Resistance of electronic medical implants to 50-60 Hz electric and magnetic fields

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Extended Abstract

Current medical practice guidelines and an aging population have led to an increasing number of electronic medical implants being implanted annually world-wide. A pacemaker is a small device that is placed in the chest or abdomen to control abnormal heart rhythms (arrhythmias). An implantable cardioverter defibrillator uses electrical shocks to help control life-threatening arrhythmias. The leadless pacemaker is a single chamber pacemaker able to detect and stimulate only in the cardiac chamber in which it is implanted (ventricle). In Canada, one model is currently available and approved by Health Canada (the *Micra* , by *Medtronic*). The *Boston Scientific* sub-cutaneous defibrillator is a system comprised of the defibrillator and the lead implanted under the skin, extra-vascularly and extra-thoracic, usually in a left pectoral position. An insulin pump is a different type of implant that contains a cartridge of rapid-acting insulin and a motor that pushes the insulin from the cartridge into the abdomen through an infusion set. A neurostimulator delivers mild electrical signals to the epidural space near the spine through one or more leads. The electrical signals cause a tingling sensation in the area of the back and limb pain, for better control of chronic pain. A cochlear implant is replaces the function of the damaged cochlea (inner ear), so to provide sound signals to the brain.

To protect carriers, several safeguards are built into the devices to shield them from normal daily interference. According to manufacturers, medical implants have been designed and tested to operate normally during an exposure to electromagnetic fields commonly encountered in residential, commercial or medical environments. Most ISO standards or standard letters that are issued by manufacturers state 50-60 Hz electric and magnetic field thresholds that exclude many industrial environments. For utilities, potential problems may arise from this situation, from a public or worker's perspective:

- The maximum 50-60 Hz electric field threshold is either not reported, lower than the typical values found in substations (up to 15 kV/m) or underneath high voltage power lines (up to 8.5 kV at ground level, mid-span between 735 kV towers) or lower than ICNIRP's and IEEE's recommendations for public exposure (4.2 and 5 kV/m).
- The 50-60 Hz magnetic field limit is exceeded in several environments: power generation stations (up to 1,000 µT) and substations (more than 100 µT near inductances).

In many cases, manufacturers provide an exhaustive list of possible sources of electromagnetic interference to be avoided, both at home and in the workplace. Most of the time, in their official publications, no mention is made of the specific recommended approach under and in proximity to power lines. Although clinically significant interference events have rarely been reported in practice by the general public in relation to passing underneath a high voltage power line, the potential consequences might, in some cases, be deleterious to the carrier and needed to be better assessed.

The reassuring results of the registry of interference with cardiac implants (P, DIEM) will be highlighted. Two collaborative projects involving the Montreal Heart Institute, Hydro-Québec, IREQ and EPRI were conducted in 2014 and 2016, looking at traditional (as well as leadless and subcutaneous cardiac devices) from the five (5) large manufacturers. The experimental studies were performed in IREQ's high voltage lab. Devices were exposed to high controlled electric fields and the individual electrical field thresholds for each model tested were successfully determined. The conclusions of a work trial done at a 735 kV substation, concerning the secure 60 Hz electric field threshold for an insulin pump carrier working at Hydro-Québec, will be presented. The results of these studies enable Hydro-Québec to establish a procedure (Medical Council advice) to manage a safe return to work for utility workers.

References

1. G. Ostiguy, D.H. Nguyen, M. Plante, A. Turgeon, K. Dyrda. Hydro-Québec internal technical reports. "Pacemaker and defibrillator resistance to 60 Hz electric fields", 2015. (unpublished: articles in preparation).