



***BioSpec<sup>®</sup> Systems***  
*(actively shielded magnets)*  
**Site Planning Information**  
Instructions and Comments  
for site preparation





Manufacturer's note:

Products that bear a CE mark fulfill the provisions of EU Council Directive LVD 73/23/EEC and 89/336/EEC.

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# Summary of Contents

|  |           |
|--|-----------|
| <b>1. Preamble</b>   | <b>1</b>  |
| <b>2. Safety Information</b>                                 | <b>3</b>  |
| 2.1. Magnet security zone                                    | 3         |
| 2.2. Installation of caution and warning signs               | 4         |
| 2.3. Emergency plan and emergency room                       | 6         |
| 2.4. Instructions for security and cleaning staff            | 6         |
| 2.5. First aid and fire brigade instructions                 | 6         |
| 2.6. Transport and storage of cryogen liquids                | 7         |
| 2.7. Air monitoring and ventilation in the magnet room       | 7         |
| 2.8. Country-specific safety regulation                      | 8         |
| 2.9. Standards on health and safety in the workplace         | 8         |
| 2.10. Contour plots of the magnetic flux density             | 10        |
| <b>3. Site planning and preparation</b>                      | <b>17</b> |
| 3.1. General instructions and conditions                     | 17        |
| 3.2. Magnet installation                                     | 22        |
| 3.3. Hardware cabinet installation inside the technical room | 37        |
| 3.4. Installation of operating console                       | 51        |
| <b>4. Transportation of the magnet</b>                       | <b>53</b> |
| 4.1. General handling and lifting procedures                 | 53        |
| 4.2. Moving  | 53        |
| 4.3. Lifting   | 53        |
| 4.4. Crane operation   | 54        |
| 4.5. Fork lift operation                                     | 54        |
| 4.6. Access for system integration                           | 54        |
| <b>5. Transportation of cabinets</b>                         | <b>55</b> |
| 5.1. General handling and lifting procedures                 | 55        |
| <b>6. Appendix</b>   | <b>57</b> |
| 6.1. Information about the required stray field and drawings | 57        |
| 6.2. Installation examples                                   | 78        |
| 6.3. Design criteria for the quench line                     | 84        |
| 6.4. Pre-Installation Checklist <i>BioSpec</i> <sup>®</sup>  | 91        |
| 6.5. Example of an emergency plan                            | 95        |
| 6.6. Index   | 99        |
| 6.7. Figures   | 101       |
| 6.8. Tables  | 105       |

|   |           |
|---|-----------|
| <b>1. Preamble</b>  | <b>1</b>  |
| <b>2. Safety Information</b>  | <b>3</b>  |
| 2.1. Magnet security zone   | 3         |
| 2.1.1. Controlled access area:  | 4         |
| 2.1.2. Exposed area, adjacent to the controlled access area/restricted area | 4         |
| 2.2. Installation of caution and warning signs                              | 4         |
| 2.3. Emergency plan and emergency room                                      | 6         |
| 2.4. Instructions for security and cleaning staff                           | 6         |
| 2.5. First aid and fire brigade instructions                                | 6         |
| 2.6. Transport and storage of cryogen liquids                               | 7         |
| 2.7. Air monitoring and ventilation in the magnet room                      | 7         |
| 2.8. Country-specific safety regulation                                     | 8         |
| 2.9. Standards on health and safety in the workplace                        | 8         |
| 2.10. Contour plots of the magnetic flux density                            | 10        |
| 2.10.1. Inner bore field intensities for magnet B-C 47/40USR                | 10        |
| 2.10.2. Inner bore field intensities for magnet B-C 70/30USR                | 11        |
| 2.10.3. Inner bore field intensities for magnet B-C 94/20USR                | 12        |
| 2.10.4. Inner bore field intensities for magnet B-C 94/30USR                | 13        |
| 2.10.5. Inner bore field intensities for magnet M-C 70/20AS                 | 14        |
| 2.10.6. Inner bore field intensities for magnet M-C 94/20AS                 | 15        |
| 2.10.7. Inner bore field intensities for magnet M-C 94/30AS                 | 16        |
| <b>3. Site planning and preparation</b>                                     | <b>17</b> |
| 3.1. General instructions and conditions                                    | 17        |
| 3.1.1. Interactions between the Building and an MRI Magnet                  | 17        |
| 3.1.2. Installation   | 18        |
| 3.1.3. Passing of Risk  | 18        |
| 3.1.4. Smoke and fire detectors   | 18        |
| 3.1.5. Electrical installation, requirements and conditions                 | 18        |
| 3.1.5.1. Power requirements (standard configuration without options)        | 19        |
| 3.1.5.2. Grounding  | 19        |
| 3.1.5.3. Potential compensation   | 19        |
| 3.1.5.4. Block diagram for electrical main power supply:                    | 20        |
| 3.1.5.5. Cable trays  | 21        |
| 3.1.6. Prerequisites for installation                                       | 21        |
| 3.2. Magnet installation  | 22        |
| 3.2.1. Choosing an ideal installation site                                  | 22        |
| 3.2.1.1. Availability of laboratory space that meets the mandatory demands  | 23        |
| 3.2.1.2. Integration into laboratory facilities                             | 23        |
| 3.2.1.3. Typical magnet foundation (basement)                               | 23        |
| 3.2.1.4. Floor vibrations (seismic vibrations)                              | 24        |
| 3.2.1.5. Interaction with surrounding departments                           | 25        |
| 3.2.1.6. Exhaust system (quench line)                                       | 25        |
| 3.2.1.7. Distance to technical and operating areas                          | 25        |
| 3.2.1.8. Cable trays between the magnet and filter plate                    | 26        |
| 3.2.1.9. RF Shielding (Faraday Cage)  | 26        |

# Table of Contents

|           |   |           |
|-----------|---|-----------|
| 3.2.1.10. | Lighting (lighting facilities in the magnet room) .....   | 28        |
| 3.2.1.11. | Air conditioning / ventilation system.....  | 29        |
| 3.2.1.12. | Helium Gas Supply System 4.6 (> 99.996 volume %) .....  | 31        |
| 3.2.2.    | Mandatory requirements .....  | 32        |
| 3.2.2.1.  | Installation data overview for Bruker USR magnets 47/40 and 70/30 .....   | 34        |
| 3.2.2.2.  | Installation data overview for Bruker USR magnet 94/20 and 94/30 .....  | 35        |
| 3.2.2.3.  | Installation data overview for Magnex AS magnets .....  | 36        |
| 3.3.      | Hardware cabinet installation inside the technical room .....   | 37        |
| 3.3.1.    | Overview of the <i>BioSpec</i> <sup>®</sup> components for the technical room .....   | 37        |
| 3.3.1.1.  | Example of an installed standard electronic system (Copley 231P).....   | 37        |
| 3.3.1.2.  | View and dimensions of the electronic cabinets .....  | 40        |
| 3.3.1.3.  | View and dimensions of the system electrical distributor .....  | 41        |
| 3.3.1.4.  | View and dimensions of the chiller system for gradient coil cooling .....   | 41        |
| 3.3.1.5.  | View and dimensions of the cryo-refrigerator for magnet cooling.....  | 42        |
| 3.3.1.6.  | View and dimensions of the water heat exchanger for the cryo-refrigerator.....  | 42        |
| 3.3.1.7.  | View and dimensions of the water chiller for refrigerator cooling (optional component as a replacement for the heat exchanger)..... | 43        |
| 3.3.2.    | Choosing an ideal site .....  | 44        |
| 3.3.2.1.  | Distance to operator console .....  | 44        |
| 3.3.2.2.  | Distance between cabinets and filter plate (cable tray).....  | 44        |
| 3.3.2.3.  | Electrical wiring and main connection sockets.....  | 45        |
| 3.3.2.4.  | Electrical supply lines for a <i>BioSpec</i> <sup>®</sup> system: .....   | 45        |
| 3.3.2.5.  | Grounding/equipotential bonding.....  | 46        |
| 3.3.2.6.  | Air conditioning /ventilation system.....   | 46        |
| 3.3.2.7.  | Entrance doors, floor strength .....  | 46        |
| 3.3.2.8.  | Interaction with surrounding departments.....   | 46        |
| 3.3.2.9.  | Cold Water Supply for Cryo-Refrigerator .....   | 47        |
| 3.3.2.10. | Cooling Water Connections for the Heat Exchanger: B-ER 090 .....  | 47        |
| 3.3.2.11. | Cooling Water Requirements for the Heat Exchanger: B-ER 090.....  | 48        |
| 3.3.2.12. | View of small components in the technical room .....  | 48        |
| 3.3.3.    | Mandatory requirements .....  | 49        |
| 3.4.      | Installation of operating console .....   | 51        |
| 3.4.1.    | Lighting and window surfaces .....  | 51        |
| 3.4.2.    | Air ventilation technique .....   | 51        |
| 3.4.3.    | Cable terrace for system wiring .....   | 52        |
| 3.4.4.    | Telephone /Internet/Intranet .....  | 52        |
| 3.4.5.    | Mandatory requirements .....  | 52        |
| <b>4.</b> | <b>Transportation of the magnet.....</b>  | <b>53</b> |
| 4.1.      | General handling and lifting procedures .....   | 53        |
| 4.2.      | Moving.....   | 53        |
| 4.3.      | Lifting.....  | 53        |
| 4.4.      | Crane operation.....  | 54        |
| 4.5.      | Fork lift operation.....  | 54        |
| 4.6.      | Access for system integration.....  | 54        |
| <b>5.</b> | <b>Transportation of cabinets .....</b>   | <b>55</b> |
| 5.1.      | General handling and lifting procedures.....  | 55        |

|  |           |
|--|-----------|
| <b>6. Appendix</b>   | <b>57</b> |
| 6.1. Information about the required stray field and drawings                         | 57        |
| 6.1.1. Bruker magnet: B-C 47/40USR   | 57        |
| 6.1.1.1. Stray field plots   | 57        |
| 6.1.1.2. Vertical view and dimensions  | 58        |
| 6.1.1.3. Quench pipe connection  | 59        |
| 6.1.1.4. Footprint and foundation area   | 59        |
| 6.1.2. Bruker magnet: B-C 70/30USR   | 60        |
| 6.1.2.1. Stray field plots   | 60        |
| 6.1.2.2. Vertical view and dimensions  | 61        |
| 6.1.2.3. Quench pipe connection  | 62        |
| 6.1.2.4. Footprint and foundation area   | 62        |
| 6.1.3. Bruker magnet: B-C 94/20USR   | 63        |
| 6.1.3.1. Stray field plots   | 63        |
| 6.1.3.2. Vertical view and dimensions  | 64        |
| 6.1.3.3. Quench pipe connection  | 65        |
| 6.1.3.4. Footprint and foundation area   | 65        |
| 6.1.4. Bruker magnet: B-C 94/30USR   | 66        |
| 6.1.4.1. Stray field plots   | 66        |
| 6.1.4.2. Vertical view and dimensions  | 67        |
| 6.1.4.3. Quench pipe connection  | 68        |
| 6.1.4.4. Footprint and foundation area   | 68        |
| 6.1.5. Magnex magnet: M-C 70/20AS  | 69        |
| 6.1.5.1. Stray field plots   | 69        |
| 6.1.5.2. Vertical view and dimensions  | 70        |
| 6.1.5.3. Quench pipe connection  | 71        |
| 6.1.5.4. Footprint and foundation area   | 71        |
| 6.1.6. Magnex magnet: M-C 94/20AS  | 72        |
| 6.1.6.1. Stray field plots   | 72        |
| 6.1.6.2. Vertical view and dimensions  | 73        |
| 6.1.6.3. Quench pipe connection  | 74        |
| 6.1.6.4. Footprint and foundation area   | 74        |
| 6.1.7. Magnex magnet: M-C 94/30AS  | 75        |
| 6.1.7.1. Stray field plots   | 75        |
| 6.1.7.2. Vertical view and dimensions  | 76        |
| 6.1.7.3. Quench pipe connection  | 77        |
| 6.1.7.4. Footprint and foundation area   | 77        |
| 6.2. Installation examples   | 78        |
| 6.2.1. Installation example with Faraday cage, B-C 94/20USR                          | 78        |
| 6.2.2. Installation example with Faraday cage, B-C 94/30USR                          | 79        |
| 6.2.3. Example of compact installation of a magnet: M-C 94/30AS                      | 80        |
| 6.2.4. View of <i>BioSpec</i> <sup>®</sup> in the Faraday cage                       | 81        |
| 6.2.5. Installation example for a compact “ <i>BioSpec</i> <sup>®</sup> B-C 70/20AS” | 82        |
| 6.2.6. <i>BioSpec</i> <sup>®</sup> installation without Faraday cage                 | 83        |
| 6.3. Design criteria for the quench line   | 84        |
| 6.3.1. Quench line design for Bruker USR magnets                                     | 84        |
| 6.3.2. Quench line design for Magnex AS magnets                                      | 85        |
| 6.3.3. Calculation example for a B-C 94/20USR quench line                            | 89        |
| 6.4. Pre-Installation Checklist <i>BioSpec</i> <sup>®</sup>                          | 91        |

## Table of Contents

|        |   |     |
|--------|---|-----|
| 6.4.1. | Customer Information.....                     | 91  |
| 6.4.2. | Magnet Installation .....                     | 92  |
| 6.4.3. | Characterisation of the laboratory rooms..... | 93  |
| 6.4.4. | Declaration:.....                             | 94  |
| 6.5.   | Example of an emergency plan .....            | 95  |
| 6.6.   | Index.....                                    | 99  |
| 6.7.   | Figures .....                                 | 101 |
| 6.8.   | Tables.....                                   | 105 |





# 1. Preamble

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The quality of preparation of the site and installation of an MR system will have a strong influence on the future success of the work. Selecting the optimal arrangement within existing department structures and carrying out all building alterations correctly, reliably and in an aesthetically pleasing fashion requires a high degree of cooperation between experts from several different fields as well as well-planned project management. Project management should focus on the following most important topics:

- selection of an ideal site for installation
- preparation of the installation site, including:
  - checking/modifying magnet transport inside the building
  - checking/modifying the magnet installation site
  - supplying the customer part of the quench line
  - checking/installing the electrical power supplies
  - air conditioning or ventilation system
  - preparing the operating area
- time schedule and communication with the system provider

The first chapter gives an overview of safety requirements for installing and operating an MRI system.

Chapter 3 lists and discusses the various topics of the installation process and installation requirements. The first part of each subchapter contains a brief discussion about different aspects; this helps the customer find the optimum solution for individual laboratory conditions. The second part of these subchapters contains a brief overview of the requirements the customer must meet before and during installation. The last part of these chapters gives details of the requirements set out in the overview.

All requests associated with system installation are marked as “requirements” and are highlighted within a box.

Chapter 4 and 5 provide general information about the process of magnet and cabinet integration and transportation into the magnet area.

Appendix (6.4) contains the pre-installation checklist. This form must be returned to the system provider at least 2 months before the system is installed.

Appendix (6.2) shows one installation example, Appendix (6.1) provides detailed drawings of the *BioSpec*<sup>®</sup> magnet types.

BRUKER's representative does not accept any responsibility for the accuracy of information regarding building regulations, bills, internal instructions and directions of the institute and/or operation.



## 2. Safety Information

---

It is the customer's responsibility to follow the safety regulations given below. In addition, any country-specific regulations for installation and operation of MR systems must be fulfilled.

- 1) Magnet and security zone
- 2) Installation of caution and warning signs
- 3) Emergency plan and emergency room
- 4) Instructions for security and cleaning staff
- 5) First aid and fire brigade instructions
- 6) Transport and storage of cryogen liquids
- 7) Air monitoring and ventilation in the magnet room
- 8) Country-specific safety regulation
- 9) Country-specific health and safety standards for working in the stray field of a high magnetic field
- 10) Contour plots of the magnet flux density

### 2.1. Magnet security zone

---

The permanent organization of a control area is stipulated as mandatory for operating an MRI system by national and international standards (e.g.: IEC 60601-2-33 or EN 60601-2-33). Local legal or institutional standards may further tighten or provide further particulars on the safety clauses stipulated in the standard.

Magnetic stray fields exist outside the magnet body even when magnets are actively shielded. The volume expansion of these stray fields is significantly smaller than when magnets are passively shielded or even unshielded. Heavy shielding of the magnetic stray fields also leads to a considerably stronger field gradient. The maximum attractive force of the magnet is therefore a great deal stronger. Even experienced MR users may be surprised by the stronger field gradient.

When the MRI system is in active operation, an electromagnetic interference level also emerges during recording in addition to a sound emission. This level may exceed the limit values specified in the standards inside the control area around the magnet. The electromagnetic interference level is defined, for example, in the IEC 60601-1-2 supplementary standard. There are no uniform standards for the noise level, therefore particular attention should be paid to compliance with the national standards.

### 2.1.1. Controlled access area:

The three-dimensional volume expansion of the stray fields is regarded as a control area around the magnet, inside which the magnetic field strength is greater than 0.5mT (5 Gauss) and the electromagnetic interference level exceeds the limit value according to IEC 60601-1-2.

Administrative and physical switch cabinets are involved in setting up a control area around the magnet. In the simplest case these can be markers on the floor, barriers or cabinets. This demand is usually met, however, by using a lockable Faraday cage and a lockable plant room behind the magnet and Faraday room.

All entries and admissions to the control area must be clearly labeled. Labels must provide warnings about the risks inside the control area. To this end, warning signs as illustrated in Point 2.7 are included in a standard delivery.

The staff responsible for operating the equipment must be able to run adequate checks on the admission of unauthorized personnel. Thus admission to this area, particularly by people with medical implants such as cardiac pacemakers or insulin injection units, is off limits.

### 2.1.2. Exposed area, adjacent to the controlled access area/restricted area

This means the three-dimensional volume area around the magnet, in which the magnetic field strength reaches values between 0.1 and 0.5mT and the electromagnetic interference fulfils the requirements of IEC 60601-1-2:2001.

It is generally true that this area does not represent any potential risk. Nor do any administrative control measures therefore have to be taken or physical cabinets installed. Admittedly, the function of other items of equipment sensitive to the magnet field may also be disturbed in this area. This includes items of equipment such as X-ray tubes, cathode ray tubes, scintillation cameras, X-ray image intensifiers, PET systems and CRT monitors. This equipment must be protected if necessary by a respective ferromagnetic shield in front of the magnetic stray field.

## 2.2. Installation of caution and warning signs

---

Every access to the magnet room must be provided with warning signs about the risks of high magnetic fields. A set of warning signs will be supplied when the system is delivered. The five gauss stray field region and the controlled access area must be clearly visible also on the floor.

No ferromagnetic objects are allowed within the 0.5mT stray-field, and access by individuals with cardiac pacemakers is strictly forbidden. Objects such as ball-point pens, scissors, screw-drivers, keys and even coins can be dangerous to staff as these objects will be attracted by the magnet and will fly through the room like a projectile.





**Warnzeichen: Magnetfeld**  
Starkes magnetisches Feld

**Warning sign: Magnetic**  
Strong magnetic field

**Signal d'avertissement: Champ Magnétique**  
Champs magnetique intense

**Simbolo de advertencia: Campo Magnetico**  
Campo magnético intenso



**Warnzeichen: Hochfrequenzfeld**  
Nicht ionisierende Strahlung

**Warning sign: High Frequency Field**  
Non ionizing radiation

**Signal d'avertissement: Champ haute Frequence**  
Rayonnements non-ionisants

**Simbolo de advertencia: Campo de ultra frecuencia**  
Radiación no ionizante



| Verbotzeichen  | Prohibitive Signs  | Signals d'Interdictions   | Simbole de prohibitions  |
|--|--|---|--|
| <p><b>Aktive Implantate</b><br/>Kein Zugang für Personen mit:<br/><b>HERZSCHRITTMACHERN, Defibrillatoren, Hörgeräten, Insulinpumpen, Medikamentendosiergeräten</b></p> | <p><b>Active Implants</b><br/>No entry for persons with:<br/><b>CARDIAC PACEMAKERS, defibrillators, hearing aids, insulin pumps, dosage devices for medication</b></p>   |    | <p><b>Implants actifs</b><br/>Entrée interdite aux personnes porteuses de:<br/><b>PACEMAKER, defibrillateurs, prothèses auditives, pompes à insuline, doseurs de médicaments</b></p> <p><b>Implantes activos</b><br/>Prohibida la entrada a personas con:<br/><b>MARCAPASOS, defibriladores, audifonos, bombas de insulina, dosificadores de medicamentos</b></p>  |
|   | <p>Datenträger wie: Kreditkarten, Schickkarten und Ausweise mit Magnetstreifen oder Magnetbänder</p> <p>Data carriers, such as credit cards and identity cards with magnetic strips, or magnetic tapes</p> <p>Supports de données tels que cartes de crédit, badges avec bandes magnétiques, bandes magnétiques</p> <p>Portadores de datos, p. ej. tarjetas de crédito, tarjetas de identificación con franja magnética, cintas magnéticas</p>   |    | <p>Implantate aus Metall und sonstige Metallgegenstände im Körper, z. B. Splitter</p> <p>Metalic implants and other metallic objects in the body such as splinters</p> <p>Implants en métal et objets métalliques intra-corporels, par ex éclats</p> <p>Implantes metálicos y otras piezas metálicas en el cuerpo p. ej. fragmentos</p>                            |
|   | <p>Ferromagnetische Behälter wie: Feuerlöscher mit magnetisierbarem Metallgehäuse oder Druckgasflaschen mit medizinischen/technischen Gasen</p> <p>Ferromagnetic objects like: Fire extinguishers with magnetizable metal housing or pressure gas cylinder with medical or technical gasses</p> <p>Objets ferromagnétique comme: Extincteurs avec boîtier métallique magnétisable ou cylindre de gaz médicaux pressurisés/autres gaz techniques</p> <p>Envases ferromagnéticos: Como botellas de gas nitrógeno o extintores con carcasa metálica de hierro</p> |    | <p>Metallteile, Uhren, Taschenrechner und Handys mitführen verboten</p> <p>Do not carry metal parts, watches, pocket calculators and mobile phones</p> <p>Interdit de porter avec soi des objets métalliques, montres et calculateurs de poche, clés, téléphones mobile</p> <p>Prohibido introducir partes metálicas, relojes, calculadoras, teléfonos móviles</p> |
|   | <p>Bewegliche ferromagnetische Gegenstände und medizinische Instrumente aller Art</p> <p>Mobile ferromagnetic objects and medical instruments of all types</p> <p>Objets ferromagnétique transportables et instruments médicaux divers</p> <p>Utensillos ferromagnéticos móviles: tijeras, pinzas, bolígrafos y demás instrumentos médicos</p>   |  | <p>Ferromagnetische Gegenstände und Werkzeuge</p> <p>Ferromagnetic objects and tools</p> <p>Objets et outils ferromagnétiques</p> <p>Objetos ferromagnéticos, herramientas, sillas de ruedas, camas de ruedas</p>  |



Doc./Part No.: T590796 / T5955

Figure 1: Table of warning signs (Dimension: 60cm x 40cm; Part-No.: T5955)

## 2.3. Emergency plan and emergency room

---

In the event of a medical emergency, emergency treatment must take place outside the magnet area, in another room specifically equipped as an emergency room (this room may be used for other purposes as well).

Those using an MR-system are obliged to draw up an emergency plan with instructions for security and cleaning staff and the fire brigade responsible.

For an example of an emergency plan, see Appendix point 6.5 in this manual.

## 2.4. Instructions for security and cleaning staff

---

Security and cleaning staff must be instructed not to enter the magnet room unless supervised by operating personnel and having been introduced to their safety procedures.

Example:

If a vacuum cleaner or some other object is attracted to the magnet, simple removal is not permitted. If a person is pressed by any object to the magnet and cannot be released, the magnet must be discharged by pressing the emergency discharge button. Instructions can be found on the "Emergency Instructions sheet".

## 2.5. First aid and fire brigade instructions

---

A visit to the installation site with the local fire brigade and the local first aid provider is recommended in order to discuss the following precautions and the correct procedure in the event of an emergency.

- Only non-magnetic fire extinguishers equipped with CO<sub>2</sub> must be used in the magnet room.
- Ferro-magnetic objects must not be carried into the magnet room.
- People using respiratory equipment must not enter the magnet room when the magnet is charged.
- Interruption to the system power supply does not influence the magnetic field.
- If it is absolutely necessary to enter the magnet room with ferromagnetic objects, the magnet must first be discharged by pressing the emergency discharge button.
- Fire extinguishers with CO<sub>2</sub> may be used in the technical room.

### 2.6. Transport and storage of cryogen liquids

---

Cryogen liquids must only be handled by trained staff. The customer is responsible for all necessary safety precautions.

- Access doors of all transport routes must be adequately proportioned internally, i.e. at least 100 x 200cm.
- When cryogen gases are transported in a closed elevator, individuals are not allowed to use them at the same time.
- Very small rooms (e.g. corridors), in which shortages of oxygen can occur in theory, may constitute part of the transport route only if appropriate permission (from the relevant technical or governmental authorities) has been given in writing and all necessary safety precautions have been taken beforehand.

Cryogen gases are supplied in transportation dewars and can be stored for several days. Special precautions must be taken in the storage room:

- There is a risk of asphyxiation in closed rooms.
- The storage room must be equipped with an air ventilation system.
- We recommend an oxygen monitoring system with an alarm device and an automatically switched exhaust system.
- We also recommend that the guidelines specified in documents such as TRGS 220 for inert and liquefied gases are strictly observed.

Emergency plan and emergency room

In the event of a medical emergency, emergency treatment must take place outside the magnet area, in another room specifically designated as an emergency room (this room may be used for other purposes as well).

Those using an MR-system are obliged to draw up an emergency plan with instructions for safety and cleaning staff and the fire brigade responsible.

### 2.7. Air monitoring and ventilation in the magnet room

---

Cryogen liquids at extremely low temperatures (to  $-270^{\circ}\text{C}$ ) are used to cool the magnet. When cryogen liquids are being refilled or the magnet quenched,  $\text{N}_2$  and He gas may escape from the system into the magnet room and displace the oxygen in the air. Oxygen concentrations of less than 19% are insufficient for human respiration. All rooms must therefore be equipped with sufficient air ventilation. The air conditioning system must be switched on and functioning.

## 2.8. Country-specific safety regulation

In addition to the above safety precautions, any country-specific safety regulations for operating MRI systems must be fulfilled. These may include, for example, regulations on

- facilities of a controlled access area around the magnet
- working conditions at computer stations
- use of anesthesia gases
- handling of laboratory and transgenic animals

## 2.9. Standards on health and safety in the workplace

The maximum length of time human beings can be exposed in the stray field of strong magnets is given by country-specific standards on health and safety in the workplace. It is the customer's responsibility to choose and evaluate the right country-specific regulation and to ensure that maximum doses are not exceeded by anyone with access to the system.

We strongly recommend using all the mounting devices supplied to change gradient coils or probe heads. Furthermore, samples should be exchanged by using the sample supports without entering the extremities inside the magnet's bore. These preventive measures minimize doses of magnetic flux and must be applied as a general rule of thumb.

### Example:

In Germany, regulation BGV B11 describes the maximum exposure doses in two basic tables. Table 1 applies to situations under the standard precautionary conditions, whereas table 2 applies to systems with field strengths above 5 Tesla and can only be applied to certain subgroups of people, which meet non-standard precautionary conditions. Details on the different precautionary conditions and subgroups of people are given in the BGV B11 document.

| Exposure                      | Maximum magnetic flux density |
|-------------------------------|-------------------------------|
| Average over 8 hours          | 212mT                         |
| Peak values for head and body | 2T                            |
| Peak values for extremities   | 5T                            |

Table 1: Standards on health and safety in the workplace for standard precautions and users, according to BGV B11



| Exposure  | Maximum magnetic flux density |
|---|-------------------------------|
| Peak values for head and body, max.<br>2hrs/day | 4T                            |
| Exposure duration > 2hrs                        | table 1 is valid              |
| Peak values for extremities                     | 10T                           |

**Table 2:** Health and safety standard in the workplace applicable under special conditions to selected subgroups of people, according to BGV B11

Table 1 shows the maximum retention periods within different stray field regions below 5 Tesla for standard precautionary situations. The corresponding spatial regions within and around the super-conducting magnet can be worked out from the stray-field plots of the magnet being used. See example.

| Magnetic flux | Retention period  | Parts of the body |
|---------------|-------------------|-------------------|
| 5T            | < 20 Minutes      | Extremities       |
| 4T            | < 25 Minutes      | Extremities       |
| 3T            | < 34 Minutes      | Extremities       |
| 2T            | < 52 Minutes      | Head/Body         |
| 1T            | < 1hr 42 Minutes  | Head/Body         |
| 0.5T          | < 3hrs 23 Minutes | Head/Body         |
| 0.3T          | < 5hrs 39 Minutes | Head/Body         |

**Table 3:** Example of maximum retention periods <sup>(\*)</sup>  
<sup>(\*)</sup> we do not take any responsibility for the numbers given in table 3

If higher field strength is accessible inside the magnet by a user's extremities, a corresponding table for non-standard situations can be worked out from table 2. However, the analysis must be carried out in a more detailed and differentiated manner and a greater number of more important conditions must be strictly fulfilled.

2.10. Contour plots of the magnetic flux density

2.10.1. Inner bore field intensities for magnet B-C 47/40USR

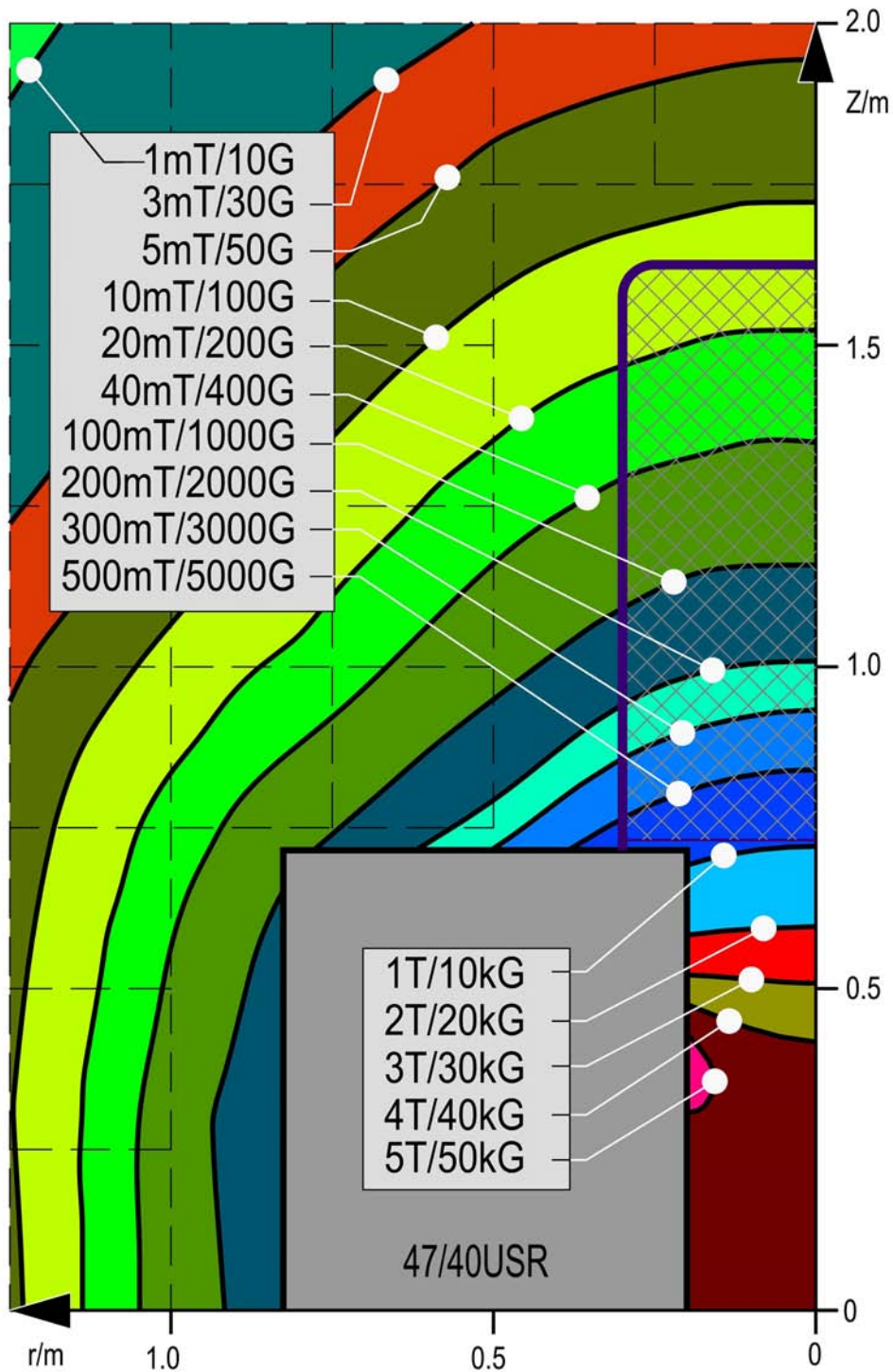


Figure 2: Contour plots of magnetic flux density for B-C 47/40USR

**2.10.2. Inner bore field intensities for magnet B-C 70/30USR**

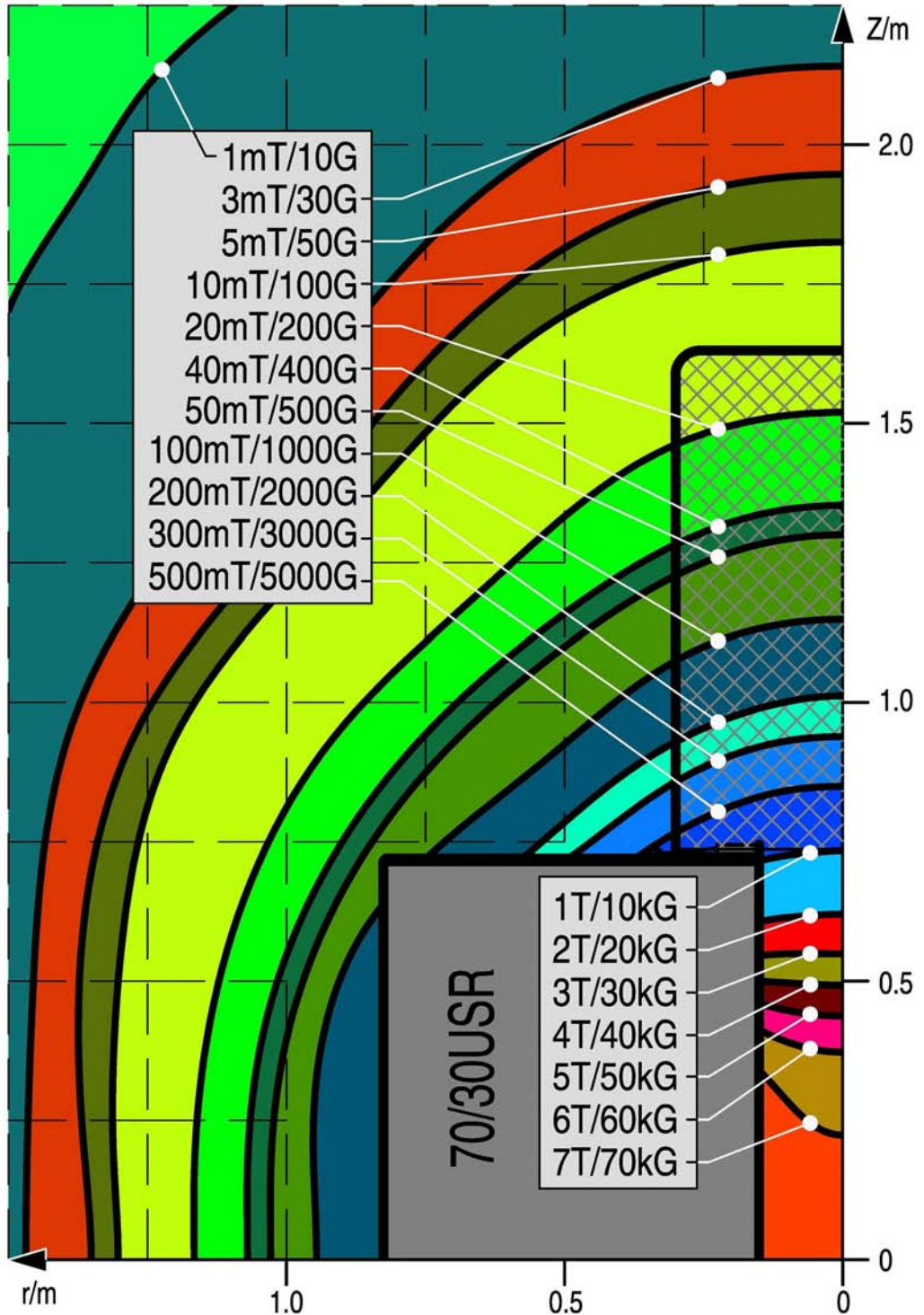


Figure 3: Contour plots of magnetic flux density for B-C 70/30USR

2.10.3. Inner bore field intensities for magnet B-C 94/20USR

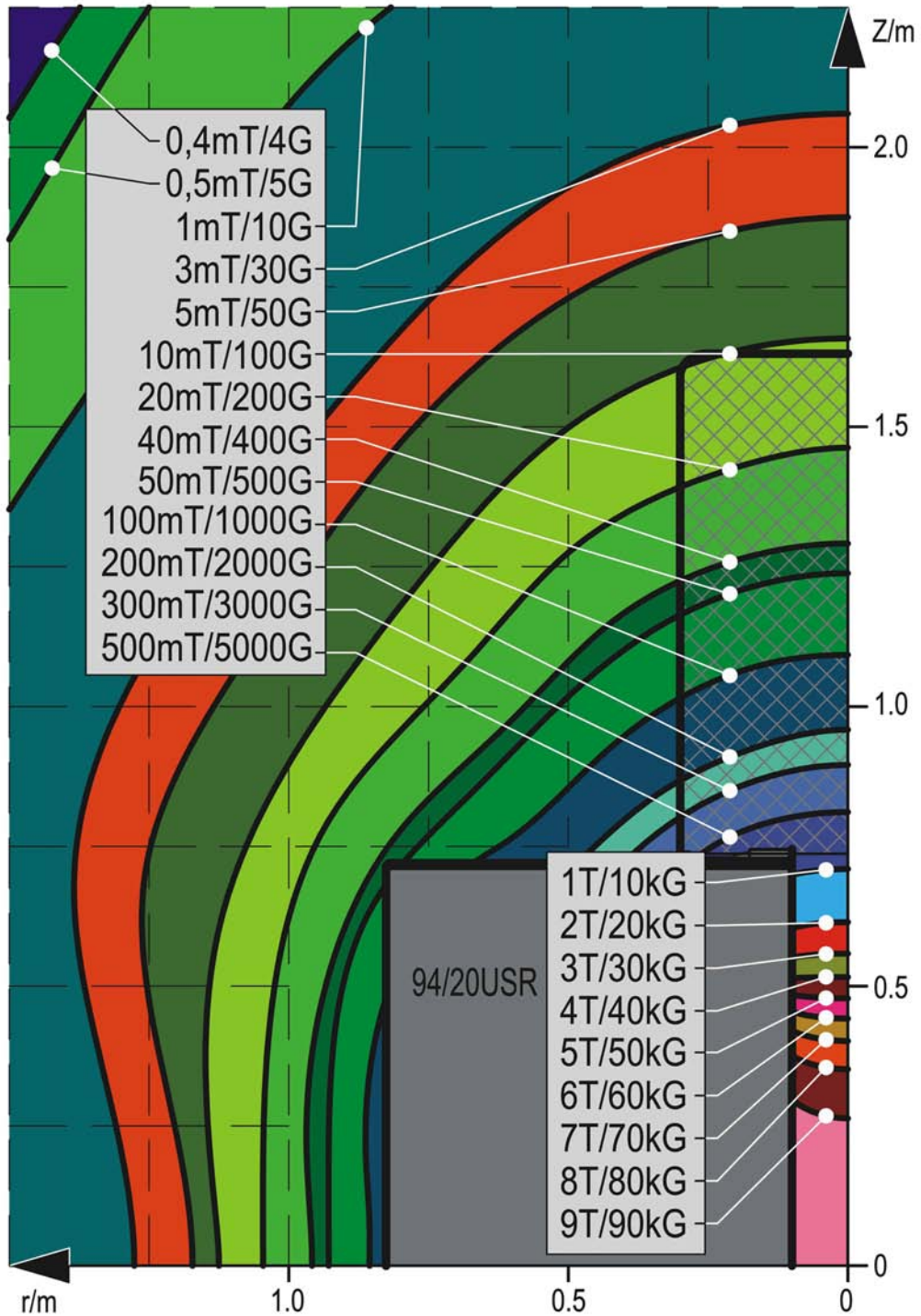


Figure 4: Contour plots of magnetic flux density for B-C 94/20USR

**2.10.4. Inner bore field intensities for magnet B-C 94/30USR**

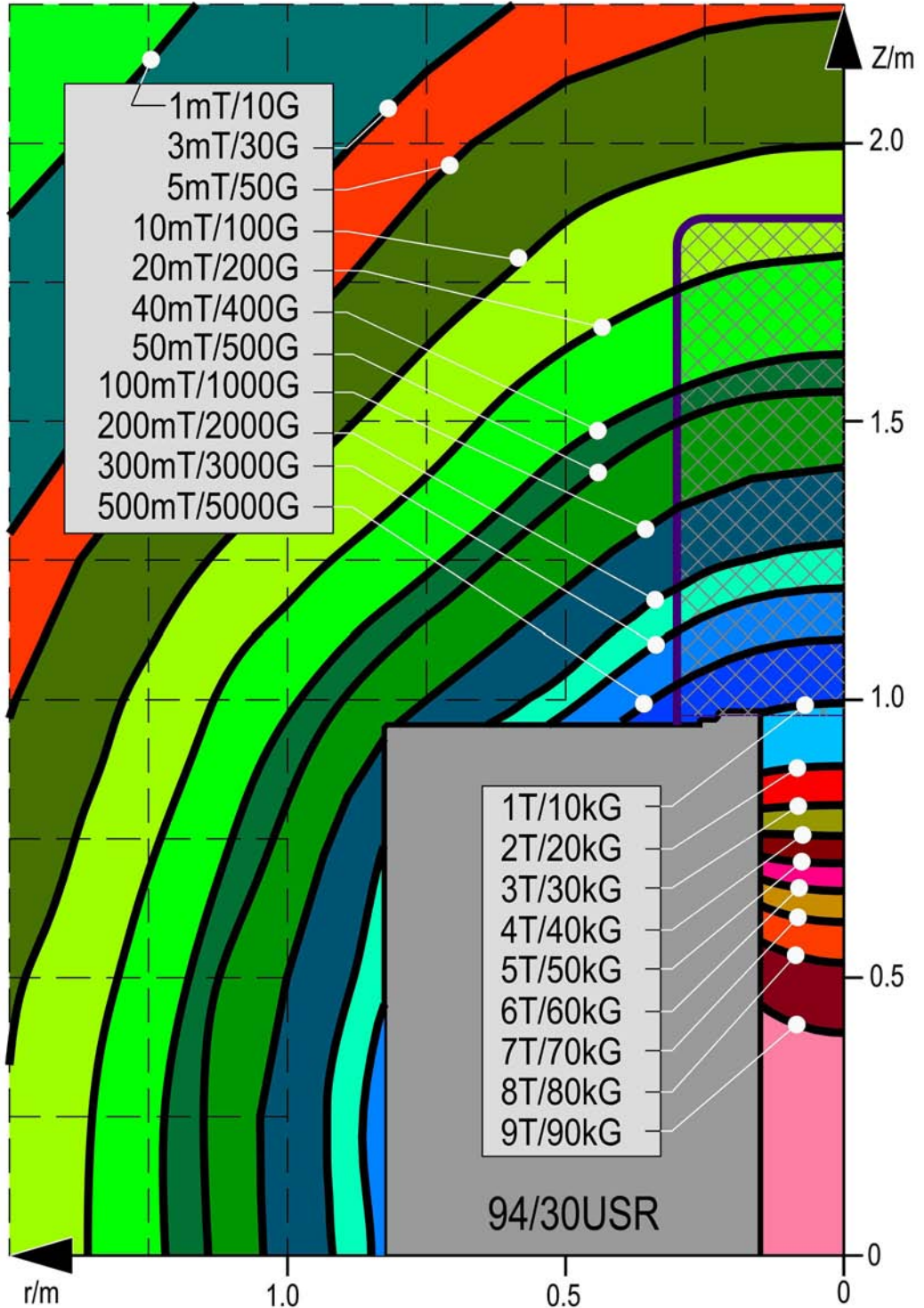


Figure 5: Contour plots of magnetic flux density for B-C 94/30USR

2.10.5. Inner bore field intensities for magnet M-C 70/20AS

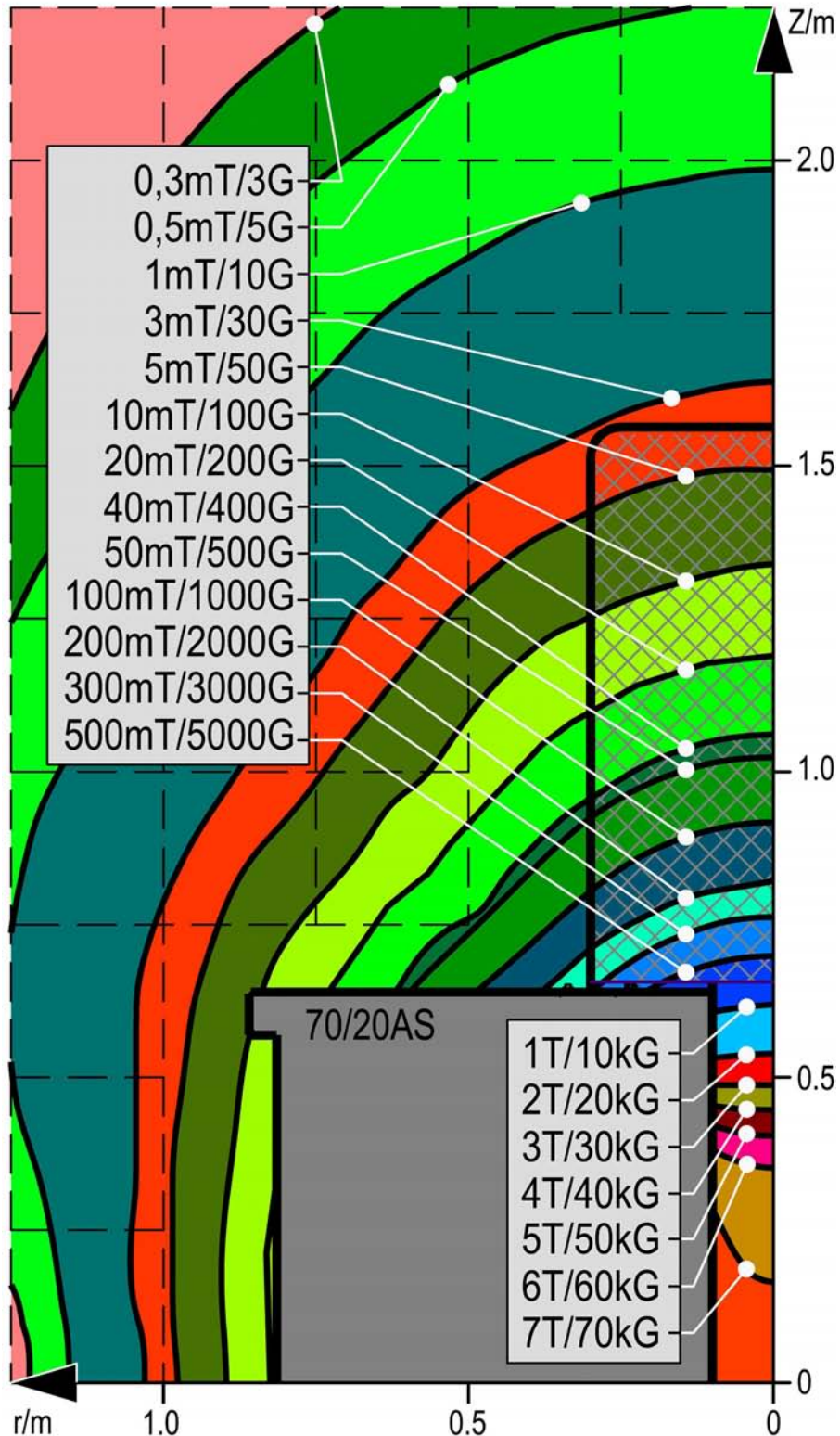


Figure 6: Contour plots of magnetic flux density for M-C 70/20AS

**2.10.6. Inner bore field intensities for magnet M-C 94/20AS**

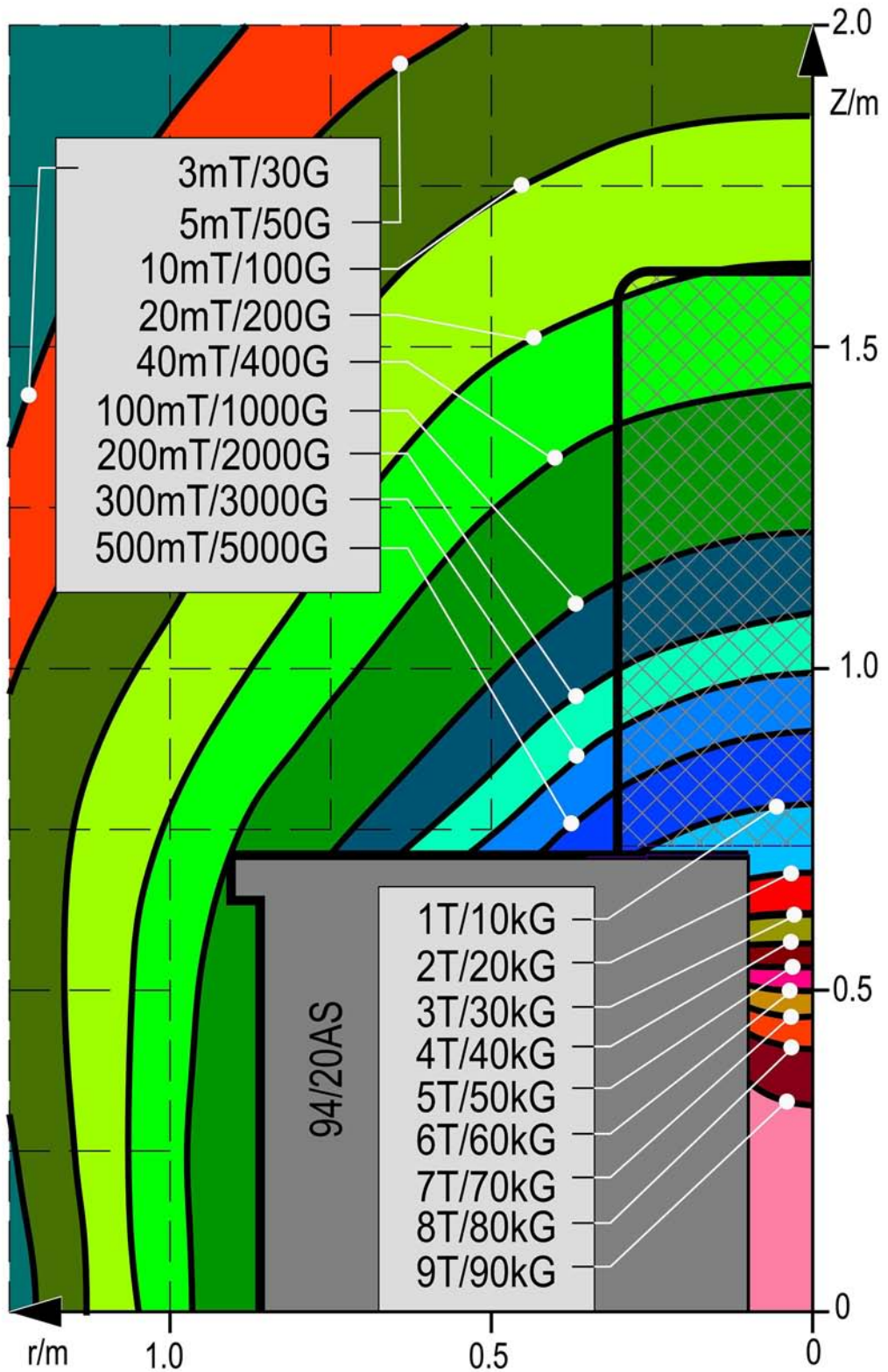


Figure 7: Contour plots of magnetic flux density for M-C 94/20AS

2.10.7. Inner bore field intensities for magnet M-C 94/30AS

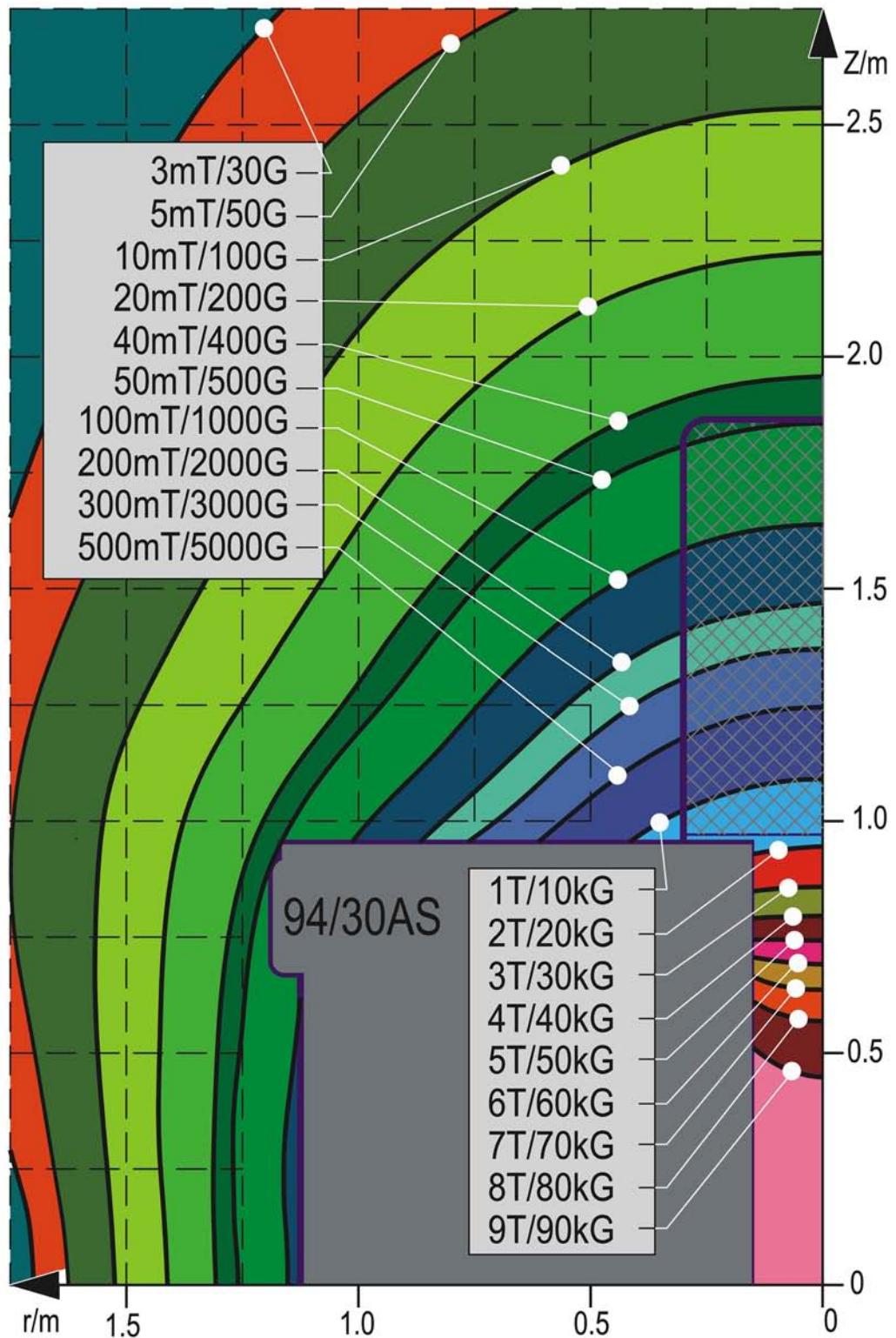


Figure 8: Contour plots of magnetic flux density for M-C 94/30AS



## 3. Site planning and preparation

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*Installation of the MR system requires installation of the following main components:*

- *The magnet and its gas-exhaust system (Quench line) plus air conditioning with fresh air in the magnet room.*
- *The hardware cabinets, the electrical distributor with mains supply lines, and a room cooling system in the technical room. Cold water is also needed to cool the magnet in a Bruker USR magnet system.*
- *Operating console in the operating area.*

### 3.1. General instructions and conditions

---

#### 3.1.1. Interactions between the Building and an MRI Magnet

Structural steel is usually used in floors, roofs and load-bearing structures when constructing buildings. This structural steel is usually ferromagnetic and is permanently magnetized and magnetically polarized by an installed high-field magnet (MRI system).

Two problem areas are the result of this interaction between the steels of the building and the MRI magnet.

1. When the MRI magnet is in operating phase, the magnetic flux can be delayed by the structural steel. This occasionally then also leads to magnetic contamination of sections of rooms that have something indirectly to do with the installation of the magnet.  
Use of these rooms can then be limited due to these delays in the magnetic field. The function of highly sensitive measuring devices or badly shielded monitors can then be impaired.  
Fortunately, the outer magnetic fields of modern MRI magnets are actively shielded. This means that these problems can be significantly reduced.
2. At the end of the operating phase or after relocation of the MRI magnet, the magnetic field continues in a weaker form as residual magnetization (Remanence) of the structural steel. This remanence in a building could be removed only by a correspondingly strong counter magnetic field (coercive magnetic field). In practice it is difficult to set up a coercive field. Use of the rooms concerned also continues to be restricted, but less stringently, after they have been used by the MRI.

### 3.1.2. Installation

(Extract from „Terms and Conditions of Sale“)

It is the responsibility of the Customer and at his own expense to prepare the site according to proper environmental requirements and to provide all the services requisite or necessary to enable such an installation to be effected as expeditiously as practicable including, but not restricted to power, water, drain, air, bottled gases, permits, licenses and approvals. Customer must also provide at his own expense whatever is required, including labor to uncrate and move the goods into their final location. Failure to so prepare and provide may result in a service charge by BRUKER to cover lost time on the part of its service engineers. Customer shall advise BRUKER within 60 days of written acceptance by BRUKER of the purchase order of details of all safety, building and electrical codes which must be complied with relevant to the installation of the goods. Any additional costs to BRUKER of complying with the requirements of such codes shall be added to the Contract Prices and paid for by Customer. If any certificates or other approvals by governmental and/or other authorities are required for the installation, the same shall be procured by Customer without delay and at his own expense.

### 3.1.3. Passing of Risk

(Extract from our “Terms and Conditions of Sale”)

Risk passes to the Customer as soon as the goods have left BRUKER’s premises (i.e. postal delivery, transport by BRUKER itself, etc) or have been delivered to the forwarding agent or as soon as the Customer has been advised by BRUKER that the goods are ready for dispatch. These are *allies mutatis mutandis* for partial deliveries and the delivery of spare parts.

### 3.1.4. Smoke and fire detectors

For safety reasons, Bruker recommends installation of smoke and fire detectors in all laboratory rooms.

### 3.1.5. Electrical installation, requirements and conditions

The customer is responsible for providing and installing all the necessary electrical supply lines to the electrical distributor. The customer is also responsible for providing the connections to the transformer station and the electrical distributor, as well as the supply and installation of all necessary electrical supply lines and sockets inside the operating and magnet room.

### 3.1.5.1. Power requirements (standard configuration without options)

The AC power mode based upon TN-S, according to DIN 57100 part 300, will be installed (Separate Neutral and Protective Grounding over the Entire Network). Other types of electrical supplies must be approved and confirmed by BRUKER.

|                     |  |
|---------------------|--|
| Voltage:            | 400/230 V $\pm$ 5 %                            |
| Current, frequency: | 3-phase current, alternating current, 50-60 Hz |
| Connected loads:    | approx. 20 kVA (with BRUKER USR magnet)        |
| Consumption:        | approx. 15,5 kW (with BRUKER USR magnet)       |
| Connected loads:    | approx. 8.8 kVA (with MAGNEX AS magnet)        |
| Consumption:        | approx. 7.0 kW (with MAGNEX AS magnet)         |

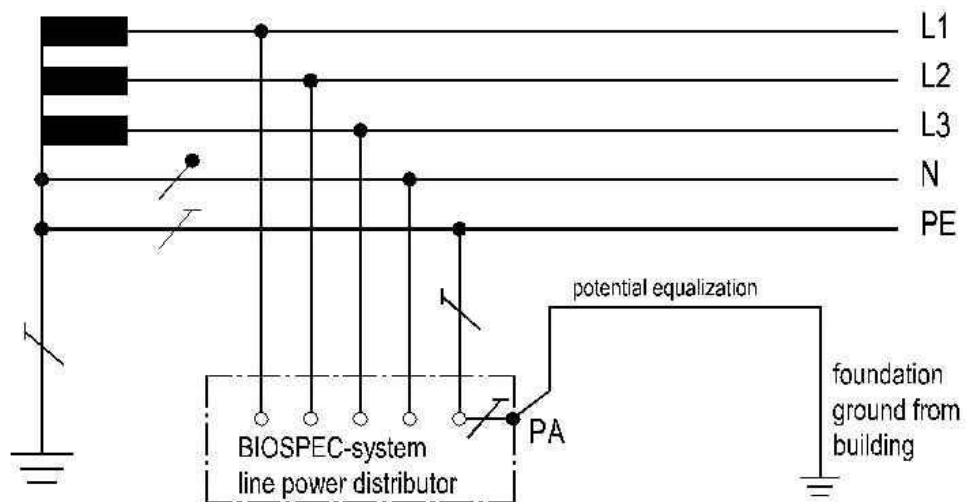


Figure 9: Line Power Connection Scheme for *BioSpec*® System

### 3.1.5.2. Grounding

The grounding of the *BioSpec*® system, measured from the central grounding point of the system's electrical distribution box in relation to control grounding outside the building, must not be greater than 5Ohm. We recommend installing a separate grounding wire from the building land to the grounding point at the system electrical distributor.

### 3.1.5.3. Potential compensation

The *BioSpec*® system must be incorporated into the potential compensation of the installation site.

### 3.1.5.4. Block diagram for electrical main power supply:

Example for an electrical wiring of line power connection with 208V(AC) 3phase supply. The transformers are needed only to adaptation to the local power supply system.

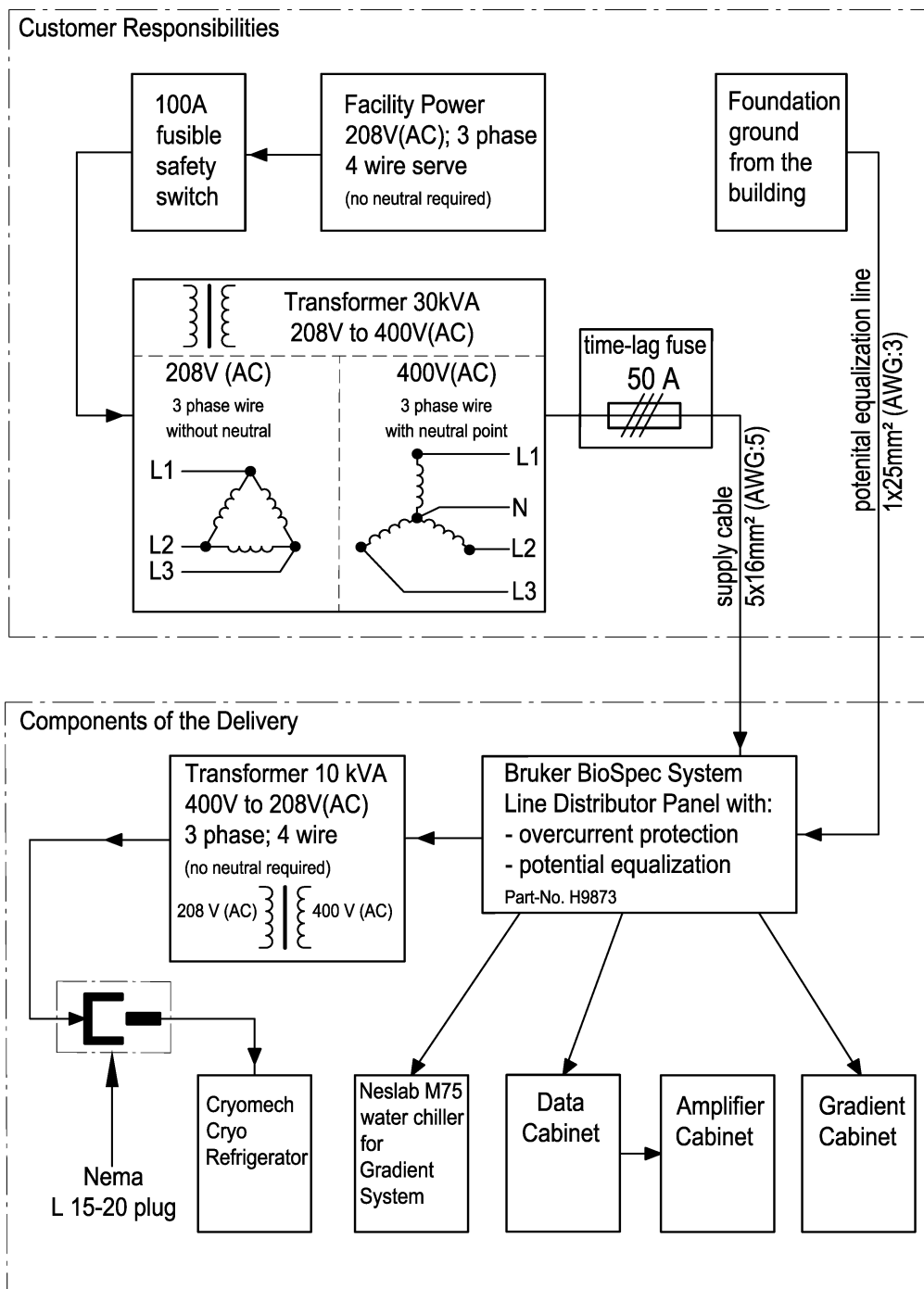


Figure 10: Blockdiagram for line power connection with 208V (AC)

### 3.1.5.5. Cable trays

Cable trays to handle system wiring are supplied and installed by the customer. The cable trays will be defined by BRUKER according to the local situation and the system's requirements! Cables must be able to be accommodated vertically. Cables must be free from pinching or binding at all curves or bends. Possible variants are:

a) Pedestal, b) Balustrade, c) Under-floor, d) Under-ceiling

### 3.1.6. Prerequisites for installation

Before BRUKER carries out installation, the said party shall meet the following requirements:

- All earthworks, concrete work, cutting work, construction work, etc. is complete
- The rooms set aside for installation must be clean and ready for occupancy
- Power, including fuels and all necessary connections leading to the installation site, heating, lighting and air-conditioning, installation of mains, electrical connections, cable channels, pipes, etc., is available
- Safety measures have been taken and, when necessary, safety barriers have been installed
- Transport routes provided, which are large enough in width and height, and of sufficient load-bearing capacity, both inside and outside the building
- Spacious, dry rooms provided to store service and installation materials and equipment (approx. 18 m<sup>2</sup>)
- During installation, access of individuals to the installation area and to the neighboring rooms (which may be locked by BRUKER staff) must be controlled. Admittance to these areas within this period of time requires prior approval from BRUKER staff
- Objects and materials required and assistant workers provided or can be provided at short notice

### 3.2. Magnet installation

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Figure 11: View of a Bruker USR magnet system

#### 3.2.1. Choosing an ideal installation site

Selection of an ideal installation site will often be a compromise between available laboratory space and factors affecting the installation process and the final image quality. The following aspects might be taken into account:

- Availability of laboratory space that meets the mandatory demands
- Integration into laboratory facilities
- Exhaust system (Quench line)
- Accessibility for system integration
- Interaction with surrounding departments
- Floor vibrations
- Air ventilation and lighting
- System for supplying helium gas
- Distance to operating and technical area
- Organization of a controlled access area around the magnet

### 3.2.1.1. Availability of laboratory space that meets the mandatory demands

When planning the site, it is absolutely vital that the floor surface on which the magnet will be installed is taken into account, as well as the load-bearing capacity of this surface. Specific solutions, such as replacing the magnet stand with another option, which distributes the magnet weight over a larger area, are possible but do not constitute part of a standard delivery and must therefore be approved by BRUKER beforehand.

### 3.2.1.2. Integration into laboratory facilities

To achieve high throughputs for standard animal investigations, it is important to integrate the MR system well into the surrounding laboratory facilities and this important factor should be highlighted.

### 3.2.1.3. Typical magnet foundation (basement)

Reinforced concrete made from ferromagnetic steel up to  $100\text{kg}/\text{m}^2$  can be used for the magnet foundation. If this limitation has to be exceeded, other reinforcement materials e.g. fiber glass or stainless steel, must be used.

The magnet base must be in direct contact with the building, thereby ensuring impact sound transmission will be decoupled. These measures are sufficient if the magnet is to be sited in the basement. Floating floors must be guaranteed not to have any contact with the magnet base.

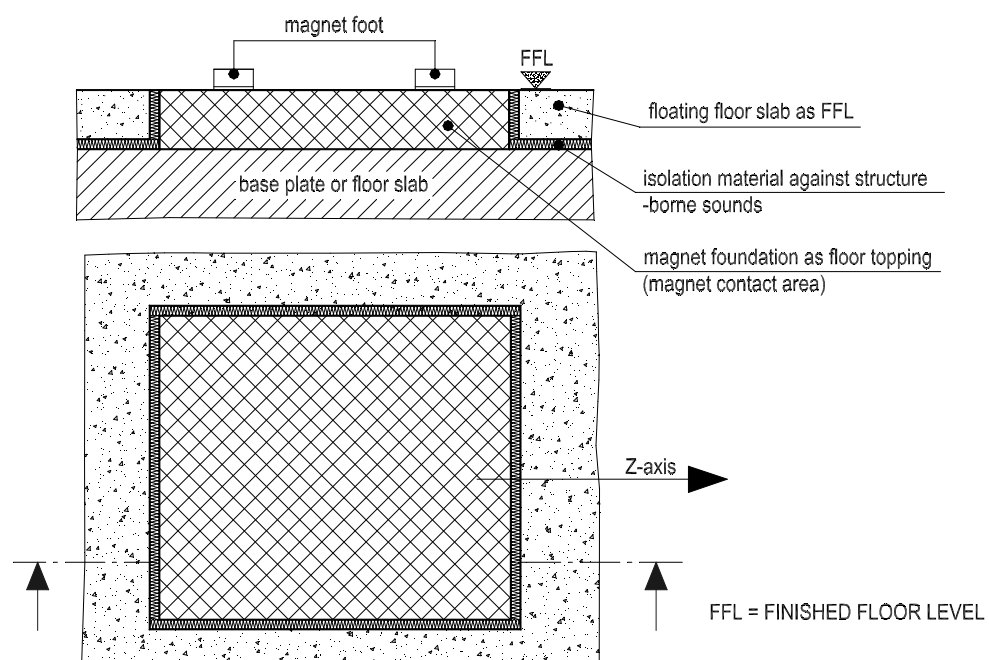


Figure 12: Schematic diagram of a typical magnet foundation

### 3.2.1.4. Floor vibrations (seismic vibrations)

Every building has mechanical vibrations, which unfortunately have an accelerating effect on the magnet. The magnet system feels these vibrations as a seismograph and reacts with alterations in the magnetic field proportional to the acceleration forces. If the vibrations within the frequency range of 5 to 30Hz lead to greater acceleration forces, significant image artifacts may appear. The performance specifications of the system can be guaranteed only when these acceleration forces are lower in amplitude than the limiting value in the table below.

BRUKER delivers a system for flexible siting of the magnet and a vibration absorber is included. Acceleration forces of up to 14000 $\mu\text{g}$  can be tolerated with this system in the frequency ranges mentioned below.

The drawing below specifies the positioning of the measuring devices needed as well as their analogue circuit design.

Different structural measures can help in achieving these requirements. When planning the site and during its subsequent construction, floating floors must be guaranteed not to have any contact with the magnet base. The magnet base must be in direct contact with the building, thereby ensuring the impact sound transmission will be decoupled. These measures are sufficient if the magnet is to be sited in the basement.

Should the magnet be sited on an upper floor, these measures will prove insufficient since external forces can also have a bearing on the magnet.

BRUKER can on request measure the spread of these vibrations and provide appropriate advice regarding the system's site.

| Floor vibrations frequency range [ Hz ] | Bruker standard configuration with integrated vibration absorbers (tolerated vibration amplitude) |                     | Configuration without integrated vibration absorbers (tolerated vibration amplitude) |                     |
|---|---|---------------------|--|---------------------|
|   | [ $\mu\text{g}$ ]   | [ $\text{mm/s}^2$ ] | [ $\mu\text{g}$ ]  | [ $\text{mm/s}^2$ ] |
| 5 - 10                                  | $\leq 800$  | $\leq 7.848$        | $\leq 220$   | $\leq 2.1582$       |
| > 10 - 15                               | $\leq 600$  | $\leq 5.886$        | $\leq 35$  | $\leq 0.34335$      |
| > 15 - 20                               | $\leq 1200$   | $\leq 11.772$       | $\leq 50$  | $\leq 0.4905$       |
| > 20 - 30                               | $\leq 14000$  | $\leq 137.34$       | $\leq 450$   | $\leq 4.4145$       |

Table 4: Maximum tolerated floor vibration amplitude in the frequency range.

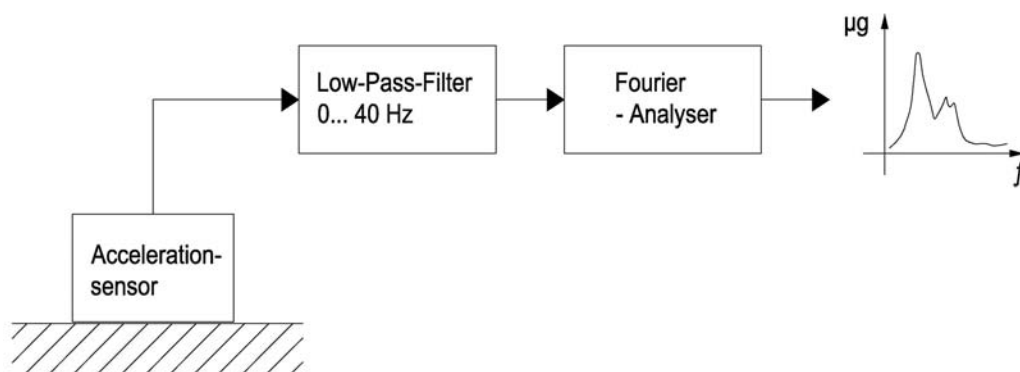


Figure 13: Principle of Layout for Vibration Measuring Instruments



### 3.2.1.5. Interaction with surrounding departments

During installation, site planning and site construction, it is important to consider the noise level anticipated in the vicinity of the operator's console and prevent system personnel from being exposed to values, which exceed established thresholds. Whenever an examination sequence is performed on the MR system acoustic, noise is produced inside the magnet room. Sound levels between 75 and 100dB (A) can be measured at a distance of 1m from the magnet bore during conventional scanning. Typical values are around approx. 86dB (A). Examination sequences which incorporate extreme performance criteria may produce even higher sound levels. The system operator thus determines how great these sound or acoustic noise levels are when the examination sequence selected is subsequently run. To avoid vibrations spreading, the magnet should stand on a rubberized platform or surface. Thus the noise produced by gradient switching will be decoupled from the area under the magnet. The relevant frequency range is between 50 and 800Hz.

### 3.2.1.6. Exhaust system (quench line)

The magnet system must be attached to a gas exhaust system, called a quench line. The quench line is needed for quenching the magnet (uncontrolled discharge process of the super-conducting magnet system). During the quenching process, cryogenic gases evaporate as the volume increases by approximately 749 times that of the liquid state. The evaporated cryogen gases are removed from the magnet room in a controlled manner by the quench line.

The outlet structure must make it impossible for animals, snow and the like to enter. Furthermore, the outlet must be constructed so that all risk of injury to individuals is avoided (a barrier at a distance of 3m is recommended). The quench line can be hand-made by a metalworker as a sheet-metal cylinder composed of copper or stainless steel. The completed cylinder comprises a round ventilation tube; the surface of the cylinder may be covered as desired. To avoid condensed water forming, we recommend using strong insulation, approximately 40mm thick.

For design criteria and details on calculation, see Appendix item 6.3 in this manual.

### 3.2.1.7. Distance to technical and operating areas

The magnet area must not be the same room as the operating area or the technical area. In many cases, it is more comfortable to run the final system operation if these sites are physically separated.

However, many systems can only be delivered with limited lengths of sets of connecting cables. Furthermore, the longer the cables, the more important losses along the lines are, which might reduce the effective RF power available for signal excitation. When selecting the required cable length, please remember that the cables must be installed in cable trays, which will reduce the maximum distance possible to the electrical area.

In many cases, it is good to have easy access to the magnet. If studies are to be carried out on animals, a visual check on the magnet area is strongly recommended.

### 3.2.1.8. Cable trays between the magnet and filter plate

A series of connection wires must be placed between the filter plate and the magnet. We prefer a direct path in a cable channel, which will be connected to the rear of the magnet as an inspection stage (platform) or as a socket channel. Since some of the cables are very rigid and can only be bent in large radii, the cables should be laid so that they are placed next to one another. If the cable way runs horizontally and the cables are mounted vertically, one on top of the other, the cables must be anchored every 80 to 100cm. The same applies to a vertical cable way for tension relief.

Two different lengths are available as standard connection cables:

**Short length = 6 m, long length = 9 m.**

Non-standard connection lengths are not part of standard deliveries/installations and therefore require BRUKER's prior approval.

### 3.2.1.9. RF Shielding (Faraday Cage)

For the *BioSpec*<sup>®</sup> system to be able to operate uninterruptedly, the test sample must be shielded against high-frequency irradiation. Technically-speaking two installation variants are possible for the magnet.

**Variante 1:** in areas where the legal requirements so allow, room shielding can be waived. For this application, BRUKER will supply a shielding box, instead of the filter plate, that is mounted on the rear side of the magnet. The effect of this, together with the magnet body, is to shield the test sample sufficiently for MRI exposure.

**Variante 2:** installation of the magnet in a Faraday type of room shield. In a particularly exposed environment, e.g. in the vicinity of an airport or radio transmitter, or when the local legal requirements demand it, the magnet may have to be integrated into a Faraday cage. A Faraday cage should reach attenuation of approx. 80dB at the operating frequency of the MRI system. For this application, BRUKER will then supply a filter plate, instead of a shield box, for integration into a Faraday cage. The opening needed for installation is shown in the illustration below.

A Faraday cage is not part of the standard delivery. Faraday cages are manufactured in different models. Bruker prefer the wooden stand construction for reasons of cost and offer them as optional components. More detailed information on this method of construction can be found in the "Faraday Cage" product description (document part no. T9998).

**N.B.: Use of a Faraday cage increases the dimensions of the magnet room needed for the shell.** An extra 10 to 25cm in the shell dimensions are required in each direction in the building than the floor space dimensions of the finished magnet room listed on the table of technical magnet data.

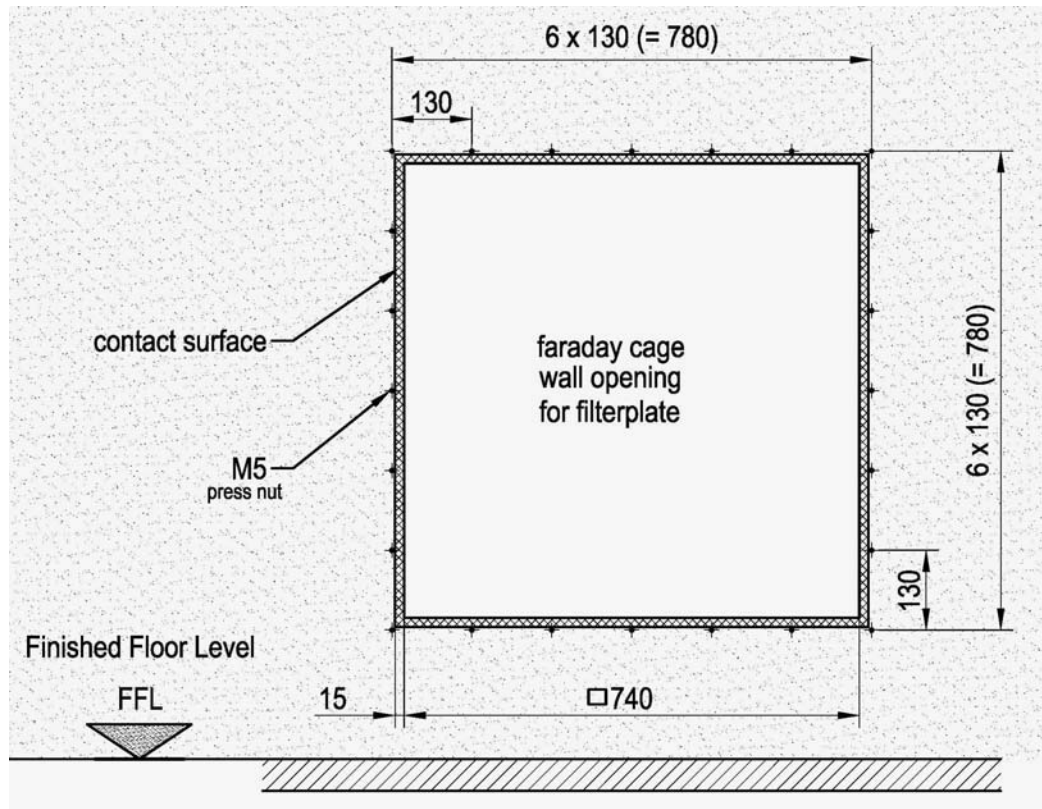


Figure 14: Opening for filter plate inside the Faraday cage wall



Figure 15: Filter plate mounted on the wall opening of a Faraday cage



Figure 16: Filter box on the rear side of the magnet (solution without Faraday cage)

### 3.2.1.10. Lighting (lighting facilities in the magnet room)

We highly recommend 230V/150W halogen lamps, which are mounted on the wall and reflect on to the ceiling to provide indirect lighting. This usually involves a slight alteration to the color temperature of the light towards warmer shades.

In our experience light intensity of at least 500 Lux is needed in the working area in front of the magnet. The color temperature of this lighting should be similar to daylight and therefore amount to approx. 5000 Kelvin. Hence we recommend color-adjusted halogen lights (e.g. 12V/50W cool beam down lights) over the working area in front of the magnet.

To avoid RF interference, use of switch mode power supplies, AC transformers, dimmers or energy-saving lamps is not permitted close to the magnet.

For safety purposes, we recommend installing battery-buffered emergency lighting (< 10 Lux) close to the exit of the magnet room.

### 3.2.1.11. Air conditioning / ventilation system

In compliance with the safety regulations on working with cryogenes, the magnet room air ventilation system must be capable of exchanging approximately 1.5 times the volume of air in a room every hour. Since air ventilation systems of this kind can fail, we recommend device for monitoring the air flowing into the ventilation system and the O<sub>2</sub>-content or air in the room. This monitoring device should be equipped with the appropriate alarm mechanisms.

In principal, the instrument may be operated with anesthetic gas devices that use ISO-N-Fluorine. Whenever anesthetic gases (medical gases) are used, ventilation must be dimensioned according to local regulations. In dimensioning the ventilation and evacuation equipment, it is particularly important to adhere to the MWC values for the various anesthetic agents used. This particularly applies to the area immediately surrounding the breathing equipment (e.g. the MWC value for halothane is currently 5ppm, where MWC = Maximal Working area Concentration). In Germany the DIN 1946 specifications (part 4) apply whenever a ventilation system is chosen for a hospital. It has been established that the air ventilation system must be capable of exchanging the volume of air in a room approximately 15 times every hour.

At a Faraday box installation:

An anesthesia gas outlet is provided on the lower side of the Faraday box, which is internally connected directly to the probe head and used to remove the magnet bore from the anesthesia gas. The interface is an 1 1/4" (diameter approx. 31mm) connection piece, which might be connected to a silicon tube.

The capacity of air condition system is based on the:

- heat dissipated from the system
- heat dissipated from the lights in the room
- heat created by adjacent room or sun light

The air condition system must be capable of establishing constant working conditions within the following limits:

- Temperature: 21°C ± 3°C
- Relative humidity 40...60% (no condensation)



Figure 17: Anesthesia gas outlet is connected with a silicone tube. Filter box on rear side of the magnet (solution without Faraday cage)



Figure 18: Example of an anesthesia gas extraction hood behind the magnet in a Faraday cage room. Model with swivel arm and extraction hood as a non-magnetic structure

### 3.2.1.12. Helium Gas Supply System 4.6 (> 99.996 volume %)

Pressurized helium gas is required when filling the magnet with liquid helium. This pressurized gas will be used to force the liquid helium from the transport container into the magnet. Recently it has become possible to use transport containers that do not require pressurized helium gas when filling the magnet.

Since it is not permitted to bring metal objects (gas cylinders) into the area of the magnet, we recommend installation of a fixed device comprising an assembly support for the gas cylinder and a release station in the technical room as well as a gas valve in the area of the magnet for additional security.

### 3.2.2. Mandatory requirements

The customer must meet the following requirements for the magnet installation site:

- 1) The intended transport route of the system must provide adequate clear passage and load-bearing capacity. Transport routes must be strong and wide enough to transport and install a mobile crane (if necessary). The specific dimensions are given in the tables below with an overview of installation data.
- 2) The site intended for magnet installation must provide sufficient surrounding space and adequate load-bearing capacity. The space required and load-bearing capacities are given in the tables below. If a crane is required for installation, the installation site must be strong and wide enough to transport and install a mobile crane.
- 3) The magnet's site or foundation must be selected so that the building vibrations do not exceed the limits. For further details, see section 3.2.1.4.
- 4) Reinforced concrete made from ferro-magnetic steel up to 100kg/m<sup>2</sup> can be used for the magnet base. If this limitation has to be exceeded, other reinforcement materials e. g. fiber glass or stainless steel, must be used.
- 5) The location of all ferromagnetic objects and materials within the vicinity of the magnet installation site must be defined and forwarded to BRUKER.
- 6) All moveable ferromagnetic objects must be removed from the magnet area.
- 7) The magnet supervision unit requires one socket in the vicinity of the magnet.
- 8) The magnet needs joint grounding with the electrical installation (see section 3.3.2.5).
- 9) Liquid cryogenes for initial system installation must be provided by the customer. The quantities are listed in the tables below.
- 10) Helium gas supply systems
- 11) The maximum distance between the magnet and the hardware cabinets must fit the available cable length (see section 3.2.1.8 and 3.3.2.2)
- 12) The customer must install a quench line from the magnet to the building.
- 13) Installation of an air ventilation system.
- 14) Supply and installation of lighting from the magnet area.

The detailed quantities concerning these requirements are given in the following tables and sections:



## Site planning and preparation

| Configuration for a <i>BioSpec</i> with a Bruker USR magnet   | Standard                          | Options        |
|---|-----------------------------------|----------------|
| <b>Available Cable length</b><br>Magnet ↔ Filter plate  | 6m                                | 9m             |
| <b>Available pressure tube length</b><br>(stainless steel flexible tube as Helium high and low pressure hoses)<br>Magnet ↔ Filter plate | 6m                                | 9m             |
| <b>Cable tray dimensions</b><br>Width/Height<br>Minimum bending radius<br>Maximum anchored distance                                     | 35cm/12cm<br>10cm<br>100cm        | --<br>--<br>-- |
| <b>Heat dissipation into air</b><br>Magnet system excluding lighting<br>Typical magnet room lightning                                   | 0.35kW<br>0.85kW                  |                |
| <b>Dimensions (l/w/h)</b><br>RF-Filter plate<br>RF filter box (solution without Faraday cage)   | 54cm/80cm/80cm<br>31cm/85cm/110cm | --<br>--       |
| <b>Weights:</b><br>RF filter plate<br>RF-Filter box   | approx. 45kg<br>approx. 68kg      | --<br>--       |
| <b>Line connections</b><br>Mains socket (AC) for service  | Schuko connector 230V 10A         |                |

Table 5: Hardware installation data for system configuration with a Bruker USR magnet.

| Configuration for a <i>BioSpec</i> with a Magnex AS magnet  | Standard                          | Options        |
|---|-----------------------------------|----------------|
| <b>Available Cable length</b><br>Magnet ↔ Filter plate  | 6m                                | 9m             |
| <b>Cable tray dimensions</b><br>Width/Height<br>Minimum bending radius<br>Anchored distance           | 25cm/12cm<br>15cm<br>100cm        | --<br>--<br>-- |
| <b>Heat dissipation into air</b><br>Magnet system excluding lighting<br>Typical magnet room lightning | 0.35kW<br>0.85kW                  | --             |
| <b>Dimensions (l/w/h)</b><br>RF filter plate<br>RF filter box (solution without Faraday cage)         | 54cm/80cm/80cm<br>31cm/85cm/110cm | --<br>--       |
| <b>Weights:</b><br>RF-Filter plate<br>RF filter box   | approx. 45kg<br>approx. 68kg      | --<br>--       |
| <b>Line connections</b><br>Mains socket (AC) for service  | Schuko connector 230V 10A         |                |

Table 6: Hardware installation data for system configuration with a Magnex AS magnet.

## 3.2.2.1. Installation data overview for Bruker USR magnets 47/40 and 70/30

| Type of Magnet   | B-C 47/40USR                                | B-C 70/30USR                                 |
|--|---|--|
| <b>Field strength</b>  | 4.7 Tesla                                   | 7.0 Tesla                                    |
| <b>Larmor frequency (1H)</b>   | 200MHz                                      | 300MHz                                       |
| <b>Helium capacity</b> maximum<br>Typ. refill interval<br>Typ. refill quantity (transfer loss inclusive)   | 800 liter<br>365 days<br>~450 liter         | 800 liter<br>365 days<br>~450 liter          |
| <b>Nitrogen capacity</b> maximum I<br>Typ. refill interval<br>Typ. refill quantity (transfer loss inclusive)   | -/- liter<br>-/- days<br>-/- liter          | -/- liter<br>-/- days<br>-/- liter           |
| <b>Warm transport</b><br><b>Liquid gas for installation</b><br>Helium/Nitrogen (liquid)  | not usual!                                  | not usual!                                   |
| <b>Cold transport</b><br><b>Liquid gas for installation</b><br>Helium/Nitrogen (liquid)  | 350 liter                                   | 350 liter                                    |
| <b>Height of magnet iso-center</b>   | 106cm                                       | 106cm  |
| <b>Minimum room height</b>   | 278cm                                       | 278cm  |
| <b>Magnet Dimension</b><br>Length/Width/Height   | 144/165/241cm                               | 144/165/241cm                                |
| <b>Magnet Weight</b>   | 4900kg                                      | 5500 kg                                      |
| <b>Magnet foundation area</b><br>Length/Width  | 1.95m <sup>2</sup><br>150/130cm             | 1.95m <sup>2</sup><br>150/130cm              |
| <b>Floor loading</b>   | 2515kg/m <sup>2</sup>                       | 2825kg/m <sup>2</sup>                        |
| <b>Suggested floor space</b> (for magnet room)<br>Length/Width   | ~16 m <sup>2</sup><br>440/360cm             | ~16 m <sup>2</sup><br>440/360cm              |
| <b>Transportation data for openings</b><br>Standard dimension: L/W /H<br>Minimum dimension: L/W/H<br><b>Transportation weight</b>  | 164/185/240cm<br>149/170/230cm<br>4600kg    | 164/185/240cm<br>149/170/230cm<br>5200kg     |
| <b>Quench line design</b><br>Cryogen gas mass flow (max.)<br>Maximum loss of pressure<br>Detailed information in chapter<br>Typical Diameter<br>Proposed thermal isolation | 1.0kg/s<br>0.4 bar<br>6.3.1<br>200mm<br>40m | 1.0kg/s<br>0.4 bar<br>6.3.1<br>200mm<br>40mm |
| <b>Emergency quench button</b><br>Dimension: L/W/H<br>Typical installation height<br>Position, nearby:   | 12/7/7 cm<br>160cm<br>entrance/exit         | 12/7/7cm<br>160cm<br>entrance/exit           |

Table 7: Installation data overview: B-C 47/40USR, B-C 70/30USR

### 3.2.2.2. Installation data overview for Bruker USR magnet 94/20 and 94/30

| Type of magnet   | B-C 94/20USR                                 | B-C 94/30USR   |
|--|--|--|
| <b>Field strength</b>  | 9.4 Tesla                                    | 9.4 Tesla  |
| <b>Larmor frequency (1H)</b>   | 400 MHz                                      | 400 MHz  |
| <b>Helium capacity</b> maximum<br>Typ. refill interval<br>Typ. refill quantity (transfer loss inclusive)   | 800 liter<br>730 days<br>~450 liter          | 1000 liter<br>265 days<br>~450 liter                 |
| <b>Nitrogen capacity</b> maximum I<br>Typ. refill interval<br>Typ. refill quantity (transfer loss inclusive)   | -/- liter<br>-/- days<br>-/- liter           | -/- liter<br>-/- days<br>-/- liter                   |
| <b>Warm transport</b><br><b>Liquid gas for installation</b><br>Helium/Nitrogen (liquid)  | not usual!                                   | not usual!   |
| <b>Cold transport</b><br><b>Liquid gas for installation</b><br>Helium/Nitrogen (liquid)  | 500 - 800 liter                              | 500 liter  |
| <b>Height of magnet iso-center</b>   | 106cm  | 106cm  |
| <b>Minimum room height</b>   | 278cm  | 290cm  |
| <b>Magnet Dimension</b><br>Length/Width/Height   | 144/165/24cm                                 | 196/171/241cm  |
| <b>Magnet Weight</b>   | 5300kg                                       | 11800kg  |
| <b>Magnet foundation area</b><br>Length/Width  | 1.95m <sup>2</sup><br>150/130cm              | ~2.55m <sup>2</sup><br>196/130cm                     |
| <b>Floor loading</b>   | 2720kg/m <sup>2</sup>                        | 4640kg/m <sup>2</sup>                                |
| <b>Suggested floor space</b> (for magnet room)<br>Length/Width   | ~16m <sup>2</sup><br>440/360cm               | ~19m <sup>2</sup><br>480/400cm                       |
| <b>Transportation data for openings</b><br>Standard dimension: L/W/H<br>Minimum dimension: L/W/H<br><b>Transportation weight</b>   | 164/185/240cm<br>149/170/230cm<br>5000kg     | 216/191/240cm<br>201/176/230cm<br>1000kg             |
| <b>Quench line design</b><br>Cryogen gas mass flow (max.)<br>Maximum loss of pressure<br>Detailed information in chapter<br>Typical Diameter<br>Proposed thermal isolation | 1.0kg/s<br>0.4 bar<br>6.3.1<br>200mm<br>40mm | 1.4kg/s<br>0.15 bar<br>6.3.1<br>200 or 300mm<br>40mm |
| <b>Emergency quench button</b><br>Dimension: L/W/H<br>Typical installation height<br>Position, nearby:   | 12/7/7cm<br>160cm<br>entrance/exit           | 12/7/7cm<br>160cm<br>entrance/exit                   |

Table 8: Installation data overview: B-C 94/20USR, B-C 94/30USR

### 3.2.2.3. Installation data overview for Magnex AS magnets

| Type of magnet   | M-C 70/20AS                                    | M-C 94/20AS                                     | M-C 94/30AS                                   |
|--|--|---|---|
| <b>Field strength</b>  | 7.0 Tesla                                      | 9.4 Tesla                                       | 9.4 Tesla                                     |
| <b>Larmor frequency (1H)</b>   | 300 MHz  | 400 MHz   | 400 MHz                                       |
| <b>Helium capacity</b> maximum<br>Typ. refill interval<br>Typ. refill quantity (transfer loss incl.)   | 750 liter<br>>90 days<br>~280 liter            | 800 liter<br>>100 days<br>~340 liter            | 2500 liter<br>>125 days<br>~750 liter         |
| <b>Nitrogen capacity</b> maximum<br>Typ. refill interval<br>Typ. refill quantity (transfer loss incl.)   | 180 liter<br>>12 days<br>~176 liter            | 200 liter<br>>14 days<br>~198 liter             | 400 liter<br>>14 days<br>~400 liter           |
| <b>Warm transport</b><br><b>Liquid gas for installation</b><br>Helium/Nitrogen (liquid)  | 2500/2500 l                                    | 2500/2500 l                                     | 7000/7000 l                                   |
| <b>Cold transport</b><br><b>Liquid gas for installation</b><br>Helium/Nitrogen (liquid)  | not usual!                                     | not usual!                                      | not usual!                                    |
| <b>Height of magnet iso-center</b>   | 107cm  | 110cm   | 121cm   |
| <b>Minimum room height</b>   | 332cm  | 335cm   | 334cm   |
| <b>Magnet Dimension</b><br>Length/Width/Height   | 128/172/233cm                                  | 142/181/235cm                                   | 190/238/283cm                                 |
| <b>Magnet Weight</b>   | 3550kg   | 4850kg  | 12600kg                                       |
| <b>Magnet foundation area</b><br>Length/Width  | ~1.79m <sup>2</sup><br>138/130cm               | ~1.98m <sup>2</sup><br>152/130cm                | ~5.47m <sup>2</sup><br>230/238cm              |
| <b>Floor loading</b>   | 1980kg/m <sup>2</sup>                          | 2460kg/m <sup>2</sup>                           | 2310kg/m <sup>2</sup>                         |
| <b>Suggested floor space</b><br>(for magnet room)<br>Length/Width  | ~16m <sup>2</sup><br>440/360cm                 | ~16m <sup>2</sup><br>440/360cm                  | ~19m <sup>2</sup><br>480/400cm                |
| <b>Transportation data</b><br>Standard dimension: L/W/H<br>Minimum dimension: L/W/H  | 148/192/231cm<br>133/182/226cm                 | 162/201/260cm<br>147/186/235cm                  | 210/258/285cm<br>200/248/280cm                |
| <b>Transportation weight</b>   | 3300kg   | 4600kg  | 11750kg                                       |
| <b>Quench line design</b><br>Cryogen gas mass flow (max.)<br>Maximum loss of pressure<br>Detailed information in chapter<br>Typical Diameter<br>Proposed thermal isolation | 0.56kg/s<br>0.34 bar<br>6.3.2<br>150mm<br>40mm | 0.804kg/s<br>0.13 bar<br>6.3.2<br>150mm<br>40mm | 1.4kg/s<br>0.34 bar<br>6.3.2<br>200mm<br>40mm |
| <b>Emergency quench button</b><br>Dimension: L/ W/H<br>Typical installation height<br>Position, nearby:  | 12/7/7cm<br>160cm<br>entrance/exit             | 12/7/7cm<br>160cm<br>entrance/exit              | 12/7/7cm<br>160cm<br>entrance/exit            |

Table 9: Installation data overview: M-C 70/20AS, M-C 94/20AS, M-C 94/30AS

### 3.3. Hardware cabinet installation inside the technical room

#### 3.3.1. Overview of the *BioSpec*<sup>®</sup> components for the technical room

##### 3.3.1.1. Example of an installed standard electronic system (Copley 231P)



Figure 19: View of the *BioSpec*<sup>®</sup> system cabinets.

- Standard system cabinets with a Copley 231P gradient amplifier (2 racks).
- Cooled water connection and heat exchanger for cryo-refrigerator cooling.



Figure 20: View of the *BioSpec*<sup>®</sup> system electrical distributor and cold water connection.



Figure 21: View of the rear side of the system cabinets and the filter plate on the left.



Figure 22: View of the gradient coil cooler and cryo-refrigerator.  
On the top you can see the connection panel of the electrical distributor.

## 3.3.1.2. View and dimensions of the electronic cabinets



Figure 23: View of the *BioSpec* system cabinets with Copley 265P option.  
- Standard system cabinets with a Copley 265P gradient amplifier (3 racks).

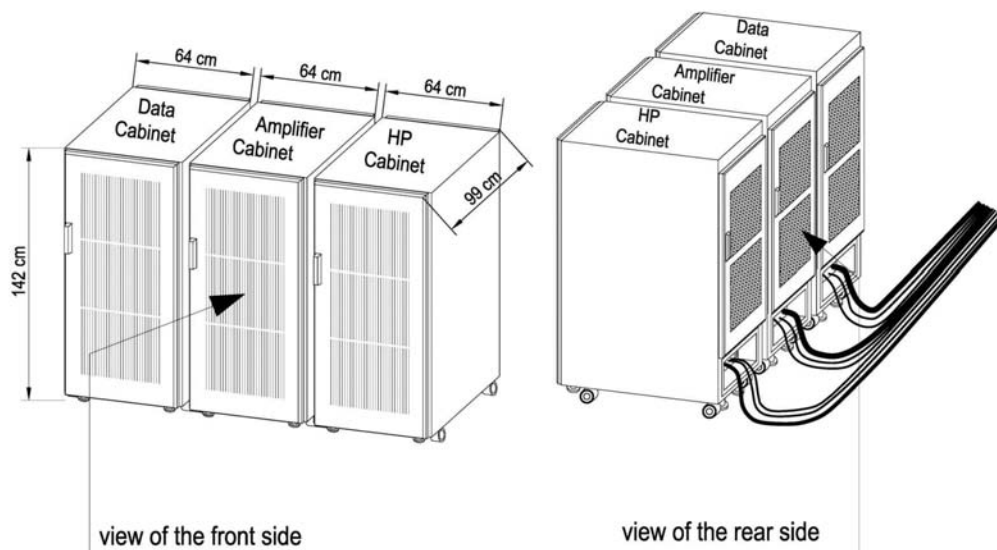


Figure 24: View of the system cabinets: dimensions and cable connection



## Site planning and preparation

### 3.3.1.3. View and dimensions of the system electrical distributor

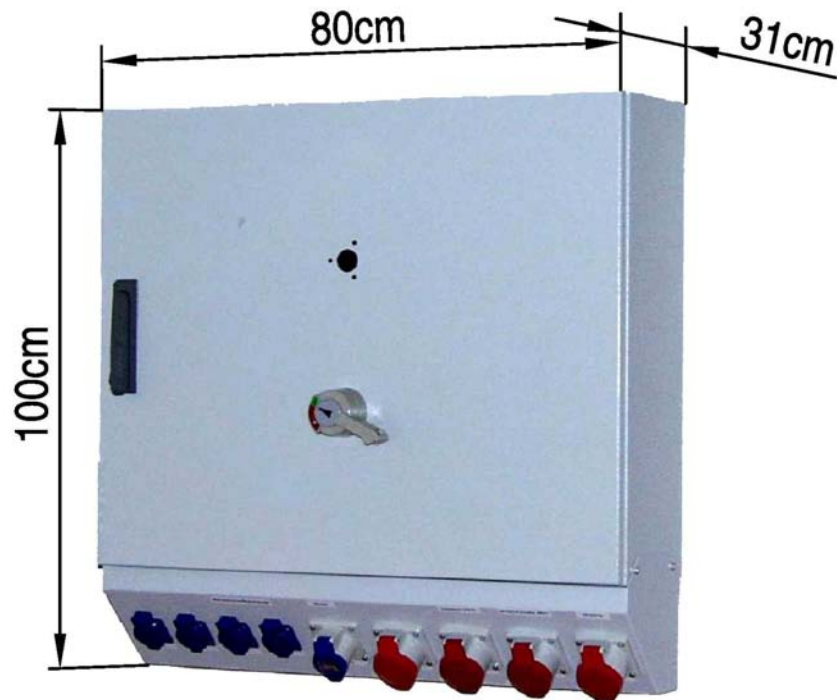


Figure 25: View of the system electrical distributor

### 3.3.1.4. View and dimensions of the chiller system for gradient coil cooling

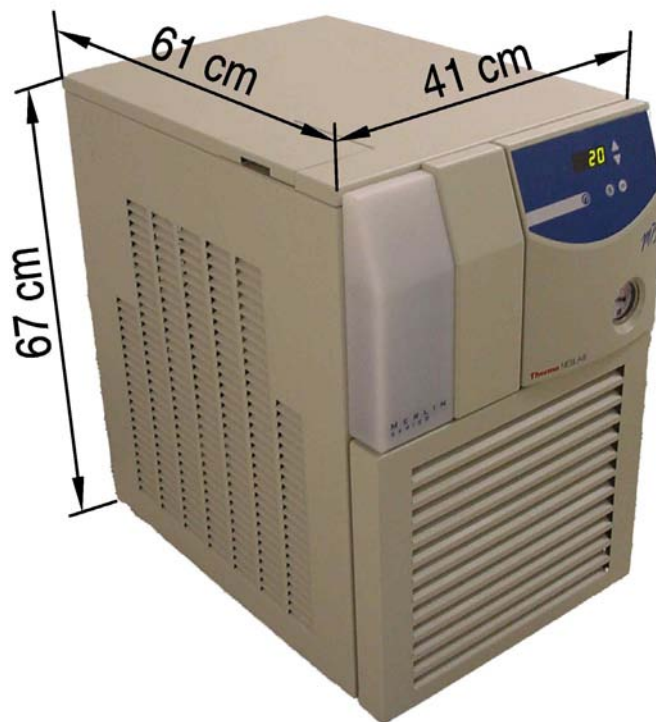


Figure 26: View of the Thermo NESLAB M75 chiller system (gradient coil cooler)

### 3.3.1.5. View and dimensions of the cryo-refrigerator for magnet cooling



Figure 27: View of the cryo-refrigerator for magnet cooling

### 3.3.1.6. View and dimensions of the water heat exchanger for the cryo-refrigerator

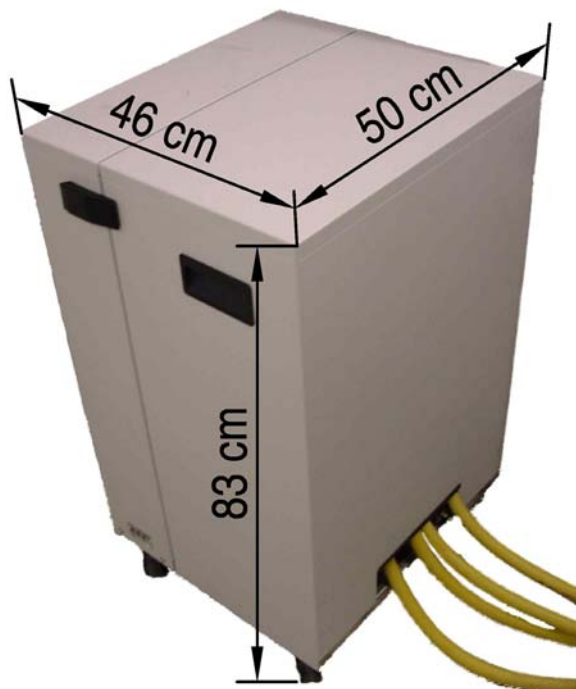


Figure 28: View of the B-ER090 heat exchanger (for refrigerator cooling)

### 3.3.1.7. View and dimensions of the water chiller for refrigerator cooling (optional component as a replacement for the heat exchanger)



Figure 29: View of the Thermo NESLAB CFT-300 water chiller system

### 3.3.2. Choosing an ideal site

A few considerations should be taken into account when selecting an ideal installation site for the hardware racks:

- distance to filter plate or magnet
- distance to operator console
- installation of cable trays
- availability of a main line connection and grounding points
- air conditioning/ventilation system

#### 3.3.2.1. Distance to operator console

The maximum distance between cabinets and operator console is given by the available cable length. When selecting the required cable length, the additional cable length from the installation of the cables in cable trays and cable traverses must be taken into account.

**Only 25m lengths are available as a standard cable length.**

Non-standard connection lengths are not part of standard deliveries/installations and therefore require BRUKER's prior approval.

#### 3.3.2.2. Distance between cabinets and filter plate (cable tray)

The maximum distance to this element is set by the cable length available. When selecting the required cable length, the additional cable length resulting from the installation of the cables in cable trays and cable traverses must be taken into account.

A series of connection wires must be placed between the filter plate and the electronic cabinets. We prefer a direct path in a cable channel that will be connected on the exit side of the filter plate to the rear of the cabinets. Since some of the cables are very rigid and can only be bent in large radii, the cables should be laid so they are placed next to one another. If the cable way runs horizontally and the cables are mounted vertically, one on top of the other, the cables must be anchored every 80 to 100cm. The same applies to a vertical cable way for tension relief.

Two lengths are available as standard connection cables:

**Short length = 10m/long length = 18m.**

Non-standard connection lengths are not part of standard deliveries/installations and therefore require BRUKER's prior approval.

### 3.3.2.3. Electrical wiring and main connection sockets

Three alternating current sockets of 10A each are needed to operate the *BioSpec*<sup>®</sup> System.

Two alternating current sockets (10A) will be required in the direct vicinity of the operating console to supply the computer components, while a third will be required in the vicinity of the magnet to supply the emergency quench device. If the first two sockets can be mounted at any height in the vicinity of the operating console, the third socket must be placed in the area of main access to the magnet at a height of approx. 140cm above the ground and marked or secured against accidental removal.

Alternating current socket-type: Schuko connector 230V/10A

### 3.3.2.4. Electrical supply lines for a *BioSpec*<sup>®</sup> system:

- Main power supply line: 5 x 16mm<sup>2</sup> for length < 200m.  
The voltage loss on the supply lines should be less than 3% ( $U_v < 3\%$ ).  
The fuse value required for connecting the supply line (e.g. building AC power distribution or transformer station) must be within a 50A range.
- Potential equalization line: 1 x 25mm<sup>2</sup> for length < 200m.  
To be connected to central building's ground bar.

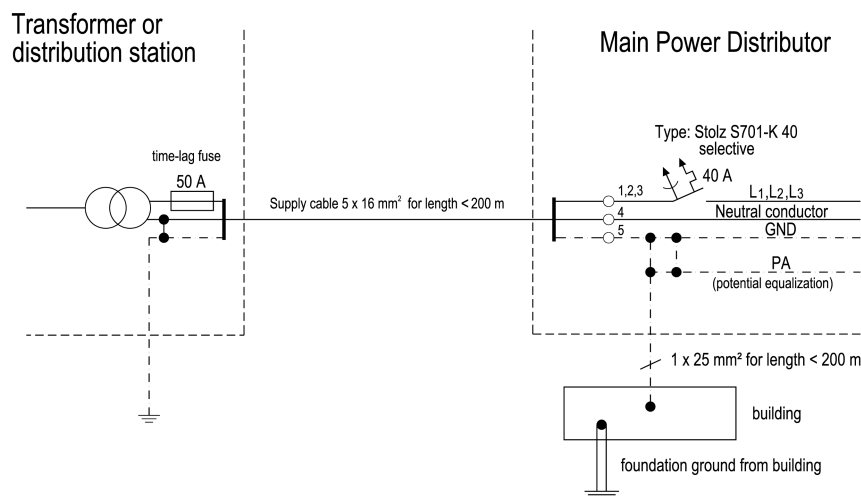


Figure 30: Electrical Supply to a *BioSpec*<sup>®</sup> System with a BRUKER USR Magnet

### 3.3.2.5. Grounding/equipotential bonding

Installation of the hardware cabinets and the magnet requires a central equipotential bonding point for *BioSpec*<sup>®</sup> Systems inside the electrical distribution box. The resistance of this grounding point with regard to a central grounding point outside the building must not be greater than 50Ω. We recommend installing a separate grounding wire from the building land to the grounding point at the system electrical distributor.

Example: Potential compensation wire 1 x 16mm<sup>2</sup> for lengths < 200m.

For central equipotential bonding, an equipotential bonding bar must be installed behind the Cabinets. This equipotential bonding bar has to include no less than 4 x 16mm<sup>2</sup> and 4 x 10mm<sup>2</sup> line connections.

### 3.3.2.6. Air conditioning /ventilation system

The air ventilation or air conditioning system must be capable of establishing constant working conditions within the following limits:

- Temperature: 22°C ± 2°C
- Relative humidity: 40 - 80% (no condensation)

The capacity of the air conditioning system is based on the heat dissipated from the system, the heat dissipated from the lights and the heat created by adjacent rooms or sun light.

### 3.3.2.7. Entrance doors, floor strength

The minimum measurements of the entrance doors to the system's technical room are 90 x 200cm. The floor strength must be checked, especially for the racks. Each rack stands on four disk feet, with a surface area of 28cm<sup>2</sup> each.

### 3.3.2.8. Interaction with surrounding departments

Whenever an examination sequence is performed on the MR system, acoustic noise is produced by the fans and the electrical motors inside the cabinets in the technical room. Only the chillers can produce a sound level of 69dB (A) each measured at a distance of 1m. The total acoustic noise level depends on the system configuration and the spectrometer electronics. Typical total acoustic values in the technical room are approx. 77dB (A).

During installation, site planning and site construction, it is important to consider the noise level anticipated in the vicinity of the operator's console and prevent system personnel from being exposed to values that exceed established thresholds.

### 3.3.2.9. Cold Water Supply for Cryo-Refrigerator

The cryo-refrigerator for cooling the magnet releases its waste heat to the existing cold water piping. For ecological reasons, we recommend the use of the existing cold water piping. To protect the cryo refrigerator we deliver a heat exchanger to decouple the cold water piping from the refrigerator.

A cold water net is not available for this, but decentralized cold water chillers can also be installed by the customer in this case. These chillers emit heat, which is dissipated in the air of the technical room. This chiller is not a standard component of the system delivery.

For ecological reasons, the installation of a stationary, decentralized cold water circuit is useful, e.g. closed cold water circuit as a split construction for external heat emission. A system such as this can be delivered, installed and serviced by a local supplier. BRUKER can deliver such a system upon request but is not responsible for installation and service.

### 3.3.2.10. Cooling Water Connections for the Heat Exchanger: B-ER 090

Piping to the connection points for water flowing in and out must be  $\frac{3}{4}$  inch in diameter and be made of either copper or PVC. The piping must be protected against condensation, at least within the technical room. This piping will be connected to the refrigerator; a high-pressure hose is included in the delivery of the BioSpec. To connect this to the  $\frac{3}{4}$  inch hose, the end of the piping should have an externally-threaded connector with an outer diameter of 1/1 inch. The end of the piping must be oriented so that the hose is connected from below. The connection should be at a height of 55cm above the floor. A ball valve must be installed before the end of the piping.

### 3.3.2.11. Cooling Water Requirements for the Heat Exchanger: B-ER 090

- Intake cooling water temperature: 8°C - 15°C
- Outlet water temperature of the cooling water: 23°C - 30°C
- Temperature stability of the cooling water: no special requirements
- Pressure stability of the cooling water: no special requirements
- Maximum pressure: 16 bar
- Minimum pressure: 2.5 bar
- Maximum pressure difference intake/outlet: 6.0 bar
- Minimum pressure difference intake/outlet: 1.0 bar
- Minimum cooling performance needed: 8.0kW
- Typical water flow: 18l/min
- Minimum water flow: 8l/min
- Typical temp. difference between Input/Output: 10°C
- PH value of the cooling water: 6 - 8
- Suspended matter after filtering: less than 10 micrometer (10 microns)
- Water hardness: 7 - 10°d (German scale)
- Water quality:

The compression units possess a countercurrent heat exchanger made from copper. To prevent excessive calcification in the heat exchanger, the degree of water hardness should be kept within the range of 1.25 to 1.8mmol/l.

|         |   |         |                                    |
|---------|---|---------|------------------------------------|
| 1 mol/l | = | 5.6°d,  | German scale for water hardness.   |
|         | = | 7.02°e, | English scale for water hardness.  |
|         | = | 10.0°f, | French scale for water hardness.   |
|         | = | 5.85°a, | American scale for water hardness. |

If water with markedly different properties is used, the deposit of chalk in the heat exchanger may impede the flow of water and heat removal. Therefore, under such circumstances, the heat exchanger should be decalcified at regular intervals.

### 3.3.2.12. View of small components in the technical room



Figure 31: Emergency Discharge (Magnet Run-down Unit for a Magnex AS Magnet)



### 3.3.3. Mandatory requirements

The customer must meet the requirements below for installing hardware in the technical room:

- 1) All line connections and additional main line safety devices
- 2) Grounding point
- 3) Selection of cable length
- 4) Cable trays
- 5) Air ventilation/conditioning system
- 6) Sufficient transportation openings

Detailed quantities with regard to these requirements are given in the tables below:

| Configuration for a <i>BioSpec</i> <sup>®</sup> with a <i>Magnex AS</i> magnet | Standard  | Options   |
|--|---|-----------|
| <b>Available Cable length</b>  |   |           |
| Magnet ↔ Filter plate  | 6m  | 9m        |
| Cabinet ↔ Filter plate or Filter box   | 10m   | 18m       |
| Cabinet ↔ Console  | 25m   | --        |
| Cabinet ↔ Chiller  | 5m  | --        |
| Cabinet ↔ power plugs (sockets)  | 4.5m  |           |
| <b>Cable tray dimensions</b>   |   |           |
| Width/Height   | 25cm/12cm                                       | --        |
| Minimum bending radius   | 10cm  | --        |
| Anchored distance  | 100cm   | --        |
| <b>Heat dissipation into air</b>   |   |           |
| Cabinets & chiller (standard, 231P)  | < 6.5kW   | --        |
| Gradient cabinet (optional cabinet)  |   | 0.8kW     |
| <b>Dimensions (l/w/hr)</b>   |   |           |
| RF/Data cabinet  | 99cm/64cm/142cm                                 | --        |
| Amplifier cabinet (standard, 231P)   | 99cm/64cm/142cm                                 | --        |
| Gradient cabinet (optional cabinet)  | 99cm/64cm/142cm                                 | --        |
| Chiller for gradient coil cooling  | 61cm/41cm/67cm                                  | --        |
| Electrical distributor   | 31cm/80cm/100cm                                 |           |
| Emergency discharge (Quench Unit)  | 22cm/45cm/13cm                                  |           |
| <b>Weights:</b>  |   |           |
| RF/Data cabinet  | approx 350kg                                    | --        |
| Amplifier cabinet (standard, 231P)   | approx 380kg                                    | --        |
| Gradient cabinet (option, 265P)  | 340kg   | --        |
| Chiller for gradient coil cooling  | 91kg  | --        |
| Electrical distributor   | 45kg  |           |
| Emergency discharge (Quench Unit)  | 5kg   |           |
| <b>Line connections</b>  |   |           |
| Electrical supply line   |   |           |
| Gradient coil chiller, AC socket:  | CEE form 230V - 16A                             | 208V/60Hz |
| Emergency discharge, AC socket   | Schuko connector 230V10A                        | --        |
| Magnet supervis. monitor, AC socket  | Schuko connector 230V10A                        | --        |
| Mains socket (AC) for service  | Schuko connector 230V10A                        | --        |
| Central equipotential bonding bar  | 4 x 16mm <sup>2</sup> and 4 x 10mm <sup>2</sup> | --        |

Table 10: Hardware installation data for a System configuration with a *Magnex AS* magnet.

| Configuration for a <i>BioSpec</i> <sup>®</sup> with a Bruker USR magnet                                       | Standard  | Options    |
|--|---|------------|
| <b>Available Cable length</b>  |   |            |
| Cabinet ↔ Filter plate or Filter box   | 10m   | 18m        |
| Cabinet ↔ Console  | 25m   | --         |
| Cabinet ↔ Chiller  | 5m  | --         |
| Cabinet ↔ power plugs (sockets)  | 4.5m  | --         |
| <b>Available pressure tube length</b><br>(stainless steel flexible tube as Helium high and low pressure hoses) | 6m  |            |
| Cryo refrigerator ↔ Filter plate/box   | 30cm  | 12m        |
| Minimum bending radius   | 100cm   |            |
| Anchored distance  |   |            |
| <b>Cable tray dimensions</b>   |   |            |
| Width/Height   | 35cm/12cm                                       | --         |
| Minimum bending radius   | 15cm  | --         |
| Anchored distance maximum  | 100cm   | --         |
| <b>Heat dissipation into air</b>   |   |            |
| Cabinets, chiller and cryo-refrigerator  | < 7.5kW   | --         |
| Gradient cabinet (optional cabinet)  | --  | 0.8kW      |
| Water chiller system (option only)   |   | 12.5kW     |
| <b>Heat dissipation into water</b>   |   |            |
| Heat exchanger for cryo-refrigerator   | < 9.5kW   | --         |
| <b>Dimensions (l/w/h)</b>  |   |            |
| RF/Data cabinet  | 99cm/64cm/142cm                                 | --         |
| Amplifier cabinet (standard, 231P)   | 99cm/64cm/142cm                                 | --         |
| Gradient cabinet (optional cabinet)  | 99cm/64cm/142cm                                 | --         |
| Chiller for gradient coil cooling  | 61cm/41cm/67cm                                  | --         |
| Cryo-refrigerator for magnet   | 59cm/53cm/66cm                                  | --         |
| Heat exchanger for cryo-refrigerator   | 46cm/50cm/83cm                                  | --         |
| Bruker magnet monitoring unit  | 34cm/45cm/19cm                                  | --         |
| Electrical distributor   | 31cm/80cm/100cm                                 | --         |
| Water chiller system (option only)   | 71cm/65cm/110cm                                 | --         |
| <b>Weights :</b>   |   |            |
| RF/Data cabinet  | approx 350kg                                    | --         |
| Amplifier cabinet (standard, 231P)   | approx 380kg                                    | --         |
| Gradient cabinet (optional cabinet)  | 340kg   | --         |
| Chiller for gradient coil cooling  | 91kg  | --         |
| Cryo-refrigerator for magnet   | 119kg   | --         |
| Heat exchanger for cryo-refrigerator   | 54kg  |            |
| Bruker magnet monitoring unit  | 10kg  |            |
| Electrical distributor   | 45kg  |            |
| Water chiller system (option only)   | 5kg   |            |
| <b>Line connections</b>  |   |            |
| Electrical supply Line   |   |            |
| Cryo-refrigerator, AC socket:  | CEE Form 400/230V - 16A                         | 208V/60Hz  |
| Heat exchanger, AC socket:   | Schuko connector 230V 10A                       |            |
| Gradient coil chiller, AC socket:  | CEE Form 230V - 16A                             | 208V/60Hz  |
| Workstation, AC socket   | Schuko connector 230V 10A                       | 110 V/60Hz |
| Magnet supervis. monitor, AC socket  | Schuko connector 230V 10A                       | 110 V/60Hz |
| Central equipotential bonding bar  | 4 x 16mm <sup>2</sup> and 4 x 10mm <sup>2</sup> | --         |

Table 11: Hardware installation data for a System configuration with a Bruker USR magnet.

### 3.4. Installation of operating console

---



Figure 32: View of the operating console for the *BioSpec*<sup>®</sup> system

#### 3.4.1. Lighting and window surfaces

Regulations on working at visual display units must be complied with (DIN 66234, Part 7).

This means:

operating console and lighting devices must be installed at the same time. Any glare or direct beam of light on monitor surfaces must be avoided. Window surfaces in the vicinity should be darkened in order to eliminate glare. This requirement is essentially fulfilled if the light level does not exceed the lighting power stipulated (300 Lux maximum). Neighboring or background areas (walls or ceiling) should be darkly painted with no reflecting surface.

#### 3.4.2. Air ventilation technique

As the heat emitted by devices in the operating room is very low, installation of a ventilation system is not vital. Room temperatures up to 35°C are not dangerous for operating devices.

### 3.4.3. Cable terrace for system wiring

A series of connection wires must be placed between the electronic cabinets and the operating console. We prefer a direct path in a cable channel that will be connected to the rear of the console as a socket channel or as an inspection stage (platform).

**The standard length of this connection cable is 25m.**

Connection cable lengths can be modified for specific situations.

**These specific situations, however, do not form part of standard deliveries/installations and therefore require BRUKER's prior approval.**

### 3.4.4. Telephone /Internet/Intranet

A telephone connection near the operating console is required for service purposes. If access to external networks is permitted, this makes direct data interchange and technical support by BRUKER possible in the event of service being required.

### 3.4.5. Mandatory requirements

The customer must meet the following requirements for installing hardware:

- 1) space available for operation
- 2) workstation line connections
- 3) telephone access
- 4) local regulations for computer work stations

|                          | Standard                    | Options   |
|--------------------------|-----------------------------|-----------|
| <b>Dimensions</b>        |                             |           |
| Width                    | 117cm                       | --        |
| Length                   | 120cm                       | --        |
| Height                   | 145cm                       | --        |
| Weight                   | 140kg                       | --        |
| <b>Line connection</b>   |                             |           |
| AC workstation socket    | Schuko connector 230V – 10A | 110V/60Hz |
| <b>Power Consumption</b> |                             |           |
| Operating console        | 0.4kW                       | --        |
| Various small units      | 0.1kW                       | --        |
| <b>Heat dissipation</b>  |                             |           |
| Operating console        | 0.4kW                       | --        |
| Various small units      | 0.1kW                       | --        |

Table 12: Operating console dimensions

## 4. *Transportation of the magnet*

---

### 4.1. **General handling and lifting procedures**

---

The BRUKER USR magnets are designed to be strong enough to be shipped without disassembly and in cold conditions; the strength is therefore optimized so that it does not affect cryogenic performance. However, care must be exercised when handling the magnet since abnormal forces due to faulty or careless handling practices may damage the system.

Only trained staff may lift and move the magnet containing cryogenic gases (liquids) and under no circumstances may the system be dropped or slid along the floor because these actions damage the magnet system.

The magnet must be moved in an upright position by using appropriate transportation methods (e.g. air pads). When moving the magnet, it should not be tilted by more than 3 degrees.

With any type of movement, the resulting acceleration forces must be lower than 2.0g. When movement occurs in the vertical direction alone, forces up to 3.0g can be tolerated. However, in such cases no acceleration forces whatsoever may be experienced simultaneously in another direction (acceleration forces ( $g = 9,81 \frac{m}{s^2}$ )).

### 4.2. **Moving**

---

The system should preferably be moved on air pads or, if unavailable, skates may be used. If skates are used, the surface must be planned so that plates have to be laid out on the floor before the magnet is moved. The system must be supported on the pads or skates directly under the feet of the cryostat. This must be carried out by experienced staff.

The system must not be allowed to fall off the pad or skate, but must be gently lowered on to the floor.

Support structures and ascents (inclines) must not be bent by more than 2mm.

### 4.3. **Lifting**

---

It is recommended that the magnet is lifted during transportation by the packing crate, using either a crane or a fork-lift truck.

It must be lifted, lowered and traversed at low speed. Care must be taken not to grab it when lifting or drop it when lowering. The system must not touch other objects when traversing.

**Important:**

**The transport lugs should not experience any lateral forces at any time!**

### 4.4. Crane operation

---

The crane must lift, lower and traverse the magnet slowly. Care must be taken not to grab it when lifting or drop it when lowering. The system must not touch other objects when traversing.

Any crane and equipment used to move the magnet must have a safe working load equal to, or greater than, 15 000kg minimum.

### 4.5. Fork lift operation

---

**Lifting, lowering and transportation by fork lift are not permitted!**

### 4.6. Access for system integration

---

To place the magnet in the magnet area, the transport route must be big enough, adhere to the load-bearing capacity and be free of surface irregularities. The magnet will be transported on air pads or skates. The surface of the transport route must be even and should be at the same level as the floor of the magnet area. There must be no surface irregularities, even within the range of a few millimeters. If no simple transportation route can be found, an opening either in the wall or the foot of the building or in the ceiling might be necessary. An example is a B-C 70/30USR magnet:

The transport route of the magnet to the site should be 185cm x 256cm (w x h) min. and even, with no irregularities. Typical narrow places such as wall openings should not be less than 165cm x 251cm (w x h).

Specific information about different magnet types can be found on tables 7, 8 and 9 in this manual.

## 5. *Transportation of cabinets*

---

### 5.1. **General handling and lifting procedures**

---

The cabinets should only be moved by trained staff. Cabinets should be moved with caution; shocks and tilts must be avoided under all circumstances. The hardware cabinets provide transport rollers which should be used whenever possible. The cabinets provide four lifting hooks on top of the cabinet for lifting or transportation by crane. All four hooks must always be used simultaneously and loaded with equal weights. Each lifting rope must be suitable for carrying the load. Do not use a subset of hooks to lift the cabinets.



#### **WARNING**

- To lift by crane, the cabinets must be lifted using the four hooks simultaneously.
- 
- 



Figure 33: View of the system cabinets





## 6. Appendix

### 6.1. Information about the required stray field and drawings

#### 6.1.1. Bruker magnet: B-C 47/40USR

##### 6.1.1.1. Stray field plots

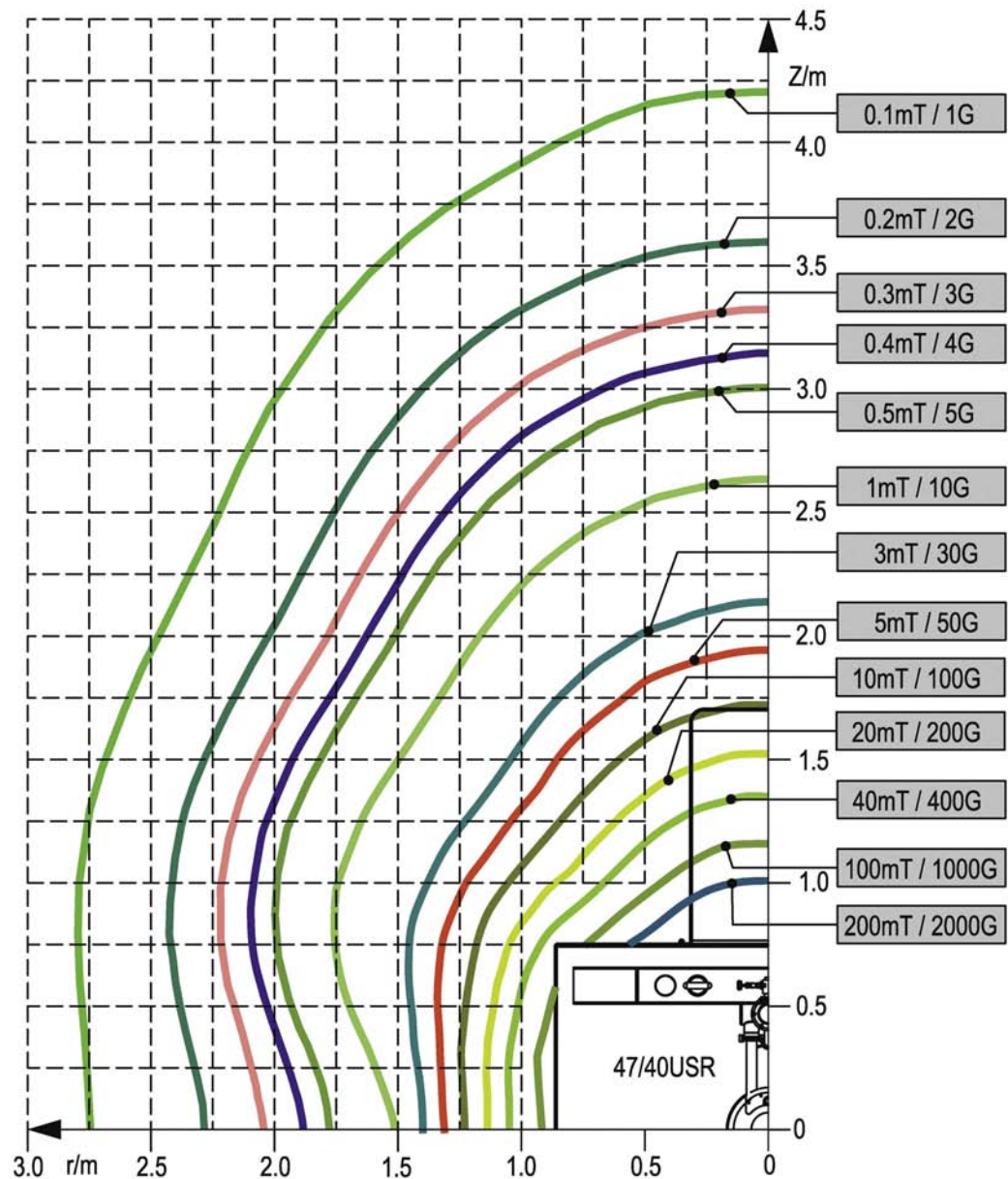


Figure 34: Stray field B-C 47/40USR

## 6.1.1.2. Vertical view and dimensions

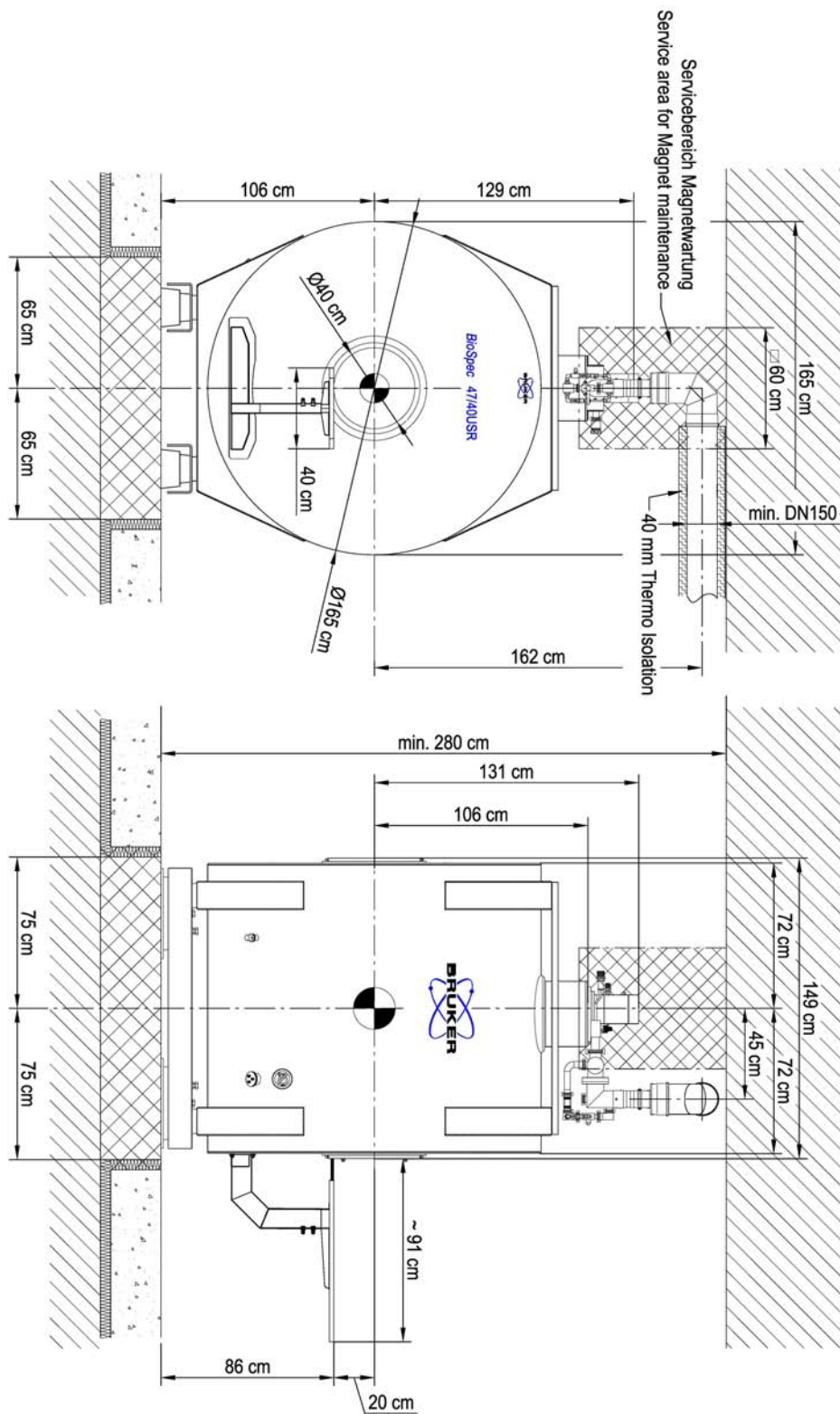


Figure 35: *BioSpec*<sup>®</sup> Magnet B-C 47/40USR vertical view

## 6.1.1.3. Quench pipe connection

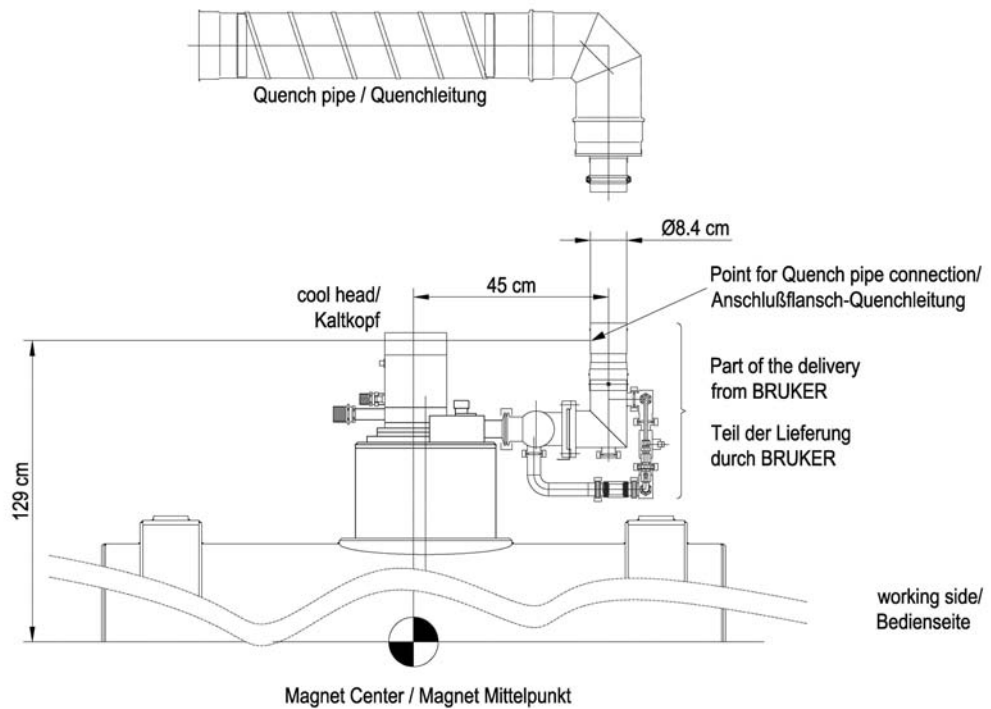


Figure 36: B-C 47/40USR Quench line connection detail at the Magnet

## 6.1.1.4. Footprint and foundation area

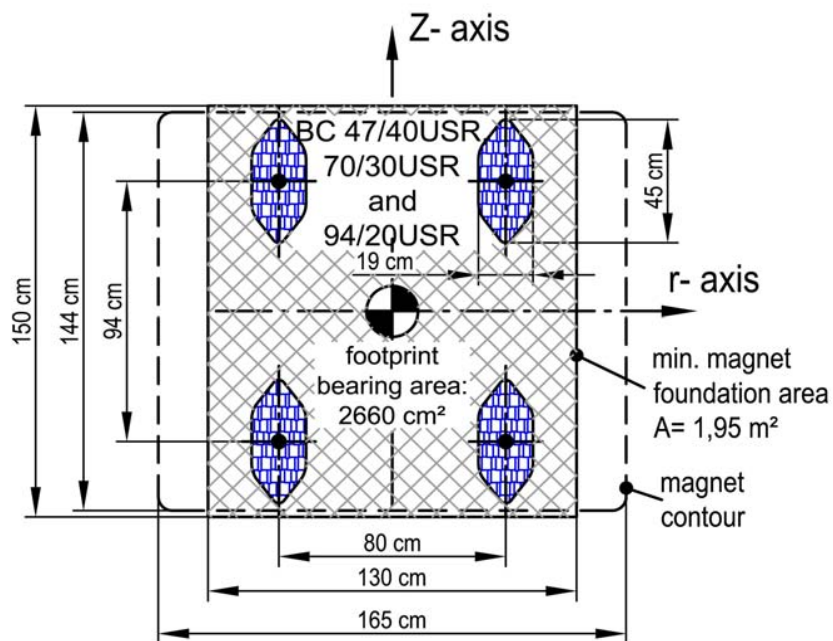


Figure 37: B-C 47/40USR footprint and foundation area

## 6.1.2. Bruker magnet: B-C 70/30USR

### 6.1.2.1. Stray field plots

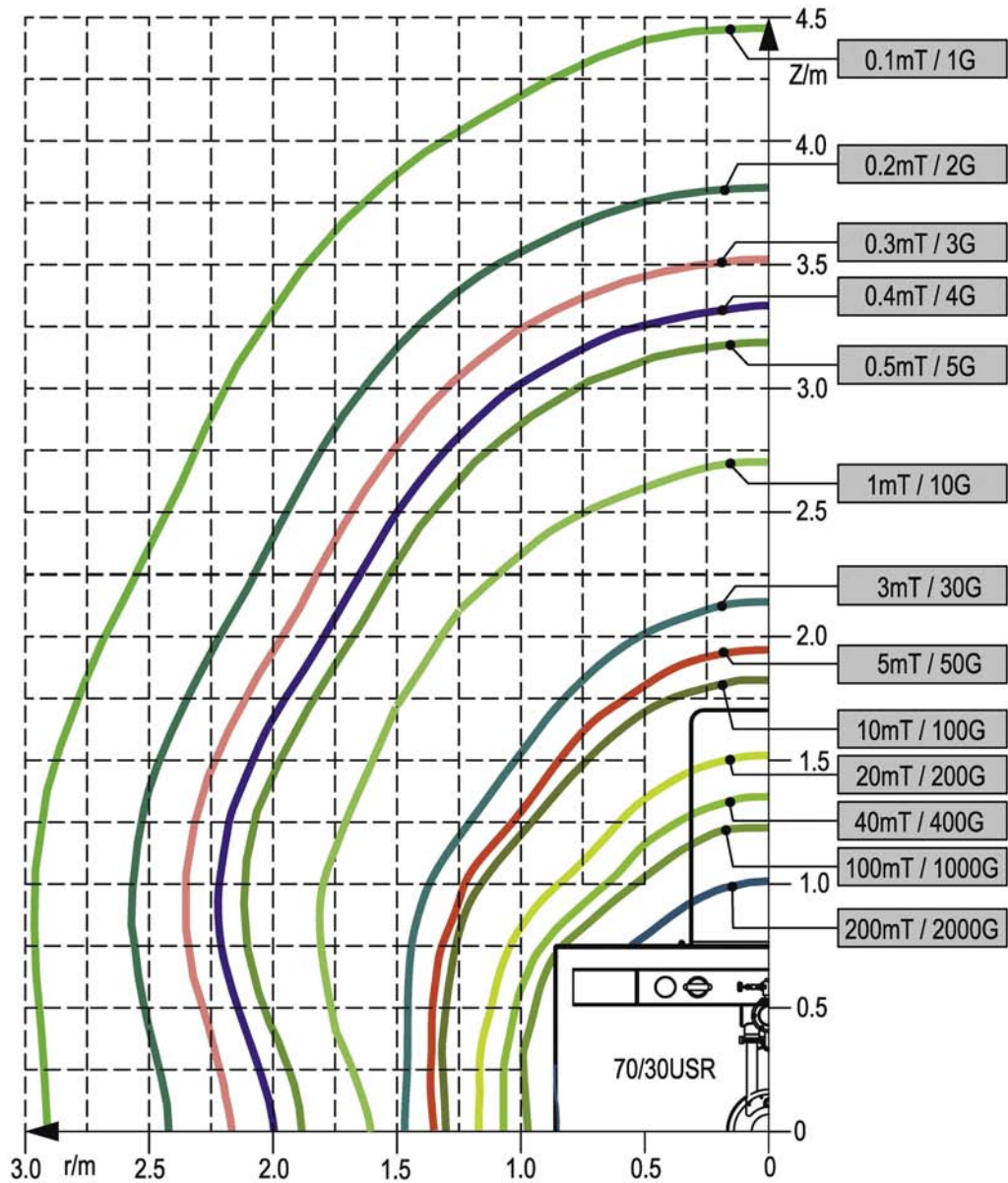


Figure 38: Stray field B-C 70/30USR

## 6.1.2.2. Vertical view and dimensions

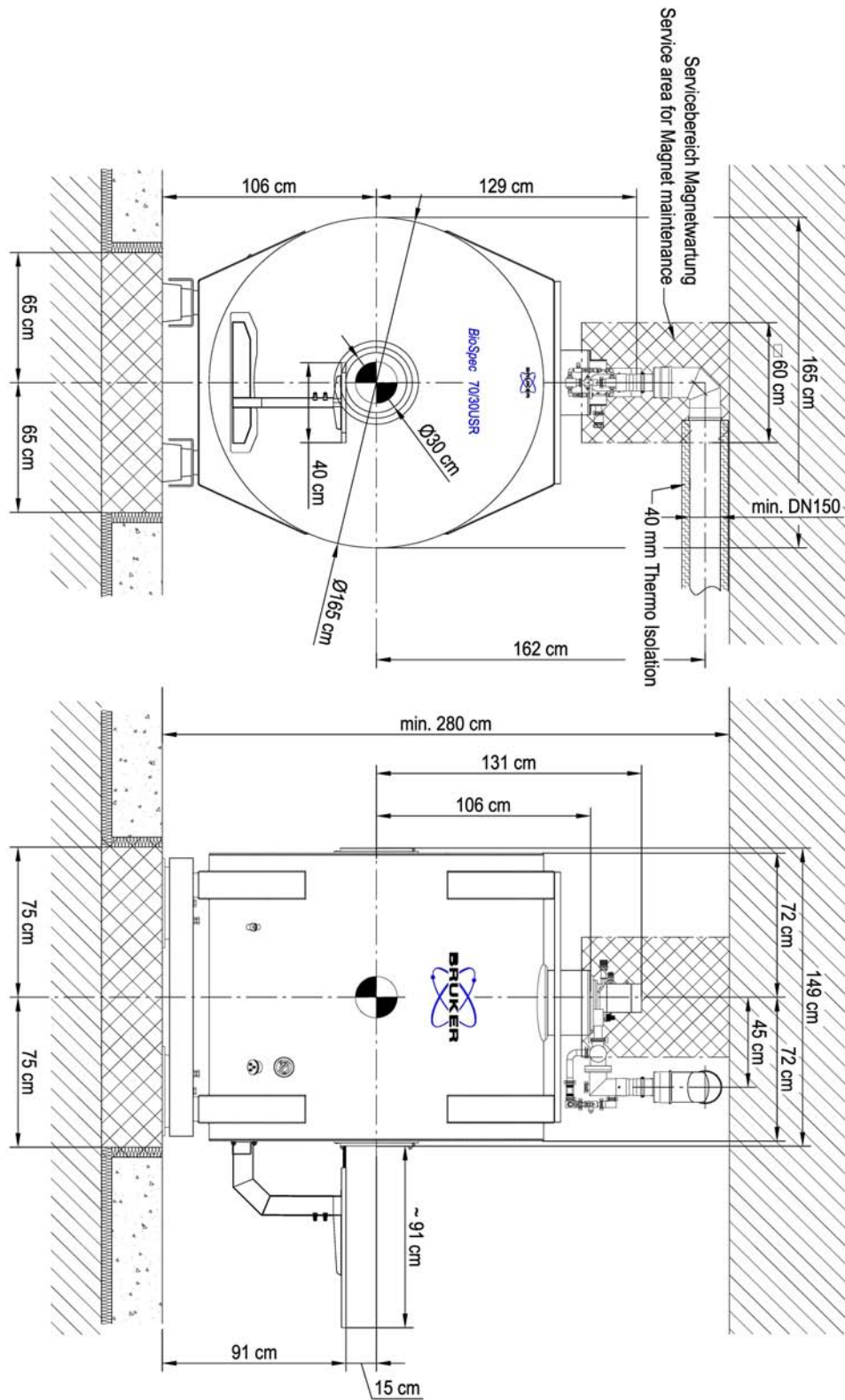


Figure 39: BioSpec® Magnet B-C 70/30USR vertical view

## 6.1.2.3. Quench pipe connection

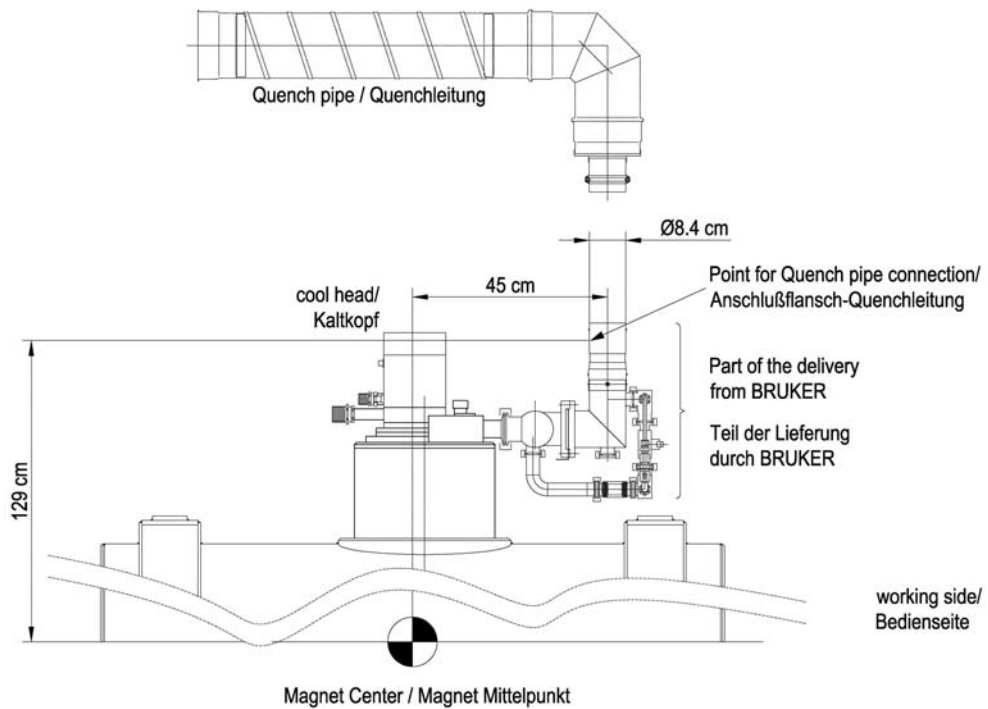


Figure 40: B-C 70/30USR Quench line connection detail at the Magnet

## 6.1.2.4. Footprint and foundation area

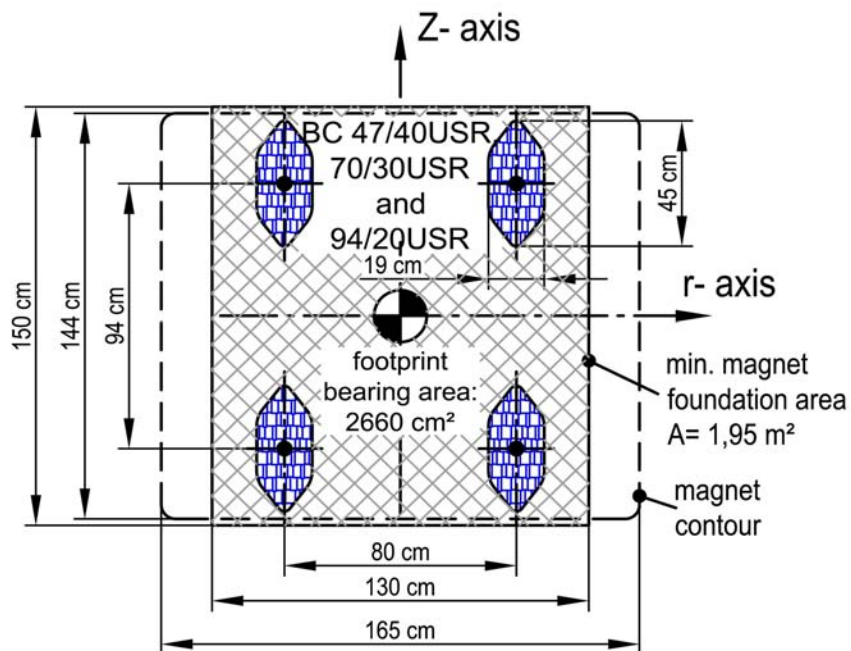


Figure 41: B-C 70/30USR footprint and foundation area

## 6.1.3. Bruker magnet: B-C 94/20USR

### 6.1.3.1. Stray field plots

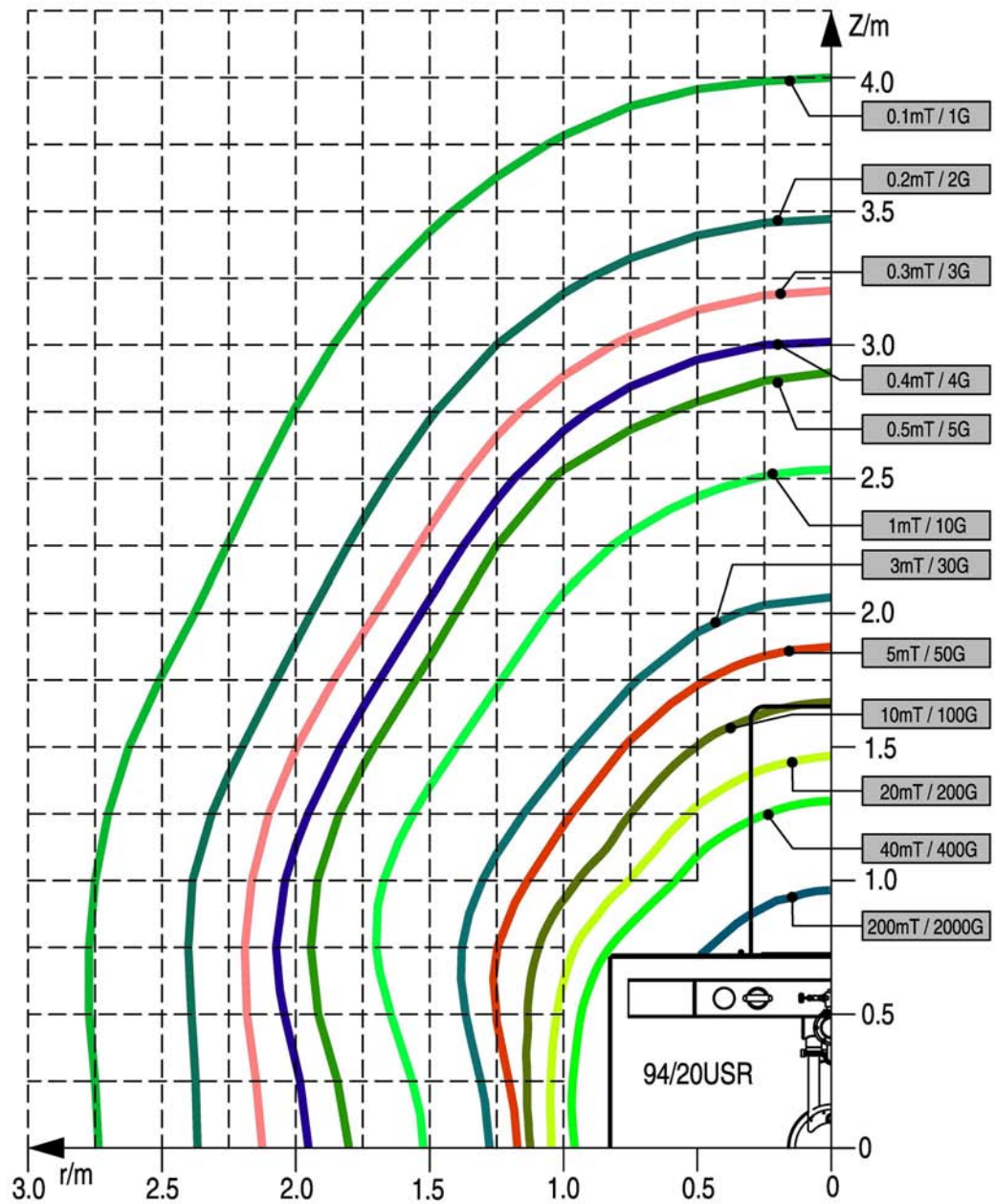


Figure 42: Stray field B-C 94/20USR

## 6.1.3.2. Vertical view and dimensions

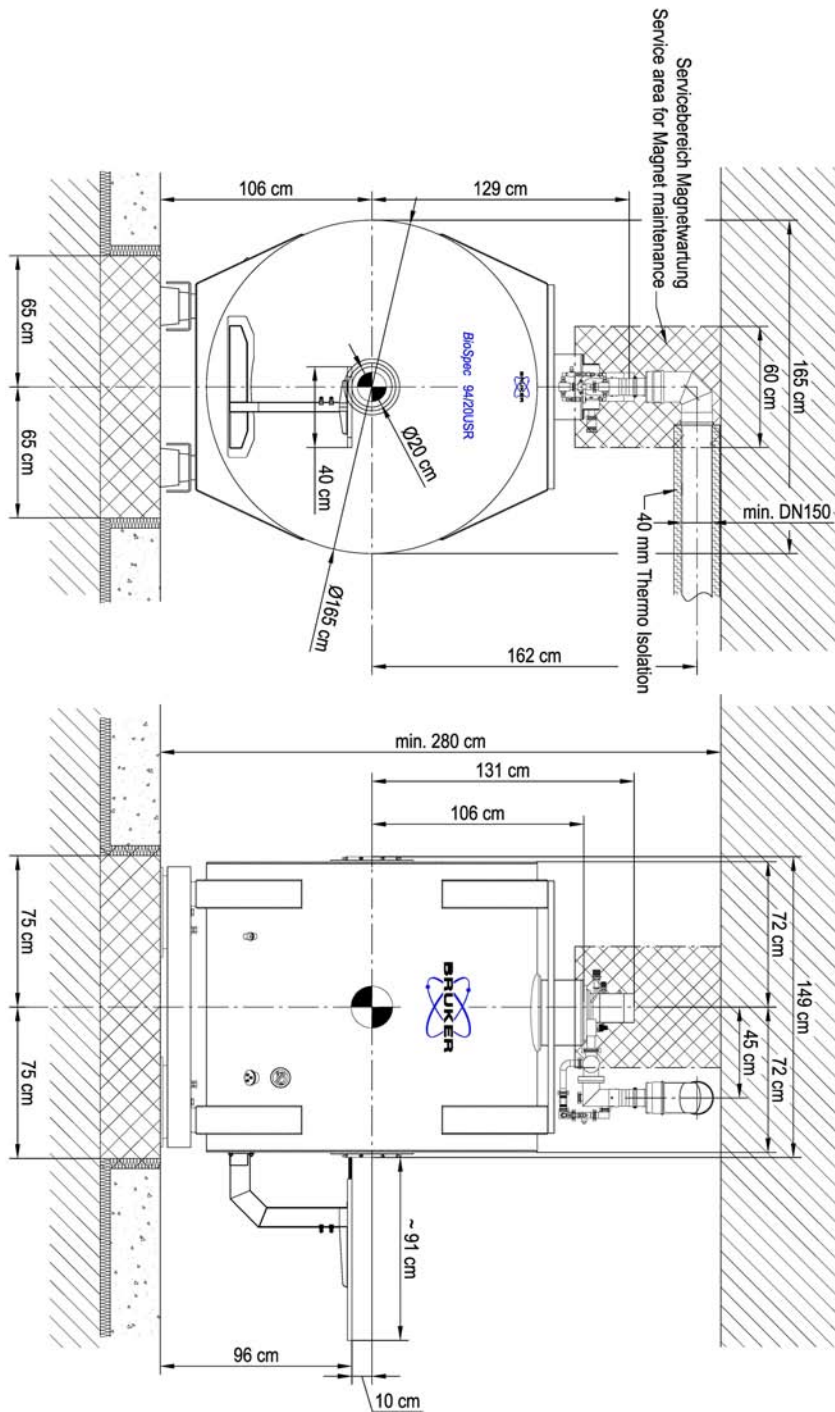


Figure 43: *BioSpec*<sup>®</sup> Magnet B-C 94/20USR vertical view



## 6.1.3.3. Quench pipe connection

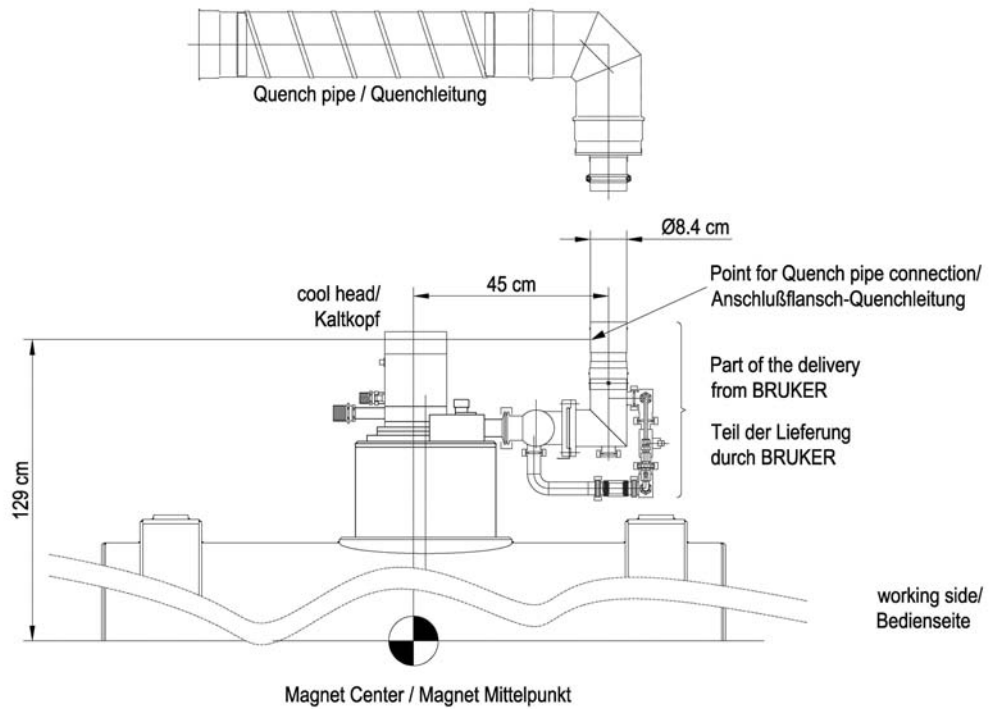


Figure 44: B-C 94/20USR Quench line connection detail at the Magnet

## 6.1.3.4. Footprint and foundation area

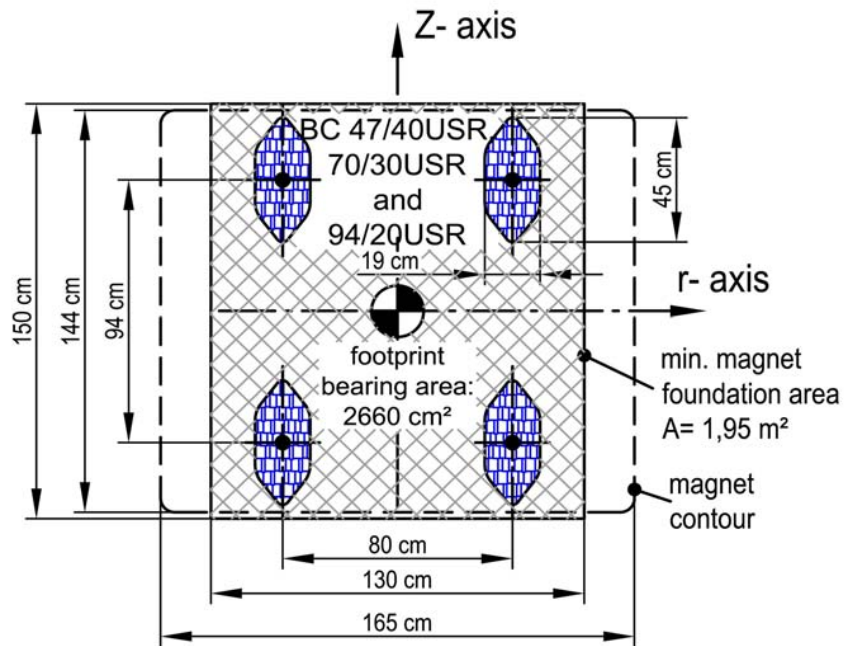


Figure 45: B-C 94/20USR footprint and foundation area

## 6.1.4. Bruker magnet: B-C 94/30USR

### 6.1.4.1. Stray field plots

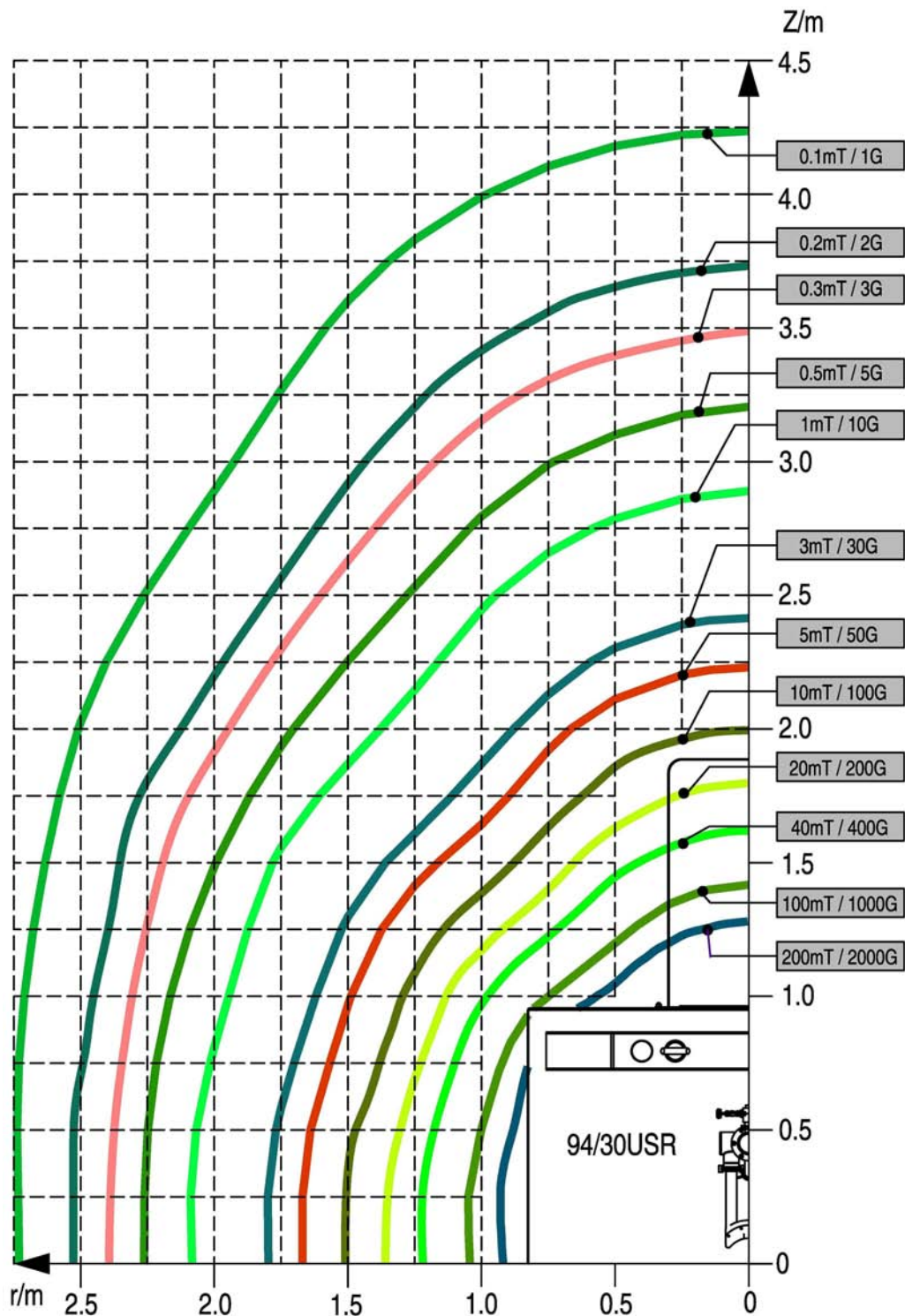


Figure 46: Stray field B-C 94/30USR

## 6.1.4.2. Vertical view and dimensions

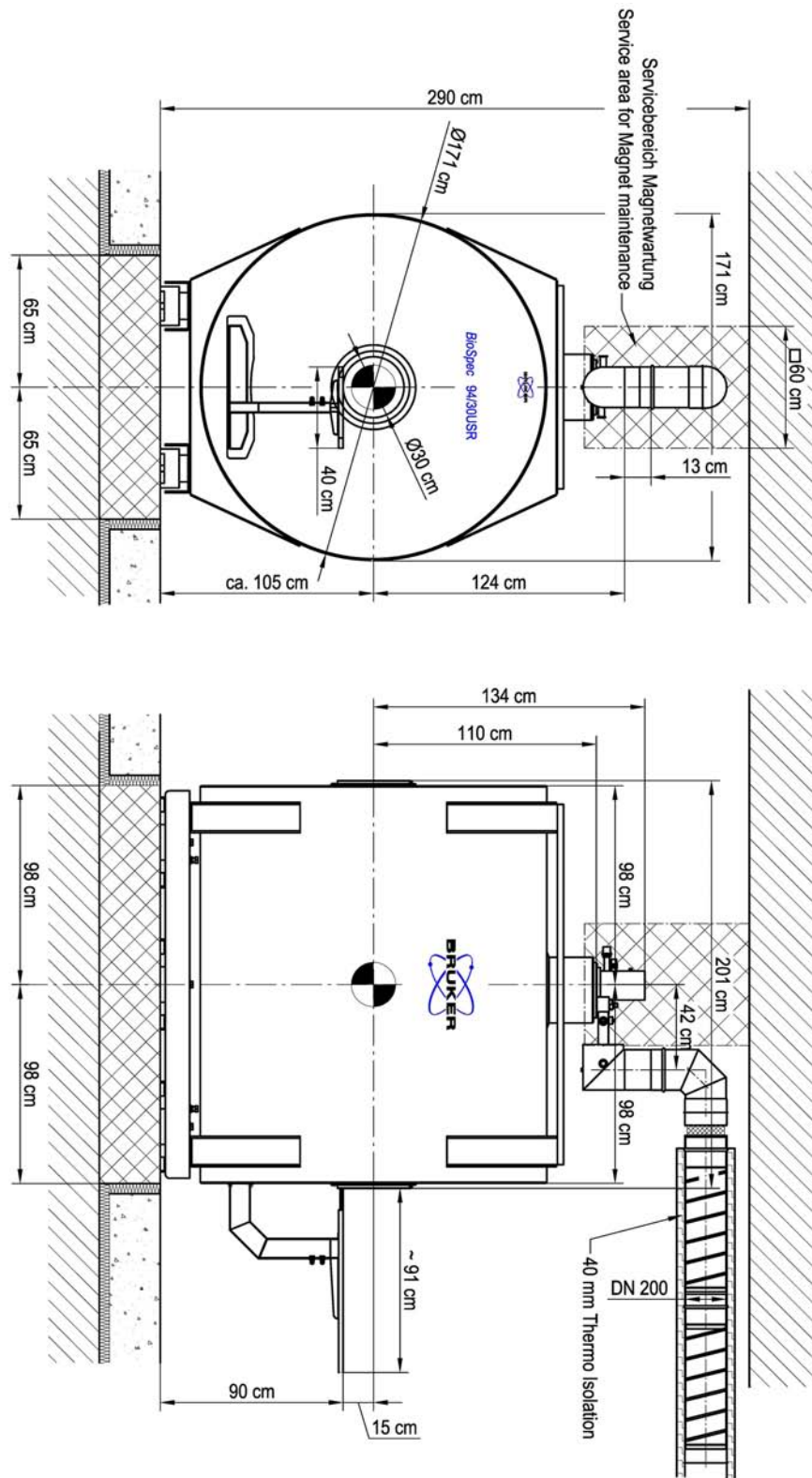


Figure 47: BioSpec® Magnet B-C 94/30USR vertical view

## 6.1.4.3. Quench pipe connection

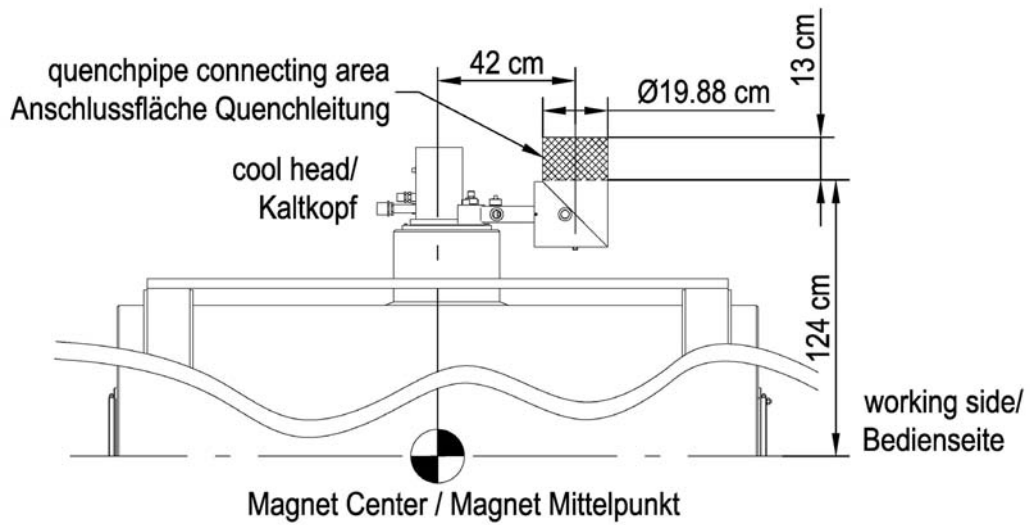


Figure 48: B-C 94/30USR Quench line connection detail at the Magnet

## 6.1.4.4. Footprint and foundation area

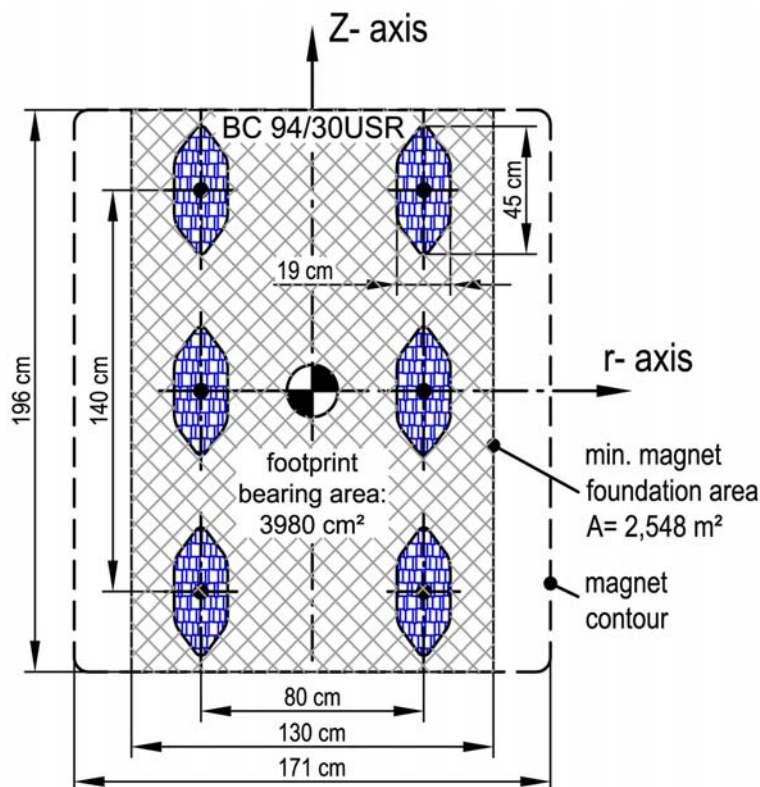


Figure 49: B-C 94/30USR footprint and foundation area

## 6.1.5. Magnex magnet: M-C 70/20AS

### 6.1.5.1. Stray field plots

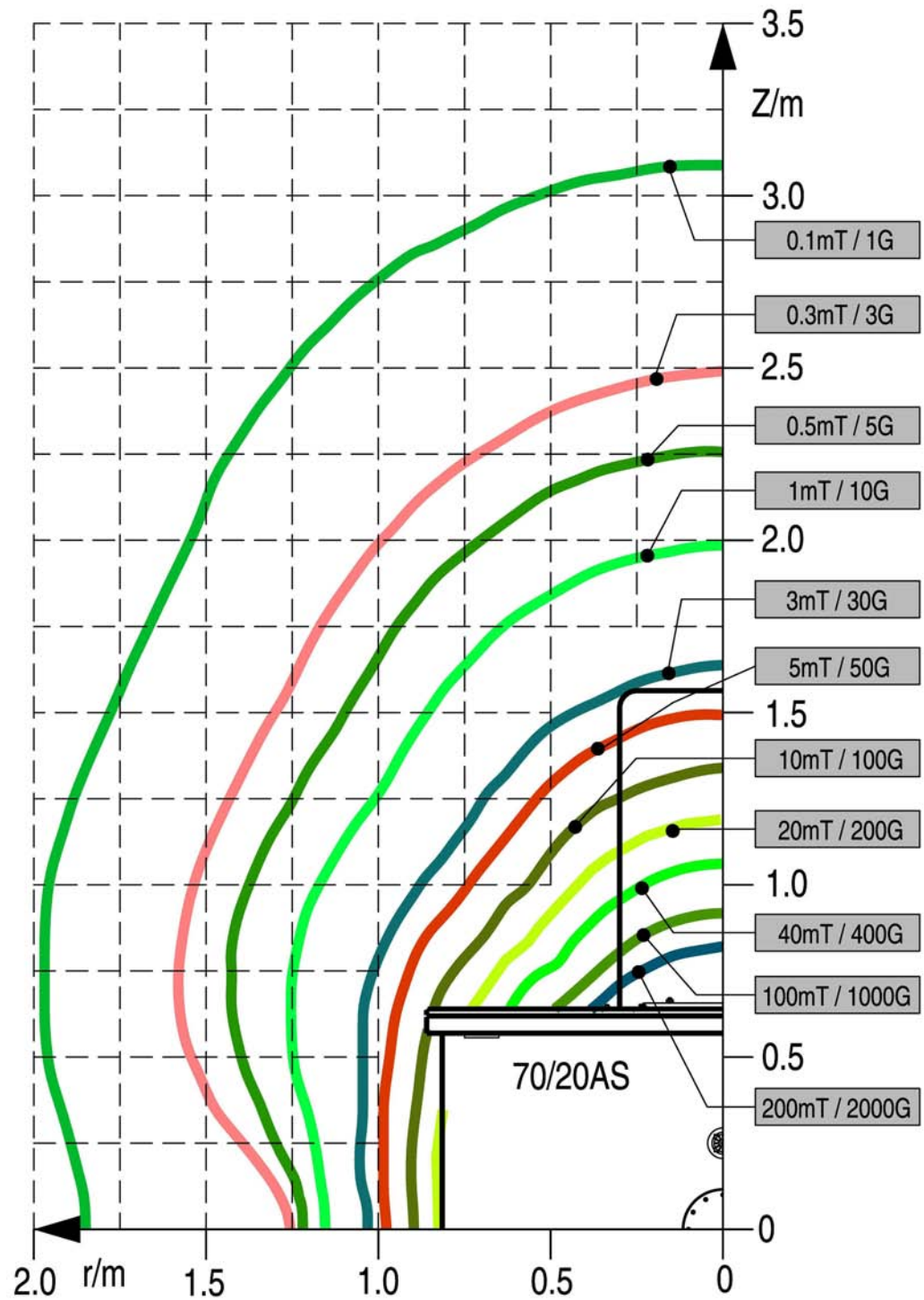


Figure 50: Stray field M-C 70/20AS

## 6.1.5.2. Vertical view and dimensions

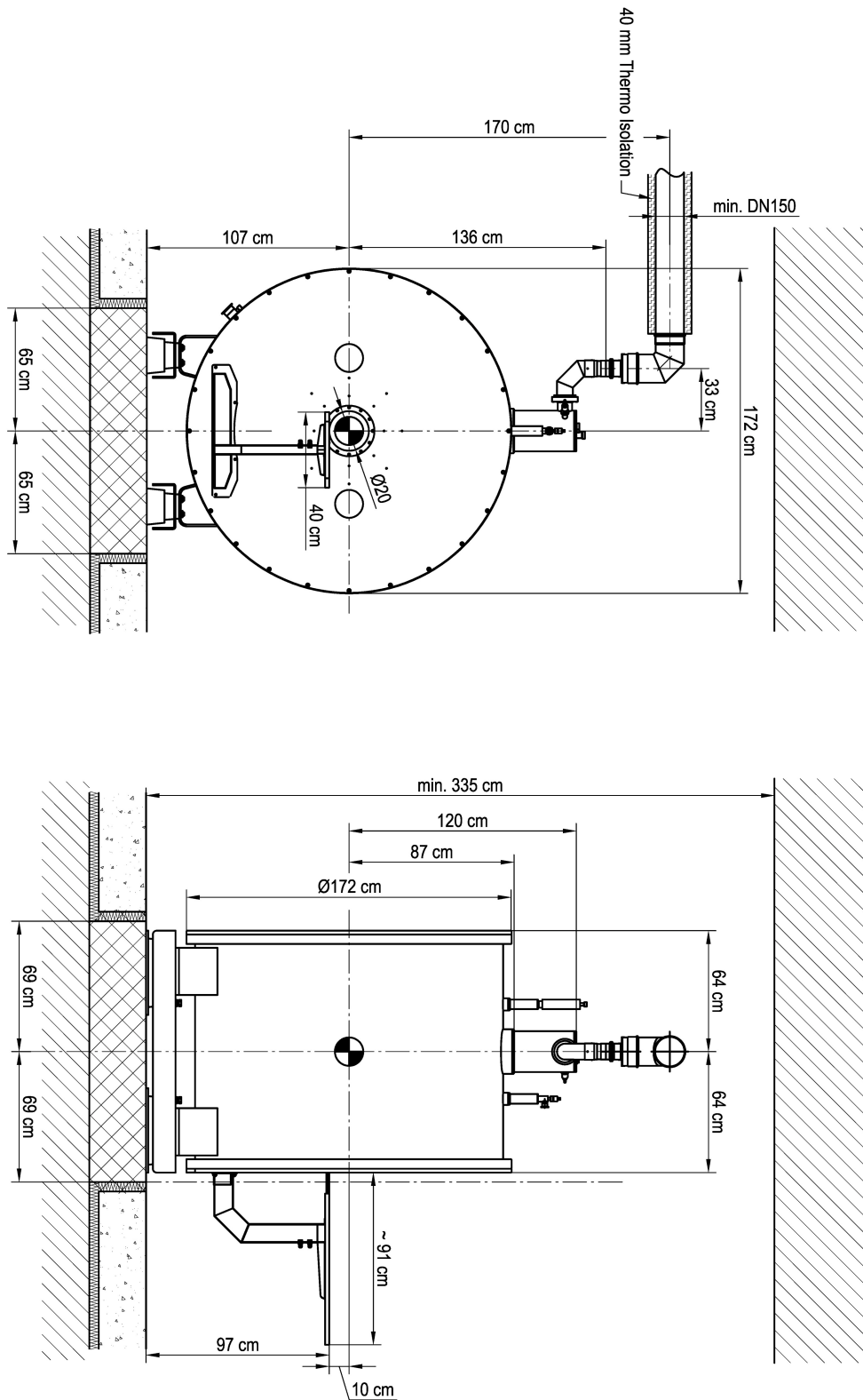


Figure 51: *BioSpec*<sup>®</sup> Magnet M-C 70/20AS vertical view

## 6.1.5.3. Quench pipe connection

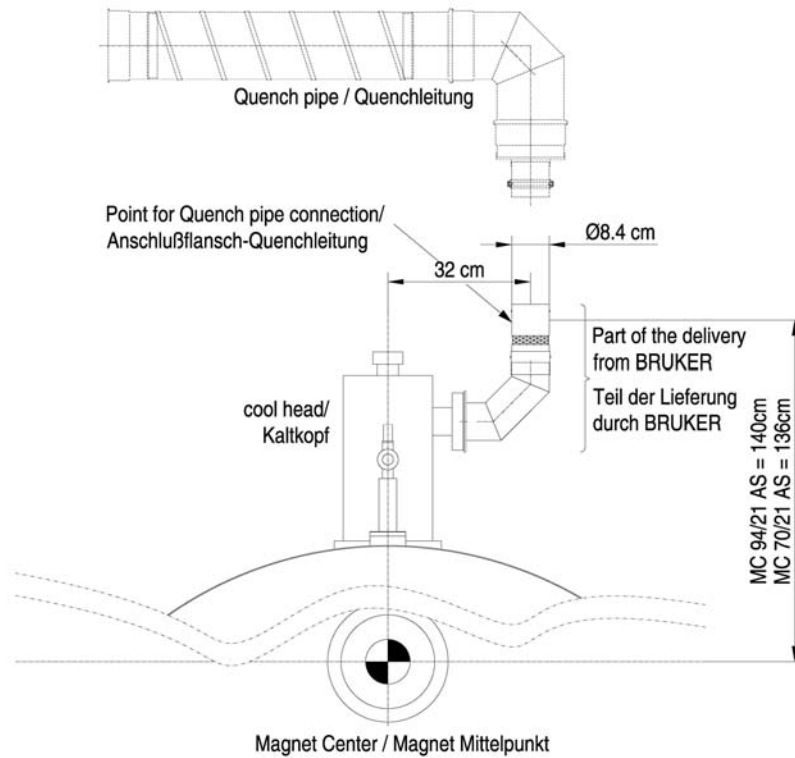


Figure 52: M-C 70/20AS Quench line connection detail at the Magnet

## 6.1.5.4. Footprint and foundation area

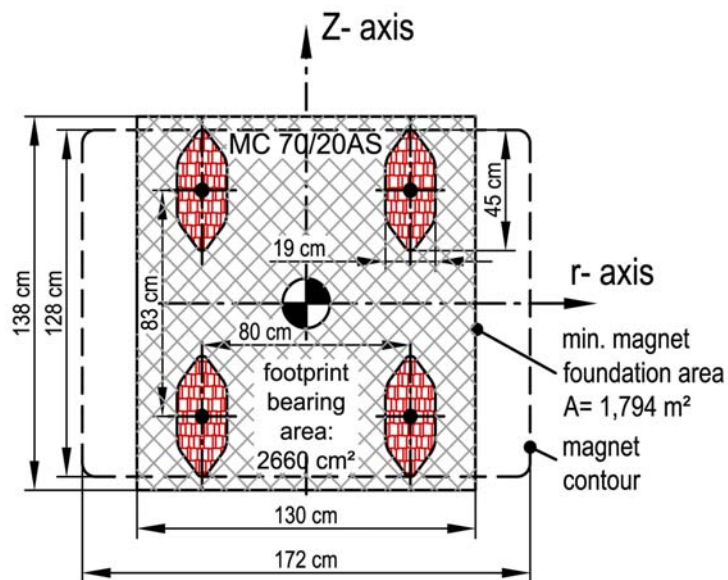


Figure 53: M-C 70/20AS footprint and foundation area

## 6.1.6. Magnex magnet: M-C 94/20AS

### 6.1.6.1. Stray field plots

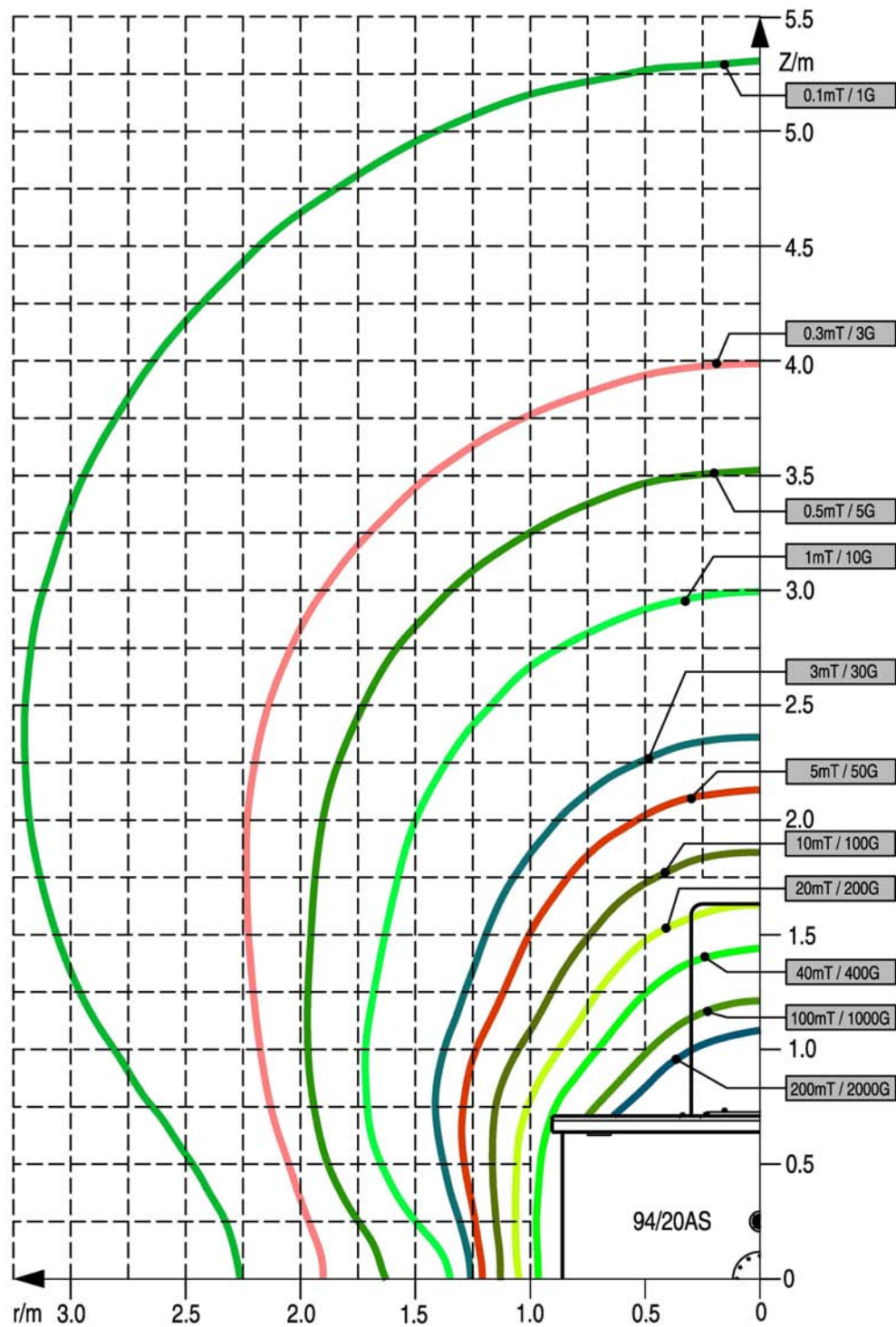


Figure 54: Stray field M-C 94/20AS





## 6.1.6.3. Quench pipe connection

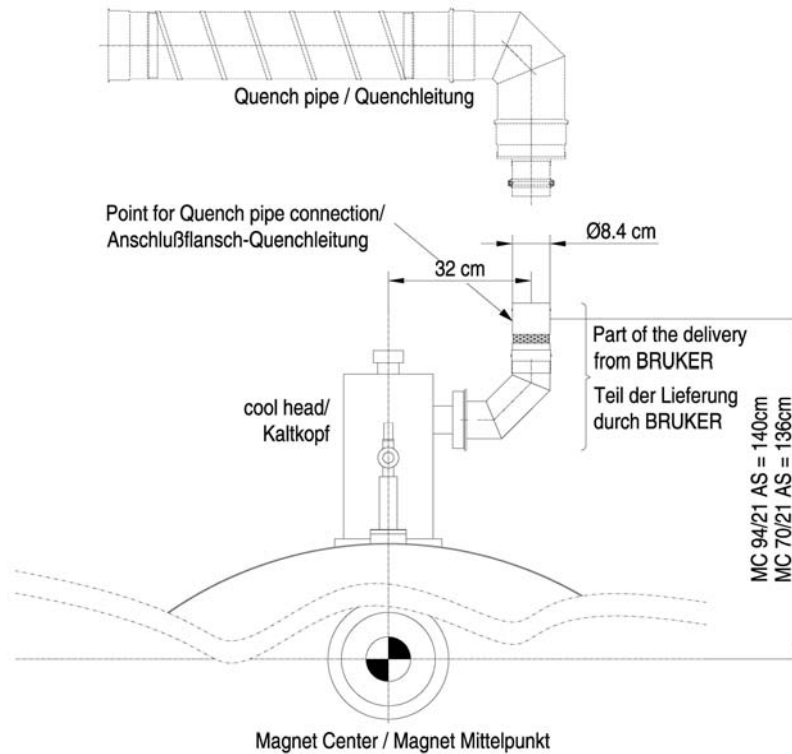


Figure 56: M-C 94/20AS Quench line connection detail at the Magnet

## 6.1.6.4. Footprint and foundation area

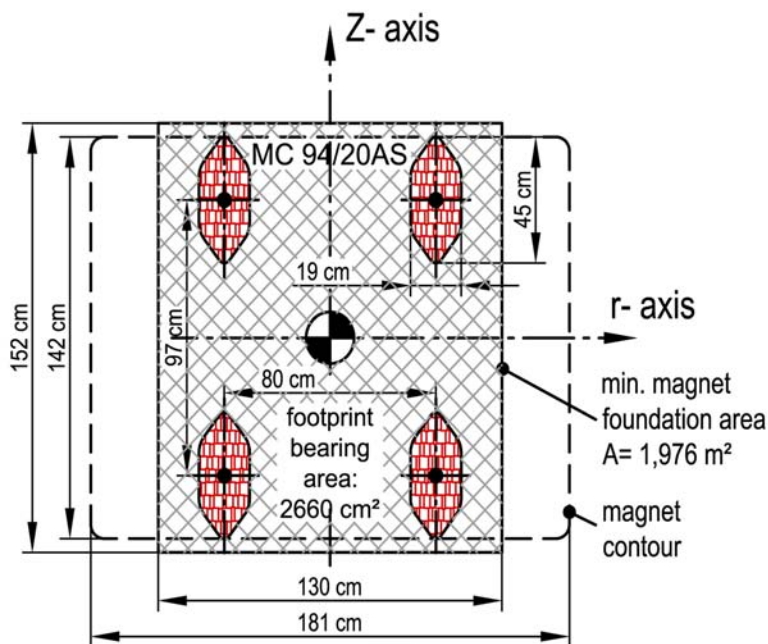


Figure 57: M-C 94/20AS footprint and foundation area

## 6.1.7. Magnex magnet: M-C 94/30AS

### 6.1.7.1. Stray field plots

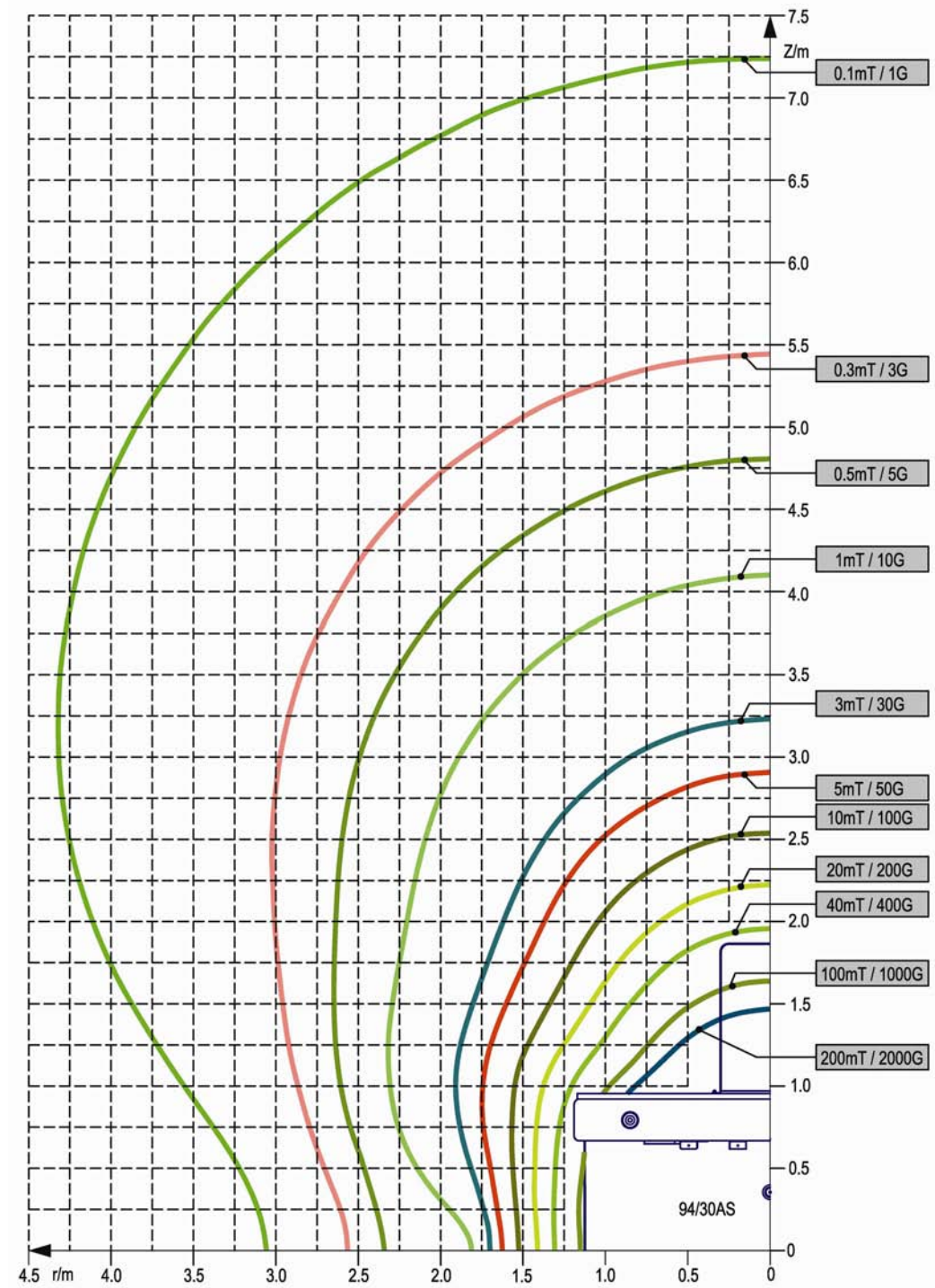


Figure 58: Stray field M-C 94/30AS



## 6.1.7.3. Quench pipe connection

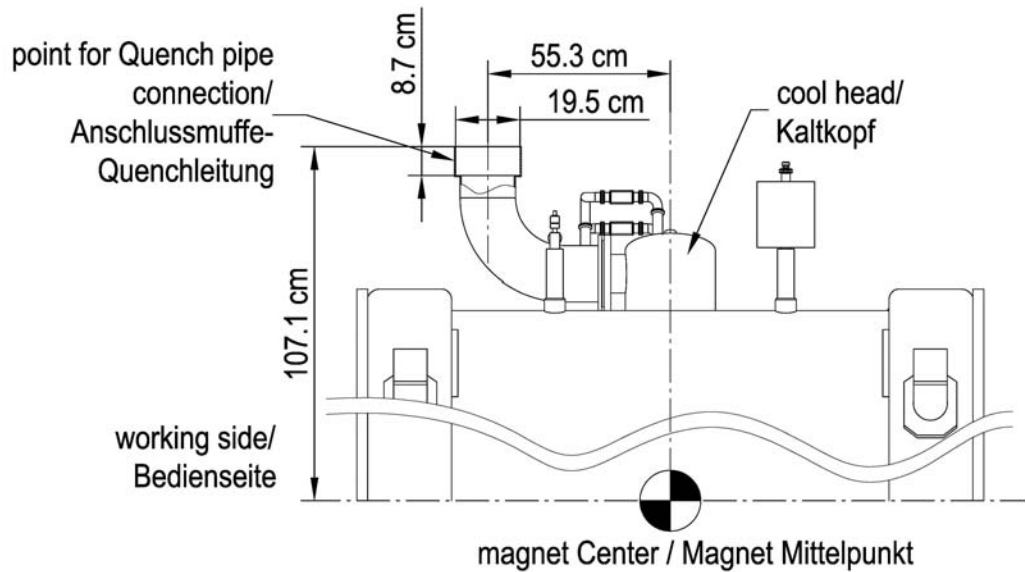


Figure 60: M-C 94/30AS Quench line connection detail at the Magnet

## 6.1.7.4. Footprint and foundation area

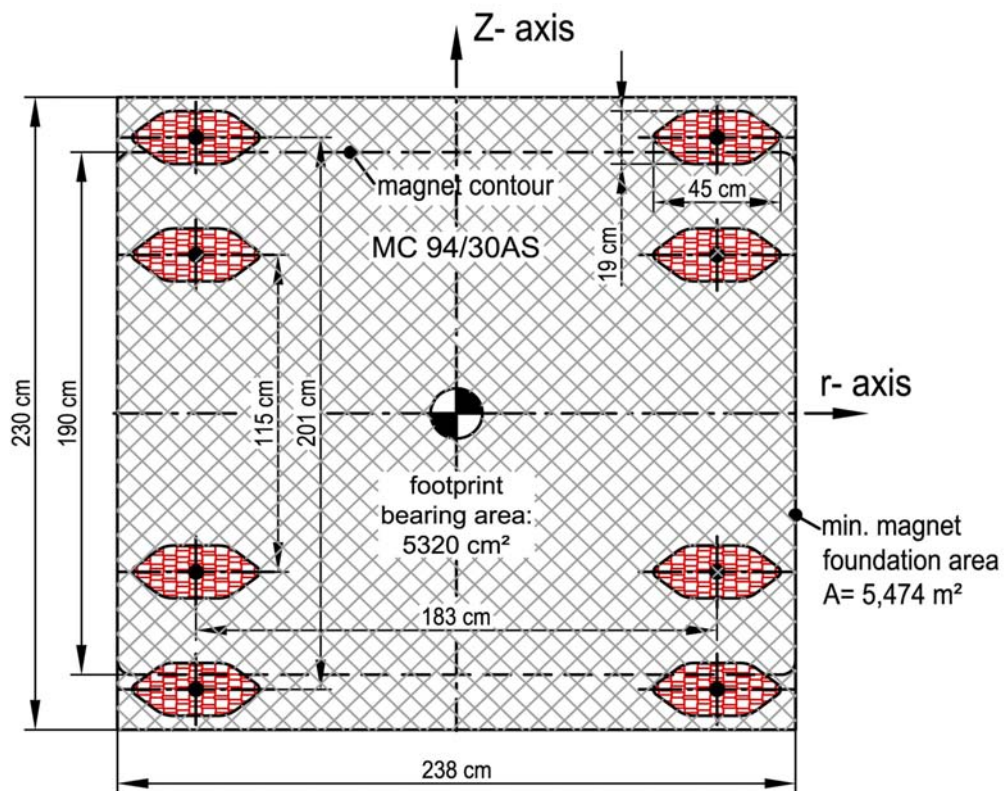


Figure 61: M-C 94/30AS footprint and foundation area

## 6.2. Installation examples

### 6.2.1. Installation example with Faraday cage, B-C 94/20USR

This installation example is a typical standard configuration and can also be used for magnets 47/40USR and 70/30USR. The measurements of the magnet are identical for all three magnets

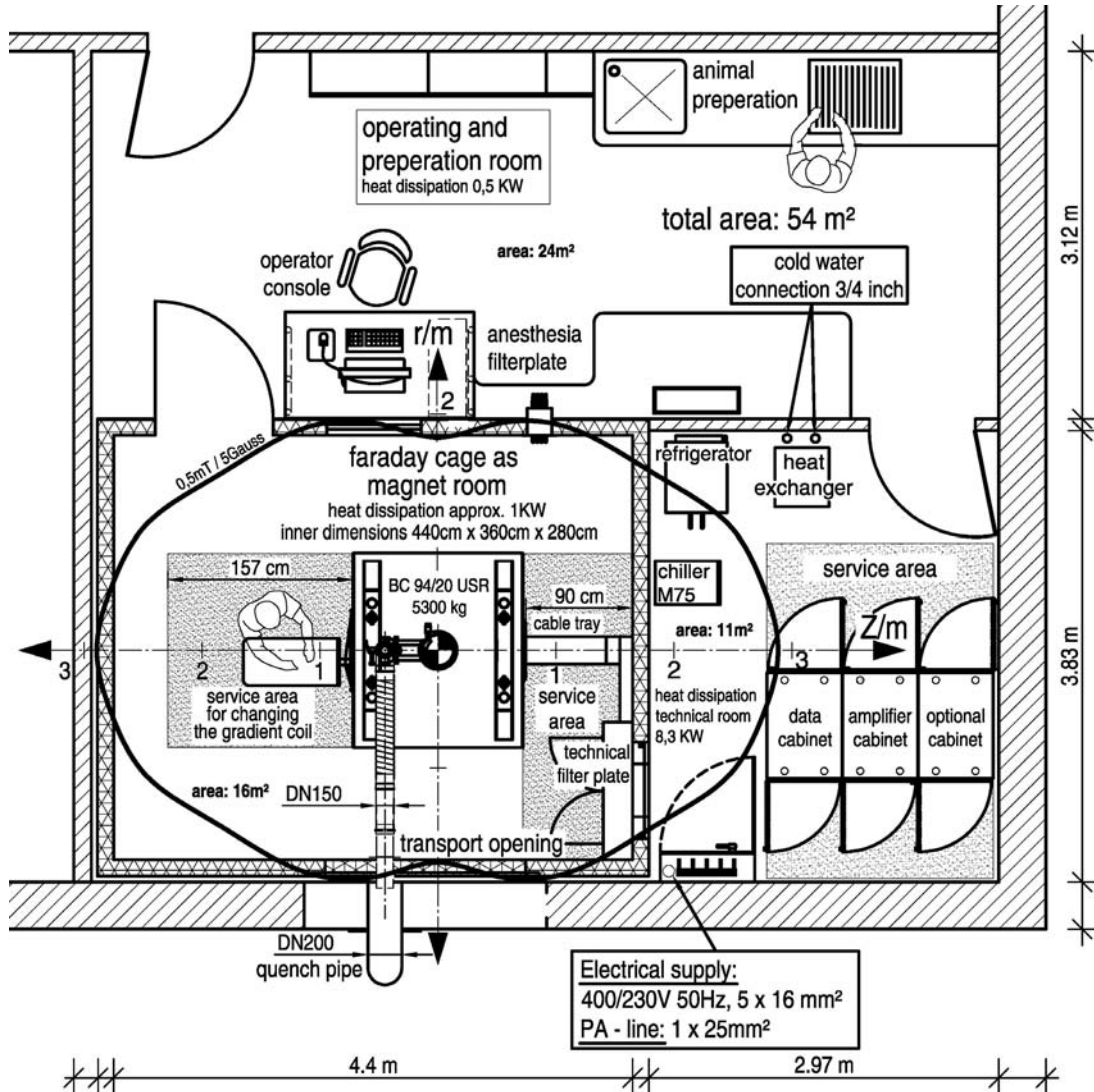


Figure 62: Floor layout B-C 94/20 USR in a Faraday cage

## Appendix: Installation Example

### 6.2.2. Installation example with Faraday cage, B-C 94/30USR

This installation example is a typical standard configuration for magnet 94/30USR. The measurements of the magnet are larger than those of the other USR magnets, therefore a considerably bigger Faraday cage is needed.

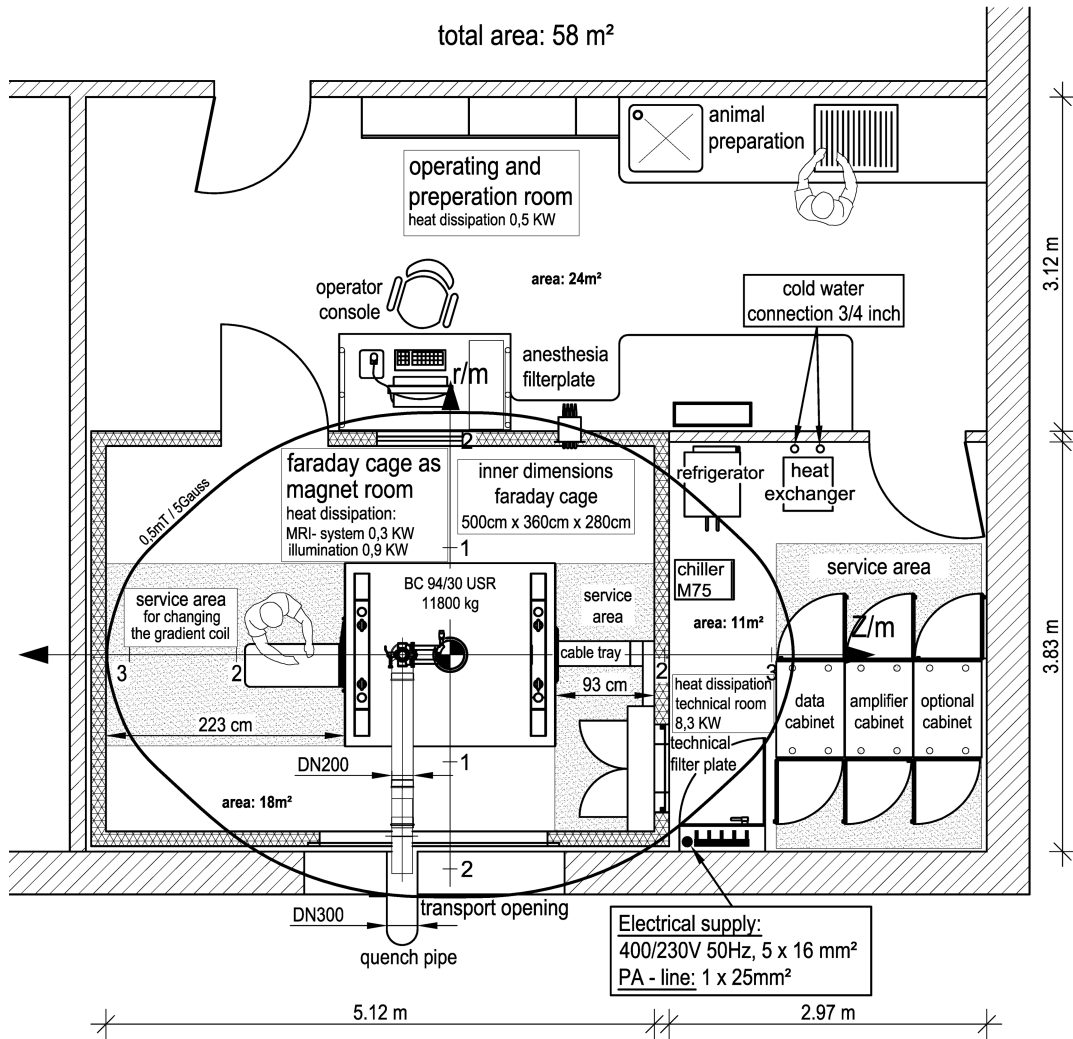


Figure 63: Floor layout B-C 94/30USR in a Faraday cage (area required: 58m<sup>2</sup>)

## 6.2.3. Example of compact installation of a magnet: M-C 94/30AS

This installation example is not a typical configuration for magnet 94/30AS. The measurements of the magnet are larger than those of all other magnets, therefore a considerably bigger Faraday cage is currently needed. Since an entrance door is available on the Z axis of the magnet, it is possible to provide the service sector required.

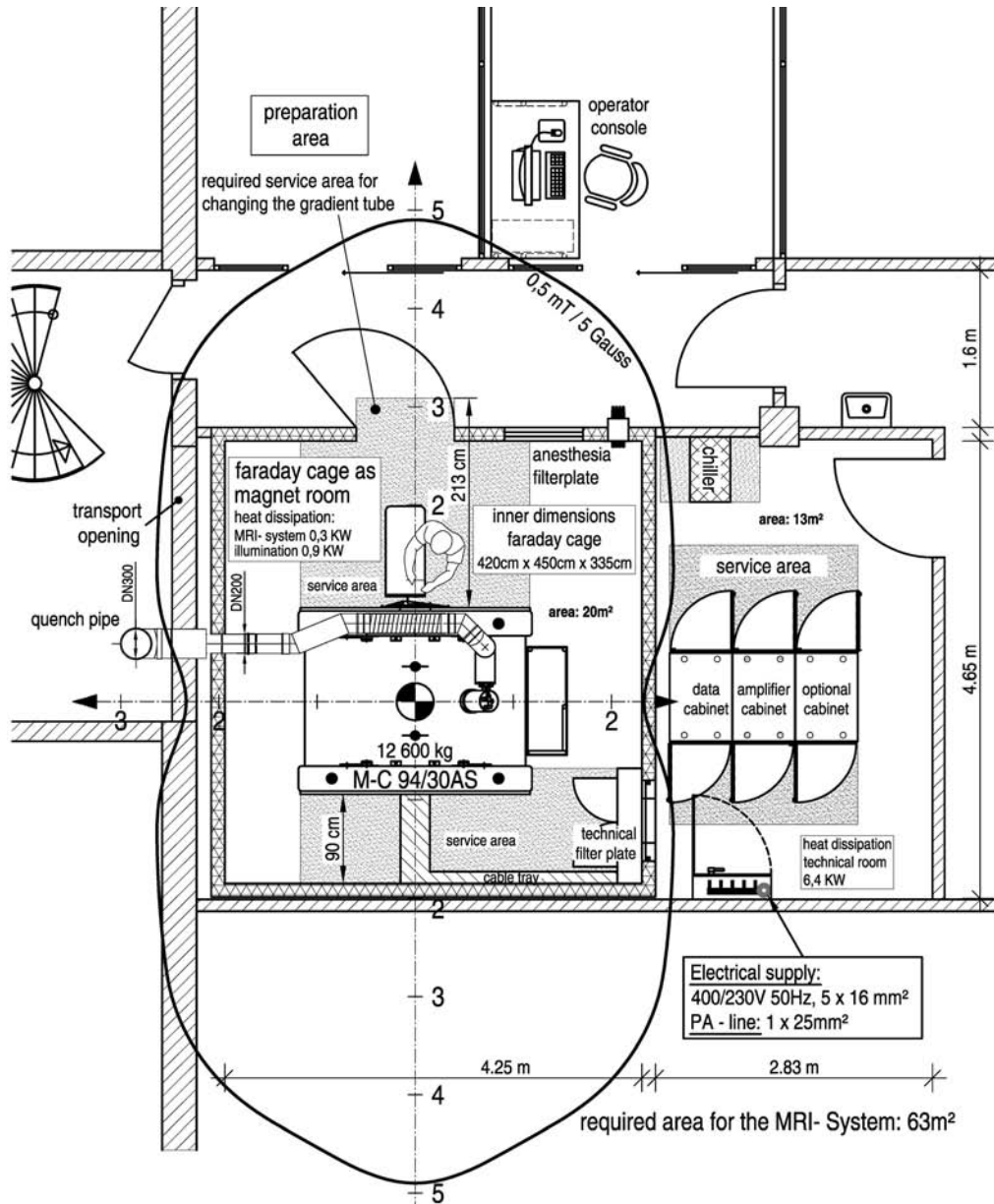


Figure 64: Floor layout M-C 94/30AS in a Faraday cage (area required: 63m<sup>2</sup>)



## Appendix: Installation Example

### 6.2.4. View of *BioSpec*<sup>®</sup> in the Faraday cage

Example of a vertical section for a typical Faraday cage installation.

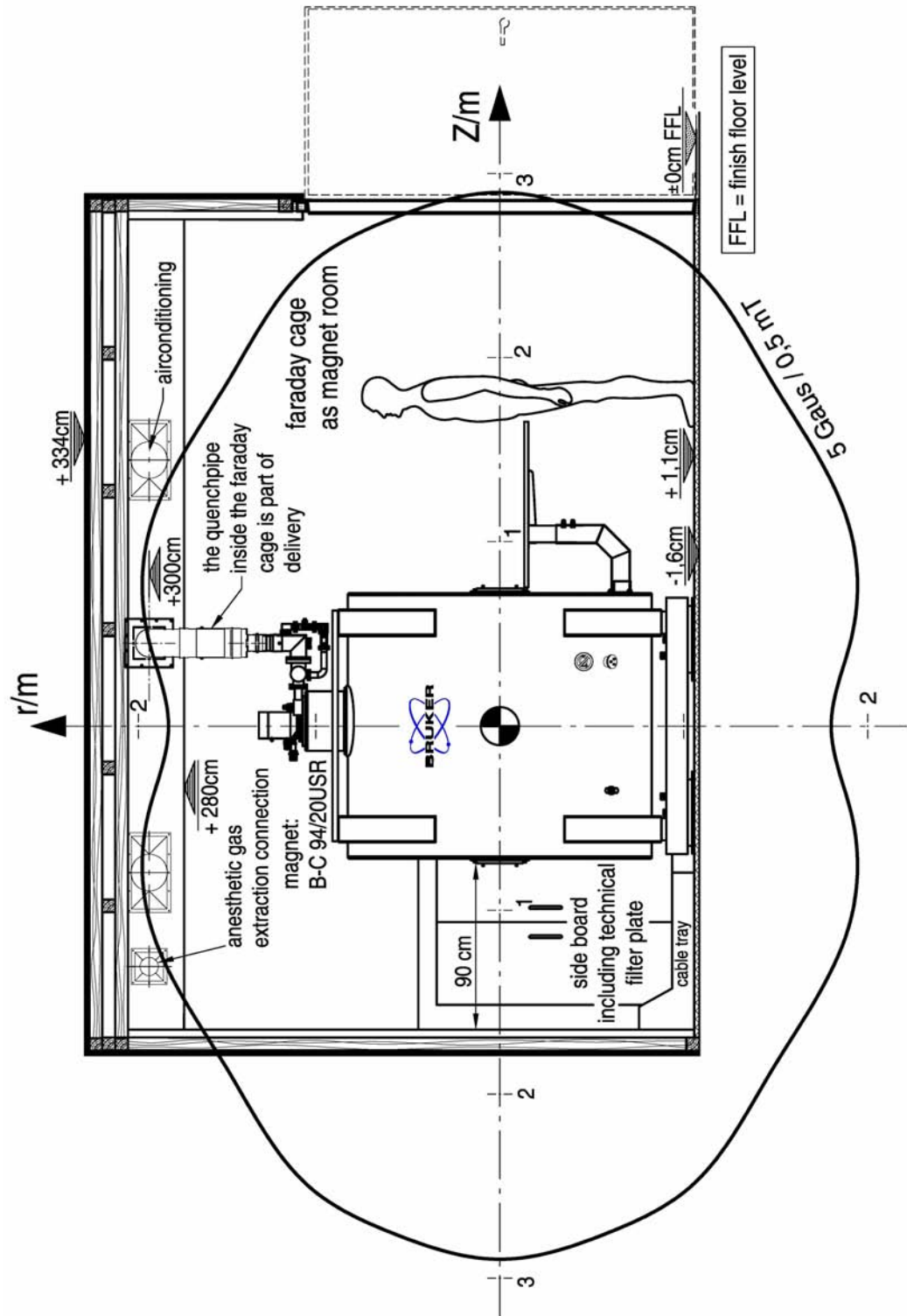


Figure 65: Faraday cage: vertical

## 6.2.5. Installation example for a compact “BioSpec® B-C 70/20AS”

Typical example of installation without a Faraday cage. To provide the RF protection required, a filter box is mounted on the rear side of the magnet.

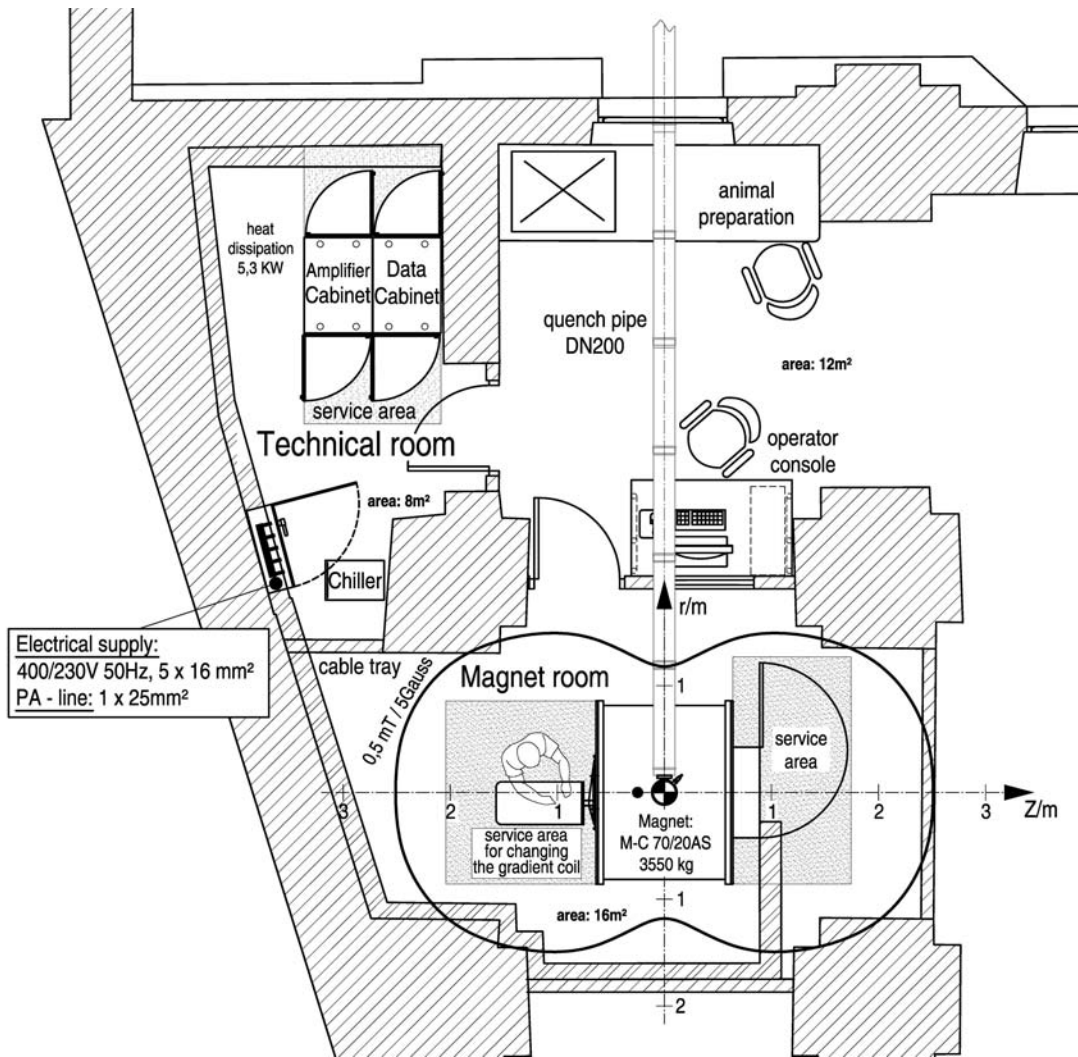


Figure 66: Floor layout B-C 70/20USR with filter box (area required: 36m<sup>2</sup>)

### 6.2.6. *BioSpec*<sup>®</sup> installation without Faraday cage

RF shielding with a filter box on the rear side of the magnet.

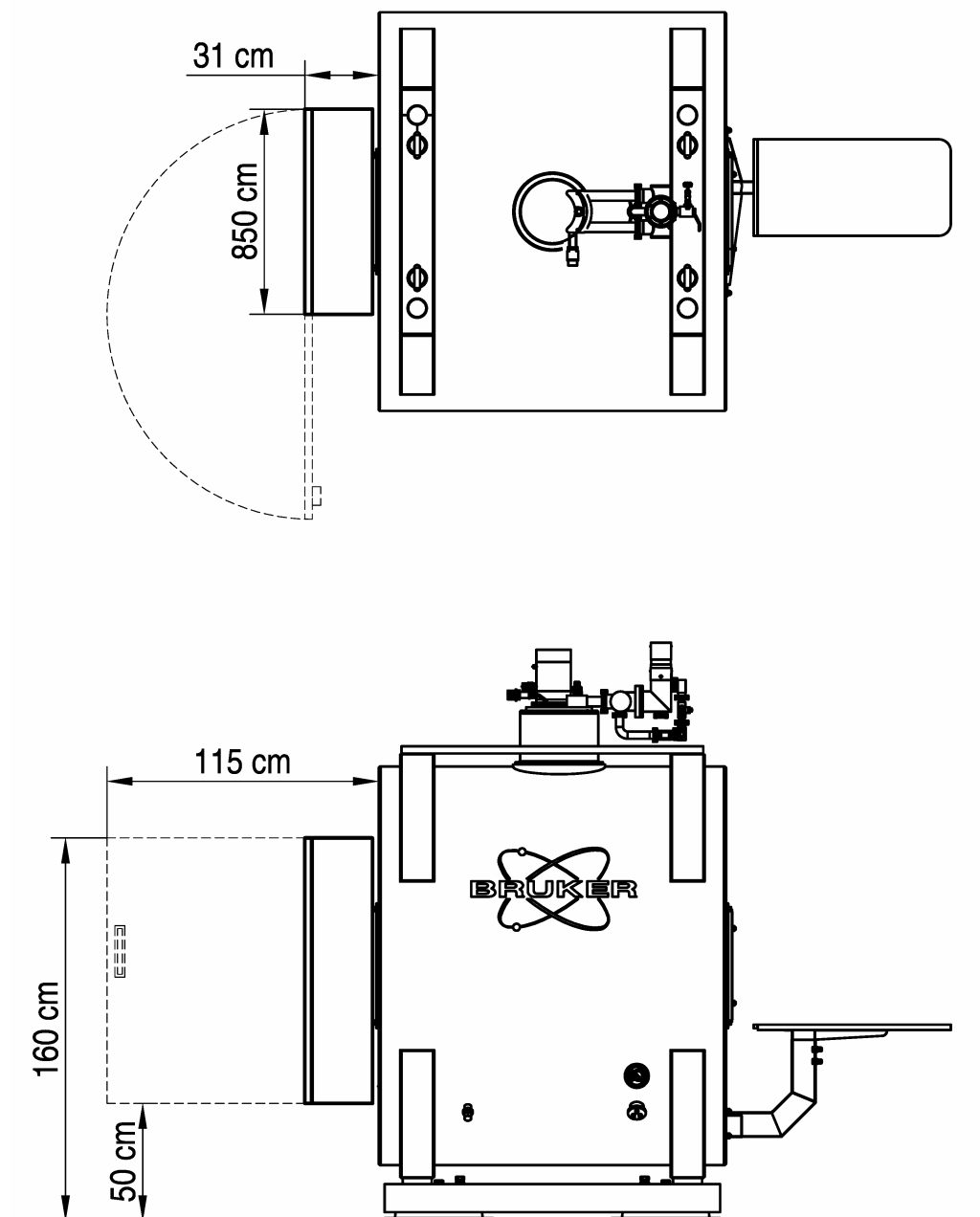


Figure 67: Filter box on rear side of the magnet.

## 6.3. Design criteria for the quench line

The quench line must be designed so that during magnet quenching, the fast evaporating cryogen gases can move freely outside the magnet room. This requirement is met by designing the quench line so that the total pressure drop of the quench line is lower than the specified value as given in this chapter and on tables 7, 8 and 9.

Each element used in the quench line has three properties:

- the geometric form
- the inner diameter
- its position within the quench line

The Tables below show the pressure drop factors as a function of these properties for all *BioSpec*<sup>®</sup> magnet types. The bending radius for any bend must be between 1 to 5 times the inner diameter. The total pressure drop is calculated by adding the pressure drops of the individual quench line elements.

### 6.3.1. Quench line design for Bruker USR magnets

The table below is based on experimental values; they include the volume expansion of the quench gas when heating up. The hotter the quench gas, the greater the pressure drop. It means that the line elements further away have a greater pressure drop than the nearer ones.

**Special information for: B-C 47/40USR; B-C 70/30USR; B-C 94/20USR:**

During magnet quenching, the maximum mass flow of cryogen gases will be 1.0kg per second. The quench line must be designed so that the maximum pressure loss is less than 0.4 bar (400 mbar).

| Quench line elements<br>(smooth inside) | Pressured drop factor dependent on the pressure drop in distance to the magnet (mbar) |                    |                    |                    |                    |                    |
|---|---|--------------------|--------------------|--------------------|--------------------|--------------------|
|   | 0-5m  | 5-10m              | 10-15m             | 15-20m             | 20-25m             | 25-30m             |
| Straight pipe segment<br>150mm diameter | 6.4<br>per meter  | 12.8<br>per meter  | 19.2<br>per meter  | 25.6<br>per meter  | 32.0<br>per meter  | 38.4<br>per meter  |
| 90° degree bend<br>150mm diameter       | 80  | 160                | 240                | 320                | 400                | 480                |
| Straight pipe segment<br>200mm diameter | 1.4<br>per meter  | 2.8<br>per meter   | 4.2<br>per meter   | 5.6<br>per meter   | 7.0<br>per meter   | 8.4<br>per meter   |
| 90° degree bend<br>200mm diameter       | 20  | 40                 | 60                 | 80                 | 100                | 120                |
| Straight pipe segment<br>250mm diameter | 0.34<br>per meter   | 0.68<br>per meter  | 1.02<br>per meter  | 1.36<br>per meter  | 1.70<br>per meter  | 2.04<br>per meter  |
| 90° degree bend<br>250mm diameter       | 7.2   | 14.4               | 21.6               | 28.8               | 36.0               | 43.2               |
| Straight pipe segment<br>300mm diameter | 0.175<br>per meter  | 0.350<br>per meter | 0.525<br>per meter | 0.700<br>per meter | 0.875<br>per meter | 1.050<br>per meter |
| 90° degrees bend<br>300mm diameter.     | 2.8   | 5.6                | 8.4                | 11.2               | 14.0               | 16.8               |

Table 13: Pressure drop in line elements at a mass flow of 1.0kg/s

### Special information exclusively for: B-C 94/30USR:

During magnet quenching, the maximum mass flow of cryogen gases will be 1.4 kg per second. The quench line must be designed so that the maximum pressure loss is less than 0.15 bar (150 mbar).

| Quench line elements<br>(smooth inside) | Pressure drop factor dependent on distance to the magnet (mbar) |                   |                   |                   |                   |                   |
|---|---|-------------------|-------------------|-------------------|-------------------|-------------------|
|   | 0-5m  | 5-10m             | 10-15m            | 15-20m            | 20-25m            | 25-30m            |
| Straight pipe segment<br>200mm diameter | 2.8<br>per meter  | 5.6<br>per meter  | 8.4<br>per meter  | 11.2<br>per meter | 14.0<br>per meter | 16.8<br>per meter |
| 90° degree bend<br>200mm diameter       | 40  | 80                | 120               | 160               | 200               | 240               |
| Straight pipe segment<br>250mm diameter | 0.68<br>per meter   | 1.36<br>per meter | 2.04<br>per meter | 2.72<br>per meter | 3.40<br>per meter | 4.08<br>per meter |
| 90° degree bend<br>250mm diameter       | 14.4  | 28.8              | 43.2              | 57.6              | 72.0              | 86.4              |
| Straight pipe segment<br>300mm diameter | 0.35<br>per meter   | 0.70<br>per meter | 1.05<br>per meter | 1.40<br>per meter | 1.75<br>per meter | 2.10<br>per meter |
| 90° degree bend<br>300mm diameter       | 5.6   | 11.2              | 16.8              | 22.4              | 28.0              | 33.6              |

Table 14: Pressure drop in line elements at a mass flow of 1.4 kg/s

### 6.3.2. Quench line design for Magnex AS magnets

During quenching or emergency run-down, a huge amount of liquid helium will evaporate and be expelled from the cryostat. The size of ducting required will depend on the duct length and how many bends the ducting has to take; in general, the number of bends should be kept to an absolute minimum. The graph gives the expected additional pressure drop for the length of pipe. The table shows the expected pressure drop for various types of bend. This can be used as a general guide in designing the vent system; note that the pressure drop depends on the distance the component is from the magnet.

### Special information exclusively for: M-C 70/20AS

During magnet quenching, the maximum mass flow of cryogen gases will be 0.56kg per second. The quench line must be designed so that the maximum pressure loss is less than 0.34 bar (340 mbar).

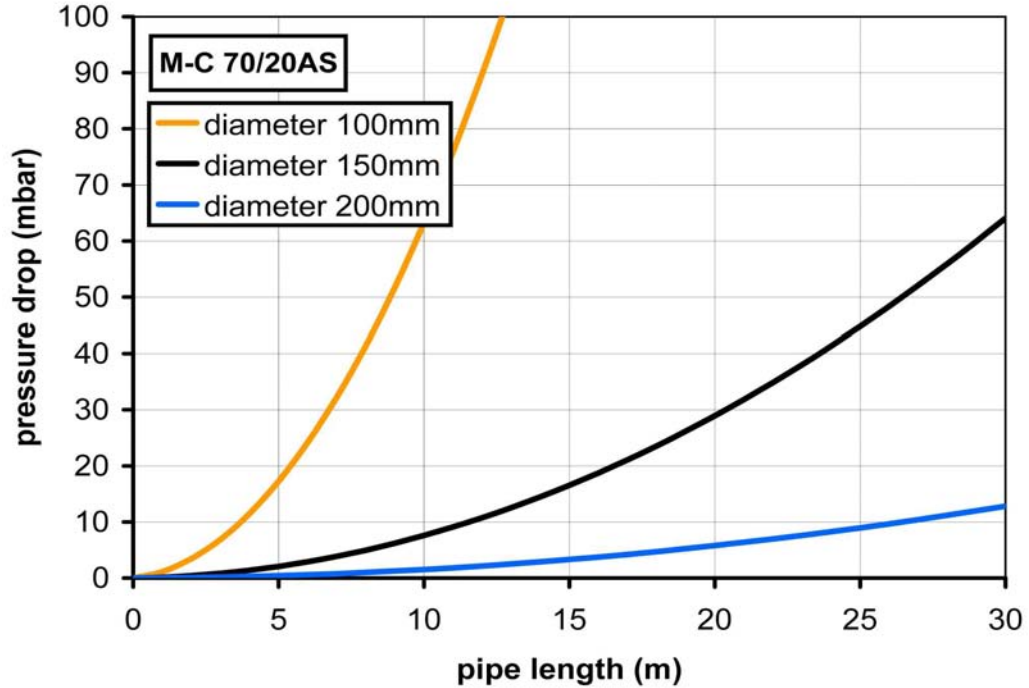


Figure 68: Diagram of quench duct pipe loss for the M-C 70/20AS magnet (excludes bends, “smooth” pipe)

| Quench line elements (smooth inside) | Pressure drop per bend (mbar) |       |        |        |        |        |
|--------------------------------------|-------------------------------|-------|--------|--------|--------|--------|
|                                      | 0-5m                          | 5-10m | 10-15m | 15-20m | 20-25m | 25m +  |
| 45° bend, diameter 100mm             | 10.95                         | 22.05 | 33.07  | 44.10  | 55.12  | 65.45  |
| Tight 90° bend, diameter 100mm       | 23.47                         | 46.85 | 70.28  | 93.70  | 117.13 | 140.55 |
| Long 90° bend, diameter 100mm        | 15.65                         | 31.00 | 46.85  | 62.70  | 78.54  | 93.70  |
| 45° bend, diameter 150mm             | 2.16                          | 4.13  | 6.20   | 8.96   | 11.02  | 13.09  |
| Tight 90° bend, diameter 150mm       | 4.64                          | 8.96  | 13.78  | 18.60  | 23.43  | 27.56  |
| Long 90° bend, diameter 150mm        | 3.09                          | 6.20  | 8.96   | 12.40  | 15.16  | 18.60  |
| 45° bend, diameter 200mm             | 0.68                          | 1.38  | 2.07   | 2.76   | 3.44   | 4.13   |
| Tight 90° bend, diameter 200mm       | 1.47                          | 2.76  | 4.13   | 6.20   | 7.58   | 8.96   |
| Long 90° bend, diameter 200mm        | 0.98                          | 2.07  | 2.76   | 4.13   | 4.82   | 6.20   |

Table 15: Pressure drop in line elements at a mass flow of 0.56 kg/s

## Appendix: Quench line design

### Special information exclusively for: M-C 94/20AS

During magnet quenching, the maximum mass flow of cryogen gases will be 0.804kg per second. The quench line must be designed so that the maximum pressure loss is less than 0.13 bar (130 mbar).

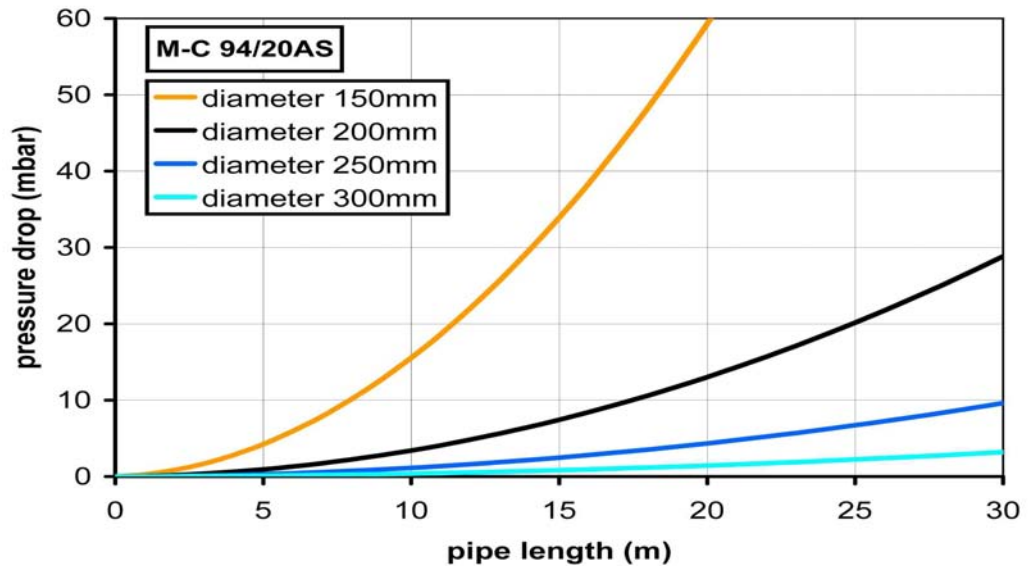


Figure 69: Diagram of quench duct pipe loss for the M-C 94/20AS magnet (excludes bends, “smooth” pipe)

| Quench line elements<br>(inside smooth) | Pressure drop per bend (mbar) |       |        |        |        |       |
|---|-------------------------------|-------|--------|--------|--------|-------|
|   | 0-5m                          | 5-10m | 10-15m | 15-20m | 20-25m | 25m + |
| 45° bend<br>diameter 150mm              | 4.44                          | 8.96  | 13.09  | 17.91  | 22.05  | 26.87 |
| Tight 90° bend<br>diameter 150mm        | 9.51                          | 19.29 | 28.25  | 37.89  | 47.54  | 57.19 |
| Long 90° bend<br>diameter 150mm         | 6.34                          | 12.40 | 19.29  | 25.49  | 31.69  | 37.89 |
| 45° bend<br>diameter 200mm              | 1.41                          | 2.76  | 4.13   | 5.51   | 6.89   | 8.27  |
| Tight 90° bend<br>diameter 200mm        | 3.01                          | 6.20  | 8.96   | 11.71  | 15.16  | 17.91 |
| Long 90° bend<br>diameter 200mm         | 2.00                          | 4.13  | 6.20   | 8.27   | 10.33  | 11.71 |
| 45° bend<br>diameter 250mm              | 0.57                          | 1.38  | 2.07   | 2.07   | 2.76   | 3.44  |
| Tight 90° bend<br>diameter 250mm        | 1.23                          | 2.76  | 3.44   | 4.82   | 6.20   | 7.58  |
| Long 90° bend<br>diameter 250mm         | 0.82                          | 1.38  | 2.76   | 3.44   | 4.13   | 4.82  |
| 45° bend<br>diameter 300mm              | 0.28                          | 0.69  | 0.69   | 1.38   | 1.38   | 1.38  |
| Tight 90° bend<br>diameter 300mm        | 0.59                          | 1.38  | 2.07   | 2.07   | 2.76   | 3.44  |
| Long 90° bend<br>diameter 300mm         | 0.40                          | 0.69  | 1.38   | 1.38   | 2.07   | 2.07  |

Table 16: Pressure drop in line elements at a mass flow of 0.804 kg/s

### Special information exclusively for: M-C 94/30AS

During magnet quenching, the maximum mass flow of cryogen gases will be 1.4kg per second. The quench line must be designed so that the maximum pressure loss is less than 0.34 bar (340 mbar).

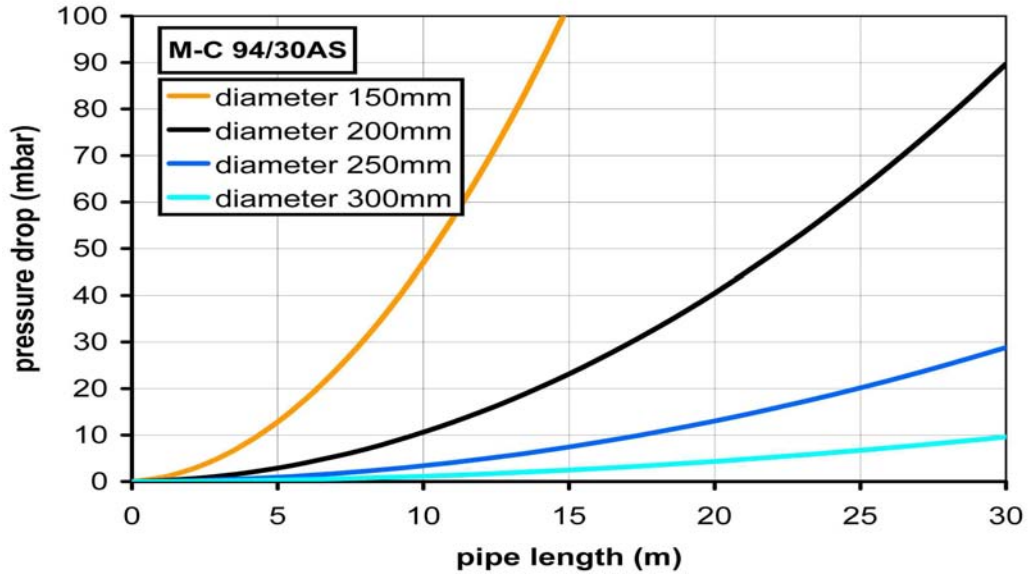


Figure 70: Diagram of quench duct pipe loss for the M-C 94/30AS magnet (excludes bends, “smooth” pipe)

| Quench line elements<br>(smooth inside) | Pressure drop per bend (mbar) |       |        |        |        |        |
|---|-------------------------------|-------|--------|--------|--------|--------|
|   | 0-5m                          | 5-10m | 10-15m | 15-20m | 20-25m | 25m +  |
| 45° bend<br>diameter 150mm              | 13.46                         | 26.87 | 40.65  | 53.74  | 67.52  | 80.61  |
| Tight 90° bend<br>diameter 150mm        | 28.85                         | 57.88 | 86.81  | 115.75 | 144.00 | 172.94 |
| Long 90° bend<br>diameter 150mm         | 19.24                         | 38.58 | 57.88  | 77.17  | 96.46  | 115.75 |
| 45° bend<br>diameter 200mm              | 4.26                          | 8.27  | 13.09  | 17.22  | 21.36  | 25.49  |
| Tight 90° bend<br>diameter 200mm        | 9.13                          | 18.60 | 27.56  | 36.52  | 45.47  | 55.12  |
| Long 90° bend<br>diameter 200mm         | 6.08                          | 12.40 | 18.60  | 24.11  | 30.32  | 36.52  |
| 45° bend<br>diameter 250mm              | 1.74                          | 3.44  | 5.51   | 6.89   | 8.96   | 10.33  |
| Tight 90° bend<br>diameter 250mm        | 3.74                          | 7.58  | 11.02  | 15.16  | 18.60  | 22.74  |
| Long 90° bend<br>diameter 250mm         | 2.49                          | 4.82  | 7.58   | 9.65   | 12.40  | 15.16  |
| 45° bend<br>diameter 300mm              | 0.84                          | 1.38  | 2.76   | 3.44   | 4.13   | 4.82   |
| Tight 90° bend<br>diameter 300mm        | 1.81                          | 3.44  | 5.51   | 6.89   | 8.96   | 11.02  |
| Long 90° bend<br>diameter 300mm         | 1.21                          | 2.07  | 3.44   | 4.82   | 6.20   | 6.89   |

Table 17: Pressure drop in line elements at a mass flow of 1.4 kg/s



## 6.3.3. Calculation example for a B-C 94/20USR quench line

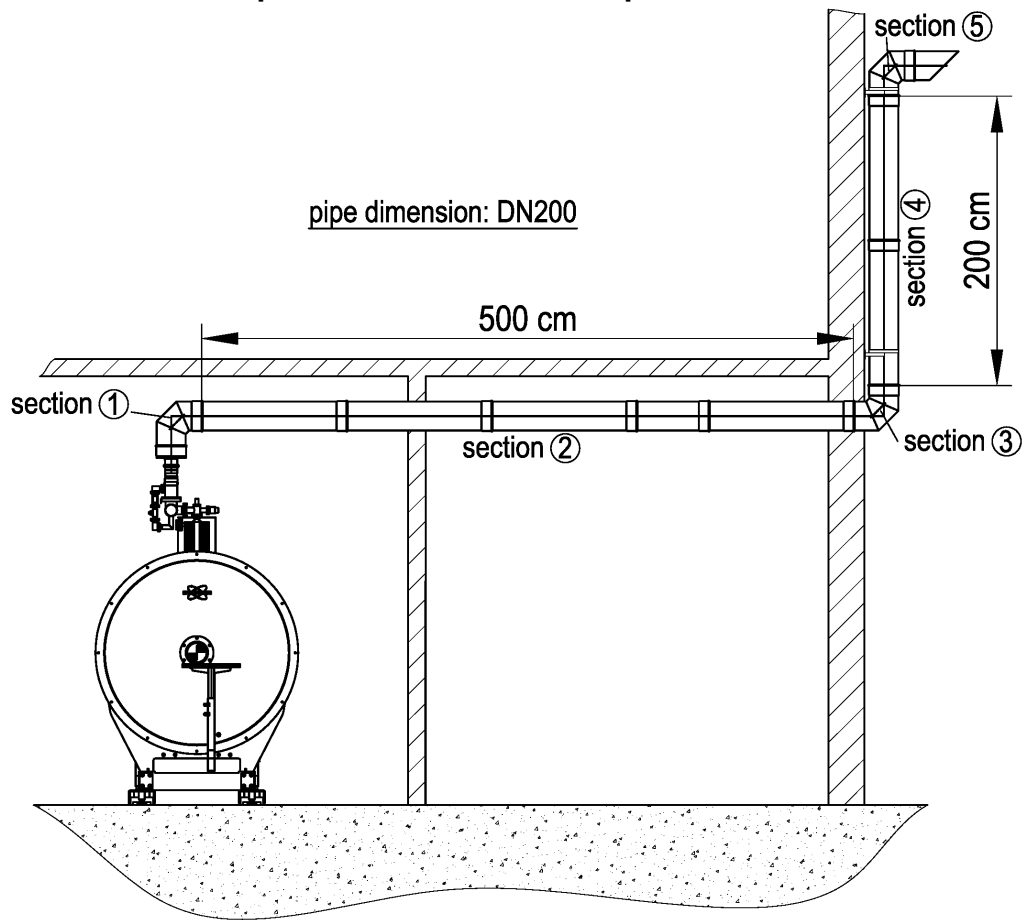


Figure 71: Example of quench line installation for a B-C 94/20USR

| Section No.   | Length (m) Meter | Sum of lengths (m) | Calculation or comment   | Pressure loss $\Delta P$ (mbar) |
|---|------------------|--------------------|--|---------------------------------|
| ①   |                  |                    | DN 200: 90° bend (position < 5m)   | 20.0                            |
| ②   | 5.00             | -/-                | DN 200: 5.00 x 1.4 mbar = 7.00 mbar  | 7.0                             |
| ③   |                  |                    | DN 200: 90° bend (position < 10m)  | 12.0                            |
| ④   | 2.00             | 7.0 m              | DN 200: 2.00 x 2.8 mbar = 5.60 mbar  | 5.6                             |
| ⑤   |                  |                    | DN 200: 90° bend (position < 10m)  | 40.0                            |
|   |                  |                    | Air pressure for the height difference of < 3 meter:<br>(air pressure per meter height: 0.127mbar) | 0.4                             |
| <b>Summary of pressure loss in quench pipe configuration:</b> |                  |                    |  | <b>113</b>                      |
| The maximum allowed pressure droop is 400 mbar.               |                  |                    |  |                                 |
| <b>The quench pipe design would work!</b>                     |                  |                    |  |                                 |

## Appendix: Quench line design

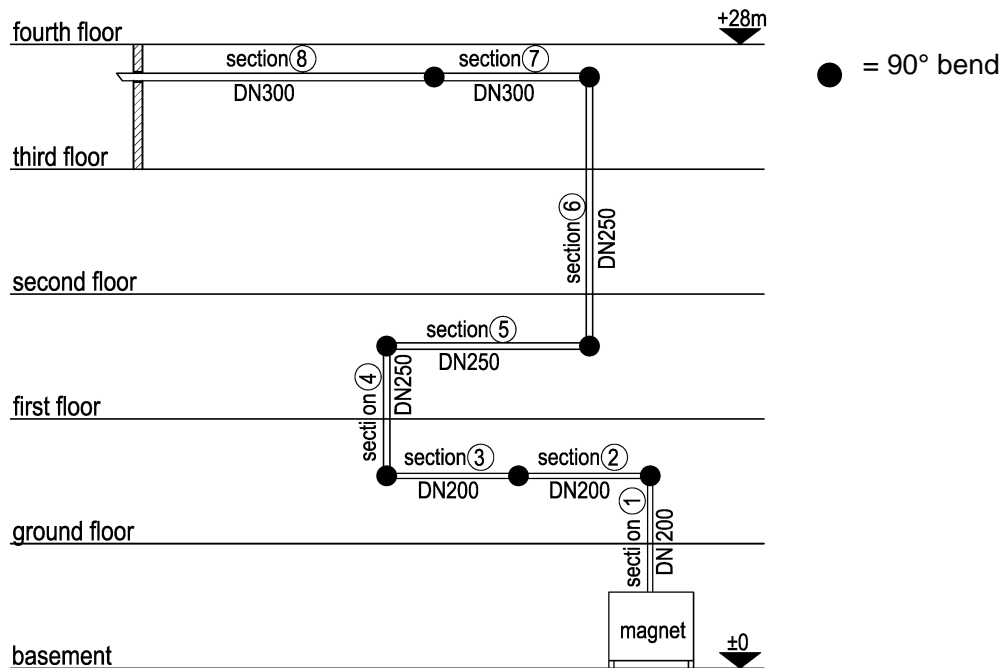


Figure 72: Example of along quench line installation for B-C 70/30 USR

| Section No.   | Length (m) Meter | Sum of lengths (m) | Calculation or comment  | Pressure loss $\Delta P$ (mbar) |
|---|------------------|--------------------|---|---------------------------------|
| ①   | 2.13             | -/-                | DN 200: $2.13 \times 1.4 \text{ mbar} = 2.98 \text{ mbar}$  | 3.0                             |
|   |                  |                    | DN 200: bend $90^\circ$   | 20.0                            |
| ②   | 3.66             | 5.8 m              | DN 200: $3.66 \times 1.4 \text{ mbar} = 5.124 \text{ mbar}$   | 5.1                             |
|   |                  |                    | DN 200: bend $90^\circ$   | 20.0                            |
| ③   | 4.30             | 10.1 m             | DN 200: $4.3 \times 2.8 \text{ mbar} = 12.04 \text{ mbar}$  | 12.0                            |
|   |                  |                    | DN 250: bend $90^\circ$   | 21.6                            |
| ④   | 4.90             | 15.0 m             | DN 250: $4.9 \times 1.02 \text{ mbar} = 4.998 \text{ mbar}$   | 5.0                             |
|   |                  |                    | DN 250: bend $90^\circ$   | 21.6                            |
| ⑤   | 4.00             | 19.0 m             | DN 250: $4.0 \times 1.36 \text{ mbar} = 5.44 \text{ mbar}$  | 5.4                             |
|   |                  |                    | DN 250: Elbow $90^\circ$  | 28.8                            |
| ⑥   | 9.40             | 28.4 m             | DN 250: $1.0 \times 1.36 \text{ mbar} = 1.36 \text{ mbar}$<br>DN 250: $5.0 \times 1.7 \text{ mbar} = 8.5 \text{ mbar}$<br>DN 250: $3.4 \times 2.04 \text{ mbar} = 6.936 \text{ mbar}$ | 16.8                            |
|   |                  |                    | DN 300: bend $90^\circ$   | 16.8                            |
| ⑦   | 2.70             | 31.1 m             | DN 300: $2.7 \times 1.05 \text{ mbar} = 2.835 \text{ mbar}$   | 2.8                             |
|   |                  |                    | DN 300: bend $90^\circ$   | 16.8                            |
| ⑧   | 19.20            | 50.3 m             | DN 300: $19.2 \times 1.05 \text{ mbar} = 20.16 \text{ mbar}$  | 20.6                            |
|   |                  |                    | Air pressure for the height difference of 30 meter:   | 3.8                             |
| <b>Summary of pressure loss in quench pipe configuration:</b> |                  |                    |   | <b>220.1</b>                    |
| The maximum allowed pressure droop is 400 mbar.               |                  |                    |   |                                 |
| <b>The quench pipe design would work!</b>                     |                  |                    |   |                                 |

## 6.4. Pre-Installation Checklist *BioSpec*<sup>®</sup>

The intention of this document is to ensure that Bruker BioSpin and the end user have all the information required for the successful commissioning of the *BioSpec*<sup>®</sup> magnet system. Please read the following questionnaire carefully and return/fax a signed copy of it to the sender (Address / Fax number see cover letter). Detailed and full information concerning the installation requirements is available in this *BioSpec*<sup>®</sup> Systems Site Planning Information manual (BSSPI) enclosed to this questionnaire. Please note that we are not able to schedule the installation before receiving a completely filled out pre-installation check list.

### 6.4.1. Customer Information

|  |                                  |
|--|----------------------------------|
| <b>Responsible person for the installation at customer site:</b><br>Please send back these pages to the attention of Bruker BioSpin no later than 9 weeks before the scheduled delivery given below. |                                  |
| <b>Name:</b>   | _____                            |
| <b>Position:</b>   | _____                            |
| <b>Telephone:</b>  | _____ Fax: _____                 |
| <b>Email:</b>  | _____                            |
| <b>Delivery information:</b>   |                                  |
| <b>Delivery address:</b>   | _____<br>_____<br>_____<br>_____ |
| <b>Scheduled delivery:</b><br>(planned or desired delivery date) _____   |                                  |
| <b>Return to address:</b><br><b>Bruker BioSpin MRI GmbH</b> <b>Tel.: +49 (0)721 51 61 -533</b><br><b>Rudolf-Plank-Strasse 23</b> <b>Fax: +49 (0)721 51 61 -539</b><br><b>D-76275 Ettlingen</b>       |                                  |

## 6.4.2. Magnet Installation

| <b>Transport to the Magnet room:</b>  |                              |                             |
|---|------------------------------|-----------------------------|
| Was a rigging company ordered and advised?<br><small>(cf. section 3.1.2)</small>  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Is the rigging company insured against transport damage (starting from the loading ramp) so that the value of the <i>BioSpec</i> <sup>®</sup> scanner is covered?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Has the local rigging company visited the site and discussed their installation strategy with Bruker BioSpin MRI representatives?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Is there a suitable unloading area?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Is a suitable crane available?<br><small>Working load of the crane see (cf. section 4.4)</small>  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Is heavy lift equipment (air pads or skates, max. load capacity) available for transport from the unloading area to the magnet room and positioning in the magnet room?<br><small>(cf. section 4 and 5)</small> | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If yes, maximum load?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Minimum floor loading capacity along route of transport?<br><small>(cf. sections 3.2.2, table 7)</small>  | _____ kg/m                   |                             |
| Minimum door opening/constriction along route of transport?<br><small>(W / H) (cf. sections 3.2.2, table 7)</small>   | _____ cm / _____ cm          |                             |
| Steps along route of transport?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If yes, how many / height?  | _____ / _____ cm             |                             |
| Lift/elevator required?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If yes, maximum load?   | _____ kg                     |                             |
| Crane available?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If yes, maximum load?   | _____ kg                     |                             |
| Hand-operated lift truck available?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Is there a particular obstruction along the route of transport?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If yes, provide details on separate pages.  |                              |                             |

### 6.4.3. Characterisation of the laboratory rooms

| <b>Magnet room:</b>  |                              |                             |
|--|------------------------------|-----------------------------|
| Will the magnet room be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the floor be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the ceiling be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the electrical installation be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the ventilation installation be finished in time?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If a faraday cage was installed, will it be finished in time?                                    | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Drawing of the magnet room attached to this form?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If not, dimensions of the room (W x L x H)   | _____ x _____ x _____ cm     |                             |
| Minimum distance between magnet and any wall?  | _____ cm                     |                             |
| Floor loading capacity? (cf. section 3.2.2 table 7, 8, 9)  | _____ kg/m <sup>2</sup>      |                             |
| Cable trays installed? (cf. section 3.1.5.4, table 10, 11)                                       | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Customer part of the quench tube installed?<br>(cf. section 3.2.1; section 3.2.2, table 5; 6; 7) | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| 230V /10A current socket installed at 1.4m height?<br>(cf. section 3.3.2.3, table 10, 11)        | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Air conditioning / ventilation installed?<br>(cf. section 3.2.1.11, 3.3.2.6, 3.4.2)              | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| <b>Operating area:</b>   |                              |                             |
| Will the operating area be finished in time?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the ceiling be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the floor be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the electrical installation be finished in time?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Will the water installation be finished in time?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Is the ventilation installation finished?  | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Drawing of the operating area attached to this form?   | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| If not, Dimensions of the room (W x L x H)   | _____ x _____ x _____ cm     |                             |
| Cable length/distance console to electronics cabinets < 25 m? (cf. section 3.3.3 table 10)       | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Cable trays installed? (cf. section 3.1.5.5, table 10, 11)                                       | YES <input type="checkbox"/> | NO <input type="checkbox"/> |
| Two 230 V / 10 A socket outlets available?<br>(cf. section 3.3.2.3, table 10, 11)                | YES <input type="checkbox"/> | NO <input type="checkbox"/> |

## Appendix: Pre-Installation Checklist

| <b>Technical room:</b>  |                                 |                                 |
|---|---------------------------------|---------------------------------|
| Will the technical room be finished in time?  | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Will the floor be finished in time?   | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Will the electrical installation be finished in time?   | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Will the chilled water installation be finished in time?  | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Will the ventilation installation be finished in time?  | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Will the ceiling be finished in time?   | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Will the power distributor be installed in time?  | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Drawing attached to this form?  | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| If not, Dimensions of the room (W x L x H) _____ x _____ x _____ cm                               |                                 |                                 |
| Cable length/distance electronics cabinet to magnet<br>(cf. section 3.3.2.1, table 10, 11)        | < 10 m <input type="checkbox"/> | < 18 m <input type="checkbox"/> |
| Cable trays installed? (cf. section 3.3.2, table 10, 11)  | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| One three phase 400/230 V / 16 A socket outlet available?<br>(cf. section 3.3.3, table 11)        | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| One 230 V / 16 A socket outlet available?<br>(cf. section 3.3.2, table 8)                         | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |
| Potential compensation (grounding) wire 16 mm <sup>2</sup><br>(cf. section 3.3.2.5; table 10, 11) | YES <input type="checkbox"/>    | NO <input type="checkbox"/>     |

### 6.4.4. Declaration:

I understand that a review of the site will be carried out by a Bruker magnet installation engineer immediately on arrival at the site in order to validate this document. The installation will not continue until the site is finished and safe for installation & operation of a *BioSpec*<sup>®</sup> magnet. Bruker BioSpin reserves the right to charge the customer for additional costs which arise from a delayed installation which is due to a demonstrable customer misrepresentation in the pre-installation check list.

**Responsible person for the installation (customer site):**

**Name (in block letters):** \_\_\_\_\_

**Date, Signature:** \_\_\_\_\_

## 6.5. Example of an emergency plan

### Contents:

- A. Responsibilities
- B. Introduction to basic safety aspects
- C. General procedure in an emergency
- D. Procedure in the event of fire
- E. Procedure for medical emergencies

### A. Responsibilities

The following people must be informed in an emergency **during working hours**:

|                   |  |
|-------------------|--|
| <b>Name</b>       |  |
| <b>Department</b> |  |
| <b>Telephone</b>  |  |

Deputy:

|                   |  |
|-------------------|--|
| <b>Name</b>       |  |
| <b>Department</b> |  |
| <b>Telephone</b>  |  |

The following people must be informed in an emergency **outside normal working hours**.

|                         |  |
|-------------------------|--|
| <b>Name</b>             |  |
| <b>Home address</b>     |  |
| <b>Telephone/mobile</b> |  |
| <b>Hours of travel</b>  |  |

Deputy:

|                         |  |
|-------------------------|--|
| <b>Name</b>             |  |
| <b>Home address</b>     |  |
| <b>Telephone/mobile</b> |  |
| <b>Hours of travel</b>  |  |

### B. Introduction to basic safety aspects

- 1) **Read Safety Instructions:** All users must be familiar with the basic safety aspects of the MR system given in the chapter on Safety in the system manual.
- 2) **Emergency On/Off switch:** All users must be familiar with the appropriate use and effects of the Emergency On/Off switch.
- 3) **Emergency Quench:** All users must be familiar with the appropriate and proper use and effects of the emergency quench unit.
- 4) **General staff:** General staff must be instructed to enter the magnet room only under trained supervision (i.e. security or cleaning staff).
- 5) **Local services:** It is generally recommended that the operator carry out a local inspection and introduction to safety aspects with the relevant local services, i.e. the fire brigade or medical and first aid organizations.

### C. General procedure in an emergency

All users and staff in general must be familiar with procedures in emergencies as stated below:

- 1) **All circumstances:** inform the above-mentioned staff members responsible.
- 2) **Fire or electric shock:** disconnect the system immediately from the mains by using the Emergency On/Off switch.
- 3) **Objects attracted to the magnet with acute life-threatening risk:** discharge the magnet immediately by using the Emergency Quench unit.
- 4) **Objects attracted to the magnet with no acute life-threatening risk:** Do not try to remove the object from the magnet.



### D. Procedure in the event of fire

The people responsible for the system must be kept informed under all circumstances. If necessary or if in doubt, inform the fire brigade.

#### *Fire in the technical room*

In the event of fire, all electronic components of the system must be immediately switched off by the Emergency On/Off Switches at the console or by disconnecting the entire system from the mains.

In principle, standard CO<sub>2</sub> extinguishers can be used in the electrical room, whereas the standard precautions must be taken when fighting electrical fires. Note: it is good practice to use only non-magnetic fire extinguishers in the vicinity of the entire MR system.

#### *Fire in the magnet room*

In the event of fire, the main magnetic field does not inevitably have to be run down. This decision depends on the actual risk posed by the fire. If the magnet has to be run down, use the magnet run-down unit for this purpose.

Only non-magnetic CO<sub>2</sub> fire extinguishers must be used in the exclusion zone of the magnet. These fire extinguishers must be clearly marked as non-magnetic.

As long as the magnet is on field, only non-magnetic equipment can be used to fight fires. People wearing gas masks or breathing equipment are in acute, life-threatening danger inside the magnet room.

In the event that magnetic appliances have to enter the magnet room, it is imperative that the magnet be discharged. Make sure that the field has been ramped down completely before entering the magnet room.

### E. Procedure during medical emergencies

The people responsible for the system must be kept informed under all circumstances. If necessary or if in doubt, call for medical assistance. You must provide first aid treatment under all circumstances.

First aid or medical assistance must always be performed outside the magnet room.

If it is not possible to carry the patient outside the magnet room, discharge the magnet before entering with magnetic equipment.



## 6.6. Index

---

### A

|                                      |            |
|--------------------------------------|------------|
| acoustic noise.....                  | 25, 46     |
| Air conditioning.....                | 46         |
| Air ventilation.....                 | 29         |
| anesthesia gas extraction hood ..... | 30         |
| Available Cable length.....          | 33, 49, 50 |

### B

|                           |    |
|---------------------------|----|
| basement.....             | 23 |
| Building vibrations ..... | 32 |

### C

|  |            |
|--|------------|
| Cable tray dimensions.....               | 33, 49, 50 |
| Checklist <i>PharmaScan</i> ® .....      | 91         |
| Cold Water Supply .....                  | 47         |
| compact installation 94/30AS.....        | 80         |
| Country-specific safety regulation ..... | 8          |
| Crane Operation.....                     | 54         |
| Cryogen gases .....                      | 7          |
| Cryogen liquids.....                     | 7          |

### D

|   |        |
|---|--------|
| Dimensions Amplifier Cabinet .....      | 49, 50 |
| Dimensions chiller .....                | 50     |
| Dimensions magnet supervision unit .... | 49     |
| Dimensions RF/Data cabinet .....        | 49, 50 |
| Dimensions RF/Data Cabinet.....         | 33     |
| Doors of all transport routes.....      | 7      |

### E

|                                   |      |
|-----------------------------------|------|
| Electrical supply lines .....     | 45   |
| Emergency Instructions.....       | 6    |
| Emergency plan .....              | 6, 7 |
| Emergency room .....              | 6, 7 |
| Example of an Emergency Plan..... | 95   |
| Exhaust System .....              | 25   |

### F

|                           |    |
|---------------------------|----|
| Faraday Cage .....        | 26 |
| Filter box.....           | 28 |
| Filter plate.....         | 26 |
| Fire brigade .....        | 6  |
| First aid.....            | 6  |
| Floor vibrations.....     | 24 |
| Fork Lift Operation ..... | 54 |

### G

|                |        |
|----------------|--------|
| Grounding..... | 19, 46 |
|----------------|--------|

### H

|   |            |
|---|------------|
| Handling and Lifting .....              | 53         |
| Handling of cryogen liquids .....       | 7          |
| Hardware cabinet installation .....     | 37         |
| <b>Hardware installation data</b> ..... | 33, 49, 50 |
| Health and Safety Standards .....       | 8          |
| Heat output.....                        | 33, 49, 50 |
| Helium Gas.....                         | 31         |

### I

|  |    |
|--|----|
| Installation 3, 4, 17, 18, 22, 32, 34, 35, 36,<br>78 |    |
| Installation example USR-magnet .....                | 79 |

### L

|   |            |
|---|------------|
| Lengths of sets of connecting cables .... | 25         |
| Line connection .....                     | 33, 49, 50 |

### M

|                              |    |
|------------------------------|----|
| Magnet area .....            | 25 |
| magnet foundation .....      | 23 |
| Magnet Transport Route ..... | 32 |
| Mobile crane.....            | 32 |

|                                      |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|--------------------------------------|---|-------------------------|---|---------------|---|--------------------------|----|--------------------------------|----|---------------------------|----|--------------------------|----|---------------------------|----|--------------------------|----|---------------------------|----|--------------------------|----|---------------------------|----|-------------------------------|----|
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <b>O</b>                             |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Operating console .....              | 51  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <b>P</b>                             |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Passing of Risk.....                 | 18  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Placing the magnet.....              | 54  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Potential compensation .....         | 19  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <i>Power requirements</i> .....      | 19  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Precaution .....                     | 4   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Prerequisites for Installation ..... | 21  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <b>Q</b>                             |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Quench line .....                    | 25  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Quench line design.....              | 34, 35, 36  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Quench line design AS magnets .....  | 85  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Quench line design USR magnets ..... | 84  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <b>R</b>                             |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Reinforced concrete .....            | 23, 32  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| requirements for magnet site.....    | 32  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| RF Shielding.....                    | 26  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <b>S</b>                             |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Safety Information .....             | 3   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding-left: 20px;">Safety regulation .....</td> <td style="text-align: right; vertical-align: bottom;">8</td> </tr> <tr> <td style="padding-left: 20px;">Security.....</td> <td style="text-align: right; vertical-align: bottom;">6</td> </tr> <tr> <td style="padding-left: 20px;">Seismic vibrations .....</td> <td style="text-align: right; vertical-align: bottom;">24</td> </tr> <tr> <td style="padding-left: 20px;">Smoke and fire detectors .....</td> <td style="text-align: right; vertical-align: bottom;">18</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 47/40USR.....</td> <td style="text-align: right; vertical-align: bottom;">57</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 70/20AS.....</td> <td style="text-align: right; vertical-align: bottom;">69</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 70/30USR.....</td> <td style="text-align: right; vertical-align: bottom;">60</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 94/20AS.....</td> <td style="text-align: right; vertical-align: bottom;">72</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 94/20USR.....</td> <td style="text-align: right; vertical-align: bottom;">63</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 94/30AS.....</td> <td style="text-align: right; vertical-align: bottom;">75</td> </tr> <tr> <td style="padding-left: 20px;">Stray field 94/30USR.....</td> <td style="text-align: right; vertical-align: bottom;">66</td> </tr> <tr> <td style="padding-left: 20px;">surrounding departments .....</td> <td style="text-align: right; vertical-align: bottom;">25</td> </tr> </table> | Safety regulation ..... | 8 | Security..... | 6 | Seismic vibrations ..... | 24 | Smoke and fire detectors ..... | 18 | Stray field 47/40USR..... | 57 | Stray field 70/20AS..... | 69 | Stray field 70/30USR..... | 60 | Stray field 94/20AS..... | 72 | Stray field 94/20USR..... | 63 | Stray field 94/30AS..... | 75 | Stray field 94/30USR..... | 66 | surrounding departments ..... | 25 |
| Safety regulation .....              | 8   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Security.....                        | 6   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Seismic vibrations .....             | 24  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Smoke and fire detectors .....       | 18  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 47/40USR.....            | 57  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 70/20AS.....             | 69  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 70/30USR.....            | 60  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 94/20AS.....             | 72  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 94/20USR.....            | 63  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 94/30AS.....             | 75  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| Stray field 94/30USR.....            | 66  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| surrounding departments .....        | 25  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | <b>T</b>  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | Telephone .....   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | 52  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | Transportation .....  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | 53  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | Transportation of cabinets.....   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | 55  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | <b>V</b>  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | Ventilation system .....  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | 46  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
| <hr/>                                |   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | <b>W</b>  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | Warning signs.....  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | 4   |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | Weights.....  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |
|                                      | 33, 49, 50  |                         |   |               |   |                          |    |                                |    |                           |    |                          |    |                           |    |                          |    |                           |    |                          |    |                           |    |                               |    |

### 6.7. Figures

---

|            |   |    |
|------------|---|----|
| Figure 1:  | Table of warning signs (Dimension: 60cm x 40cm; Part-No.: T5955).....   | 5  |
| Figure 2:  | Contour plots of magnetic flux density for B-C 47/40USR.....  | 10 |
| Figure 3:  | Contour plots of magnetic flux density for B-C 70/30USR.....  | 11 |
| Figure 4:  | Contour plots of magnetic flux density for B-C 94/20USR.....  | 12 |
| Figure 5:  | Contour plots of magnetic flux density for B-C 94/30USR.....  | 13 |
| Figure 6:  | Contour plots of magnetic flux density for M-C 70/20AS.....   | 14 |
| Figure 7:  | Contour plots of magnetic flux density for M-C 94/20AS.....   | 15 |
| Figure 8:  | Contour plots of magnetic flux density for M-C 94/30AS.....   | 16 |
| Figure 9:  | Line Power Connection Scheme for <i>BioSpec</i> <sup>®</sup> System.....  | 19 |
| Figure 10: | Blockdiagram for line power connection with 208V (AC).....  | 20 |
| Figure 11: | View of a Bruker USR magnet system.....   | 22 |
| Figure 12: | Schematic diagram of a typical magnet foundation.....   | 23 |
| Figure 13: | Principle of Layout for Vibration Measuring Instruments.....  | 24 |
| Figure 14: | Opening for filter plate inside the Faraday cage wall.....  | 27 |
| Figure 15: | Filter plate mounted on the wall opening of a Faraday cage.....   | 27 |
| Figure 16: | Filter box on the rear side of the magnet (solution without Faraday cage).....  | 28 |
| Figure 17: | Anesthesia gas outlet is connected with a silicone tube. Filter box on rear side of the magnet (solution without Faraday cage).....                               | 29 |
| Figure 18: | Example of an anesthesia gas extraction hood behind the magnet in a Faraday cage room. Model with swivel arm and extraction hood as a non-magnetic structure..... | 30 |
| Figure 19: | View of the <i>BioSpec</i> <sup>®</sup> system cabinets.....  | 37 |
| Figure 20: | View of the <i>BioSpec</i> <sup>®</sup> system electrical distributor and cold water connection.....  | 37 |
| Figure 21: | View of the rear side of the system cabinets and the filter plate on the left.....  | 38 |
| Figure 22: | View of the gradient coil cooler and cryo-refrigerator.....   | 39 |
| Figure 23: | View of the <i>BioSpec</i> system cabinets with Copley 265P option.....   | 40 |
| Figure 24: | View of the system cabinets: dimensions and cable connection.....   | 40 |
| Figure 25: | View of the system electrical distributor.....  | 41 |
| Figure 26: | View of the Thermo NESLAB M75 chiller system (gradient coil cooler).....  | 41 |
| Figure 27: | View of the cryo-refrigerator for magnet cooling.....   | 42 |

|            |   |    |
|------------|---|----|
| Figure 28: | View of the B-ER090 heat exchanger (for refrigerator cooling)....                       | 42 |
| Figure 29: | View of the Thermo NESLAB CFT-300 water chiller system .....                            | 43 |
| Figure 30: | Electrical Supply to a <i>BioSpec</i> <sup>®</sup> System with a BRUKER USR Magnet..... | 45 |
| Figure 31: | Emergency Discharge (Magnet Run-down Unit for a Magnex AS Magnet) .....                 | 48 |
| Figure 32: | View of the operating console for the <i>BioSpec</i> <sup>®</sup> system .....          | 51 |
| Figure 33: | View of the system cabinets.....  | 55 |
| Figure 34: | Stray field B-C 47/40USR .....  | 57 |
| Figure 35: | <i>BioSpec</i> <sup>®</sup> Magnet B-C 47/40USR vertical view .....                     | 58 |
| Figure 36: | B-C 47/40USR Quench line connection detail at the Magnet .....                          | 59 |
| Figure 37: | B-C 47/40USR footprint and foundation area .....  | 59 |
| Figure 38: | Stray field B-C 70/30USR .....  | 60 |
| Figure 39: | <i>BioSpec</i> <sup>®</sup> Magnet B-C 70/30USR vertical view .....                     | 61 |
| Figure 40: | B-C 70/30USR Quench line connection detail at the Magnet .....                          | 62 |
| Figure 41: | B-C 70/30USR footprint and foundation area .....  | 62 |
| Figure 42: | Stray field B-C 94/20USR .....  | 63 |
| Figure 43: | <i>BioSpec</i> <sup>®</sup> Magnet B-C 94/20USR vertical view .....                     | 64 |
| Figure 44: | B-C 94/20USR Quench line connection detail at the Magnet .....                          | 65 |
| Figure 45: | B-C 94/20USR footprint and foundation area .....  | 65 |
| Figure 46: | Stray field B-C 94/30USR .....  | 66 |
| Figure 47: | <i>BioSpec</i> <sup>®</sup> Magnet B-C 94/30USR vertical view .....                     | 67 |
| Figure 48: | B-C 94/30USR Quench line connection detail at the Magnet .....                          | 68 |
| Figure 49: | B-C 94/30USR footprint and foundation area .....  | 68 |
| Figure 50: | Stray field M-C 70/20AS.....  | 69 |
| Figure 51: | <i>BioSpec</i> <sup>®</sup> Magnet M-C 70/20AS vertical view.....                       | 70 |
| Figure 52: | M-C 70/20AS Quench line connection detail at the Magnet .....                           | 71 |
| Figure 53: | M-C 70/20AS footprint and foundation area .....   | 71 |
| Figure 54: | Stray field M-C 94/20AS.....  | 72 |
| Figure 55: | <i>BioSpec</i> <sup>®</sup> Magnet M-C 94/20AS vertical view.....                       | 73 |
| Figure 56: | M-C 94/20AS Quench line connection detail at the Magnet .....                           | 74 |
| Figure 57: | M-C 94/20AS footprint and foundation area .....   | 74 |
| Figure 58: | Stray field M-C 94/30AS.....  | 75 |
| Figure 59: | <i>BioSpec</i> <sup>®</sup> Magnet M-C 94/30AS vertical view.....                       | 76 |
| Figure 60: | M-C 94/30AS Quench line connection detail at the Magnet .....                           | 77 |

|            |   |     |
|------------|---|-----|
| Figure 61: | M-C 94/30AS footprint and foundation area.....  | 77  |
| Figure 62: | Floor layout B-C 94/20 USR in a Faraday cage .....  | 78  |
| Figure 63: | Floor layout B-C 94/30USR in a Faraday cage (area required:<br>58m <sup>2</sup> ).....              | 79  |
| Figure 64: | Floor layout M-C 94/30AS in a Faraday cage (area required:<br>63m <sup>2</sup> ).....               | 80  |
| Figure 65: | Faraday cage: vertical .....  | 81  |
| Figure 66: | Floor layout B-C 70/20USR with filter box (area required: 36m <sup>2</sup> )                        | .82 |
| Figure 67: | Filter box on rear side of the magnet. ....   | 83  |
| Figure 68: | Diagram of quench duct pipe loss for the M-C 70/20AS magnet<br>(excludes bends, “smooth” pipe)..... | 86  |
| Figure 69: | Diagram of quench duct pipe loss for the M-C 94/20AS magnet<br>(excludes bends, “smooth” pipe)..... | 87  |
| Figure 70: | Diagram of quench duct pipe loss for the M-C 94/30AS magnet<br>(excludes bends, “smooth” pipe)..... | 88  |
| Figure 71: | Example of quench line installation for a B-C 94/20USR .....  | 89  |
| Figure 72: | Example of along quench line installation for B-C 70/30 USR.....                                    | 90  |





### 6.8. Tables

---

|           |   |    |
|-----------|---|----|
| Table 1:  | Standards on health and safety in the workplace for standard precautions and users, according to BGV B11 .....                              | 8  |
| Table 2:  | Health and safety standard in the workplace applicable under special conditions to selected subgroups of people, according to BGV B11 ..... | 9  |
| Table 3:  | Example of maximum retention periods (*) .....  | 9  |
| Table 4:  | Maximum tolerated floor vibration amplitude in the frequency range.....   | 24 |
| Table 5:  | Hardware installation data for system configuration with a Bruker USR magnet.....   | 33 |
| Table 6:  | Hardware installation data for system configuration with a Magnex AS magnet.....  | 33 |
| Table 7:  | Installation data overview: B-C 47/40USR, B-C 70/30USR .....  | 34 |
| Table 8:  | Installation data overview: B-C 94/20USR, B-C 94/30USR .....  | 35 |
| Table 9:  | Installation data overview: M-C 70/20AS, M-C 94/20AS, M-C 94/30AS .....   | 36 |
| Table 10: | Hardware installation data for a System configuration with a Magnex AS magnet. ....   | 49 |
| Table 11: | Hardware installation data for a System configuration with a Bruker USR magnet. ....  | 50 |
| Table 12: | Operating console dimensions.....   | 52 |
| Table 13: | Pressure drop in line elements at a mass flow of 1.0kg/s.....   | 84 |
| Table 14: | Pressure drop in line elements at a mass flow of 1.4 kg/s.....  | 85 |
| Table 15: | Pressure drop in line elements at a mass flow of 0.56 kg/s.....   | 86 |
| Table 16: | Pressure drop in line elements at a mass flow of 0.804 kg/s.....  | 87 |
| Table 17: | Pressure drop in line elements at a mass flow of 1.4 kg/s.....  | 88 |

