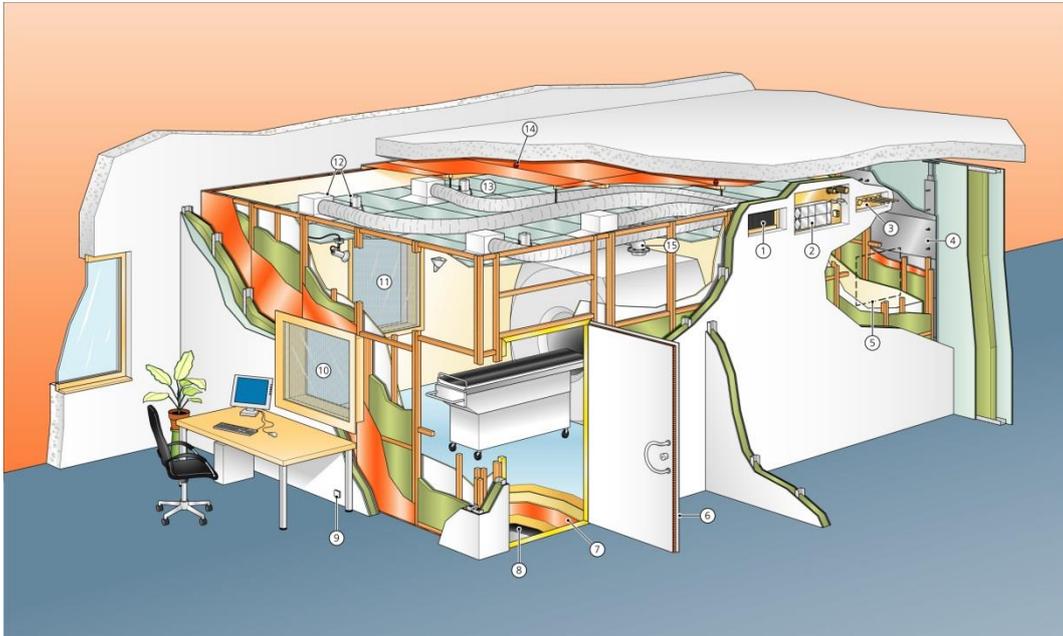


# ARCHITECTURAL SITE PLANNING GUIDE FOR MRI ROOMS

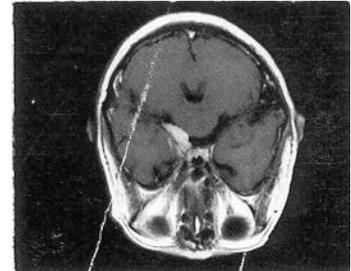
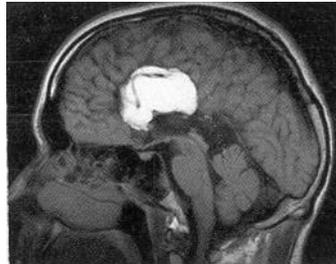


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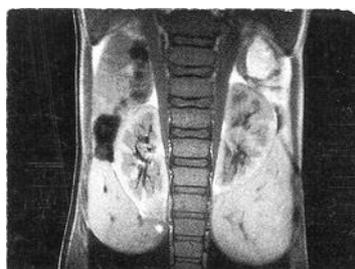
# 1. Magnetic Resonance



Magnetic Resonance Imaging (MRI) is a modern diagnostic imaging technology for radiologists. The system uses echo principles to acquire data from the body of a patient, which a powerful computer then reconstructs to an anatomical image. No x-ray radiation is present.

The patient must be placed in a homogeneous magnetic field. Hydrogen nuclei (Protons) in the human body are excited with radio waves and during quiet periods their echo is transformed to an image on a video screen.

The very powerful magnet and the special environment that is required are unknown domains for many architects. It is important that they understand all of the requirements that must be satisfied to guarantee trouble free and safe operation of an MRI unit in a clinic or hospital.



## 2. The magnet

Field strength is an important factor. It is quoted in TESLA or GAUSS:

$$1 \text{ Tesla} = 10'000 \text{ Gauss} \quad (1\text{T} = 10'000 \text{ G}); \quad 1\text{mT} = 10 \text{ G.}$$

Clinical magnets between 0,2 and 3,0 Tesla are used by different system manufacturers.

- Low field magnets from 0,2 to 0,4 Tesla are predominantly permanent magnets. They do not need electricity or cooling, but require a fairly stable temperature environment.
- Mid field magnets from 0,5 to 1,0 Tesla are primarily super conductive and are designed similarly in concept to high field magnets. Some manufacturers use resistive (electro) magnets which require much more power and a large cooling unit when in actual use. The magnetic field of a resistive magnet is turned off when the system is not in use.
- High field magnets from 1,0 to 3,0 Tesla are exclusively super conductive. Superconductivity is a phenomenon whereby certain materials lose their resistance to electric current at temperatures near the absolute zero (-274°C). This is why these magnets are filled with liquid helium. The magnetic field is always present.

The above defined field strengths are measured inside the magnet where the patient is situated. It should be homogeneous for non-distorted images.

Like with any other magnet, the field lines or flux leave one pole of the magnet and enter the other. These lines are imaginary and form a closed loop. Most magnets have symmetric fields. Therefore the same fringe field typically exists below as well as above the magnet.

When placing a magnet, several aspects should be considered. Of primary importance are the following:

- Weight: A magnet may be as light as 3,5 tons, or as heavy as 40 tons depending on its construction, field strength and the amount of shielding.
- Magnetic shielding may be necessary to limit the fringe field in certain sites. It may also be necessary to improve image quality by eliminating external disturbances.
- Safety of people. In most countries it is generally accepted that a controlled area must exist. This area is limited by the 0,5 mT (5 Gauss) line. Fields stronger than 0,5 mT should not extend into any public area. Fences, access controlled doors, warning signs and places for safe keeping of magnetic material, money and credit-cards must all be foreseen.
- Homogeneity of the field inside the magnet is important to obtain quality images. Ferrous material in close proximity such as reinforcing iron, columns, girders, elevators and cars all influence the homogeneity. Their existence must be known and evaluated by the system manufacturer. It should be noted that certain disturbances can be corrected on the magnet by shimming, which can be done by the manufacturer on site.

### 3. Magnetic shielding

As stated previously, magnetic shielding primarily protects the environment from the strong magnetic field of the magnet and assures the safety of the public. Several approaches exist to reduce the extension of the fringe field. They are classified as:

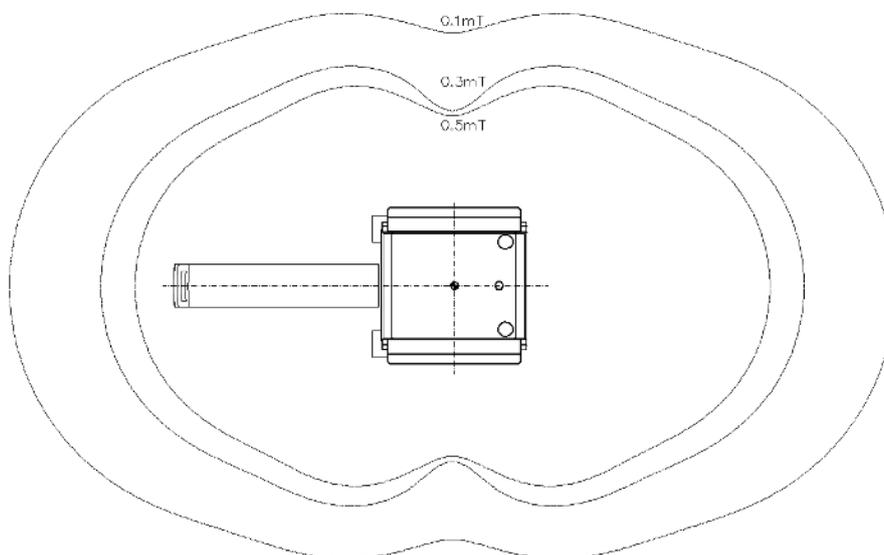
- Passive shielding of the magnet
- Passive shielding of the room
- Active shielding of the magnet

Passive shielding of the magnet is only done by the system manufacturer. Iron is placed on the magnet itself, most often in pieces of 2 to 4 tons, during magnet installation. Consideration must be given to the floor loading as the weight of shielded magnets may exceed 20 tons.

Passive shielding of the room by use of low carbon content, especially annealed iron is very effective. IMEDCO has such iron in stock or available from sources where it can be obtained on fairly short notice. The amount of iron needed and its location on walls, floor and ceiling may be estimated by IMEDCO, but in most cases the MRI system manufacturer provides a calculation of dimensions and exact location.

Active shielded magnets are today more or less the standard technology. While they may weigh less than passively shielded magnets, other constraints by the manufacturer must be considered.

Some systems may not perform optimally because of magnetic field fluctuation caused by changes in the earth magnetic field or by vagabonding electrical current in the ground or building. In this case the magnetic shield must protect the magnet by attenuating these disturbances. A single or multi layer shield built from aluminum or galvanized steel may serve this purpose. IMEDCO has also experience in providing active compensation systems to reduce low frequency magnetic noise generated by electric (DC) driven trains, elevators, large moving ferro-magnetic masses etc.



## 4. Radio Frequency (RF) shielding

The majority of magnetic resonance systems require RF shielding. The RF shielding serves two purposes. The first purpose is that radio wave emission from the MRI system may disturb other electronic equipment of the clinic or television and radio reception in the neighborhood. The other purpose is that external radio waves entering the examination room may be picked up by the system coils and corrupt the image. Radio waves are especially harmful in the region of the so-called resonance frequency. The value of this frequency is directly related to the field strength of the magnet and is 42.6 MHz (Megahertz) for a 1.0 Tesla unit. For a 3.0 Tesla unit this frequency is 127.8 MHz. A good RF shield should therefore attenuate radio waves between 1 MHz and 180 MHz minimum. The attenuation factor should be at least 1:100'000, or expressed in decibel (dB) = 100.

IMEDCO's radio frequency shield is made from a copper foil placed on wooden frames. With the copper floor these frames form a complete, totally air tight cubicle. All penetrations into or out of this room need special attention.

No wire, gases, water, or air may enter or leave the MRI room shielding unless they pass through filters. These filters are of special design and each one serves its assigned purpose. Electrical filters must not only satisfy the attenuation requirements, but must also have low earth leakage current for patient safety. IMEDCO has been the leader in providing these types of filters. Special honeycomb filters are used for venting and air-conditioning. They must be non-magnetic and have low pressure drop. Honeycomb of all sizes up to 900 mm x 600 mm are available from IMEDCO. Also unique filters are required for medical gases. (See section 6.7 Wave guides)

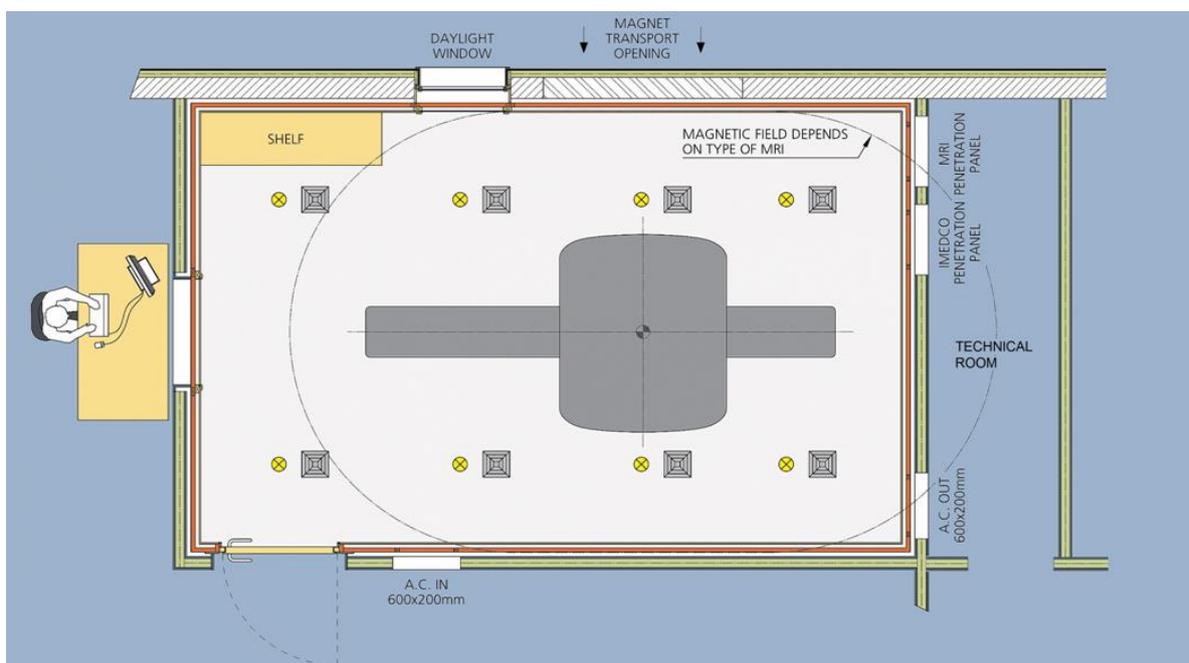
Information in this guide will assist you in designing the room and also provide critical data to electricians, air conditioning companies and other trades involved in the construction.

IMEDCO will provide the planner, the architect or hospital with a complete set of drawings. These drawings are usually based on dimensional information from the site and on installation requirements from the system supplier.

To give the architect design and planning information, this guide includes drawings with proposals and details of typical installation, using the most cost effective solutions. Of course other alternatives are usually possible and IMEDCO will work with you on specific problems imposed by local conditions.

## 5. Questions concerning site location

- Is the floor strong enough to support a magnet?
- Does the access for delivery of the magnet have adequate clearance and structure?
- Can either the floor or access way be reinforced and how?
- Is enough ceiling height available?
- Can the air-conditioning requirements be met?
- Can the cryogen gases be safely vented?
- Will existing iron masses or planned ferromagnetic structures disturb the magnetic field?
- Moving masses are especially critical and can cause artifacts.  
Are elevators, cars or trains in close proximity?
- Does the magnetic fringe field disturb the surrounding environment?  
Is additional magnet shielding necessary and possible?
- It is advisable to build an image center in a way that patients can not adversely enter higher field areas.  
Can this recommendation become part of the architectural design?
- Will the MRI be noisy and are there noise sensitive rooms below, above or near the MRI room?
- Have all of the above concerns been discussed with the system supplier and the physician as well as the hospital planning department?
- Are there rules for electrical, medical gases and sanitary installations?  
Do local guidelines for patient and operator safety exist?
- Furthermore, are there other restrictions imposed by the national building code that must be considered?



## 6. Construction detail

### 6.1 The enclosure

IMEDCO uses mainly copper, the ideal material for long term performance which enables IMEDCO to grant a 5 year warranty. The entire shell is bolted using special proprietary screws that maintain a constant pressure at the seams. This modular construction makes installation of the magnet through a large opening easy, facilitates magnet replacement if needed, and also allows the entire enclosure to be relocatable. Another important fact for the architect is IMEDCO's ability to build an enclosure to any size and shape, should building constraint or aesthetic so demand.

### 6.2 The floor

IMEDCO recommends a design which utilizes a depressed floor if at all possible, which will avoid a ramp and provide a smooth entry of beds and helium Dewar container.

The depression or depth recommendation for a standard floor is 25 mm if the door opens outward.

The surface of the slab must be smooth, flat and level to 2,5 mm/m with a total unevenness not to exceed 5 mm over the whole room. The sub base must be dry. A maximum moisture content of < 8% should be guaranteed. If this is not possible, IMEDCO must be informed and another solution will be proposed.

The floor consists of several layers. Most important is the dielectric separation of the RF enclosure from the rest of the building. IMEDCO uses special tar sheets.

The copper is protected after soldering by a floor board. An additional high density masonite layer assures flawless installation of the final floor cover.

It is important to realize that an antistatic or conductive vinyl floor, if required by the system supplier, needs a special installation procedure inside an RF enclosure. IMEDCO uses copper ribbons which are placed so that they are interconnected and grounded. It is also important that the adhesive for the floor surface material is conductive.

### 6.3 The wall

The walls of the RF enclosure are made from self supporting wooden frames. These approximately 1 m wide frames are built to the desired room height and are placed at an average of 50 mm distance from the structural room walls. The structural room walls of brick or plaster, as built by the contractor, do not need to be finished on the inside. It is possible to build these walls before or after erection of the RF enclosures. However, precaution must be taken not to damage the copper if built afterwards.

With some exceptions, the walls will usually contain filters for air, electricity and other services. To give access to these filters the architect will provide openings in the structural room wall according to drawings provided by IMEDCO. In a few cases these filters are installed in the ceiling or the floor.

The wall frames of the RF enclosure receive vertical furring strips at 62,5 cm center distance. This dimension may be changed at the customer's request. These wooden strips provide solid fixing points for the interior decoration panels. The interior finish may be provided by local trades or can be ordered from IMEDCO. The base frames are filled with rock wool insulation to provide thermal protection and soundproofing. System generated noise may be quite loud and sound dampening is necessary for users and patients comfort. IMEDCO has designs for the enclosures to provide this additional noise insulation.

## 6.4 The door

---

The standard door is 1.20 m x 2.10 m, other custom size doors are available. The door may be placed anywhere in the perimeter of the enclosure. Some restrictions however do exist in corners.

The door has a conductive frame (nickel-plated aluminum) on which special contact fingers are attached. These fingers are relatively delicate. For good performance the frame will be cleaned after completion of construction and it is the only item that needs regular maintenance.

The door lock has a standard lock, it may be locked with a key, but can always be opened from the inside.

## 6.5 The window

---

The standard window measures 0.90 m x 1.20 m. Custom size windows are available with the largest single window being 1.00 m x 2.50 m. If a larger window is required, two windows side by side will be necessary.

Openings for daylight where Moiré patterns are of less importance can be made as large as 3.00 m x 3.00 m.

**Note:** Window frames are not part of the RF enclosure and will be supplied on special request or with the interior decoration only.

## 6.6 The ceiling

---

The ceiling is built with similar panels as the wall described in 6.3.

The ceiling is suspended from the structural room ceiling using dielectric isolators. The minimum suspension height is 50 mm. For structural calculation purposes, the weight of the ceiling may be

assumed as 12 kg/m<sup>2</sup> plus the weight of suspended ceiling tiles and eventual electrical components and any other installations in the plenum.

## 6.7 Wave guides

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Air, gas and liquid medias must enter or leave the RF enclosure through wave guides. This is a device that blocks RF waves and it is available in different forms and sizes.

- Honey-comb type air vents are used for ventilation and air conditioning. The standard size is 600 mm x 200 mm. On special request almost any other rectangular size up to 900 mm x 600 mm may be built.
- Brass pipes are used for other media including fiber optic cable. Medical gases or liquids are usually carried in plastic or rubber hoses.
- In some countries special wave guides are required for medical gases. They have copper pipes on both ends and can therefore be incorporated directly into the medical gas distribution system of the hospital.

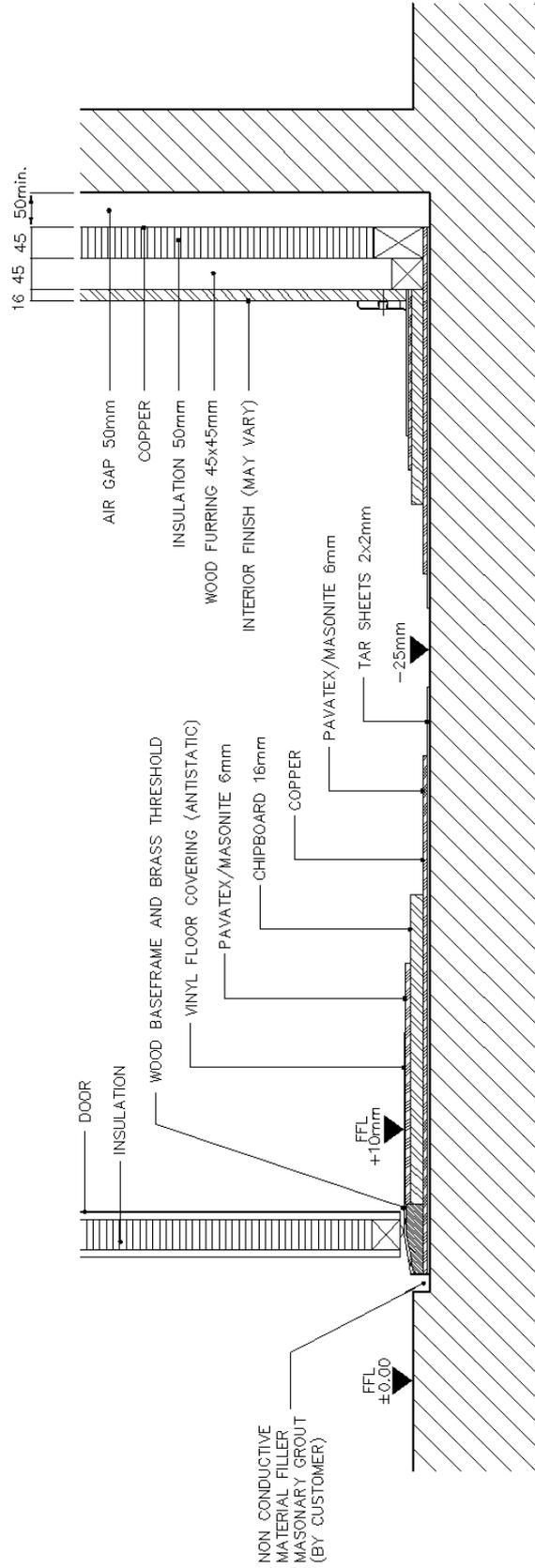
## 6.8 Electrical Filter

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These filters are not only used to supply electricity for lighting and wall outlets, they are also used for signal leads from oxygen monitors, fire alarms or other devices. IMEDCO assures patient safety in providing filters with very low leakage current to ground. A residual current operated circuit breaker (FI), tripping at 10 or 30 mA, must be provided by the electrician.

## 7. Drawings

## COPPER RF ENCLOSURE: OUT-SWING DOOR



NON CONDUCTIVE MATERIAL FILLER MASONARY GROUT (BY CUSTOMER)

FFL ±0.00

FFL +10mm

PAVATEX/MASONITE 6mm

TAR SHEETS 2x2mm

PAVATEX/MASONITE 6mm

INTERIOR FINISH (MAY VARY)

WOOD FURRING 45x45mm

INSULATION 50mm

COPPER

AIR GAP 50mm

16 45 45 50min.

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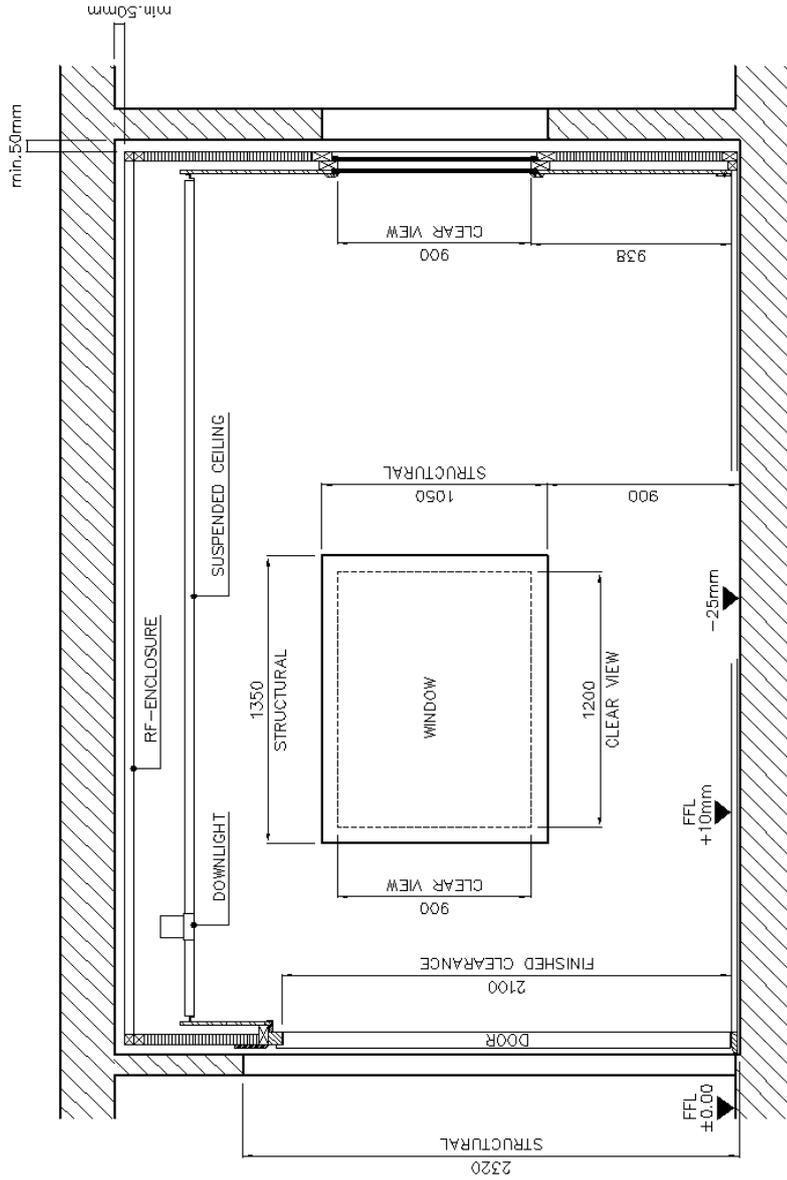
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B		06.06.2009-CF	
C		06.06.2009-CF	
E		06.06.2009-CF	
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FLOOR- AND WALLED TAIL RECESS IN FLOOR -25mm SITE PLANNING GUIDE	
MEDGO 3. 1998. 1999. 2000. 2001. 2002. 2003. 2004. 2005. 2006. 2007. 2008. 2009. 2010. 2011. 2012. 2013. 2014. 2015. 2016. 2017. 2018. 2019. 2020. 2021. 2022. 2023. 2024. 2025. 2026. 2027. 2028. 2029. 2030.	E-0101
Page	1

EXAMINATION ROOM:  
 FINISHED STRUCTURAL FLOOR MUST BE WATERPROOFED, DRY,  
 (MAX. MOISTURE CONTENT OF SUBSTRUCTURE <8%)  
 FLAT & LEVEL WITHIN 2.5mm/m MAX. 5mm TOTAL

COPPER RF ENCLOSURE: OUT-SWING DOOR



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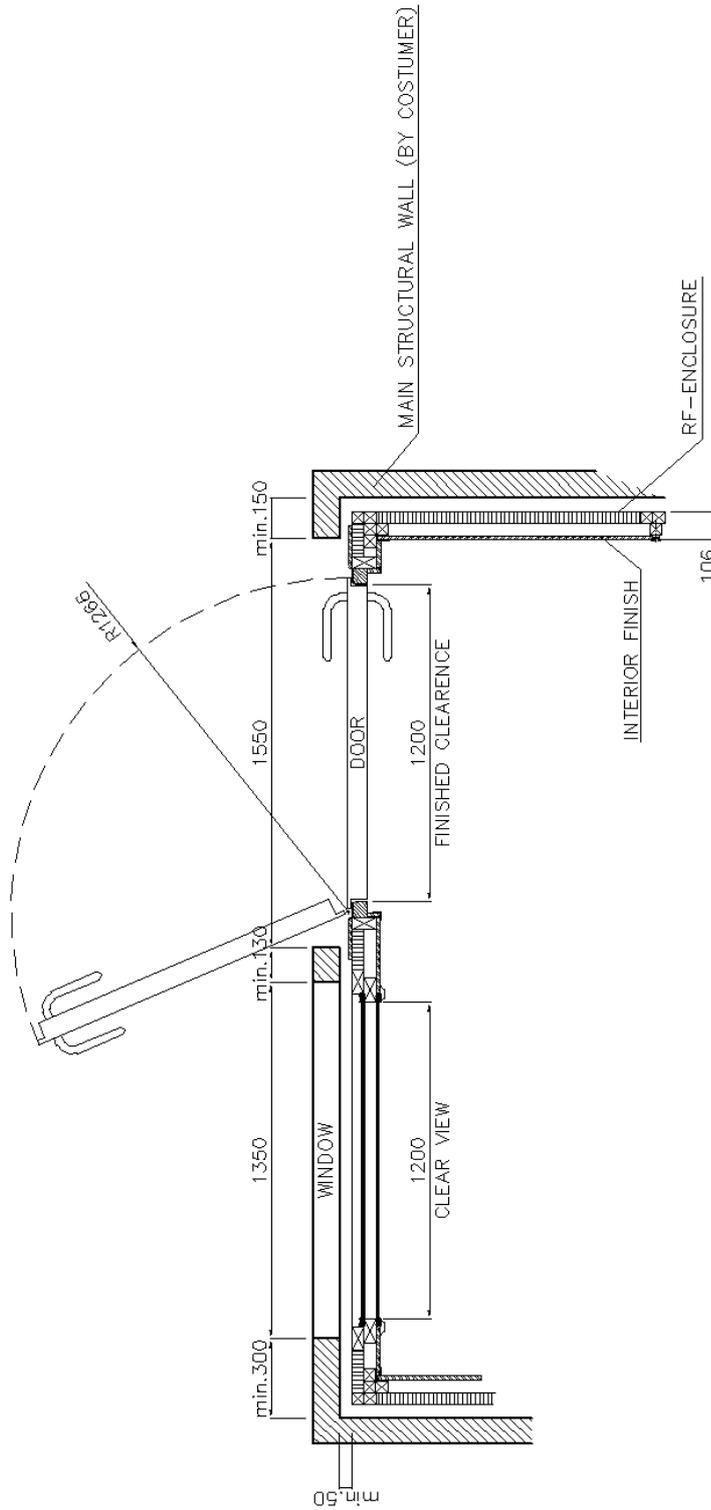
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B		Checked by	06.06.2009-CT	
C		Approved by	06.06.2009-CT	
E		Created by		1
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**TYPICAL STRUCTURAL WALL CLEARANCES FOR DOOR AND WINDOW SITE PLANNING GUIDE**

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 (MAX. MOISTURE CONTENT OF SUBSTRUCTURE <8%)  
 FLAT & LEVEL WITHIN 2.5mm/m MAX. 5mm TOTAL

COPPER RF ENCLOSURE: OUT-SWING DOOR



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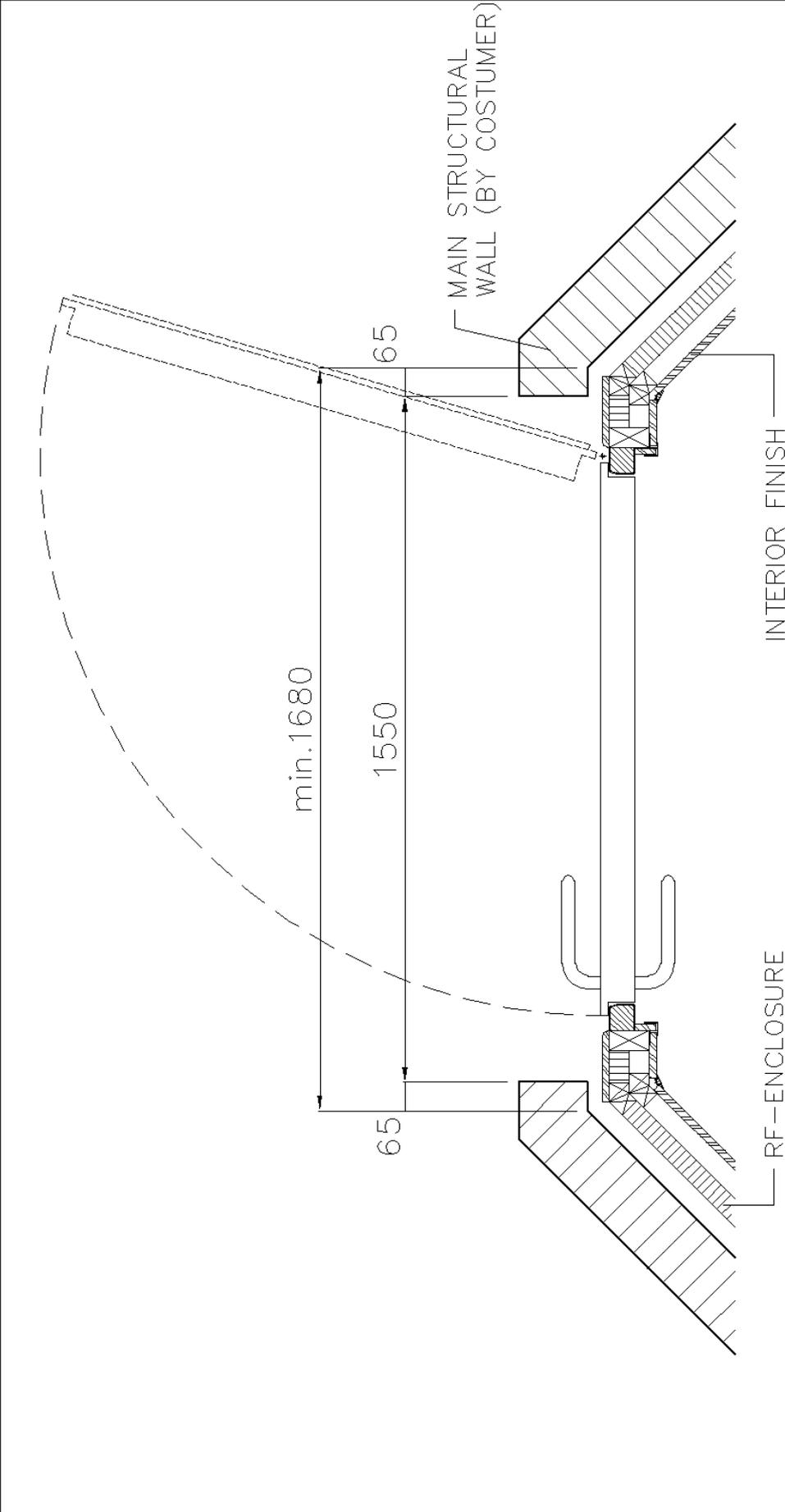
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MINIMAL STRUCTURAL WALL AND CORNER CLEARANCE		Created by	01.05.2009-BR
SITE PLANNING GUIDE		Checked by	06.06.2009-CP
		Approved by	06.06.2009-CP
		Drawn by	
		Page	1
		Rev.	E-0103

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COPPER RF ENCLOSURE: OUT-SWING DOOR

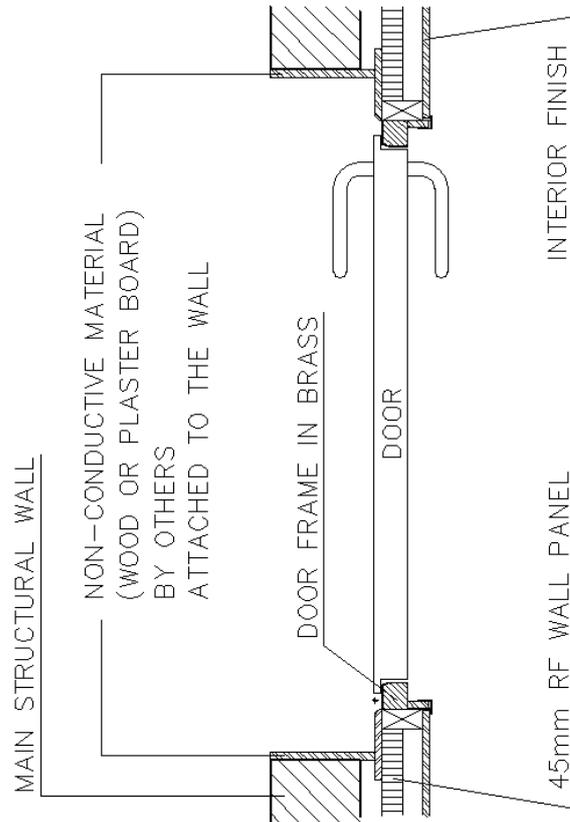


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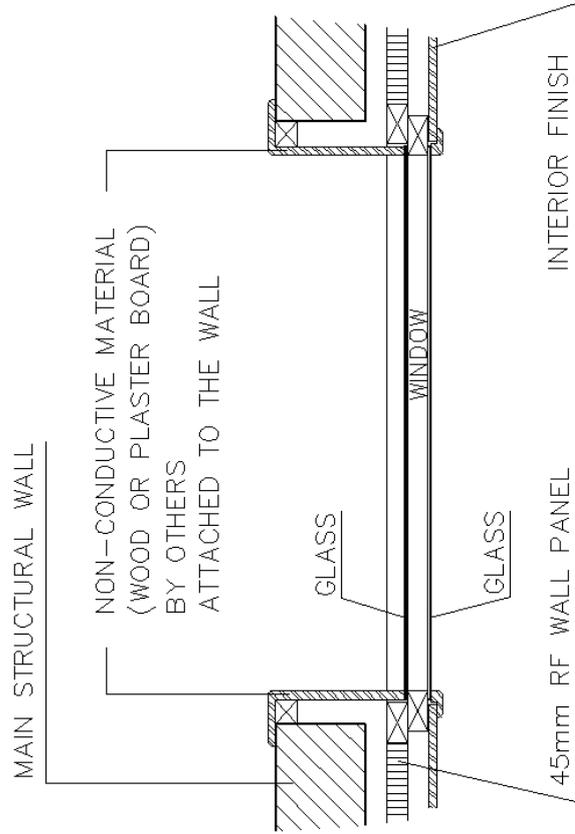
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B		Checked by	06.06.2009-DR		
C		Approved by	06.06.2009-DR		
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# COPPER RF ENCLOSURE: OUT-SWING DOOR

## DOOR DETAIL



## WINDOW DETAIL



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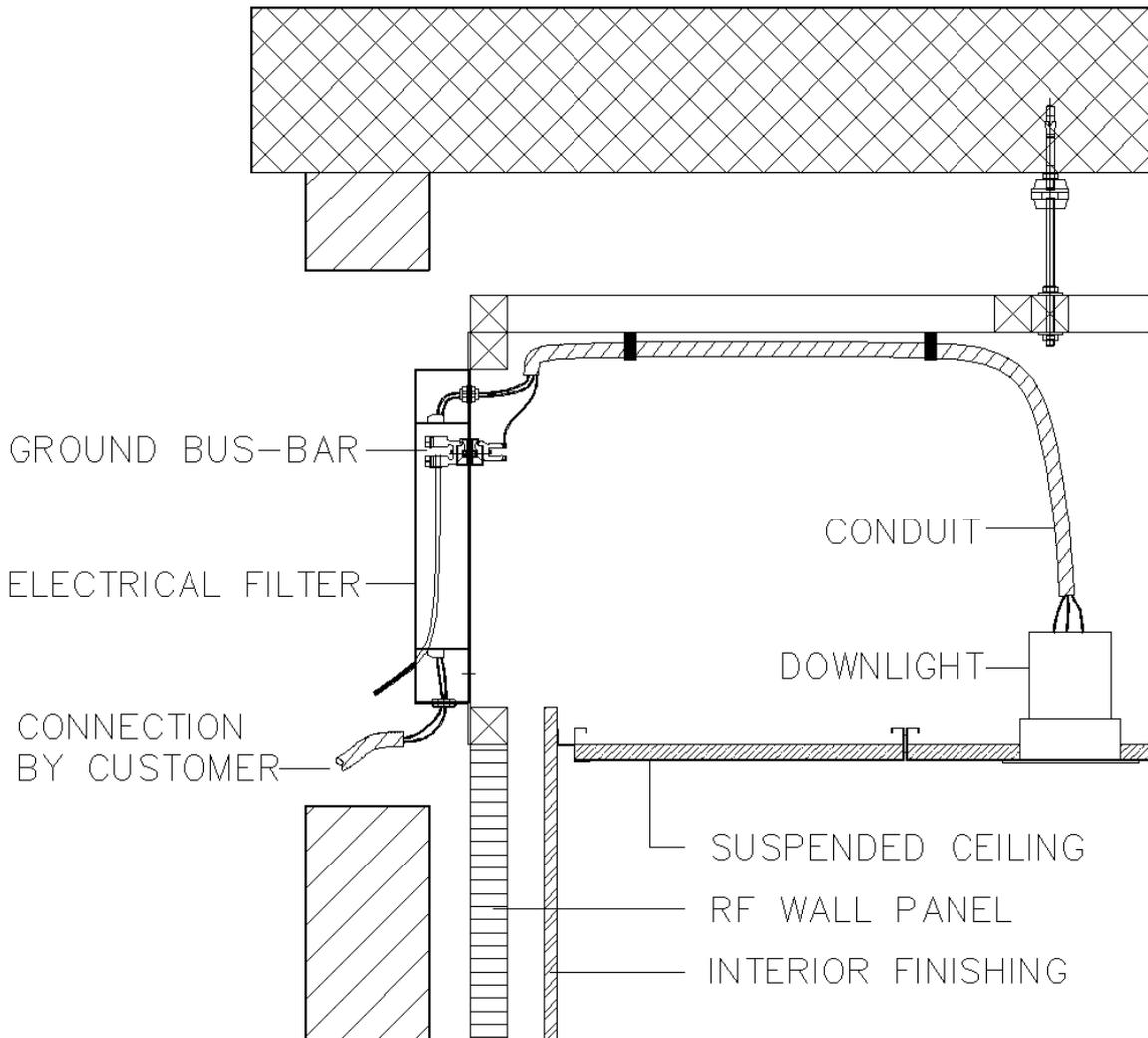
TYPICAL DOOR AND WINDOW FRAME

SITE PLANNING GUIDE



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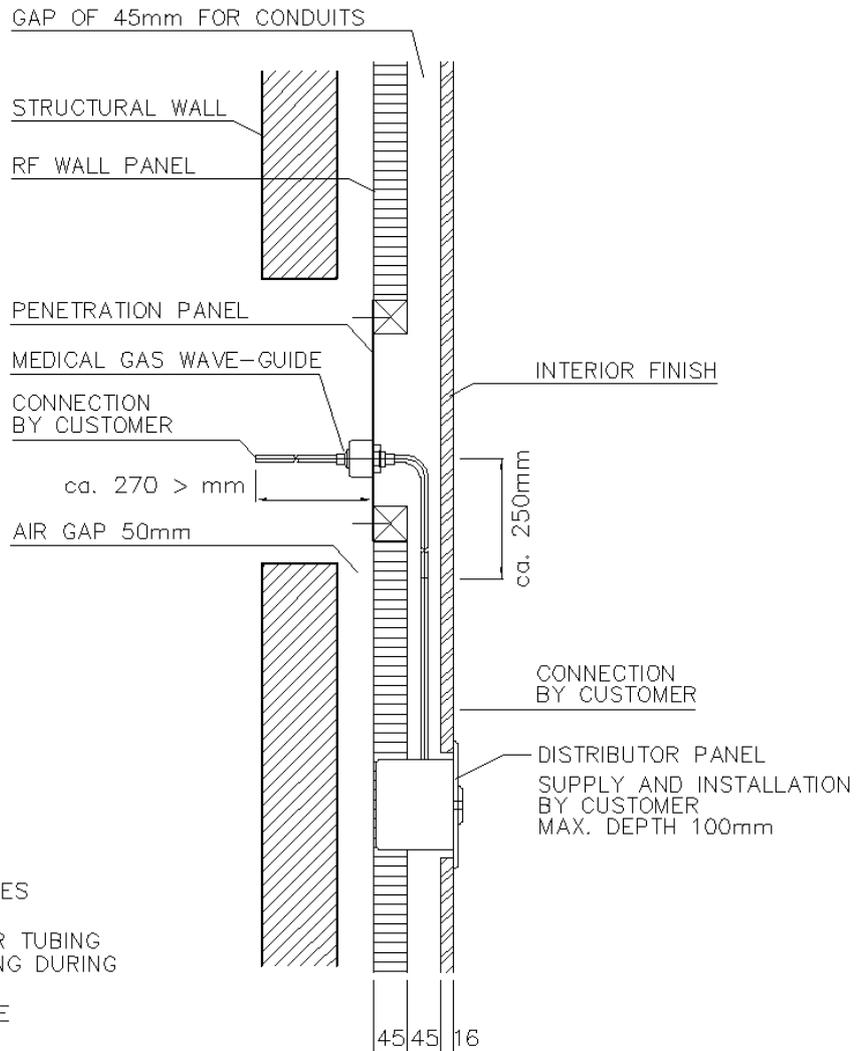
## COPPER RF ENCLOSURE: PENETRATION



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A			Drawn by	12.05.2009-BR		
B			Checked by	06.06.2009-CH		
C			Approved by	06.06.2009-CH		
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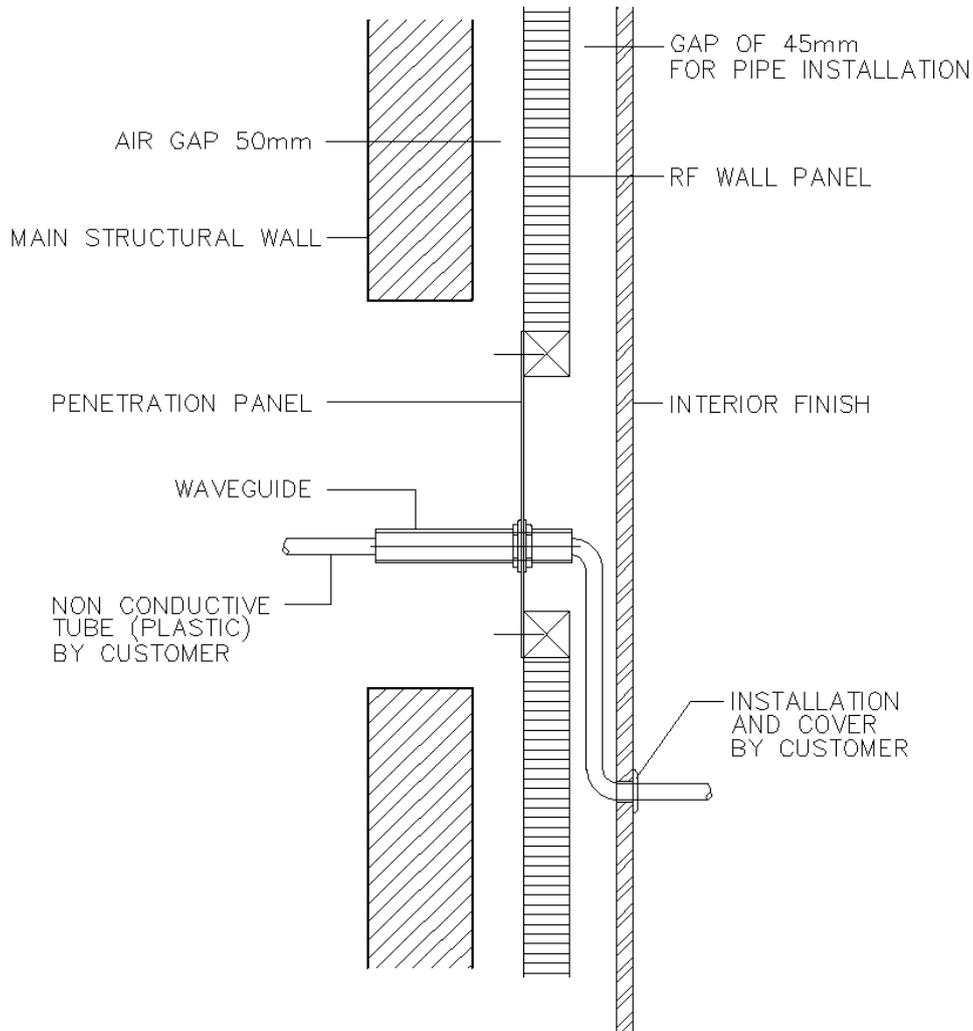
### IMPORTANT:

- MEDICAL GAS WAVE GUIDES MUST NOT BE OPENED
- SHORTENING THE COPPER TUBING RESULTS IN OVER HEATING DURING WELDING
- TYPE RA, RAL 5010 BLUE FOR OXYGEN ONLY
- TYPE RB, FOR ALL OTHER GASES. MUST BE COLOR CODED BY INSTALLER
- STANDARD TUBE DIAMETER 8/10mm OTHER DIAMETERS ON REQUEST
- WAVE GUIDE WAS CLEANED AND PROTECTED ACCORDING TO STANDARD PRESCRIPTION
- MOUNTING HOLE DIAMETER IN PENETRATION PLATE=22mm

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Revision	PENETRATION WITH MEDICAL GAS DETAIL	%	A4	
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B		Checked by	06.06.2009-CH	
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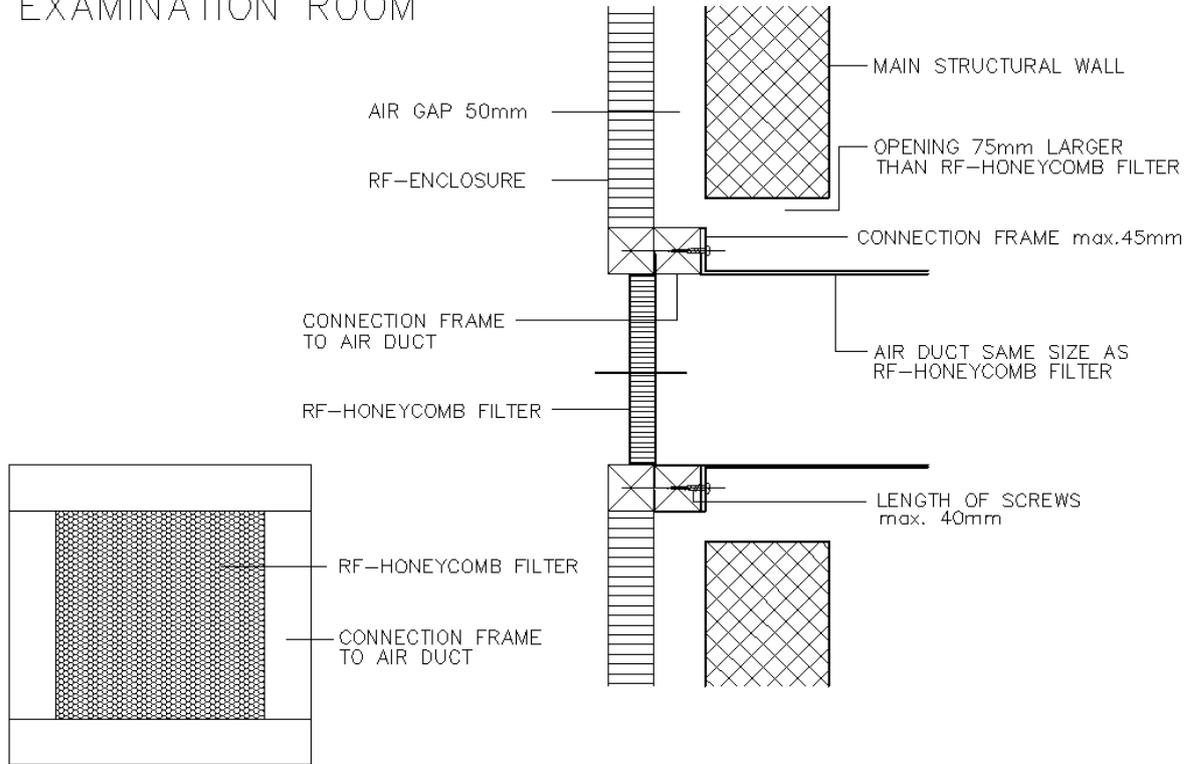
STANDARD WAVEGUIDE			
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3000059	3/4"	21mm	97mm
3000062	1"	27mm	122mm
3000064	1 1/2"	40mm	197mm
3000066	2"	52mm	245mm

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Revision		%	A4	
A	PENETRATION WITH PLASTIC PIPE DETAIL TYPICAL WAVE GUIDE SITE PLANNING GUIDE	Drawn by	12.05.2009-BR	
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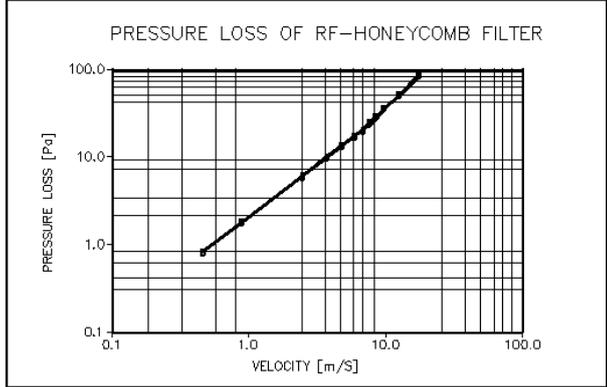
## COPPER RF-ENCLOSURE: CONNECTION OF AIR DUCTS

EXAMINATION ROOM



AIR DUCT MUST NOT CONTACT RF-HONEYCOMB FILTER OR RF-ENCLOSURE

RF-HONEYCOMB FILTERS: STANDARD DIMENSIONS	
600 x 300 mm	
600 x 200 mm	
500 x 300 mm	
500 x 200 mm	
400 x 400 mm	
400 x 200 mm	
300 x 300 mm	
200 x 200 mm	
MAXIMUM DIMENSION	
600 x 600 mm	



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Revision		<b>CONNECTION OF AIR DUCTS WITH RF-HONEYCOMB FILTER SITE PLANNING GUIDE</b>	%	A4		
A			Drawn by	18.01.2011-BR		
B			Checked by	19.01.2011-CH		
C			Approved by	19.01.2011-CH		
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