Measurements of radiofrequency fields from a WEL Networks Smart Meter

EMF Services
Professional EMF measurement and advisory services

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This report was prepared for:
WEL Networks Ltd
P O Box 925
Hamilton

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) and an MSc in Medical Physics. He is a member of the Australasian Radiation Protection Society and of the Bioelectromagnetics Society. 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 25006
Christchurch
New Zealand

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

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Introduction and summary

This report describes measurements of radiofrequency (RF) fields from a WEL Networks Smart Meter. The Smart Meter incorporates a Silver Spring Network Interface Card (NIC) which communicates with the metering network by radio. The NIC includes a second transmitter which can communicate with a Home Area Network, but by default this functionality is disabled and it was not tested. The measurements were made in November 2012.

Measurements behind a typical WEL Networks metering installation (meter installed on an outside wall inside a metal meter box with glass viewing panels) showed that the exposure measured during the day (averaged over 30 seconds) was normally less than 0.0005% of the limit allowed for the public in NZS 2772.1:1999 *Radiofrequency Fields Part 1: Maximum exposure levels – 3 kHz to 300 GHz*. The highest exposure averaged over 30 seconds was less than 0.003% of the public limit.

The peak instantaneous exposure (ie the exposure while the meter was transmitting) measured in this setting was 0.18% of the public limit. On average, the meter was transmitting 0.095% of the time, equivalent to a total transmission time of one minute 22 seconds per day. The highest duty cycle (proportion of time during which the meter transmits) measured over any 30 second interval was 3%.

The peak instantaneous exposure measured 30 cm from the front of the meter was 13% of the public limit in the Standard. If the meter were operating with the measured worst-case duty cycle of 3%, the time-averaged exposure at this point would be 0.39% of the public limit.

Full details of the measurement techniques and results are contained in appendices to this report.

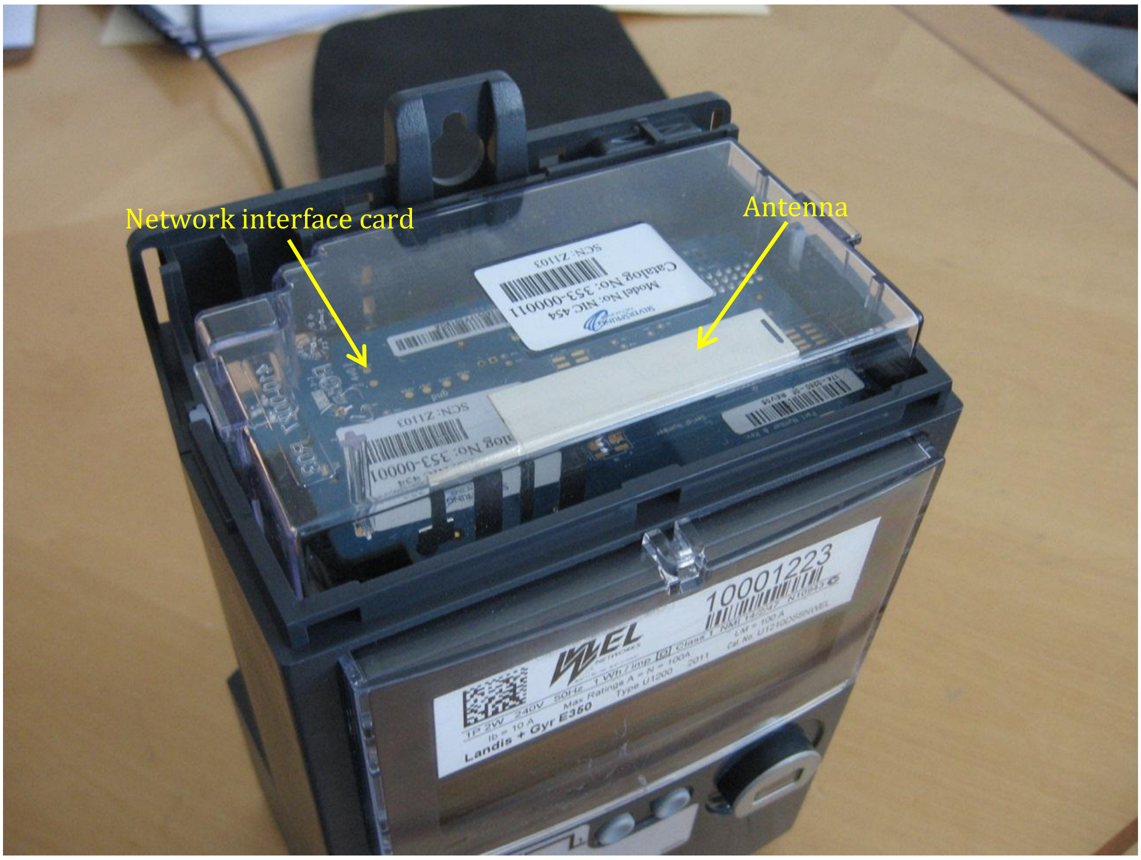
The NZ Standard at 923 MHZ is 4,615,000 uW/m2
Any time averaged reading is not really valid as the body must cope with the full pulse of the transmission.
13% of the public standard is therefore 599,950 uW/m2.
Even if we did accept the time averaged reading this would still be 17,999 uW/m2, similar to being 50m from a cell phone tower.

Appendix 1 Equipment description

The meter tested was a standard WEL Networks Smart Meter with a Landis + Gyr E350 meter and a Silver Spring model 454 Network Interface Card (NIC) mounted at the top.

The NIC transmits at frequencies between 921.5 and 928 MHz using a frequency-hopping spread spectrum technique. The rated transmitter power is 0.5 – 1 watt. The transmitter operates intermittently as needed to send its information back to the metering operator via a nearby access point, and maintain information on the optimum transmission path to that access point. The metering system is set up to receive information from each meter six times per day.

A ZigBee Home Area Network radio system transmitting at around 2.4 GHz with a power of 0.1 – 0.2 watt is built into the NIC but by default is not enabled. This functionality was not tested.



The Smart Meters operate in a mesh network. Metering information is fed back to a nearby access point either directly, or by being relayed through one or more other meters in the network.

When the meter is initially powered up, it automatically transmits several sets of signals to try and establish connections with the network and nearby meters.

This meter and NIC combination have previously been successfully tested for compliance with AS/NZS 4268:2008 *Radio equipment and systems - Short range devices - Limits and methods of measurement*, as specified under the General User Radio License and Product Compliance requirements of the Ministry of Economic Development. These tests were undertaken by MiCOM Labs Inc of Pleasanton, California, USA.

The meter and NIC have also been successfully tested for compliance with the Class B requirements of AS/NZS CISPR 22:2009 *Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement*. These tests were undertaken by EMC Technologies Pty Ltd of Seven Hills, NSW, Australia.

Appendix 2 Measurement equipment and techniques

The planning, execution and reporting of the measurement survey followed the procedures recommended in AS/NZS 2772.2:2011 *Radiofrequency fields Part 2: Principles and methods of measurement and computation – 3 kHz to 300 GHz*.

2.1 Measuring equipment

RF fields were measured with a Narda SRM-3006 Selective Radiation Meter and three-axis electric field probe connected by a 1.5 m cable. Full specifications are presented in Annexe A.

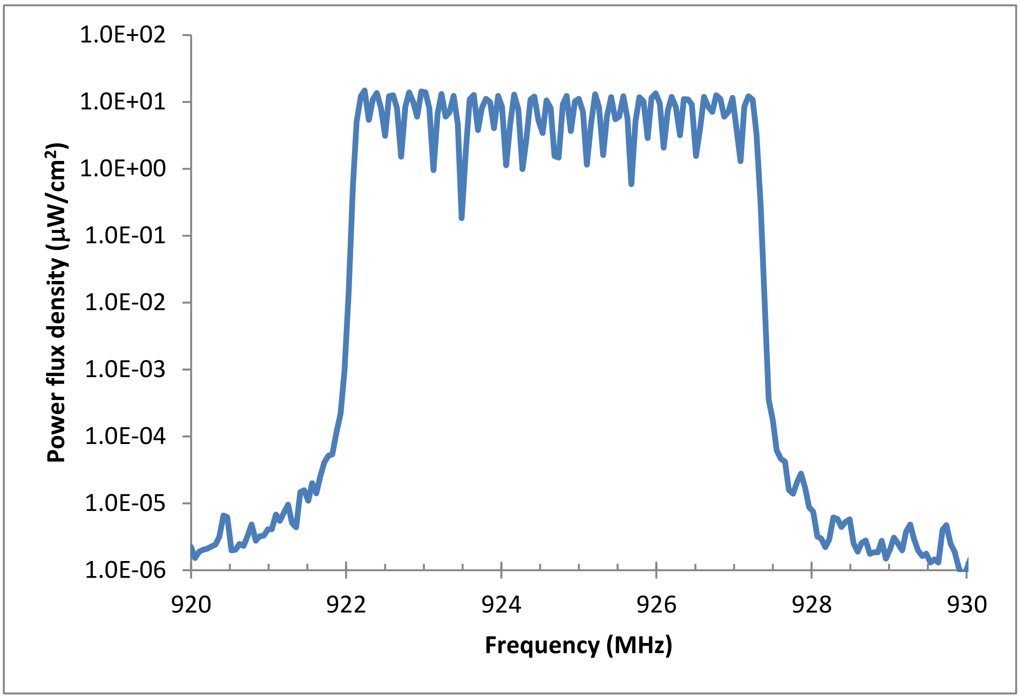
The meter and probe combination measures electric field strength, which is expressed in units of volts per metre (V/m). For ease of comparison with the exposure limits recommended in NZS 2772.1:1999, the meter was set to record data as the equivalent power flux density of a plane wave, and results are presented as a percentage of the power flux density reference level recommended in the NZ RF field exposure Standard.

2.2 Verification of the transmitting frequency range

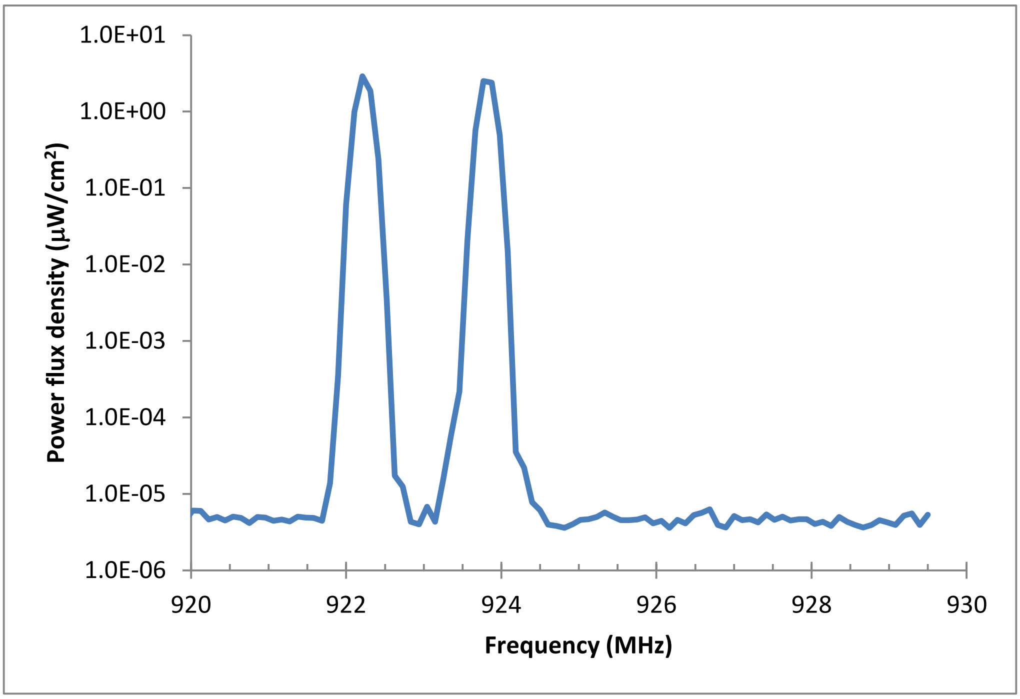
The meter was put on maximum hold in spectrum analysis mode and a spectrum acquired on a single axis over about one minute after powering up the Smart Meter.

This confirmed that all transmissions were inside the specified 921.5 – 928 MHz frequency band.

The two graphs below show the spectrum accumulated over the whole frequency band after two or three minutes acquisition, and the spectrum from two successive transmissions, each at a different frequency.



Accumulated spectrum from Silver Spring NIC model 454



Spectrum from Silver Spring NIC model 454 showing successive transmissions at two frequencies.

2.3 Measurement techniques – peak exposures

Measurements of peak exposures were made in Level Recorder mode, using a centre frequency of 924.5 MHz and a resolution bandwidth of 10 MHz. In this mode the meter records the peak exposure from pulsed transmissions (such as those from the Smart Meter), and also the root-mean-square (RMS) exposure over a preset time interval. The measurement range was set to 40 µW/cm^2 to ensure that the input stages of the meter were not saturated.

In order to allow for the fact that the radio signal from the meter may have any polarisation, Level Recorder measurements were made in manual isotropic mode. In this mode a continuous measurement is made on each axis of the probe in turn to obtain the exposure on that axis, and then the three values added to give the total exposure[1].

To make the measurements, the Smart Meter was placed in the desired location and then powered up. This would cause the NIC to start transmitting as it tried to establish connections with nearby meters or access points. The measurement probe was held on a non-conducting stand, with the centre of the probe at the same height as the NIC antenna and at distances of 30, 50 or 100 cm from the Smart Meter. A measurement was made on each axis in turn. Initially the peak reading on each axis increased very quickly and then stabilised at its maximum value. Once the value had stabilised the meter was set to read the next axis, and so on until the peak exposure on all three axes was obtained. The meter was then set to present the total exposure (sum of the exposures measured on the three axes).

[1] Level Recorder mode operation is explained in more detail in the Narda Application note *Principles and applications of the Selective Radiation Meter SRM-3000* available on request from support@narda-sts.de. It is referred to as Time Analysis mode in that document.

Peak exposure being measured 30 cm from the front of the meter

2.4 Measurement technique – average exposure from a typical installation

Measurements were made at a house on the north-west side of Hamilton which had the meter installed in a standard metal meter box (with two glass viewing windows on the front door of the box) mounted on the outside wall of a garage.

The measurement probe was set up inside the garage so that it was behind the top of the meter (where the antenna is located), with the centre of the probe about 15 cm from the internal garage wall. It is considered that this represents a worst-case exposure for someone inside the house.

A reading of the peak exposure was made as described in section 2.3. This showed that the z-axis of the probe recorded the highest exposure. The meter was then set to record the RMS exposure on the z-axis, averaged over 30 seconds, every 12 seconds. (The z-axis was chosen as the reading was higher on this axis than on the other two.) During later processing, this recorded value was scaled by the ratio of the peak isotropic exposure to the peak z-axis exposure to obtain the RMS average isotropic exposure.

Appendix 3 Exposure Standards

The New Zealand Ministry of Health recommends using NZS 2772.1:1999 *Radiofrequency Fields Part 1: Maximum exposure levels – 3 kHz to 300 GHz* to manage exposure to RF fields. This Standard is based closely on Guidelines published by the International Commission on Non-Ionising Radiation Protection (ICNIRP). ICNIRP is an independent scientific body recognised by the World Health Organisation for its expertise in this area. Their exposure Guidelines, which are based on a careful review of the health effects research, were first published in 1998[2], and reaffirmed in 2009[3] following a review of more recent research in this area[4].

NZS 2772.1 sets limits for exposure to the RF fields produced by all types of transmitters, and covers both public and occupational exposures. Occupational limits should normally be applied only to people who are expected to work on RF sources (eg radio technicians and engineers, riggers, RF welder operators etc), who have received training about potential hazards and precautions which should be taken to avoid them. Their exposures to occupational levels would normally be limited to the working day and over their working lifetime. Occupational exposure limits are set at levels 10 times lower than the threshold at which adverse health effects might occur. The public limits have a safety factor of 50.

The Standard sets fundamental limits, called *basic restrictions,* on the amount of RF power absorbed in the body. As absorption of RF power is difficult to measure, the Standard also specifies *reference levels* in terms of the more readily measured (or calculated) electric and magnetic field strengths, and power flux density. Compliance with the reference levels ensures compliance with the basic restrictions, and in many situations they can effectively be regarded as the NZS 2772.1 "exposure limits", although this term is not used as such in the Standard. If exposures exceed the reference levels, this does not necessarily mean that the basic restriction has also been exceeded. However, a more comprehensive analysis is required before compliance can be verified.

The exposure limit depends on the frequency of the RF field. At the frequencies used by the WEL Networks Smart Meter NIC, the limit varies from 460 to 464 $\mu W/cm^2$. In this report, a limit of 460 $\mu W/cm^2$ has been used as it is the most conservative.

The most restrictive limit at any frequency is 200 $\mu W/cm^2$.

At the frequencies of interest in this survey, the limits prescribed in the Standard are average values over six minutes. Spatial averaging, at the four corners and centre of a 30 cm square, is also permitted. In this report, the measurements made in the typical WEL Networks installation are averaged over 30 seconds rather than six minutes, which would tend to give increased maximum values. The peak exposure levels reported have had no averaging applied. No spatial averaging has been applied.

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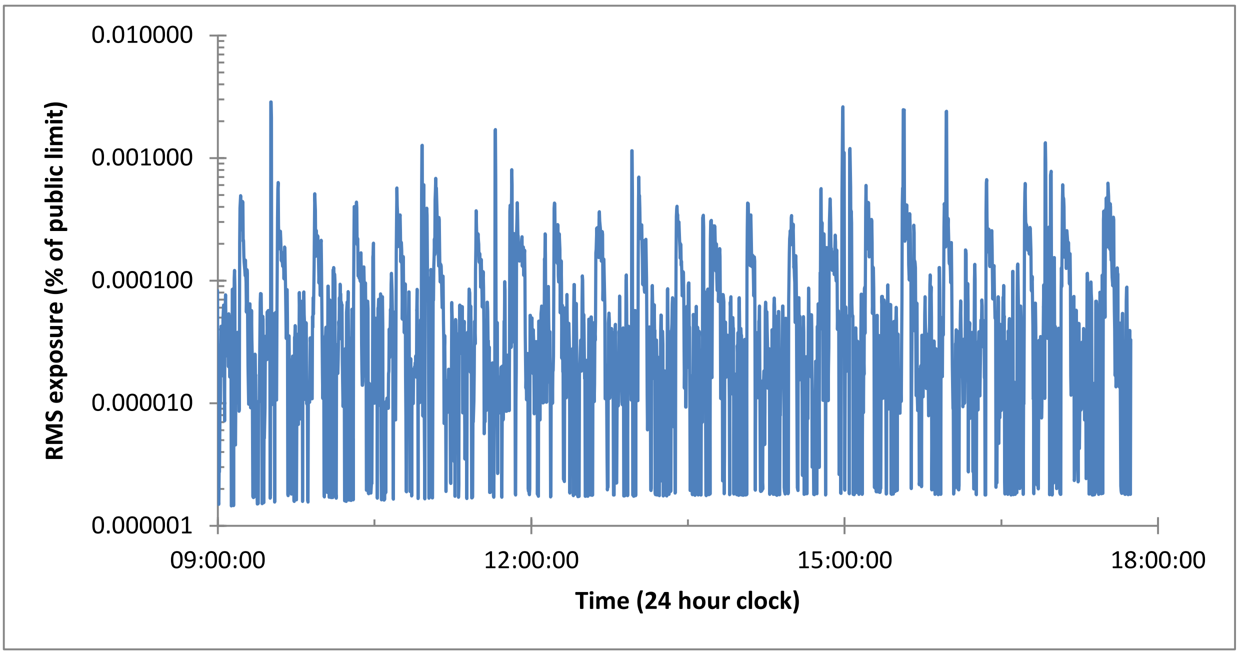
[2] http://www.icnirp.de/documents/emfgdl.pdf
[3] http://www.icnirp.de/documents/StatementEMF.pdf
[4] http://www.icnirp.de/documents/RFReview.pdf

Appendix 4 Measurement results

4.1 Exposures behind a typical installation

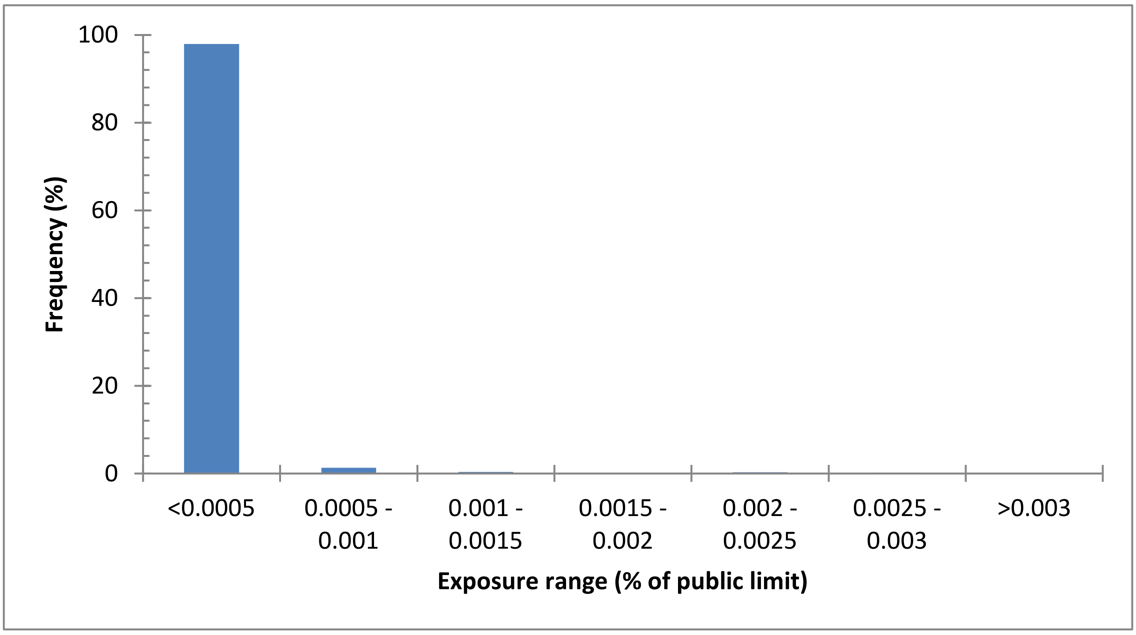
A plot showing the exposure averaged over 30 seconds between 9 am and 5.45 pm, expressed as a percentage of the public limit, is shown below.



Exposure measured behind a Smart Meter in a typical installation. Plot shows exposure averaged over 30 seconds between 9.00 am and 5.45 pm

In order to display the full range of values obtained, the vertical axis is logarithmic (compressed). The exposure averaged over 30 seconds ranged from 0.000002% (the detection threshold of the meter) to just under 0.003%.

The distribution of exposures is presented in the histogram below.



Distribution of 30 second-average exposures

This shows that 98% of the time, exposures averaged over 30 seconds were less than 0.005% of the public limit.

The data can also be used to estimate the duty cycle of the Smart Meter's transmitter, by dividing the time averaged exposure by the peak exposure. This shows that over the whole of the measurement period, the average duty cycle was 0.095%, with a maximum value over any 30 second interval of 3%.

4.2 Peak exposures

Peak exposures are the exposures measured when the Smart Meter is actually transmitting, and do not take into account time averaging permitted in the exposure Standard. Peak exposures can be converted into a time-averaged exposure by multiplying by the relevant duty cycle.

4.2.1 Peak exposures from typical WEL Networks installation

The peak exposure (ie the exposure during a transmission from the Smart Meter) recorded at the typical WEL Networks installation was equivalent to 0.18% of the public limit in the New Zealand exposure Standard.

4.2.2 Peak exposures in other mounting arrangements

Measurements of peak exposures were made in several different mounting arrangements:

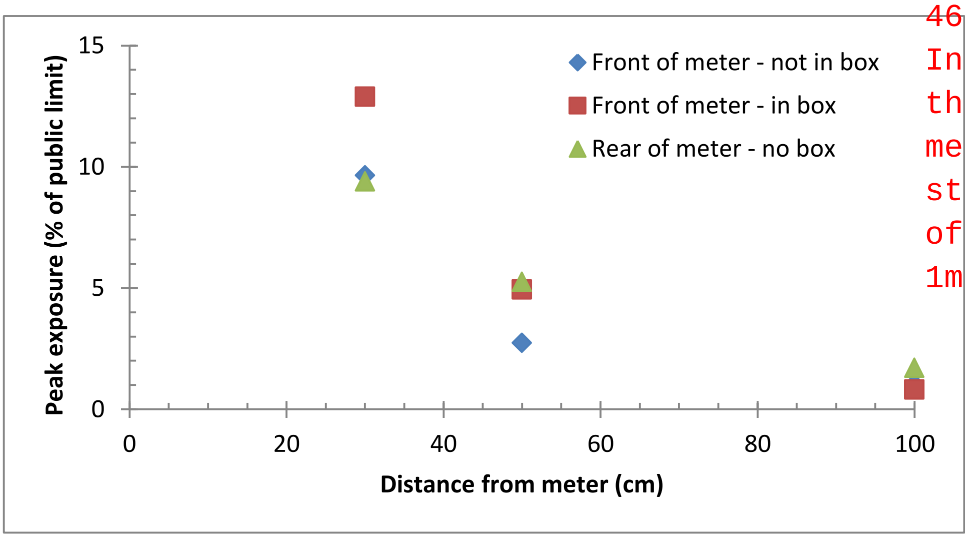
- Front and rear of the meter, meter on a wooden table
- Front and rear of the meter, meter in a standard WEL Networks metal meter box with two glass windows in the door of the box
- Rear of the meter, meter on the outside of a weatherboard wall
- Rear of the meter, meter in a metal box on the outside of a weatherboard wall[5]

Measurements were made 30, 50 and 100 cm from the meter or, where measurements were made with the meter on the far side of a wall, at those distances from the inside surface of the wall. Three sets of readings were made for each mounting arrangement, except for the measurements at the rear of the meter with the meter on a wooden table, where only one set was made.

The graphs below shows the maximum value of the peak exposure measured at each distance.

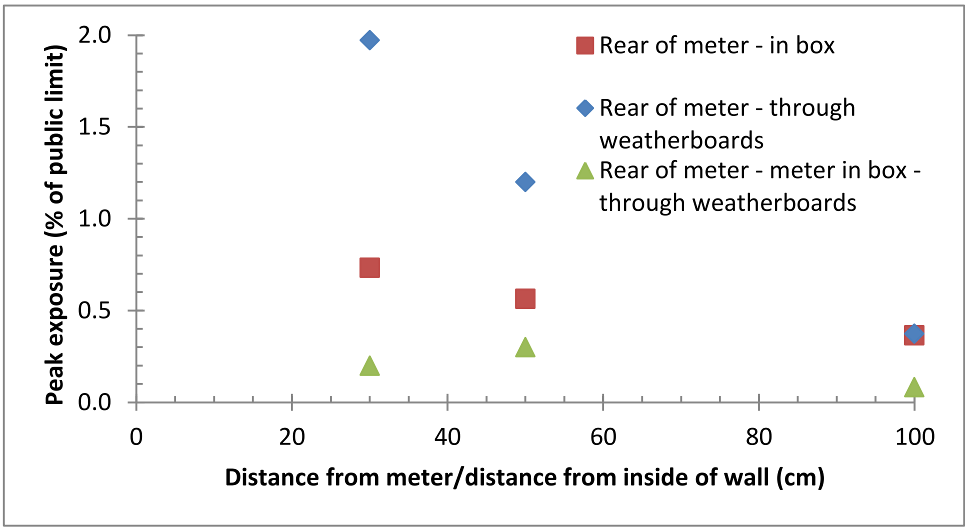
[5] The meter box used was a not a standard WEL Networks box, but one with a solid metal front panel, hinged at the top. The front panel was opened about 15 cm at the bottom.

1% of the public limit is 46,150 uW/m2 Interesting to note that the rear of the meter with no box was stronger than in front of meter in the box at 1m



Peak exposure measured in front of the meter in and out of the meter box, and behind the meter (no box)

At distances of 30 and 50 cm, exposures at the front of the meter were higher with the meter inside the meter box than with no box. This can possibly be attributed to an additional contribution from signals reflected off the back of the meter box.



At 1m the readings would be 18,460 uW/m2 (0.4%) or 4,615 uW/m2 (0.1%)

Peak exposure measured behind the meter in a meter box, and behind the meter and a weatherboard wall with and without a box

It is likely that a significant amount of the exposure recorded behind the meter when it was in the WEL Networks meter box was due to signals transmitted through the glass panels at the front of the box being reflected back by the walls of the room in which the tests were made.

The weatherboards and plasterboard lining reduced exposures by a factor of about 3 or 4 (after taking into account the thickness of the wall, which means that true distances behind the meter are about 15 cm greater than the distance at which measurements were made). With the meter inside the metal meter box on the outside of a weatherboard wall, exposures were greater at 50 cm than at 30 cm, but had decreased again at 100 cm. This is probably due to the effects of radio signals which propagated through the opening at the bottom of the meter box being reflected back inside the house.

Appendix 5 Discussion

5.1 Comparison with data obtained elsewhere

Detailed measurements of exposure from the Silver Spring NIC have been reported by the Victoria Department of Primary Industries (DPI)[6] and the Electric Power Research Institute (EPRI)[7].

5.1.1 Victoria DPI

The DPI measurements recorded exposures in front of meters with the meter box door open. Results are summarised in the table below.

	Distance from meter	
	30 cm	***50 cm***
Number of meters tested	7	5
Range of exposures (% of public limit)	4.5 - 29	0.47 - 11
Mean value (% of public limit)	15.7	6.3

29% of the limit is 1,338,350 uW/m2 and 11 % is 507,650 uW/m2

As noted previously any averaging or mean value is not an accurate measure of the exposure a person would receive. Australian standard is same as ours .

The measurement circumstances were not exactly the same as in the tests reported here. Most of the meters tested were mounted in a metal box, and measurements were made with the meter box door open. It is possible that the measured exposures were enhanced by signals reflected off the back of the box.

Data recorded over 6 minute and 11 minute intervals showed duty cycles ranging from 0.010 to 1.2%.

Although the measurement approach in the DPI survey was not exactly the same as that undertaken for this report, the results are consistent.

5.1.2 EPRI

Meters tested in the EPRI survey appear to have not been mounted in a box, but straight onto an outside wall. Two types of meter were used, both with the same transmitter power but one with a slightly higher antenna gain, which would produce higher maximum exposures.

The results were presented in terms of the exposure Standard set by the Federal Communications Commission (FCC), which at the frequencies of interest is 601 $\mu W/cm^2$. In order to provide a fair comparison, the results have been rescaled to show the exposure in terms of the New Zealand Standard.

Results are summarised in the table below.

[6] www.dpi.vic.gov.au/smart-meters/publications/reports-and-consultations/ami-meter-em-field-survey-repor

[7] www.silverspringnet.com/pdfs/EPRI-Final1021829.pdf

	Distance from meter	
	30 cm	***100 cm***
Number of meters tested	11	10
Range of exposures (% of public limit)	5.9 – 19.2	0.69 – 5.9
Mean value (% of public limit)	13.7	2.3

Data from Figure 5.1 of the EPRI report suggests that averaged over one minute, duty cycles ranged from 0.04 – 2.2%, with an average of 0.13%.

Again, while there were some differences in the measurement techniques and hardware, the results are consistent with those obtained on the WEL Networks equipment.

5.2 Conclusions

Measurements show that exposures to RF fields in houses with a typical WEL Networks Smart Meter installation are very low in comparison to the limits recommended for the public in the New Zealand RF field exposure Standard. 98% of the time, the exposure averaged over a 30 second interval is less than 0.0005% of the public limit. The maximum exposure averaged over a 30 second interval was 0.003% of the limit.

There are several reasons why the time-averaged exposure is so low:

- The relatively low power of the transmitter
- The fact that most of the time the transmitter is not transmitting
- The fact that the metal meter box and building wall significantly reduce the level of any transmissions back into the building.

The measurements were made on what was assumed to be a typical day, and is assumed that the duty cycles observed were representative of normal operation. From time to time the firmware in the meter may be updated over the radio link, and the upgrade relayed on to other meters through the mesh network. In this situation, the duty cycle may be greater than observed here. However, even if the duty cycle were to approach 100%, measurements of the peak exposure (ie with no allowance for time averaging) showed that in all the configurations tested, the exposure would still be well below the limit allowed for the public for continuous exposures.

Measurements in front of a meter installed inside a standard meter box were higher than behind it, but still well below the recommended limit. The time-averaged exposure 30 cm from the front of the Smart Meter when it is installed inside the box can be calculated by multiplying the peak exposure found at that position by the duty factors found at the typical installation. This results in a maximum time-averaged exposure which is 0.39% of the limit, and an average exposure which is 0.012% of the limit.

Having a time averaged reading is like saying that the bullet can not penetrate you if you average the force of impact over sufficient time. When the peak output of a meter is only 5-10 milliseconds, averaging the output over 30 seconds or a minute diminishes the reading by 100-200 times from the actual pulse the body must cope with.

Annexe A Measuring equipment specifications and uncertainty

A1 Meter specifications

Manufacturer	Narda Safety Test Solutions GmbH, Pfullingen, Germany
Meter	SRM-3006 s/n H-0010, firmware v 1.1.2
Probe	3-axis electric field probe 3501/03 s/n K-0543
Measurement range	Lower detection threshold: dependent on measurement parameters (see section 4). Upper limit 200 V/m (10,600 μW/cm^2)
Frequency range	27 MHz – 3 GHz
Calibration	By the manufacturer, March 2012
Recommended calibration interval	2 years

Full specifications are available at:
www.narda-sts.de/fileadmin/user_upload/literature/high_frequency/DS_SRM3006_EN.pdf

A2 Measurement uncertainty

A2.1 Expanded measurement uncertainty of SRM-3006 and probe

Data source: equipment specifications from manufacturer.

Frequency range	**Expanded uncertainty**
27 – 85 MHz	+3.2/-4.8 dB
85 – 900 MHz	+2.5/-3.6 dB
900 – 1400 MHz	+2.5/-2.4 dB
1400 – 1600 MHz	+2.6/-3.8 dB
1600 – 1800 MHz	+2.2/-3.0 dB
1800 – 2200 MHz	+2.4/-3.3 dB
2200 – 2700 MHz	+2.7/-3.8 dB
2700 – 3000 MHz	+3.3/-5.3 dB

This includes all uncertainties associated with the meter, calibration, probe isotropy and connection mismatches, with a coverage factor of 2.

A2.2 Expanded measurement uncertainty for this survey

Parameter	**Uncertainty data source**	**Standard uncertainty *u* (dB)**
Meter + probe over whole frequency range of interest	Data sheet (as above)	+1.6/-2.4
RF propagation differences and environmental clutter	Assume spread of ±2 dB, triangular distribution*	±0.82
	Combined standard uncertainty	+1.80/-2.54
	Coverage factor	2
	Expanded uncertainty	**+3.6/-5.1**

*AS/NZS 2772.2:2011 recommends assuming triangular distribution for this type of uncertainty. Examination of the detailed peak exposure data for the measurements at the typical WEL Networks installation showed variations of ±1.3 dB as, for example, the garage door was opened and closed.

No allowance has been made for the following potential sources of uncertainty:

Potential source	**Comment**
Variations in transmitter power	Maximum values taken when measuring peak exposures. Variations in power all recorded while logging data from typical installation.
Signal reflection off operator	Reflections can produce increases and decreases in measured PFD over distances of 100 – 250 mm. Probe held in a stand and operator well off to one side to minimise any effects of reflections from the operator's body.
Position of probe in high field gradients	Probe positioned with a tape measure, with an accuracy of about ±1 cm. Highest of three readings taken in most situations, so exposure tends to be overestimated as a function of distance.
Signal reflections off movable objects	Readings show exposures under the conditions present at the time of measurement. A uncertainty contribution due to environmental clutter (objects near the Smart Meter and measurement probe which could change propagation patterns and affect the measured exposure) has been included in the expanded uncertainty.