Facility Planning Information for the Bruker EPR-Spectrometer Series

ELEXSYS
ELECTRON PARAMAGNETIC RESONANCE

EMX plus

EMX micro

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Outline

0 Preface

This publication is intended to assist the EPR customer in selecting and preparing a location for an EPR-spectrometer system.

All information regarding the EPR-system location is provided here.

If the guidelines and instructions given herein are adhered to, the EPR-spectrometer system will perform well within its respective specifications.

Any compromise made in preparating for the EPR-system installation might degrade the spectrometer performance. In some cases this may lead to system operation even below specifications.

Once the preparations are completed, a Bruker service engineer will arrive and install the EPR-system. An acceptance test is performed during which the customer will receive a first introduction and training to the EPR-system.

1 Safety Notes

Safety is an important site planning consideration. The customer must ensure that the site is sufficiently spacious to allow safe and comfortable operation.

It is the sole responsibility of our customers to ensure safety in the EPR laboratory and to comply with local safety regulations. Bruker is not responsible for any injuries or damage due to an improper room layout or due to improper operating routines.

Caution

There are high magnetic fields associated with all magnets especially with the superconducting magnets. People with pacemakers or medical implants should not work in the immediate area of the magnet.

Further, warning signs should be posted at key locations to avoid unpleasant or dangerous occurences.

All governmental codes as well as any state legislation take precedence over any suggestions made in this publication.

2 Site Selection

For the installation and operation of an EPR-spectrometer quite a number of different requirements have to be met beforehand. The crates or the individual units must be moved to the place of interest, the system units have to be arranged optimally in the designated room, the proper electric and cooling supplies must be installed while complying to safety terms and electrical regulations.

The following sections detail the requirements for laboratory size and shape (sec. 2.1), the laboratory infrastructure and the floor loading (sec. 2.2 and 2.3) as well as the requirements for magnetic and the electric environment (sec. 2.4).

2.1 Laboratory Size and Shape

Every site is unique and customer requirements differ. Very often a compromise between system performance and practical realities has to be made. It may not be feasible to remove previously installed structures. The proposed site may appear quite adequate for present needs but future developments in EPR must be considered as well, *e.g.* extention to high-frequency EPR.

All the arrangements shown below have to be considered as one of the optimal suggestions for placing the various units of the EPR-spectrometer system. It may well be that your system does have more or less components. However, the figures depict the most common cases.

2.1.1 Ceiling Height

In most cases the standard ceiling height (about 2.50 m) is well above the required clearance. The exceptions are:

- **ELEXSYS systems E 600, E 680, E 680X**. Topping up of liquid helium of the superconducting magnet as well as sample insertion required a **ceiling height of at least 3.20 m**
- The **chiller**, **ER 091C**, requires a **ceiling height of nearly 3.10 m**. This is due to the height of the chiller itself and the top space requirement (air discharge proceeds via the top).
- In case of **low temperature experiments with liquid helium** (LHe), insertion of the transfer line into the LHe storage vessel may require an enlarged clearance. However, this is determined by the LHe storage tank dimension. Ask your LHe supplier for the respective details

2.1.2 Magnet System

Since the magnet is the heaviest element of the system, it is recommended that the magnet is put in place first. The other elements can then be placed according to the figures given below.

The back side of the magnet should be in a distance of at least 0.8 m to the wall. This ensures serviceability: The magnet and the rear side of the microwave bridge can be accessed easily. In addition, enough space is available for operation of the liquid nitrogen dewar for low temperature experiments.

Low-temperature EPR experiments and the regular topping up of cryogens for superconducting magnets require space behind or in front of the spectrometer. Depending on the local laboratory conditions there must be paths for the liquid helium and liquid nitrogen storage dewars. In addition, it is highly recommended to allow enough free space around superconducting magnets because of its possibly high fringe fields (see sec. 2.4).

NOTE

The dimensions, **F** and **E**, of the electromagnet given in Table 2-1 and the Figures must not be confused with the footprint of the magnet. **F** and **E** are the outmost extensions of the **combination of magnet and magnet table**. The latter can be dismounted from the magnet for transport.

NOTE

Due to the magnet's weight, the magnet cannot be moved without using lifting forks or a hoist.

2.1.3 Layout of the EPR-Spectrometer Systems

All the dimensions are in mm. The magnet dimensions **F** and **E** are listed in Table 2-1.

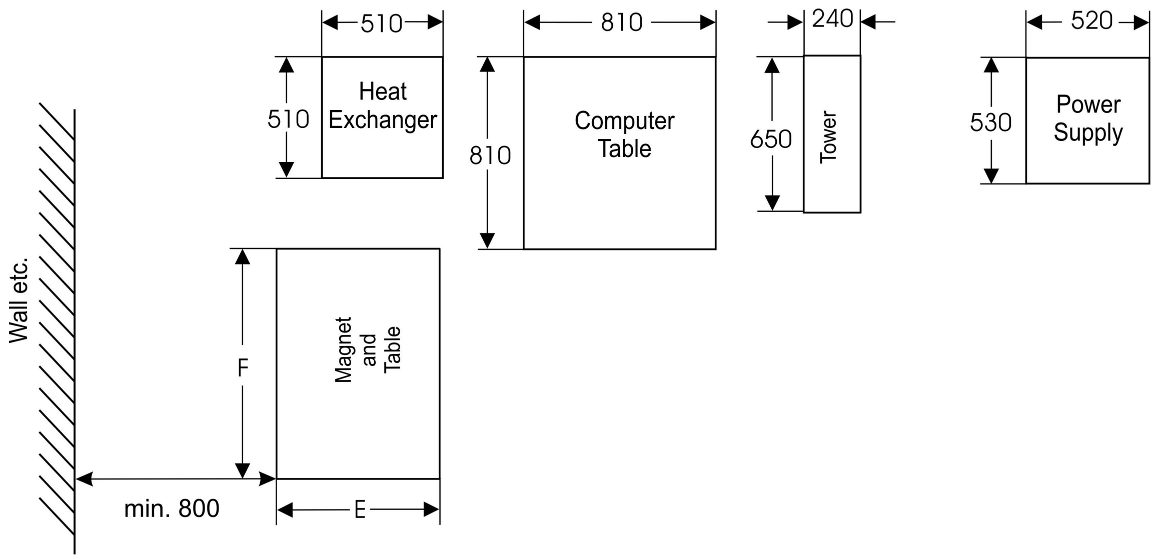

Figure 2-1: Top view of the layout of an EMXmicro system. Magnet dimensions are listed in Table 2-1. The mirror image configuration applies as well

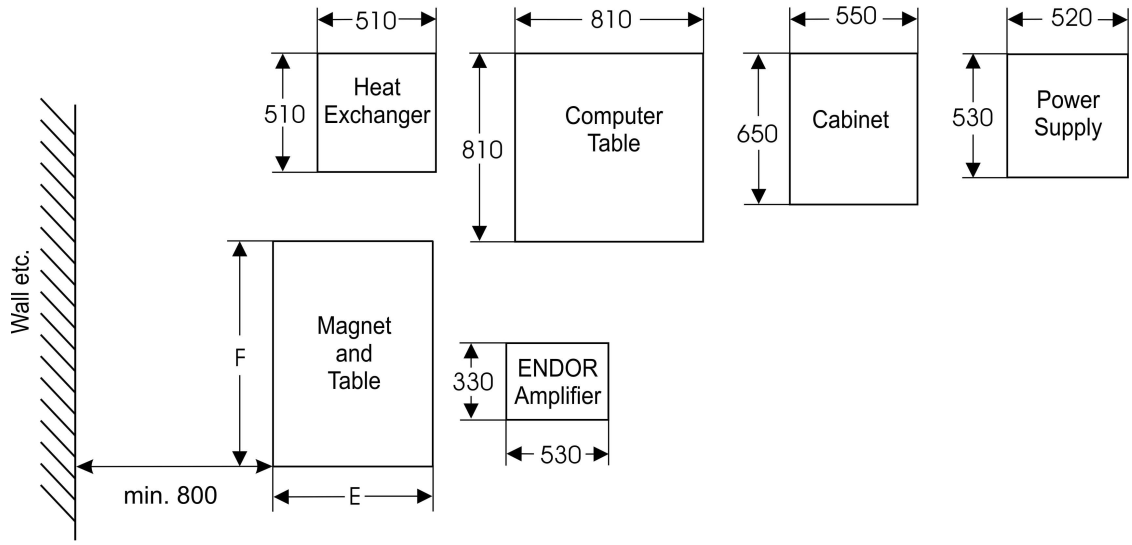

Figure 2-2: Top view of the layout of an <u>EMXplus</u> system. Magnet dimensions are listed in Table 2-1. The mirror image configuration applies as well

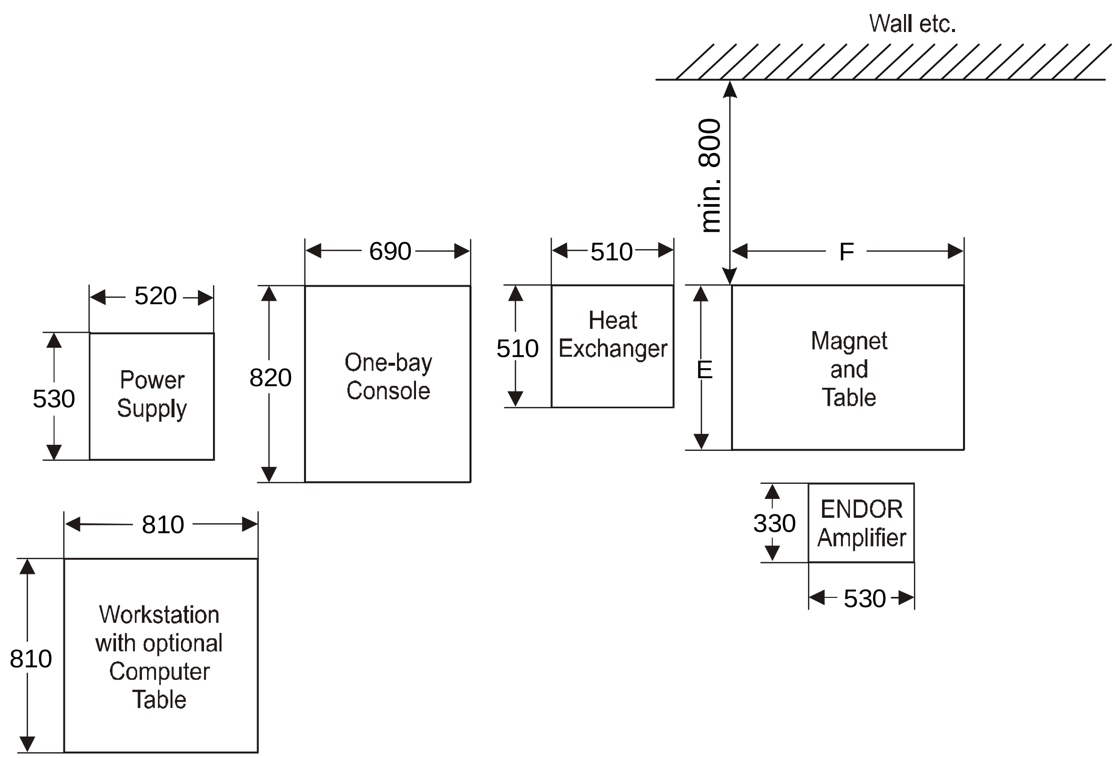

Figure 2-3: Top view of the layout of an ELEXSYS E 500. Magnet dimensions are listed in Table 2-1. It is possible to place the units in a mirror image configuration. This layout includes the E 560 option (ENDOR amplifier)

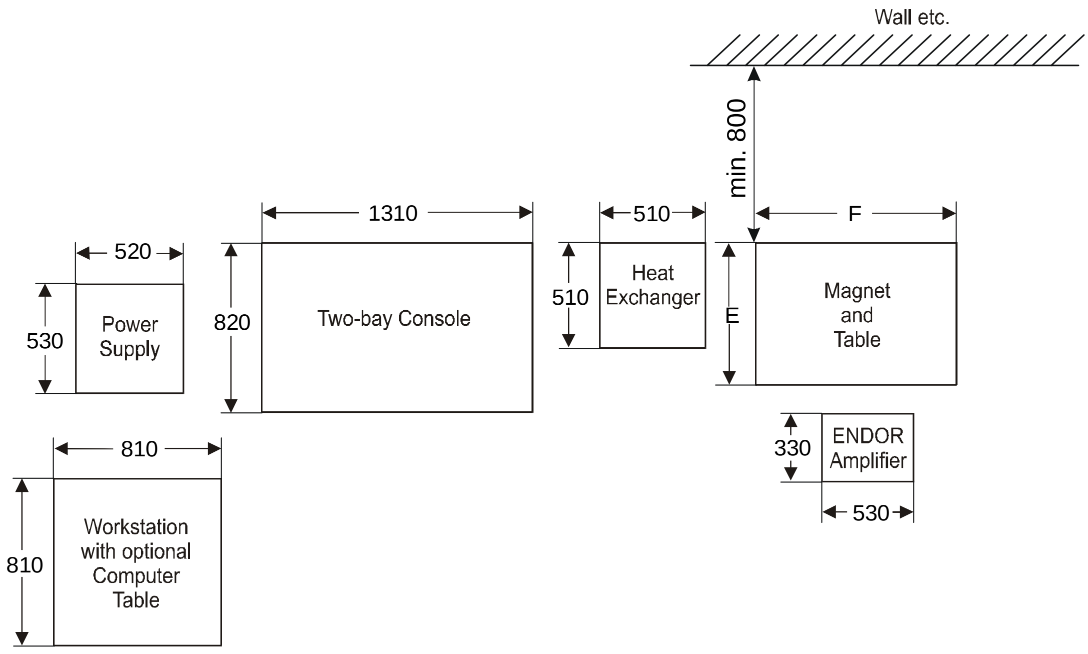

Figure 2-4: Top view of the layout of an ELEXSYS E 580 system. Magnet dimensions are listed in Table 2-1. It is possible to place the units in a mirror image configuration. The ENDOR amplifier is part of the E 560 DICE system, an option to the E 580.

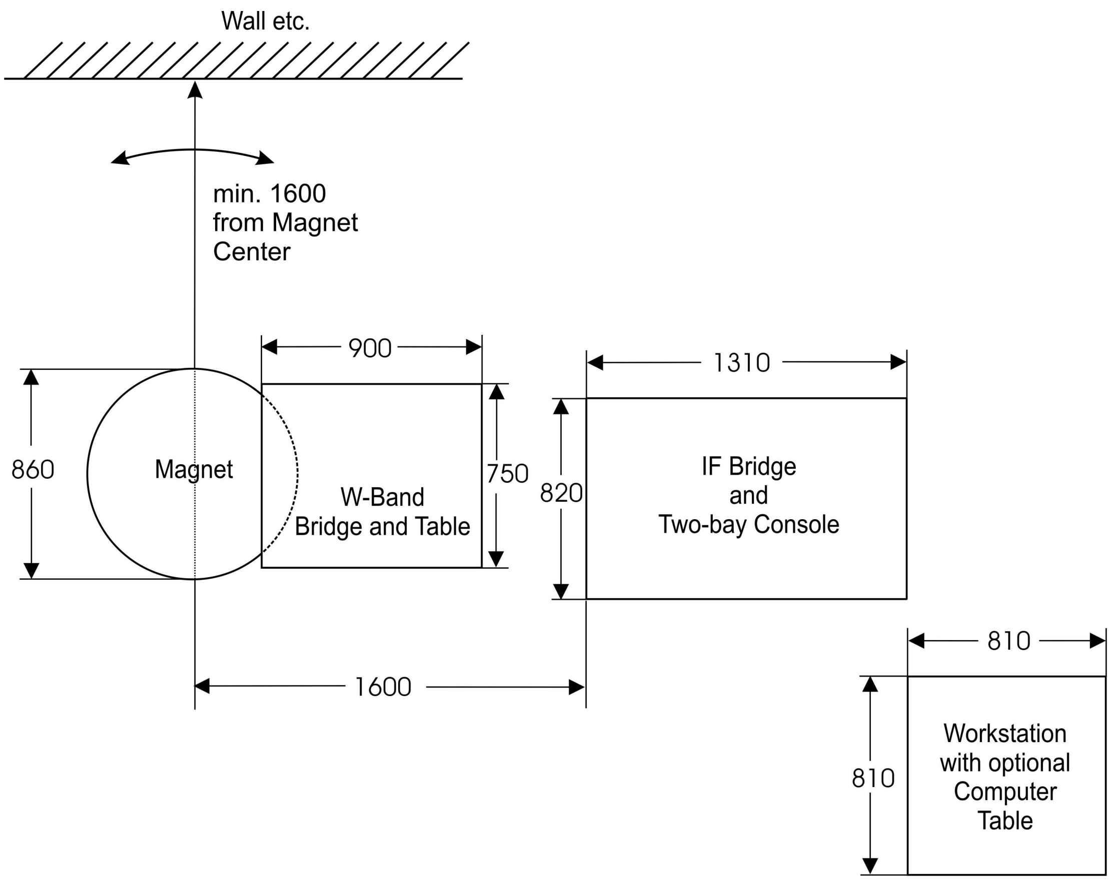

Figure 2-5 Top view of an ELEXSYS E 600 and E 680 layout. It is not possible to place the units in a mirror image configuration.

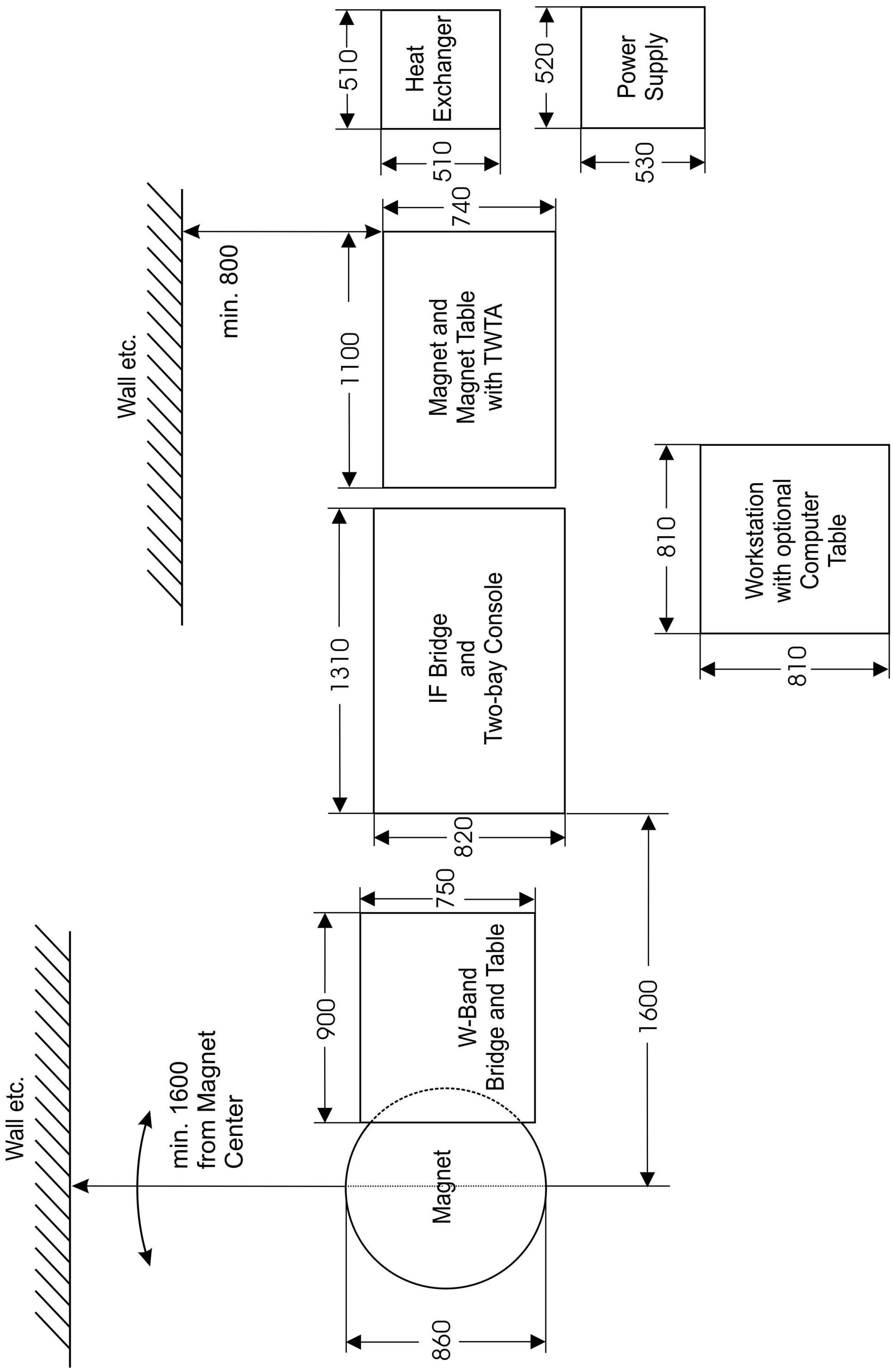

Figure 2-6: Top view of the layout of an ELEXSYS E 680X system. It is <u>not</u> possible to place the units in a mirror image configuration.

Table 2-1: Spatial dimensions, weight and footprint of the magnet systems. In case of the electromagnets ER 070-ER 077, *F* and *E* represent the overall depth and width of the magnet-table combination

Magnet	*Depth **E*** *mm*	*Width **F*** *mm*	*Height* *mm*	*Weight* *kg*	*footprint* $mm \times mm$
ER 070	740	1100	960	480	540×680
ER 071	740	1100	1090	960	680×680
ER 072	840	1100	1090	890	680×680
ER 073	970	1100	1280	1700	720×780
ER 074	970	1400	1280	1800	800×1200
ER 075	780	1100	1100	905	680 x 680
ER 077	1012	1560	1470	2700	800×1340
ER 078	1100	1560	1470	2900	800×1340
E-600-1071 (Hybrid[3])	860	860	1890	700	860 (circle)
EPR 6T-SC	860	860	1760	550	860 (circle)

Table 2-2: Spatial dimensions and weight of power supplies, consoles, heat exchangers, chillers and microwave bridges. (*)Optional

	Depth / mm	*Width / mm*	*Height / mm*	*Weight / kg*
Power Supplies				
EMX 080	650	550	340	63
EMX 081	650	550	340	98
ER 080	510	510	305	53
ER 081	400	510	305	88
ER 083	530	520	1040	220
ER 085	530	520	1040	230
ER 086	780	600	1415	370
Consoles				
EMXmicro Tower	650	240	550	25
EMXplus Cabinet	650	550	600	70
EMX Table(*)	800	800	730	40
E 500 Console	820	690	1300	180
E 540 Console	820	1310	1300	410
E 580 Console	820	1310	1300	290
E 600 / 680 Console	820	1310	1300	360
Heat Exchangers				
ER 090-ER 093	455	500	810	83
Chillers				
ER 090C	585	1000	540	110
ER 091C	975	770	1560	350
Microwave Bridges				
SuperX, PremiumX etc.	490	490	155	30
ER 041 XG / K	490	490	155	30
E-580-1010	610	800	185	45

2.1.4 Chiller

If the system is cooled with a chiller (see section 3.2.1, p. 19), further spatial requirements have to be met (cf. Table 2-2 for dimension and weight details). The space requirements for the two chillers are given in **Table 2-3**.

Table 2-3: Spatial requirements for the chillers[1]

Chiller	front[2]	back	left	right	height
ER 090C	1.5 m	0.5 m	1.0 m	1.0 m	1.0 m
ER 091C	./.	./.	1.0 m	1.0 m	1.5 m[3]

[1]The dimensions are from the respective housing of the chiller and not from the center of the chiller
[2]The front side is equivalent to the operator's side
[3]Note, the height of the ER 091C is already ca. 1.6 m (cf. Table 2-2)

In case of an indoor chiller with forced air cooling (*e.g.* model ER 090C), it is recommended to place the chiller in a separate room. This is because of the noise level during operation (50-60 dB(A)). Note, the chiller's main power switch may be operated remotely.

2.2 Laboratory Environment and Infrastructure

2.2.1 Transportation Route and Customer's Responsibilities

The customer is responsible for moving the magnet and the instrument to the site within the building. Unless otherwise agreed, delivery is to your loading dock. It is the sole responsibility of the customer to hire riggers for transport to the site.

Accessibility to the site must be considered to ensure adequate transportation route clearance for the instrument components. All flooring and elevators enroute to the laboratory must be able to support the weigth of the instrument including the magnet.

2.2.2 Transportation of Equipment to the Laboratory

The spectrometer console and the magnet are shipped in crates or mounted on loading pallets. If possible, the sealed boxes should be transported to the installation site.

2.2.3 Laboratory Access

Extensive traffic or public access should be avoided. Access to the lab should be restricted to trained personnel.

2.2.4 Environmental Conditions

The laboratory environment is a significant consideration in the installation process.

The heat dissipated into the room is approximately 12000 BTU / h, or 3.5 kW. Sufficient air conditioning should be provided to maintain the following conditions:

Temperature: 18 °C ... 30 °C (64 °F ... 86 °F)
Humidity: 20 % ... 60 %

If air conditioners are used, they must be filtered.

Microphonics due to noise as well as mechanical vibrations will make spectrum acquisition unreliable. However, commonly no special vibration isolation is necessary (see also section 2.3 below).

The magnet system must be protected from any drafts originating from heating systems, open windows and air conditioning outlets. Shielding may be required to minimize air flow.

Dust and smoke should be avoided since they might leave deposits inside the cavity and add spurious lines to your spectra.

Avoid installing the console below any fire safety sprinklers as water may severly damage parts within the console.

NOTE

The site must meet all local safety codes.

2.3 Floor Loading

The load carrying capacity of the floor in the prospective laboratory is of utmost importance in selecting an installation site.

The floor must be strong enough to support the weight of the instrument, especially of the magnet system. Table 2-1 and Table 2-2 list the weights of the respective units. The building specifications should be reviewed to determine the floor loading capability of the location. In case of insufficient structural strength, I-beams or a weight distribution plate may be utilized.

The best floor for a laboratory is a concrete slab poured directly on the ground.

To minimize the effects of an uneven floor a heavy felt mat or carpet may be placed between a weight distribution plate and the floor. Such padding must be anti-static. No special floor covering is necessary. However, if carpeting is used it must be of anti-static type. In case of tiles, under the magnet a weight distribution plate may be necessary to prevent them from breakage.

In addition, the floor should be rigid enough to suppress or at least dampen out vibrations. If one expects vibrations due to external factors such as heavy mechanical equipment, installation of heavy flat padding or carpeting under the magnet might be desirable.

2.4 Magnetic and Electrical Environment

2.4.1 Surrounding of the EPR-system

The EPR-system should be placed away from other magnetic fields. If this is not to be avoided, their relative orientation should be perpendicular to each other.

The EPR-system should not be located adjacent to elevator shafts or other large metal objects in motion. The presence of such objects in the vicinity of the magnet might alter the homogeneity of the field inside the air gap.

The EPR-system should be located away from any source of electromagnetic radiation such as high power wires, high voltage lines, large motors, radio transmitters, radar, or any other microwave emitting source.

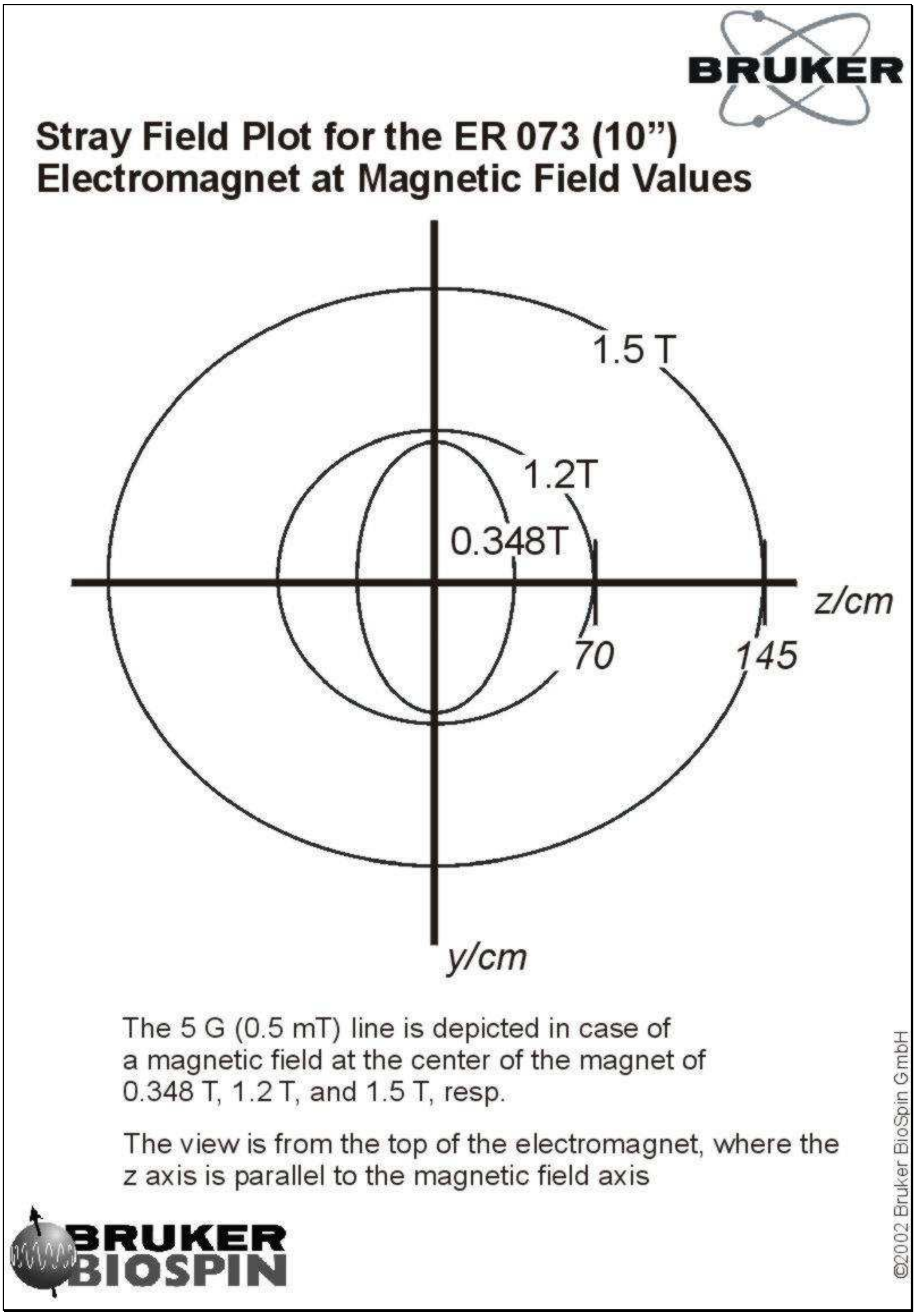

Figure 2-7: The 5 Gauss (0.5 mT) lines of the Bruker ER073 10" Electromagnet for different center fields.

2.4.2 Superconducting Magnets

Superconducting magnets may be operated in complete safety as long as correct procedures are adhered to, negligence can however result in serious accidents.

Caution

Superconducting magnets are potentially hazardous due to:

- The effect on people fitted with medical implants.
- The large attractive forces it may exert on metal objects.
- The effect magnetic fields have on certain equipment.
- The large content of liquid cryogens.

Caution

The operation of cardiac pacemakers may be affected by magnetic fields. There is also a possibility of harmful effects to people fitted with ferromagnetic implants such as surgical clips.

Under no circumstances should people fitted with cardiac pacemakers be allowed to approach the magnet.

The 0.5 mT line represents a suitable safety limit for medical devices. This effectively imposes a safety limit upon the general public.

The customer must ensure that areas within which the fringe field exceeds 0.5 mT are not open to public.

NOTE

A magnetic field surrounds the magnet in all directions. This field (known as the fringe field) is invisible. Hence adequate **warning signs** have to be posted in areas close to the magnet. The spatial extention of the fringe field will depend on the magnet. Moreover, the higher the frequency and the larger the bore, the larger the fringe field.

NOTE

The fringe field exists in three dimensions and is often significantly greater along the main field direction. Since the fringe field will permeate walls, ceilings and floors, remember to consider personnel and equipment on the floors immediately above and below as well as next door to the magnet. A list of maximum allowed fringe field strenghts for different devices is given in the Appendix.

The fringe field of the Bruker/Magnex 6 T EPR Magnet is larger than that of conventional solenoid magnets.

NOTE

Due to the split-coil design of the EPR magnet, the magnetic field direction is horizontally aligned.

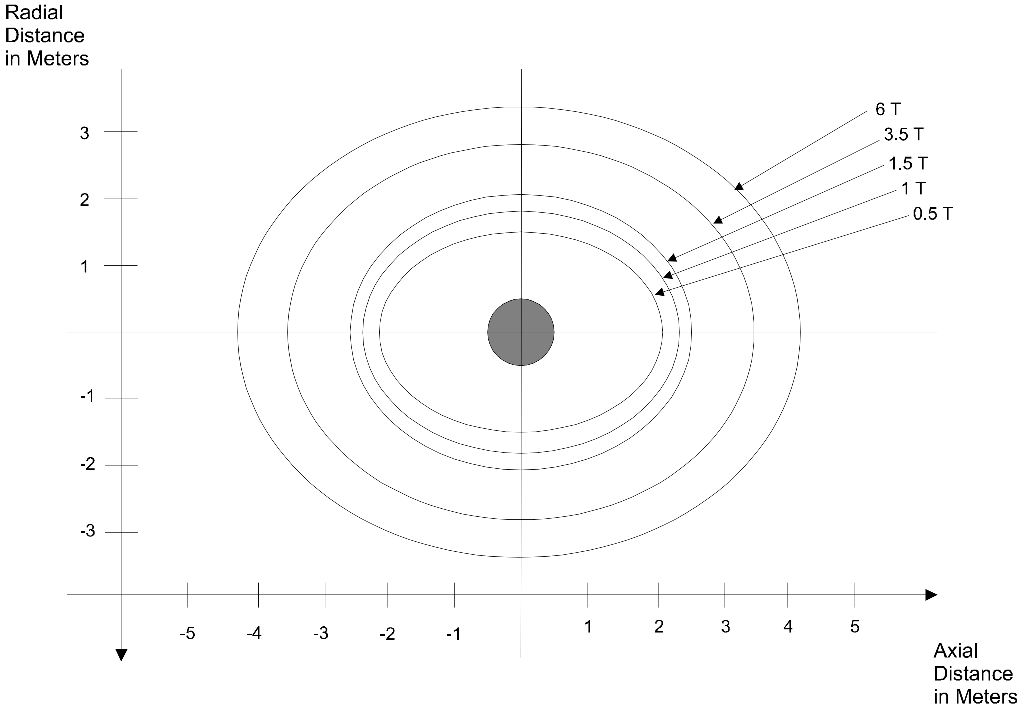

Figure 2-8: The 5 Gauss (0.5 mT) lines of the Bruker 6 Tesla EPR Magnets for different center fields.

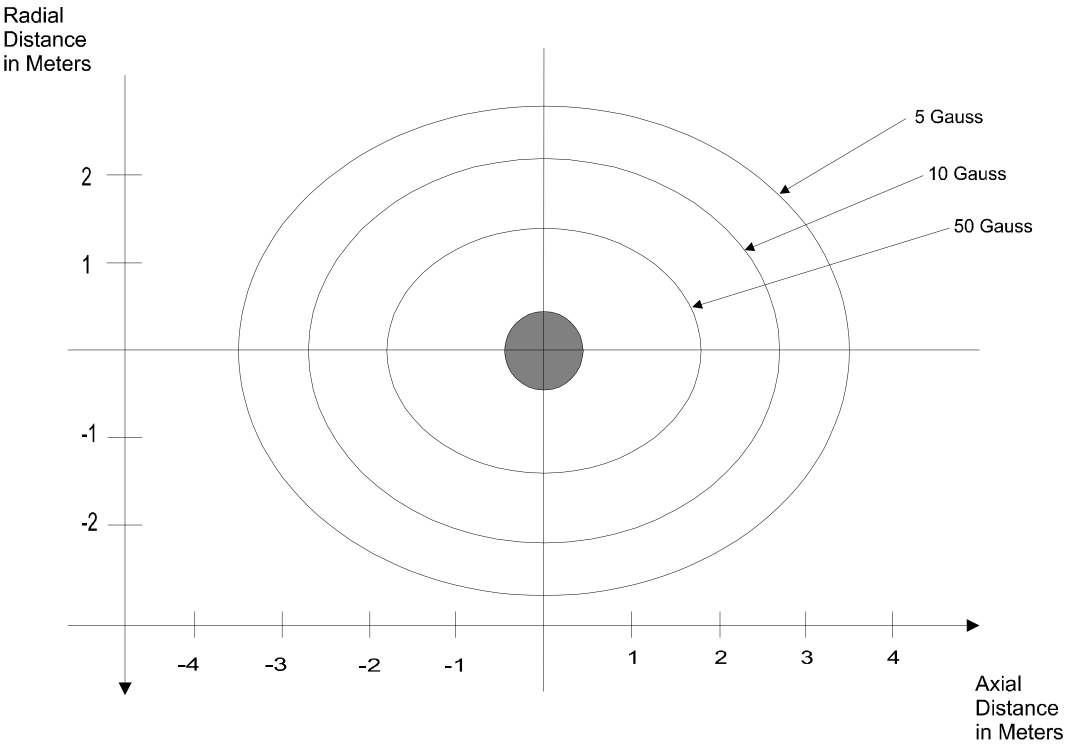

Figure 2-9: The 5, 10, and 50 Gauss lines (0.5, 1.0 and 5 mT) of the Bruker 6 Tesla EPR Magnets with a center field of 3.5 T.

Site Considerations for a Superconducting Magnet

While minimum requirements for routine EPR operation are not particularly stringent, it is worthwhile to optimize the magnet's environment if more sophisticated experiments are carried out.

The presence of any ferromagnetic materials in the immediate vicinity of the magnet will decrease the superconducting magnet's homogeneity and may degrade overall performance. The effect of such objects as metal pipes, radiators etc. can be overcome by appropriate shimming but where possible this should be avoided.

When estimating the effect of ferromagnetic materials the following points should be noted:

- The strength of interaction depends most strongly on distance (by the 7^{th} power) whereas it varies in direct proportion with mass
- Moving magnetic material will cause a much greater problem than static masses. In addition, the effect of moving masses (*e.g.* metal doors, chairs etc.) upon the magnetic field inhomogeneity is rather unpredictable

In general, there should no static iron be present within the 5 mT region (cf. Figure 2-5 and Figure 2-6). The customer should consider to remove iron piping that is likely to lie within such fields prior to installation. If the superconducting magnet must be located close to iron or steel support beams, the alignment of the beam direction to the magnetic field direction becomes important: The beams should pass through or should be symmetric to the magnet axis.

The 5 mT (50 G) limit is suitable for a mass of up to 200 kg. For greater masses the limiting area must be extended accordingly. The presence of static magnetic material close to the magnet presupposes that these masses are firmly secured *e.g.* radiators, pipes.

No moveable masses should be located within the 0.5 mT (5 G) region. Potential sources of moving iron are metal doors, drawers, tables, chairs etc. For larger masses than 200 kg distorting effects may be experienced at fringe fields as low as 0.1 mT (1 G).

For high precision work extending the region within which there are no moveable magnetic material to 0.05 mT may be justified.

Table 2-4 gives a list of recommended limits outside which various objects should be located with respect to the fringe field. Note, the fringe field depends on the magnetic field strenght as well (cf. Figure 2-8). It must be emphasised that such recommendations represent a situation which may not always be achievable.

Table 2-4: Recommended maximum fringe field strenght for different objects

Object	*max. Fringe Field*
Steel reinforced walls	5 mT / 50 G
Iron beams	3 mT / 30 G
Radiators, plumbing pipes	3 mT / 30 G
Metal table, metal doors	3 mT / 30 G
Filing cabinet, steel cabinet	3 mT / 30 G
Massive objects, e.g. boiler	3 mT / 30 G
Hand trolley	0.2 mT / 2 G
Elevators	0.05 mT / 0.5 G
Cars, fork-lifts	0.05 mT / 0.5G
Trains, trams	0.01 mT / 0.1G

3 Site Preparation

3.1 Electrical Aspects

The power outlets within the laboratory must be of sufficient capacity to meet the power requirements of the instrument, the instrument accessories, and other possible instruments used inside the laboratory.

The EPR-spectrometer power consumption depends mainly on the magnet power supply. The power consumption of the cabinet or the console depends on the amount of accessories installed in the actual configuration.

Both the magnet power supply and the spectrometer cabinet/console are based on 230 VAC or 400 VAC. In countries in which the voltage differs, appropriate transformers have to be used. For the most common cases, Bruker offers transformers which have been tailored for the use with the EPR-spectrometer systems.

3.1.1 Power and Phase Requirements

All systems with a power supply greater than 1 kW are three phase systems. Only the EMXplus/micro-6/1 spectrometer (6" magnet and 1 kW power supply) requires one single phase supply at 220-230 VAC. Optionally it can be supplied with two phases with 110 V. See Table 3-1 for the power supply connection.

The instrument power supply must be a well grounded four wire, three phase dedicated line in delta configuration, or a five wire, three phase star configuration.

3.1.2 Breaker Box

The customer should provide the necessary termination(s) of a circuit breaker or fuse box:

- One single phase termination for an EMXplus-6/1 or an EMXmicro-6/1
- Two three phase terminations for the E 680X as well as the E 540 systems
- One three phase termination for all the other systems.

The termination should be located not more than 3 m (10 ft) from the designated position of the magnet power supply and/or console.

We recommend a hard-wired connection to avoid accidental loss of power. By such an occurence, the instrument might be damaged. If the voltage variations exceed ±10%, a voltage regulation must be implemented. It is advisable not to connect any other appliances like an air conditioner to the same power lines of the spectrometer.

Caution

Access to the circuit breaker must be kept unobstructed.

3.1.3 Power Line Connectors

Please note, that the EPR spectrometer systems will be delivery without a power line connector. Please make sure, you have the proper connector available to fit the power outlet socket.

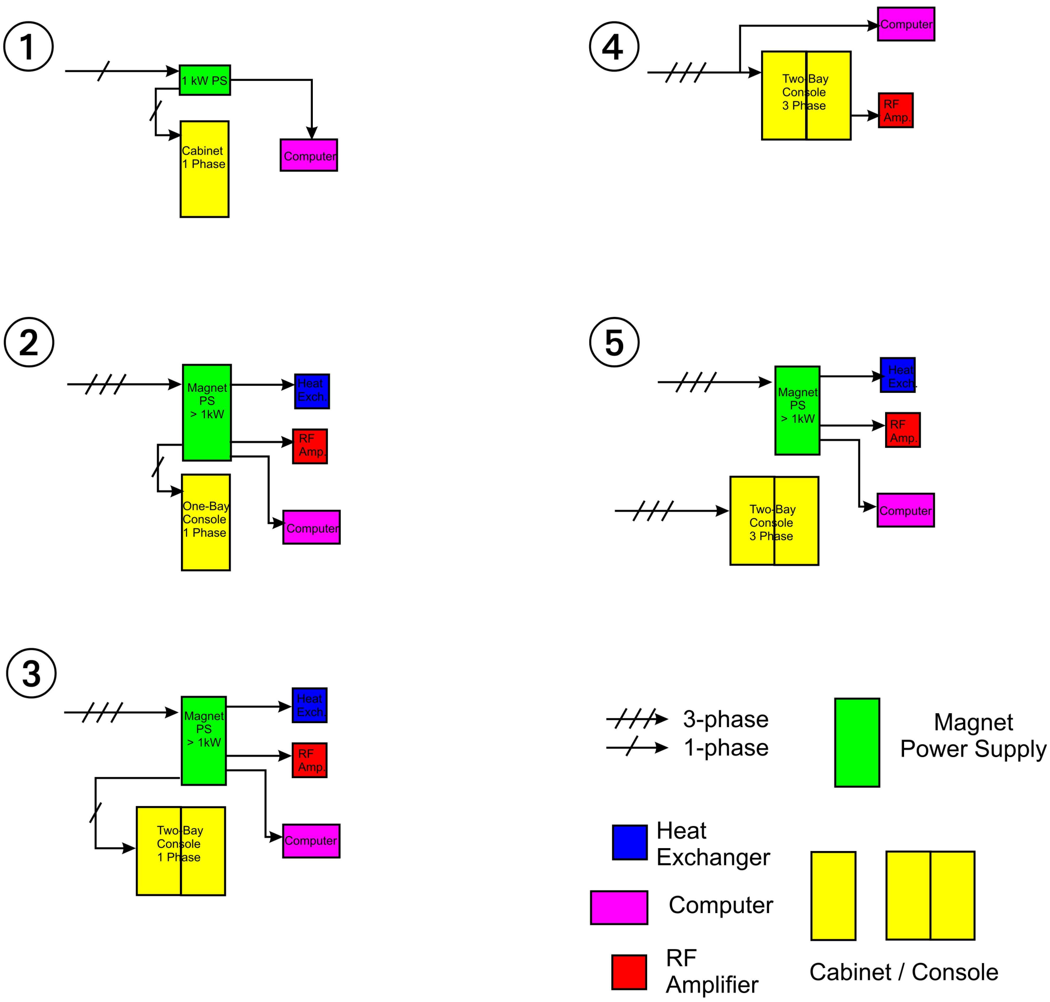

Figure 3-1: Power supply connection diagrams. Connection diagram (1) applies for the EMXplus-6/1 or EMXmicro-6/1. Diagram (2) applies for all EMXplus/micro, E500 and E560 spectrometers with large magnet; diagram (3) for all E580 also with large magnet. The connection for E600 and E680 is given in diagram (4), while the diagram for an E540 and an E680X is depicted in diagram (5).

Table 3-1: Power consumption of the various EPR-systems and recommended breaker current

Spectrometer Type	*Magnet power supply power consumption*	*Complete system power consumption(1)*	*Recommended minimum breaker current 400 / 440 V (three phase)*
EMXplus/micro-6/1	1.7 kW	3.2 kW	20 A (230 V single phase)
EMXplus/micro-*/2.7(2)	3.4 kW	4.9 kW	30 A
EMXplus/micro-*/12	15.6 kW	17.1 kW	50 A
EMXplus/micro-*/15	22.0 kW	23.8 kW	60 A
EMXplus/micro-*/22.5	30.0 kW	31.8 kW	80 A
E 500-A(3)	./. kW	4.2 kW	20 A (230 V single phase)
E 500-*/2.7	3.4 kW	8.2 kW	40 A
E 500-*/12	15.6 kW	20.4 kW	50 A
E 500-*/15	22.0 kW	27.1 kW	60 A
E 500-*/22.5	30.0 kW	35.1 kW	80 A
E 540-*/2.7	3.4 kW	8.1 kW	16 A + 32 A
E 580-A	./. kW	5.5 kW	20 A
E 580-*/2.7	3.4 kW	9.7 kW	40 A
E 580-*/12	15.6 kW	21.9 kW	50 A
E 580-*/15	22.0 kW	28.5 kW	60 A
E 580-*/22.5	30.0 kW	36.5 kW	80 A
E 600	./. kW	4.4 kW	20 A
E 680	./. kW	4.8 kW	20 A
E 680X-*/2.7	3.4 kW	12.5 kW	20 A + 40 A(4)
E 680X-*/12	15.6 kW	24.7 kW	20 A + 50 A(4)
E 680X-*/15	22.0 kW	30.1 kW	20 A + 60 A(4)
E 680X-*/22.5	30.0 kW	38.8 kW	20 A + 80 A(4)

(1) In addition to the magnet power supply, under 'complete system' the following is considered:
EMXplus/micro: Cabinet, heat exchanger, variable temperature unit;
E 500: Console, heat exchanger, variable temperature unit, acquisition server and ENDOR unit;
E 540: Console, heat exchanger, acquisition server and gradient power supply;
E 580: Console, heat exchanger, variable temperature unit, acquisition server, ENDOR unit and TWTA;
E 680X: Console, heat exchanger, variable temperature unit, acquisition server, ENDOR unit and TWTA
(2) The * stands for the magnet size, *e.g.* 10 for a 10" magnet ER 073
(3) An E 500-A is an ELEXSYS E 500 system without magnet and magnet power supply
(4) Two three-phase lines with one breaker each are required, cf.

3.2 System Cooling

In general, system cooling is done with either forced air or water cooling. Forced air cooling is applied on the cabinet or console as well as in case of the RF amplifier.

The main equipment which has to be water-cooled is:

- The magnet power supply

- The electro-magnet[1]
- The microwave bridge

3.2.1 Heat Exchanger vs. Chiller

Bruker recommends the use of a heat exchanger with all of the EPR-spectrometers. Tap water will cause residues to build up in the cooling system. For the ER 081 or EMX 081 power supplies corrosion may also occur. No warranty against any water-related problems is given under such circumstances.

With a heat exchanger, water is pumped at sufficient rate through a closed circuit (the secondary circuit) continuously. Tap water (the primary circuit) is used only to that extent that it must provide the required cooling power to establish a constant temperature of the secondary circuit. This way, tap water consumption is minimized and tap water is not in contact with system devices. In addition, the EPR-system is always cooled with constant temperature of the coolant, thus, establishing reliable system performance.

However, for heat exchanger operation, an upper temperature limit exists for the primary circuit: The maximum allowed temperature of the input water is restricted to 18 °C (64 °F). This is due to working principle of the heat exchanger in which the temperature difference between primary and secondary circuit is used only for heat exchange. For temperatures above that limit, a chiller has to be used for system cooling.

Chillers are available for indoor and outdoor operation. The chiller features three circuits: the refrigeration circuit, the water circuit and the cooling circuit. The refrigeration circuit makes use of a freon. The water circuit is a closed system for cooling the attached devices. Forced air or external water may be utilized for the cooling circuit (cf. section 2.1.4, p. 10).

3.2.2 Requirements of the primary water circuit

In what follows, it is assumed that a heat exchanger is utilized for system cooling (see above). The primary circuit water system must meet the requirements given in Table 3-2, which are mainly dependent on the magnet and the magnet power supply.

For the secondary circuit, deionized distilled water must be used. The minimal resistivity should be 1 MΩ.

3.2.3 Tubing

Inlet and outlet water piping depends on the magnet power supply and the magnet itself. New piping should be thoroughly flushed. The recommended tubing i.d.'s are given in Table 3-3. Appropriate hoses are part of the EPR-system.

The inlet pipe should be fit with a shut-off valve, a small particle filter, a flow meter, a pressure gauge, and a thermometer. The particle filter should remove

[1]In case of the superconducting magnet, Hybrid[3], only the room-temperature magnet has to be cooled

dust and sediment greater than 50...100 µm from the water. The low temperature control must be provided to avoid condensation inside the system.

Table 3-2: Requirements for the water cooling

Spectrometer Type[(1)]	*Approx. heat power*[(2)]	*Recommended flow rate*[(3)]	*Max. input water temperature*	*Min. pressure drop*
EMX-6/1 E 600 E 680	2.5 kW	8 l/min	18 °C (64 °F)	0.10 MPa (1.0 bar)
EMX-*/2.7 E 500-*/2.7 E 580-*/2.7 E 680X-*/2.7	4.5 kW	14 l/min	18 °C (64 °F)	0.20 MPa (2.0 bar)
E 540-*/2.7	6.5 kW	20 l/min	18 °C (64 °F)	0.25 MPa (2.5 bar)
EMX-*/12 E 500-*/12 E 580-*/12 E 680X-*/12	15 kW	45 l/min	18 °C (64 °F)	0.30 MPa (3.0 bar)
EMX-*/15 E 500-*/15 E 580-*/15 E 680X-*/15	23 kW	69 l/min	18 °C (64 °F)	0.40 MPa (4.0 bar)
EMX-*/22.5 E 500-*/22.5 E 580-*/22.5 E 680X-*/22.5	30 kW	90 l/min	18 °C (64 °F)	0.45 MPa (4.5 bar)

(1) EMX stands equally for EMXplus and EMXmicro

(2) This approximate heat power contains only the heat to be dissipated by water cooling, not that part dissipated by forced air.

(2) This recommendation is based on maximum allowed input water temperature of 18 °C. The lower the input water temperature, the lower the flow rate.

Table 3-3: Recommended tubing i.d. for the different magnet power supplies and magnets

Magnet or Magnet Power Supply	ER 070 - ER 072 ER 080 - ER 082 EMX 080 - EMX 081	ER 085 - ER 087	ER 073	ER 077 - ER 078
Tubing i.d.	8 mm	13 mm	16 mm	25 mm

3.3 Environmental Conditions

The laboratory environment must meet the specifications given in section 2.2.4 (pp. 10). Appropriate air conditioning must be installed.

4 Upon System's Arrival

When the EPR spectrometer arrives examine the shipment for any damage or check the shock-/tilt-indicators attached to the crates or devices. In case of damages note it on the carrier's release form.

Notify your Bruker's representative about any dented crates or any other apparent damage.

Do not discard any packing materials before you are sure they do not contain any further spectrometer parts.

5 Installation Preparation

5.1 Moving the Instrument

The magnet and control console should be moved to the lab while still mounted within crates or on shipping pallets. Special care should be taken when moving the magnet. It is heavy and, moreover, has a high center of gravity.

Fork lifts or pallet jacks have to be organized by the customer.

Contact your Bruker representative when ready for installation.

5.2 EMXplus, EMXmicro and ELEXSYS E 500, E 540 and E 580 Systems

The necessary infrastructure has to be ready before the installation starts.

Consult sections 'Site Selection' and 'Site Preparation' (section 2, pp.4 and section 3, pp. 16) for the details.

5.3 ELEXSYS E 600, E680, and E 680X Systems

For successful installation of a High-Frequency EPR-spectrometer system, further installation requirements have to be met.

For vacuum pumping of the superconducting magnet a turbomolecular pump with 100 l/s power and a two-stage pump with 4 m^3/h are recommended. A helium leak detector may be useful during installation.

Table 5-1: Check list for ELEXSYS High-Frequency Systems E 600, E 680 and E 680X

#	*Issue*	*Note/Requirement*
1	Laboratory space	see section 2.1, pp. 4
2	Laboratory access	see section 2.2, pp. 10
3	Cooling water outlet	see Table 3-2, p. 20
4	Electricity outlet	see Table 3-1, p. 18
6	Vacuum pump available	100 l/s, 4 m^3/h
7	Nitrogen gas	200 bar
8	Helium gas	200 bar
9	Liquid nitrogen	400 l
10	Liquid helium	400 l
11	Adaptor at helium storage dewar for transfer siphon	depends on on-site helium storage dewars
12	Adaption of magnet to recovery line	DN 25 outlet at magnet
13	Sufficient capacity of the helium recovery system	100 l LHe/h correspond to 74 m^3 helium gas per hour
14	Protection considerations of high magnetic fields taken into account	see section 2.4, pp. 11

The customer in advance must prepare the positions listed in **Table 5-1**. The installation of the ELEXSYS High-Frequency system cannot begin, if not all of these requirements are fulfilled.

6 Appendix

6.1 Fringe Field Limits for Selective Devices

Various devices are affected by the magnet field produced by an superconducting magnet. They should be located outside the limits specified in the following (see Figure 2-8 and Figure 2-9 for corresponding fringe fields).

5 mT Magnet power supply, RF power amplifier, turbomolecular pumps, helium mass spectrometer leak detector.

Electrical transformers which are a component of many electrical devices may become magnetically saturated in fields above 5 mT. The safety characteristics of equipment may also be affected.

2 mT Magnetic storage material, *e.g.* tapes.

The information stored on tapes may be destroyed or corrupted.

1 mT Computers, X-ray tubes, radiography equipment, credit cards, bankers cards, watches, clocks, cameras.

The magnetically stored information in computers and credit cards may be corrupted in fields greater than 1 mT. Small mechanical devices such as watches or cameras may be irreparably damaged. (Digital watches may be worn safely).

0.5 mT Cathode ray tubes, monochrome computer displays.

Magnetic fields greater than 0.5 mT will deflect a beam of electrons leading to a distortion of the screen display.

0.2 mT Colour computer displays.

Colour displays, televisions, and video monitors are more sensitive to distortion than monochrome displays. The precise threshold field strength at which computer displays are distorted will depend on shielding and orientation relative to the magnet.

0.1 mT Only very sensitive electronic equipment such as image intensifiers, nuclear cameras, electron microscopes, PET scanners, CT scanners, ultrasound instruments, linear accelerators, lithotriptors, high-precision measuring scales, and cyclotrons will be affected.