NON-MAGNETIC CONNECTORS

Guidelines

Radiall

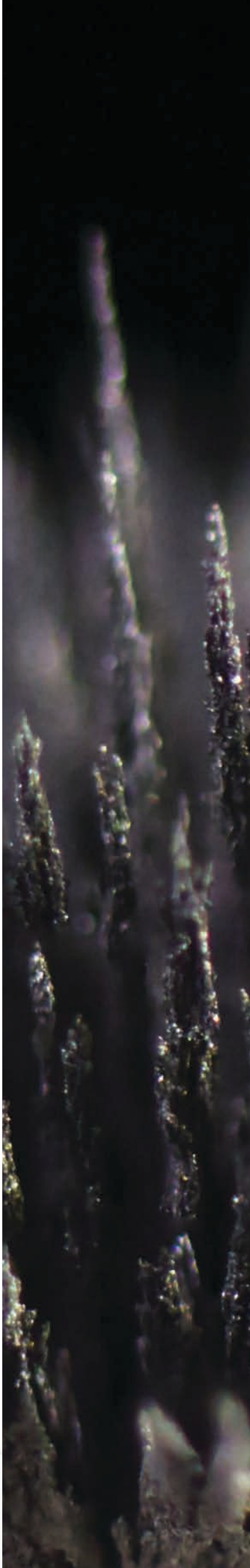
NON-MAGNETIC CONNECTORS

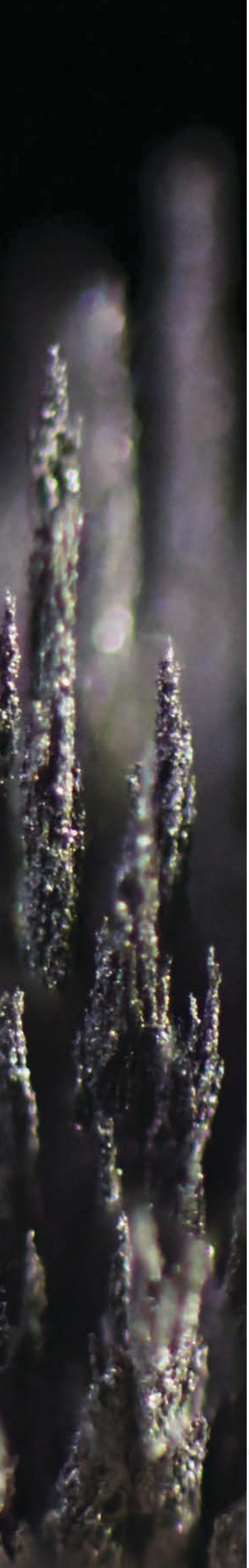
Radiall provides a comprehensive selection of connectors including SMP, SMPM, SMB, MCX, MMCX, BNC, SMA (...) all designed only from non-magnetic materials like brass, gold, silver or bronze. These connectors find applications in critical areas such as medical, space and quantum technology.

In space, where equipment is subjected to extreme environments and reliability is crucial, the use of non-magnetic materials ensures that electronic systems are not disturbed by magnetic fields. This is essential for the precise operation of measuring instruments, communication systems and on-board sensors. Radiall's connectors, manufactured with materials such as gold, ensure optimal electrical conductivity while resisting oxidation and corrosion, extending the life of components in the harsh conditions of space.

For quantum technologies, where magnetic interference can alter quantum states and therefore calculations and communications based on these states, the use of non-magnetic connectors is fundamental. The intrinsic properties of the materials used by Radiall, combined with a rigorously controlled manufacturing process, make it possible to minimize magnetic susceptibility. This provides stability and precision essential for quantum applications where each disturbance can have significant effects on the results.

In environments like MRI (Magnetic Resonance Image) where magnetic interference can compromise image quality, standard manufacturing processes may fall short in achieving the required level of non-magnetism. To ensure exceptional non-magnetic properties and consistency, Radiall has developed and implemented a manufacturing process that rigorously controls every step of connector manufacturing. Therefore the magnetic susceptibility is 100 times better than standard connectors using non-magnetic materials.





THE CHALLENGE

The quality of MRI images relies heavily on the uniformity of the magnetic field and signal-to-noise ratio. To maintain field homogeneity, all equipment within the magnetic field must be non-magnetic with a relative permittivity of 1. Coils within the field are connected to electronics to prevent distortion.

Connectors on these coils must be non-magnetic with a relative permittivity close to 1 and must meet mechanical requirements.

MRI MEDICAL EQUIPMENT

- *One magnet or electromagnet is used to create an intense and homogeneous magnetic field (1.5-2 Tesla) in the chamber where the patient lies.*
- *Gradient coils are used to position the area under analysis within the space.*
- *Two high-frequency coils are used, one for transmitting the excitation impulses to the atomic nucleus contained in the area under analysis and the other for receiving signals like a true signal capture device that constitutes the image after treatment.*

ADVANTAGES

- *Connection inside the field core*
- *Minimal distortion of the field*
- *Field homogeneity*
- *High signal-to-noise ratio*
- *High level of non-magnetic*

MAGNETIC MAGNITUDES

MAIN MAGNETIC MAGNITUDES

- *B: magnetic induction (tesla)*
- *H: magnetic field (A/m)*
- *M: magnetization (A/m)*
- *X: magnetic susceptibility*
- *µ0: vacuum magnetic permittivity*

IN PRACTICE

Under a H_{ext} external magnetic field, a material will get a M magnetization such as:

$$M = X H_{ext}$$

MAGNETIC INDUCTION THAT STANDS INSIDE THIS MATERIAL IS EQUAL TO

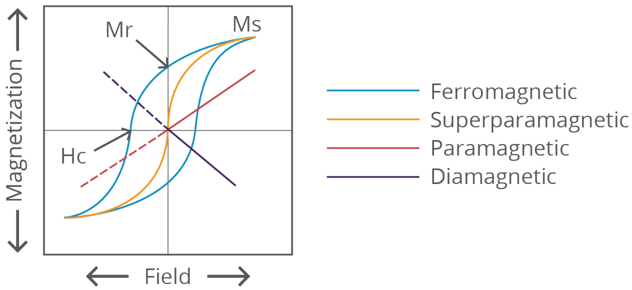
- $B = \mu 0 (M + H_{ext})$
- $B = \mu 0 (1 + X) H_{ext}$
- Thus: $B = \mu 0 \mu r H_{ext}$

EXAMPLES

- *The Earth's magnetic field distance is about 0.5 x 10-4T.*
- *The strengh of electromagnets used in junk yards is about that of MRI machines 1.5 - 2.0T*

MAGNETIC MATERIALS

There are four types of materials: Diamagnetic, Paramagnetic, Superparamagnetic and Ferromagnetic. Dia- or para-magnetic materials feature rather weak magnetic properties and are linear.



DIAMAGNETISM

- *The M magnetization is proportional to the H field*
- *The X_{dia} susceptibility is independent of temperature*
- *X_{dia} is negative: M and H are opposite*
- *X_{dia} is around: -10-4, -10-9*

PARAMAGNETISM

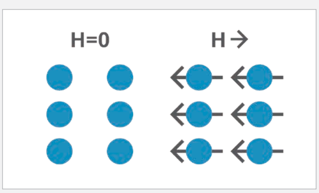
- *The M magnetization is proportional to the H field*
- *The magnetic susceptibility X_{para} is proportional to T^{-1} (Curie law)*
- *X_{para} is positive: M and H have the same sense*
- *X_{para} is around: 10^{-2}, 10^{5}*

SUPERPARAMAGNETISM

Superparamagnetic materials consist of individual domains of elements that exhibit ferromagnetic properties in bulk. The magnetic susceptibility lies between that of ferromagnetic and paramagnetic materials.

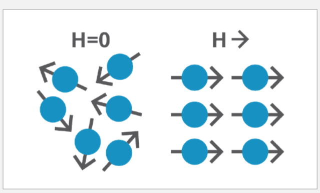
FERROMAGNETISM

M cannot be linked to H or to B by a simple relation because of the hysteresis phenomenon. The magnitude of the susceptibility of ferromagnetic materials is one thousand times greater than that of paramagnetic materials.



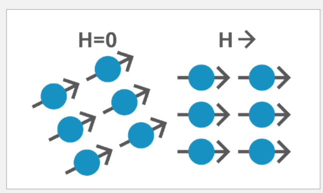
DIAMAGNETISM

Diamagnetic materials do not possess intrinsic magnetic moments.



PARAMAGNETISM

Paramagnetic materials possess some intrinsic magnetic moments even in the absence of an external magnetic field.



FERROMAGNETISM

M cannot be linked to H or to B by a simple relation because of the hysteresis phenomenon. The magnitude of the susceptibility of ferromagnetic materials is one thousand times greater than that of paramagnetic materials.

CONSEQUENCES

DISTURBING MAGNETIZATION

When an external magnetic field H_{ext} is applied, a magnetization M appears inside the material, here the connector.

This M magnetization generates a ΔH disturbing field, that disturbs the flux lines of the H_{ext} magnetic field. Thus the quality of the picture received is poor and many corrections have to be made.

The ΔH disurbing field, generated by the connector depends on:

1. The distance between the connector and the point where it is calculated.
2. The connector dimensions. The larger the connector is, the greater the ΔH field is.
3. The M magnetization of the connector, and thus, its X susceptibility:

   $B = \mu 0 \; \mu r \; H_{ext}$

   With $\mu r = (1+X)$.

DEMAGNETIZING FIELD

Under a H_{ext} external field, H_d demagnetizing field appears inside the connector such as:

$$H_d = -n,M$$

N, demagnetizing coefficient, depends on the direction of the magnetization compared to the connector. (0 < n < 1)

The connector is subject to a total field:

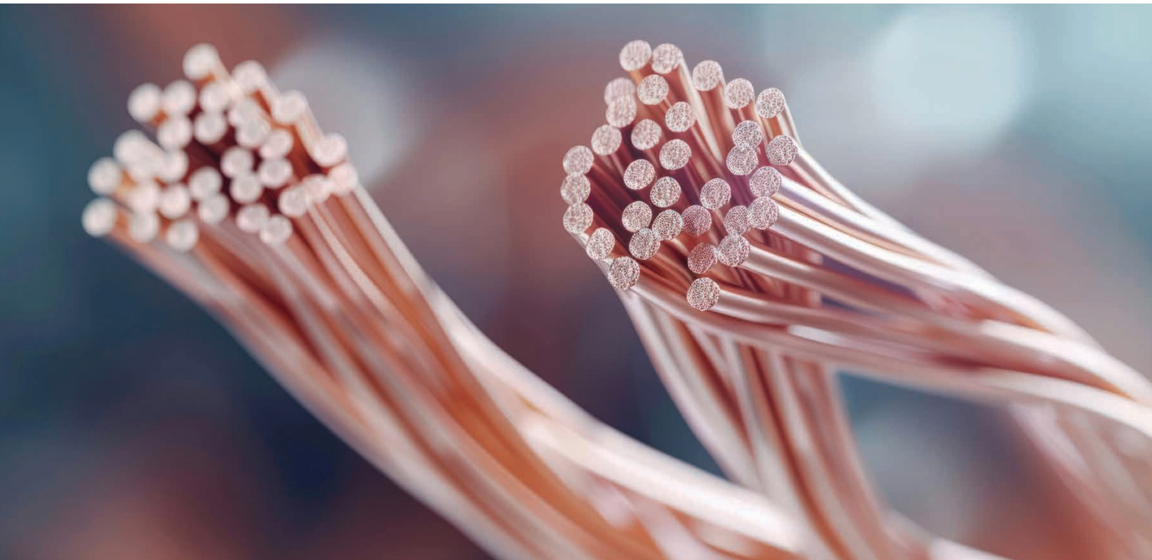
$$H_1 = H_{ext} + H_d$$

$$M = {}_{X} H_{I} = {}_{X} (H_{ext} + H_d) = {}_{X} (H_{ext} - n.M)$$

The magnetization is then: $M = \dfrac{X H_{ext}}{1 + r X}$

For $X \ll 1$, $M = X H_{ext}$

The demagnetizing field is then negligible relative to the external field.



THE SOLUTION: **NON-MAGNETIC RANGE**

PERFORMANCE

Coaxial connectors traditionally considered non-magnetic are typically designed using materials such as brass, gold, silver and bronze. However, for magnetic resonance imaging (MRI) applications, these materials may not provide a sufficient level of non-magnetism.

To address this limitation, one solution is to relocate the connections away from the magnetic field using long coaxial cable assemblies. However, this approach often leads to significant distortion or signal loss. Furthermore, it is not viable when connections need to be made within the magnetic field itself.

Radiall provides a solution with its non-magnetic range of connectors. These connectors maintain the homogeneity of the magnetic field even when positioned within the main magnetic field, effectively addressing the issues of distortion or signal loss encountered previously. The X magnetic susceptibility of a non-magnetic range is around 10-5, that is over 100 times less than that of a standard non-magnetic connector.

- *The $\Delta H/H_{ext}$ relative distortion of a magnetic field of 1,5 T, generated by non-magnetic range is only 5.10-7 maximum, at a distance of 10 mm from the surface of the connector.*
- *The magnetization of a non-magnetic range is independent from temperature and from the connector position relative to the field. The distortion is the same whatever temperature and whatever position of the connector.*
- *The non-magnetic range allow a high signal-to-noise ratio. They are adapted then to static MRI and also dynamic MRI where no picture averaging is possible.*

MATERIALS

The bodies and center contacts are crafted from materials specifically tailored for non-magnetic properties, with each rod selected based on direct measurements using a vibrating magnetometer.

Radiall offers non-magnetic plating such gold plated over a copper underplate and BBR, diamagnetic alloy of copper-tin-zinc.

PRODUCTION

The production of non-magnetic connectors entails a specialized process carried out in a controlled environment to prevent any contact with ferromagnetic materials during machining and cleaning. Our manufacturing process adheres to a stringent quality assurance plan to guarantee consistent non-magnetism and reproducibility across all products.

SIMPLIFICATION
is our **INNOVATION**

We advance the design and engineering process for innovators, groundbreakers and pioneers of technology. We reduce weight, improve durability and streamline installation to provide leading-edge connectors that drive product performance.

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