters) above the ground
  - c. The outlet must be covered with a 0.5 inch (12.7 mm) square screen mesh
  - d. The vent exit must be covered to prevent foreign material from entering or blocking the opening (e.g., louvers, etc.)
  - e. The exhaust vent exit must be included in the pressure drop calculation

**Illustration 4-20: Cryogenic Exterior Venting Volume**

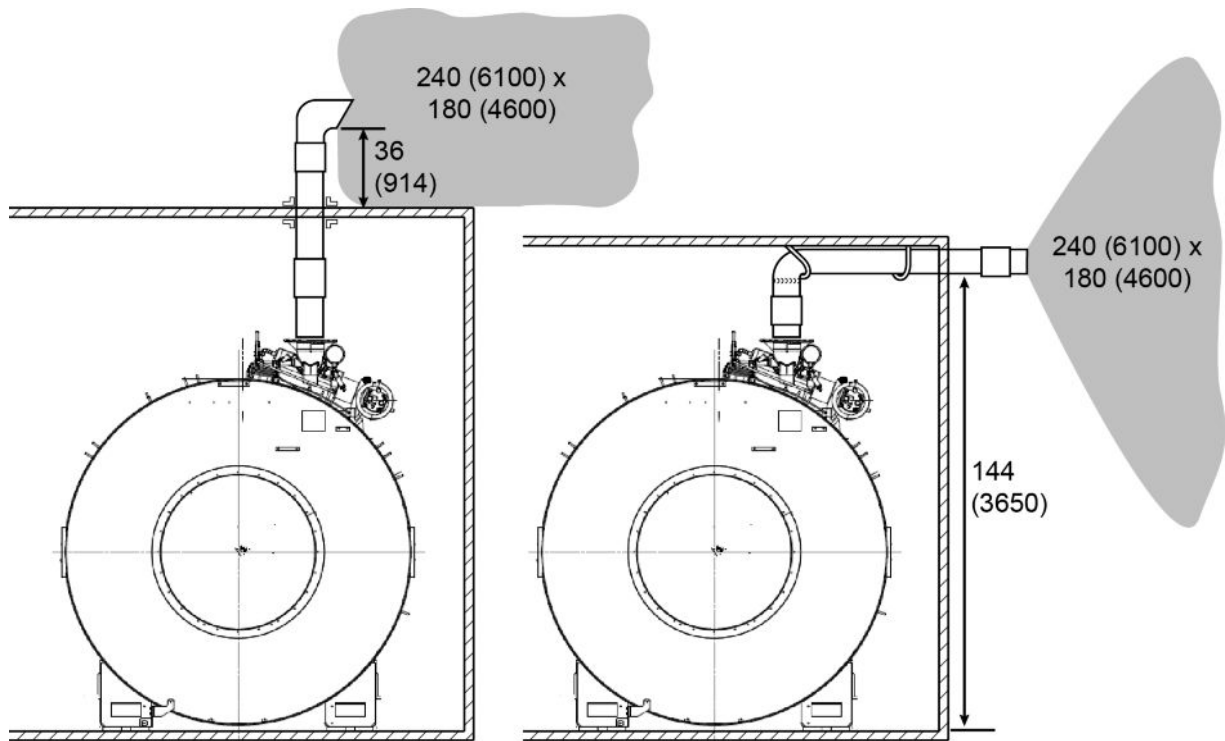
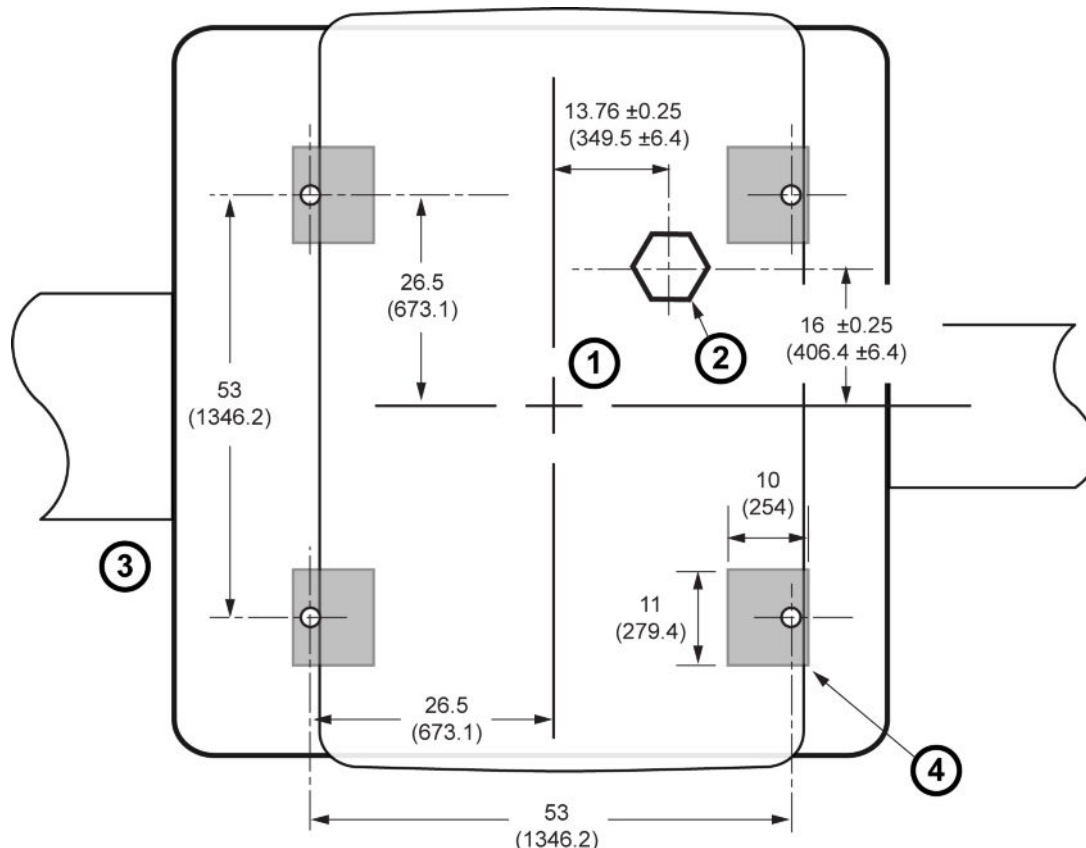


Illustration 4-21: Magnet Cryogenic Vent Location



## 6.8 Combined Vent

A site can combine cryogen venting from two GEHC MR systems.

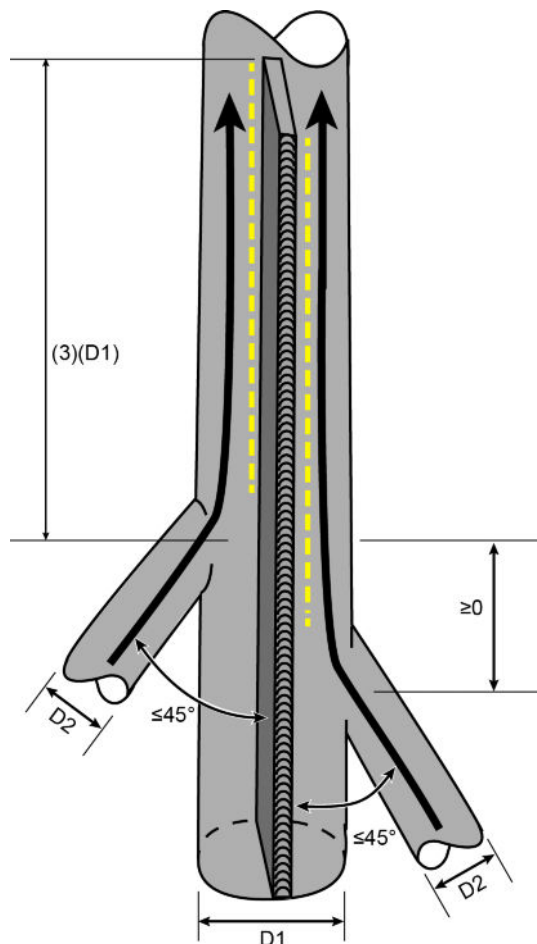
**NOTE:** The customer chooses this option with the risk that a magnet quench may quench the second magnet.

The waveguides of each system can connect via 45 degree elbow connectors to a 12 in. (305) pipe as shown in the illustration below. The pipe must be sealed at the bottom, and a plate must be fully welded to the inside of the pipe to correctly direct all cryogenics out of the magnet room. The plate and pipe used for the combined vent must be the same as the waveguide material.

1. The total pressure drop of the cryogenic venting system for each magnet (from the flanged vent adaptor to the vent exit including the vent exit) must be less than 17 psi (117.2 kPa).
2. The pressure drop in the shared section of the vent must not exceed 4 psig
3. The combined vent pipe diameter selected to maintain the pressure drop will require the combined pipe section diameter meet the back pressure and 35 psi internal pressure forces
4. The two magnet vents require a plate separating the entering pipes to prevent one magnet quench from imposing a back pressure to the other magnet
5. The separation plate must be able to withstand the quench up to 35 psi internal pressure caused by the impinging gas flow. Inspection/replacement of combined pipe section should the separation plate distort post quench.

6. The venting system must have a structural support along any pipe section elbow and at the joining of the two (2) magnet vents to the combined vent.

Illustration 4-22: Combined Vent



**Combined Vent Illustration Notes:**

1. The distance between the magnet and the tie-in point to the large diameter common pipe should be minimized as much as possible.
2. The maximum pressure drop for each magnet between the magnet tie-in to the common pipe and the vent exit to outside shall be less than or equal to 4 psi.
3. An additional pressure drop, equivalent to a standard 90 degree elbow, shall be added to each magnet branch due to the entrance effect to the common pipe section.
4. Use the hydraulic diameter (instead of pipe diameter) when calculating the pressure drop after a magnet branch ties-in to common vent pipe until it leaves the edge of the splitter plate (yellow dashed lines in figure)
5. For a circular cross section of diameter D1, with the divider of height D1:  
Hydraulic diameter =  $(\pi D1) / (\pi + 2)$
6. D2 is typically 8(203) in diameter (Illustration 4-22 is not to scale).

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## Chapter 5 Electrical Requirements

### 1 Power Requirements

#### 1.1 System Power Introduction

The MR system includes a Power Distribution module (PD1) in the lower portion of the System Cabinet which distributes power to most MR system components. Refer to 'Critical Power Requirements' for required customer power specifics.



#### **WARNING**

THE FACILITY TRANSFORMER AND FEEDER WIRES NEED TO BE CORRECTLY SIZED FOR THE SYSTEM POWER DEMANDS.



#### **WARNING**

CUSTOMER SUPPLIED MAIN DISCONNECT PANEL DESIGN NEEDS TO HAVE CORRECTLY SIZED WIRES AND RATED COMPONENTS TO MEET THE MR SYSTEM POWER REQUIREMENTS.



#### **WARNING**

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

Customers should carefully consider the advantages and disadvantages of raised flooring, conduits, floor ducts, and surface raceways for running cables in accordance with local codes. If used, conduits should be large enough to pass any cable and its connector through with all other cables in the conduit.

To reduce voltage regulation problems and wiring costs, minimize the cable length between the primary power source and the Power Distribution Unit. When routing cables, keep all phase conductors and ground for a circuit in the same trough. Whenever possible, keep power cables away from signal and data cables. Use separate trough or dividers in duct.

Table 5-1: Required Customer Power

| MR Component                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Voltage (VAC)                                                                                                                       | Frequency      | Phase                | Max. Amps           | Comments                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power Distribution Unit (PD1) Module located in the lower portion of System Cabinet. See Notes 1 & 4 See Note 5 if customer MDP                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 480Y/277 VAC 10% or<br>415Y/240 VAC 10% or<br>400Y/230 VAC 10% or<br>380Y/219 VAC 10% or<br>208Y/120 VAC 10% or<br>200Y/115 VAC 10% | 60 Hz or 50 Hz | (3+GND) See Comments | See Note 2          | 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 System Cabinet. Optional input configuration: 3 phase DELTA with Ground (4 wire) input, recommend corner Grounded Delta configuration |
| *Shield/Cryo Cooler Cabinet (F-50H)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 460, 480                                                                                                                            | 60 Hz          | 3+GND                | 13                  | 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 3.                                                                                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 380, 400, 415                                                                                                                       | 50 Hz          |                      |                     |                                                                                                                                                                                                                                                                                                                                             |
| *Shield/Cryo Cooler Cabinet (F-50L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 200                                                                                                                                 | 50 Hz/60 Hz    | 3+GND                | 23/26 (50 Hz/60 Hz) |                                                                                                                                                                                                                                                                                                                                             |
| *Shield/Cryo Cooler Cabinet (Air Cooled)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 200                                                                                                                                 | 50 Hz/60 Hz    | 3+GND                | 25                  |                                                                                                                                                                                                                                                                                                                                             |
| Magnet Rundown Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100-120 or 200-240                                                                                                                  | 50/60 Hz       | 1                    | 1.0                 | Hard wired in unit and at facility power. 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, Magnet Monitor power is required to be ON 24 hours per day to minimize cryogen costs and for proper LCC Magnet performance. Also see Note 4.                                                                                                                                                                           |
| 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.                                                                                                                                                                                                                                     |
| **11kW Chiller                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 460/480 ± 10%                                                                                                                       | 60 Hz          | 3                    | 13                  | 13 Amp minimum circuit required, customer supplied power wire, 10 AWG (6 mm2) maximum wire size.                                                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 380/400 ± 10%                                                                                                                       | 50 Hz          |                      |                     |                                                                                                                                                                                                                                                                                                                                             |
| ** Lytron BRM Chiller                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 208+/-10%                                                                                                                           | 50 Hz/60 Hz    | 1+GND                | 19.6                | This Chiller is used for Type D, E System Configuration.                                                                                                                                                                                                                                                                                    |
| *** O <sup>2</sup> Monitor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 110-120 or 200-240                                                                                                                  | 50/60 Hz       | 1                    | 3.0                 | Hard wired in monitor                                                                                                                                                                                                                                                                                                                       |
| <b>Notes</b><br>1. Power phase conductors, neutral (if present), and ground conductor must be routed inside the same raceway, cable tray, trench cable. or cord per National Electric Code (NEC) 2005 or 2002 Articles 250.134, 300.3, 517.13.<br>2. Maximum amps dependent on voltage selected.<br>3. 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.<br>4. If customer provided MDP has been selected then Customer provided MDP MUST meet all MDP requirements.<br>5. For maximum instant current is 300% Rated Input Current 10 sec, and rating input current = 25KVA / (3 x input voltage).<br>* / ** Selectable unit per configuration. Refer to Basic System for system configuration.<br>*** Optional equipment. |                                                                                                                                     |                |                      |                     |                                                                                                                                                                                                                                                                                                                                             |



## 1.2 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). A GE pre-engineered Main Disconnect Panel is an option available per flowcharts in Basic System.



### NOTICE

If customer provided MDP has been selected then customer provided MDP **MUST** meet all MDP requirements.

Refer to Main Disconnect Panel Requirements for Main Disconnect Panel capability and set up. All work is to be done in accordance with national and local electrical codes.



### WARNING

THE FACILITY TRANSFORMER AND FEEDER WIRES NEED TO BE CORRECTLY SIZED FOR THE SYSTEM POWER DEMANDS.



### WARNING

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

Table 5-2: Critical Power Requirements

| Parameter                                                 | Requirements                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Configuration                                             | <ul style="list-style-type: none"> <li>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 and not brought to the System Cabinet.</li> <li>Optional input configuration 3 phase DELTA with Ground (4 wire) input, recommend corner Grounded Delta configuration.</li> </ul> |
| 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 (Water Cooled Type) | 380/400/415 VAC 50 Hz, 460/480 VAC 60Hz, or 200VAC 50Hz/60Hz                                                                                                                                                                                                                                                                                                                                              |
| Shield/Cryo Cooler Compressor Voltage (Air Cooled Type)   | 200VAC 50Hz/60Hz                                                                                                                                                                                                                                                                                                                                                                                          |
| 11kW Chiller Voltage                                      | 380/400 VAC 10% 50 Hz or 460/480 VAC 10% 60Hz                                                                                                                                                                                                                                                                                                                                                             |
| Lytron BRM Chiller                                        | 208+/-10%VAC 50Hz/60Hz,                                                                                                                                                                                                                                                                                                                                                                                   |

| Parameter                                                                                                                                                                  | Requirements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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"> <li>Main facility ground conductor to Main Disconnect Panel (MDP) shall be copper and the minimum as required by the local coding regulations, such as the National Electric Code (NEC) 2005 or 2002 Article 250.122.</li> <li>Main facility ground wire to be insulated.</li> <li>Ground impedance to earth at power source to be 10 ohms or less.</li> <li>Main facility ground wire to be bonded at every distribution box in an approved grounding block.</li> </ul>                                                                                                         |
| Maximum Momentary Demand                                                                                                                                                   | The power demands specified as a function of the duration of the power demand. <a href="#">Table 5-4</a> , <a href="#">Table 5-5</a> , <a href="#">Table 5-6</a> , and <a href="#">Table 5-7</a> list points on the curve. The power system feeding the 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 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 system is designed to tolerate these short voltage sags. |
| Average (while scanning) Power Demand                                                                                                                                      | 20kVA for PDU and 9KVA (continuous operation) for Shield/Cryo Cooler Cabinet. See Note1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 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. See Note1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Notes</b><br>1. There are 4 Cooling Configurations and Critical Power Requirements is different per each configuration. Refer to Basic System for system configuration. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

**Table 5-3: Required Current for each system configuration**

| Input Voltage (V) (+/-10%)                                                                                                                                                                                                                                                                                                                                                                                                       | Total Current (A) |           |        |        |              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----------|--------|--------|--------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                  | Type A            | Type B    | Type C | Type D | Type E       |
| 480                                                                                                                                                                                                                                                                                                                                                                                                                              | 86                | 54        | 70     | 95     | 79           |
| 415                                                                                                                                                                                                                                                                                                                                                                                                                              | 92                | 60        | 76     | 101    | 85           |
| 400                                                                                                                                                                                                                                                                                                                                                                                                                              | 94                | 61        | 78     | 103    | 87           |
| 380                                                                                                                                                                                                                                                                                                                                                                                                                              | 96                | 64        | 80     | 105    | 89           |
| 208(50Hz/60Hz)                                                                                                                                                                                                                                                                                                                                                                                                                   | N/A               | 122.5/126 | N/A    | 142    | 147.5/151.25 |
| 200(50Hz/60Hz)                                                                                                                                                                                                                                                                                                                                                                                                                   | N/A               | 126/130   | N/A    | 146    | 151.25/155   |
| <b>Notes</b><br>1. Each site should be planned according to input voltage and system configuration type.<br>2. Local chiller or facility water power needs not included in Type B configuration.<br>3. Step Down Transformer option (M3335TZ) could be used in Type D or Type E, in calculation 97% transforming efficiency is considered.<br>4. All the calculation is based on nominal value with 125% derating consideration. |                   |           |        |        |              |

**Table 5-4: System With BRM Coil Peak Power Demand for Type A Configuration**

| System Equipment                                                                                                                                                                                                                                                                                                                                                       | Power Demand |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| PDU(in System Cabinet) draw for 5.0 sec. See Note 1                                                                                                                                                                                                                                                                                                                    | 30 KVA       |
| Magnet Monitor. See Note 2                                                                                                                                                                                                                                                                                                                                             | 0.15 KVA     |
| 11kW Chiller for Shield/Cryo Cooler Compressor See Note3                                                                                                                                                                                                                                                                                                               | 10 KVA       |
| 11kW Chiller for 8kW Chiller and BRM See Note3                                                                                                                                                                                                                                                                                                                         | 10 KVA       |
| Shield/Cryo Cooler Compressor.                                                                                                                                                                                                                                                                                                                                         | 9 KVA        |
| TOTAL for 5.0 sec.                                                                                                                                                                                                                                                                                                                                                     | 59.15 KVA    |
| <b>Notes</b><br>1. The PDU draw on the line will not exceed list values. Continuous power demand of PDU in System Cabinet is 25 kVA.<br>2. The Magnet Monitor equipment power is 0.15 KVA 1 phase on an unbalanced leg of 3 phase input (0.45 KVA 3 phase equivalent).<br>3. 10.9KVA is for 11kW Chiller 60Hz Model. For 11kW Chiller 50Hz model, peak power is 8.8kVA |              |

**Table 5-5: System With BRM Coil Peak Power Demand for Type B Configuration**

| System Equipment                                                                                                                                                                                                                                                                                                                                                                               | Power Demand |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| PDU(in System Cabinet) draw for 5.0 sec. See Note 1                                                                                                                                                                                                                                                                                                                                            | 30 KVA       |
| Magnet Monitor. See Note 2                                                                                                                                                                                                                                                                                                                                                                     | 0.15 KVA     |
| Shield/Cryo Cooler Compressor.                                                                                                                                                                                                                                                                                                                                                                 | 9 KVA        |
| TOTAL for 5.0 sec. See Note 3                                                                                                                                                                                                                                                                                                                                                                  | 39.15 KVA    |
| <b>Notes</b><br>1. The PDU draw on the line will not exceed list values. Continuous power demand of PDU in System Cabinet is 25 kVA.<br>2. The Magnet Monitor equipment power is 0.15 KVA 1 phase on an unbalanced leg of 3 phase input (0.45 KVA 3 phase equivalent).<br>3. If local chilller is used as Type B' configuration, this table does not include the peak demand of Local Chiller. |              |

**Table 5-6: System With BRM Coil Peak Power Demand for Type C Configuration**

| System Equipment                                                                                                                                                                                                                                                                                                                                                               | Power Demand |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| PDU(in System Cabinet) draw for 5.0 sec. See Note 1                                                                                                                                                                                                                                                                                                                            | 30 KVA       |
| Magnet Monitor. See Note 2                                                                                                                                                                                                                                                                                                                                                     | 0.15 KVA     |
| 11kW Chiller for Shield/Cryo Cooler Compressor and BRM<br>See Note3                                                                                                                                                                                                                                                                                                            | 10 KVA       |
| Shield/Cryo Cooler Compressor.                                                                                                                                                                                                                                                                                                                                                 | 9 KVA        |
| TOTAL for 5.0 sec.                                                                                                                                                                                                                                                                                                                                                             | 49.15 KVA    |
| <b>Notes</b><br>1. The PDU draw on the line will not exceed list values. Continuous power demand of PDU in System Cabinet is 25 kVA.<br><br>2. The Magnet Monitor equipment power is 0.15 KVA 1 phase on an unbalanced leg of 3 phase input (0.45 KVA 3 phase equivalent).<br><br>3. 10.9KVA is for 11kW Chiller 60Hz Model. For 11kW Chiller 50Hz model, peak power is 8.8kVA |              |

**Table 5-7: System With BRM Coil Peak Power Demand for Type D, E Configuration**

| System Equipment                                                                                                                                                                                                                                                                                                                     | Power Demand |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| PDU(in System Cabinet) draw for 5.0 sec. See Note 1                                                                                                                                                                                                                                                                                  | 30 KVA       |
| Magnet Monitor. See Note 2                                                                                                                                                                                                                                                                                                           | 0.15 KVA     |
| Water chiller for BRM                                                                                                                                                                                                                                                                                                                | 4.6KVA       |
| Shield/Cryo Cooler Compressor                                                                                                                                                                                                                                                                                                        | 9 KVA        |
| TOTAL for 5.0 sec.                                                                                                                                                                                                                                                                                                                   | 43.75 KVA    |
| <b>Notes</b><br>1. The PDU draw on the line will not exceed list values. Continuous power demand of PDU in System Cabinet is 25 kVA.<br><br>2. The Magnet Monitor equipment power is 0.15 KVA 1 phase on an unbalanced leg of 3 phase input (0.45 KVA 3 phase equivalent).<br><br>3. The power of step-down transformer is 11.5 KVA. |              |

## 1.3 Power Distribution

### 1.3.1 Main Disconnect Panel (MDP) Requirements



#### NOTICE

If customer provided MDP has been selected then customer provided MDP MUST meet all MDP requirements.



#### WARNING

CUSTOMER PROVIDED MAIN DISCONNECT PANEL DESIGN NEEDS TO HAVE CORRECTLY SIZED WIRES AND RATED COMPONENTS TO MEET THE MR SYSTEM POWER REQUIREMENTS.



#### WARNING

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

**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).

Both the GE pre-engineered MDP (M3088TM) and customer provided MDP can be applied for Type A, B and C system configuration. For Type D and Type E, only the customer provided MDP could be applied. If you select customer provided MDP, please refer to Required Customer Power shown in [Table 5-1](#), [Table 5-2](#) and [Table 5-3](#).

The GE pre-engineered MDP (M3088TM) provides multi-point remote control capability which is shown in [Illustration 5-1](#).

The design of the MDP shall incorporate an adjustable time delay auto restart control circuit for the 11kW Chiller (or Lytron BRM Chiller), the Shield/Cryo Cooler Compressor Cabinet, and the single phase transformer for Magnet Monitor equipment (Magnet Monitor, optional UPS for Magnet Monitor, modem and the optional Multiplexer Box). The PDU shall not be included in the auto restart control circuit. Operation of any remote Emergency Off pushbutton MUST disable all MDP power and control circuits. LED pilot lights shall indicate system power status.

All control shall be low voltage. Power components shall be selected to provide type 2 coordination between overcurrent devices and all contactors. The 120 VAC supply receptacles for remotely mounted Magnet Monitor UPS (option) and Mux Box (option) must be included along with properly protected control power transformer. The 120 VAC UPS output power shall be connected back into the MDP for distribution to the Magnet Monitor and Modem. Operation of the previously mentioned Emergency Power Off pushbuttons shall disconnect and isolate the Magnet Monitor UPS output circuits from the Magnet Monitor and modem as well as disable the auto restart function.

The GE pre-engineered MDP (M3088TM) consists of the following:

- A three-pole Main Circuit breaker rated for the total current of all the sub-breakers circuits. The short-circuit current interrupting rating of the breaker is 25,000 Amperes minimum or higher interrupting rating sufficient to interrupt the facility available short circuit current at its installed location per NEC 2002 Article 110.9.
- A three-pole circuit breaker rated for the current of the PDU circuit. The short-circuit current interrupting rating of the breaker is 25,000 Amperes minimum or higher interrupting rating sufficient to interrupt the facility available short circuit current at its installed location per NEC 2002 Article 110.9.
- A three-pole circuit breaker rated for the current of the Cryo Cooler Compressor Chiller (1st 11kW Chiller unit) circuit. The short-circuit current interrupting rating of the breaker is 25,000 Amperes to accommodate facility available short circuit current.
- A three-pole circuit breaker rated for the current of the Gradient Chiller (2nd 11kW Chiller unit) circuit. The short-circuit current interrupting rating of the breaker is 25,000 Amperes to accommodate facility available short circuit current.
- A three-pole circuit breaker rated for the current of the Shield/Cryo Cooler Compressor Cabinet circuit. The short-circuit current interrupting rating of the breaker is 25,000 Amperes to accommodate facility available short circuit current.
- A circuit to provide 120VAC single phase power to the Magnet Monitor, Modem, UPS for Magnet Monitor (optional), and Multiplexer Box (optional). The short-circuit current interrupting rating of the breaker is 25,000 Amperes to accommodate available fault current. The MDP includes a single phase step down transformer for 120VAC loads such as Magnet Monitor equipment (Magnet Monitor, optional UPS for Magnet Monitor, modem and the optional Multiplexer Box).
- The MDP Panel has receptacles inside the panel enclosure for connections of the UPS for Magnet Monitor input and output, Multiplexer Box, Magnet Monitor, and modem. The enclosure has provision for these cables to enter through the access panels in the bottom left side of the enclosure. Mounting of the panel must allow for 5-6 inch (127-152 mm) of free space to allow for cable bending and installation. Strain relief bushings are provided with the individual equipment for each of these cables, not provided with the MDP.

The MDP is to be located so the top of the upper circuit breaker handle when in the ON position does not exceed 79 inches (2000 mm) from the floor and visible to Power Distribution Unit (PD1), 11kW Chiller or its RCP, Shield/Cryo Cooler Compressor Cabinet, and the service personnel. The optional UPS for the Magnet Monitor may be located below the MDP if sufficient space is available or adjacent if sufficient space is not available.

**NOTE:** The GE pre-engineered MDP circuits for the 11kW Chiller, the Shield/Cryo Cooler Compressor Cabinet, and the single phase transformer for Magnet Monitor equipment (Magnet Monitor, optional UPS for Magnet Monitor, modem and the optional Multiplexer Box) have auto restart upon return of normal power after a time delay of 3 to 30 seconds (field adjustable) to minimize cryogen consumption of the system. The MDP Emergency Off circuit turns off power to all branch circuits including the Magnet Monitor UPS option output and turns off the auto restart function.

**NOTE:** The PDU circuit has low voltage release feature which disconnects power from the PDU upon the first loss of power. Power to the PDU is not restored automatically after a power interruption. Emergency Off operation disconnects power from all circuits including the PDU.

The circuit breakers or fuses ahead of the MDP must be capable of handling the magnetizing inrush currents of the Coldhead 11kW Chiller, Gradient 11kW Chiller (or Lytron BRM Chiller), Shield/Cryo Cooler Compressor, Magnet Monitor equipment, and transformer of the PDU module (PD1) in the System Cabinet (MR3). If fuses are used time delayed fuses are recommended.

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 set-up.

The GE pre-engineered MDP (M3088TM) 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 pre-engineered MDP (M3088TM) 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 system which powers down only a portion of system equipment for patient safety.

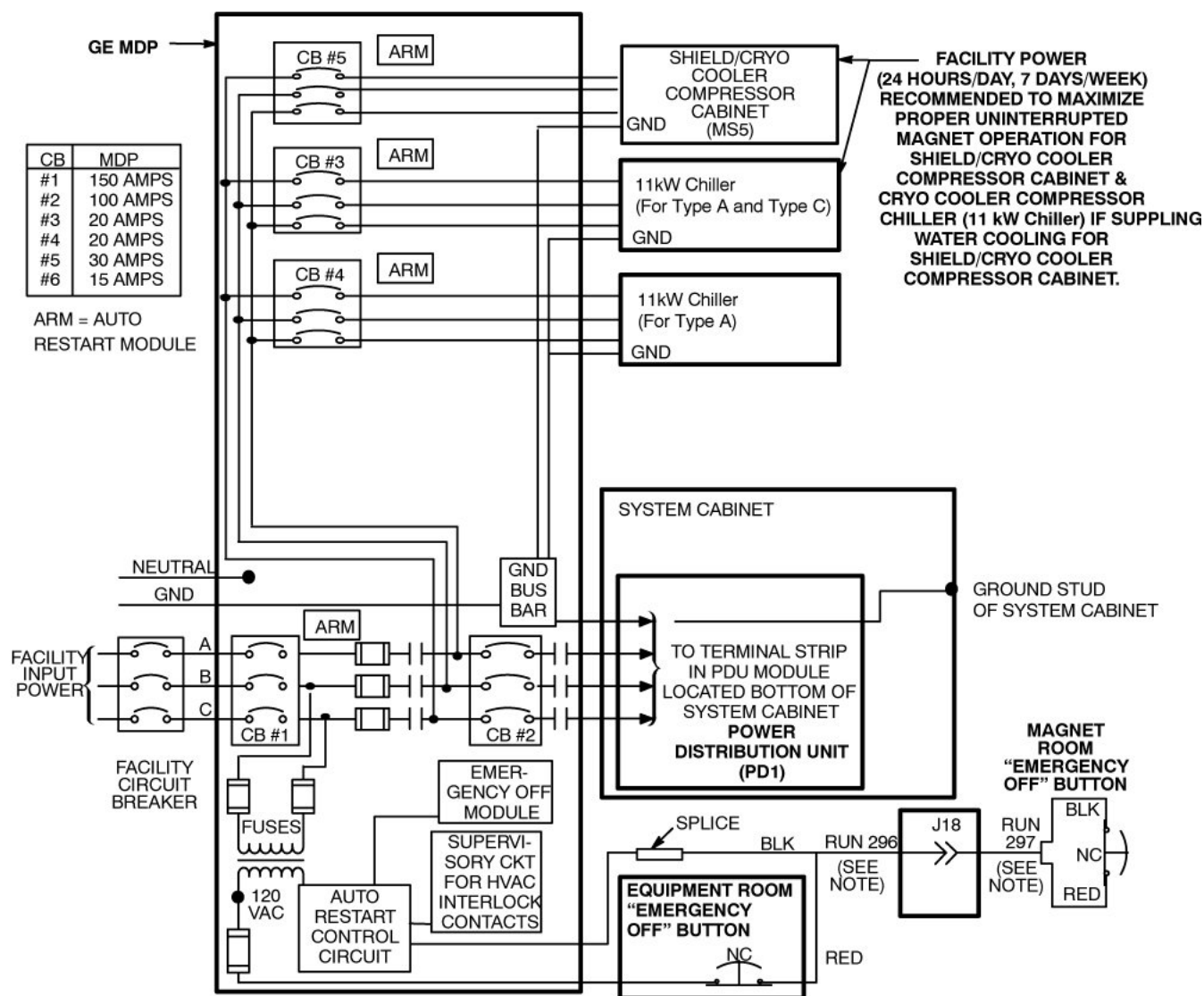
**NOTE:** The emergency off circuit disconnects power to the PDU, 11kW Chiller, Shield/Cryo Cooler Compressor Cabinet, the single phase 120V transformer output and optional UPS (if purchased) for Magnet Monitor equipment. Power can be restored to the MDP outputs by pressing the MAIN POWER ON pushbutton on the MDP for the 11kW Chiller, Shield/Cryo Cooler Compressor Cabinet, Magnet Monitor equipment (Magnet Monitor, optional UPS for Magnet Monitor, modem and the optional Multiplexer Box). Power to the PDU is restored by pressing the PDU POWER ON pushbutton and also requires pressing the EMO Reset button on the PDU.

The MDP must be lockable to provide for single point power Lockout/Tagout requirements. The MDP provides for the disconnection of the facility power to the PDU, 11kW Chiller, and Shield/Cryo Cooler Compressor Cabinet. Individual branch circuits for the PDU, Magnet Monitor equipment, 11kW Chiller, and Shield/Cryo Cooler Compressor Cabinet must be lockable circuit breakers. The GE pre-engineered MDP has lockable GE Spectra circuit breakers and also has electrical contacts for an interlock to the air-conditioning units in the Equipment Room. Check local and national codes to determine if an interlock to the air-conditioning unit in the Computer/Equipment Room is required in the protective disconnect set-up.

The MDP must be listed and labeled by a Nationally Recognized Testing Lab (NRTL) such as Underwriters Laboratory (UL) in accordance with 2002 National Electric Code (NEC) Article 110.2. The GE pre-engineered MDP (M3088TM) is UL labeled in accordance with 2002 National Electric Code (NEC) Article 110.2. The GE pre-engineered MDP is cUL and CE labelled. A customer designed and manufactured MDP labeling must bear the appropriate markings per local/national regulations.

**NOTE:** The maximum conductor the GE pre-engineered MDP (M3088TM) can accept is #3/0 AWG (83 mm<sup>2</sup>). For feeders larger than 3/0 AWG (83 mm<sup>2</sup>) the wires must be reduced (ie. splice, junction box, etc.) to 3/0 AWG (83 mm<sup>2</sup>) 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 mm<sup>2</sup>).

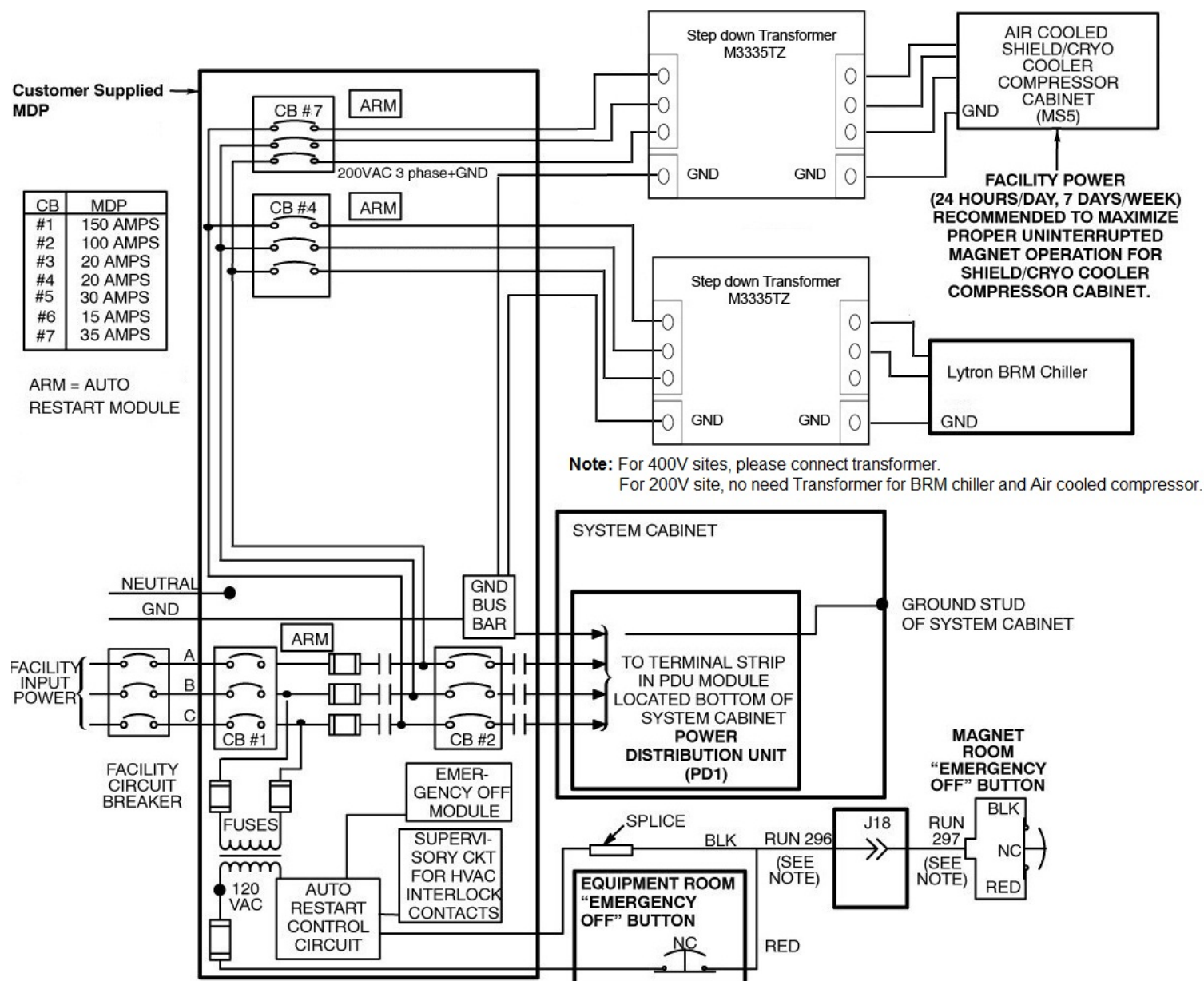
**Illustration 5-1: GE pre-engineered MDP (M3088TM) schematic for Type A, B or C configuration**



**NOTE:** All the numbers showing in [Illustration 5-1](#) is the rated value of GE pre-engineered MDP (M3088TM), not the system's requirements. Please refer to [Table 5-1](#), [Table 5-2](#), [Table 5-3](#) for specific system requirements while you select customer provided MDP.

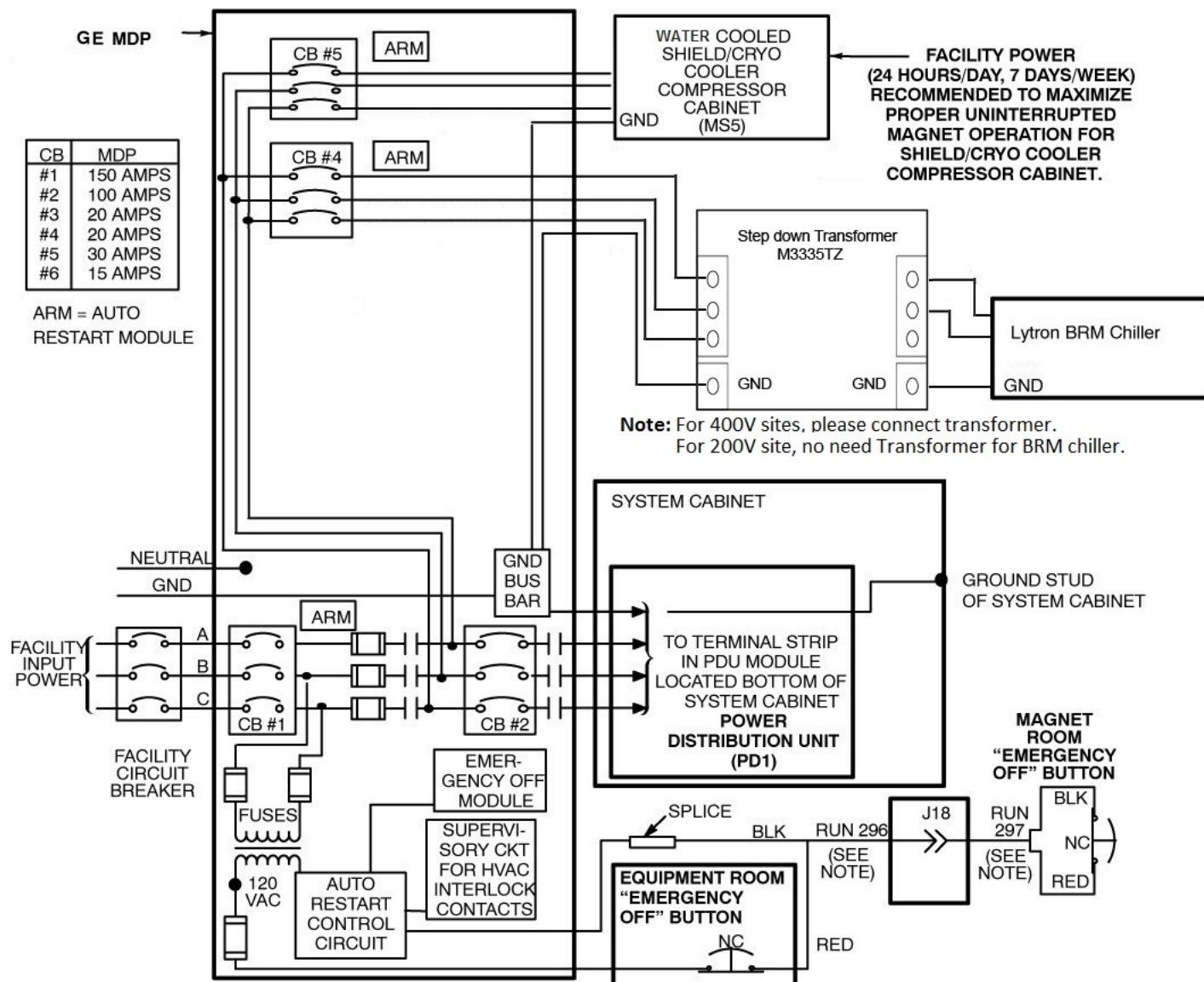


**Illustration 5-2: Step down transformer connected method with customer provided MDP (Type D)**



**NOTE:** All the MDP information in [Illustration 5-2](#) just is used for explaining how the step down transformer will be connected. The actual customer provided MDP may different from above. Please refer to [Table 5-1](#), [Table 5-2](#), [Table 5-3](#) for specific system requirements while you select customer provided MDP.

**Illustration 5-3: Step down transformer connected method with customer provided MDP (Type E)**



**NOTE:** All the MDP information in [Illustration 5-3](#) just is used for explaining how the step down transformer will be connected. The actual customer provided MDP may different from above. Please refer to [Table 5-1](#), [Table 5-2](#), [Table 5-3](#) for specific system requirements while you select customer provided MDP.

### **1.3.2 System Power Distribution Unit**

The PDU Module in the lower portion of System Cabinet /PDU Cabinet has an integrated filter for a level of power conditioning. The largest allowable phase conductor the PDU will accept is 3/0 AWG (83 mm<sup>2</sup>). Larger feeder wires can be connected to the MDP with 3/0 AWG (83 mm<sup>2</sup>) between the MDP and PDU.

**NOTE:** The ground conductor between the MDP and PDU shall be minimum size of 1/0 AWG copper or the same size as the feeder wire, which ever is larger. Lug connector for the ground wire is to be provided by the contractor, recommended Amp Inc. number 36919 lug.

**NOTE:** The resistance between any two grounded devices in the MR system must not exceed 0.1 ohm (ie. PDU and MDP).

**NOTE:** Neutral, if present, must be terminated prior to or inside the Main Disconnect Panel and not brought to the PDU Module in the lower portion of System Cabinet/PDU Cabinet (MR3).

## **1.4 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.

## **1.5 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.

## 2 Grounding

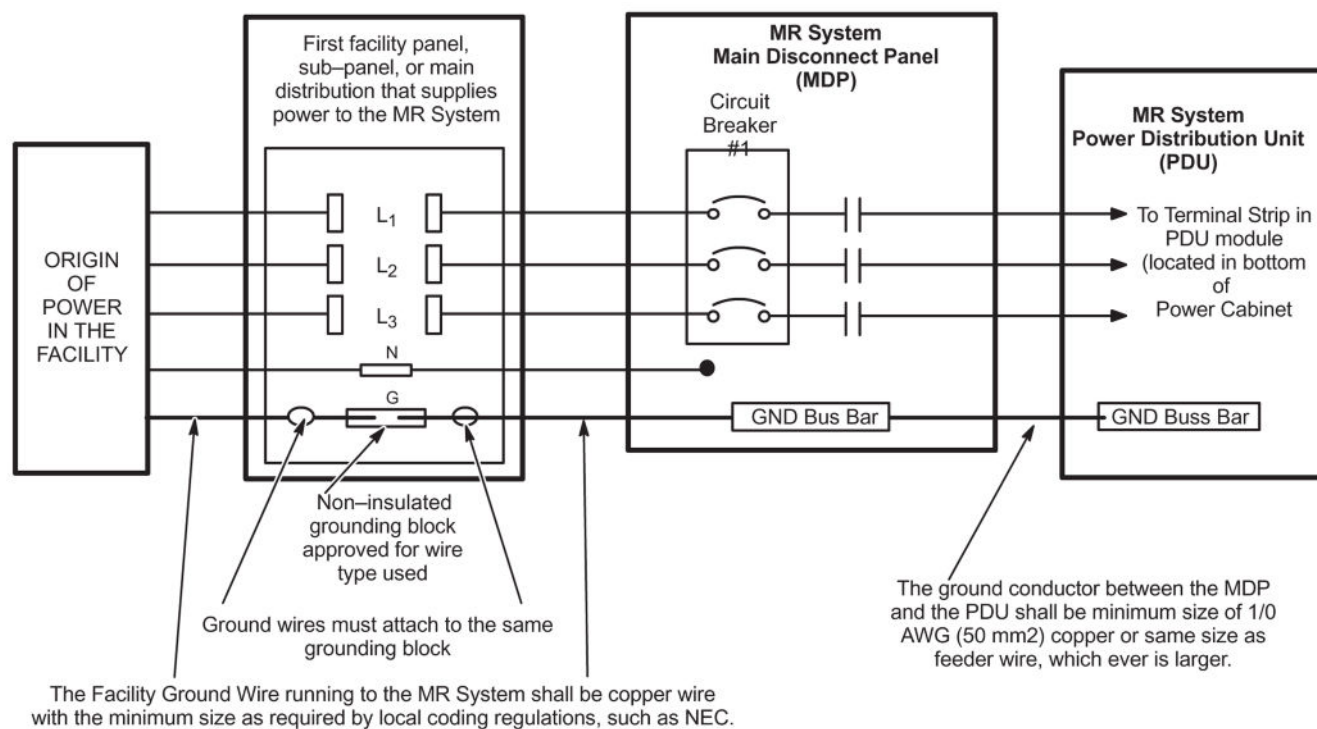
### 2.1 Grounding

#### 2.1.1 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 5-4](#).

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 5-4: 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 5-4](#). The ground wire impedance from the MR system disconnect, including the ground rod, shall not have an impedance greater than 10 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.

### **2.1.2 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 in the System Cabinet, Ground Stud of System Cabinet (Scan Room Side), the enclosure ground points (ground studs located in each cabinet or enclosure), and the RF shielded room common ground point (Customer Prepared Option). 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 3, Electrical](#) for a further description of the RF shielded room common ground point.

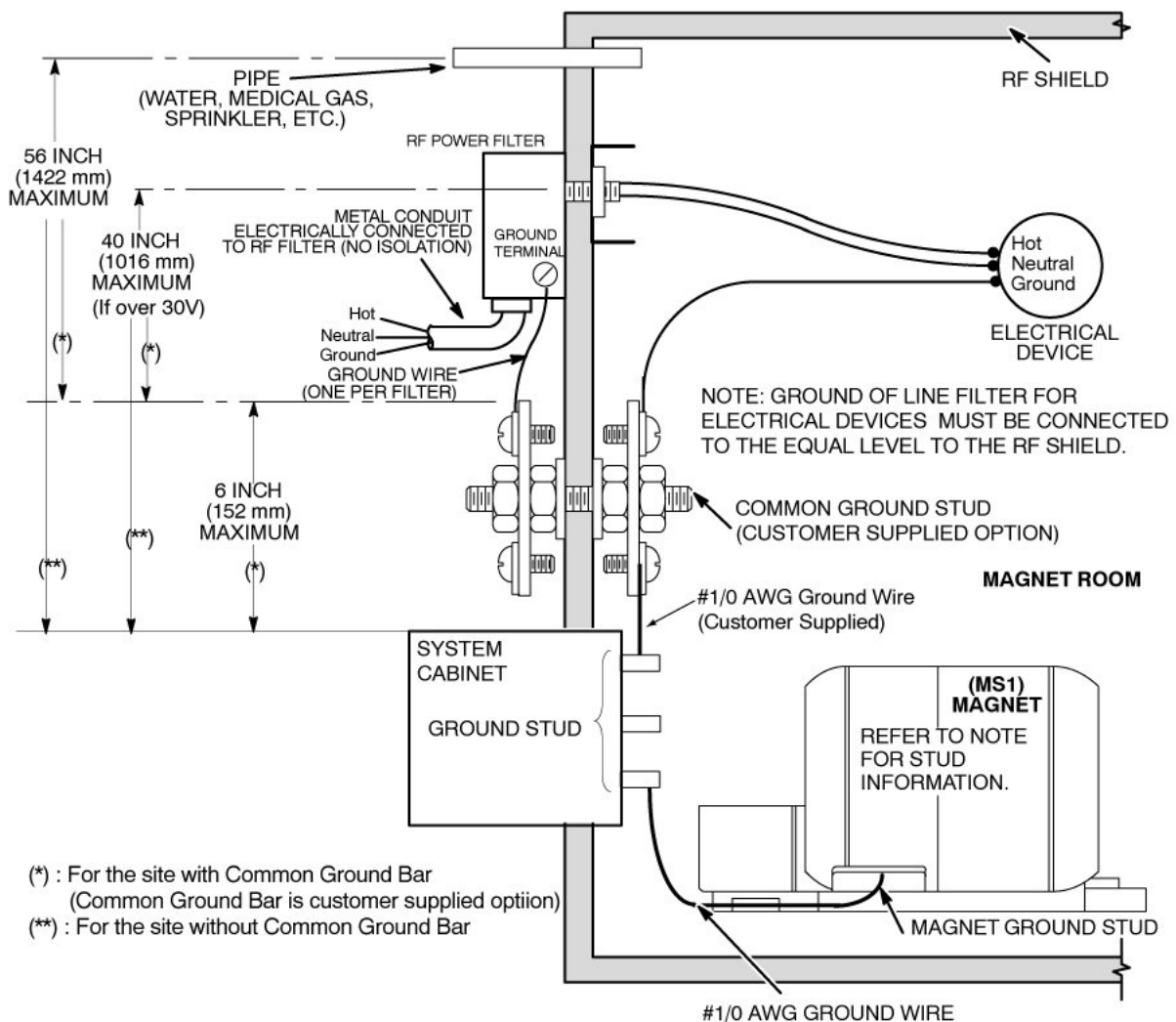
To ensure patient safety and system performance, the conditions defined in [Illustration 5-5](#) must be met when running power lines into the Magnet Room.

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 5-5: MR Magnet Room Grounding Requirements And Typical Diagram

### Note:

1. All items shown are customer supplied except System Cabinet, Magnet, and #1/0 AWG Ground Wire between System Cabinet Ground stud and Magnet Ground stud.
2. Resistance between any two grounded devices must not exceed 0.1 ohm to ensure equal potential ground system within the Magnet Room.
3. RF Power Filters over 30 volts must be located within 40 in. (1016 mm) of the RF Common Ground Stud or Cabinet Rear Panel.
4. RF Power Filters of 30 volts or less may be located anywhere on the RF Shield.
5. All metallic pipes (including water, medical gas, sprinklers, etc.) entering the RF Shield, excluding the Cryogenic Vent and floor drains, must be located within 56 inches (1422 mm) of the RF Common Ground Stud or Cabinet Rear Panel.
6. All electrical devices (e.g., outlets, light fixtures, etc.) must have a ground wire from device power source and be grounded to the RF Shield at the RF Common Ground Stud.
7. One #1/0 AWG Ground Wire to be connected to only one ground stud on Magnet Foot or Cryostat.
8. Do not ground non-MR equipment to the MR ground system.
9. The illustration below shows a typical ground layout.





## **2.2 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.

## 3 Interconnections

### 3.1 MR System Interconnects Routing Requirements

#### 3.1.1 Cabling Requirements

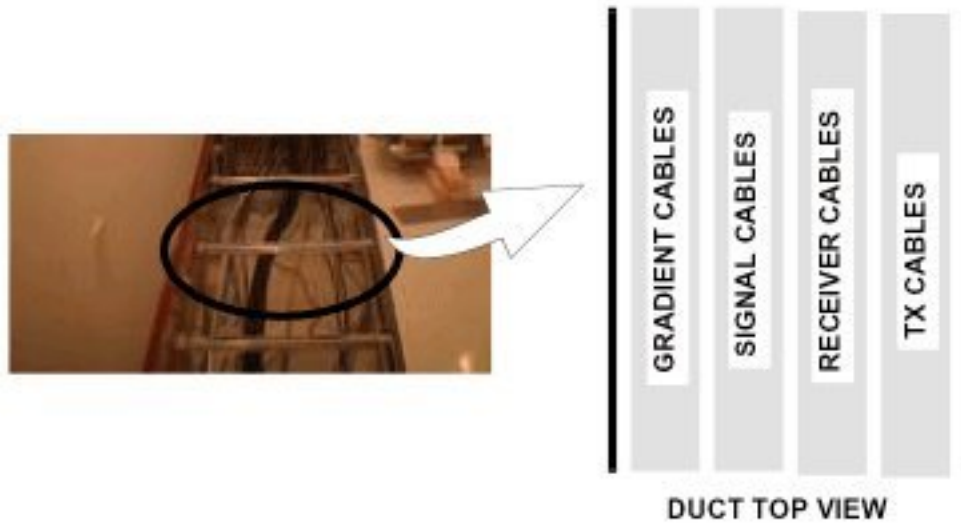
1. The customer is responsible for design, purchase, and installation of any Interconnect Cable Routing Mechanism (ICRM)

**NOTE:** For Optima MR360/ Brivo MR355 System, ICRM is pit or duct in Magnet Room. Recommended duct example in Magnet Room is shown in Magnet Room equipment specification

2. Any ICRM may be used provided it meets all MR system requirements and any applicable local and national codes
3. Any Magnet Room ICRM must attach to the RF Shield Room and installation must be coordinated with the RF shield vendor
4. All cables must enter the back of the magnet along the Z-axis (the Z-axis runs parallel to the patient table and the bore of the magnet).
5. The magnet-end subsection of the ICRM routing the gradient cables must be aligned to the center of the magnet (when viewed from the top)
6. Cables must be accessible for maintenance at all points along the route.
7. The ICRM must be nonferrous (e.g., composites or aluminum)
8. The ICRM must meet the minimum cable bend radius. See [MR System Cable Specifications](#)
9. Run the gradient cables, signal cables, receiver cables, and Tx cables separately in the duct. Otherwise, cables may cause the noise problem. See [Illustration 5-6](#)
10. All electrical and mechanical connections and fasteners must be tightened and secured to supplier specifications to prevent broadband interference
11. Excess cable length in the equipment must be stored in the Equipment room.
12. Excess cable length in the Magnet room must be stored in the pit or duct.

### **3.1.2 Cable Groupings**

**Illustration 5-6: Cable Groupings**



## 3.2 MR System Interconnects Specifications

### 3.2.1 Component Designator Definitions

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

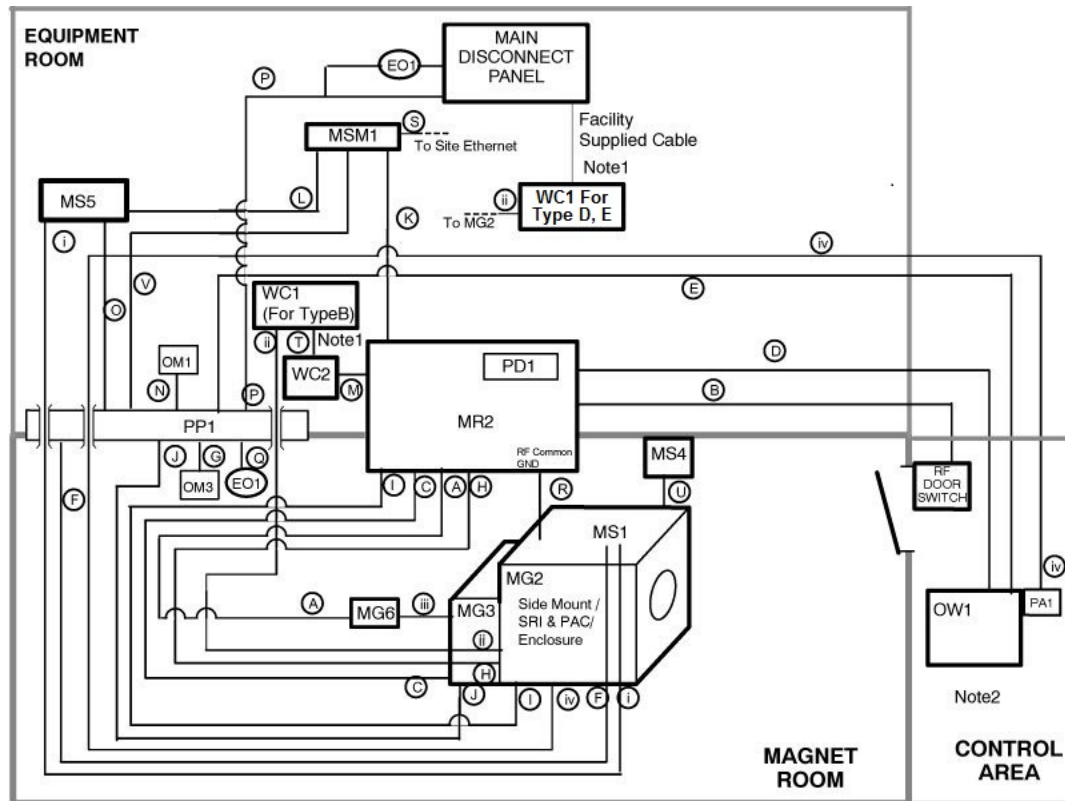
**Table 5-8: Component Designation**

| 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                  | System Cabinet                                                                |
|                        | MS1                  | Superconducting Magnet                                                        |
|                        | MS4                  | Magnet Rundown Unit                                                           |
|                        | MS5                  | Shield/Cryo Cooler Compressor Cabinet                                         |
|                        | 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 for BRM                                                         |
|                        | WC2                  | Water Chiller for System Cabinet                                              |
| Option                 | OM1                  | Oxygen Monitor                                                                |
|                        | OM3                  | Remote Oxygen Sensor Module                                                   |

### 3.2.2 Group Interconnect

Illustration 5-7 shows the Group Interconnect Diagram for System. Each group contains one or more cables. For detail cable specification, refer to [MR System Cable Specifications](#).

Illustration 5-7: Group Interconnect Diagram



Note1: WC1 is used in Type B, Type D and Type E configuration.

For Type B, 4kW LCS is used and the power is supplied by 8kW LCS (WC2).

For Type D, Type E, Lytron BRM Chiller is used and the power is supplied from Facility PDU

Note2: This diagram shows both Equipment Room and Control Room.

Note3: This diagram shows electrical wiring supplied by GE.

For cooling diagram, refer to Water Cooling Section.

### 3.2.3 Usable Cable Lengths

Table 5-9: The Length Provided By Fixed Site Catalogs

| Group (See Note2)                                                                                        | Between Units             |                    | Site option: Short Kit (M50002LW)                                                                                                             | Site Option: Long Kit (M50002LT)                |
|----------------------------------------------------------------------------------------------------------|---------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
|                                                                                                          | From                      | To                 | usable cable length ft(m) (See Note1)                                                                                                         |                                                 |
| A                                                                                                        | MR2                       | MG6                | 14.11(4.3)                                                                                                                                    | 37.07(11.3)                                     |
| B                                                                                                        | MR2                       | RF Door Switch     | 72 (22) allows 15 ft takeup at RF Door Switch                                                                                                 |                                                 |
| C / I                                                                                                    | MR2                       | MG3/2              | 13.12 (4)                                                                                                                                     | 30.18(9.2)                                      |
| D                                                                                                        | MR2                       | OW1                | 68 (21)                                                                                                                                       |                                                 |
| E                                                                                                        | PP1                       | OW1                | 72 (22)                                                                                                                                       |                                                 |
| F                                                                                                        | PP1                       | MS1                | 34 (10.5)                                                                                                                                     |                                                 |
| G                                                                                                        | PP1                       | OM1                | 62 (19)                                                                                                                                       |                                                 |
| H / J                                                                                                    | PP1                       | MG2/3              | 19.68(6)                                                                                                                                      | 37.07(11.3)                                     |
| K                                                                                                        | MR2                       | MSM1               | 39 (12) allows 8 ft (2.44 m) takeup at MSM1;                                                                                                  |                                                 |
| L                                                                                                        | MS5                       | MSM1               | 49 (14.94) allows 8 ft (2.44 m) takeup at MSM1;                                                                                               |                                                 |
| M                                                                                                        | MR2                       | WC2                | 23 (7)                                                                                                                                        |                                                 |
| N                                                                                                        | PP1                       | OM1                | 38 (21)                                                                                                                                       |                                                 |
| O                                                                                                        | PP1                       | MS5                | 42 (12.8)                                                                                                                                     |                                                 |
| P                                                                                                        | PP1                       | EO2                | 40 (12.2)                                                                                                                                     |                                                 |
| Q                                                                                                        | PP1                       | EO1                | 10.72(3.268m) allows EO1 takeup of 2.37 ft (0.72 m)                                                                                           | 67.91(20.7) allows EO1 takeup of 15 ft (4.57 m) |
| R                                                                                                        | MS1                       | RF Common GND      | 13.94(4.25)                                                                                                                                   | 51.67(15.75)                                    |
|                                                                                                          |                           |                    | minus takeup at RF Common Ground Stud                                                                                                         |                                                 |
| S                                                                                                        | MSM1                      | Site Ethernet      | 56 (17)                                                                                                                                       |                                                 |
| T                                                                                                        | WC1                       | WC2                | 11.5 (3.5), For Type B config Only.                                                                                                           |                                                 |
| U                                                                                                        | MS1                       | MS4                | 72 (22)                                                                                                                                       |                                                 |
| V                                                                                                        | MSM1                      | PP1                | 67 (20.42) allows 8 ft (2.44 m) takeup at MSM1                                                                                                |                                                 |
| i                                                                                                        | MS5                       | MS1                | 40 (12.2) Flexible Helium Gas line routed through waveguides in PP1.                                                                          |                                                 |
| ii                                                                                                       | WC1                       | MG2                | 78.7 (24) Flexible water tubing routed through waveguides in PP1.                                                                             |                                                 |
| iii                                                                                                      | MG6                       | MG3                | 16(4.88) Flexible vinyl hose can be cut to length during installation.                                                                        |                                                 |
| iv                                                                                                       | patient alert control box | patient alert grip | Pneumatic tubing, 115(35), is routed from patient alert control box to patient alert grip (via PAC/PAC Remote) through alert air line in PP1. |                                                 |
| Note                                                                                                     |                           |                    |                                                                                                                                               |                                                 |
| 1. Usable length: Cable length minus take up at each end.                                                |                           |                    |                                                                                                                                               |                                                 |
| 2. A, B, C, ... represents electrical cables, whereas i, ii, iii, iv represents flexible hoses or tubes. |                           |                    |                                                                                                                                               |                                                 |

### 3.3 Facility Supplied System Interconnects Specifications



#### NOTICE

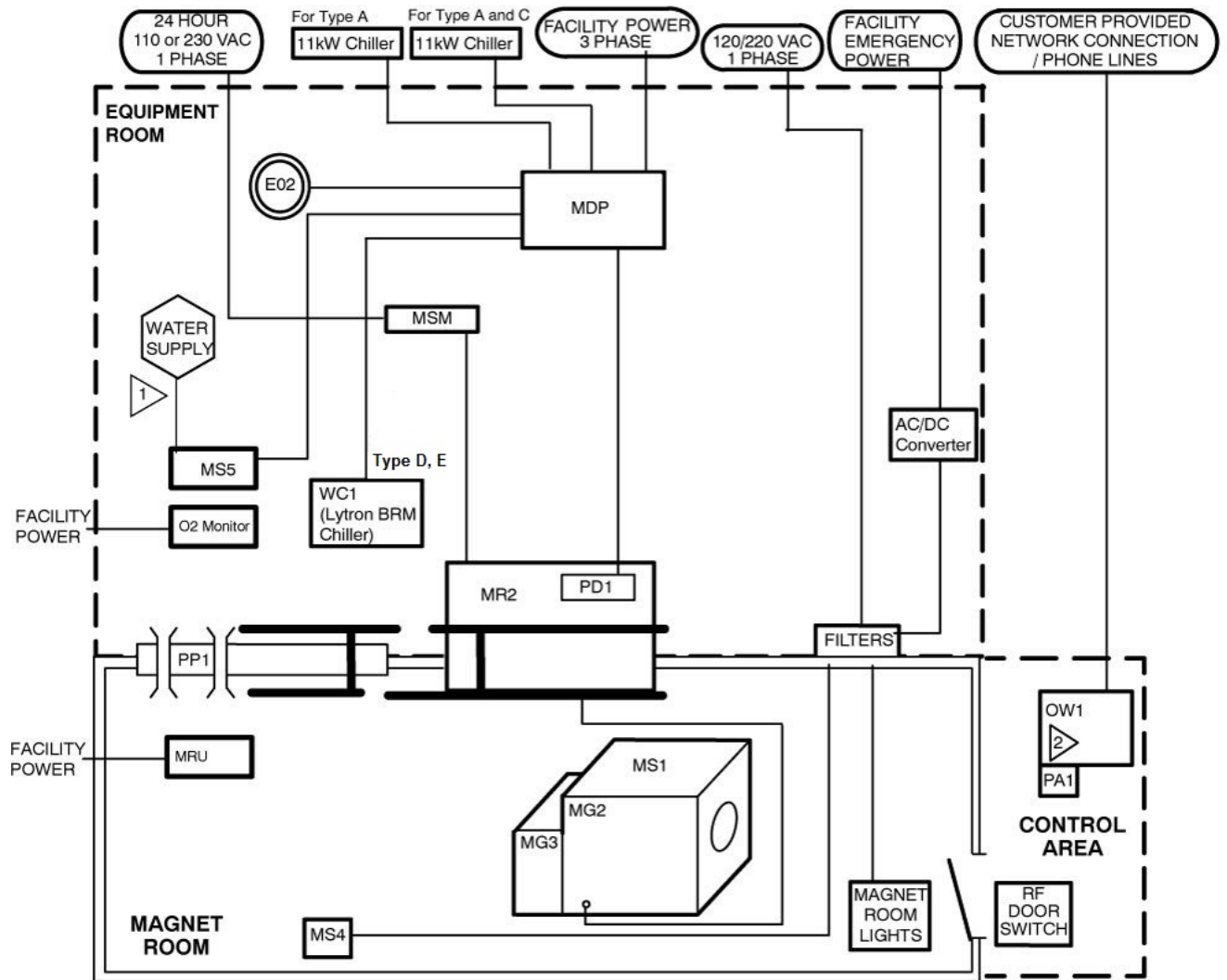
On installation sites in China, please make sure that the power cables and ground cables provided by customers have China Compulsory Certification (CCC). This information is supplied to the customer by Part Number 5159493 'China Power Cable Requirements'.

The following table lists the required facility supplied system interconnects. Refer to [Illustration 5-8](#) for additional information.

**Table 5-10: Customer Supplied Interconnects**

| Between Units                                                                                                                                                                                                                                                             |                           | Notes                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| From                                                                                                                                                                                                                                                                      | To                        |                                                                                                                                                                                                                                                 |
| Facility Power                                                                                                                                                                                                                                                            | MDP                       | See Note 1.                                                                                                                                                                                                                                     |
| MDP                                                                                                                                                                                                                                                                       | PD1 See Note 2            | Refer to <a href="#">Critical Power Requirements</a> for wire size information.                                                                                                                                                                 |
| Facility Emerg Power Filter                                                                                                                                                                                                                                               | PP1                       | Customer supplied Ground.                                                                                                                                                                                                                       |
| Facility Emergency Power                                                                                                                                                                                                                                                  | Filter                    | Refer to <a href="#">DC Lighting Controller (Facility Option)</a> for DC Lighting Controller cabling.                                                                                                                                           |
| Filter                                                                                                                                                                                                                                                                    | Magnet Room Lights        | Refer to <a href="#">Emergency Power</a> and <a href="#">DC Lighting Controller (Facility Option)</a> .                                                                                                                                         |
| MDP                                                                                                                                                                                                                                                                       | EO2                       | Refer to Main Disconnect Panel(MDP).                                                                                                                                                                                                            |
| Facility Power                                                                                                                                                                                                                                                            | Filter                    | Customer supplied Magnet Room power (refer to System Power Introduction ).                                                                                                                                                                      |
| Filter                                                                                                                                                                                                                                                                    | MS4 (Magnet Rundown Unit) | Customer supplied (refer to System Power Introduction).                                                                                                                                                                                         |
| Filter                                                                                                                                                                                                                                                                    | O2 Monitor                | Customer supplied (refer to System Power Introduction)                                                                                                                                                                                          |
| Network &/or Phone Line Connection                                                                                                                                                                                                                                        | MSM1 or MSM4 (Option)     | Refer to <a href="#">Chapter 6, Communications Requirements</a> for additional customer network and/or phone line information.<br>WITH UPS FOR MAGNET MONITOR OPTION: Customer provided phone line routed through UPS for transient protection. |
| MDP                                                                                                                                                                                                                                                                       | 11 kW Chiller             | Refer to Critical Power Requirements.<br>For Type A Configuration, prepare cables for two 11 kW Chiller.<br>For Type C Configuration, prepare cables for one 11 kW Chiller.                                                                     |
| Facility supplied MDP                                                                                                                                                                                                                                                     | Lytron BRM Chiller        | Refer to Critical Power Requirements.<br>This cable is for Type D, E configuration.                                                                                                                                                             |
| <b>Note</b><br>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.<br>2. The PDU is a module (PD1) in the lower portion of the System Cabinet (MR1). |                           |                                                                                                                                                                                                                                                 |

Illustration 5-8: Facility Supplied System Interconnects



1 THIS GROUP CONTAINS WATER LINES WHICH SHALL BE ROUTED SEPARATE FROM ELECTRICAL LINS (I.E. POWER & SIGNAL)

**NOTE:** GE Healthcare recommends installing the RF Door switch on the outside wall of the Magnet room.



## 4 System Cable Information

### 4.1 MR System Cable Specifications

Table 5-11: MR System Cable Specifications

| Group | Run#             | From            | To                 | Length(m<br>m) | AWG             | Connector Type           |                          |
|-------|------------------|-----------------|--------------------|----------------|-----------------|--------------------------|--------------------------|
|       |                  |                 |                    |                |                 | From                     | To                       |
| A     | M4502            | MR2             | MG6                | 15000          | 10              | Ring tongue              | Ring tongue              |
|       | M0503            | MR2             | MG6                | 15000          | 8               | Ring tongue              | Hubbell-F                |
|       | M0504            | MR2             | MG6                | 15000          | 8               | Ring tongue              | Hubbell-F                |
| B     | E3506            | MR2             | RF-Door-<br>switch | 30480          | 22              | D-sub 9-F                | N/A                      |
| C     | M1500<br>(Note1) | MR2             | MG3-A3             | 10000          | LMR-600F<br>R   | N-type-M<br>Right Angle  | N-type-M                 |
|       | M1504<br>(Note2) | MR2             | MG3-PED-<br>IF     | 10000          | LMR-400F<br>R   | N-type-M<br>Right Angle  | N-type-M                 |
|       | M3535            | MR2             | MG3-A7             | 15090          | 22              | D-sub 9-M                | D-sub 9-F                |
|       | M3534            | MR2-A11         | MG3-A3             | 15088          | RGU 58C         | MHV Coaxial<br>-M        | MHV Coaxial<br>-M        |
|       | M3522            | MR2             | MG3-A40            | 15000          | 22              | D-Sub37-M                | D-Sub37-M                |
| D     | E0500            | MR2             | OW1-A11            | 26060          | 10              | APP-4                    | APP-4                    |
|       | E3501            | MR2             | Run_E304<br>7      | 26365          | 22              | D-Sub9-F                 | D-Sub9-M                 |
|       | E3502            | MR2             | OW1-A15            | 27584          | 24              | RJ-45                    | RF-45                    |
| E     | E3503            | PP1             | OW1-A21            | 27280          | 24              | D-Sub25-F                | D-Sub15-M                |
| F     | 828              | PP1             | MS1-A3-<br>A1      | 18440          | 22              | D-sub 9-M                | D-sub 9-F                |
|       | 624              | PP1             | MS1-A2             | 15000          | 18              | Ring tongue              | Plug (4 pin)             |
| G     | 458              | PP1             | OM3                | 27400          | 22              | D-sub 9M                 | Ring                     |
| H     | M1515            | MR2             | MG2-A41            | 18500          | LMR-400F<br>R   | BNC-Plug                 | BNC-Plug                 |
|       | M1514            | MR2             | MG2-A41            | 18500          | BELDEN,<br>9207 | Twinax-M                 | Twinax-M                 |
|       | M1513            | MR2             | MG2-A41            | 18500          | BELDEN,<br>9207 | Twinax-M                 | Twinax-M                 |
|       | M3519            | MR2-A11         | MG2-A41            | 18500          | 22              | D-Sub15-F                | D-Sub15-M                |
|       | M3521            | MR2-A11         | MG2-A41            | 18500          | 22              | D-Sub37-F                | D-Sub37-M                |
|       | M3520            | MR2-A11         | MG2-A41            | 18500          | 22              | D-Sub37-F                | D-Sub37-M                |
| I     | 2009             | MR2             | MG2-A29            | 16916          | 20              | D-sub25-F                | D-sub25-F                |
|       | 2011/20<br>12    | MR2-CAM         | MG2-A33            | 17210          | N/A             | HFBR Du-<br>plex Simplex | HFBR Du-<br>plex Simplex |
|       | P2500            | MR2-ICN,<br>CAM | MG2-A43            | 17000          | POF             | LC Duplex                | LC Duplex                |
|       | M3513            | MR2             | MG2-A42            | 20000          | 22              | D-Sub37-M                | D-Sub37-M                |

|   |               |         |                     |         |         |                    |                    |
|---|---------------|---------|---------------------|---------|---------|--------------------|--------------------|
|   | M3514         | MR2     | MG2-A42             | 20000   | 22      | D-Sub37-M          | D-Sub37-M          |
|   | M3532         | MR2-A11 | MG2-A12-A2          | 16002   | RGU 58C | MHV Coaxial-M      | MHV Coaxial-M      |
|   | M3533         | MR2-A11 | MG2-A12-A2          | 16002   | RGU 58C | MHV Coaxial-M      | MHV Coaxial-M      |
|   | M3531         | MR2     | MG2-A12-A1          | 15000   | 2       | N/A                | Ring tongue        |
|   | M3530         | MR2     | MG2-A12-A1          | 15000   | 2       | N/A                | Ring tongue        |
|   | M3529         | MR2     | MG2-A12-A1          | 15000   | 2       | N/A                | Ring tongue        |
|   | 2018          | MR2-A11 | MG2-A12-A2          | 17831   | 20      | MHV Coaxial-M      | MHV Coaxial-M      |
|   | 2019          | MR2-A11 | MG2-A12-A2          | 17831   | 20      | MHV Coaxial-M      | MHV Coaxial-M      |
| J | M3528         | PP1     | MG3-A2              | 15000   | 22      | D-Sub25-M          | D-Sub25-M          |
| K | E3507         | MR2     | RUN_826             | 25000   | 22      | Mini MateN-M       | D-sub 15-M         |
|   |               | RUN_827 |                     | 500     | 22      | D-sub 15-F         |                    |
|   | 823           | MR2     | MSM1                | 18288.0 | 22      | D-sub 15-F         | D-sub 15-M         |
| L | 827           | FJ3     | FJ4                 | 914.4   | 22      | D-sub15-M          | Circular Connector |
|   |               |         | MS5-A5              | 914.4   | 22      |                    | D-sub9-F           |
| M | E0503         | MR2     | WC2                 | 10000   |         | APP-6              | Ring tongue        |
|   | E3504         | MR2     | WC2                 | 10000   | 22      | MateN-6-M          | MateN-6-M          |
|   | E0501         | MR2     | WC2                 | 10000   | 14      | APP-6              | Ring tongue        |
|   | E3505 (Note3) | MR2     | WC1                 | 15000   | 22      | MateN-6-M          | MateN-6-M          |
|   |               |         | WC2                 | 10000   | 22      |                    | MateN-6-M          |
| N | 457           | PP1     | OM1                 | 30632   | 22      | D-sub9-F           | U Shape            |
| O | 824TR         | PP1     | FJ1                 | 24384   | 22      | D-sub 9-F          | D-sub 9-M          |
|   | 623           | PP1     | MS5-A1              | 15000   | 18      | Ring tongue        | Plug (4pin)        |
| P | E3500         | PP1     | FACILITY DISCONNECT | 19812   | 22      | D-sub 9-F          | Stripped Wire      |
| Q | M3527         | PP1     | EMERGENCY OFF SW    | 27432   | 22      | D-sub 9-M          | Stripped Wire      |
| R | M4500         | MS1     | RF-COM-GRND         | 20000   | 1/0     | Ring tongue        | Stripped wire      |
| S | 942           | MSM1    | Site Ethernet       | 24384   | 26      | RJ45               | RJ45               |
| T | E0502 (Note3) | WC1     | WC2                 | 5000    | 14      | Ring tongue        | Ring tongue        |
| U | 606           | MS4     | MS1-A3-A1           | 30480   | 22      | Circular Connector | DIN Connector      |
| V | 825TR         | PP1     | MSM1-A1             | 24384   | 22      | D-sub 25-F         | D-sub 25-F         |

|                                                                                                                                                                                                              |     |     |         |       |    |            |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|---------|-------|----|------------|------------|
|                                                                                                                                                                                                              | 826 | FJ3 | MSM1-A1 | 18440 | 22 | D-sub 15-M | D-sub 15-F |
| <b>Note</b><br>1. 6611055 (M1501) can be used as 5m extension cable.<br>2. 6611057 (M1505) can be used as 5m extension cable<br>3. Used for 2 LCS Configuration (4kW LCS and 8kW LCS) Only (Type B, B' Only) |     |     |         |       |    |            |            |

## 5 Lighting Specifications

### 5.1 Lighting Specifications

Magnet Room Lighting requirements are listed in .

**Table 5-12: Magnet Room Direct DC Lighting Requirements**

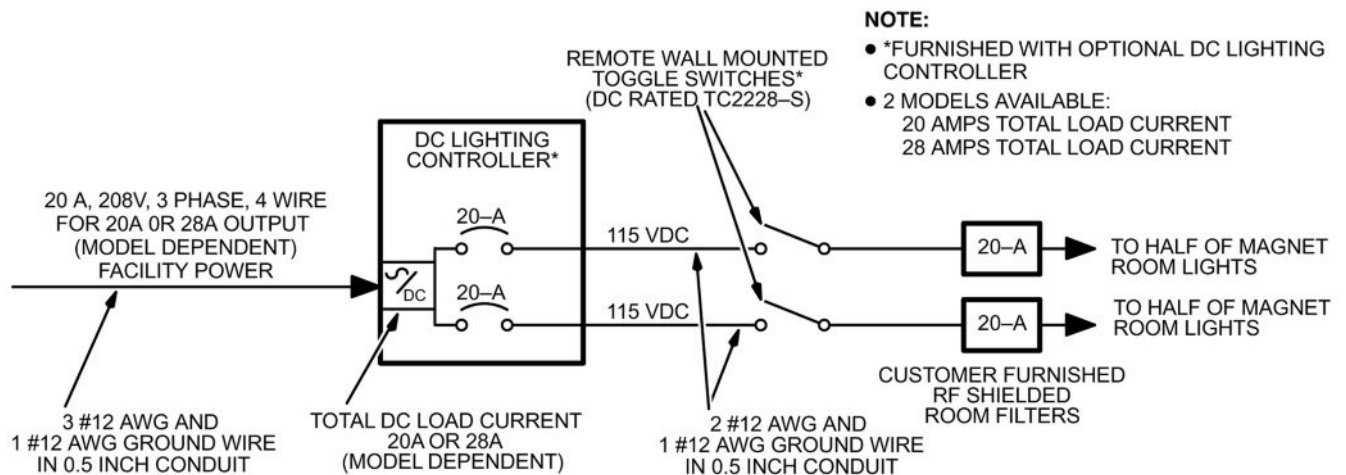
| Requirements                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                 | <div data-bbox="383 512 699 569" data-label="Section-Header"> <h4>NOTICE</h4> </div> <p data-bbox="383 569 1520 590">Fluorescent lighting is not allowed in the Magnet Room due to the RF noise generated by the fluorescent light tubes.</p> <ol data-bbox="191 667 1520 1220" style="list-style-type: none"> <li>1. Direct Current (DC) lighting is required in the magnet room to avoid RF broadband noise impacts to image quality.</li> <li>2. Illumination of 300 lux around the front of the magnet for patient access.</li> <li>3. Need to provide 300 lux above the magnet service work (non-magnetic, portable lighting is acceptable).</li> <li>4. The AC ripple from the DC power should be not greater than 5%.</li> <li>5. Discrete switch or variable lighting level DC Lighting Controller (GE option available refer to <a href="#">Chapter 2, DC Lighting Controller (Facility Option)</a> ) must be used for selectable light levels. Dimmers (i.e. SCR, rheostats, etc.) are not allowed.</li> <li>6. Lighting fixtures selection and installation must comply with requirements in <a href="#">Chapter 3, RF Shielded Room Requirements</a> to minimize the possibilities of electrical discharge.</li> <li>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 <a href="#">Grounding System Ground</a> subsection.</li> <li>8. Light Emitting Diode (LED) lighting, if used, must meet the following: <ol style="list-style-type: none"> <li>a. Power source must be located external to the Magnet Room RF Shield.</li> <li>b. All wiring, filters, and ground requirements must be met, refer to <a href="#">Grounding System Ground</a> subsection.</li> </ol> </li> <li>9. Battery chargers (e.g. emergency lighting) are required to be located outside the Magnet Room.</li> </ol> |
| Comments                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>• Short filament length is recommended, linear lamps are not recommended because of the filament length and high incidence of filament failure.</li> <li>• Track lighting fixtures do not comply with light fixtures requirement listed above.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

## 5.2 DC Lighting Controller (Facility Option)

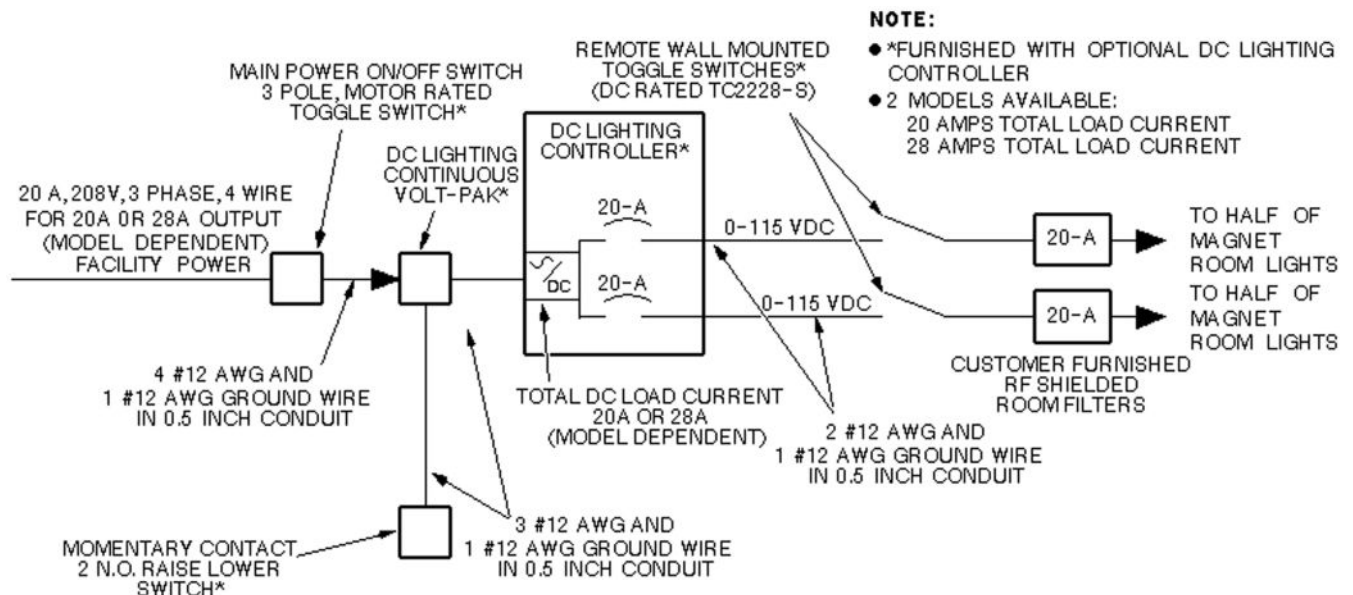
Direct current (DC) powered lighting is recommended in the Magnet Room per Lighting. A constant lighting level DC Light Controller is available from GE as well as a variable DC lighting controller system. The wiring diagrams for these units are shown in [Illustration 5-9](#) and [Illustration 5-10](#). 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:  $I = \text{Total Lamp Wattage} \div 115V$ . 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 5-9: DC Lighting Controller (Facility Option) Wiring Diagram**



**Illustration 5-10: Variable DC Lighting Controller (Facility Option) Wiring Diagram**



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# Chapter 6 Communications Requirements

## 1 Communications Requirements

One of the system monitoring and support connectivity configurations listed in [Table 6-1](#) 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 6-1: System Monitoring & Support Connectivity Requirements**

| Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Connection Type                                                                                 | Use/Location                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Broadband Network Connection & Telephone Line ( <b>Recommended</b> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Two Broadband Internet Accessible connections with individual Static IP addresses<br>See Note 1 | One access located near the Operator Workspace (OW) in the Control Room (RJ45 wall mounted connection minimum speed of 10Mbps).                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                 | 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 ( <b>Alternate</b> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 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 )                                                                                                                                |
| <p>Notes</p> <p>1. <b>For Europe:</b> An ISDN Connection with static IP address may be substituted for Broadband Internet Accessible connections.</p> <p>2. 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.</p> <p>46-328475P1 4 Line Phone Multiplexer box; 115 VAC input power</p> <p>46-328475P3 4 Line Phone Multiplexer box; 220 VAC input power</p> <p>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.</p> <p>3. If a Multiplexer Box is used then the Magnet Monitor MUST be Channel 1 to allow for call out after a power outage.</p> |                                                                                                 |                                                                                                                                                                                                                                                                                     |

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## Chapter 7 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.

#### **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.

### **NB**

Abbreviation for Narrow Band

### **Quench**

Condition when a superconducting magnet becomes resistive thus rapidly boiling off liquid helium. The magnetic field 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.

### **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.

## 2 MR Site Vibration Test Guidelines

### 2.1 Test Measurements

- Vibration measurements are in the range of  $10^{-6}$  g. Test equipment must have the required sensitivity to these levels.
- Instrumentation is recommended to have a low tolerance to temperature effects as many times the low frequency thermal drift may influence the measurements.
- It is highly recommended all measured data is real time data acquisition. 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 are to be narrowband Fast Fourier Transforms (FFT's) over the frequency bands listed in [Table 7-1](#).
- 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 transient activity exceeds the trigger level, then expand the time history data to exhibit the structural response.

**Table 7-1: Frequency Bands For FFT'S**

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

### 2.2 Equipment (Spectral Analyzer) Set-Up

- Frequency average a minimum of 20 linear averages Do not use peak hold or 1/3 octave analysis.
- Average and store a minimum of 10 plots to support the site vibrations consistency.
- Hanning window 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. Please note that the equipment mentioned are 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 and must be made in a 'quiet' environment. That is, in areas where excessive traffic, subway trains, etc. exists, 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 levels exceed the Magnet specifications in [Chapter 2, Vibration](#) must be identified as to the source of the vibration disturbance. 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 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 FFT's and time histories. The transient measurements must be provided to define the dynamic disturbances the MR system might 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 must be identified and supported with vibration plots. If the source of any transient is not able to be located, it is recommended that the customer should have an alternate location identified and vibration studied.

Transient vibration can be difficult to assess if the details of the transient vibration is not understood. The **0.0005g, zero to peak trigger level** is a starting point to begin 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 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 can help determine compliance to the vibration guidelines.

Test consultant must prove design recommendations for all sites/building structures which are found to exceed the LCC Magnet specifications in [Chapter 2, Vibration](#).

## **2.4 Presentation/Interpretation Of Results**

The recommended format for site vibration data collection, presentation, and analysis is illustrated in the examples shown in [Illustration 7-1](#), [Illustration 7-2](#), [Illustration 7-3](#), and [Illustration 7-4](#). Presentation of the data in any other format (linear units only) may result in an incorrect interpretation and diagnosis of the site. Additional data collection or presentation methods is at the option of the vibration testing service.

All plots must be properly annotated with:

- Instrumentation setup including number of averages, frequency resolution, etc.
- Test location
- Test conditions
  - Steady State
  - Transient

- Heal drop
- Normal Environment
- Typical traffic

**NOTE:** Please note that 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's specifications. [Illustration 7-1](#) and [Illustration 7-2](#) are examples provided to assist a test consultant in the use of GE Steady State specifications (vibration specifications above ambient baseline). If the vibration levels are too high, additional data acquisition may be necessary to:

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

[Illustration 7-1](#), [Illustration 7-2](#), [Illustration 7-3](#), and [Illustration 7-4](#) are examples provided to assist a test consultant in the use of GE 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 in [Chapter 2, Vibration](#).

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

Illustration 7-1: Example Site Environmental Vibration

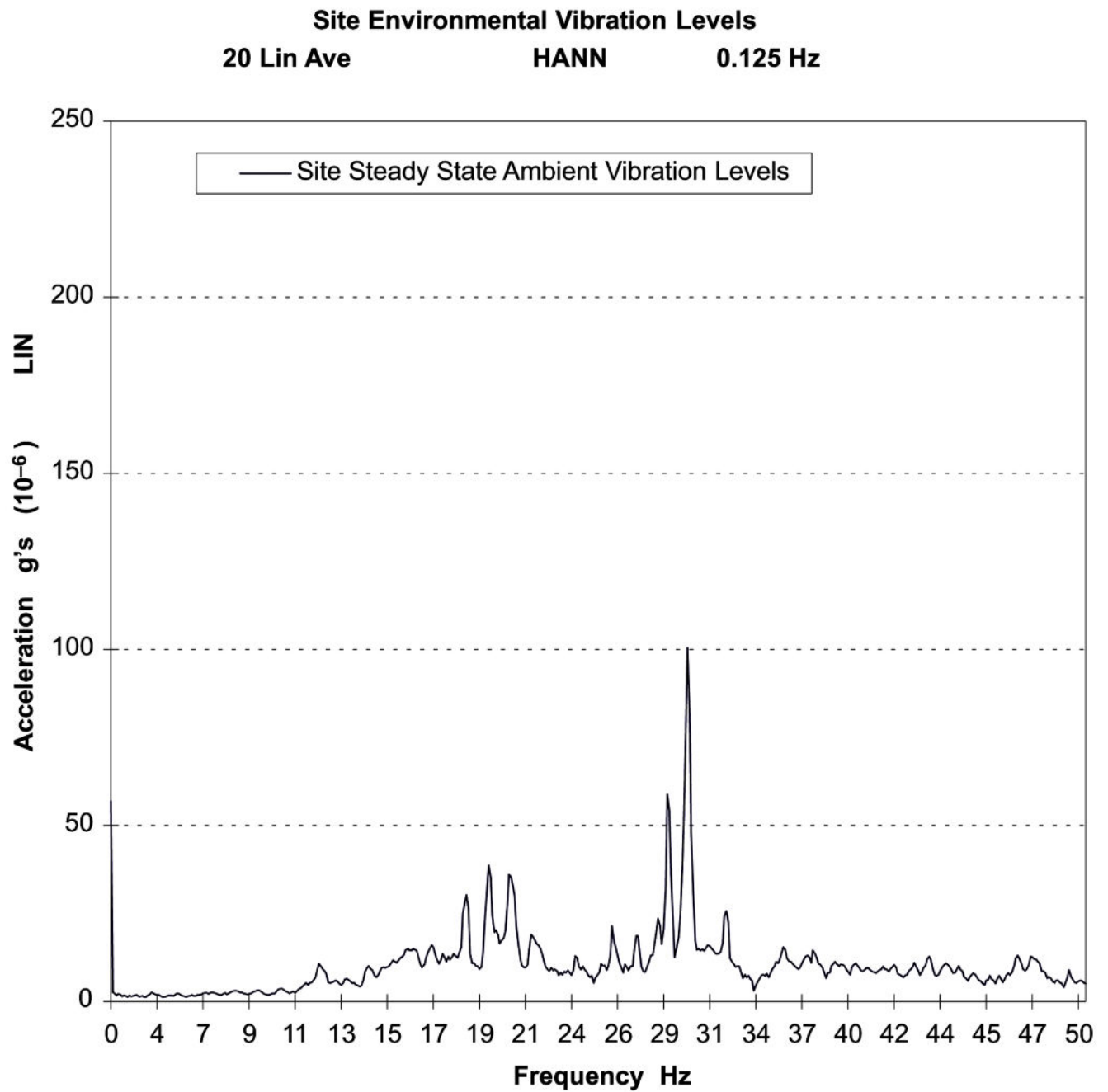


Illustration 7-2: Example Site Environmental Vibration

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

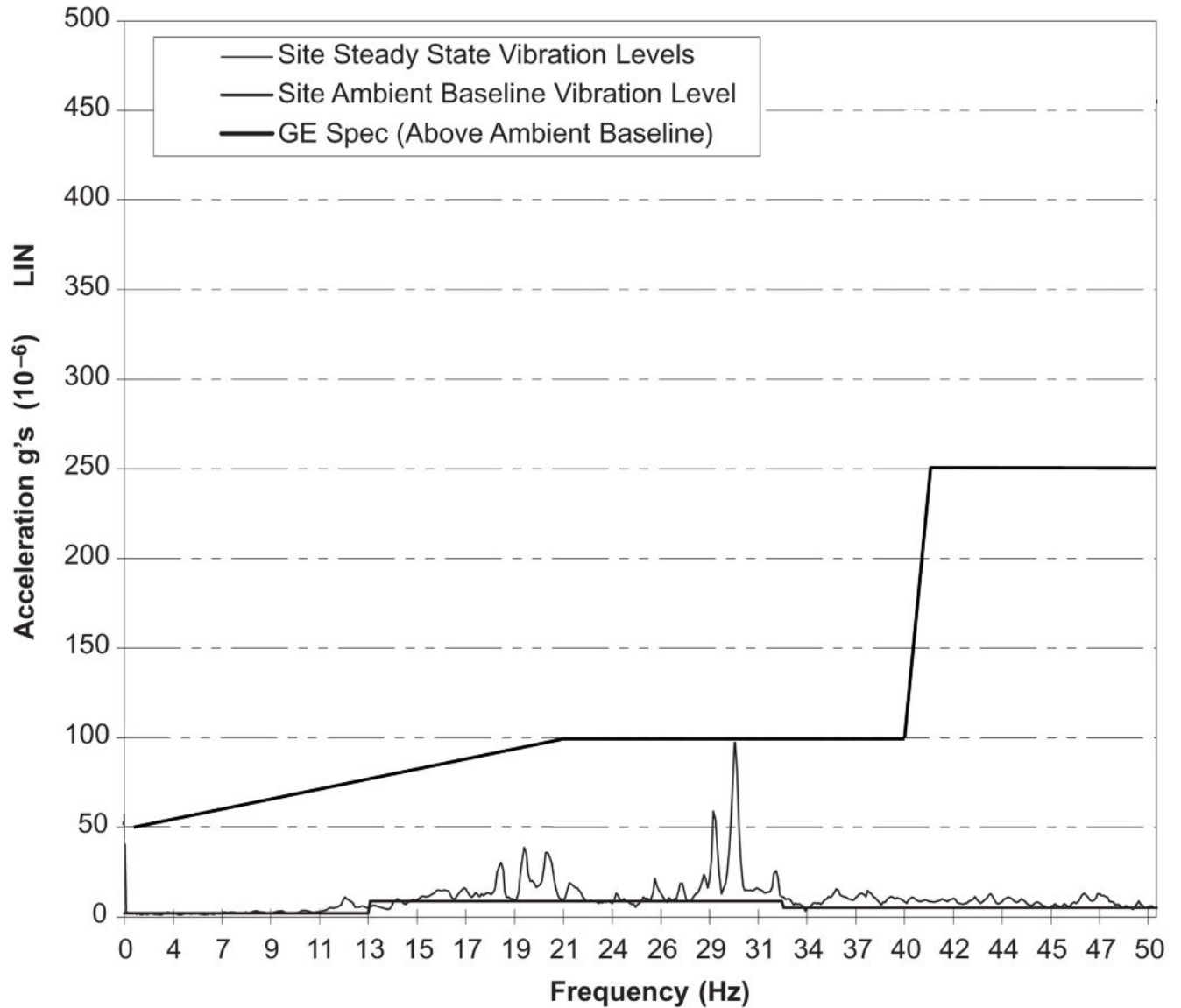




Illustration 7-3: Acceleration Time History

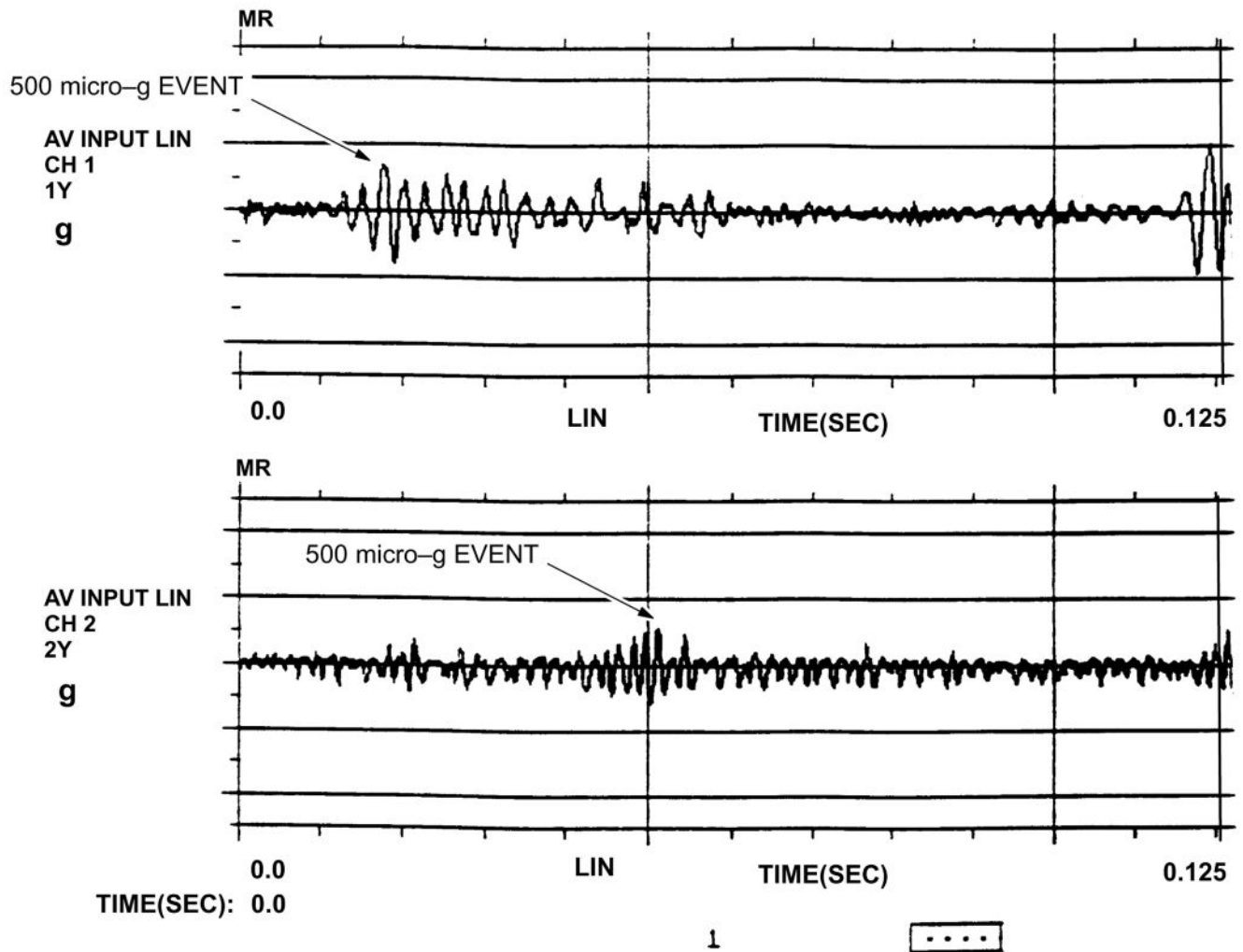
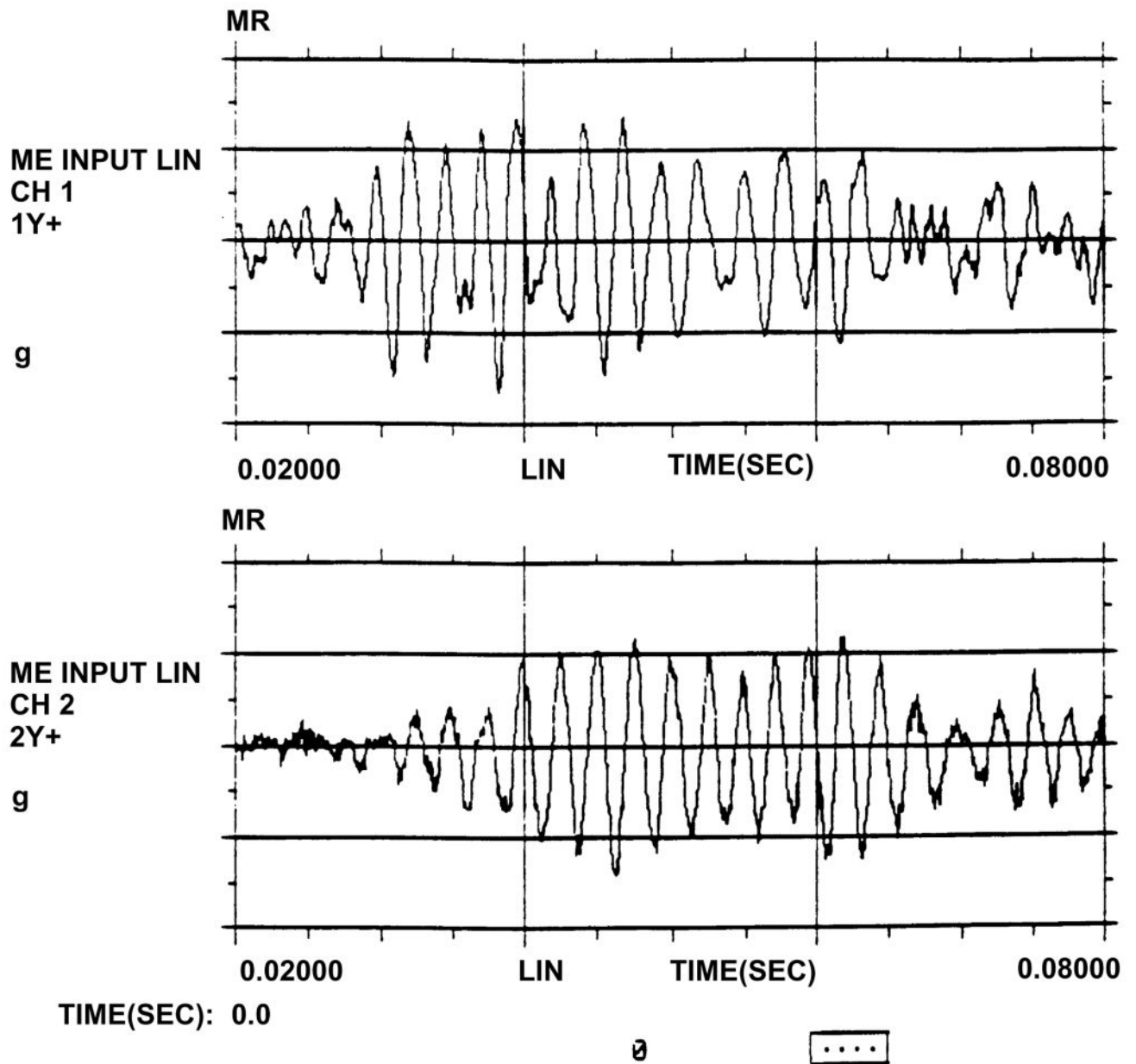


Illustration 7-4: Acceleration Time History (Zoomed In On Transient Event)



## 3 RF Shielded Enclosure Test Guidelines

### 3.1 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.

#### 3.1.1 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.

### 3.2 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                                           |

### 3.3 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.

### 3.4 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.

### 3.5 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.

#### 3.5.1 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.

#### 3.5.2 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.

#### 3.5.3 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.

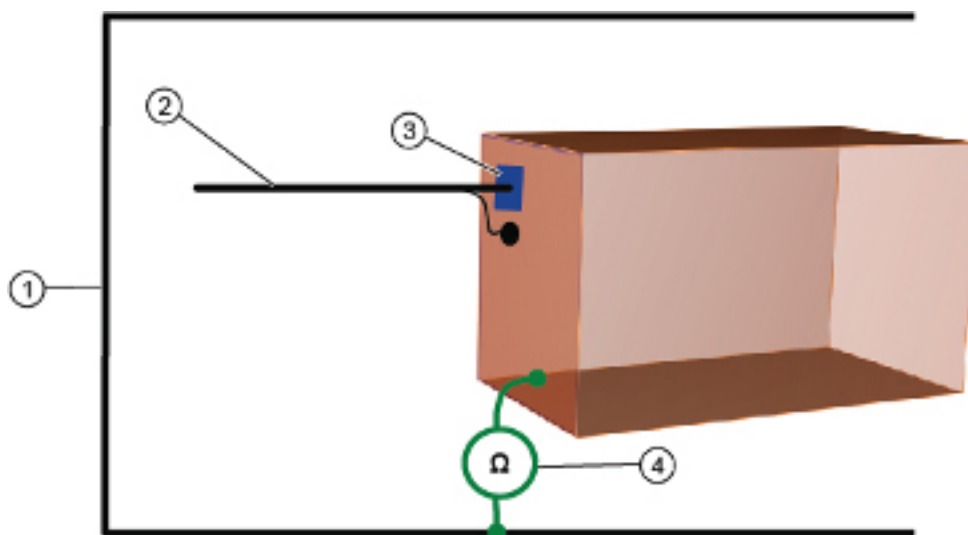
### 3.6 RF shielded Room Ground Isolation Resistance Measurement Method



**WARNING**  
ELECTRICAL SHOCK HAZARD

THE RF SHIELDED ROOM MUST BE PROPERLY GROUNDED.

Illustration 7-5: RF Shielded Room



|   |                          |
|---|--------------------------|
| 1 | Hospital ground grid     |
| 2 | AC lines and ground wire |
| 3 | Filter                   |
| 4 | Low resistance reading   |

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

### 3.7 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  $\pm 2$  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).

### **3.8 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.

### **3.9 Test Report**

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

1. Name of the owner organization or hospital
2. Name of testing organization
3. Identification name for the RF shielded room being tested
4. Name of test personnel
5. Date of test
6. Frequencies tested
7. Shielding effectiveness measured for each test point location (each test point location must be identified in the test report)
8. RF shielded room drawing showing each test point location
9. List any changes pertinent to the test setup or SE results (e.g., limited separation distance of antennas, limited access to test points, etc.)
10. Ground isolation test results and the condition of the room when tested (e.g., RF room completed without internal finishes and no electrical connections)
11. Pass/Fail conclusion
12. The following information for each piece of all calibrated equipment used for measurement:
  - a. Manufacturer
  - b. Model
  - c. Serial number
  - d. Current calibration date and calibration due date

Recommended additional information:

1. Location of RF shielded room relative to the whole building where it is installed
2. Pictures of RF shielded room shielding effectiveness test showing:
  - a. Overall view of RF shielded room
  - b. Window(s), door(s), filter(s), skylights, patient view window
  - c. Blank penetration panels
  - d. Installed additional penetration points (waveguides, vents, ducts, etc.)
  - e. Test set-up for reference level measurement
  - f. Test set-up for attenuated level measurement

## **4 Acoustic Background and Design Guidelines**

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

### **4.1 Acoustic Background**

A typical MR suite has two types of acoustic noise issues. The first is the acoustics within the rooms in which the patients and technicians are impacted by the noise of the MR system as the gradients are pulsed. The second is noise transmitted to other spaces via airborne and structureborne paths.

#### **4.1.1 Airborne**

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

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

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

#### **4.1.2 Structureborne**

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

**NOTE:** Less than 5% of installed base sites have experienced structureborne acoustic issues.

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

- Areas directly above or below the Magnet Room, may not always be an issue
- Image reading rooms adjacent to Magnet Room, may be separated by hallways
- Secretarial, offices, meeting rooms, patient rooms (ICU, exam, primary care, etc.)
- Adjacent residential areas/spaces



- In-house library facilities

## **4.2 Acoustic Design Guidelines**

### **4.2.1 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.

### **4.2.2 Inter-Spacial Areas**

Acoustic Noise Control to mitigate noise from being transmitted to other spaces often amounts to paying attention to small details while working with ordinary construction materials. The key objectives are to eliminate all cracks and gaps in the wall construction while making sure that the doors, walls, floor, and ceiling have adequate transmission loss 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.

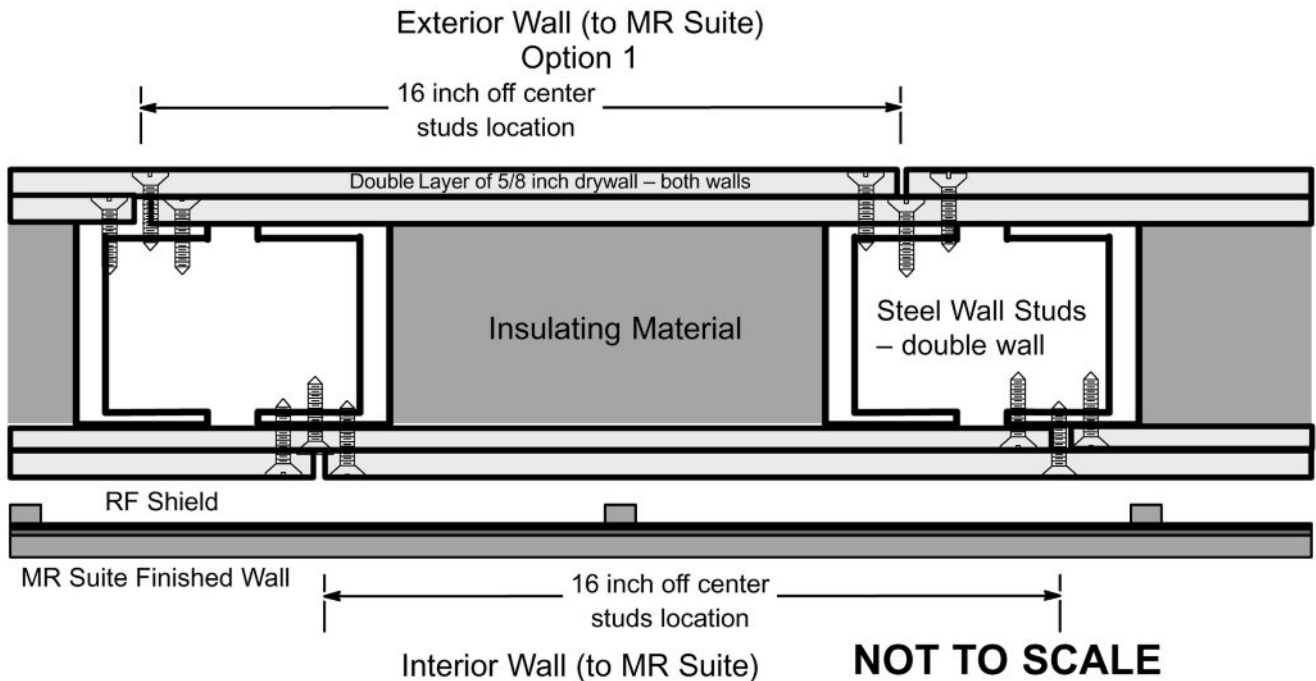
#### **4.2.2.1 Wall Construction**

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

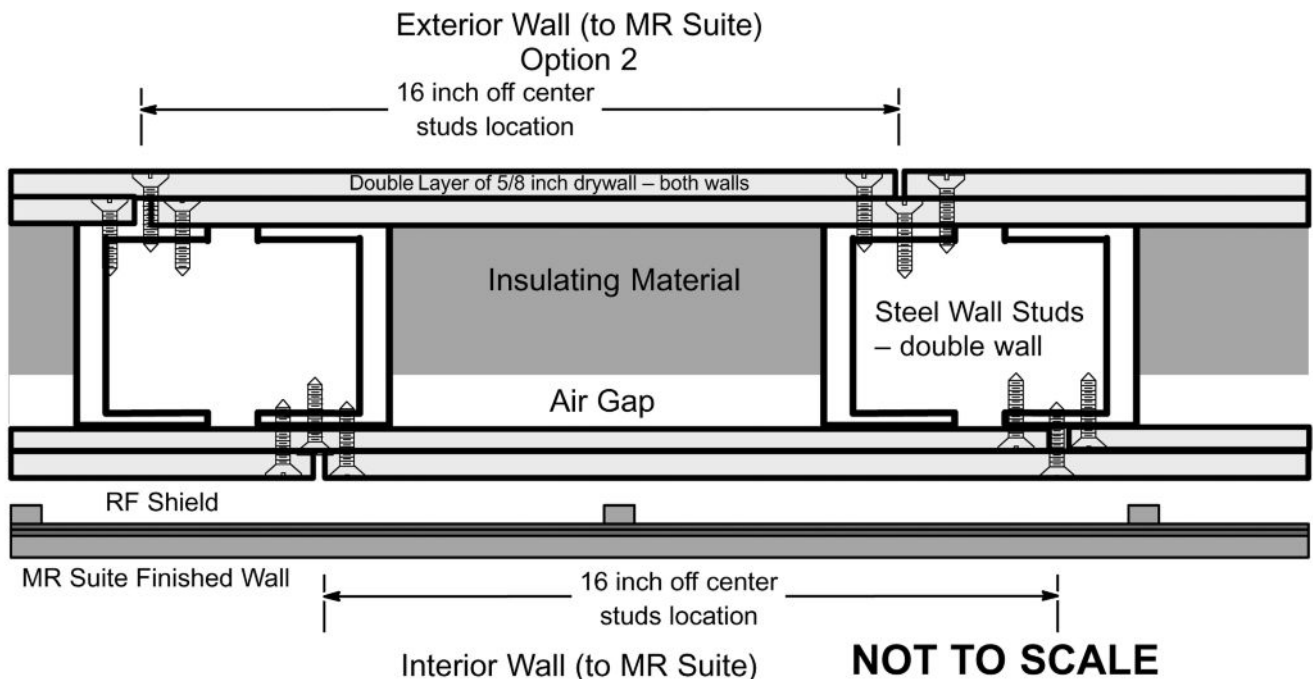
- The preferred wall would have an ASTM STC 50 construction which entails the use of standard wall construction of steel studs (typically 3-5/8 inch (92 mm)) with 2 layers of Type X drywall (typically 5/8 (16 mm)) on each side totaling 4 layers and fiberglass batt in the stud cavity. All drywall must 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 [Illustration 7-6](#) and [Illustration 7-7](#).

- 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 7-6: Example Of Wall Construction For Airborne Noise Control - Option 1**



**Illustration 7-7: Example Of Wall Construction For Airborne Noise Control - Option 2**



#### **4.2.2.2 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".

#### **4.2.2.3 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.

## 5 Sample Calculation AC Power Equipment Minimum Distance

This is a sample calculation to determine minimum distance from a feeder, transformer, or other AC electrical source, using the Formula found in Magnetic Field Consideration Electrical Current subsection to determine minimum distance from a feeder, transformer, or other AC electrical source.

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

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.

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



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

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.

## 6 Selecting Magnet Anchor Size

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

1. Determine magnet clamping force (for the Magnet: 2500 lbs + 200 lbs = 2700 lbs or 11,100 N + 900 N = 12,000 N).
2. Refer to the examples of anchor vendor catalogs below 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

3. 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 7-8: Allowable Anchor Loads in Concrete (English Units)

| ANCHOR DIAMETER<br>in. (mm)<br>See Note 1                                                                        | EMBEDMENT DEPTH<br>in. (mm) | 2000 psi (13.8 MPa) |                  | 3000 psi (20.7 MPa) |                  | 4000 psi (27.6 MPa) |                  | 6000 psi (41.4 MPa) |                  |
|------------------------------------------------------------------------------------------------------------------|-----------------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|
|                                                                                                                  |                             | TENSION<br>lb (kN)  | SHEAR<br>lb (kN) | TENSION<br>lb (kN)  | SHEAR<br>lb (kN) | TENSION<br>lb (kN)  | SHEAR<br>lb (kN) | TENSION<br>lb (kN)  | SHEAR<br>lb (kN) |
| 5/8<br>(15.9)                                                                                                    | 2 3/4<br>(70)               | 1250<br>(5.6)       | 2800<br>(12.5)   | 1600<br>(7.1)       | 3070<br>(13.7)   | 1810<br>(8.1)       | 3330<br>(14.8)   | 1920<br>(8.5)       | 3330<br>(12.5)   |
|                                                                                                                  | 4<br>(102)                  | 1870<br>(8.3)       | 3330<br>(14.8)   | 2400<br>(10.7)      | 3330<br>(14.8)   | 2930<br>(13.0)      | 3330<br>(14.8)   | 3200<br>(14.2)      | 3330<br>(12.5)   |
|                                                                                                                  | 7<br>(178)                  | 2500<br>(11.2)      | 3330<br>(14.8)   | 3010<br>(13.4)      | 3330<br>(14.8)   | 3650<br>(16.2)      | 3330<br>(14.8)   | 3650<br>(16.2)      | 3330<br>(12.5)   |
| 3/4<br>(19.1)                                                                                                    | 3 1/4<br>(83)               | 1550<br>(6.9)       | 2880<br>(12.8)   | 1950<br>(8.7)       | 3310<br>(14.7)   | 2350<br>(10.5)      | 3730<br>(16.6)   | 2610<br>(11.6)      | 4800<br>(21.4)   |
|                                                                                                                  | 4 3/4<br>(121)              | 2510<br>(11.2)      | 4510<br>(20.1)   | 3250<br>(14.5)      | 4650<br>(20.7)   | 3870<br>(17.2)      | 4800<br>(21.4)   | 4670<br>(20.8)      | 4800<br>(21.4)   |
|                                                                                                                  | 8<br>(203)                  | 2930<br>(13.0)      | 4800<br>(21.4)   | 3870<br>(17.2)      | 4800<br>(21.4)   | 4530<br>(20.2)      | 4800<br>(21.4)   | 5120<br>(22.8)      | 4800<br>(21.4)   |
| 1<br>(25.4)                                                                                                      | 4 1/2<br>(114)              | 3120<br>(13.9)      | 6080<br>(27.0)   | 3870<br>(17.2)      | 6770<br>(30.1)   | 4610<br>(20.5)      | 7470<br>(33.2)   | 4800<br>(21.4)      | 7470<br>(33.2)   |
|                                                                                                                  | 6<br>(152)                  | 4400<br>(19.6)      | 7470<br>(33.2)   | 6400<br>(28.5)      | 7470<br>(33.2)   | 7200<br>(32.0)      | 7470<br>(33.2)   | 7330<br>(32.6)      | 7470<br>(33.2)   |
|                                                                                                                  | 9<br>(229)                  | 5600<br>(24.9)      | 7470<br>(33.2)   | 8000<br>(35.59)     | 7470<br>(33.2)   | 9390<br>(41.77)     | 7470<br>(33.2)   | 9390<br>(41.8)      | 7470<br>(33.2)   |
| <b>Note 1</b> All shaded values fail to meet the clamping force (tension), therefore are not acceptable anchors. |                             |                     |                  |                     |                  |                     |                  |                     |                  |

**Illustration 7-9: Allowable Anchor Loads in Concrete (Metric Units)**

| ANCHOR<br>DIAMETER<br>See Note 1                                                                                 | EMBEDMENT<br>DEPTH<br>mm (in.) | 13.8 MPa (2000 psi) |                  | 20.7 MPa (3000 psi) |                  | 27.6 MPa (4000 psi) |                  | 41.4 MPa (6000 psi) |                  |
|------------------------------------------------------------------------------------------------------------------|--------------------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|---------------------|------------------|
|                                                                                                                  |                                | TENSION<br>kN (lb)  | SHEAR<br>kN (lb) | TENSION<br>kN (lb)  | SHEAR<br>kN (lb) | TENSION<br>kN (lb)  | SHEAR<br>kN (lb) | TENSION<br>kN (lb)  | SHEAR<br>kN (lb) |
| M16                                                                                                              | 105<br>(4 1/8)                 | 11.2<br>(2500)      | 25.1<br>(5650)   | 20.9<br>(4705)      | 39.9<br>(8965)   | 24.2<br>(5450)      | 10125<br>(45.0)  | 6900<br>(30.7)      | 10550<br>(46.9)  |
| M20                                                                                                              | 130<br>(5 1/8)                 | 25.1<br>(5650)      | 52.9<br>(11900)  | 30.7<br>(6910)      | 58.7<br>(13195)  | 36.4<br>(8175)      | 14490<br>(64.5)  | 10005<br>(44.5)     | 14490<br>(64.5)  |
| M24                                                                                                              | 155<br>(6 1/8)                 | 30.0<br>(6735)      | 61.2<br>(13760)  | 36.9<br>(8300)      | 70.5<br>(15855)  | 43.9<br>(9860)      | 29.8<br>(17950)  | 57.7<br>(12980)     | 95.6<br>(21490)  |
| <b>Note 1</b> All shaded values fail to meet the clamping force (tension), therefore are not acceptable anchors. |                                |                     |                  |                     |                  |                     |                  |                     |                  |

## 7 Magnet Cryogenic Venting Pressure Drop Reference Tables

Use the following tables to calculate the cryogenic vent pressure drop through the pipe used.

Table 7-2: 1.5T 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 F <sub>l</sub> )                              |       | Std sweep 90° elbow (K = 30 F <sub>l</sub> ) |       | Long sweep 45° elbow (K = 7.5 F <sub>l</sub> ) |       | Long sweep 90° elbow (K = 15 F <sub>l</sub> ) |       |
|                              | 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  |

| 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 F <sub>t</sub> )                              |      | Std sweep 90° elbow (K = 30F <sub>t</sub> ) |       | Long sweep 45° elbow (K = 7.5F <sub>t</sub> ) |      | Long sweep 90° elbow (K = 15 F <sub>t</sub> ) |      |
|                              | ft                                            | m          | psi/ft                                                     | kPa/m | psi                                                                       | kPa  | psi                                         | kPa   | psi                                           | kPa  | psi                                           | kPa  |
| 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 |
|                              | 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 F<sub>t</sub>
  - e. 90° standard sweep elbow K = 30 F<sub>t</sub>
  - f. 45° long sweep elbow K = 7.5 F<sub>t</sub>
  - g. 90° long sweep elbow K = 15 F<sub>t</sub>





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