INFN Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI FRASCATI
Servizio del Personale

All.1c) - II verbale LNF/T3/22124

Frascati, 10 settembre 2020

**LNF/T3/22124**
**Bando di concorso per un posto con il profilo di Tecnologo di III livello professionale con contratto di lavoro a tempo determinato presso i Laboratori Nazionali di Frascati**

**DOMANDE PROVA ORALE**

1. Il candidato discuta i principali limiti nelle prestazioni di magneti permanenti ed elettromagneti non superconduttori.

2. Il candidato discuta l'architettura di un quadrupolo a magnete permanente in grado di realizzare un campo di induzione magnetica variabile lungo la traiettoria del fascio.

**Domande di informatica**

3. Descrivere brevemente un ambiente di sviluppo adatto a realizzare il controllo remoto di magneti per macchine acceleratrici.

4. Si descrivano brevemente tecniche di progettazione CAD per magneti utilizzati in acceleratori di particelle.

**Prova di lingua Inglese**

5. Magnetostatic fields in accelerators are conventionally described in terms of multipoles. We show that in two dimensions, multipole fields do provide so- lutions of Maxwell's equations, and we consider the distributions of electric currents and geometries of ferromagnetic materials required (in idealized sit- uations) to generate specified multipole fields. Then, we consider how to de- termine the multipole components in a given field. Finally, we show how the two-dimensional multipole description may be extended to three dimensions; this allows fringe fields, or the main fields in such devices as undulators and wigglers, to be expressed in terms of a set of modes, where each mode provides a solution to Maxwell's equations.

6. Magnetic materials, both hard and soft, are used extensively in several components of particle accelerators. Magnetically soft iron–nickel alloys are used as shields for the vacuum chambers of accelerator injection and extraction septa; Fe-based material is widely employed for cores of accelerator and experiment magnets; soft spinel ferrites are used in collimators to damp trapped modes; innovative materials such as amorphous or nanocrystalline core materials are envisaged

in transformers for high- frequency polyphase resonant convertors for application to the International Linear Collider (ILC). In the field of fusion, for induction cores of the linac of heavy-ion inertial fusion energy accelerators, based on induction accelerators requiring some $10^7$ kg of magnetic materials, nanocrystalline materials would show the best performance in terms of core losses for magnetization rates as high as $10^5$ T/s to $10^7$ T/s. After a review of the magnetic properties of materials and the different types of magnetic behaviour, this paper deals with metallurgical aspects of magnetism. The influence of the metallurgy and metalworking processes of materials on their microstructure and magnetic properties is studied for different categories of soft magnetic materials relevant for accelerator technology. Their metallurgy is extensively treated. Innovative materials such as iron powder core materials, amorphous and nanocrystalline materials are also studied. A section considers the measurement, both destructive and non- destructive, of magnetic properties. Finally, a section discusses magnetic lag effects.

7. Magnetic materials are key elements of magnet technology. They should be procured on the basis of careful selection and adapted specifications, since their primary and secondary metallurgy, chemical composition, purity, applied thermal treatments, and microstructure will have a significant influence on their final properties. Low-carbon steel laminations, but also general-purpose constructional steels, such as type 1010, generally used for applications that require 'less than superior' magnetic properties [4], are often applied as yoke materials for accelerator and experiment magnets. They are not always purchased to magnetic specifications. Soft ferromagnetic materials of better controlled composition and impurity limits, properties and metallurgy might be considered for specific applications, such as fast magnet systems. On the other hand, innovative materials such as nanocrystalline and amorphous alloys are being considered or are already used for an increasing number of devices, including for high-energy physics and fusion-related applications. Examples are high-frequency transformers for the International Linear Collider and induction cores of heavy-ion inertial fusion-energy accelerators, respectively. In 2007 nanocrystalline materials represented a production of 1000 t. The importance and use of powder metallurgy is also increasing for application to structural components of magnets, soft magnetic materials, and materials for permanent magnets. In 2003, powder-based soft ferrites represented 5% of the world market of magnetic materials, including semihard and hard materials, compared to 27% covered by conventional steels [60].