Magnets

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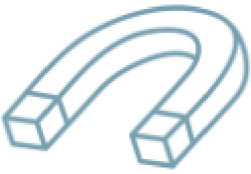

Strong magnets of different shapes and sizes are widely used, for instance in the home, as toys, in headphones or also incorporated into utility articles, jewellery and clothes. Although some magnets are very small (a few millimetres) they may be very powerful, locally generating a strong static magnetic field.

Such strong magnetic fields can disturb the operation of active electronic implants such as pacemakers or implanted defibrillators and this can be dangerous for patients. There is a powerful attractive force between a magnet and a magnetic object or between two magnets. This can lead to a magnet flying through the air like a shot and splintering on impact, so caution is advisable when handling strong magnets.

Small magnets can be very dangerous for children or adolescents. If several magnets get swallowed, the attraction between the magnets can lead to injury of the stomach or intestine, or to intestinal blockage.

Tips on how to handle magnets safely:

- Keep magnets away from young children as it is very dangerous for them to swallow magnets. Point out the danger to older children and adolescents. If magnets are swallowed, immediately contact a doctor!
- Handle magnets carefully and keep them in a safe place.

Tips for patients with a pacemaker or implanted defibrillator:

- Keep a distance of at least 10 centimetres between your implant and the magnet, and at least 5 cm distance between headphones and the implant.
- Be aware that small strong magnets may be embedded in everyday objects (jewellery, toys, clothes, spectacles, nameplates etc.).

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1 Technical data

1.1 Magnets

Very strong magnets can be produced from alloys of rare earths such as samarium-cobalt or neodymium-iron-boron. These have been used for some time in industry. Inexpensive neodymium-iron-boron magnets (neodymium magnets) are increasingly used for various applications such as in headphones, in offices, the home, as toys and jewellery. They can also be embedded in everyday objects such as clothes, jewellery and spectacles, and thus may not be easily recognisable as magnets. The magnets can be any shape, as they can be pressed from a powder, then coated with nickel, silver, gold etc.

Figure 1 shows a selection of neodymium magnets used in different ways: as jewellery (A), office magnets (B, F), toys (D, E) and in the home to attach magnetic objects (such as tools or bicycles) (C).

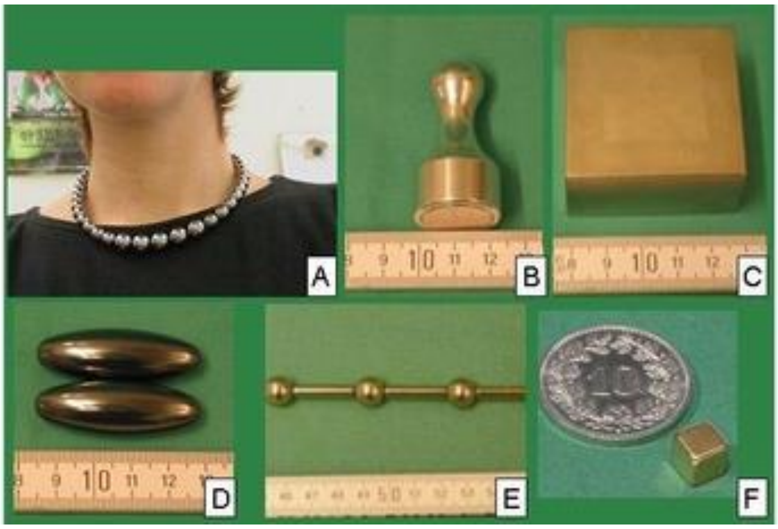

Figure 1: Selection of neodymium magnets: A: necklace (magnetic beads 8, 10 and 13 mm in diameter), B: office magnet, C: block, D: toy magnet, E: stick and steel balls (not magnetic), F: small cubes

1.2 Pacemakers and implanted defibrillators

Some people with serious irregularities of cardiac rhythm are fitted with a pacemaker or implanted cardioverter defibrillator (ICD). These appliances consist of a pulse generator, implanted in the chest, under the skin, and electrodes leading from the pulse generator to the heart, and which when required support the heart beat by electrical impulses (pacemakers) or in the event of fibrillations return the heartbeat to a steady rate (ICDs). Pacemakers and ICDs have to be programmed and checked on a regular basis. To do this, a magnet is placed on the patient's chest, switching the pulse generator to a particular mode (magnet mode) in which it can be programmed. In everyday life the pulse generator should be prevented from switching to the magnet mode, since ICDs do not work at all under these conditions, and pacemakers only work in a limited way. Modern pulse generators must be immune to static magnetic fields of up to 1 milliTesla (mT) [1], i.e. they should not switch to the magnet mode.

2 Measurements of the magnetic field

Measurements of the static fields of various neodymium magnets that are readily available were carried out at the Institute for Biomedical Technology of the Swiss Federal Institute of Technology in Zurich (ETHZ) in collaboration with the FOPH (Figure 1) [2].

The field decreases rapidly with increasing distance from the magnet, depending on the size and shape of the magnet. Figure 2 shows the magnetic field around various neodymium magnets as a function of distance. The magnetic fields are very local, with only the large block generating a somewhat more extensive magnetic field.

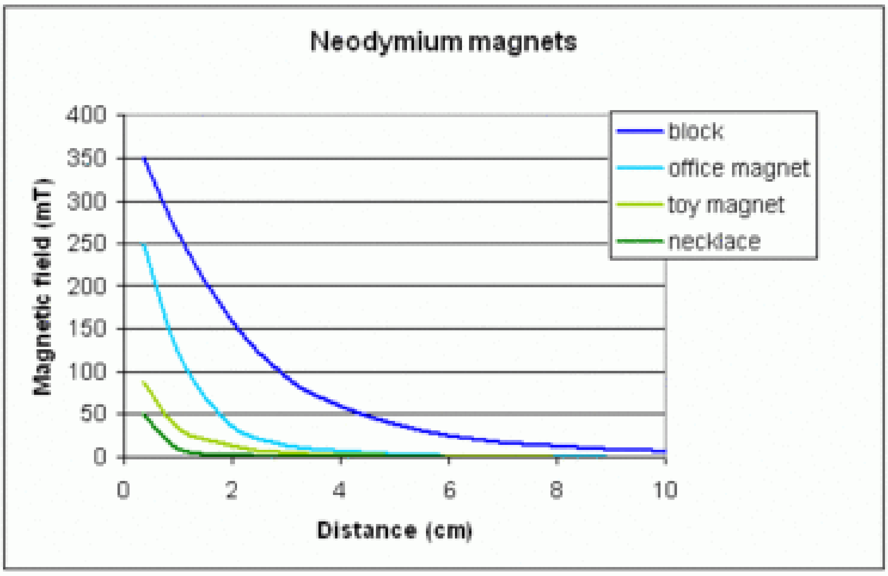

Figure 2: Magnetic fields surrounding neodymium magnets. The magnetic field decreases very rapidly with distance. [2]

Table 1 shows the distance below which a magnetic field of 1 mT or more is generated, and could therefore possibly interfere with pacemakers and ICDs. This was also checked and confirmed with a pacemaker in the laboratory.

Magnet	Dimensions (mm)	Adhesive force (kg)	Distance from the magnet for 1mT (cm)
Large block	50,8 x 50,8 x 25,4	100	22
Medium block	25,4 x 25,4 x 12,7	20	11
Toy magnet (ellip-soid)	16 x 16 x 45	unkown	9
Office magnet	10, diameter 20	12	8,5
Necklace, beads small/me-dium/large	diameter: 8 / 10 / 13	0,9 / 1,5 / 2,9	7,5
Small sticks (and steel balls)	25, diameter 5	1	6
Small cubes	5 x 5 x 5	1,1	5

Table 1: Distance within which the magnets produce a magnetic field of 1 mT or more and can inter-fere with pacemakers and ICDs [2]

In a study in Boston the magnetic fields of various headphones were measured at a distance of 0 to 3 cm [5]. At a distance of 0 cm magnetic fields between 1.1 and 34.4 mT were measured and at a dis-tance of 3 cm were still up to 0.7 mT. At a distance of 3 cm, six of the eight tested headphones fell well below the interference threshold of 0.5 mT.

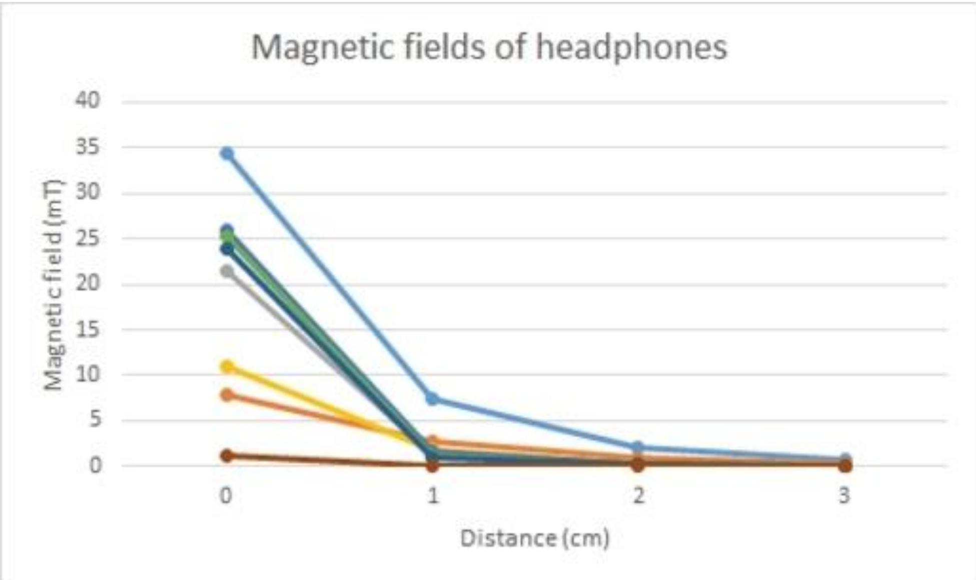

Figure 3: Magnetic fields of eight different models of headphone at a distance of 0 to 3 cm [5]

3 Effects on health

3.1 Static magnetic fields

There has not yet been sufficient research on the effects of static magnetic fields on health. The limit for protection of the general population, under continuous whole body exposure is 40 mT [3]. The field generated by a neodymium magnet is only very local; within a range of a few centimetres the field falls well below this value.
Very strong, spatially extended magnetic fields (more than 2 Tesla), such as those used in magnetic resonance tomography, can cause temporary effects such as dizziness, a metallic taste in the mouth or the appearance of light on the retina.
If splinters of metal cause injury, e.g. to the eye, the surrounding tissue could be damaged if the splinter aligns itself with the magnetic field. So far, no such effects have been observed with the fields of neodymium magnets.

3.2 Indirect effects on pacemakers and on implanted cardioverter defibrillators (ICDs)

In the presence of strong magnetic fields the pulse generators of pacemakers and ICDs can switch to the magnet mode. In this mode the pulse generator no longer responds for a certain time to the patient's heartbeat, but stimulates the heart at a fixed frequency. In rare cases this can lead to a heart, which has its own rhythm and is not constantly dependent on an implant, being stimulated in a vulnerable phase. The heart starts fibrillating and the movement of the heart becomes uncoordinated, so insufficient blood is pumped through the circulation. If the person is not given immediate medical attention the supply of blood can drop to a dangerously low level. Strong magnetic fields inhibit the action of ICDs. If a patient suffers from ventricular fibrillation whilst the ICD is inhibited, the ICD will not have any therapeutic effect, and this can lead to an insufficient supply of blood. Consequently, patients with a pacemaker or ICD should not bring magnets close to their chest without ECG monitoring.

A study carried out at Zurich University Hospital investigated the effect of a necklace made of neodymium magnet beads on the pulse generators of 41 patients with pacemakers and 29 patients with ICDs (Figure 1) [4]. In all patients the necklace interfered with the pulse generator up to a maximum distance of 3 cm.

In another study in Boston interferences with various headphones were tested on 100 patients with pacemakers and ICDs [5]. The headphone with the strongest magnetic field (see the blue curve in Fig. 3) disrupted 20 % of the pacemakers and 38.2 % of the ICDs. A second headphone (orange curve in Fig. 3) disrupted about 10 % of the implants. The other six headphones did not cause any disruption. When the headphones were held at a distance of more than 3 cm away from the body no more interferences could be observed.

There are other medical implants that can be activated and/or displaced by magnets, but it is not known to what extent neodymium magnets can cause interference in them.

3.3 Danger if swallowed

Swallowing strong magnets is extremely dangerous. If several magnets are swallowed they can attract one another, leading to intestinal perforation, infection or blockage. Several children have been injured in this way, sometimes fatally [6-8]. This sort of accident applies not only to small children, but also to older children or adolescents, so they must be warned of the dangers of swallowing magnets. It is essential to keep magnets away from young children.

4 Legal regulation

Magnets in toys are governed by the Toy standard EN 71-1 [9]. Magnets in toys must either not be able to be swallowed or have a magnetic flux index of less than 0.5 T2 mm2. A suitable warning must be displayed on the packaging of science kits containing magnets destined for older children. According to European standard EN 45502-2-2 [1] pacemakers and ICDs must function undisturbed in static magnetic fields of up to 1 mT.

5 References

1. SN EN 45502-2-1: Active implantable medical devices: Particular requirements for active implantable medical devices intended to treat bradyarrhymia (cardiac pacemakers); SN EN 45502-2-2: Particular requirements for active implantable medical devices intended to treat tachyarrhythmia (includes implantable defibrillators).
2. Ryf S et al.: Interference of neodymium magnets with cardiac pacemakers and implantable cardioverter defibrillators: An in vitro study. Technol Health Care. 2008;16(1):13-8.
3. 1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (OJ L 199 30.07.1999, p. 59, ELI: **http://data.europa.eu/eli/reco/1999/519/oj**)
4. Wolber T et al.: Potential interference of small neodymium magnets with cardiac pacemakers and implantable cardioverter-defibrillators, Heart Rhythm 4 (2007), 1-4.
5. Lee S et al. Clinically significant magnetic interference of implanted cardiac devices by portable headphones. Heart Rhythm, Vol 6, No 10. 2009
6. Brown J. C. et al. Too attractive: The growing problem of magnet ingestions in children. Pediatric Emergency Care, 29(11):1170-1174. 2013
7. Agha B.S. et al. Rare-earth magnet ingestion: A childhood danger reaches adolescence. Pediatric Emergency Care, 29(10):1116-1118. 2013
8. Olczak M. et al. A case of child death caused by intestinal volvulus following magnetic toy ingestion. Legal Medicine, Volume 17, Issue 3, May 2015, Pages 184-187
9. SN EN 71-1: Safety of toys - Part 1: Mechanical and physical properties.

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