SCHEMATIC DESIGN FOR:

16.4T MRI System

Expansion to the Center for Magnetic Resonance Research – Bldg. #180
2021 6th Street SE, Minneapolis MN

Department of Radiology

UNIVERSITY OF MINNESOTA
MINNEAPOLIS CAMPUS
UM Project: 01-180-07-1485

SEPTEMBER 2007
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PROGRAM ANALYSIS - 16.4 TESLA MAGNET

INTRODUCTION
A March 24, 2006 PreDesign Study for the expansion and renovation of the Center for Magnetic Resonance Research identified a 40,000 square foot $41 million expansion that included several new magnets. While funding strategies are being considered for the expansion, the Academic Health Center has identified an immediate need to develop space for a 16.4T magnet. This Schematic Design Report addresses the 16.4T magnet expansion only.

The new 16.4 T MRI system intended for the CMRR will be used specifically for non-human research. As the present facility segregates human from non-human research activities, the logical location for the new 16.4T Magnet was within existing space of the non-human side. Of the three MRI systems currently in use within that portion of the building, it was the 4.7T magnet location which was chosen to be remodeled for the new 16.4T system. To accommodate the larger system, a small building expansion will be required. The existing 4.7T magnet will be placed in storage. A description of the programmatic spaces supporting the new 16.4T system follow along with square foot calculations for those spaces.

SPACE TYPES

• **16.4 Tesla Magnet:**
  Construction of approximately 520 sf room to house the 16.4T magnet. The room will be RF and passive-magnetically shielded with an insulated four sided iron box weighing approximately 220 tons. The magnet will be installed through a removable wall section on the west side. The interior will have a suspended aluminum ceiling grid, painted gyp bd walls and an epoxy aggregate floor coating.

• **RF Equipment Room**
  The equipment room will individually contain the MRI support equipment. The room will have access flooring over a 2’-0” deep cable and power distribution zone. The room will have a room-specific cooling system to maintain optimum temperature control for the high heat loads generated by the equipment.

• **Control Room:**
  The control room will contain a fixed work surface with cable management to set the MRI control system.
<table>
<thead>
<tr>
<th>Space</th>
<th>Net area (ASF)</th>
<th>Net area (ASF)</th>
<th>Assignable area (ASF)</th>
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<tbody>
<tr>
<td><strong>16.4 T Magnet</strong></td>
<td>386</td>
<td></td>
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<tr>
<td>Remodeled Space</td>
<td></td>
<td>158</td>
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<tr>
<td>New Space</td>
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<td>228</td>
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<tr>
<td><strong>RF Room</strong></td>
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<tr>
<td>Remodeled Space</td>
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<td>117</td>
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<tr>
<td>New Space</td>
<td></td>
<td>486</td>
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<tr>
<td><strong>Control Room</strong></td>
<td>310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remodeled Space</td>
<td></td>
<td>310</td>
<td></td>
</tr>
<tr>
<td>New Space</td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Total: Remodeled area 585

Total: New Construction 714

Total: 16.4T Assignable area 1299

**PROJECT ASSUMPTIONS**

**SCHEDULE**

As part of the 16.4 T remodeling, various steps will be necessary prior to and during the actual construction efforts. Those steps will affect project schedule and may impact overall project costs.

- De-Energizing and de-commissioning of existing 4T magnet.
- Removal and storage of existing 4T magnet
- Final design of the passive iron shielding by magnet manufacturer.
- Rigging and setting the 220 ton iron shield by the rf shielding contractor during the construction process.
- Installation of new 16.4T magnet during the construction process.

**CONSTRUCTION ISSUES**

The new addition and remodeling will occur in the center of the west side of the existing building.

- Construction of weatherproof and temporary partitions to allow for removal and restructuring of approximately 800 sf of foundation, roof and floor slab.
- Underpinning of approximately 40 feet of existing foundation to allow installation of the bearing slab for the 220 ton iron shield.
- Construction of the new addition structure and envelope while maintaining operation of the adjacent 9.4T and 3T MRI systems.
CODE ANALYSIS

For the design and construction of the 16.4 T MRI remodeling / expansion, the University of Minnesota’s Building Department enforces the following codes:

- 2007 Minnesota State Building Code
- 2006 International Building Code
- 2007 Minnesota Building Conversation Code
- 2007 Minnesota State Fire Code
- 2006 International Fire Code
- 2005 National Electric Code (NFPA 70)
- 2006 International Mechanical Code
- 2006 International Mechanical Code
- 2006 International Fuel Gas Code

CODE HIGHLIGHTS

Note: For the following areas figures, this review does not take into account the proposed area of the future CMRR PreDesign expansion plan. Should that expansion go forward in the future, an additional 38,967 SF would be added to the CMRR which would exceed present allowable areas under the present construction type. Therefore, any future additions would require a rated building separation of a 2-hr fire rated building separation.

Occupancy:
IBC Section 304
Existing Occupancy:
B – Research, Education above 12th Grade
B - Labs - Chemical use is below Table 307.1(1) & 307.1(2).

Type of Construction:
IBC Chapter 6, Tables 601, 602, 704.8
Existing Construction Type: Type V - B (Table 503)

Height and Number of Stories:
IBC Table 503 and Section 504
Existing Height: 21’ (Street Floor elev. to Top of Roof elev.)
Existing Stories: one story above the grade plane.
Fire Protection System: Existing Building has a complete automatic fire protection system.
**Allowable Floor Area:**  
IBC Table 503 and Section 506

Allowable Floor Area per Floor: 9,000 SF (Table 503)  
Allowable Height: 2 Stories (Table 503)

Building Maximum Allowable Area: 42,750 SF (Section 506)  
(Building Area Increase for Frontage (506.2) and 1 story (506.4).)  
Aa = (At+(At x If)+(At x Ix)) = 9,000 + (9,000 x .75)+(9,000 x 3)=42,750 SF

Area Existing 40,319 SF  
Area New Addition 786 SF  
Total New 41,005 SF

**Fire Resistive Requirements:**  
Table 601

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE V</th>
<th></th>
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<tbody>
<tr>
<td>Structural Frame</td>
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<tr>
<td>Bearing Walls</td>
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<td>Interior</td>
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<td>Exterior</td>
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<td></td>
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<tr>
<td>Nonbearing Walls and Partitions</td>
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<td></td>
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<tr>
<td>Exterior</td>
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<tr>
<td>Nonbearing Walls and Partitions</td>
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<tr>
<td>Interior</td>
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</tr>
<tr>
<td>Floor Construction</td>
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<td></td>
</tr>
<tr>
<td>Roof Construction</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**Exiting Requirements:**  
IBC Table 1004.1.1

**Occupancy B**  
Laboratory 100 SF gross  
Office 100 SF gross  
Accessory Storage, Mech. 300 SF gross

Existing Occupant Load: 388 Occ.  
Added Occupant Load 7 Occ.  
Total Occupant Load 395 Occ.

**Egress Width:**  
Table 1005.1

First Floor Required  
Provided:  
0.15”/Occ. x 395 Occ. = 60” or 5’-0”  
6 x 34” = 204” or 17’-0”

**Travel Distance:**  
Section 1014.3  
Table 1016.1

Maximum Common Path of Travel distance in  
A fully sprinklered B occupancy: 100’  
*Common Path of Travel in the 16.4T addition:* 71’
Maximum Exit Access travel distance in A fully sprinklered B occupancy: 300’
All spaces in the CMRR are within 300’ of an exit.

Plumbing Fixtures
IBC Table 2902.1

Water Closets: B Occupancy WC Required
   WC Provided
   1 per 25 for first 50 WC  9
   1 per 50 for remainder
Lavatories: B Occupancy Lavs Required
   Lavs Provided
   1 Per 40 for first 80  6
   1 per 80 remainder
Drinking Fountains B Occupancy DF Required
   DF Provided
   1 per 100 for fountains  4

Note: Bottled water dispensers may be substituted for up to 50% of required drinking fountains.

COST ANALYSIS

INTRODUCTION
The following cost information has been prepared to assist the University in its review of the proposed 16.4T MRI Remodeling / Expansion program. Cost Figures below are in 2007 dollars. Numbers have not been modified to anticipate inflation.

COST ASSUMPTIONS
• Iron Shielding – a cost per ton figure was used in determining costs based on an anticipated 220 tons of iron shielding. Figures were based on 2007 values.
• Soils Corrections – Soils beyond the present footprint of the CMRR are considered to be correctable and those figures are incorporated into the cost estimate.
• Underpinning Foundations – 16.4T demolition efforts may disturb adjacent foundations. Protection will be required during the demolition and remodeling phases.

PROJECT BUDGET
• Total Construction costs: $1,970,599
• Soft costs (non building): $469,846
• Total Project Costs: $2,440,045

COST ESTIMATE
A preliminary cost estimate can be found in the Appendix of this report.
# PRELIMINARY PROJECT SCHEDULE

<table>
<thead>
<tr>
<th>Proposed Schedule</th>
<th>Duration</th>
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<tr>
<td>Design Development Phase</td>
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<td>Design Development Review</td>
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<td>Construction Document Phase</td>
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<td>Construction Document Review</td>
<td>3 weeks</td>
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<td>Construction Award</td>
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<tr>
<td>Construction Phase</td>
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<tr>
<td>Total project Duration</td>
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DIAGRAMS/CONCEPT PLANS

INTRODUCTION
Following are plan images showing the location and remodeling strategies anticipated for the 16.4 T Magnet Demolition and Reconstruction efforts.

SKETCHES LISTED BELOW

- Partial Campus Plan
- Building Context Plan
- Enlarged Demolition Plan
- Enlarged Proposed Floor Plan
- Proposed Exterior Elevations
- Construction Section
DESIGN NARRATIVE - ARCHITECTURAL

Architecture
The proposed 16.4 T remodeling / expansion is intended to follow the same design aesthetic of the adjacent magnet spaces. Materials to be used are: Red/Orange veneer brick, corrugated aluminum wall panels clear anodized aluminum window systems with lightly tinted glazing and buff tone cast stone accents.

Exterior expression for this remodeling would be handled in such a way as to replicate the manner in which massing and finish material usage is emphasized on the facility’s other magnet spaces.

Civil / Site
In the vicinity of the 16.4T expansion, soils have been identified as being correctable. Soils will be excavated, and removed from site. A new base will be provided, compacted and backfilled when foundation work is complete.

Disturbed landscaping and turf will be replaced to match existing / adjacent, though landscaping is considered to be negligible.

The contractor will be expected to erect a construction fence around the zone of construction. CPPM will need to identify a staging area for the contractor prior to mobilization.

Storm water will be handled via new roof drains on the upper and lower portions of the 16.4T expansion. An overflow drain on the lower roof will lead to an internal rain leader, day-lighting at grade.

Envelope
Foundation walls typically will be of 12” CMU walls and spread footings to frost depth. Floor construction will be a 5” reinforced concrete slab over a 6” minimum sand cushion and vapor barrier over grade. Reinforcement will be fiberglass rebar and fiber mesh.

Foundation slab for the iron shielded magnet spaces will be of 48” thick reinforced concrete over a sand base substrate with ½” rubber isolation continuous around the sides.

Exterior bearing walls will be of a cavity wall construction utilizing an inner wall of 8” wood studs. A four inch gap will contain 2” of rigid insulation. The outer most layer will be of 4” face brick veneer to match the adjacent CMRR.
Exterior enclosure walls will be of 4” face brick, a 2” air space, felt over sheathing, on 2x8 wood studs with full 6” batt insulation. Inner wall finish to be 5/8” gyp. bd.

The roof structure will be structural wood joists 24” O.C. and micro-laminated lumber beams with ¾” plywood with a vapor retarding membrane under 3” rigid insulation. A built-up bituminous roofing system will finish off the roofing system. Roof flashings will be of aluminum. Copings will be pre-finished metal to match existing.

**Interior Environment**

Interior partitions will be of wood stud framing with 5/8” gyp. bd. sheathing. Stud size may vary depending on application.

Flooring in Control Room spaces and Magnet rooms will be epoxy resinous flooring with integral coved base. Flooring in RF room will be aluminum access flooring with vinyl base.

Wall surfaces throughout the remodeled spaces will be primarily painted gyp. bd.

Ceilings will be predominantly suspended aluminum grid Acoustical Ceiling Tile with instances of painted gyp. bd. accents and soffiting.

New interior door frames will be clear anodized aluminum with doors of flush Maple, naturally stained and varnished, with glass half lites.
DESIGN NARRATIVE - MECHANICAL

Overview

A. Design Intent Document

This document is intended to represent and describe the mechanical system design intent for the 16T Magnet to be installed in the Center for Magnetic Resonance Research (CMRR) Building.

B. Scope of Work

1. Demolition work includes selective demolition of existing HVAC, plumbing and fire protection systems in the area of work.
2. New work in this scope includes complete mechanical systems for a new 16T Magnet room and support rooms in the existing CMRR building.

C. General

The following building systems are described in this document:

   HVAC Systems
   Heating and Cooling
   Ventilation and Exhaust
   Humidification

   Plumbing Systems
   Roof drainage systems
   Laboratory Gases

   Fire Protection Systems
   Sprinkler systems

D. Code Compliance

The design of this facility is to be in compliance with the current NFPA, IBC, NEC, approved Minnesota amendments, Minnesota Codes and local code officials as of the date published in this report.

HVAC Systems

A. Heating and Cooling Systems

Cooling for the RF Room and Control Room will be provided by dedicated computer room cooling units which will be connected to the existing chilled water loop. A pair of ¾” CHS/R lines will be installed to a new ceiling mounted unit for the control room (CRCU-9). A new floor mounted unit (CRCU-10) will be used to condition the RF room by pressurizing the raised floor plenum. CRCU-10 will be supplied by 1-1/4” CHS/R piping extending through the raised floor from the existing chilled water mains in the adjacent corridor ceiling. Also, a pair of ¾” CHS/R pipes will be extended through the raised floor for direct connection to the gradient heat exchanger, RF Amp heat exchanger, and magnet cold heads.

All chilled water piping will be constructed of type K copper with copper, brass, or plastic supports.
B. Ventilation and Exhaust Systems

Removal of the existing VAV-13, VAV-15 and all associated duct work and diffusers will be required. Also, the existing piping in the RF room from CRCU-3 must be relocated during construction. Three new VAV terminal units will be installed (VAV-37, VAV-38, and VAV-39), each with hot water reheat coils. Each of these terminals will supply the 16.4T magnet, RF room, and procedure room respectively. A 400 cfm exhaust fan will be installed to the procedure room. A new return duct will be extended in to the RF room for return of ventilation air.
A 1,200 cfm purge exhaust fan with Oxygen sensors will be provided for emergency exhaust of the area within the RF shield. A gradient blower duct will be provided to supply conditioned air to the magnet. A dedicated humidifier will be provided for humidification of this air. A new quench vent will be provided for the 16.4T magnet and will discharge out the side wall of the new structure.
All new supply, exhaust, and return ductwork will be constructed of aluminum. All grilles, registers, and diffusers will be constructed of aluminum. All duct hangers and supports will be aluminum.

Plumbing Systems

A. Roof Drainage

The existing 6” RWL piping in the floor slab will be removed when excavation for the magnet footings begin. The 6” RWL will then be extended to a location in the floor where a new 4” roof drain will go up to the existing roof and to where a new 4”RD will be installed in the roof of the magnet addition. In addition, a 6” overflow roof drain to a discharge on the grade will be installed for the new roof.

B. Domestic Water

From the main line, a ¾” CW and PC will be routed to CRCU-10. A ¾” CW and PC will be routed to CRCU-9 from the mains in the corridor as well. All domestic water piping will be constructed of type K copper with copper, brass, or plastic supports.

C. Sanitary Sewer

There is no existing sanitary sewer located in the area of the future magnet. No new plumbing fixtures are anticipated at this time; therefore extension of the sanitary line into this area is not included.

D. Laboratory Gases

The existing N20, O2, LVAC, and LA lines in procedure room will be removed and re-routed to the 16.4T magnet, where lab gas outlets will be mounted. All laboratory gas piping will be constructed of type K copper with copper, brass, or plastic supports.

Fire Protection Systems

A. Sprinkler System

The existing wet sprinkler system will be modified and extended to provide coverage for the RF room, control room and areas above the magnet. A new FM-200 system will be provided for protection of the under floor space.
A. Design Intent Document

This document is intended to represent and describe the electrical system design intent for the 16T Magnet to be installed in the Center for Magnetic Resonance Research (CMRR) Building.

B. Scope of Work

1. Work under this contract includes complete electrical systems for a new 16T Magnet room and support rooms in the existing CMRR building
   a) Coordinate phasing of all work.
   b) Provide all interior lighting and lighting controls. Provide DC dimming system for magnet room lighting.
   c) Provide new electrical distribution panels fed from existing electric service switchgear and power distribution system.
   d) Provide emergency distribution system fed from existing emergency system infrastructure.
   e) Provide new raceway(s) and power connections to new equipment being installed.
   f) Provide grounding system for magnet equipment to be connected to existing grounding grid system.
   g) Provide all required connections to HVAC equipment and Owner furnished equipment.
   h) Provide raceway system for voice/data cabling, Local Area Network (LAN) system.
   i) Provide new fire alarm devices to be connected to existing fire alarm system serving the building.
   j) Provide new public address speakers to be connected to existing public address system serving the building.

C. General

The following building systems are described in this document:

Power Distribution System
Emergency Power Distribution System
Equipment Connections
Grounding and Bonding System
Wiring Devices

Lighting System
General Lighting
Interior Lighting
Lighting Control System
Fire Alarm System
Voice/Data System
Audio/Visual System
Cable TV System
D. Code Compliance

The design of this facility is to be in compliance with the current NFPA, IBC, NEC, approved Minnesota amendments, Minnesota Codes and local code officials as of the date indicated in the construction documents.

Power Distribution Systems

A. Power Distribution System

(1) 100 amp 3-pole circuit breaker will be provided in existing 3000 amp switchboard for feed to (1) 50 KVA power conditioner (480 volt to 208/120 volt). The power conditioner shall have (1) 90 amp 3-pole shunt trip circuit breaker on the output side. It will feed a 100 amp 3-pole panelboard on the load side of power conditioner for electrical loads designated to be installed in the magnet support R.F. Room.

(1) 45 KVA Step down transformer and (1) 150 amp 120/208 VAC panel board to be provided for powering receptacles, small motors, and low power equipment loads.

(1) 600 amp 3-phase 4-wire panelboard will be provided for large mechanical equipment loads.

All conductors shall be copper. Conductors shall be type THHN, THWN or XHHW unless otherwise indicated or required. Branch circuit conductors shall be #12 AWG or larger. Wire shall be color-coded. All conductors shall be installed in PVC conduit. MC cables are not permitted.

Electrical contractor to provide construction temporary service and power.

All equipment shall be rated to withstand available fault current of 42,000 AIC.

B. Emergency Power Distribution System

Emergency power for the new 16T magnet and support spaces will be provided from existing emergency panelboard infrastructure serving the adjacent spaces.

Emergency power will be utilized for egress lighting and exit signage.

C. Equipment Connections

Contractor shall provide overcurrent protection devices, disconnecting means and final connections to all building equipment, including, but not limited to: Magnet, R.F. equipment and Mechanical equipment.

Variable frequency drives (VFD) shall be furnished by Mechanical Contractor and installed by Electrical Contractor. Manual motor starter switches (MSS) and combination motor starters shall be provided by the Electrical Contractor.

D. Grounding and Bonding System

The electrical system and equipment shall be grounded in accordance with the National Electrical Code.
The 16.4 T Magnet room and support spaces shall have a minimum of (2) ¾” diameter x 20’-0” long copper clad ground rods with a #4/0 AWG copper conductor tie-in to existing building ground grid. Use tinned copper conductors and tinned bonding jumpers where conductors are installed in direct contact with the earth. Provide (1) ¾” x 2” x 18” ground bus bar to be installed below raised floor of the R.F. room for grounding of R.F. equipment. Ground bus bar will be tied into existing building ground grid.

An insulated green equipment grounding conductor shall be installed in all feeder and branch circuits. Non-current carrying parts of electrical equipment shall be securely bonded to the system ground.

**F. Wiring Devices**

Typical wiring devices shall be minimum 20A rated, commercial grade. Devices in drywall construction Devices shall be per University of Minnesota Standards.

Emergency power off pushbuttons (EPO) will be provided at each exit door location for the R.F. room.

Floor boxes shall be concealed service with a hinged access door and non-ferrous metal trim plate coordinated with floor material it will be installed in. Install appropriate device fittings. Provide receptacle face plate for special purpose power receptacles. Provide blank plates over unused device ports.

Multiple Outlet Assemblies (MOA) will be used as raceway systems in support spaces. Wiremold 4000 series with non-ferrous metal construction or Panduit Twin 70 series will be the multiple outlet assemblies acceptable for this project.

Special purpose receptacles will be provided for specific power requirements in the R.F. room. Quantity and type will be shown on the design documents. The following is a list of special purpose receptacles for schematic cost estimating purposes;

- (4) 208 volt single phase L6-30R receptacles
- (2) 208 volt 3-phase L15-20R receptacles.
- (1) 208 volt 3-phase L15-30R receptacle.
- (2) 480 volt 3-phase L16-20R receptacles

**Lighting Systems**

**A. General Lighting**

Provide LED exit signs as required per NFPA 101. Connect fixtures to dedicated circuit from emergency power panels.

Provide emergency egress lighting and/or night lighting for 16T magnet room and support spaces.
B. Interior Lighting

Light fixtures for the Magnet Room will be recessed 200 watt quartz downlights. Kirlin model number #RR00728 to be controlled by DC controller. See lighting control section.

Light fixtures for the Control Room will be recessed 2’-0” x 4’-0” 3-lamp fluorescent troffers with (2) ballasts for dual level lighting control. Lighting in the R.F. Room will be recessed 2’-0” x 4’-0” 3-lamp fluorescent troffers fixtures with (2) ballasts for dual level lighting control pendant hung. Coordination of lighting fixtures locations and cable tray will be required.

C. Lighting Controls

The 16T Magnet room will have a DC lighting controller with DC wall switch and dimmer control points at a control desk. The DC lighting controller will be the GE Medical Systems model number R4503-3

The Control Room lighting will be controlled via hard wired switches and will have dual light level switching with in-board lamp on one switch and the (2) outboard lamps on another switch.

The R.F. Room lighting will be controlled via hard wired switches and will have dual light level switching with in-board lamp on one switch and the (2) outboard lamps on another switch.

D. Illumination Levels

The Illuminating Engineering Society’s Illuminance Selection Procedure is used for establishing target maintained illumination levels throughout all areas. Specific influences of glare, task complexity, surface reflectance, ceiling brightness, and usage are addressed with this procedure.

The State of Minnesota Energy Code and Local codes take precedence for maximum power density allowances and select area minimum light levels.

Design light levels for the following areas:

<table>
<thead>
<tr>
<th>Area</th>
<th>Light Level</th>
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</thead>
<tbody>
<tr>
<td>Magnet Room</td>
<td>50 fc</td>
</tr>
<tr>
<td>Control Room</td>
<td>70 fc</td>
</tr>
<tr>
<td>R.F. Room</td>
<td>70 fc</td>
</tr>
</tbody>
</table>

Communications Systems

A. Fire Alarm System

The existing fire alarm system shall be extended to accommodate new fire alarm devices for new 16T magnet room and supports spaces. The fire alarm devices shall be addressable and meets or exceeds all of the requirements and guidelines of the Americans with Disabilities Act (ADA). The current building fire alarm panel is a Notifier AF-200 panel.

Smoke detectors shall be installed only as required by code. Duct detectors will be mounted in the supply and return air ducts at each air handling unit and on the entering airside of all fire/smoke dampers.
Contractor shall provide fire alarm connection to shutdown HVAC equipment, fire suppression system, and interface with paging systems.

Audio-visual devices, strobes and speakers, shall be mounted in all with 16T magnet support spaces. Wall mounted visual devices to be installed in procedure room, control room and R.F. room. Fire alarm system shall have tie-in to paging speaker system for notification of fire alarm egress instructions.

**Voice/Data Raceway Systems**
Provide complete raceway system for Voice/Data systems to include fiber optic cabling required to prevent communication noise interference from Magnet Installation.

**Audio/Visual Equipment and Systems**

Provide complete Audio/Visual raceway systems including conduit, cable tray, and wireway to R.F. equipment and associated adjacent support room spaces.

Detailed equipment schedules will be provided in the next phase of design for specific equipment connection provisions.
APPENDIX

The sections indicated below provide additional information or data supporting the design or planning of the CMRR 16.4T MRI Remodeling.

• Preliminary Cost Estimate
• Schematic Design Planning Participants
• 16.4 T magnet equipment
PRELIMINARY COST ESTIMATE

This section contains cost estimating data for the 16.4T Magnet remodeling. Supplemental Mechanical and Electrical Breakdowns are furnished for comparison only.

U of M:CMRR 16.4T SCHEMATIC COST ESTIMATE 25/7/2007

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Cost</th>
<th>% Total</th>
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</thead>
<tbody>
<tr>
<td><strong>1.0 General Requirements</strong></td>
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<tr>
<td>Permit</td>
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<td>8,300</td>
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<td>Bond</td>
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<td>Temp Enclosures</td>
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<td><strong>FACILITY CONSTRUCTION</strong></td>
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<tr>
<td>2.0 Existing Conditions</td>
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<tr>
<td>Demolition</td>
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<td>Soil Corridor</td>
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<td><strong>3.0 Concrete</strong></td>
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<td><strong>4.0 Masonry</strong></td>
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<td><strong>5.0 Metals</strong></td>
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<td><strong>6.0 Wood and Plastics</strong></td>
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<td><strong>8.0 Openings</strong></td>
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<td><strong>9.0 Finishes</strong></td>
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<td><strong>10.0 Specialties</strong></td>
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<td><strong>11.0 Equipment</strong></td>
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<td><strong>12.0 Furnishings</strong></td>
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<td><strong>12.0 Special Construction</strong></td>
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<td><strong>FACILITY SERVICES</strong></td>
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<td>21.0 Fire Suppression</td>
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<tr>
<td>22.0 Plumbing</td>
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<tr>
<td>23.0 HVAC</td>
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<td></td>
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<tr>
<td>26.0 Electrical</td>
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<td>27.0 Communications</td>
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<tr>
<td><strong>SITE and INFRASTRUCTURE</strong></td>
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<tr>
<td>31.0 Earthwork</td>
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<td>32.0 Exterior Improvements</td>
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<td><strong>BUILDING SUBTOTAL</strong></td>
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<td>701,900</td>
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<td><strong>GENERAL CONTRACTOR MARKUP</strong></td>
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<td>General Conditions (9% of Building Subtotal)</td>
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<td>$ 701,900</td>
<td>$ 63,152</td>
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<td>$ 758,052</td>
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<tr>
<td>Overhead (5% of Subtotal &quot;A&quot;)</td>
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<td>$ 758,052</td>
<td>$ 37,903</td>
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<tr>
<td>Subtotal &quot;B&quot;</td>
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<td>$ 795,955</td>
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<td></td>
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<tr>
<td>Profit (5% of Subtotal &quot;B&quot;)</td>
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<td>$ 795,955</td>
<td>$ 39,798</td>
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<td>Subtotal &quot;C&quot;</td>
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<td>$ 835,752</td>
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<td><strong>ADJUSTED BUILDING COST</strong></td>
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<tr>
<td>Contingency (10% of Adjusted Building Cost)</td>
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<td>$ 83,575</td>
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</tr>
<tr>
<td>Cost per SF (Adjusted Bldg. Cost / 1,475 sf)</td>
<td>$ 623.27</td>
<td></td>
<td></td>
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</tbody>
</table>

RF Shield/Passive Shield $ 750,000

University of Minnesota U of M Project: 01-180-07-1485
16.4 T MRI Remodeling
### Specifications Group

<table>
<thead>
<tr>
<th>Specifications Group</th>
<th>Construction Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 22 – Plumbing [Demolition]</td>
<td>$1,200 (Material) $12,450 (Labor)</td>
</tr>
<tr>
<td>Division 22 – Plumbing [LA, LVAC, O2, and N2O gas piping and installation]</td>
<td>$6,200 (Material) $13,375 (Labor)</td>
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<tr>
<td>Division 22 – Plumbing [Roof Drain Piping]</td>
<td>$4,200 (Material) $9,450 (Labor)</td>
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<tr>
<td>Division 23 – HVAC [CRCU-9 Unit, piping and installation]</td>
<td>$4,000 (Unit cost) $1,760 (Material) $5,560 (Labor)</td>
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<td>Division 23 – HVAC [CRCU-10 Unit, piping and installation]</td>
<td>$12,000 (Unit cost) $4,800 (Material) $8,400 (Labor)</td>
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<tr>
<td>Division 23 – HVAC [Exhaust]</td>
<td>$6,600 (Unit Cost) $8,400 (Material) $8,900 (Labor)</td>
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<tr>
<td>Division 23 – HVAC [Supply Duct, VAV]</td>
<td>$9,900 (Unit Cost) $22,800 (Material) $11,400 (Labor)</td>
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<tr>
<td>Division 23 – HVAC [Demolition]</td>
<td>$2,800 (Material) $14,650 (Labor)</td>
</tr>
<tr>
<td>Division 21 – Fire Suppression [Install]</td>
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</tr>
<tr>
<td>Contingency (10%)</td>
<td>$17,933</td>
</tr>
<tr>
<td><strong>Total Estimated Construction Cost</strong></td>
<td><strong>$197,267</strong></td>
</tr>
</tbody>
</table>


Time estimate is [60] working days to complete the project.
Prepared By: Jaime Olivas
Date: 7/25/2007
Purpose: Electrical Cost Estimate
Re: U of M CMRR 16.4 T Magnet Pre Design
SB Project Nr.: 200307.00

<table>
<thead>
<tr>
<th>Specifications Group</th>
<th>Construction Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 26 - Electrical [Demolition]</td>
<td>$800 (Material) $2,000 (Labor)</td>
</tr>
<tr>
<td>Division 26 - Electrical Conduit and Wire, Lighting, Lighting Controls</td>
<td>$43,000 (Material) $46,150 (Labor)</td>
</tr>
<tr>
<td>Division 27 - Communications Fire Alarm System, Paging System Voice/Data, Cable Tray Telephone,</td>
<td>$8,130 (Material) $3,115 (Labor)</td>
</tr>
</tbody>
</table>

Contingency (10%)                                           $10,319

Total Estimated Electrical Construction Cost                $113,514

Cost estimate based on the Means 2007 Prices

Time estimate is 60 working days to complete the project.
## PARTICIPANTS

### UNIVERSITY OF MINNESOTA

**Academic Health Center**
- Lorelee Wederstrom
- Andreas Papanicolau

**Radiology**
- Jerry Froelich
- Kamil Urubugul
- Michael Garwood

**Capital Planning & Project Management**
- Kevin Ross, Project Manager

**Environmental Health and Safety**
- David Paulu, Radiation Specialist
- Brian Vetter, Assistant Director

### CONSULTANTS

**Architect – RSP Architects, Ltd**
- Bryan Gatzlaff, Sr. Associate, Project Manager
- Judd Brash, Project Manager
- John Merten, Project Representative

**Mechanical and Electrical Engineers – Sebesta Blomberg**
- Doug Lucht
- Jaime Olivas
EQUIPMENT This section contains descriptive information on select equipment users anticipate being furnished within the proposed 16.4 T MRI spaces.
SPECIFICATION FOR A
MRBR 16.4 TESLA/260MM
ROOM TEMPERATURE BORE MAGNET SYSTEM

The University of Minnesota
Request for Proposal No. 64620212089

Document Ref: TS1371H
Date: M-- 200?
CONTENTS

1. Description of System

2. The Superconducting Magnet
   i. General Description
   ii. Specifications
   iii. Superconducting Shim Coils

3. The Cryostat
   i. General Description
   ii. Specifications

4. System Configuration
   i. Standard Components
   ii. Cost Options
1. DESCRIPTION OF THE SYSTEM

The MRBR 16.4T/260 system is a pumped superconducting magnet system intended primarily for In-Vivo and NMR spectroscopy (MRS) and In-Vivo functional imaging.

The system essentially consists of a highly homogeneous superconducting magnet (700MHz $^1$P, 16.4 Tesla) housed in a horizontal room temperature bore (260mm), low-loss helium cryostat. Field shimming is accomplished using superconducting shim coils. The ultimate homogeneity specifications require room temperature shim coils.

The system is complemented with a magnet monitoring system. An emergency magnet discharge unit is also provided.

2. THE SUPERCONDUCTING MAGNET

i. General Description

The magnet is wound from multi-filamentary Nb$_3$Sn and NbTi superconductor. The windings are placed on a precision machined aluminium alloy and stainless steel formers and then fully vacuum impregnated for robustness and long-term reliability.

The field homogeneity is defined over a 10cm diameter spherical volume. Inevitably winding tolerances and small amounts of environmental influence will distort the central field. Corrections for these distortions are made in the first instance by superconducting shim coils located on a former surrounding the main coil. Further correction can be made using passive shims located in the RT bore with the ultimate homogeneity being achieved after RT shimming.

The magnet coils are fully protected from accidental damage due to a quench by a diode and resistor network located within the helium reservoir.

In order to reach 16.4T and achieve the specified field stability, the temperature of the helium reservoir must be reduced to less than 2.5K. This is done by pumping on the helium bath.

The magnet is designed to conservative levels of stress and mechanical stability to ensure reliable and stable operation. In addition the use of high quality superconducting wire ensure that a highly stable magnet system is achieved.
ii. **Specifications**

Magnet Type : Multi-coil superconducting

Central Field at 2.5K : 16.4 Tesla

Central Field at 4.2K : 12.5T

Magnet polarity : South pole at user end

Field stability : Less than 0.03 ppm/hour drift\(^1\)

Operating current at 16.4T : <300 Amps

Inductance : 2200H (nominal)

Field homogeneity values

<table>
<thead>
<tr>
<th>Superconducting shimmed</th>
<th>Less than 10ppm over 10cm dsv(^2)</th>
</tr>
</thead>
</table>

| Fully shimmed using Magnex/Varian RT shim set < 10% of range | Less than 4ppm over 10cm dsv\(^2\) (expected less than 2ppm over 10cm dsv) 0.1ppm hhlw over 7cm dsv\(^3\) |

Fringe field (position of 5 gauss contour) unshielded case (see figure 1)

<table>
<thead>
<tr>
<th>Axially from magnet centre line</th>
<th>18 metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radially from magnet centre line</td>
<td>15 metres</td>
</tr>
</tbody>
</table>

---

\(^1\) Varian, Inc reserve the right to use a RT B\(_0\) drift compensation coil to meet the ultimate field stability.

\(^2\) Defined as the peak to peak variations of points plotted over a seven plane plot on the surface of the stated spherical volume.

\(^3\) Predicted using the spherical harmonic expansion derived from the final plot. This is not a measured NMR line width.
iii. **Superconducting Shim Coils**

These coils are positioned on a former surrounding the main coil in the helium reservoir. Each coil set is fitted with a superconducting switch for persistent mode operation.

**Coil Details:**

- **Shims provided**: $Z, Z^2, X, Y, ZX, ZY, XY, X^2-Y^2$
- **Maximum recommended current**: 20 Amps
- **Coupling**: All shims are designed to be decoupled from main coil
3. **THECRYOSTAT**

i. **General Description**

The cryostat consists of a central all-welded stainless-steel helium vessel, which is surrounded by an aluminium gas-cooled radiation shield and liquid nitrogen reservoir.

The magnet is offset in the cryostat to allow space for the niobium tin joints to be configured. In this way a robust and reliable magnet can be designed whilst minimising the distance from the cryostat end flange to the centre of the field. It is also asymmetric in that the centre line of the bore is 50mm below the centre line of the cryostat to optimise the refill volume.

The complete assembly is contained in a stainless-steel outer vacuum vessel with a vertical service turret located centrally on top of the cryostat. The turret provides access to the helium reservoir for the demountable magnet leads and helium transfer siphon. The outer vessel has end-flange closures constructed from aluminium which are sealed to the main body and bore-tube by compressed rubber "O" ring seals. The room-temperature bore-tube is constructed from stainless steel.

The cryostat will be designed and manufactured to meet the pressure equipment directive 97/23/EC. The assembly will be suitably CE marked for shipment in to Europe.
ii. **Specifications**

The unshielded cryostat is generally as shown in figure 2. Full specifications for the system areas follows:-

**Dimensions:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of cryostat</td>
<td>3320 ± 10 mm</td>
<td>130.7 in</td>
</tr>
<tr>
<td>Height of system</td>
<td>2838 ± 10 mm</td>
<td>111.7 in</td>
</tr>
<tr>
<td>Room temperature clear bore (without RT shims and gradient coils)</td>
<td>260 ± 2 mm¹</td>
<td>10.2 in</td>
</tr>
<tr>
<td>Room temperature bore-tube material</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>Centre of field to base of stand</td>
<td>1050 ± 5 mm</td>
<td></td>
</tr>
<tr>
<td>Cryostat end-flange to centre of field</td>
<td>1286± 5mm (user end)²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2034± 5mm (service end)</td>
<td></td>
</tr>
<tr>
<td>Outside diameter</td>
<td>2140 ± 5 mm</td>
<td>84.25 in</td>
</tr>
<tr>
<td>Minimum installation ceiling height</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>Weight of cryostat (excluding cryogens)</td>
<td>25 tonnes (approximately) 55,115.5 lbs.</td>
<td></td>
</tr>
</tbody>
</table>

¹ If a third party gradient/RT shim system is to be supplied Magnex/Varian will need to advise on shim requirements.

² This value will be minimised during final design
Liquid helium cryogen detail (approximate):-

Volume for initial installation (includes cooling the magnet from 77K to 2.5K including to top-up of helium reservoir after magnet energisation) : 20,000 litres

Estimated maximum required helium after a training quench, including filling, cooling to 2.5K. : 10,000 litres

Helium can volume : 2700 litres (nominal)

Recommended refill volume during normal operation : 500 litres (nominal)\(^1,2\)

Hold-time during normal operation (static magnetic field, leads withdrawn) : Greater than 32 days\(^6\)

Liquid nitrogen cryogen details:--

Volume for initial installation (includes pre-cool of magnet to 77K and volume required to completely fill LN\(_2\) reservoir) : 12,000 litres

Volume of reservoir : >500 litres

Refill volume : 500 litres

Hold-time in static condition : Greater than 14 days

---

\(^1\) Cryogenic performance will be verified at 4.2K
\(^2\) The refill volume stated is actual volume excluding transfer losses and pump down losses
4. SYSTEM CONFIGURATION

i. Standard Components

1) 16.4T/260mm superconducting magnet in a horizontal bore cryostat supplied with:
   Vent kit and pressure gauge
   Burst disc
   Demountable nitrogen level probe
   Main current lead and shim current lead

2) Two piece siphon with shut-off valve

3) Nitrogen flow meter

4) Helium level monitors

5) Magnet emergency discharge unit with two remote buttons

6) Magnet pumping station with redundant pump

7) Magnet monitoring control system

8) UPS to support magnet monitoring system

9) Full set of cables

10) Liquid nitrogen transfer line

11) Spares kit consisting of:
    1. Bursting disk
    2. Spare clamps for KF fittings
    3. Spare o-rings & carrier rings for KF fitting
    4. Fuse kit for electronics.
    5. Complete set of serviceable turret seals
    6. Complete set of serviceable turret clamps
    7. Helium siphon diffuser

12) System documentation consisting of:
    1. Safety Consideration for the installation & operation of magnet systems
    2. Operating Data for 16.4T 260mm
    3. User Manual for 16.4T 260mm
    4. Diagrams and Cabling information for magnet monitoring
    5. Helium Level Monitor operating manual

TS1371H May 2007
6. Emergence discharge unit operating manual
7. Nitrogen level monitor operating manual
8. Propriety pumping station/pump manual
9. Propriety temperature monitors manual

ii. **Cost Options**

Magnex Scientific offers a mild steel room shield with this system. A 220,000kg passive shield is shown in figure 3.

If the system is supplied with the shield, the temperature of the shield needs to be maintained to within one degree Celsius in order not to affect the magnet’s homogeneity and short-term stability.
Figure 3. Magnet Shielding Option
(220,000kg room shield)