Magnetic fields in Vortex Saunas

EMF Services
Professional EMF measurement
and advisory services

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Vortex Leisure
940 Great South Road
Auckland 1061

Report prepared by: Martin Gledhill
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About EMF Services and the author of this report

EMF Services is a division of Monitoring and Advisory Services NZ Ltd (MAASNZ), and provides professional measurement and advisory services related to possible health effects of electromagnetic fields (EMFs), such as the extremely low frequency (ELF) electric and magnetic fields found around any wiring, appliances or infrastructure carrying mains electricity, and the radiofrequency (RF) fields produced by radio transmitters and some industrial equipment.

Martin Gledhill has an MA degree in Natural Sciences (Physics) from Cambridge University and an MSc in Medical Physics from the University of Otago. He is a member of the Australasian Radiation Protection Society, the Bioelectromagnetics Society, and the Ministry of Health's Interagency Committee on the Health Effects of Non-Ionising Fields. Before forming MAASNZ he was head of the non-ionising radiation section at the National Radiation Laboratory of the New Zealand Ministry of Health. In this position he provided advice to central and local government, the public and industry on the health effects of EMFs, and carried out measurement and assessment services in this area. This work included providing policy advice to the Ministries of Health and the Environment, preparation of public information material, presenting expert evidence at local authority and Environment Court hearings, and assessing exposures to EMFs by both measurements and calculations.

EMF Services
P O Box 17
Clyde
New Zealand

info@emfservices.co.nz
www.emfservices.co.nz
+64 27 545 4217

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1 Introduction and summary of results

This report presents the results of measurements of extremely low frequency (ELF) magnetic fields made inside the Vortex Linear and Prestige saunas. The measurements were made with the heater panels, lights and fan switched on.

Measurements were made where the centre of the body would be positioned when sitting in the sauna, and next to the heating panels at the back and sides of the saunas.

1.1 Prestige Sauna

Results are summarised in the table below.

	Magnetic flux density (μT)	
	Centre of the body	**Next to rear and side heater panels**
Typical value	0.024 - 0.040 μT	0.023 - 0.070 μT
Maximum value	0.070	0.26

Over much of the sauna the magnetic fields were very similar to the levels found with the heaters, lights and fan switched off.

Full results are shown in figure 1.

1.2 Linear Sauna

Results are summarised in the table below.

	Magnetic flux density (μT)	
	Centre of the body	**Next to rear and side heater panels**
Typical value	0.027 - 0.044 μT	0.028 - 0.079 μT
Maximum value	0.068	0.22

Over much of the sauna the magnetic fields were very similar to the levels found with the heaters, lights and fan switched off.

Full results are shown in figure 2.

1.3 Conclusions

Magnetic fields in the two Saunas were all very low, and over most of the sauna they were very similar to the levels present with the sauna heating panels, lights and fan switched off. The magnetic fields in the saunas were very similar to those found in many New Zealand homes. The magnetic field levels were very much lower than recommended limits, and there is no suggestion that exposures to magnetic fields at these levels would have any adverse health effects.

The measurements were made in two-person models. As the heating panels in one- and three-person models are of essentially the same design, similar fields would be expected in these.

Fig 1. Magnetic field measurements in the Prestige 2-person sauna. Left side of the sauna shown on the left, right side of the sauna on the right. Figures show the magnetic flux density in microtesla (μT). Figures in yellow show the values next to the heater panels at the rear and sides of the sauna, figures in orange show the field at the approximate position of the centre of the body of someone sitting in the sauna.

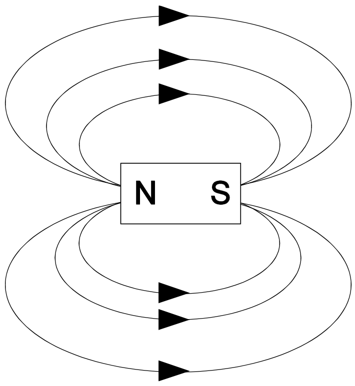
Fig 2. Magnetic field measurements in the Linear 2-person sauna. Left side of the sauna shown on the left, right side of the sauna on the right. Figures show the magnetic flux density in microtesla (μT). Figures in yellow show the values next to the heater panels at the rear and sides of the sauna, figures in orange show the field at the approximate position of the centre of the body of someone sitting in the sauna.

2 Nature of magnetic fields

A field is a concept used to explain how one body can influence or exert a force on another body that is some distance from it. A magnet, for example, attracts an iron nail even though the two objects may be separated by several centimetres. To explain this, we say that the magnet is surrounded by a magnetic field. The magnetic field has the property that it attracts anything made of iron.

A field is often represented by "lines of force", whose number or density indicate the strength of the field. Around a magnet, the strength and shape of the magnetic field can be visualised by sprinkling iron filings over a piece of paper and holding the paper over the magnet. The filings align themselves in a pattern indicating the shape and direction of the field.

A wire carrying electric current generates a magnetic field around the wire. This field is exactly the same in its nature and properties to the magnetic field around a bar magnet, except that the "lines of force" form circular loops around the wire. The strength of the field decreases with increasing distance from the wire.



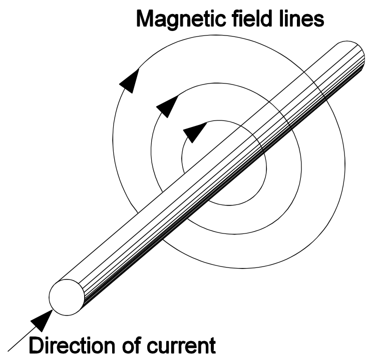


Fig 3. Magnetic field lines around a bar magnet (left) and a current-carrying wire (right)

If the wire carries an alternating current (ie, one which undergoes regular changes in its direction), then the magnetic field around the wire also undergoes regular changes in direction at the same frequency. Current in cables or equipment carrying mains electricity oscillates at a frequency of 50 Hz (ie, 50 times per second) and hence gives rise to a magnetic field that also oscillates at 50 Hz. This frequency is in a range commonly referred to as extremely low frequency (ELF).

ELF magnetic fields are found around any cables or appliances carrying mains electricity. If the current passes through a coil, as in a transformer or electric motor, the field lines are concentrated and a much stronger field is produced. However, the strength of the field falls off very quickly with distance, in inverse proportion to the square or cube of the distance (in other words, fields measured twice as far away are four to nine times lower). Magnetic fields are not shielded by most materials: special alloys or grades of steel are needed to provide effective shielding.

Magnetic field measurement results are reported in units of microtesla (μT), the unit of magnetic flux density in the SI (International System) of units. In some literature on the subject, an older unit, the milligauss, is sometimes used. There is a factor of ten difference between these two units: 1 microtesla = 10 milligauss, 0.1 microtesla = 1 milligauss etc.

Typical ELF magnetic field levels found in various locations are summarised in the table below.

Location	Typical magnetic fields (μT)
Beneath high voltage power lines (66 kV - 220 kV)	0.3 - 5
30 metres from high voltage line	0.1 - 1.2
Beneath low voltage street lines	0.15 - 2
Along central city streets (no overhead lines)	0.05 - 0.8
Background in houses, offices	0.05 - 0.15
Close to appliances	0.05 - 7
1 metre from appliances	0.005 - 1
Near electric range	0.5 - 2.2

3 Measuring equipment and procedures

The instrument used to measure the ELF fields was a Narda EHP-50F electric and magnetic field analyser, with the readout through a Narda NBM-550 broadband field meter connected via a fibre optic cable. A 24 Hz – 2 kHz filter was used for all magnetic field readings. All readings are true RMS (root-mean-square) values (a kind of average used for alternating quantities). Full specifications are given in the table below.

Manufacturer	Narda Safety Test Solutions GmbH, Pfullingen, Germany
Meter	NBM-550 s/n E-0322, firmware v 2.2.2
Probe	EHP-50F electric and magnetic field analyser, s/n 000WX60517, firmware v 5.37
Measurement ranges (selectable)	Magnetic fields: 0.003 – 100 μT, 0.03 – 10,000 μT Electric fields: 0.005 – 1,000 V/m, 0.5 – 100,000 V/m
Frequency ranges (selectable)	5 – 100 Hz, 5 – 200 Hz, 6 – 500 Hz, 12 – 1,000 Hz, 0.024 – 2 kHz, 0.12 – 10 kHz, 1.2 – 100 kHz, 4.8 – 400 kHz
Calibration	By the manufacturer, July 2020
Recommended calibration interval	2 years
Measurement uncertainty at 50 Hz (including calibration uncertainty)	Magnetic fields (0.1 – 100 μT): 5.6% Electric fields (10 V/m – 100 kV/m): 9%
Last performance check	July 2021

The measurements were made in the morning of 5 August 2021.

There are three possible sources of magnetic fields in the saunas: the heating panels, lights and fan. When the sauna is turned on, the heating panels produce a magnetic field while the sauna is warming up to the desired temperature. The strength of the magnetic field does not depend on the temperature. For these tests, the temperature was set to 60 °C to ensure that the heating panels were always on for the tests. In practice, because the sauna was turned off periodically between tests, the temperature did not rise above 30 °C, which is well within the operating range of the magnetic field meter.

Measurements were made with the probe held next to the heating panels at the sides and rear of the sauna, and in the approximate position of the centre of the body of someone sitting in the sauna. Measurements next to the heating panels were made with one of the probe measurement coils next to the panel. The fan and lights were also turned on during the tests.

In addition, a measurement of the background level in each of the two saunas tested was made with the heater panels, lights and fan switched off.

Finally, the probe was mounted on a stand in the approximate position of the centre of the chest of someone sitting in the sauna, and the magnetic field recorded for fifteen seconds with the heating panels, lights and fan switched off, and fifteen seconds with them switched on. The purpose of these measurements was to see the difference in magnetic fields with the sauna turned off (background measurement) and turned on.

4 Recommended exposure limits

The Ministry of Health recommends the use of exposure Guidelines published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP is an independent scientific body, recognised by the World Health Organisation (WHO) for its expertise in this area. Their Guidelines are based on a careful examination of the research data on the health effects of exposure to ELF fields, and include margins for safety. ICNIRP periodically reviews its Guidelines to take account of new research data, and the most recent revision was published in December 2010[1] and is largely based on a comprehensive review of the relevant research data published by the WHO[2]. The underlying basis for the Guidelines has remained unchanged for more than twenty years. The ICNIRP guidelines have been adopted by a number of overseas health bodies.

The ICNIRP guidelines set *basic restrictions* on the electric fields induced in the body by low frequency magnetic fields. As induced electric fields are difficult to measure, the guidelines also prescribe *reference levels* in terms of the more easily measured magnetic flux density. Compliance with the reference levels ensures compliance with the basic restrictions, and in most applications the reference levels can effectively be regarded as "exposure limits" (although this term is not used as such). If exposures exceed the reference levels, this does not necessarily mean that the basic restriction is also exceeded. However, a more comprehensive analysis is required in order to verify compliance with the basic restrictions.

The recommended limit varies with the frequency of the ELF field, and at a frequency of 50 Hz (the frequency of mains electricity) the reference level for continuous exposures of the public is 200 μT.

The ICNIRP Guidelines are based on the prevention of interference with the body's nervous system by magnetic fields. These were the most sensitive health effects of ELF fields which could be established with any certainty by WHO. A lot of research has been carried out to try and determine whether there may be other effects at exposure levels much lower than the ICNIRP limits. Although the major focus of the research has been possible effects of exposure to ELF magnetic fields on cancer, other outcomes such as effects on pregnancy, neurodegenerative diseases (Alzheimer's disease, amyotrophic lateral sclerosis (ALS) etc) and cardiovascular disease have also been investigated. This data has been reviewed by the WHO, and also by other groups [3,4,5,6,7].

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1 International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz). Health Physics, 99 (6), 818 – 836. Available at: www.icnirp.org.

2 WHO. Environmental health criteria 238. Extremely low frequency fields. WHO, Geneva, 2007. Available for download at: www.who.int/peh-emf/publications/elf_ehc/en/index.html

3 Swedish Radiation Safety Authority (SSM). Scientific Council on Electromagnetic Fields. Fourteenth report, 2020. Report no. 2020:04. Available at: www.stralsakerhetsmyndigheten.se.

4 SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks). Potential health effects of exposure to electromagnetic fields (EMF). 27 January 2015. Available at: http://ec.europa.eu/health/scientific_committees/consultations/public_consultations/scenihr_consultation_19_en.htm

Overall, these groups find that there is a weak but relatively consistent association between prolonged exposure to relatively strong magnetic fields and childhood leukemia. There is no known mechanism that could explain this association, and so there is doubt whether EMF magnetic fields actually cause the observed increase in childhood leukemia. Evidence of links between exposures and adult cancers are, at most, very weak, and generally inconsistent. There is no good laboratory evidence suggesting any effect of ELF fields on the development of cancer. Research data on other outcomes does not provide persuasive evidence that there are any effects, and for some conditions (eg cardiovascular disease and unusual sensitivity to ELF fields) it is sufficient to rule out any relationship.

The WHO review concluded that the evidence of an association between ELF magnetic fields and childhood leukemia is too weak to suggest a cause and effect relationship and does not justify changing current exposure guidelines. On the other hand, implementing very low cost precautionary measures to reduce exposure is reasonable and warranted provided that the health, social and economic benefits of electric power are not compromised. The WHO has published an information sheet (available at http://www.who.int/mediacentre/factsheets/fs322/en/index.html).

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[5] French Agency for Food, Environmental and Occupational Health & Safety (ANSES). Opinion on the Health effects associated with exposure to low-frequency electromagnetic fields. April 2019. Available at: https://www.anses.fr/en/system/files/AP2013SA0038EN.pdf

[6] Schuz et al. 2016. Extremely low frequency magnetic fields and risk of childhood leukemia: a risk assessment by the ARIMMORA consortium. Bioelectromagnetics, 37(3) 183-189.

[7] Health Council of the Netherlands. Power Lines and Health Part I: Childhood cancer. No. 2018/08. Available at: https://www.healthcouncil.nl/documents/advisory-reports/2018/04/18/power-lines-and-health-part-i-childhood-cancer

5 Measurement results

5.1 Background magnetic fields

The background magnetic field (arising from wiring and other electrical equipment in the area where the saunas were tested) was measured in each sauna. For both saunas the background field was in the range 0.02 – 0.04 μT. This is on the low side of what is typically found in New Zealand houses.

5.2 Magnetic fields with the sauna switched on

Magnetic field levels in the Prestige and Linear saunas with the heating panels, lights and fan switched on are shown in figures 1 and 2.

Over much of the sauna, the magnetic field levels were very similar to the background level. Where there were a few noticeable increases above the background level, these were typically in very localised spots. For example, a maximum magnetic field of 0.26 μT was measured on the right hand side of the rear panel in the Prestige sauna. 5 cm away from the rear panel (towards the front of the sauna) this had decreased to 0.03 μT.

5.3 Time recordings of the magnetic field

The measurement probe was mounted on an insulating stand at the approximate position of the centre of the chest of someone sitting in the sauna (see figure 4). A recording of the magnetic field against time was made for fifteen seconds with the sauna switched off, and fifteen seconds with the sauna on. A recording was made on the left and right sides of each sauna. Results are shown in figures 5 to 8.

The recordings show that turning the sauna on made little or no difference to the magnetic fields in the four positions tested.

Fig 4. Position of the measurement probe on the right side of the Prestige sauna for recording the magnetic field against time.

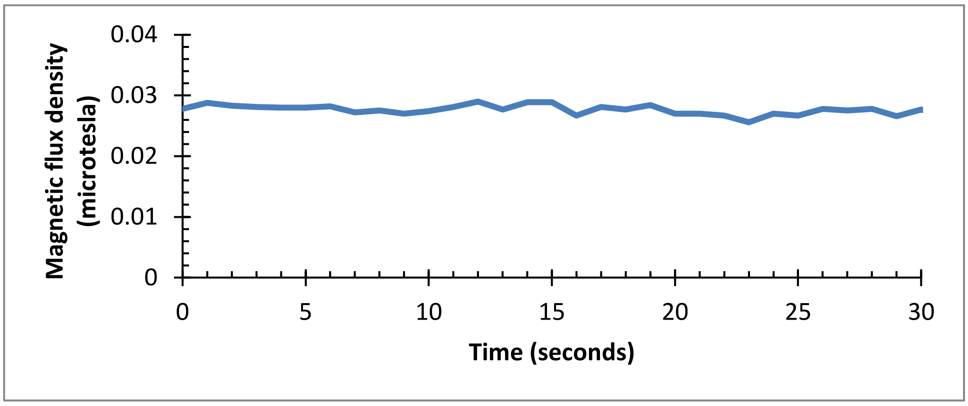

Fig 5. Magnetic field as a function of time on the left side of the Prestige sauna. The sauna was switched on after 15 seconds

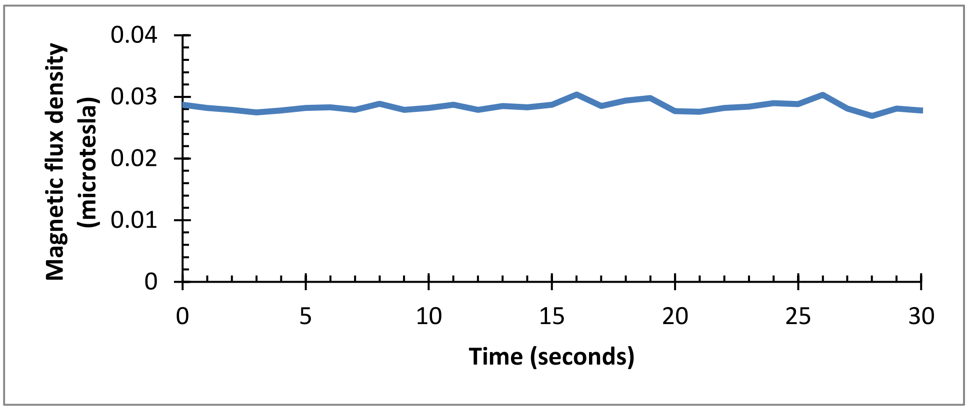

Fig 6. Magnetic field as a function of time on the right side of the Prestige sauna. The sauna was switched on after 15 seconds.

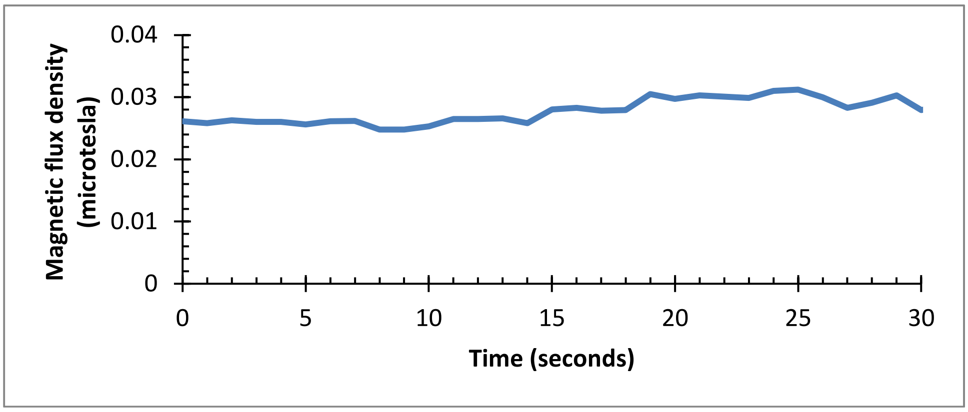

Fig 7. Magnetic field as a function of time on the left side of the Linear sauna. The sauna was switched on after 15 seconds

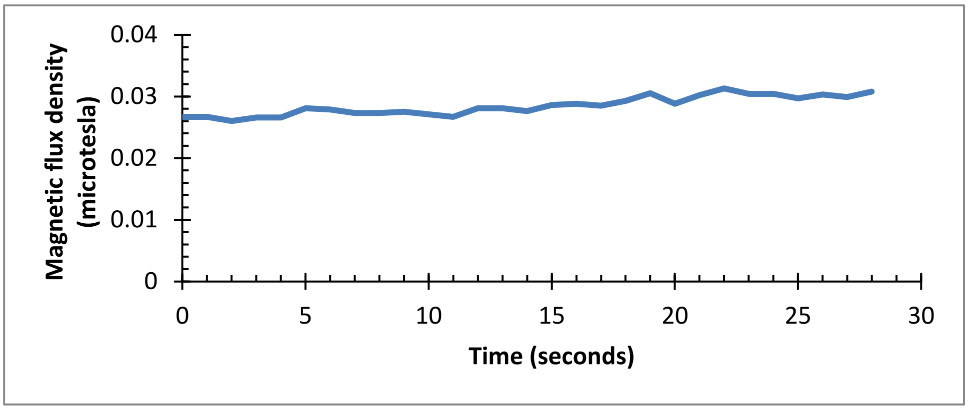

Fig 8. Magnetic field as a function of time on the right side of the Linear sauna. The sauna was switched on after 15 seconds

6 Discussion

Magnetic fields in the Prestige and Linear saunas were very low, and often indistinguishable from the background fields present when the sauna was turned off. Generally, magnetic fields with the saunas on were in the range 0.024 to 0.070 μT. In one or two isolated spots in each sauna the magnetic fields close to the heating panels were higher, reaching a maximum of 0.26 μT. However, moving away from these spots the field decreased rapidly, and was back to the typical levels within around 5 cm.

Measurements were made in two-person saunas. As the heating panels used in the one- and three-person models are of essentially the same design, similar results would be expected in these.

The magnetic fields measured in the saunas were all well below the recommended limit of 200 μT. Someone using the sauna would be exposed to magnetic fields similar to those experienced by people in most New Zealand homes. Research on the effects of magnetic fields and health does not suggest that such low levels have any effects on health.