From:	Melnykovych, Andrew (PSC)
To:	"song bird"
Subject:	your comments in case 2012-00428 - smart grid administrative case
Date:	Monday, January 26, 2015 12:06:29 PM

Dear Ms. Holloway:

Thank you for your comments to the Kentucky Public Service Commission regarding the use of smart grid technology by electric utilities in Kentucky. For ease of access, I have combined all of the attachments from your recent group of e-mails into a single document, which will be included with this response and placed into the case file for the Commission's consideration as it deliberates in this matter.

As you noted, the case number in this matter is 2012-00428. Please reference it in any further comments.

Records in the case are available on the PSC website at this location:

http://psc.ky.gov/PSC_WebNet/ViewCaseFilings.aspx?Case=2012-00428

Thank you for your interest in this matter.

RECEIVED
By Kentucky PSC at 12:12 pm, Jan 26, 2015

Andrew Melnykovych
Director of Communications
Kentucky Public Service Commission
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Andrew.Melnykovych@ky.gov

From: song bird [[redacted]
Sent: Friday, January 23, 2015 10:48 PM
Subject: Case File 2012-00428

Good Morning,
Please add this documentation to Case File 2012-00428

Electromagnetic Fields and Leakage of the Blood Brain Barrier: Dr. Leif Salford
https://www.youtube.com/watch?v=E_WJ_aJPWIA

-------- End of forwarded message --------

http://health.usnews.com/health-news/articles/2015/01/21/leaks-in-brain-may-contribute-to-dementia

Leaks in Brain May Contribute to Dementia

Health Day Jan. 21, 2015 | 4:00 p.m. EST
By Robert Preidt, *HealthDay Reporter*

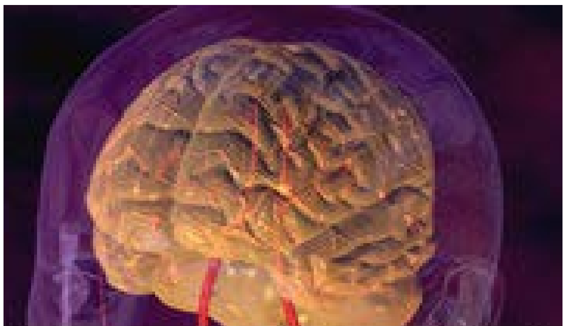

Image courtesy of Blausen Medical

WEDNESDAY, Jan. 21, 2015 (HealthDay News) -- Age-related blood vessel leaks in the brain may contribute to the development of Alzheimer's disease and other types of dementia, according to a new study.

The findings suggest it may be possible to use brain scans to detect such leaks and repair them in order to prevent damage that can lead to dementia, the University of Southern California researchers said.

The investigators analyzed contrast-enhanced brain images from 64 people of various ages and found that the brain's protective blood barrier becomes leaky with age. This leakage begins in the hippocampus, an important learning and memory center damaged by Alzheimer's disease.

"This is a significant step in understanding how the vascular system affects the health of our brains," said lead investigator Dr. Berislav Zlokovic, director of the Zilkha Neurogenetic Institute at the university's Keck School of Medicine.

"To prevent dementias including Alzheimer's, we may need to come up with ways to reseal the blood-brain barrier and prevent the brain from being flooded with toxic chemicals in the blood," Zlokovic added in a university news release.

The study was published Jan. 21 in the journal *Neuron*.

Post-death examinations of Alzheimer's patients' brains reveal damage to the blood-brain barrier. However, why and when this damage occurs is unclear, the researchers noted.

About 5.2 million Americans have Alzheimer's disease, the most common type of dementia. By 2050, about 16 million Americans over age 65 will have dementia, according to the Alzheimer's Association.

More information

The U.S. National Institute on Aging has more about Alzheimer's disease.

Advanced Studies in Medical Sciences, Vol. 2, 2014, no. 1, 1 - 15
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/asms.2014.3810

Cancer Incidence vs. Population Average Sleep Duration on Spring Mattresses

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Abstract

Objective: To review published data about breast cancer and average life time sleep duration on wave-reflecting spring mattresses, and with rates reported before body-resonant radiation were at all emitted from broadcasting transmitters, to determine any correlation.
Methods: We collected cancer trend data from cancer registries in Sweden, Denmark, Japan, and the United States. Data on cancer incidence and sleeping habits were collected by a literature survey. Hazard rates (HR) of breast cancer vs. effective sleep duration in body-resonant radiation were plotted to determine the significance

level of collected data. Practical measurements of electromagnetic fields were also performed above beds with metal spring mattresses.
Results: Breast cancer HR increased with sleep duration in the United States. In Japan, where mainly metal-free mattresses are used, HR decreased with increased sleep duration. Earlier studies on melanoma have identified a strong association between incidence and time spent in body-resonant radiation. All collected data on breast cancer and melanoma show a significant association with sleep duration on wave reflecting metal spring mattresses. Measurements also showed that the electric field increased by distance above the mattress as expected due to standing wave effects.
Conclusions: Body-resonant radiation may influence health negatively if concentrated by metal spring mattresses during sleep at night. A simple way to reduce cancer risks may be to exchange the metal spring mattress for a non-metal one like a futon or a foam type.

Keywords: Breast cancer, sleep duration, melanoma, prostate cancer, radiation, metal spring mattress, foam mattress

Intriduction

In Denmark, between 1943 and 1955, the age-standardized incidence of breast cancer was stable at around 42/100,000 person-years (py). However, from 1958 onward, the incidence increased over time, just as it did in Sweden. Despite increasing screening and lifestyle changes, there is no conclusive explanation for this rather sudden increase in breast cancer incidence after 1955, which was also noted for skin melanoma and some other cancers. In 2002, it was hypothesized that body-resonant broadcast radiation might act as a threat to the immune system of people who tended to sleep for years in resonance with an FM radio main transmitter [2] If a person sleeps on a metal spring mattress, reflected and standing waves could also explain the fact that the left side of the body in general is more prone to breast cancer [11-14] and melanoma [1] than the right side of the body. This can be explained by the fact that people tend to sleep for longer times on the right side than on the left side, so that the right side is closer to the field attenuating metal than the left side is [3]. Consequently, it might be expected that countries in which a large proportion of the population sleep on wave reflecting mattresses would have higher incidences of breast cancer and melanoma than countries in which people sleep mainly on non-metal beds, such as futons in Japan. A survey of data from different parts of the world showed that this indeed was the case; a high prevalence of metal spring beds corresponded to a high cancer incidence, and vice versa [4].

Traditionally, a good night's sleep has been associated with good health, since the body needs time every night for maintenance tasks, such as repairing the DNA in damaged cells. Short sleep duration might therefore be expected to increase breast cancer risk, while a long, good night's sleep would decrease the risk. However, if the sleep occurs in a detrimental environment, in which the body's repair capacity is temporarily reduced, we would expect longer sleep duration to increase the risk, so that the risk vs. sleep duration graph would appear U-shaped [15]. Information regarding the relationship between mattress types and sleep duration vs. cancer incidence should strengthen or weaken previously published hypotheses regarding the effect of broadcast radiation on public health [2-4].

If the hypothesis of an association between increased cancer incidence and wave-reflecting beds is correct, then one must question whether sleeping for more hours really is good for your health. It might be better to stay in bed for as short a period as possible or just to get rid of the metal spring mattress in order to minimize the cancer risk from continuous radiation stress on the body's DNA repair capacity. Thus, our objective was to review the literature related to breast cancer and sleep duration to see if the breast cancer risk is also consistent with reported use of metal spring mattresses and with data reported before body-resonant radio broadcasting became introduced.

Methods

The cancer incidence rates prior to 1955 in Sweden and Denmark occurred at a time when body-resonant radiation from FM radio transmitters was almost non-existent. Thus, these data are representative of zero sleep duration in a body-resonant radiation environment. Current cancer incidence rates were related to average sleep duration of 7.5 hours in a resonant environment. The hazard ratio (HR) of cancer incidence at zero sleep duration was defined as the ratio between the cancer incidence before 1955 and the incidence at present.

In the USA and the Nordic countries the use of metal spring mattresses is around 70 % of the population. If only, say 30 %, of the population in a country is using metal spring mattresses, this can be seen as if the whole population only sleeps for 30/70*7,5 hrs = 3.3 hrs per night in a body-resonant environment. Data from ref [4] were used to estimate such equivalent sleeping times.

In 2005, all 75 year old people had been living for 50 years in the new radiating environment we were blessed with from 1955 and onwards. Thus, in 1965 this age group had only been sleeping in this environment during ten years. If, in 2005, the same age group have been sleeping 7,5 hours per night in body-resonant radiation the last 50 years, they had in 1965 in average during the last 50 years only slept for 10/50*7.5 = 1.5 hours per night in the same environment. A corresponding approach was followed using age-standardized rates for the whole population instead of age-specific rates for one specific age group.

To test the assumption, that the hazard rate (HR) vs. the average sleep duration in body-resonant radiation also fits with HR vs. reported actual sleep duration and reported use of wave reflecting spring mattresses, we plotted all data in the same graph.

This study did not involve any individuals and did not influence sleeping habits among any individuals in the population. Instead, we collected already published results regarding sleep time and cancer incidence to compare those data with our hypothesized relationship between sleep time and breast cancer risk. Thus, there was never a need for any ethical approval of our study at all.

Results

We searched for articles related to sleep duration and breast cancer, prostate cancer, and general mortality on PubMed. Data about cancer incidence were retrieved from cancer registries. The HRs of breast cancer, prostate cancer, and general mortality were plotted against reported sleep durations from <6 to >10 hours and normalized to the reported US average cancer incidences and mortality.

Figure 1 shows the age-standardized rates of breast cancer among women in Denmark, Sweden, Japan, and the United States. Denmark released breast cancer incidence data from 1943 onward, while data from Sweden were only available from 1958 onward. The incidence of breast cancer was quite stable at approximately 42/100,000 py in Denmark until around 1955, at which point it followed the same trend as reported in Sweden. Currently, the breast cancer incidence is around 80/100,000 py in Sweden and 95/100000 py in the United States, while in Japan it is approximately 42/100,000 py.

Similarly, Figure 2 shows melanoma trends in Denmark, Sweden, Japan, and the United States. As for breast cancer, the incidence of melanoma before 1955 remained steady in Denmark and increased thereafter, as in Sweden. Data from Sweden from 1911 to 1913 revealed an incidence of 1/100,000 py (shown as a blue triangle in the graph). Japan reported remarkably low and stable current rates of melanoma, even lower than those reported by Sweden from 1911 to 1913.

Figure 3 provides the HRs of breast cancer vs. sleep duration. Included is reported HRs for breast cancer relative to nominal sleeping duration of 7.5 hours in the United States [12, 13]. Since the left side of the body is exposed to standing waves for longer periods each night [3], we also plotted the corresponding HRs for men and women based on detailed data [3] in the same graph. Equivalent average sleep durations in standing waves based on reported use of metal spring mattresses in different countries were plotted [4]. Detailed background data can be found in Tables I and II. Finally, we tested the hypothesis that the HR-trend vs. life-time sleep duration on spring mattresses in a body-resonant radiation would follow a similar route as e.g. breast cancer incidence vs. actual sleep duration in 2005. This set of data is shown separately in Figure 3.

Corresponding data for melanoma were also collected and are plotted in Figure 4. See Table III for an example with calculations explained.

Figure 5 graphs the relationship between sleep duration and breast cancer in Japan and Singapore [10, 14], as well as prostate cancer in Japan [11].

In order to test the hypothesis, that incident and reflected waves of horizontally polarized radiation cancel each other close to a metal structure and might add as standing waves further up from it, we measured the electric fields of FM-radio signals above beds with and without a metal spring mattress. A horizontal monopole antenna (0.5 metre) was connected to spectrum analyser (GW Instek, GSP 827, Taiwan). The antenna voltage signal peak in the spectrum was read on the dBμV scale and reduced to millivolts. The electric field intensity E [mV/m] was approximated using equation $E = 2U/l$, where U is the signal and l is the length of the antenna. The distance to the FM broadcasting transmitter was 20 km and the measurements were performed in a bedroom with a concrete floor in a house built on a hill.

In reality we also have to consider that both the bed and the body are in resonance forming two resonant circuits coupled to each other, thereby strengthening the currents. Close to the metal the currents in the body and in the metal are in opposite directions, cancelling each other while higher up they tend to cooperate.

Figure 6 shows that the radio frequency electric field was lower than average close to the mattress, while it increased with the height above the bed. In this case the increase was largest above the end of the mattress. Indication of standing waves of FM-radio signals in the bedroom was quite different above a wooden bed without a metal spring mattress. This is assumed to be the outcome from reflected and standing waves above a metal structure [8]. Field attenuation between incident and reflected waves causes low fields close to the metal mattress while the fields are increasing by distance above the mattress. Non-reflected fields above a wooden bed will show higher strength but will not cause standing waves constantly disturbing the same part of a human body resting on top of the bed. Thus, these measurements show clearly, that a metal spring mattress is capable of changing electromagnetic fields and creating new standing waves, which may disturb the immune system and be harmful to health if a person is sleeping in such an environment. Some persons may feel the effect soon but by some others the symptoms may become apparent only after many years.

Discussion

Our results suggest that the most common sleep environment in Japan is healthier than that of Western countries. In both regions, too little sleep is associated with an increased risk of breast cancer and general mortality, while longer sleep duration seems to have some positive health effects in Japan and some negative health effects in Western countries.

The HR data from the United States [13] were normalized to HR = 1 at 7.5 hours of sleep duration to match the data provided by McElroy et al. [12]. The association noticed between sleep duration and breast cancer is significant (Figure 3). Japan today has approximately the same breast cancer incidence as Denmark and Sweden had before 1955 (Figure 1). Studies of mortality vs. sleep duration in the US show increasing mortality by sleep durations longer than 7.5 hours [15]. The calculated HRs for breast cancer and melanoma based on life time sleep duration on spring mattresses in a body-resonant environment strongly supports the other data collected on HR vs. sleep duration.

The association between melanoma of the skin and environmental change since 1955 was investigated previously [2]. The currently reported melanoma incidence of 0.4/100 000 py in Japan is even less than it was in Denmark and Sweden before 1955 (see Figure 2, in which incidence data from 1911–1913 are plotted). According to the findings presented in reference [4], breast cancer and melanoma are most prevalent in countries that predominantly use modern metal spring mattresses, and least prevalent in countries in which these types of mattresses are less commonly used, such as Japan. A linear extrapolation of the melanoma rate from 1955 with reference to the melanoma rate today, normalized to 7.5 hours of sleep duration, suggests that the melanoma incidence would be 24% higher with a sleep duration of 9.5 hours in Western countries. Figure 4 gives HR's for melanoma vs. population average sleep time on spring mattresses from different countries.

The statistics regarding mortality vs. sleep duration[10] are compelling and warrant further investigation of differences among regions. The mean life span of Swedish men and women stopped increasing after 1955 and did not begin to increase again until after 1980. No such trend break was noticed in Japan, where women today have a median life span of close to 90 years, while the median life span of women is only 83 years in Sweden. A trend-break similar to the one in Sweden was also noticed for men in Switzerland.

Several other observations from earlier melanoma studies support the hypothesis of an increased cancer risk due to body-resonant radiation from broadcasting transmitters [5-9].

To explore whether sleeping on metal spring mattresses has a direct effect on the body's ability to respond to cancer, DNA repair capacity tests could be performed on blood samples from age- and sex-matched persons in different countries or from people using different types of beds in one country. These tests could provide clinical data that might be useful in elaborating our hypothesis that metal spring mattresses concentrate body-resonant radiation, leading to higher incidences of some types of cancer. It might also be the case that the repair capacity is only temporarily disturbed during night due to skin currents and not seen in blood tests taken during day-time; such possibilities must, of course, be controlled for.

If the hypothesis, about a temporarily or permanently disturbed DNA repair capacity from night-long exposure to standing waves from body-resonant broadcasting radiation, holds to be true, there is an immediate opportunity to reduce the cancer burden in the society. This could simply be done by changing bed standard from metal spring mattresses to non-metal foam mattresses. The effect from such a change could be estimated in a similar way as was done to model the effect of reduced repair efficiency from the introduction of FM broadcasting in the 50’s [7].

Conclusions

1. Too short average sleep duration has negative health effects and may result in an increased mortality.
2. A longer time in bed than the average 7.5 hours per night may increase the risk of breast cancer and general mortality in Western countries, but not in Japan, where the risks for breast and prostate cancer are further reduced with longer sleep times.
3. The data reported in this and previous papers support the hypothesis that the bed environment may be an important breast cancer risk factor, and that reflected and standing radio waves from metal spring mattresses should be avoided, e.g., by sleeping on mattresses that do not contain metal springs, as is common in Japan. Studies of a possible association between melanoma incidence and sleep duration should also be performed. A deeper study including detailed measurements of electrical fields around a human body resting on a metal spring mattress seems highly motivated.
4. If the hypothesis holds to be true there is an opportunity to substantially reduce the cancer burden in the society by relatively simple means.

Abbreviations used

HR = Hazard Ratio
FM radio = Frequenzy Modulated radio, most oftern using the 87-107 MHz broadcasting band
DRC = DNA Repair Capacity

Conflict of Interest Statement

The authors know of no conflict of interest related to this work.

Authors' Contributions

As the main author ÖH contributed by: Study design, Data collection (Figs 1-4), Data analysis, Interpretation of results, and Preparation of the manuscript.

PH contributed by: Data collection and EMF measurements (Fig 5), Data analysis, Interpretation of results and Preparation of the manuscript.

OJ contributed by: Data analysis, Interpretation of results, and Preparation of the manuscript.

Acknowledgements

The authors thank University of Oulu, Finland for granting funds for any publication costs. Apart from the support from University of Oulu, Örjan Hallberg and Paavo Huttunen received no other funding for this study.

Olle Johansson was supported for this study by grants from the Cancer and Allergy Foundation (Cancer- och Allergifonden), and Einar Rasmussen, Kristiansand S, Norway, Brian Stein, Melton Mowbray, Leicestershire, UK, The Irish Campaign against Microwave Pollution, and the Irish Doctors Environmental Association (IDEA; Cumann Comhshaoil Dhoctúirí na hÉireann) are gratefully acknowledged for their general support.

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FIGURE LEGENDS

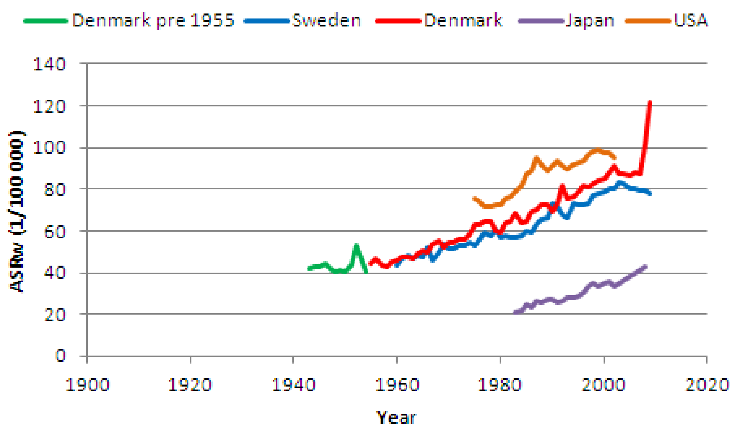

Figure 1. Age-standardized breast cancer incidence in women from Denmark, Sweden, United States, and Japan.

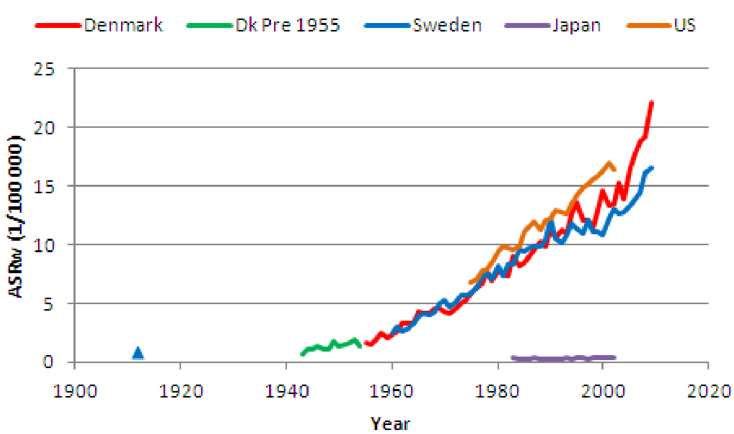

Figure 2. Age-standardized melanoma incidence in Denmark, Sweden, United States, and Japan. Blue triangle represents Sweden in 1911–1913.

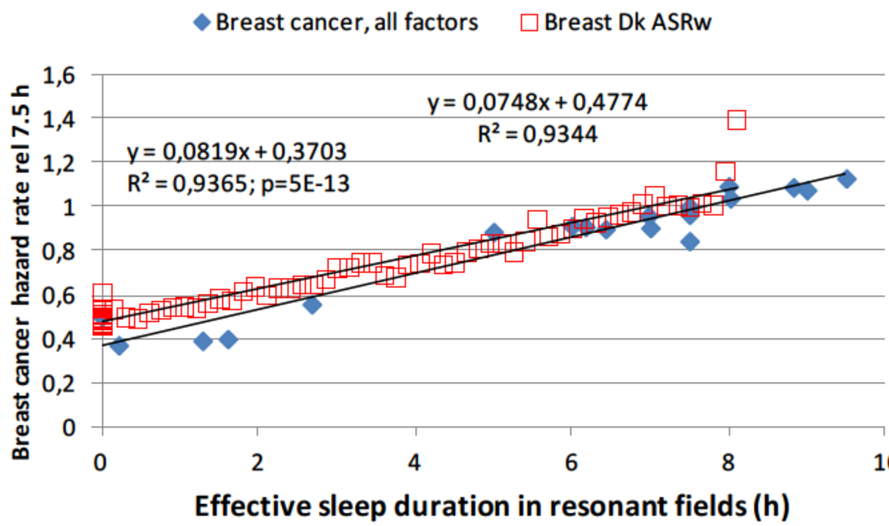

Figure 3. Estimates of hazard ratios of breast cancer vs. sleep duration in a body-resonant radiation environment based on data before 1955, when body-resonant radiation was almost non-existent and on currently reported data. Detailed data are given in Tables I and II. Red squares represent reported HR for the whole population since 1943 based on age-standardized data from Denmark with effective average sleep time calculated since 1955.

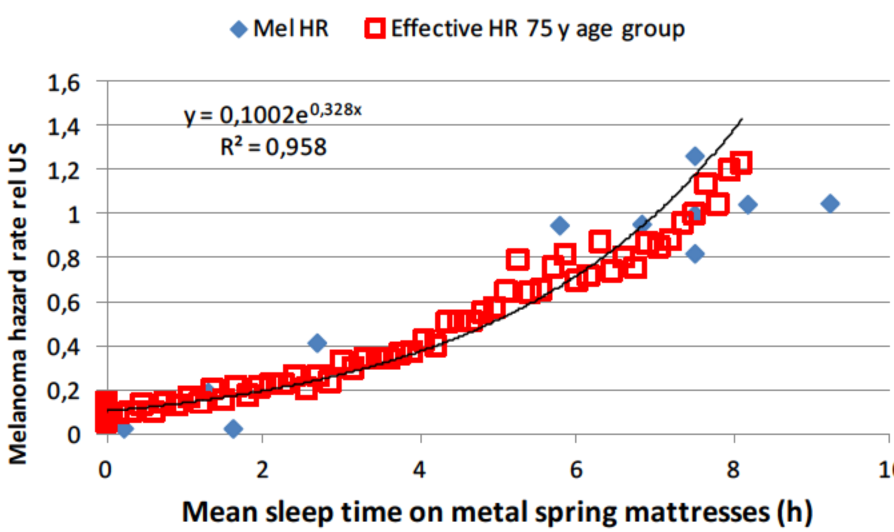

Figure 4. Estimates of hazard ratios of melanoma vs. sleep duration in a body-resonant radiation environment based on data before 1955, when body-resonant radiation was almost non-existent and on currently reported data. Red squares represent reported HR for the 75 years age group since 1943 based on data from Denmark and Sweden with effective average sleep time calculated since 1955. Examples of data and calculations are given in Table III.

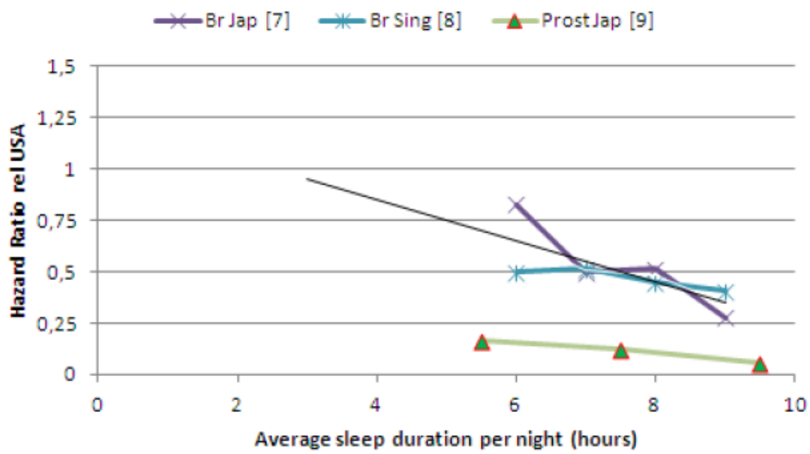

Figure 5. Reported hazard ratio (HR) of breast and prostate cancer incidence in Japan and Singapore vs. sleep duration (normalized to 7.5 hours of average sleep duration, as measured in the United States).

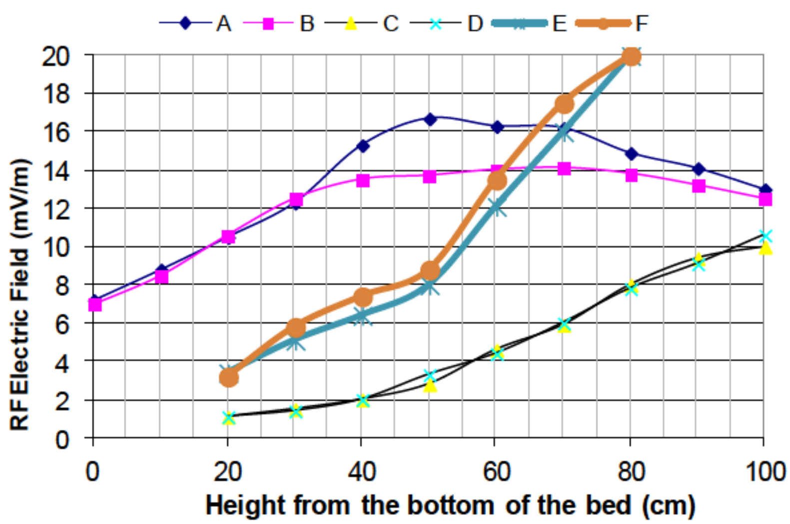

Figure 6. Electric fields measured above a wooden bed without and with a metal spring mattress of 20x140x200 cm. The electric field intensity of FM-radio signals near 100 MHz was measured two times at the same position. A-B: above the middle of the wooden bed without the mattress; C-D: above the middle of the metal spring mattress; E-F: above the end of the metal spring mattress.

Resonant Sleep (h)	**HR rel 7.5 hrs**	**Refs**
7,5	0,84482	[9] Sweden
0,214286	0,370981	[9] Japan
7,5	0,964949	[9] West Europ.
2,678571	0,557917	[9] East Europ.
7,5	1	[9]USA
1,607143	0,399296	[9]Asia
1,285714	0,391399	[9] South America
6,428571	0,900063	[9] Australia
5	0,886878	[3] Pinheiro
6	0,914027	[3] Pinheiro
7	0,904977	[3] Pinheiro
7,5	1	[3] Normalized
8	1,095023	[3] Pinheiro
9	1,076923	[3] Pinheiro
8,82716	1,09	[8] Left side men
8,023256	1,04	[8] Left side, women
7,5	1	[8] Average
6,976744	0,96	[8] Right side, women
6,17284	0,91	[8] Right side, men
9,5	1,13	[2] Mc Elroy
7,5	1	[2] Mc Elroy
0	0,5	Denmark pre 1955

Table I. Equivalent resonant sleeping time and corresponding breast cancer hazard rates (HR).

Specification	Men	Women
Right side sleepers (%)	47	33
Left side sleepers (%)	24	24
Equal side sleepers (%)	29	43
Right sleepers' exposure time E (h) and hazard rate	E=(7,5/100*(47+29/2))*2=9.23 HR=1.09	E=(7.5/100*(33+43/2))*2=8.18 HR=1.04
Left sleepers' exposure time E (h) and hazard rate	E=(7.5/100*(24+29/2))*2=5,78 HR=0.91	E=(7.5/100*(24+43/2))*2=6.83 HR=0.96

Table 2. Estimate of average sleep time corresponding to the time spent in resonant electric fields for people with different sleep side preferences and corresponding hazard rates (data from ref 8). Right side sleepers have their left side up in elevated fields for longer times etc.

Year	**Incidence**	**HR, Inc rel 2005**	**Effective sleep (h)**
1955	6,785	0,110541	0
1956	5,58	0,090909	0,15
1957	6,02	0,098078	0,3
1958	8,06	0,131313	0,45
1959	6,125	0,099788	0,6
1960	8,615	0,140355	0,75
1961	7,85	0,127892	0,9
1962	10,105	0,16463	1,05
1963	8,535	0,139052	1,2
1964	12,28	0,200065	1,35
1965	9,365	0,152574	1,5

Table 3. Melanoma HR for age group 75 years in Denmark is calculated as Inc(Year)/Inc(2005). Effective sleep time in body-resonant radiation is calculated as (Year-1955)/50*7.5 h.

Received: August 1, 2013

Journal of Microscopy and Ultrastructure 2 (2014) 197–204

Contents lists available at ScienceDirect

Journal of Microscopy and Ultrastructure

journal homepage: www.elsevier.com/locate/jmau

Review

Why children absorb more microwave radiation than adults: The consequences

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ARTICLE INFO

Article history:
Received 4 April 2014
Received in revised form 3 June 2014
Accepted 24 June 2014
Available online 15 July 2014

Keywords:
Tumors
Myelin
Carcinogen
Fetus
Children
Latency

ABSTRACT

Computer simulation using MRI scans of children is the only possible way to determine the microwave radiation (MWR) absorbed in specific tissues in children. Children absorb more MWR than adults because their brain tissues are more absorbent, their skulls are thinner and their relative size is smaller. MWR from wireless devices has been declared a possible human carcinogen. Children are at greater risk than adults when exposed to any carcinogen. Because the average latency time between first exposure and diagnosis of a tumor can be decades, tumors induced in children may not be diagnosed until well into adulthood. The fetus is particularly vulnerable to MWR. MWR exposure can result in degeneration of the protective myelin sheath that surrounds brain neurons. MWR-emitting toys are being sold for use by young infants and toddlers. Digital dementia has been reported in school age children. A case study has shown when cellphones are placed in teenage girls' bras multiple primary breast cancer develop beneath where the phones are placed. MWR exposure limits have remained unchanged for 19 years. All manufacturers of smartphones have warnings which describe the minimum distance at which phone must be kept away from users in order to not exceed the present legal limits for exposure to MWR. The exposure limit for laptop computers and tablets is set when devices are tested 20 cm away from the body. Belgium, France, India and other technologically sophisticated governments are passing laws and/or issuing warnings about children's use of wireless devices.

Contents

Abbreviations: MRI, magnetic resonance imaging; MWR, microwave radiation; CNS, central nervous system; FDTD, finite-difference, time-domain; GBM, glioblastoma multiforme (also called glioblastoma); cm, centimeter.

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E-mail address: Lloyd.L.Morgan@gmail.com (L.L. Morgan).

http://dx.doi.org/10.1016/j.jmau.2014.06.005

1. Introduction

Here we discuss: how the amount of MWR can be calculated, children's greater absorption of MWR compared to adults' adsorption, MWR's listing as a Class 2B (possible) carcinogen, the existing legal limits for human exposure to MWR, and that the existing legal limits do not incorporate the greater exposure to children.

1.1. Computer simulation

The finite-difference, time-domain (FDTD) computer algorithm has been the best way to simulate the amount of absorbed MWR in tissues for many decades. In 1997 the U.S. Federal Communications Commission (FCC) stated, "Currently, the finite-difference time-domain (FDTD) algorithm is the most widely accepted computational method for SAR modeling. This method adapts very well to the tissue models that are usually derived from MRI or CT scans. FDTD method offers great flexibility in modeling the inhomogeneous structures of anatomical tissues and organs. The FDTD method has been used in many far-field electromagnetic applications during the last three decades. With recent advances in computer technology, it has become possible to apply this method to near-field applications for evaluating handsets" [1].

1.2. Children's greater absorption of MWR

There are multiple studies showing that children absorb more MWR than adults. In 1996 a study reported that the absorbed MWR penetrated proportionally deeper into the brain of children age 5 and 10 compared to adults' brains [2].

In 2008 Joe Wiart, a senior researcher for French telecom and Orange reported that the brain tissue of children absorbed about two times more MWR than adults' brain tissue [3].

A 2009 study reported the CNS absorption by children is "significantly larger (~2×) because the RF [MWR] source is closer and skin and bone layers are thinner", and "bone marrow exposure strongly varies with age and is significantly larger for children (~10×)" [4].

In 2010, Andreas Christ and team reported children's hippocampus and hypothalamus absorbs 1.6–3.1 times higher and the cerebellum absorbs 2.5 times higher MWR compared to adults'; children's bone marrow absorbs 10 times higher MWR radiation than in adults, and children's eyes absorb higher MWR than adults [5]. These calculations were based on porcine measurements taken from sacrificed animals.

1.3. Microwave radiation is a Class 2B (possible) carcinogen

After 30 experts from 14 countries reviewed the science, the World Health Organization's (WHO's) International Agency for Research on Cancer (IARC) declared that RF-EMF [MWR] is a Class 2B (possible) carcinogen [6]. It was a near unanimous declaration (one dissenter).

Including MWR, there are 285 agents listed by WHO's IARC as Class 2B carcinogens [7]. Exposures to almost all of these agents are regulated. Some of the commonly recognized agents are: carbon black, carbon tetrachloride, chloroform, DDT, lead, nickel, phenobarbital, styrene, diesel fuel, and gasoline.

Like these other Class 2B Carcinogens, should anyone, particularly children, be exposed to MWR?

1.3.1. Children are at increased risk when exposed to carcinogens

Children are at greater risk from exposure to carcinogens than adults, and the younger the child, the higher the risk [8–10].

1.4. Exposure limits

In 1996, the FCC adopted the IEEE 1991 [11] standard with some details from the 1986 NCRP Report [12] as exposure limits in the United States. Nineteen years after the FCC exposure limits were published, based on documents published 24 and 29 years previously, the legal exposure limit has remained unchanged. Yet during these decades an enormous body of scientific studies was published reporting risk well below the legal exposure limit.

The Institute of Electrical and Electronic Engineers (IEEE) is an industry professional organization, as is the National Council on Radiation Protection (NCRP). Neither organization had medical or public health expertise.

In European countries and a few other countries, the exposure limits are based on the 1998 "Guidelines" of the International Commission for Non-Ionizing Radiation Protection (ICNIRP) [13]. These "Guidelines" were based on publications from 1984, 1987, 1991, and 1993 [page 494]. That is the "Guidelines" were based on publications up to 31 years ago, Similar to the IEEE and NCRP, ICNIRP is an organization without medical or public health expertise. It is accountable to no government and its funding sources are not transparent.

1.4.1. The 19 year old IEEE and 17 year old ICNIRP exposure limits are based on a false premise

The exposure limits are premised on an assumption that the only biological effect from MWR exposure is acute (short-term) heating sufficient to cause tissue damage. There is no consideration of the effects from chronic (long-term) exposures. There are many scientific papers that report biological impacts tied with non-thermal (no measurable temperature change) effects. Indeed, the 480-page IARC Monograph 102 that documents the science that led to the declaration that MWR is a Class 2B (possible) carcinogen is a virtual compendium of such papers [14].

1.4.2. FCC compliance requirements do not comport with current testing systems

The FCC requires "For purposes of evaluating compliance with localized SAR guidelines, portable devices should be tested or evaluated based on normal operating positions or conditions" [15]. But phones are not tested in pants or shirt pockets. As a result *every* cellphone manual has warnings that the phone should be kept at various distances from the body otherwise the human exposure limits can be exceeded.

Here are two of many examples:

(1) The BlackBerry Torch 9800 Smart Phone warns, "keep the BlackBerry device at least 0.98 in. (25 mm) from your body (including the abdomen of pregnant women and the lower abdomen of teenagers)." "Lower abdomen" is an oblique reference to testicles and "abdomen of pregnant women" is an oblique reference to the fetus.

(2) The iPhone 5's manual is embedded within the phone: Users must go to "Settings," and scroll down to "General," then scroll to the bottom to "About," go to "Legal," scroll down to "RF [MWR] Exposure" where it reads, "To reduce exposure to RF energy, use a hands-free option, such as the built-in speakerphone, the supplied headphones, or other similar accessories. Carry iPhone at least 10 mm away from your body to ensure exposure levels remain at or below the as-tested [exposure limit] levels."

1.4.3. There is a 20 cm distance rule for tablets and laptop computers

"For purposes of these requirements mobile[1] devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 cm is normally maintained between radiating structures and the body of the user or nearby persons" [16].

Clearly, this 20 cm rule contradicts the "normal operating position" regulation in the description "a separation distance of at least 20 cm is normally maintained." Indeed, "laptop" computer directly implies that it is to be placed on a lap which is not 20 cm distant from the user.

The growing use of tablets by young children in schools contradicts these normal tested conditions as well, as these children have shorter arms that do not allow them to hold devices 20 cm from their bodies.

2. Materials and methods

We have performed a review of the peer-reviewed cellphone exposure epidemiology from 2009 to 2014, and cellphone dosimetry since the 1970s from a previous paper [17], along with relevant governmental and other policy documents, manufacturers' manuals and similar documents.

3. Results

3.1. Early development

Here we present evidence of harmful effects from exposure to MWR during early developmental stages both in animals and in humans.

3.1.1. Fetal exposures

A study from Yale University School of Medicine exposed mice in utero to MWR [18]. The study reported that these mice were hyperactive and had impaired memory "due to altered neuronal developmental programming. Exposed mice had dose-responsive impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex." During pregnancy the mice were irradiated by a cellphone positioned above each cage positioned over the feeding bottle at a distance of 4.5–22.3 cm from each mouse depending on the location of the mouse within the cage. Controls were under the same condition but the phone was not active. The observed effects were

[1] The FCC defines laptop computers, tablets and similar devices as "mobile devices" in comparison to "portable devices" which are cell and cordless phones and similar devices; the former falls under the 20 cm rule, the latter has no such rule.

similar to attention deficit hyperactivity disorder (ADHD) in children.

A Turkish study reported on a 900 MHz in utero exposure of rats [19]. "The results showed that prenatal EMF exposure caused a decrease in the number of granule cells in the dentate gyrus of the rats ($p < 0.01$). This suggests that prenatal exposure to a 900 MHz EMF affects the development of the dentate gyrus granule cells in the rat hippocampus."

A Chinese study investigated effects of MWR emitted by cellphones on rat CNS, in vitro (cortical neuronal cells) and in vivo (rat's brain) [20]. Neuronal cells had a significantly higher death rate at power densities of 0.05 mW/cm^2 and above. In vivo results show increased apoptosis with DNA fragmentation.

3.1.2. Myelination

A myelin sheath covering neurons acts as an insulation of the electrical activity of neurons. In human embryos, the first layer develops from mid-gestation to 2 years of age and continues into adolescence [21]. Myelination of the brain is not complete until early adulthood.

There are two studies with reported degeneration of the myelin sheath after MWR exposure:

A 1972 study from Poland reported myelin degeneration and glial cell proliferation in guinea pigs and rabbits from a 3 GHz exposure [22].

In 1977 Switzer & Mitchell reported a 2.45 GHz exposure in rats increased myelin degeneration in rat brains at 6 weeks after exposure. They concluded "The results of our study and related investigations by others indicated that exposures to low-intensity MW irradiation can result both in transient and in long-term structural anomalies in CNS tissue and may result in various hematologic irregularities" [23].

3.2. Children and adolescents

Aydin et al. in a study of cellphone use by children and adolescents (median age 13 years), reported a significant risk of brain cancer and a significant exposure–response relationship for >2.8 years since first cellphone subscription, OR = 2.15, CI = 1.07–4.29, p-trend = 0.001 for increasing risk with increasing time since first subscription with operator recorded use data (billing records) [24]. Yet the study's conclusion states, "The absence of an exposure–response relationship either in terms of the amount of mobile phone use . . . argues against a causal association." It is unclear why the conclusion directly contradicts the published results. The study was funded in part by cellphone companies.

A Swedish study reported when first cellphone use began as a teenager or younger there was a significant ipsilateral risk of brain cancer, OR = 7.8, CI = 2.2–28, $p < 0.01$, and an almost identical ipsilateral risk from cordless phone use, OR = 7.9, CI = 2.5–25, $p < 0.001$ [9].

A Korean study found risks for ADHD in first grade (ages 7–8) children and followed them to ages 12–13 [25]. "The ADHD symptom risk associated with mobile phone use for voice calls but the association was limited to children exposed to relatively high [blood] lead [levels]." With an average time per cellphone call of ½ to <1 min, OR = 5.66, CI = 1.31–24.51 and for 1+ minutes per call, OR = 7.20, CI = 1.37–37.91, p-trend = 0.02. For children playing games for 3+ minutes/day a significant risk for ADHD, OR = 1.94, CI = 1.30–2.89, $p < 0.001$, and p-trend < 0.001 in the lower blood lead level group.

Elsewhere it has been shown the low-level exposures to MWR increases the permeability of the blood–brain barrier [26–28]. This suggests children exposed to lead who use cellphone might have increased blood lead levels in the brain.

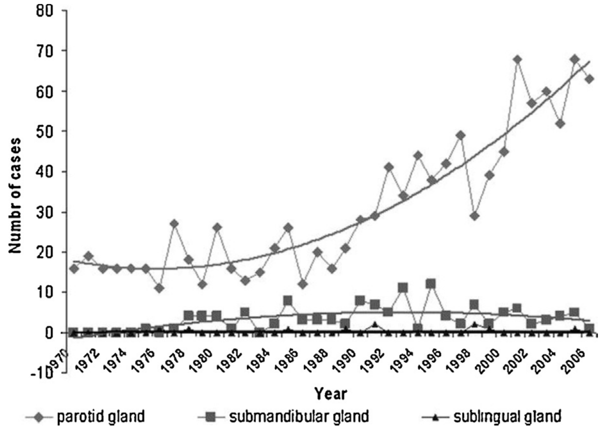

Fig. 1. Increase of parotid gland tumors relative to other salivary gland tumors in Israel.

3.2.1. Breast cancers resulting from placement of cellphones in bras

A case study reported 4 women who placed cellphones in their bras. Two were diagnosed at age 21, with one who had begun placing her cellphone in her bra at age 15. This resulted in multiple primary breast cancers immediately beneath where the cellphone were placed [29].

3.2.2. Parotid gland tumors

The parotid gland is a large salivary gland in the cheek immediately next to where a cellphone is held to the ear.

A Chinese study reported statistically significant increased risks of 10- to 30-fold [30]. With more than 10 years since first use of a cellphone, the risk of epithelial parotid gland cancer, OR = 10.631, CI = 5.306–21.300, $p < 10^{-10}$; similarly the risk for mucoepidermoid carcinoma, OR = 20.72, CI = 9.379–45.821, $p < 10^{-13}$, and for average daily use of >3.5 h, OR = 30.255, CI = 10.799–90.456, $p < 10^{-10}$.

An Israeli Interphone study found significant risk of parotid gland tumors [31]. "For ipsilateral use, the odds ratios in the highest category of cumulative number of calls and call time without use of hands-free devices were 1.58 (95% confidence interval: 1.11, 2.24) and 1.49 (95% confidence interval: 1.05, 2.13), respectively."

Another Israeli study showed that among the 3 salivary glands, the only increase was the parotid gland [32]. "The total number of parotid gland cancers in Israel increased 4-fold from 1970 to 2006 . . . whereas two other salivary gland cancers remained stable." Fig. 1 illustrates the enormous increase in parotid gland tumors relative to other salivary gland tumors.

A newspaper in Israel reported "[S]alivary gland cancer, which researchers suspect to be linked to cellphone use, was disproportionately common among young patients. One fifth of those patients were under 20" [33].

3.2.3. Sperm damage

Perhaps more than any other adverse health effect from exposure to MWR, damage to sperm is the most documented including in vitro, in vivo and human epidemiological studies.

A 2005 study with data collection from November 2002 to March 2004 examined the motility of sperm. "The proportion of slow progressive motile sperm increased with increase of the duration of the daily transmission time $p < 0.01$" [34].

A study of cellphone usage among men who attended an infertility clinic concluded, "Use of cell phones decrease the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality" [35].

A Japanese study reported "This study has indicated significant decrease in sperm count [$p = 0.004$] and motility [$p = 0.003$] . . . because of exposure to MP [Mobile Phone] emission, respectively" [36].

An Australian study investigated how sperm cells are damaged by cellphone MWR. Its conclusions stated "RF-EMR [Radio Frequency-Electro Magnetic Radiation] in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and well-being of their offspring" [37].

Professor Stanton A. Glantz is a Professor of Medicine at the University of California, San Francisco Medical School. He is also author of a renowned graduate level statistics textbook, *Primer of Biostatistics, Seventh Edition* [38]. Referring to the above four studies on sperm damage from MWR he concludes:

> "Taking all the information we have discussed on cell phones and sperm allows us to confidently conclude that exposure to cell phones adversely effects sperm."

A study of temperature controlled human sperm placed 3 cm beneath a laptop computer connected to Wi-Fi for 4 h [39] reported, "Donor sperm samples, mostly normozoospermic [normal sperm], exposed ex vivo during 4 h to a wireless internet-connected laptop showed a significant decrease in progressive sperm motility and an increase in sperm DNA fragmentation." The study concluded "Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility."

Fig. 2. SAM Phantom. The red devices are clamps to hold the cellphone in a specified location. "CTIA" is the Cellular Telecommunications Industry Association.
Source: Speag Phantom Product Flyer.

3.3. Tumor latency times

The *average* time between exposure to a carcinogen and the diagnosis of a resultant solid tumor is 3 or more decades. Brain tumors, like lung cancer and many other solid tumors have, *on average*, long latency times [8,40]. Therefore, it may be several decades before tumors induced by current MWR exposures in children are diagnosed. For example, the Israeli study showing brain tumor risk was inverse with age had long latency times [8]. In contrast the Aydin et al. study had relatively short latency times [24].

4. Discussion

4.1. Wireless device exposure limit certification

The FCC has approved two processes to certify that a wireless device meets the required exposure limit:

(1) The computer simulation process, and
(2) The Specific Anthropomorphic Mannequin (SAM) process.

The computer simulation process is discussed above.

The SAM process is based on a plastic mannequin representing the top 10% largest U.S. military recruits in 1989. Any head smaller than SAM will absorb more MWR (~97% of the U.S. population) [17]. A liquid with the average adult absorption properties of the 40 tissues of the head is poured into a hole at the top of this head. A robotic arm with an electric field probe is positioned within the mannequin such that the location of the highest electric field is located within any one cubic centimeter volume. A cellphone to be certified is clamped to either side of SAM (see Fig. 2). The electric fields values are used to calculate the maximum spatial peak Specific Absorption Rate (SAR) for any 1 g of

Table 1
A comparison of the capability to measure SAR using the computer simulation certification process or the SAM certification process for various exposures.

Attribute	SAM process	FDTD process	Comments
Children's exposure	No	Yes	Multiple ages
Pregnant women's exposure	No	Yes	1, 3 and 9 months
Female exposure	No	Yes	
Specific tissue parameters	No	Yes	
3-D resolution	$\sim$1 cm^3	<1 mm^3	
Relative cost	Higher	Lower	
Medical implant exposure	No	Yes	
Testicle exposure	No	Yes	
Female breast exposure	No	Yes	With and without wire frame bra
Eye exposure	No	Yes	With and without wire frame eyeglasses
Thyroid gland exposure	No	Yes	With and without metal necklace
Parotid gland exposure	No	Yes	With and without dental braces

Adapted from Gandhi et al. [17].

tissue (equivalent to 1 cm^3 volume). If the maximum SAR is at or below the U.S. exposure limit of 1.6 W/kg the phone is certified for sale without regard to the ±30% tolerance of the SAM certification process [41].

Table 1 compares the capabilities of the two cellphone certification processes.

As can be seen in Table 1 the SAM process is not capable of determining the MWR absorption as measured by SAR in every category except the relative cost and volume resolution. Nevertheless, the SAM process has been *exclusively used* to certify every cellphone to date.

4.2. Cellphone manual warnings and 20 cm distance rule

In spite of an FCC regulation "For purposes of evaluating compliance with localized SAR guidelines, portable devices should be tested or evaluated based on normal operating positions or conditions" [15], this regulation is ignored by the FCC. Holding a cellphone at a defined distance from your body is not "based on normal operating positions"!

For laptop computers, tablets and similar devices, an exposure limit that begins at a distance of 20 cm is not "based on normal operating positions." Indeed the very term "laptop" computer defines the normal operating position, which when placed on the lap is not 20 cm distant.

4.3. Increasing brain cancer incidence

There are studies showing an increased risk of brain cancer from wireless phone use. It is a current problem. The worst brain cancer, glioblastoma, has increased in the United States, and Denmark. Brain cancer incidence has increased in Australia in recent years. These results are based on brain cancer incidence from each country's cancer registries.

A United States study examined 3 cancer registries (Los Angeles County, California and SEER 12[2]) [42]. It examined incidence rates between years 1992–2006 and reported the Average Percent Change (APC) during those years. "RESULTS: Increased AAIRs [Age-Adjusted Incidence Rates] of frontal (APC +2.4–3.0%, $p \le 0.001$) and temporal (APC +1.3–2.3%, $p \le 0.027$) lobe glioblastoma multiforme (GBM) tumors were observed across all registries . . . The AAIR of cerebellar GBMs increased according to CCR (APC +11.9%, $p < 0.001$)."

The Danish Cancer Registry issued a press release that stated, "The number of men who are diagnosed with the most malignant form of brain cancer (glioblastoma), has almost doubled over the past ten years" [43].

The Australian study reported, "an overall significant increase in primary malignant brain tumors was observed over the study period from 2000 to 2008 (APC, 3.9; 95%CI, 2.4–5.4), particularly since 2004 (overall AAPC, 3.9; 95% CI, 2.6–5.2)" [44].

4.4. Selling toys for infants and toddlers

The iPad, tablets, laptop computers and cellphones are not children's toys. Within 20 cm of the device, the exposure limit can be exceeded with iPads and laptop computers. Figs. 3–5 are examples of toys for sale (there are many more similar toys).

4.5. Digital dementia

Digital dementia also referred to as FOMO (Fear Of Missing Out) is a real concern. A science publication's review

Fig. 3. An iPad placed within a rattle. Note the device is immediately over the boy's testicles.

[2] SEER 12 is cancer registry data maintained by the National Cancer Institute (NCI) using 12 States of the United States.

Fig. 4. 2-in-1 iPotty with Activity Seat for iPad.

Fig. 5. An iPad for entertaining a baby.

article describes the problem in great depth [45]. An empirical study of the problem was published in 2013 [46].

4.6. Governmental warnings

Many countries have issue warning about children's cellphone use. Some examples are:

Turkey 2013:
Governor Aksoy Huseyin, of the Samsun province announced he would launch a cellphone campaign to bring awareness of their hazards.

Belgium 2013:
The Public Health Minister bans cellphone sales for children under 7 years old. Advertisements are also banned during children's TV programs.

Australia 2013:
The federal government created a fact sheet providing citizens ways to reduce exposure from wireless devices. The agency advises parents to limit children's exposure to cellphones.

France, 2010
Laws make advertising cellphones to children under the age of 12 illegal.

5. Conclusions

The risk to children and adolescent from exposure to microwave radiating devices is considerable. Adults have a smaller but very real risk, as well.

(1) Children absorb greater amount of microwave radiation (MWR) than adults;
(2) MWR is a Class 2B (possible) carcinogen as is carbon black, carbon tetrachloride, chloroform, DDT, lead, nickel, phenobarbital, styrene, diesel fuel, and gasoline. It seems clear that we would not expose children to these other agents, so why would we expose children to microwave radiation?
(3) Fetuses are even more vulnerable than children. Therefore pregnant women should avoid exposing their fetus to microwave radiation.
(4) Adolescent girls and women should not place cellphones in their bras or in hijabs.
(5) Cellphone manual warnings make clear an overexposure problem exists.
(6) Wireless devices are radio transmitters, not toys. Selling toys that use them should be banned.
(7) Government warnings have been issued but most of the public are unaware of such warnings.
(8) Exposure limits are inadequate and should be revised such that they are adequate.

Acknowledgements

Barb Payne for her special proof reading skills and Mary Redmayne for her advice and guidance.

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RADIATION INHIBITION OF AMINO ACID UPTAKE BY *Escherichia coli*

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ABSTRACT The inhibition of macromolecular synthesis in *Escherichia coli* by ionizing radiation has been investigated. The survival of the ability to incorporate arginine, leucine, isoleucine, histidine, uracil, and glucose after various doses of gamma radiation, deuteron and alpha particle bombardment has been measured. All amino acids are incorporated by processes which show the same radiation sensitivity. The sensitivity of uracil corresponds to a volume which is roughly spherical, of radius about 160A, whereas the amino acids possess sensitive regions which are long and thin in character. The uptake of glucose is concerned with a smaller, roughly spherical unit. The possible identification of the radiation-sensitive targets with cellular constituents is discussed. The long thin character observed for amino acids suggests that the sensitive region affected by radiation is an unfolded form of a ribosome, or alternatively a long nucleic acid molecule. For uracil the sensitive region fits with a 70S ribosome, while for glucose a smaller particle would fit the data.

INTRODUCTION

Studies on the uptake of amino acids by bacterial cells have begun to reveal some of the aspects of the cellular synthetic mechanism. Roberts and coworkers at the Carnegie Institution, in particular, have exploited the method in a sustained series of studies (Roberts *et al.*, 1957). Recently McQuillen, Roberts, and Britten (1959) have shown, by rapid pulse-labeling methods, that fractions of the particulate structure of *Escherichia coli*, the 70S and 85S ribosomes, are the site of first synthesis of protein in the cell. It is of great interest to determine the actual nature of the macromolecular organelle responsible for this process. It is possible that within the cell the ribonucleoprotein particles do not all possess the character of being spherical. Instead they may be extended in some way, or at least might be expected to be a mixed population, some being unfolded and others not. Alternatively, some of the processes of amino acid uptake may be concerned with large RNA molecules themselves.

Preliminary indications regarding these questions can be made by studying the way ionizing radiation inhibits the uptake of amino acids. Such studies employ a simple statistical analysis of the inhibition, taking advantage of the fact that ionizing radiation produces energy releases which are largely localized, either in small separate clusters occupying a region not more than a few Angstrom units across, or along lines of relatively dense ionization, with ionizations spread apart to a greater or lesser extent depending on the kind of ionization source used. The technique of such irradiation studies has been under development in this laboratory for some time and the validity of some of the necessary assumptions has also been the subject of much research (Pollard *et al.,* 1955). Recent work supporting this method of analysis may be found in the papers of Pollard (1959), Hutchinson (1957), and Pollard and Barrett (1959).

Comparative studies of various kinds of cell damage by radiation have been made and are briefly reviewed by one of the authors (Pollard, 1960). The uptake of amino acids is quite insensitive, by comparison with cell division or uptake of phosphate, and it therefore seems probable that amino acid uptake (and so probably protein synthesis) is thus a measure of ribosomal damage, or at any event, of a process which does not require the whole organization of the cell. On the other hand, ionizing radiation is not disruptive of the entire cellular contents, as is the case for extractive techniques, and therefore the statistical study of inhibition should be informative of the character of the synthetic units.

Preliminary experiments on the incorporation of certain amino acids have been reported (Hutchinson *et al.,* 1957; Kempner and Pollard, 1958); these have now been extended to include four other amino acids, and glucose and uracil for comparative purposes. In this paper we report the extended work and include a summary of all the findings.

MATERIALS AND METHODS

Cultures of *Escherichia coli* B (A.T.C.C. No. 11303) were grown with aeration at 37°C in Roberts' (1957) minimal "C" medium containing five gm of glucose per liter. Growth was measured turbidimetrically in a Bausch and Lomb "spectronix 20" colorimeter at 650 mμ. When the cultures reached a concentration of 3.0 to 5.0 $\times$ 10^8 cells/ml, samples were removed and treated as follows:—

1. Irradiation in a cobalt^{60} source. Twenty ml samples of the bacterial culture were placed in screw-top culture tubes and placed in a 1500 curie cobalt^{60} source. The dose rate was found to be 330,000 r/hr. by ferric sulfate dosimetry. Irradiations were performed at 30°C, and also at dry ice temperatures. For the latter experiments, the bacterial samples were rapidly frozen and then placed in the cooled cobalt source.

2. Cyclotron irradiations. Samples of 1 $\times$ 10^8 or 1 $\times$ 10^9 cells were drawn through "HA" millipore filters. The excess liquid was removed, and the filters carrying the bacteria were kept moist with a porous backing containing minimal medium with no glucose added. The samples were irradiated in the Yale cyclotron at 2°C as described elsewhere (Kempner and Pollard, 1958; Pollard *et al.,* 1955). After irradiation, the bacteria were resuspended in minimal C medium and equilibrated to 37°C.

3. Incubation with isotopically labeled compounds. Irradiated bacterial suspensions were added to an equal volume of minimal medium containing glucose and 0.1 μc of carbon per 20 ml of incubation medium.

The isotopically labeled compounds used in these studies and their specific activities are listed below. All were commercially available and checked for chromatographic purity.

L—Arginine—C^{14}	13.1 mc/millimole
L—Histidine—2 (ring)-C^{14}	0.284 mc/millimole
L—Isoleucine—C^{14}	12.6 mc/millimole
L—Leucine—C^{14}	5.13 mc/millimole
Uracil—2—C^{14}	2.94 mc/millimole
Glucose—C^{14}	1.0 mc/millimole

Studies on the incorporation of glucose were performed in the same medium without the addition of carrier (C-12) glucose. Incubation was conducted with aeration in a 37°C water bath. During an incubation period of 15 minutes, 2.0 ml samples were withdrawn after various time intervals. Half of the samples were drawn through individual collodion membrane filters with an average pore size of 0.85μ. The filters were washed with 2.0 ml of minimal medium and dried in air. These constituted the "intact cell" samples. The remaining samples were added to 2.0 ml of cold 10 per cent trichloroacetic acid (TCA) and placed at 2°C for 1 hour. These were then drawn through membrane filters, washed with 2.0 ml cold 5 per cent (TCA), and air-dried. These are referred to as the (TCA) insoluble samples.

The dried filters were counted under a thin-window Geiger tube on an automatic sample changer (Kempner and Bisbee, 1958).

RESULTS

After various doses of radiation, cultures of *E. coli* all showed increases in optical density during a 90 minute growth period in minimal glucose medium. As an example, after 360,000 r the optical density rose from 0.35 to 0.40. At the doses used in these experiments there is essentially no colony-forming ability left.

To see whether any great redistribution of activity among fractions took place, the proportion of radioactive label in the cold TCA-insoluble material was further extracted with 75 per cent ethanol, ethanol-ether, and hot TCA by the method of Roberts *et al.* (1957). This method of study did not reveal any differential effect in amino acid or uracil uptake.

In Fig. 1 we show the incorporation of C^{14}-leucine as a function of time for unirradiated cells and cells which had received various doses of gamma radiation. The control cells show a normal uptake behavior, with a small difference (which we will refer to as the pool) between whole cell and (cold) TCA-insoluble fractions. The tracer quantity of exogenous label is soon exhaused and the activity of each fraction reaches a plateau. After 665,000 r the cellular uptake has been depressed markedly and similarly the labeled TCA-soluble fraction is lower. The pool size is also decreased. After still greater radiation doses (1,110,000 r) the pool size is unmeasurable.

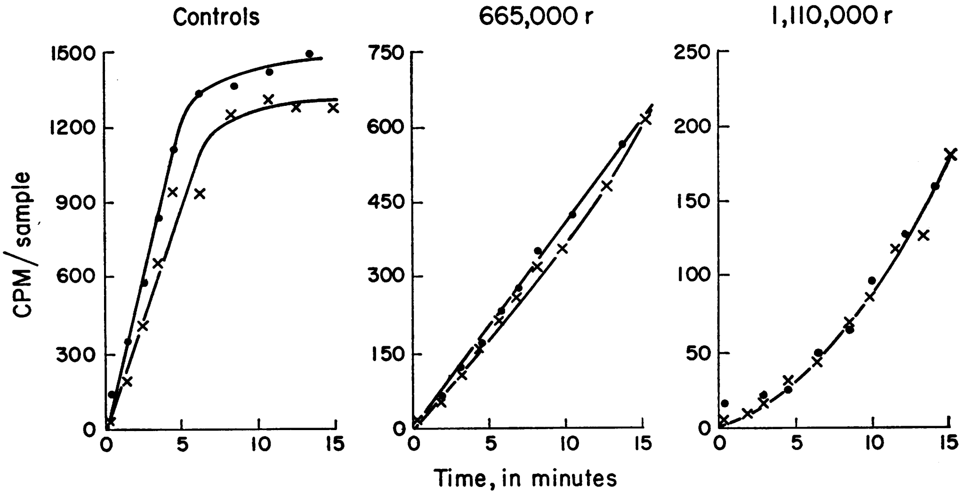

FIGURE 1 Incorporation of L-leucine into the whole cell (upper) and TCA-insoluble (lower curve) fractions as affected by various doses of Co^{60} gamma radiation. There is always a steady increase in the TCA-insoluble fraction even after massive radiation dosage.

The data of Fig. 1 are from a single experiment of five different radiation doses. We generally completed at least two or three such experiments and drew conclusions from the average of all.

In Fig. 2, the incorporation of uracil by *E. coli* after irradiation by $cobalt^{60}$ is shown. The depression of cellular activity is similar to that shown with leucine in Fig. 1, except that although the pool-forming ability is diminished by radiation, it is not completely destroyed.

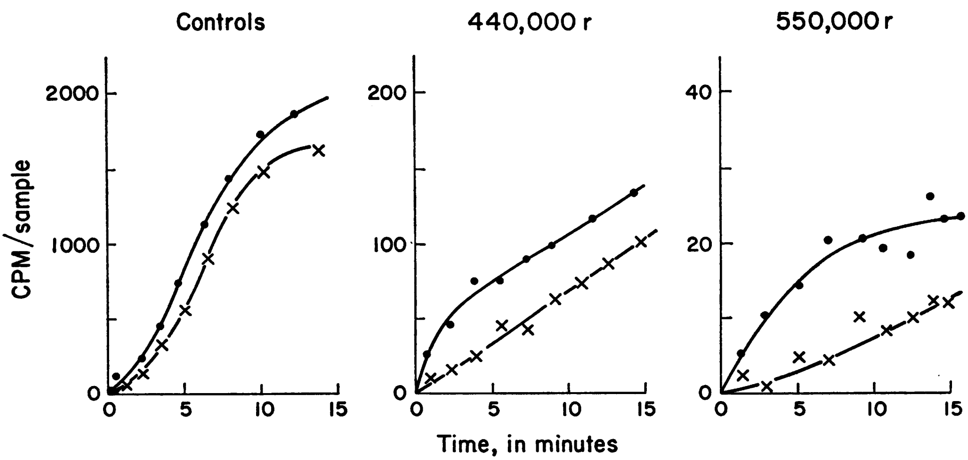

FIGURE 2 Incorporation of C^{14}-uracil into the whole cell (upper) and TCA-insoluble (lower curve) fractions as affected by various doses of Co^{60} gamma radiation.

In order to have some estimate of the relative effects of different doses, we adopted the procedure of plotting the ratio of uptake to that of the control for several different doses, choosing also several different times. Such a set of points for 7 minutes' incorporation of leucine and uracil into the TCA-insoluble fraction is shown in Fig. 3.

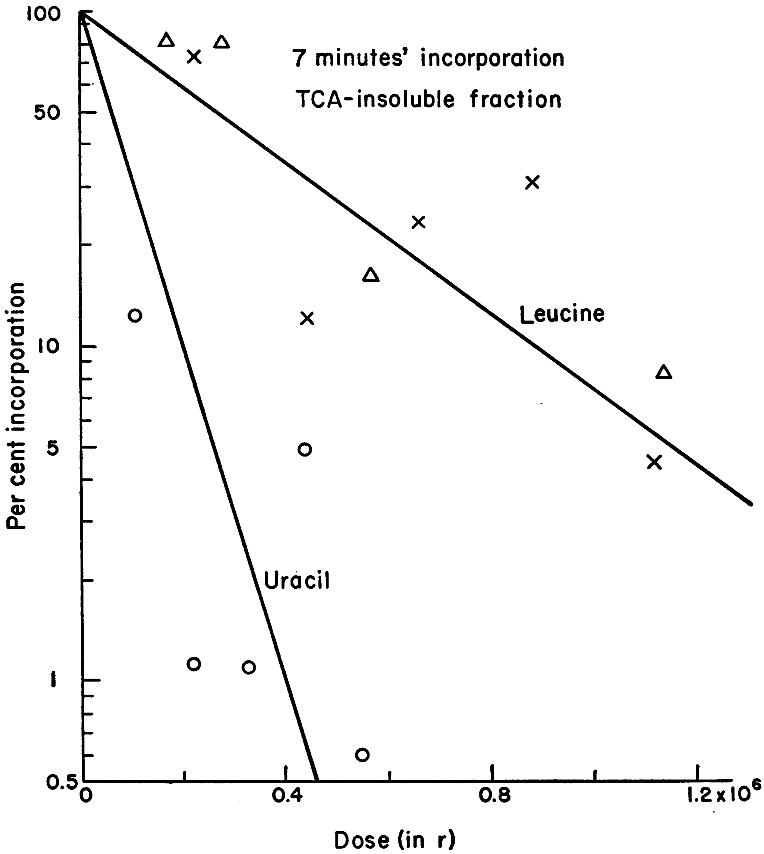

FIGURE 3 The percentage uptake of L-leucine and uracil into the TCA-insoluble fraction at 7 minutes, as a function of gamma radiation dose. Leucine data (×) from experiment shown in Fig. 1. Triangles from a duplicate experiment. The plot of the per cent is on a logarithmic scale and it can be seen that if n/n_0 is the ratio of uptake to original uptake, then the relation $\ln n/n_0$ = constant × dose is obeyed.

The ordinate in this graph is plotted logarithmically, and it can be seen that although there is considerable scatter in the points, there is a plausible relationship between the logarithm of the ratio, so plotted, and the dose. If different times are chosen, essentially the same slope is found. The agreement between different times and duplicate experiments was usually 20 per cent or better.

In some experiments the uptake was carried out in the presence of all exogenous

TABLE I

SUMMARY OF RADIATION TARGETS ASSOCIATED WITH THE INCORPORATION OF METABOLITES INTO THE TCA-INSOLUBLE MATERIAL OF *E. coli*

Metabolite	Sensitive volume (V) cm^3	Corrected maximum cross-section (S_o) cm^2	Length (A)*	Radius (A)*
L-Arginine	5.3×10^{-18}	32×10^{-12}	16,000	10
L-Isoleucine	6.9×10^{-18}	25×10^{-12}	7800	18
L-Leucine	5.6×10^{-18}	25×10^{-12}	9000	14
L-Histidine	5.6×10^{-18}	25×10^{-12}	9000	14
L-Proline	4.3×10^{-18}	30×10^{-12}	17,000	9
L-Cystine	4.3×10^{-18}	Not available		
L-Methionine	10.0×10^{-18}	10.0×10^{-12}	Spherical	150
Uracil	15.1×10^{-18}	10.0×10^{-12}	Spherical	160
D-Glucose	5.9×10^{-18}	1.5×10^{-12}	Spherical	90

* The calculation of the length l and the radius r was made by equating $\pi r^2 l$ to V and $2rl$ to S_o.

unlabeled amino acids, as well as the labeled one under study. Within 10 per cent, there was no effect on the slope of the line. Nor was there any difference between the effects of radiation at dry ice temperatures and at the normal temperature of the cobalt source within the same limit of error. This is significant, in that it implies that indirect inactivation due to migrating radicals of short half-life must be at a very low value.

Data very similar to the results with leucine were obtained for arginine, isoleucine, cystine, and proline. The radiation-sensitive volumes calculated from these data are shown in Table I.

Bacterial cells were also irradiated in the Yale cyclotron with deuterons at two different energies and also with alpha particles. Subsequent to this treatment, the

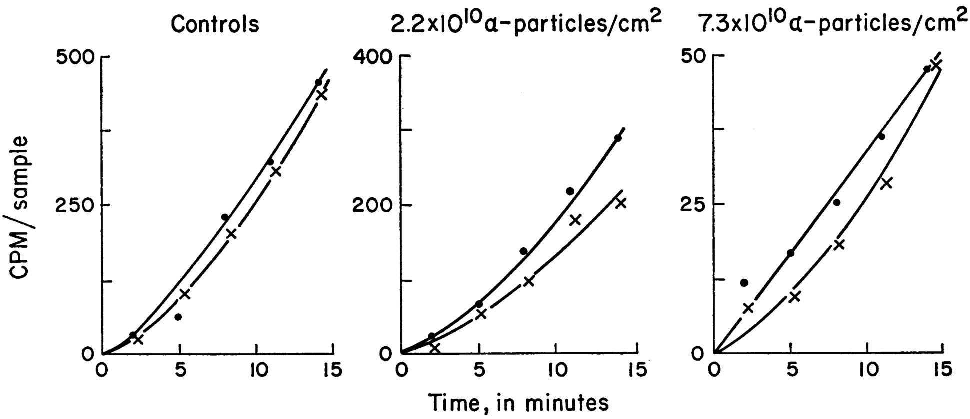

FIGURE 4 Incorporation of L-leucine as affected by various alpha particle bombardments.

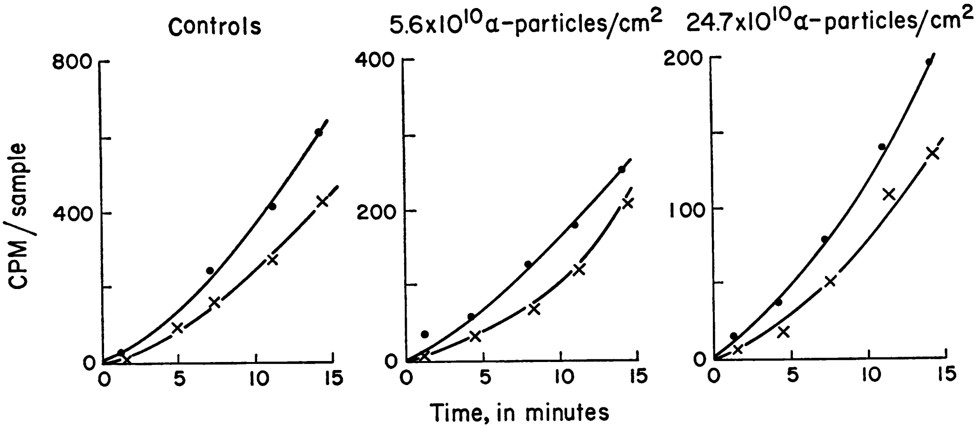

FIGURE 5 Incorporation of uracil as affected by various alpha particle bombardments.

incorporation of the labeled compounds was studied as in the case of gamma ray irradiation. Figs. 4 and 5 show the incorporation of leucine and uracil, respectively, after alpha particle bombardment of *E. coli*. The inhibition of cellular utilization appears to be similar to the results previously shown for gamma ray irradiations. However, the survival curve of the TCA-insoluble fraction, shown in Fig. 6, clearly indicates a distinct difference. The greater sensitivity to gamma rays of cellular incorporation of uracil over leucine is reversed, and the alpha particle radiation shows 37 per cent dose for leucine incorporation to be some 5 times smaller than for uracil. Other amino acids (arginine, isoleucine, and histidine) show the same sensitivity as leucine. Glucose incorporation into a TCA-precipitable form is extremely insensitive to alpha particle bombardment, with a D_{37} some 40 times greater than that of the amino acids.

ANALYSIS

An ionization within, or very near a macromolecule of protein or nucleic acid causes it to lose its function (Pollard, 1959). In material of the density of a bacterial cell (1.05), the number of primary ionizations per cm^3 per roentgen is 5.0×10^{11}. Since ionization is an "all-or-none" process, one very simple basis for analysis is to inquire as to the probability that a macromolecule of volume V can wholly escape an ionization when these are distributed randomly such that there is a number of ionizations I per unit volume. Since VI is the average number per macromolecule, the application of Poisson's equation yields the probability of no ionization, by purely random occurrence, as e^{-VI}. Thus we can suggest that the fraction left active, which is an experimental measure of the probability of escape, can be equated to

e^{-VI}. If we denote by n the number still active and by n_o the number initially, before radiation, we obtain

$$\frac{n}{n_o} = e^{-VI}$$

or equivalently,

$$\ln \frac{n}{n_o} = -VI$$

The fact that a plausible fit to this relation holds, makes it possible to calculate V within rather large limits of error. It will be seen that the limits of error are still not

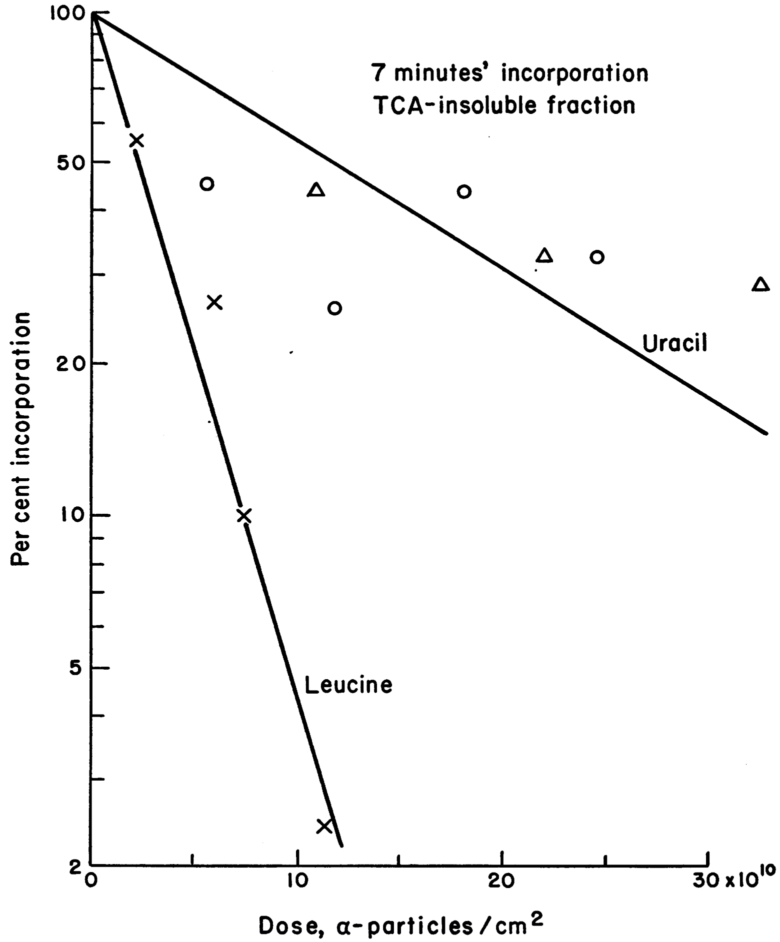

FIGURE 6 The percentage of uptake of L-leucine and uracil into the TCA-insoluble fraction at 7 minutes, as a function of alpha particle dose. Uracil data (o) from experiment shown in Fig. 5. Triangles from a duplicate experiment. The relative sensitivity is seen to be the reverse of that shown in Fig. 3 for gamma radiation.

so great as to preclude interesting deductions, and in fact, the power of the radiation analysis lies in the truth of this last statement.

Before calculating the values of V we can turn to the case of heavy particle radiation. The heavy charged particle cuts a narrow swath of ionization along its path. The swath is, however, accompanied by secondary ionization by ejected electrons, known as delta rays (Pollard *et al.*, 1955). If, for the moment, we ignore these delta rays, we can approach the "escape probability" by reasoning in terms of the idea that if one of densely ionizing tracks passes through the target, an inactivation will result. If we denote the sensitive area by S and the number of particles per unit area by D, then the average number passing through S is SD, and the same reasoning leads to the probability of there being a complete escape as e^{-SD}, so that we obtain

$$\frac{n}{n_0} = e^{-SD}$$

or equivalently,

$$\ln \frac{n}{n_0} = -SD$$

The same kind of logarithmic plot shows that this relation also plausibly holds. Thus a value of S can be calculated from the experimental data.

The value of S is found to vary with the ionization density. There are two major reasons for the variation. The first is the effect of delta rays; the second is the possibility of "straddling" a thin target, by which we mean that sometimes, even though a charged particle has gone through the target, the target is so thin that it may have failed to receive an ionization within it. The first can be corrected for by a simple method described by Pollard and Barrett (1959). Straddling effects have been discussed by Ore (1957) and his corrections have also been used in our analysis. After such corrections we can make an estimate of V from colbalt irradiation, S the area, and t the thickness, from heavy particle data. These estimates are only rough, but they are informative.

In Fig. 7 we show the results of plotting the experimentally found (uncorrected) values of S, which we call the cross-section, *versus* the rate of energy loss for the bombarding particles, for the uptake into the TCA-insoluble fraction of arginine, histidine, isoleucine, leucine, uracil, and glucose, as well as proline and methionine (Kempner and Pollard, 1958). The slopes of the lines near the origin are fixed by the values of V found from cobalt irradiation as described by Pollard *et al.* (1955). Even without any corrections it is quite apparent that there are three groupings. The cellular "targets" for arginine, histidine, isoleucine, leucine, and proline incorporation show a steady increase in radiation cross-section with the rate of energy loss, while the targets for methionine and uracil do not. The case of glucose is even more striking, in that a clear leveling off at a low cross-section can be seen.

In Table I we show the values of the sensitive volume and the values (corrected

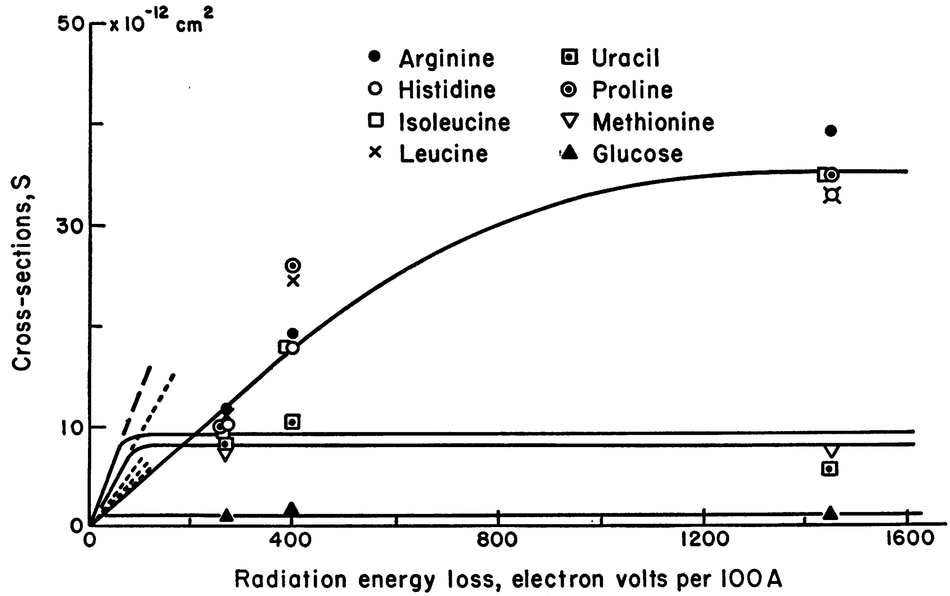

FIGURE 7 A plot of the sensitive cross-section for seven metabolites against the rate of energy loss. The initial slope is found from Co^{60} inactivation. Three groupings appear: arginine, histidine, leucine, isoleucine, and proline are all characterized by high sensitivity at high rates of energy loss; methionine and uracil have rather low sensitivities for such radiation and glucose is consistently low. Probably the first grouping are long thin objects, but the others are more nearly spherical.

for delta rays) of S_0, the maximum cross-section for heavily ionizing particles. In addition, we calculate the appropriate lengths and radii for long cylinders, or spheres according to which is the most suitable approximation. Since the calculation of radii involves $V^{1/3}$ or $A^{1/2}$, a 20 per cent experimental error in the determination of the 37 per cent inhibition dose results in only a 10 per cent error in the linear dimensions of the target.

If we apply the statistical analysis previously used, we can consider the falling aspect of pool size. Roughly speaking, the relation

$$\ln \frac{n}{n_0} = -VI$$

can be held to apply. In most cases the dose necessary to reduce the survival ratio to 0.37 (for which the natural logarithm is -1) is very roughly 500,000 r, giving a value of V of 4×10^{-18}cm^3, or a molecular weight of

$$4 \times 10^{-18} \times 1.3 \times 6.03 \times 10^{23} = 3.1 \times 10^6$$

assuming material of density 1.3. This is interesting in that it indicates that some rather large, organized molecular structures are responsible for the maintenance of a pool.

DISCUSSION

The effects of radiation which we have roughly measured can be looked at in two ways. The first is essentially empirical and regards radiation as a kind of stress applied to the cell, which can perhaps produce differential effects on the structures that react with various metabolites. Thus one can look simply at any grouping of effects and consider whether they have any significance. Such grouping shows very clearly in the response to heavy particle irradiation. Data in Table I show that the radiation-sensitive elements associated with the uptake of the amino acids arginine, leucine, isoleucine, histidine, and proline fall into one class, characterized by behavior which radiation analysis associates with long, thin, sensitive units, whereas another amino acid, methionine, differs markedly. Methionine incorporation seems to require the intervention somewhere of a much shorter, thicker structure. Uracil seems to behave in the same way. Glucose, on the other hand, appears to be involved with a still smaller, but thick and roughly spherical object.

A second way of looking at the experiments is to consider the results of cell fractionation to see which of the known cellular structures could be involved with the various operations. Such a method is limited by our knowledge of cell components, which is admittedly imperfect, but it is still a useful viewpoint. An *E. coli* cell has a cell wall, a protoplast membrane, two or more "nuclear bodies," a rather organized complement of DNA within the nuclear bodies, and a large number of ribosomal particles with sedimentation constants ranging from 20 to 100 Svedberg units. These ribosomes contain RNA and protein in a tight bonding. There is in addition an amount of soluble RNA of smaller molecular weight, and a large number of enzymes.

The radiation data enable us to eliminate from this list the whole nucleus, as being too large a radiation target, and the enzymes or soluble RNA as being too small. Interest therefore centers on DNA, large specific RNA, and the ribosomes. The effect of radiation on the uptake of methionine and uracil fits rather remarkably well with the idea that ribosomal particles of sedimentation constant about 80 Svedberg units are involved. On the other hand, the sensitivity found for the five other amino acids studied is much more in agreement with that to be expected from a nucleic acid chain of molecular weight about 4×10^6. Whether this be DNA or RNA, we have no basis for telling. It is possible that a ribonucleoprotein particle, in action, is unrolled in some way, and could therefore result in the long, thin appearance of a radiation target.

Present concepts of protein synthesis postulate the existence of a protein-forming "template." In such a frame of reference, it would be expected that the incorporation of amino acids would be inhibited by destruction of a radiation target identical for all. Our results indicate that at least for five of the six amino acids studied, this indeed is the case. The results for methionine (Kempner and Pollard, 1958) therefore are quite paradoxical. It is extremely difficult to see how these results could be consistent with any simple model of protein synthesis. Further studies on the radiation inhibition of the incorporation of methionine and other amino acids might be very informative about the mechanism of such synthesis.

The ability of cells to utilize glucose after exposure to each type of radiation used was found to be a simple exponential function of dose. No evidence for a "multiple hit" requirement (Pollard *et al.,* 1955) or for targets of two or more different sizes was found. This implies that all exogenous glucose passes through a common structure which is the most radiation-sensitive element in its biochemical pathways. The target analysis of this unit is given in Table I. If it is assumed that the target is a single macromolecular structure, then a calculation of the expected sedimentation constant leads to a value of 20 to 30S.

We can mention briefly the radiation sensitivity found for the "pool." The fact that radiation does have an effect on the pool seems to dispose of the idea that no more is involved than an inert sieve-like membrane. It is of interest that the doses at which an effect on the pool becomes great are also those at which radioactive label begins to leak out of the cell. Whether the action of radiation is on large molecular units within the cell, or on large units comprising the protoplast membrane itself, we cannot say.

We wish to thank Dr. R. B. Roberts and Dr. E. T. Bolton of the Carnegie Institution of Washington for helpful advice with the technical problem of cell filtration and uptake studies, and Mr. J. Lowry and Miss N. Barrett for help in running the cyclotron.

This work is part of a dissertation presented to the faculty of Yale University in candidacy for the degree of Doctor of Philosophy.

Aided by grants from the John A. Hartford Foundation and the United States Atomic Energy Commission.

Received for publication, October 5, 1960.

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SAGE Associates
ENVIRONMENTAL CONSULTANTS

Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters

Sage Associates
Santa Barbara, CA
USA

January 1, 2011

TABLE OF CONTENTS

SUMMARY OF FINDINGS

This Report has been prepared to document radiofrequency radiation (RF) levels associated with wireless smart meters in various scenarios depicting common ways in which they are installed and operated.

The Report includes computer modeling of the range of possible smart meter RF levels that are occurring in the typical installation and operation of a single smart meter, and also multiple meters in California. It includes analysis of both two-antenna smart meters (the typical installation) and of three-antenna meters (the collector meters that relay RF signals from another 500 to 5000 homes in the area).

RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits (Tables 1 - 14).

Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are predicted in this Report, based on computer modeling (Tables 10 – 17).

Tables 1 – 17 show power density data and possible conditions of violation of the FCC public safety limits, and Tables 18 – 33 show comparisons to health studies reporting adverse health impacts.

FCC compliance violations are likely to occur under normal conditions of installation and operation of smart meters and collector meters in California. Violations of FCC safety limits for uncontrolled public access are identified at distances within 6” of the meter. Exposure to the face is possible at this distance, in violation of the time-weighted average safety limits (Tables 10-11). FCC violations are predicted to occur at 60% reflection (OET Equation 10 and 100% reflection (OET Equation 6) factors*, both used in FCC OET 65 formulas for such calculations for time-weighted average limits. Peak power limits are not violated at the 6” distance (looking at the meter) but can be at 3” from the meter, if it is touched.

This report has also assessed the potential for FCC violations based on two examples of RF exposures in a typical residence. RF levels have been calculated at distances of 11” (to represent a nursery or bedroom with a crib or bed against a wall opposite one or more meters); and at 28” (to represent a kitchen work space with one or more meters installed on the kitchen wall).

FCC compliance violations are identified at 11” in a nursery or bedroom setting using Equation 10* of the FCC OET 65 regulations (Tables 12-13). These violations are predicted to occur where there are multiple smart meters, or one collector meter, or one collector meter mounted together with several smart meters.

FCC compliance violations are not predicted at 28” in the kitchen work space for 60% or for 100% reflection calculations. Violations of FCC public safety limits are predicted for higher reflection factors of 1000% and 2000%, which are not a part of FCC OET 65 formulas, but are included here to allow for situations where site-specific conditions (highly reflective environments, for example, galley-type kitchens with many highly reflective stainless steel or other metallic surfaces) may be warranted.*

*FCC OET 65 Equation 10 assumes 60% reflection and Equation 6 assumes 100% reflection. RF levels are also calculated in this report to account for some situations where interior environments have highly reflective surfaces as might be found in a small kitchen with stainless steel or other metal counters, appliances and furnishings. This report includes the FCC's reflection factors of 60% and 100%, and also reflection factors of1000% and 2000% that are more in line with those reported in Hondou, 2001; Hondou, 2006 and Vermeeren et al, 2010. The use of a 1000% reflection factor is still conservative in comparison to Hondou, 2006. A 1000% reflection factor is 12% (or 121 times as high) a factor for power density compared to Hondou et al, 2006 prediction of 1000 times higher power densities due to reflection. A 2000% reflection factor is only 22% (or 441 times) that of Hondou's finding that power density can be as high as 2000 times higher.

In addition to exceeding FCC public safety limits under some conditions of installation and operation, smart meters can produce excessively elevated RF exposures, depending on where they are installed. With respect to absolute RF exposure levels predicted for occupied space within dwellings, or outside areas like patios, gardens and walk-ways, RF levels are predicted to be substantially elevated within a few feet to within a few tens of feet from the meter(s).

For example, one smart meter at 11" from occupied space produces somewhere between 1.4 and 140 microwatts per centimeter squared (uW/cm2) depending on the duty cycle modeled (Table 12). Since FCC OET 65 specifies that continuous exposure be assumed where the public cannot be excluded (such as is applicable to one's home), this calculation produces an RF level of 140 uW/cm2 at 11" using the FCCs lowest reflection factor of 60%. Using the FCC's reflection factor of 100%, the figures rise to 2.2 uW/cm2 – 218 uW/cm2, where the continuous exposure calculation is 218 uW/cm2 (Table 12). These are very significantly elevated RF exposures in comparison to typical individual exposures in daily life. Multiple smart meters in the nursery/bedroom example at 11" are predicted to generate RF levels from about 5 to 481 uW/cm2 at the lowest (60%) reflection factor; and 7.5 to 751 uW/cm2 using the FCCs 100% reflection factor (Table 13). Such levels are far above typical public exposures.

RF levels at 28" in the kitchen work space are also predicted to be significantly elevated with one or more smart meters (or a collector meter alone or in combination with multiple smart meters). At 28" distance, RF levels are predicted in the kitchen example to be as high as 21 uW/cm2 from a single meter and as high as 54.5 uW/cm2 with multiple smart meters using the lower of the FCCs reflection factor of 60% (Table 14). Using the FCCs higher reflection factor of 100%, the RF levels are predicted to be as high as 33.8 uW/cm2 for a single meter and as high as 85.8 uW/cm2 for multiple smart meters (Table 14). For a single collector meter, the range is 60.9 to 95.2 uW/cm2 (at 60% and 100% reflection factors, respectively) (from Table 15).

Table 16 illustrates predicted violations of peak power limit (4000 uW/cm2) at 3" from the surface of a meter. FCC violations of peak power limit are predicted to occur for a single collector meter at both 60% and 100% reflection factors. This situation might occur if someone touches a smart meter or stands directly in front.

Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

Consumers, for whatever personal reason, choice or necessity who have already eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from smart meters on a 24-hour basis. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the structure, and how it is furnished.

People who are afforded special protection under the federal Americans with Disabilities Act are not sufficiently acknowledged nor protected. People who have medical and/or metal implants or other conditions rendering them vulnerable to health risks at lower levels than FCC RF limits may be particularly at risk (Tables 30-31). This is also likely to hold true for other subgroups, like children and people who are ill or taking medications, or are elderly, for they have different reactions to pulsed RF. Childrens' tissues absorb RF differently and can absorb more RF than adults (Christ et al, 2010; Wiart et al, 2008). The elderly and those on some medications respond more acutely to some RF exposures.

Safety standards for peak exposure limits to radiofrequency have not been developed to take into account the particular sensitivity of the eyes, testes and other ball shaped organs. There are no peak power limits defined for the eyes and testes, and it is not unreasonable to imagine situations where either of these organs comes into close contact with smart meters and/or collector meters, particularly where they are installed in multiples (on walls of multi-family dwellings that are accessible as common areas).

In summary, no positive assertion of safety can be made by the FCC, nor relied upon by the CPUC, with respect to pulsed RF when exposures are chronic and occur in the general population. Indiscriminate exposure to environmentally ubiquitous pulsed RF from the rollout of millions of new RF sources (smart meters) will mean far greater general population exposures, and potential health consequences. Uncertainties about the existing RF environment (how much RF exposure already exists), what kind of interior reflective environments exist (reflection factor), how interior space is utilized near walls), and other characteristics of residents (age, medical condition, medical implants, relative health, reliance on critical care equipment that may be subject to electronic interference, etc) and unrestrained access to areas of property where meter is located all argue for caution.

INTRODUCTION

How Smart Meters Work

This report is limited to a very simple overview of how smart meters work, and the other parts of the communication system that are required for them to transmit information on energy usage within a home or other building. The reader can find more detailed information on smart meter and smart grid technology from numerous sources available on the Internet.

Often called ‘advanced metering infrastructure or AMI’, smart meters are a part of an overall system that includes a) a mesh network or series of wireless antennas at the neighborhood level to collect and transmit wireless information from all the smart meters in that area back to a utility.

The mesh network (sometimes called a distributed antenna system) requires wireless antennas to be located throughout neighborhoods in close proximity to where smart meters will be placed. Often, a municipality will receive a hundred or more individual applications for new cellular antenna service, which is specifically to serve smart meter technology needs. The communication network needed to serve smart meters is typically separate from existing cellular and data transmission antennas (cell tower antennas). The mesh network (or DAS) antennas are often utility-pole mounted. This part of the system can spread hundreds of new wireless antennas throughout neighborhoods.

Smart meters are a new type electrical meter that will measure your energy usage, like the old ones do now. But, it will send the information back to the utility by wireless signal (radiofrequency/microwave radiation signal) instead of having a utility meter reader come to the property and manually do the monthly electric service reading. So, smart meters are replacements for the older ‘spinning dial’ or analog electric meters. Smart meters are not optional, and utilities are installing them even where occupants do not want them.

In order for smart meters to monitor and control energy usage via this wireless communication system, the consumer must be willing to install power transmitters inside the home. This is the third part of the system and involves placing power transmitters (radiofrequency/microwave radiation emitting devices) within the home on each appliance. A power transmitter is required to measure the energy use of individual appliances (e.g., washing machines, clothes dryers, dishwashers, etc) and it will send information via wireless radiofrequency signal back to the smart meter. Each power transmitter handles a separate appliance. A typical kitchen and laundry may have a dozen power transmitters in total. If power transmitters are not installed by the homeowner, or otherwise mandated on consumers via federal legislation requiring all new appliances to have power transmitters built into them, then there may be little or no energy reporting nor energy savings.

Smart meters could also be installed that would operate by wired, rather than wireless means. Shielded cable, such as is available for cable modem (wired internet connection) could connect smart meters to utilities. However, it is not easy to see the solution to transmit signals from power transmitters (energy use for each appliance) back to the utility.

Collector meters are a special type of smart meter that can serve to collect the radiofrequency/microwave radiation signals from many surrounding buildings and send them back to the utility. Collector meters are intended to collect and re-transmit radiofrequency information for somewhere between 500-5000 homes or buildings. They have three operating antennas compared to two antennas in regular smart meters. Their radiofrequency microwave emissions are higher and they send wireless signal much more frequently. Collector meters can be place on a home or other building like smart meters, and there is presently no way to know which a homeowner or property owner might receive.

Mandate

The California Public Utilities Commission has authorized California's investor-owned utilities (including Pacific Gas & Electric, Southern California Edison Company and San Diego Gas & Electric) to install more than 10 million new wireless* smart meters in California, replacing existing electric meters as part of the federal SmartGrid program.

The goal is to provide a new residential energy management tool. It is intended to reduce energy consumption by providing computerized information to customers about what their energy usage is and how they might reduce it by running appliances during 'off-time' or 'lower load' conditions. Presumably this will save utilities from having to build new facilities for peak load demand. Utilities will install a new smart meter on every building to which electrical service is provided now. In Southern California, that is about 5 million smart meters in three years for a cost of around $1.6 billion dollars. In northern California, Pacific Gas & Electric is slated to install millions of meters at a cost of more than $2.2 billion dollars. If consumers decide to join the program (so that appliances can report energy usage to the utility), they can be informed about using energy during off-use or low-use periods, but only if consumers also agree to install additional wireless power transmitters on appliances inside the home. Each power transmitter is an additional source of pulsed RF that produces high exposures at close range in occupied space within the home.

> *"Proponents of smart meters say that when these meters are teamed up with an in-home display that shows current energy usage, as well as a communicating thermostat and software that harvest and analyze that information, consumers can see how much consumption drives cost -- and will consume less as a result. Utilities are spending billions of dollars outfitting homes and businesses with the devices, which wirelessly send information about electricity use to utility billing departments and could help consumers control energy use."*
>
> Wall Street Journal, April 29, 2009.

The smart meter program is also a tool for load-shedding during heavy electrical use periods by turning utility meters off remotely, and for reducing the need for utility employees to read meter data in the field.

Purpose of this Report

This Report has been prepared to document radiofrequency radiation (RF) levels associated with wireless smart meters in various scenarios depicting common ways in which they are installed and operated.

The Report includes computer modeling of the range of possible smart meter RF levels that are occurring in the typical installation and operation of a single smart meter, and also multiple meters in California. It includes analysis of both two-antenna smart meters (the typical installation) and of three-antenna meters (the collector meters that relay RF signals from another 500 to 5000 homes in the area).

RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits (Tables 1 - 14).

Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are illustrated in this Report, based on computer modeling (Tables 10 – 17).

Tables which present data, possible conditions of violation of the FCC public safety limits, and comparisons to health studies reporting adverse health impacts are summarized (Tables 18 – 33).

The next section describes methodology in detail, but generally this Report provides computer modeling results for RF power density levels for these scenarios, analysis of whether and under what conditions FCC public safety limit violations may occur, and comparison of RF levels produced under these scenarios to studies reporting adverse health impacts with chronic exposure to low-intensity radiofrequency radiation at or below levels produced by smart meters and collector meters in the manner installed and operated in California.

1) Single ‘typical’ meter - tables showing RF power density at increasing distances in 0.25’ (3”) intervals outward for single meter (two-antenna meter). Effects of variable duty cycles (from 1% to 90%) and various reflection factors (60%, 100%, 1000% and 2000%) have been calculated.
2) Multiple ‘typical’ meters - tables showing RF power density at increasing distances as above.

3) Collector meter - tables showing RF power density related to a specialized collector meter which has three internal antennas (one for every 500 or 5000 homes) as above.
4) Collector meter - a single collector meter installed with multiple ‘typical’ two-antenna meters as above.
5) Tables are given to illustrate the distance to possible FCC violations for time-weighted average and peak power limits (in inches).
6) Tables are given to document RF power density levels at various key distances (11” to a crib in a bedroom; 28” to a kitchen work area; and 6” for a person attempting to read the digital readout of a smart meter, or inadvertently working around a meter.
7) Tables are given to compare RF power density levels with studies reporting adverse health symptoms and effects (and those levels of RF associated with such health effects).
8) Tables are given to compare smart meter and collector meter RF to BioInitiative Report recommended limit (in feet).

Framing Questions

In view of the rapid deployment of smart meters around the country, and the relative lack of public information on their radiofrequency (RF) emission profiles and public exposures, there is a crucial need to provide independent technical information.

There is very little solid information on which decision-makers and the public can make informed decisions about whether they are an acceptable new RF exposure, in combination with pre-existing RF exposures.

On-going Assessment of Radiofrequency Radiation Health Risks

The US NIEHS National Toxicology Program nominated radiofrequency radiation for study as a carcinogen in 1999. Existing safety limits for pulsed RF were termed “not protective of public health” by the

Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others). Recently, the NTP issued a statement indicating it will complete its review by 2014 (National Toxicology Program, 2009). The NTP radiofrequency radiation study results have been delayed for more than a decade since 1999 and very little laboratory or epidemiological work has been completed. Thus, he explosion of wireless technologies is producing radiofrequency radiation exposures over massive populations before questions are answered by federal studies about the carcinogenicity or toxicity of low-intensity RF such as are produced by smart meters and other SmartGrid applications of wireless. The World Health Organization and the International Agency for Research on Cancer have not completed their studies of RF (the IARC WHO RF Health Monograph is not expected until at least 2011). In the United States, the National Toxicology Program listed RF as a potential carcinogen for study, and has not released any study results or findings a decade later. There are no current, relevant public safety standards for pulsed RF involving chronic exposure of the public, nor of sensitive populations, nor of people with metal and medical implants that can be affected both by localized heating and by electromagnetic interference (EMI) for medical wireless implanted devices.

Considering that millions of smart meters are slated to be installed on virtually every electrified building in America, the scope of the question is large and highly personal. Every family home in the country, and every school classroom – every building with an electric meter – is to have a new wireless meter – and thus subject to unpredictable levels of RF every day.

1) Have smart meters been tested and shown to comply with FCC

public safety limits (limits for uncontrolled public access)?

2) Are these FCC public safety limits sufficiently protective of public health and safety? This question is posed in light of the last thirty years of international scientific investigation and public health assessments documenting the existence of bioeffects and adverse health effects at RF levels far below current FCC standards. The FCC's standards have not been updated since 1992, and did not anticipate nor protect against chronic exposures (as opposed to acute exposures) from low-intensity or non-thermal RF exposures, particularly pulsed RF exposures.

3) What demonstration is there that wireless smart meters will comply with existing FCC limits, as opposed to under strictly controlled conditions within government testing laboratories?

4) Has the FCC been able to certify that compliance is achievable under real-life use conditions including, but not limited to:

- In the case where there are both gas and electric meters on the home located closely together.

- In the case where there is a "bank" of electric and gas meters, on a multi-family residential building such as on a condominium or apartment building wall. There are instances of up to 20 or more meters located in close proximity to occupied living space in the home,in the classroom or other occupied public space.

• In the case where there is a collector meter on a home that serves the home plus another 500 to 5000 other residential units in the area, vastly increasing the frequency of RF bursts.

• In the case where there is one smart meter on the home but it acts as a relay for other local neighborhood meters. What about 'piggybacking' of other neighbors' meters through yours? How can piggybacking be reasonably estimated and added onto the above estimates?

• What about the RF emissions from the power transmitters? Power transmitters installed on appliances (perhaps 10-15 of them per home) and each one is a radiofrequency radiation transmitter.

• How can the FCC certify a system that has an unknown number of such transmitters per home, with no information on where they are placed?

• Where people with medical/metal implants are present? (Americans with Disabilities Act protects rights)

5) What assessment has been done to determine what pre-existing conditions of RF exposure are already present. On what basis can compliance for the family inside the residence be assured, when there is no verification of what other RF sources exist on private property? How is the problem of cumulative RF exposure properly assessed (wireless routers, wireless laptops, cell phones, PDAs, DECT or other active-base cordless phone systems, home security systems,

baby monitors, contribution of AM, FM, television, nearby cell towers, etc).

6) What is the cumulative RF emissions worst-case profile? Is this estimate in compliance?

7) What study has been done for people with metal implants* who require protection under Americans with Disabilities Act? What is known about how metal implants can intensity RF, heat tissue and result in adverse effects below RF levels allowed for the general public. What is known about electromagnetic interference (EMI) from spurious RF sources in the environment (RFID scanners, cell towers, security gates, wireless security systems, wireless communication devices and routers, wireless smart meters, etc)

*Note: There are more than 20 million people in the US who need special protection against such exposures that may endanger them. High peak power bursts of RF may disable electronics in some critical care and medical implants. We already have reports of wireless devices disabling deep brain stimulators in Parkinson's patients and there is published literature on malfunctions with critical care equipment.

PUBLIC SAFETY LIMITS FOR RADIOFREQUENCY RADIATION

The FCC adopted limits for Maximum Permissible Exposure (MPE) are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," (NCRP, 1986).

In the United States, the Federal Communications Commission (FCC) enforces limits for both occupational exposures (in the workplace) and for public exposures. The allowable limits are variable, according to the frequency transmitted. Only public safety limits for uncontrolled public access are assessed in this report.

Maximum permissible exposures (MPE) to radiofrequency electromagnetic fields are usually expressed in terms of the plane wave equivalent power density expressed in units of milliwatts per square centimeter (mW/cm2) or alternatively, absorption of RF energy is a function of frequency (as well as body size and other factors). The limits vary with frequency. Standards are more restrictive for frequencies at and below 300 MHz. Higher intensity RF exposures are allowed for frequencies between 300 MHz and 6000 MHz than for those below 300 MHz.

In the frequency range from 100 MHz to 1500 MHz, exposure limits for field strength and power density are also generally based on the MPE limits found in Section 4.1 of "*IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*," ANSI/IEEE C95.1-1992 (IEEE, 1992, and approved for use as an American National Standard by the American National Standards Institute

(ANSI).

US Federal Communications Commission (FCC) Exposure Standards

Table 1, Appendix A FCC LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm2)	Averaging Time $[E]^2$ $[H]^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	$(900/f_2)$*	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6

B) FCC Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm2)	Averaging Time $[E]^2$ $[H]^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	30
3.0-30	824/f	2.19/f	$(180/f_2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

NOTE 1: ***Occupational/controlled*** limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: ***General population/uncontrolled*** exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure. Source: FCC Bulletin OET 65 Guidelines, page 67 OET, 1997.

In this report, the public safety limit for a smart meter is a combination of the individual antenna frequency limits and how much power output they create. A smart meter contains two antennas. One transmits at 915 MHz and the other at 2405 MHz. They can transmit at the same time, and so their effective radiated power is summed in the calculations of RF power density. Their combined limit is 655 uW/cm2. This limit is calculated by formulas from Table 1, Part B and is proportionate to the power output and specific safety limit (in MHz) of each antenna.

For the collector meter, with it's three internal antennas, the combined public safety limit for time-averaged exposure is 571 MHz (a more restrictive level since it includes an additional 824 MHz antenna that has a lower limit than either the 915 MHz or the 2405 MHz antennas). In a collector meter, only two of the three antennas can transmit simultaneously (the 915 MHz LAN and the GSM 850 MHz (from the FCC Certification Exhibit titled RF Exposure Report for FCC ID: SK9AMI-2A). The proportionate power output of each antenna plus the safety limit for each antenna frequency combines to give a safety limit for the collector meter of 571 uW/cm2. Where one collector meter is combined with multiple smart meters, the combined limit is weighted upward by the additional smart meters' contribution, and is 624 uW/cm2.

Continuous Exposure

FCC Bulletin OET 65 guidelines require the assumption of continuous exposure in calculations. Duty cycles offered by the utilities are a fraction of continuous use, and significantly diminish predictions of RF exposure.

At present, there is no evidence to prove that smart meters are functionally unable to operate at higher duty cycles that some utilities have estimated (estimates vary from 1% to 12.5% duty cycle, and as high as 30%). Confirming this is the Electric Power Research Institute (EPRI) in its "Perspective on Radio-Frequency Exposure Associated with Residential Automatic Meter Reading Technology (EPRI, 2010) According to EPRI:

> *"The technology not only provides a highly efficient method for obtaining usage data from customers, but it also can provide up-to-the-minute information on consumption patterns since the meter reading devices can be programmed to provide data as often as needed."* Emphasis added

The FCC Bulletin OET 65 guidelines specify that continuous exposure (defined by the FCC OET 65 as 100% duty cycle) is required in calculations where it is not possible to control exposures to the general public.

> *"It is important to note that for general population/uncontrolled exposures it is often not possible to control exposures to the extent that averaging times can be applied. In those situations, it is often necessary to assume continuous exposure."* (emphasis added)
>
> FCC Bulletin OET 65, p, 10

> ***"Duty factor****. The ratio of pulse duration to the pulse period of a periodic pulse train. Also, may be a measure of the temporal transmission characteristic of an intermittently transmitting RF source such as a paging antenna by dividing average transmission duration by the average period for transmissions. A duty factor of 1.0 corresponds to continuous operation."*
> (emphasis added)
>
> FCC Bulletin OET 65, p, 2

This provision then specifies duty cycles to be increased to 100%.

The FCC Guidelines (OET 65) further address cautions that should be observed for uncontrolled public access to areas that may cause exposure to high levels of RF.

Re-radiation

> *The foregoing also applies to high RF levels created in whole or in part by re-eradiation. A convenient rule to apply to all situations involving RF radiation is the following:*
>
> *(1) Do not create high RF levels where people are or could reasonably be expected to be present, and (2) [p]revent people from entering areas in which high RF levels are necessarily present.*
>
> *(2) Fencing and warning signs may be sufficient in many cases to protect the general public. Unusual circumstances, the presence of multiple sources of radiation, and operational needs will require more elaborate measures.*
>
> *(3) Intermittent reductions in power, increased antenna heights, modified antenna radiation patterns, site changes, or some combination of these may be necessary, depending on the particular situation.*
>
> FCC OET 65, Appendix B, p. 79

Fencing, distancing, protective RF shielded clothing and signage warning occupants not to use portions of their homes or properties are not feasible nor desirable in public places the general public will spend time (schools, libraries, cafes, medical offices and clinics, etc) These mitigation strategies may be workable for RF workers, but are unsuited and intolerable for the public.

Reflections

A major, uncontrolled variable in predicting RF exposures is the degree to which a particular location (kitchen, bedroom, etc) will reflect RF energy created by installation of one or more smart meters, or a collector meter and multiple smart meters. The reflectivity of a surface is a measure of the amount of reflected radiation. It can be defined as the ratio of the intensities of the reflected and incident radiation. The reflectivity depends on the angle of incidence, the polarization of the radiation, and the electromagnetic properties of the materials forming the boundary surface. These properties usually change with the wavelength of the radiation. The reflectivity of polished metal surfaces is usually quite high (such as stainless steel and polished metal surfaces typical in kitchens, for example).

Reflections can significantly increase localized RF levels. High uncertainty exists about how extensive a problem this may create in routine installations of smart meters, where the utility and installers have no idea what kind of reflectivity is present within the interior of buildings.

Reflections in Equation 6 and 10 of the FCC OET Bulletin 65 include rather minimal reflection factors of 100% and 60%, respectively. This report includes higher reflection factors in line with published studies by Hondou et al, 2006, Hondou, 2002 and Vermeeren et al, 2010. Reflection factors are modeled at 1000% and 2000% as well as at 60% and 100%, based on published scientific evidence for highly reflective environments. Hondou (2002) establishes that power density can be higher than conventional formulas predict using standard 60% and 100% reflection factors.

> *"We show that this level can reach the reference level (ICNIRP Guideline) in daily life. This is caused by the fundamental properties of electromagnetic field, namely, reflection and additivity. The level of exposure is found to be much higher than estimated by conventional framework of analysis that assumes that the level*

rapidly decreases with the inverse square distance between the source and the affected person."

"Since the increase of electromagnetic field by reflective boundaries and the additivity of sources has not been recognized yet, further detailed studies on various situations and the development of appropriate regulations are required."

Hondou et al (2006) establishes that power densities 1000 times to 2000 times higher than the power density predictions from computer modeling (that does not account properly for reflections) can be found in daily living situations. Power density may not fall off with distance as predicted by formulas using limited reflection factors. The RF hot spots created by reflection can significantly increase RF exposures to the public, even above current public safety limits.

"We confirm the significance of microwave reflection reported in our previous Letter by experimental and numerical studies. Furthermore, we show that 'hot spots' often emerge in reflective areas, where the local exposure level is much higher than average."

"Our results indicate the risk of 'passive exposure' to microwaves."

“The experimental values of intensity are consistently higher than predicted values. Intensity does not even decrease with distance from the source."

*"We further confirm the existence of microwave 'hotspots', in which he microwaves are 'localized'. The intensity measured at one hot spot 4.6 m from the transmitter is the same as that at 0.1 m from the transmitter in the case with out reflection (free boundary condition). Namely, the intensity at the hot spot is increased by **approximately 2000 times** by reflection."* Emphasis added

"To confirm our experimental findings of the greater-than-predicted intensity due to reflection, as well as the hot spots, we performed two numerical simulations...". " intensity does not monotonically decrease from the transmitter, which is in clear contrast to the case without reflection."

"The intensity at the hot spot (X, Y, Z) = 1.46, -0.78, 105) around 1.8 m from the transmitter in the reflective boundary condition is ***approximately 1000 times higher*** *than that at the same position in the free boundary condition. The result of the simulation is thus consistent with our experiments, although the values differ owing to the different conditions imposed by computational limits."*

Emphasis added

"(t)he result of the experiment is also reproduced: a greater than predicted intensity due to reflection, as well as the existence of hot spots."

"In comparison with the control simulation using the free boundary condition, we find that the power density at the hot spot is increased ***by approximately a thousand times*** *by reflection."*

Emphasis added

Further, the author comments that:

"*we may be passively exposed beyond the levels reported for electro-medical interference and health risks."*

"Because the peak exposure level is crucial in considering electro-medical interference, interference (in) airplanes, and biological effects on human beings, we also need to consider the possible peak exposure level, or 'hot spots', for the worst-case estimation."

Reflections and re-radiation from common building material (tile, concrete, stainless steel, glass, ceramics) and highly reflective appliances and furnishings are common in kitchens, for example. Using only low reflectivity FCC equations 6 and 10 may not be informative. Published studies underscore how use of even the highest reflection coefficient in FCC OET Bulletin 65 Equations 6 and 10 likely underestimate the potential for reflection and hot spots in some situations in real-life situations.

This report includes the FCC's reflection factors of 60% and 100%, and also reflection factors of 1000% and 2000% that are more in line with those reported in Hondou, 2001; Hondou, 2006 and Vermeeren et al, 2010. The use of a 1000% reflection factor in this report is still conservative in comparison to Hondou, 2006. A 1000% reflection factor is 12% of Hondou's larger power density prediction (or 121 times, rather than 1000 times)/ The 2000% reflection factor is 22% of Hondou's figure (or 441 times in comparison to 2000 times higher power density in Hondou, 2006).

Peak Power Limits

In addition to time-averaged public safety limits that require RF exposures to be time-averaged over a 30 minute time period, the FCC also addresses peak power exposures. The FCC refers back to the ANSI/IEEE C95.1-1992 standard to define what peak power limits are.

The ANSI/IEEE C95.1-1999 standard defines peak power density as "*the maximum instantaneous power density occurring when power is transmitted*." (p. 4) Thus, there is a second method to test FCC compliance that is not being assessed in any FCC Grants of Authorization.

> "*Note that although the FCC did not explicitly adopt limits for peak power density, guidance on these types of exposures can be found in Section 4.4 of the ANSI/IEEE C95.1-1992 standard.*"
>
> *Page 10, OET 65*

The ANSI/IEEE limit for peak power to which the FCC refers is:

> *"For exposures in uncontrolled environments, the peak value of the mean squared field strengths should not exceed 20 times the square of the allowed spatially averaged values (Table 2) at frequencies below 300 MHz, or <u>the equivalent power density of 4 mW/cm2 for f between 300 MHz and 6 GHz</u>".*

The peak power exposure limit is 4000 uW/cm2 for all smart meter frequencies (all transmitting antennas) for any instantaneous RF exposure of 4 milliwatts/cm2 (4 mW/cm2) or higher which equals 4000 microwatts/cm2 (uW/cm2).

This peak power limit applies to all smart meter frequencies for both the smart meter (two-antenna configuration) and the collector meter (three-antenna configuration). All these antennas are within the 300 MHz to 6 GHz frequency range where the 4000 uW/cm2 peak power limit applies (Table 3, ANSI/IEEE C95.1-1999, page 15).

Smart meters emit frequencies within the 800 MHz to 2400 MHz range.

Exclusions

This peak power limit applies to all parts of the body with the important exception of the eyes and testes.

The ANSI/IEEE C95.1-1999 standard specifically excludes exposure of the eyes and testes from the peak power limit of 4000 uW/cm2*. However, nowhere in the ANSI/IEEE nor the FCC OET 65 documents is there a lower, more protective peak power limit given for the eyes and testes (see also Appendix C).

> *"The following relaxation of power density limits is allowed for exposure of all parts of the body <u>except the eyes and testes</u>." (p.15)*
>
> *"Since most exposures are not to uniform fields, a method has been derived, based on the demonstrated peak to whole-body averaged SAR ratio of 20, for equating nonuniform field exposure and partial body exposure to an equivalent uniform field exposure. This is used in this standard to allow relaxation of power density limits for partial body exposure<u>, except in the case of the eyes and the testes</u>." (p.20)*

"In the case of the eyes and testes, direct relaxation of power density limits is not permitted."(p. 30)

*Note: This leaves unanswered what instantaneous peak power is permissible from smart meters. The level must be below 4000 uW/cm2. This report shows clearly that smart meters can create instantaneous peak power exposures where the face (eyes) and body (testes) are going to be in close proximity to smart meter RF pulses. RF levels at and above 4000 uW/cm2 are likely to occur if a person puts their face close to the smart meter to read data in real time. The digital readout of the smart meter requires close inspection, particularly where there is glare or bright sunlight, or low lighting conditions. Further, some smart meters are installed inside buildings within inches of occupied space, virtually guaranteeing exposures that may violate peak power limits. Violations of peak power limits are likely in these circumstances where there is proximity within about 6" and highly reflective surfaces or metallic objects. The eyes and testes are not adequately protected by the 4000 uW/cm2 peak power limit, and in the cases described above, may be more vulnerable to damage (Appendix C for further discussion).

METHODOLOGY

Radiofrequency fields associated with SMART Meters were calculated following the methodology described here. Prediction methods specified in Federal Communications Commission, Office of Engineering and Technology Bulletin 65 Edition 97-01, August 1997 were used in the calculations.[1]

Section 2 of FCC OET 65 provides methods to determine whether a given facility would be in compliance with guidelines for human exposure to RF radiation. We used equation (3)

$$S = \frac{P \times G \times \partial}{4 \times \pi \times R^2} = \frac{EIRP \times \partial}{4 \times \pi \times R^2} = \frac{1.64 \times ERP \times \partial}{4 \times \pi \times R^2}$$

where:

S = power density (in µW/cm^2)
P = power input to the antenna (in W)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
∂ = duty cycle of the transmitter (percentage of time that the transmitter actually transmits over time)
R = distance to the center of radiation of the antenna
EIRP = PG
ERP = 1.64 EIRP

where:

EIRP = is equivalent (or effective) isotropically radiated power referenced to an isotropic radiator
ERP = is equivalent (or effective) radiated power referenced to a half-wave dipole radiator

Analysis input assumptions

1. SMART Meters [SK9AMI-4] have two RF transmitters (antennas) and are the type of smart meters typically installed on most buildings. They contain two antennas that transmit RF signals (916 MHz LAN and 2405 MHz Zigbee). The antennas CAN transmit simultaneously, and thus the maximum RF exposure is determined by the summation of power densities (from the FCC Certification Exhibit titled RF Exposure Report for FCC ID: SK9AMI-4).

   Model SK9AMI-4 transmits on 915 MHz is designated as LAN Antenna Gain for each model.

   a. Transmitter Power Output (TPO) used is as shown on the grant issued by the Telecommunications Certification Body (TCB).

   b. Antenna gain in dBi (decibels compared to an isotropic radiator) used comes from the ACS Certification Exhibit.

2. Collector Meters [SK9AMI-2A] have three RF transmitters (antennas) and are installed where the utility needs them to relay RF signals from surrounding smart meters in a neighborhood. Collector meters contain a third antenna (GSM 850 MHz, 915 MHz LAN and 2405 MHz Zigbee). Collector meters can be placed on any building where a collector meter is needed to relay signals from the surrounding area. Estimates of the number of collector meters varies between one per 500 to one per 5000 smart meters. Collector meters will thus ‘piggyback’ the RF signals of hundreds or thousands of smart meters through the one collector meter. In a collector meter, only two of the three antennas can transmit simultaneously (the 915 MHz LAN and the GSM 850 MHz (from the FCC Certification Exhibit titled RF Exposure Report for FCC ID: SK9AMI-2A).

3. The Cell Relay transmitting at 2480 MHz is not on most meters and not considered in this analysis.

    a. Transmitter Power Output (TPO) used is as shown on the grant issued by the Telecommunications Certification Body (TCB).
    b. Antenna gain in dBi (decibels compared to an isotropic radiator) used comes from the ACS Certification Exhibit.

ERP (Effective Radiated Power) used in the computer modeling here is calculated using the TPO and antenna gain established for each model

Red figures used to Calculate ERP		ACS and TCB Certification data sheet							
		SK9AMI-2A				SK9AMI-4			
		ACS			TCB	ACS			TCB
Radio	Frequency	dBm	Watts	dBi	Watts	dBm	Watts	dBi	Watts
GSM	850	31.8	1.5136	-1.0					
LAN	915	21.92	0.1556	3.0		24.27	0.2673	**2.2**	**0.267**
LAN	916								0.257
GSM	1900	28.7	0.7413	1.0					
Register	2405	18.71	0.0743	**1.0**	**0.074**	19.17	0.0826	4.4	
Cell Relay	2480	-14.00	0.00004	4.00					

Assumptions: TPO per TCB , Antenna Gain per ACS Certification

ERP Calculation: **Bold** figures are used for single meter ERP in modeling							
Type	TPO	dBi	dB	Mult	ERP	Freq	
1900 GSM	0.741	1.0	-1.15	0.77	0.5689	1900	
850 GSM	1.514	-1.0	-3.15	0.48	0.7328	850	Model
RFLAN	0.267	2.2	0.05	1.01	**0.2704**	915	SK9AMI-4
ZIG BEE	0.074	1.0	-1.15	0.77	**0.0570**	2405	SK9AMI-2A

Reflection Factor

This equation is modified with the inclusion of a ground reflection factor as recommended by the FCC. The ground reflection factor accounts for possible ground reflections that could enhance the resultant power density. A 60% (0.6) enhancement would result in a 1.6 (1 + 0.6) increase of the field strength or a $2.56 = (1.6)^2$ increase in the power density. Similar increases for larger enhancements of the field strength are calculated by the square of the original field plus the enhancement percentage. [2,3,4]

Reflection Factors:

$60\% = (1 + 0.6)^2 = 2.56$ times
$100\% = (1 + 1)^2 = 4$ times
$1000\% = (1 + 10)^2 = 121$ times
$2000\% = (1 + 20)^2 = 441$ times

Duty Cycle

How frequently SMART Meters can and will emit RF signals from each of the antennas within the meters is uncertain, and subject to wide variations in estimation. For this reason, and because FCC OET 65 mandates a 100% duty cycle (continuous exposure where the public cannot be excluded) the report gives RF predictions for all cases from 1% to 100% duty cycle at 10% intervals. The reader can see the variation in RF emissions predicted at various distances from the meter (or bank of meters) using this report at all duty cycles. Thus, for purposes of this report, duty cycles have been estimated from infrequent to continuous. Duty cycles for SMART Meters were calculated at:

Duty cycle ∂:

1%	50%
5%	60%
10%	70%
20%	80%
30%	90%
40%	100%

Continuous Exposure

FCC Bulletin OET 65 and the ANSI/IEEE C95.1-1992, 1999 requires that continuous exposure be calculated for situations where there is uncontrolled public access. Continuous exposure in this case means reading the tables at 100% duty cycle.

> *"Another feature of the exposure guidelines is that exposures, in terms of power density, E2 or H2, may be averaged over certain periods of time with the average not to exceed the limit for continuous exposure.*[11]

> *"As shown in Table 1 of Appendix A, the averaging time for occupational/controlled exposures is 6 minutes, while the averaging time for general population/uncontrolled exposures is 30 minutes. It is important to note that for general population/uncontrolled exposures it is often not possible to control exposures to the extent that averaging times can be applied. In those situations, it is often necessary to assume continuous exposure*." (FCC OET 65, Page 15)

Calculation Distances in Tables (3-inch increments)

Calculations were performed in 3-inch (.25 foot) increments from the antenna center of radiation. Calculations have been taken out to a distance of 96 feet from the antenna center for radiation for each of the conditions above. The antenna used for the various links in a SMART Meter is assumed to be at the center of the SMART Meter from front to back – approximately 3 inches from the outer surface of the meter.

Calculations have also been made for a typical nursery and kitchen. In the nursery it has been assumed that the baby in his or her crib that is located next to the wall where the electric SMART Meters are mounted. The closest part of the baby's body can be as close as 11 inches* from the meter antenna. In the kitchen it has been assumed that a person is standing at the counter along the wall where the electric SMART Meters are mounted. In that case the closest part of the adult's body can be located as close to the meter antenna as 28 inches.

The exposure limits are variable according to the frequency (in megahertz). Table 1, Appendix A show exposure limits for occupational (Part A) and uncontrolled public (Part B) access to radiofrequency radiation such as is emitted from AM, FM, television and wireless sources.

* Flush-mounted main electric panels that house smart meters are commonly installed; placing smart meters 5” 6” closer to occupied space than box-mounted main electric panels that sit outward on exterior building walls. Assumptions on spacing are made for flush-mounted panels.

Conditions Influencing Radiofrequency Radiation Level Safety

The location of the meter in relation to occupied space, or outside areas of private property such as driveways, walk-ways, gardens, patios, outdoor play areas for children, pet shelters and runs, and many typical configurations can place people in very close proximity to smart meter wireless emissions. In many instances, smart meters may be within inches or a few feet of occupied space or space that is used by occupants for daily activities.

Factors that influence how high RF exposures may be include, but are not limited to where the meter is installed in relation to occupied space, how often the meters are emitting RF pulses (duty cycle), and what reflective surfaces may be present that can greatly intensify RF levels or create 'RF hot spots' within rooms, and so on. In addition, there may be multiple wireless meters installed on some multi-family residential buildings, so that a single unit could have 20 or more electric meters in close proximity to each other, and to occupants inside that unit. Finally, some meters will have higher RF emissions, because – as collector units – their purpose is to collect and resend the RF signals from many other meters to the utility. A collector meter is estimated to be required for every 500 to 5000 buildings. Each collector meter contains three, rather than two transmitting antennas. This means higher RF levels will occur on and inside buildings with a collector meter, and significantly more frequent RF transmissions can be expected. At present, there is no way to predict whose property will be used for installation of collector meters.

People who are visually reading the wireless meters 'by sight' or are visually inspecting and/or reading the digital information on the faceplate may have their eyes and faces only inches from the antennas.

Current standards for peak power limit do not have limits to protect the eyes and testes from instantaneous peak power from smart meter exposures, yet relevant documents identify how much more vulnerable these organs are, and the need for such safety limits to protect the eyes and testes.

No Baseline RF Assessment

Smart meter and collector meter installation are taking place in an information vacuum. FCC compliance testing takes place in an environment free of other sources of RF, quite unlike typical urban and some rural environments. There is no assessment of baseline RF conditions already present (from AM, FM, television and wireless communication facilities (cell towers), emergency and dispatch wireless, ham radio and other involuntary RF sources. Countless properties already have elevated RF exposures from sources outside their own control.

Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

Consumers, for whatever personal reason, choice or necessity who have already eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from smart meters. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the structure, and how it is furnished.

RESULTS, FINDINGS AND CONCLUSIONS

The installation of wireless 'smart meters' in California can produce significantly high levels of radiofrequency radiation (RF) depending on many factors (location of meter(s) in relation to occupied or usable space, duty cycle or frequency of RF transmissions, reflection and re-radiation of RF, multiple meters at one location, collector meters, etc).

Power transmitters that will relay information from appliances inside buildings with wireless smart meters produce high, localized RF pulses. Any appliance that contains a power transmitter (for example, dishwashers, washers, dryers, ranges and ovens, convection ovens, microwave ovens, flash water heaters, refrigerators, etc) will create another 'layer of RF signals' that may cumulatively increase RF exposures from the smart meter(s).

It should be emphasized that no single assertion of compliance can adequately cover the vast number of site-specific conditions in which smart meters are installed. These site-specific conditions determine public exposures and thus whether they meet FCC compliance criteria.

Tables in this report show either distance to an FCC safety limit (in inches) or they show the predicted (calculated) RF level at various distances in microwatts per centimeter squared (uW/cm2).

Both depictions are useful to document and understand RF levels produced by smart meters (or multiple smart meters) and by collector meters (or collections of one collector and multiple smart meters).

Large differences in the results of computer modeling occur in this report by bracketing the uncertainties (running a sufficient number of computer scenarios) to account for variability introduced by possible duty cycles and possible reflection factors.

FCC equations from FCC OET 65 provide for calculations that incorporate 60% or 100% reflection factors. Studies cited in this report document higher possible reflections (in highly reflective environments) and support the inclusion of higher reflection factors of 1000% and 2000% based on Vermeeren et al, 2010, Hondou et al, 2006 and Hondou, 2002. Tables in the report provide the range of results predicted by computer modeling for duty cycles from 1% to 100%, and reflection factors of 60%, 100%, 1000%, and 2000% for comparison purposes. FCC violations of time-weighted average calculations and peak power limit calculations come directly from FCC OET 65 and from ANSI/IEEE c95.1-1992, 1999. Duty cycle (or how frequently the meters will produce RF transmissions leading to elevated RF exposures) is uncertain, so the full range of possible duty cycles are included, based on best available information at this date.

- Tables 1-2 show radiofrequency radiation (RF) levels at 6” (to represent a possible face exposure). These are data tables.
- Tables 3-4 show RF levels at 11” (to represent a possible nursery/bedroom exposure). These are data tables.
- Tables 5-6 show RF levels at 28” to represent a possible kitchen work space exposure. These are data tables.
- Tables 7-9 show the distance to the FCC violation level for time-weighted average limits and for peak power limits (in inches). These are data tables.
- Tables 10-15 show where FCC violations may occur at the face, in the nursery or in the kitchen scenarios. These are colored tables

highlighting where FCC violations may occur under all scenarios.

- Tables 16-29 show comparisons of smart meter RF levels with studies that report adverse health impacts from low-intensity, chronic exposure to similar RF exposures. These are colored tables highlighting where smart meter RF levels exceed levels associated with adverse health impacts in published scientific studies.
- Tables 30-31 show RF levels in comparison to Medtronics advisory limit for MRI exposures to radiofrequency radiation at 0.1 W/Kg or about 250 uW/cm2. These are colored tables highlighting where smart meter RF levels may exceed those recommended for RF exposure.
- Tables 32-33 show RF levels from smart meters in comparison to the BioInitiative Report recommendation of 0.1 uW/cm2 for chronic exposure to pulsed radiofrequency radiation.

Findings

RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits (Tables 1 - 14).

Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are illustrated in this Report, based on computer modeling (Tables 10 – 17).

Tables that present data, possible conditions of violation of the FCC public safety limits, and comparisons to health studies reporting adverse health impacts are summarized (Tables 18 – 33).

Where do predicted FCC violations occur for the 655 uW/cm2 time-averaged public safety limit at the face at 6” distance from the meter?

Table 10 shows that for one smart meter, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle, but violations are predicted to occur with nearly all scenarios using either 1000% or 2000% reflection factors.

Table 10 also shows that for multiple smart meters, FCC violations are predicted to occur at 60% reflection factor @ 50% to 100% duty cycles; and also at 100% reflection factor @ 30% to 100% duty cycle. All scenarios using either 1000% or 2000% reflection factors indicate FCC violations can occur (or conservatively at 12% to 22% of those in Hondou et al, 2006).

Table 11 shows that for one collector meter, one violation occurs at 60% @ 100% duty cycle; and at 100% reflection factor for duty cycles between 60% and 100%. Violations are predicted to occur at all scenarios using either 1000% or 2000% reflection factors.

Table 11 also shows that for one collector meter plus multiple smart meters, FCC violations can occur at 60%reflection factor @ 40% to 100% duty cycles; and also at 100% reflection factor @ 30% to 100% duty cycle. All scenarios using either 1000% or 2000% reflection factors indicate FCC violations can occur.

Where do predicted FCC violations occur for the 655 uW/cm2 time-averaged public safety limit in the nursery crib at 11" distance?

Table 12 shows that for one smart meter, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle, but violations would be predicted with nearly all scenarios using either 1000% or 2000% reflection factors.

Table 12 also shows that for multiple smart meters, no FCC violations are predicted to occur at 60% reflection factor at any duty cycle; and also at 100% reflection factor @ 90% and 100% duty cycle. All scenarios using either 1000% or 2000% reflection factors indicate FCC violations can occur.

Table 13 shows that for one collector meter, one violation occurs at 100% reflection @100% duty cycle. No violations at 60% reflection are predicted. Violations are predicted to occur at all scenarios using 1000% reflection except @ 1% duty cycle. All 2000% reflection scenarios indicate FCC violations can occur.

Table 13 shows that for one collector meter plus multiple smart meters, FCC violations are not predicted to occur at 60% reflection factor. At 100% reflection factor, violations are predicted at 60% to100% duty cycles. FCC violations are predicted for all1000% and 2000% reflection factors with the exception of 1000% reflection at 1% duty cycle.

Where do predicted FCC violations occur for the 655 uW/cm2 time-averaged public safety limit in the kitchen work space at 28" distance?

Table 14 shows that for one smart meter, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle. Violations would be predicted with scenarios of 1000% reflection @ 70% to 100% duty cycles and at 2000% reflection factor @ 20% to 100% duty cycles.

Table 14 also shows that for multiple smart meters, no FCC violations are predicted to occur at 60% or at the 100% reflection factors at any duty cycle. Violations are predicted at 1000% reflection factor @ 70% to 100% duty cycles and at 2000% reflection factor @20% to 100% duty cycles.

Table 15 shows that for one collector meter, one violation occurs at 100% reflection @100% duty cycle. No violations at 60% reflection are predicted. Violations are predicted to occur at all scenarios using 1000% reflection except @ 1% duty cycle. All 2000% reflection scenarios indicate FCC violations can occur.

Table 15 shows that for one collector meter plus multiple smart meters, FCC violations are not predicted to occur at 60% or at 100% reflection factors at any duty cycle. At 1000% reflection factor, violations are predicted at 30% to 100% duty cycles. FCC violations are also predicted at 2000% reflection factor @10 to 100% duty cycles.

Where can peak power limits be violated? The peak power limit of 4000 uW/cm2 instantaneous public safety limit at 3" distance? This limit may be exceeded wherever smart meters and collector meters (face plate or any portion within 3" of the internal antennas can be accessed directly by the public.

Table 16 shows that for one smart meter, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle. Peak power limit violations would be predicted with scenarios of 1000% reflection @ 10% to

100% duty cycles and at 2000% reflection factor @ 10% to 100% duty cycles.

Table 16 also shows that for multiple smart meters, peak power limit violations are predicted to occur at 60% reflection @ 60% to 100% duty cycle and for 100% reflection @ 40% to 100% duty cycles. Violations are predicted at 1000% reflection factor @ 10% to 100% duty cycles and at 2000% reflection factor @1% to 100% duty cycles.

Table 17 shows that for one collector meter, peak power limit violations are predicted to occur at 60% reflection @80% to 100% duty cycles and at 100% reflection @ 50% to 100% duty cycles. Violations of peak power limit are predicted to occur at all scenarios using 1000% reflection except @ 1%; and for 2000% reflection violations of peak power limit are predicted at all duty cycles.

Table 17 shows that for one collector meter plus multiple smart meters, peak power limit violations are predicted to occur at 60% @ 40% to 100% and 100% reflection @ 30% to 100% duty cycles. At 1000% and 2000% reflection factors, peak power limit violations are predicted at all duty cycles.

Where are RF levels associated with inhibition of DNA repair in human stem cells at 92.5 uW/cm2 exceeded the in the nursery crib at 11" distance?

Table 18 shows that for one smart meter, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 70% to 100% duty cycles, and at 100% reflection factor @ 50% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposures except 1000% at 1% duty cycle.

Table 18 also shows that for multiple smart meters, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposure levels except 1000% at 1% duty cycle.

Table 19 shows that for <u>one collector meter</u>, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 30% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposure levels.

Table 19 shows that for <u>one collector meter plus multiple smart meters</u>, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 10% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposure levels. *Where are RF levels associated with pathological leakage of the blood-brain barrier at 0.4 – 8 uW/cm2 exceeded the in the nursery crib at 11" distance?*

Table 20 shows that for <u>one smart meter</u>, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 10% to 100% duty cycles, and at 100% reflection factor @ 5% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 20 also shows that for <u>multiple smart meters</u>, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 5% to 100% duty cycles, and at 100% reflection factor @ 5% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 21 shows that for <u>one collector meter</u>, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 5% to 100% duty cycles, and at 100% reflection factor @ 5% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 21 shows that for <u>one collector meter plus multiple smart meters, </u>.RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 5% to 100% duty cycles, and at 100% reflection factor @ 1% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Where are RF levels associated with adverse neurological symptoms, cardiac problems and increased cancer risk exceeded in the nursery crib at 11" distance?

Table 22 shows that for <u>one smart meter</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 22 shows that for <u>multiple smart meters</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 23 shows that for<u> one collector meter</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 23 shows that for<u> one collector meter plus multiple smart meterss</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Where are RF levels associated with inhibition of DNA repair in human stem cells at 92.5 uW/cm2 exceeded the in the kitchen work space at 28" distance?

Table 24 shows that for <u>one smart meter</u>, RF levels do not exceed those associated with inhibition of DNA repair at 60% or 100% reflection factor at any duty cycle. RF levels are exceeded at 1000% @ 10% to 100% duty cycles; and at 2000% reflection factor @ 5% to 100% duty cycles.

Table 24 also shows that for <u>multiple smart meters</u>, RF levels do not exceed those associated with inhibition of DNA repair at 60% or 100% reflection factor at any duty cycle. RF levels are exceeded at 1000% @ 5% to 100% duty cycles; and at 2000% reflection factor @ 1% to 100% duty cycles.

Table 25 shows that for <u>one collector meter</u>, RF levels do not exceed those associated with inhibition of DNA repair at 60% at any duty cycle; at 100% reflection factor they are exceeded at 70% to 100% duty cycles.. RF levels are exceeded at 1000% @ 5% to 100% duty cycles; and at 2000% reflection factor @ 1% to 100% duty cycles.

Table 25 shows that for one collector meter plus multiple smart meters, RF levels exceed those associated with inhibition of DNA repair at 60% reflection@100% duty cycle; at 100% reflection factor they are exceeded at 70% to 100% duty cycles.. RF levels are exceeded at 1000% @ 5% to 100% duty cycles; and at 2000% reflection factor @ 1% to 100% duty cycles.

Where are RF levels associated with pathological leakage of the blood-brain barrier and neuron death at 0.4 – 8 uW/cm2 risk in the kitchen work space at 28" distance?

Table 26 shows that for one smart meter, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 40% to 100% duty cycles, and at 100% reflection factor @ 30% to 100% duty cycles, and at all 1000% and 2000% reflections. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen work space except at 1% duty cycle for 60% and 100% reflections.

Table 26 also shows that for multiple smart meters, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 30% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles, and at all 1000% and 2000% reflections. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen.

Table 27 shows that for one collector meter, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 10% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 27 shows that for one collector meter plus multiple smart meters, .RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Where are RF levels associated with adverse neurological symptoms, cardiac problems and increased cancer risk in the kitchen work space at 28" distance?

Table 28 shows that for one smart meter, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 28 shows that for multiple smart meters, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 29 shows that for one collector meter, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 29 shows that for one collector meter plus multiple smart meterss, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Where do RF levels exceed the Medtronics Safety Advisory?

Table 30: At no duty cycles for either 60% or 100% reflection factors; between 10% and 100% duty factors for 1000% and between 5% and 100% duty factors for 2000% reflection (for one smart meter).

Table 30: At 60% reflection @ 60% to 100% duty cycle; and at 100% reflection @ 40% to 100% duty cycle; at 1000% reflection @ 5% to 100% duty cycle and for all duty cycles at 2000% reflection (for multiple smart meters).

Table 31: At 60% reflection @ 70% to 100% duty cycle; at 100% reflection at 50% to 100% duty cycles; at 1000% reflection @ 5% to 100% and at all duty cycles for 2000% reflection (for one collector meter).

Table 31: At 60% reflection @ 40% to 100% duty cycle; at 100% reflection at 30% to 100% duty cycles; and at all duty cycles for both 1000% reflection and for 2000% reflection (for one collector meter plus three smart meters).

Where are RF levels associated with smart meters in all their configurations (one meter, multiple smart meters, one collector meter, one collector plus multiple smart meters) above those recommended in the BioInitiative Report (2007)?

Tables 32 and 33 depict the distance from the center of radiation for the smart meter(s) and collector meter scenarios in feet. The distances (in feet) at which RF levels exceed the BioInitiative Report recommended limit of 0.1 uW/cm2 is as small as 3.4' (one smart meter at 60% reflection and 1% duty cycle). At 60% reflection and 100% duty cycle, the distance to the BioInitiative recommended limit increases to 34 feet for one smart meter.

When multiples of smart meters are considered, the shortest distance to where the BioInitiative Report recommended limit is exceeded is 9.7 feet (for 60% reflection @ 1% duty cycle). It increases to 97' @100% duty cycle for multiple smart meters.

For a single collector meter, the shortest distance to a BioInitiative Report exceedence is 5.9 feet (60% reflection @ 1% duty cycle). At 60% reflection and 100% duty cycle, it increases to 59 feet.

For a collector and multiple smart meters, the shortest distance is 10.9 feet at 60% reflection @ 1% duty cycle, and increases to108 feet at 100% duty cycle.

Conclusions

FCC compliance violations are likely to occur under widespread conditions of installation and operation of smart meters and collector meters in California. Violations of FCC safety limits for uncontrolled public access are identified at distances within 6" of the meter. Exposure to the face is possible at this distance, in violation of the time-weighted average safety limits (Tables 10-11). FCC violations are predicted to occur at 60% reflection and 100% reflection factors*, both used in FCC OET 65 formulas for such calculations for time-weighted average limits. Peak power limits are not violated at the 6" distance (looking at the meter) but can be at 3" from the meter, if it is touched.

This report has also assessed the potential for FCC violations based on two examples of RF exposures in a typical residence. RF levels have been calculated at distances of 11" (to represent a nursery or bedroom with a crib or bed against a wall opposite one or more meters); and at 28" (to represent a kitchen work space with one or more meters installed on the kitchen wall).

FCC compliance violations are identified at 11" in a nursery or bedroom setting using Equation 10* of the FCC OET 65 regulations (Tables 12-13). These violations are predicted to occur where there are multiple smart meters, or one collector meter, or one collector meter mounted together with several smart meters.

FCC compliance violations are not predicted at 28" in the kitchen work space for 60% or for 100% reflection calculations. Violations of FCC public safety limits are predicted for higher reflection factors of 1000% and 2000%, which are not a part of FCC OET 65 formulas, but are included here to allow for situations where site-specific conditions (highly reflective environments, for example, galley-type kitchens with many highly reflective stainless steel or other metallic surfaces) may be warranted (see Methodology Section).

In addition to exceeding FCC public safety limits under some conditions of installation and operation, smart meters can produce excessively elevated RF exposures, depending on where they are installed.   With respect to absolute RF exposure levels predicted for occupied space within dwellings, or outside areas like patios, gardens and walk-ways, RF levels are predicted to be substantially elevated within a few feet to within a few tens of feet from the meter(s).

For example, one smart meter at 11" from occupied space produces somewhere between 1.4 and 140 microwatts per centimeter squared (uW/cm2) depending on the duty cycle modeled (Table 12). Since FCC OET 65 specifies that continuous exposure be assumed where the public cannot be excluded (such as is applicable to one's home), this calculation produces an RF level of 140 uW/cm2 at 11" using the FCCs lowest reflection factor of 60%. Using the FCC's reflection factor of 100%, the figures rise to 2.2 uW/cm2 – 218 uW/cm2, where the continuous exposure calculation is 218 uW/cm2 (Table 12). These are very significantly elevated RF exposures in comparison to typical individual exposures in daily life. Multiple smart meters in the nursery/bedroom example at 11" are predicted to generate RF levels from about 5 to 481 uW/cm2 at the lowest (60%) reflection factor; and 7.5 to 751 uW/cm2 using the FCCs 100% reflection factor (Table 13). Such levels are far above typical public exposures.

RF levels at 28" in the kitchen work space are also predicted to be significantly elevated with one or more smart meters (or a collector meter alone or in combination with multiple smart meters). At 28" distance, RF levels are predicted in the kitchen example to be as high as 21 uW/cm2 from a single meter and as high as 54.5 uW/cm2 with multiple smart meters using the lower of the FCCs reflection factor of 60% (Table 14).

Using the FCCs higher reflection factor of 100%, the RF levels are predicted to be as high as 33.8 uW/cm2 for a single meter and as high as 85.8 uW/cm2 for multiple smart meters (Table 14). For a single collector meter, the range is 60.9 to 95.2 uW/cm2 (at 60% and 100% reflection factors, respectively) (from Table 15).

Table 16 illustrates predicted violations of peak power limit (4000 uW/cm2) at 3" from the surface of a meter. FCC violations of peak power limit are predicted to occur for a single collector meter at both 60% and 100% reflection factors. This situation might occur if someone touches a smart meter or stands directly in front.

Uncertainty About Actual RF Levels

Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

Consumers, for whatever personal reason, choice or necessity who have already eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from smart meters. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the structure, and how it is furnished.

People who are afforded special protection under the federal Americans with Disabilities Act are not sufficiently acknowledged nor protected. People who have medical and/or metal implants or other conditions rendering them vulnerable to health risks at lower levels than FCC RF limits may be particularly at risk (Tables 30-31). This is also likely to hold true for other subgroups, like children and people who are ill or taking medications, or are elderly, for they have different reactions to pulsed RF. Childrens' tissues absorb RF differently and can absorb more RF than adults (Christ et al, 2010; Wiart et al, 2008). The elderly and those on some medications respond more acutely to some RF exposures.

Eyes and Testes - Safety standards for peak exposure limits to radiofrequency have not been developed to take into account the particular sensitivity of the eyes, testes and other ball shaped organs. There are no peak power limits defined for the eyes and testes, and it is not unreasonable to imagine situations where either of these organs comes into close contact with smart meters and/or collector meters, particularly where they are installed in multiples (on walls of multi-family dwellings that are accessible as common areas).

What can be determined from the relevant standards (FCC and ANSI/IEEE and certain IEEE committee documents is that the eye and testes are potentially much more vulnerable to damage, but that there is no scientific basis on which to develop a new, more protective safety limit. What is certain is that the peak power limit of 4000 uW/cm2 exceeds what is safe (Appendix C).

In summary, no positive assertion of safety can be made by the FCC, nor relied upon by the CPUC, with respect to pulsed RF when exposures are chronic and occur in the general population. Indiscriminate exposure to environmentally ubiquitous pulsed RF from the rollout of millions of new RF sources (smart meters) will mean far greater general population exposures, and potential health consequences. Uncertainties about the existing RF environment (how much RF exposure already exists), what kind of interior reflective environments exist (reflection factor), how interior space is utilized near walls), and other characteristics of residents (age, medical condition, medical implants, relative health, reliance on critical care equipment that may be subject to electronic interference, etc) and unrestrained access to areas of property where meter is located all argue for caution.

Electronic Interference

Consumers may experience electronic interference (electromagnetic interference or EMI) from smart meter wireless signals. The FCC also is charged with investigating consumer complaints about electronic interference.

> *"The FCC requires that unlicensed low-power RF devices must not create interference and users of such equipment must resolve any interference problems or cease operation. According to the FCC (47CFR Part 15): "The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected."*
>
> (EPRI, 2010)

Medical and other critical care equipment in the home environment may not work, or work properly due to electronic interference from smart meters.

Security systems, surveillance monitors and wireless intercoms may be rendered inoperable or unreliable. Some cordless telephones do not work reliably, or have substantial interference from smart meter RF emissions.

Electronic equipment and electrical appliances may be damaged or have to be replaced with other, newer equipment in order not to be subject to electromagnetic interference from smart meter RF bursts.

Americans With Disabilities Act

People who have medical implants, particularly metal implants, may be more sensitive to spurious RF exposures for two reasons. Electromagnetic interference (EMI) with critical care medical equipment and medical implants is a potentially serious threat. Patients with deep-brain stimulators (Parkinson's disease patients) have reported adverse health effects due to RF from various environmental sources like security gates and RFID scanners. Patients with deep brain stimulators have reported the devices to be reprogramming or electrodes shut-down as a result of encounters with wireless RFID scanners. One manufacturer, Medtronics, has issued a warning for DBS implant patients to limit RF exposure to less than 0.1 W/Kg SAR (or sixteen times lower than for the general public) for MRI exposures.

The IEEE SC4 committee (2001) considered changes to existing ANSI/IEEE standards adopted in 1992 (C95.1-1992). They discussed vulnerable organs (eyes, testes) and metallic implants that can intensify localized RF exposures within the body and its tissues.

> *"Question 20: Are there specific tissues or points within the body that have particularly high susceptibilities to local heating due to thermal properties in the immediate vicinity of the tissue?"*

Committee minutes include the following discussion on metallic implants.

> "*Metallic implants are an interesting example of this question. There can be very localized high field concentrations around the tips of long metal structures, in the gaps of wire loops. Of course, these metal devices don't create energy, but can only redistribute it, so the effect is limited to some extent. Also the high thermal conductivity and specific heat capacity make them good thermal sinks for any localized heat sources generated around them."*

Since deep brain stimulators in Parkinson's patients involve metal implants that are essentially long metal structures with tips that interface with brain tissue and nerves within the brain and body, exposing such patients with implants to high levels of pulsed RF that can produce localized, high RF within the body is certainly inadvisable. It is clear the IEEE SC4 committee recognized the potential risk by to calling such implanted metallic devices good 'thermal sinks' for localized heating dissipation.

The FCC's Grants of Authorization and other certification procedures do not ensure adequate safety to safeguard people under Department of Justice protection under the Americans with Disabilities Act.

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Appendix A Tables A1- A 48

RADIOFREQUENCY RADIATION VERSUS DISTANCE

One Smart Meter

Table A1	60% Reflection	(1%-100% duty cycles in each table)
Table A2	100% Reflection	(1%-100% duty cycles in each table)
Table A3	1000% Reflection*	(1%-100% duty cycles in each table)
Table A4	2000% Reflection*	(1%-100% duty cycles in each table)

Multiple Smart Meters (Four)**

Table A5	60% Reflection	(1%-100% duty cycles in each table)
Table A6	100% Reflection	(1%-100% duty cycles in each table)
Table A7	1000% Reflection	(1%-100% duty cycles in each table)
Table A8	2000% Reflection	(1%-100% duty cycles in each table)

One Collector Meter

Table AA9	60% Reflection	(1%-100% duty cycles in each table)
Table A10	100% Reflection	(1%-100% duty cycles in each table)
Table A11	1000% Reflection	(1%-100% duty cycles in each table)
Table A12	2000% Reflection	(1%-100% duty cycles in each table)

One Collector Meter + 3 SM**

Table A13	60% Reflection	(1%-100% duty cycles in each table)
Table A14	100% Reflection	(1%-100% duty cycles in each table)
Table A15	1000% Reflection	(1%-100% duty cycles in each table)
Table A16	2000% Reflection	(1%-100% duty cycles in each table)

TABLES OF CRITICAL DISTANCES IN NURSERY (CRIB AT 11”) AND KITCHEN SINK (AT 28”) FROM SMART METER (A17-A48)

Table A17 Nursery Set –
Table A18 One Smart Meter – Critical Distance 11” to baby in crib
Table A19 60%, 100%, 1000%, 2000% duty cycle
Table A20 1% thru 90% duty cycle

Table A21 Nursery Set –
Table A22 Eight Smart Meters – Critical Distance 11” to baby in crib

Table A23 60%, 100%, 1000%, 2000% reflection
Table A24 1% thru 100% duty cycle

Table A25 Nursery Set –
Table A26 One Collector– Critical Distance 11” to baby in crib
Table A27 60%, 100%, 1000%, 2000% reflection
Table A28 1% thru 100% duty cycle

Table A29 Nursery Set –
Table A30 One Collector Meter + 7 SM– Critical Distance 11” to baby crib
Table A31 60%, 100%, 1000%, 2000% reflection
Table A32 1% thru 100% duty cycle

Table A33 Kitchen Set –
Table A34 One Smart Meter – Critical Distance 28” to kitchen sink person
Table A35 60%, 100%, 1000%, 2000% reflection
Table A36 1% thru 100% duty cycle

Table A37 Kitchen Set -
Table A38 Eight Smart Meters – Critical Distance 28” to kitchen sink person
Table A39 60%, 100%, 1000%, 2000% reflection
Table A40 1% thru 100% duty cycle

Table A41 Kitchen Set –
Table A42 One Collector – Critical Distance 28” to kitchen sink person
Table A43 60%, 100%, 1000%, 2000% reflection

Table A44 1% thru 100% duty cycl**e**

Table A45 Kitchen Set –
Table A46 One Collector + 7 SM – Critical Distance 28” to kitchen
Table A47 60%, 100%, 1000%, 2000% reflection
Table A48 1% thru 100% duty cycl**e**

Appendix B Tables 1 – 33 of Report

Data Tables, FCC Violation Tables, Health Comparisions

Appendix C

Other Sources of Information on sensitivity of the eyes and testes

In the most recent proposed revisions of RF safety standards, the IEEE SC4 committee (2001) deliberated at length over the problem of peak power limits and non-uniform RF exposure with respect to the eye and testes. The quotes below come from committee drafts submitted in response to questions from the committee moderator.

ANSI/IEEE standards adopted in 1992 (C95.1-1992) and 1999 revisions
June 2001 SC-4 Committee Minutes

These committee discussions are informative on the issue of particular organ sensitivity to RF, and unanswered questions and differences of opinion on the subject among members. They discussed vulnerable organs (eyes, testes) and metallic implants that can intensify localized RF exposures within the body and its tissues (see also discussion on metallic implants).

Question 20: Are there specific tissues or points within the body that have particularly high susceptibilities to local heating due to thermal properties in the immediate vicinity of the tissue?

Committee minutes include the following discussion on the particular sensitivities of 'ball shaped' organs including the eyes and testes.

"*Eye balls are commonly regarded as the critical organ*"

"In the range of a few GHz (gigahertz*), reasonances may occur in ball shaped eyes and testes. They are also electrically and thermally partly insulated from other tissues. Additionally these organs or some of their parts (lens) are thermally a little bit more vulnerable than other tissues."*

"(m)odeling has noted that rapid changes in dielectrics such as cerebral spinal fluid in the ventricles of the brain and surrounding brain tissue lead to high calculated SARs. Secondly, exposure of the eye to microwave

radiation can lead to increased temperature that is sufficient to damage tissues. The temperature rise will, of course, depend on the intensity of the irradiation, how well the energy is coupled into tissues, and how well the deposited energy is removed by normal mechanisms such as conduction and blood flow. Microwaves at the lower frequencies will be deposited deeper in the eye, while at higher frequencies they will be absorbed near the front surface of the eye. The eye does not efficiently remove heat deposited internally by microwave exposure. The main avenue of heat removal is conduction and blood flow through the retina and choroid. The lens has been thought to be the most vulnerable tissue since it has no blood flow. Other than conduction through the sclera and convection from the surface of the cornea, heat removal is poor compared to other body tissues. Because the lens is avasular it has been thought to be particularly sensitive to thermal effects of microwave exposure. These facts have led many investigators to postulate that the poor heat dissipation from within the eye of humans and other animals may lead to heat buildup and subsequent thermal damage."

"Eyes do not have good blood circulation and testes have lower than body temperature."

"These organs are not well-perfused, hence have been singled out for the exclusion."

"Are the above numbers valid for all parts of the body in all exposure conditions over the time averaging period of the exposure? They (the basic limits) were derived in the manner you describe in body reasonance conditions i.e. coherent exposure over the whole body length of a human. Could the limit values of SAR be increased for partial body exposure? Yes, but we do not have the data to make this decision. In the near field of a source, clearly the limit value will depend on frequency (depth of penetration), organ blood supply and tolerance of that organism to sustain a certain rate of temperature increase during the time averaging period and the environmental conditions. If you have to deal with possible pathologies of organs then matters become even more complicated, because you are dealing not only with heat physiology, but also with general pathology, whose books are much thicker than those on physiology.

Table 1
Radiofrequency Radiation Level at 6" at the Face in uW/cm2
(One Smart Meter, Four Meters)

One Meter	Table A1	Table A2	Table A3	Table A4
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	2.1 uW/cm2	3.3	99	361
10%	21	33	989	3606
20%	42	65	1979	7212
30%	63	98	2968	10818
40%	83	131	3958	14424
50%	105	164	4947	18030
60%	105	196	5936	21636
70%	147	229	6926	25241
80%	168	262	7915	28847
90%	188	294	8904	32453
100%***	209	327	9894	36059

Four** Meters	Table A5	Table A6	Table A7	Table A8
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
	15 uW/cm^2	24	712	2596
10%	151	236	7124	25963
20%	301	471	14247	51925
30%	452	707	21371	77888
40%	603	942	28494	103850
50%	754	1177	35618	129813
60%	904	1413	42741	155775
70%	1055	1648	49865	181738
80%	1206	1884	56988	207701
90%	1356	2119	64112	233663
100%***	1507	2355	71235	259626

This table shows RF power density for face reading a meter at 6" distance.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 2
Radiofrequency Radiation Level at 6" at the Face in uW/cm2
(One Collector, 1 Collector + 3 Smart Meters)

One Collector	Table A9	Table A10	Table A11	Table A12
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	6 uW/cm2	10	296	1078
10%	63	98	958	10780
20%	125	196	5916	21561
30%	188	293	8874	32341
40%	250	391	11832	43121
50%	313	489	14789	53902
60%	376	587	17747	64682
70%	438	685	20705	75462
80%	501	782	23663	86243
90%	563	880	26621	97023
100%***	626	978	29579	107803

One** C + 3 SM	Table A13	Table A14	Table A15	Table A16
Duty Cycle	60% Reflection	100% Reflectio	1000% Reflection*	2000% Reflection*
1%	19	29	890	3242
10%	188	294	8895	32420
20%	376	588	17990	64839
30%	565	882	26686	97259
40%	753	1176	35581	129678
50%	941	1470	43700	162098
60%	1129	1764	53371	194517
70%	1317	2058	62266	226937
80%	1506	2352	71161	259356
90%	1694	2647	80056	291776
100%***	1882	2941	88952	324195

This table shows RF power density for face reading a meter at 6" distance.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 3
Radiofrequency Radiation Level at 11" in the Nursery in uW/cm2
(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A17 60% Reflection	Table A18 100% Reflection	Table A19 1000% Reflection*	Table A20 2000% Reflection*
1%	1.4	2.2	66	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%***	140	218	6623	24139

Four** Meters Duty Cycle	Table A21 60% Reflection	Table A22 100% Reflection	Table A23 1000% Reflection*	Table A24 2000% Reflection*
1%	4.9	7.5	227	828
5%	24	38	1137	4142
10%	48	75	2273	8284
20%	96	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%***	481	751	22730	82843

This table shows RF power density for readings at 11" in the crib.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 4
Radiofrequency Radiation Level at 11" in the Nursery in uW/cm2
(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle	Table A25 60% Reflection	Table A26 100% Reflection	Table A27 1000% Reflection*	Table A28 2000% Reflection*
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%***	395	617	18652	67980

One Collector + 3 Meters** Duty Cycle	Table A29 60% Reflection	Table A30 100% Reflection	Table A31 1000% Reflection*	Table A32 2000% Reflection*
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%***	735	1149	34759	126684

This table shows RF power density for readings at 11" in the crib.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.

**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.

***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 5
Radiofrequency Radiation Level at 28" in the Kitchen in uW/cm2
(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A33 60% Reflection	Table A34 100% Reflection	Table A35 1000% Reflection*	Table A36 2000% Reflection*
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%***	21.6	33.8	1022	3726

Four** Meters Duty Cycle	Table A37 60% Reflection	Table A38 100% Reflection	Table A39 1000% Reflection*	Table A40 2000% Reflection*
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%***	54.9	85.8	2595	9458

This table shows RF power density for readings at 28" in the kitchen work space.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 6
Radiofrequency Radiation Level at 28" in the Kitchen in uW/cm2
(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle	Table A41 60% Reflection	Table A42 100% Reflection	Table A43 1000% Reflection*	Table A44 2000% Reflection*
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%***	60.9	95.2	2879	10492

One Collector + 3 Meters** Duty Cycle	Table A45 60% Reflection	Table A46 100% Reflection	Table A47 1000% Reflection*	Table A48 2000% Reflection*
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%***	94.2	147	4452	16224

This table shows RF power density for readings at 28" in the kitchen work space.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

TABLE 7

DISTANCE AT WHICH FCC TWA SAFETY LIMIT IS EXCEEDED (in inches)
(FCC limit is 655 uW/cm^2 in smart meters)

One Smart Meter	**Table A1**	**Table A2**	**Table A3**	**Table A4**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	0.5”	0.6”	3.5”	6.68”
10%	1.6”	2.0”	11.1 ”	21.1”
20%	2.3”	2.8”	15.6”	29.9”
30%	2.8”	3.5”	19.2”	36.6”
40%	3.2”	4.0”	22.1”	42.2”
50 %	3.6”	4.5”	24.7”	47.3”
60%	3.9”	4.9”	27.1”	51.7”
70%	4.3”	5.3”	29.3”	55.9”
80%	4.6”	5.7”	31.3”	59.8”
90%	4.8”	6.0”	33.2”	63.4”
100%***	5.1”	6.4”	35.0”	66.8”

Four Meters**	**Table A5**	**Table A6**	**Table A7**	**Table A8**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	1.44”	1.8”	9.4”	18.7”
10%	3.42”	4.8’	31.2”	59.7”
20%	5.70”	7.47”	44.2”	84.0”
30%	7.29”	9.39”	54.1”	103.4”
40%	8.6”	11.0”	62.5”	119.5”
50 %	9.73”	12.4”	70”	133.6”
60%	10.7”	13.6”	76.6”	146.3”
70%	11.7”	14.8”	82.2”	158.0”
80%	12”	15.8”	88.4”	169.0”
90%	13”	16.8”	93.8”	179.3”
100%***	14”	17.7”	98.9”	188.9”

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

TABLE 8

DISTANCE AT WHICH FCC TWA SAFETY LIMIT IS EXCEEDED FOR COLLECTOR METER (in inches)
(FCC limit is 571 uW/cm^2 or 624 uW/cm^2 for collector+ 3 SM)

FCC Limit=571 uW/cm^2 for collector meter

One Meter (1 collector)	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	0.9”	1.2”	6.5”	12.3”
10%	3.0”	3.7”	20.4”	39.0”
20%	4.2”	5.2”	28.9”	55.1”
30%	5.1”	6.4”	35.3”	67.5”
40%	5.9”	7.4”	40.8”	77.9”
50 %	6.6”	8.3”	45.6”	87.1”
60%	7.3”	9.1”	50.0”	95.4”
70%	7.9”	9.8”	54.0”	103”
80%	8.4”	10.5”	57.7”	110”
90%	8.9”	11.1”	61.2”	116”
100%***	9.4”	11.7”	64.5”	123”

FCC Limit = 624 uW/cm^2 for collector meter plus 3 smart meters

One Collector + 3 Smart Meters**	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	1.6”	2.1”	10.9”	21.3
10%	4.2”	5.6”	35.6”	68.1”
20%	6.7”	8.7”	50.4”	96.3”
30%	8.5”	10.8”	61.7”	118”
40%	9.9”	12.6”	71.3”	136”
50 %	11.2”	14.2”	79.7”	152”
60%	12.4”	15.6”	87.4”	167”
70%	13.4”	16.9”	94.4”	180”
80%	14.4”	18.1”	101”	193”
90%	15.3”	19.2”	107”	204”
100%***	16.1”	20.3”	113”	215”

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.

***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15)

TABLE 9

PEAK POWER LIMIT
(Distance at which 4000 uW/cm2* FCC peak limit is exceeded in inches)**

	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
One Smart Meter	2”	2.6”	14.2”	27”
Four Smart Meters	4.1”	5.2”	28.3”	54”
One Collector Meter	4”	4.5”	24”	46.7”
One Collector + 3 SM	5.0”	6.3”	34.6”	66.1”

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.

**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.

*** FCC OET 65 and ANSI/IEEE C95.1-1992, 1999 specify that 4000 uW/cm2 public safety limit be applied for frequencies between 300 MHz and 6 GHz (6000 MHz) for peak power exposure.

Table 10
Potential FCC Violations of TWA 655 uW/cm2 - Face at 6"
(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A1 60% Reflection	Table A2 100% Reflection	Table A3 1000% Reflection	Table A4 2000% Reflection
1%	2.1 uW/cm2	3.3	99	361
10%	21	33	989	3606
20%	42	65	1979	7212
30%	63	98	2968	10818
40%	83	131	3958	14424
50%	105	164	4947	18030
60%	105	196	5936	21636
70%	147	229	6926	25241
80%	168	262	7915	28847
90%	188	294	8904	32453
100%	209	327	9894	36059

Four Meters Duty Cycle	Table A5 60% Reflection	Table A6 100% Reflection	Table A7 1000% Reflection	Table A8 2000% Reflection
	15 uW/cm^2	24	712	2596
10%	151	236	7124	25963
20%	301	471	14247	51925
30%	452	707	21371	77888
40%	603	942	28494	103850
50%	754	1177	35618	129813
60%	904	1413	42741	155775
70%	1055	1648	49865	181738
80%	1206	1884	56988	207701
90%	1356	2119	64112	233663
100%	1507	2355	71235	259626

This table shows RF power density for face reading a meter at 6" distance.

Exceeds 655 uW/cm2 at 6" at the face

Table 11
Potential FCC Violations of TWA 571/624 uW/cm2- Face at 6"
(One Collector, 1 Collector + 3 Smart Meters)

One Collector	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
571 limit				
1%	6 uW/cm2	9	279	1015
10%	59	92	2786	10152
20%	118	184	5571	20305
30%	177	276	8357	30457
40%	236	368	11142	40610
50%	295	460	13928	50762
60%	354	553	16713	60914
70%	413	645	19449	71067
80%	471	737	22285	81219
90%	530	829	25070	91372
100%	589	921	27856	101524

One C + 3 SM	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflection	100% Reflectio	1000% Reflection	2000% Reflection
624 limit				
1%	18	29	874	3185
10%	185	289	8740	31854
20%	370	578	17480	63709
30%	555	867	26220	95563
40%	740	1156	34960	127418
50%	925	1445	43700	159272
60%	1109	1734	52441	191126
70%	1294	2023	61181	222981
80%	1479	2311	69921	254835
90%	1664	2600	78661	286690
100%	1849	2889	87401	318544

This table shows RF power density for face reading a meter at 6" distance.

Exceeds 571 or 624 uW/cm2 at 6" at the face.

Table 12
Potential FCC Violations of 655 uW/cm2 TWA Safety Limit
Nursery at 11"
(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A17 60% Reflection	Table A18 100% Reflection	Table A19 1000% Reflection	Table A20 2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters Duty Cycle	Table A21 60% Reflection	Table A22 100% Reflection	Table A23 1000% Reflection	Tab;e A24 2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

This table shows RF power density FCC violations at 11".

Exceeds 655 uW/cm2 FCC TWA Safety Limit

Table 13
Potential FCC Violations of the 571/624 uW/cm2 TWA Safety Limit at 11" in the Nursery
(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle 571 limit	Table A25 60% Reflection	TableA26 100% Reflection	Table A27 1000% Reflection	Table A28 2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One Collector + 3 Meters** Duty Cycle 624 limit	Table A29 60% Reflection	Table A30 100% Reflection	Table A31 1000% Reflection	Table A32 2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

This table shows RF power density FCC violations at 11"

Exceeds either 571 or 624 uW/cm2 FCC Limit

Table 14
Potential FCC Violations of the 655 uW/cm2 Safety Limit at 28" in the Kitchen
(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A33 60% Reflection	Table A34 100% Reflection	TableA35 1000% Reflection	Table A36 2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters Duty Cycle	Table A37 60% Reflection	Table A38 100% Reflection	Table A39 1000% Reflection	Table A40 2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

This table shows RF power density readings at 28" in the kitchen work space.

Exceeds 655 uW/cm2 FCC Limit

Table 15
Potential FCC Violations of 571/624 uW/cm2 FCC Limit at 28" in the Kitchen
(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle 571 limit	Table A41 60% Reflection	Table A42 100% Reflection	Table A43 1000% Reflection	Table A44 2000% Reflection
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492

One Collector + 3 Meters** Duty Cycle 624 limit	Table A45 60% Reflection	Table A46 100% Reflection	Table A47 1000% Reflection	Table A48 2000% Reflection
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

This table shows RF power density readings at 28" in the kitchen work space.

Exceeds 571/624 uW/cm2 FCC Limit

Table 16
Potential FCC Violations of Peak Power Limit 4000 uW/cm2 at 3"
(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A1 60% Reflection	Table A2 100% Reflection	Table A3 1000% Reflection	Table A4 2000% Reflection
1%	19	29	890	3245
10%	188	294	8904	32453
20%	377	589	17809	64906
30%	565	883	26713	97360
40%	754	1177	35618	129813
50%	942	1472	44522	162266
60%	1130	1766	53426	194719
70%	1319	2061	62331	227172
80%	1507	2355	71235	259626
90%	1696	2649	80140	292079
100%	1884	2944	89044	324532

Four Meters Duty Cycle	Table A5 60% Reflection	Table A6 100% Reflection	Table A7 1000% Reflection	Table A8 2000% Reflection
1%	75	118	3562	12981
10%	754	1177	35618	129813
20%	1507	2355	71235	259626
30%	2261	3532	106853	389438
40%	3014	4710	142470	519251
50%	3768	5887	178088	649064
60%	4521	7065	213705	778877
70%	5275	8242	249323	908690
80%	6029	9420	284941	1038503
90%	6782	10597	320558	1168315
100%	7536	11774	356176	1298128

This table shows RF power density at 3" distance at surface of meter

Exceeds 4000 uW/cm2 at 3" from antenna radiation center at face of meter.

Table 17
Potential FCC Violations of Peak Power Limit 4000 uW/cm2 at 3"
(One Collector, 1 Collector + 3 Smart Meters)

One Collector	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
571 limit				
1%	53	83	2507	9137
10%	530	829	25070	91372
20%	1061	1658	50140	182743
30%	1591	2486	75211	274115
40%	2122	3315	100281	365486
50%	2652	4144	125351	456858
60%	3182	4973	150421	548229
70%	3713	5801	175491	639601
80%	4243	6630	200562	730972
90%	4774	7459	225632	822344
100%	5304	8288	250702	913715

One C + 3 SM	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflection	100% Reflectio	1000% Reflection	2000% Reflection
624 limit				
1%	92	144	4370	15927
10%	925	1445	43700	159272
20%	1849	2889	87401	318544
30%	2774	4334	131101	477816
40%	3698	5779	174802	637088
50%	4623	7223	218502	796360
60%	5547	8668	262203	955632
70%	6472	10113	305903	1114904
80%	7397	11557	349604	1274176
90%	8321	13002	393304	1433448
100%	9246	14446	437005	1592720

This table shows RF power density at 3" distance at surface of meter.

Exceeds 4000 uW/cm2 at 3" from antenna radiation center at face of meter.

Table 18
Radiofrequency Radiation Levels Associated with Inhibition of DNA Repair in Human Stem Cells at 11" in the Nursery
(One Smart Meter, Four Meters)

One Meter	Table A17	Table A18	Table A19	Table A20
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters	Table A21	Table A22	Table A23	Table A24
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 19
Radiofrequency Radiation Level Associated with Inhibition of DNA Repair in Human Stem Cells at 11" in the Nursery
(One Collector/1C + 3 Smart Meters)

One Collector	Table A25	Table A26	Table A27	Table A28
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One C+ 3 SM	Table A29	Table A30	Table A31	Table A32
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 20
Radiofrequency Radiation Level Associated with Pathological Leakage of the Blood-brain Barrier at 0.4-8 uW/cm2 at 11" in the Nursery
(One Smart Meter, Four Meters)

One Meter	**Table A17**	**Table A18**	**Table A19**	**Table A20**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139
Four Meters	**Table A21**	**Table A22**	**Table A23**	**Table A24**
	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
	4.9	7.5	227	828
	24	37.6	1137	4142
	48.1	75.1	2273	8284
	96.2	150	4546	16569
	144	225	6819	24853
	192	301	9092	33137
	240	376	11365	41421
	289	451	13638	49705
	337	526	15911	57990
	385	601	18184	66274
	433	676	20457	74558
	481	751	22730	82843

Exceeds between 0.4-8	Exceeds 8 uW/cm2

Table 21
Radiofrequency Radiation Level Associated with Pathological Leakage of the Blood-brain Barrier at 0.4 - 8 uW/cm2
(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle	Table 25 60% Reflection	Table A26 100% Reflection	Table A27 1000% Reflection	Table A28 2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One Collector + 3 Meters** Duty Cycle	Table A29 60% Reflection	Table A30 100% Reflection	Table A31 1000% Reflection	Table A32 2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds between 0.4-8	Exceeds 8 uW/cm2

Table 22 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Nursery at 11" One Meter and Four Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Meter Duty Cycle	Table A17 60% Reflection	Table A18 100% Reflection	Table A19 1000% Reflection	Table A20 2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters Duty Cycle	Table A21 60% Reflection	Table A22 100% Reflection	Table A23 1000% Reflection	Table A24 2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 23 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Nursery at 11" One Meter and Four Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Collector	Table A33	Table A34	Table A35	Table A36
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4	6.2	187	680
5%	20	30.8	933	3399
10%	40	61.7	1865	6798
20%	79	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980
1C + 3 SM	**Table A37**	**Table A38**	**Table A39**	**Table A40**
Duty Cycle	60% Reflection	100% Reflection	100% Reflection	2000% Reflection
1%	7.4	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 24
Radiofrequency Radiation Levels Associated with Inhibition of DNA Repair in Human Stem Cells at 28" Kitchen Example
(One Smart Meter, Four Meters)

One Meter	Table A33	Table A34	Table A35	Table A36
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters	Table A37	Table A38	Table A39	Table A40
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 25
Radiofrequency Radiation Levels Associated with Inhibition of DNA Repair in Human Stem Cells at 28" in Kitchen
(One Collector/1C + 3 Smart Meters)

One Collector	**Table A41**	**Table A42**	**Table A43**	**Table A44**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492

One Collector + 3 SM	**Table A45**	**Table A46**	**Table A47**	**Table A48**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 26
Radiofrequency Radiation Levels Associated with Pathological Leakage of the Blood-brain Barrier at 0.4 - 8 uW/cm2 at 28" in Kitchen
(One Smart Meter, Four Meters)

One Meter	Table A33	Table A34	Table A35	Table A36
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters	Table A37	Table A38	Table A39	Table A40
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

Exceeds 8 uW/cm2 | Exceeds between 0.4 and 8 uW/cm2

Table 27

Radiofrequency Radiation Levels Associated with Pathological Leakage of the Blood-brain Barrier at 0.4 - 8 uW/cm2 at 28" in Kitchen

One Collector/1C + 3 Smart Meters

One Collector	Table A41	Table A42	Table A43	Table A44
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492
One Collector + 3 SM	**Table A45**	**Table A46**	**Table A47**	**Table A48**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

Exceeds 8 uW/cm2 | Exceeds between 0.4 and 8 uW/cm2

Table 28 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Kitchen at 28" One Meter and Four Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Meter	Table A33	Table A34	Table A35	Table A36
Duty Cycle	60% Reflectio	100% Reflection	1000% Reflection	2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters	Table A37	Table A38	Table A39	Table A40
Duty Cycle	60% Reflection	100% Reflection	100% Reflection	2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 29 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Kitchen at 28" One Collector, 1C + 3 Smart Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Collector	Table A41	Table A42	Table A43	Table A44
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492

1C, 1C+3 SM	Table A45	Table A46	Table A47	Table A48
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.9	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 30
Exceeds Medtronics Advisory Limit at 11"
(One Smart Meter, Four Meters)

One Meter	Table A17	Table A18	Table A19	Table A20
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters	Table A21	Table A22	Table A23	Tab;e A24
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

Exceeds Medtronics SAR Advisory Limit

Table 31
Exceeds Medtronics Advisory Limit at 11"
(One Collector, 1C + 3 SM)

One Collector	Table A25	TableA26	Table A27	Table A28
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One Collector + 3 Meters**	Table A29	Table A30	Table A31	Table A32
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds Medtronics SAR Advisory Limit

Table 32
Distance to the BioInitiative Report Recommendation 0f 0.1 uW/cm2 (in feet)

(One Smart Meter, Four Meters)

One Meter	Table A1	Table A2	Table A3	Table A4
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	3.4'	28.0'	23.6'	45'
10%	10.9'	13.6'	74.5'	143'
20%	15.3'	19.2'	105'	201'
30%	18.8'	23.5'	129'	247'
40%	21.7'	27.1'	149'	285'
50%	24.3'	30.4'	167'	318'
60%	26.6'	33.2'	348'	348
70%	28.7'	35.8'	197'	376'
80%	30.7'	38.3'	211'	403'
90%	32.6'	40.6'	224'	428'
100%	34.3'	42.8'	256'	450'

Four Meters	Table A5	Table A6	Table A7	Table A8
Duty Cycle	60% Reflectioi	100% Reflection	1000% Reflection	2000% Reflection
1%	9.7	12'	67'	128'
10%	30.7'	38.4'	211'	402'
20%	43.5'	54.2'	298'	570'
30%	53.2'	66.3'	365'	698'
40%	61.3'	76.8'	422'	805'
50%	68.5'	85.8'	471'	900'
60%	75.0'	94.0'	517'	985'
70%	81'	102'	558'	1065'
80%	87'	109'	598'	1140'
90%	92'	115'	632'	1210'
100%	97'	122'	667'	1275'

Exceeds the BioInitiative Recommendation of 0.1 uW/cm2 at this distance (in feet)

Table 33
Distance to the BioInitiative Report Recommendation 0f 0.1 uW/cm2 (in feet)
(One Collector, 1C + 3 Smart Meters)

One Collector	Table A9	Table A10	Table A11	Table A12
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	5.9’	7.25’	41'	78’
10%	18.6’	23.0’	129’	246’
20%	26.5’	32.5	182’	348’
30%	32.5’	39.8’	223’	426’
40%	37.5’	46.0’	258’	493’
50%	42.0’	51.3’	288’	550’
60%	46.0’	56.3’	603’	603'
70%	49.6’	60.8’	342’	650'
80%	53.0’	64.8’	365’	695'
90%	56.3’	68.8’	387’	739'
100%	59.2’	74.0’	407’	778'

1C + 3 Smart Meters	Table A13	Table A14	Table A15	Table A16
Duty Cycle	60% Reflectioı	100% Reflection	1000% Reflection	2000% Reflection
1%	10.9’	13.6’	74.7’	142’
10%	34.3’	42.8’	236’	450’
20%	48.5’	60.5’	333’	673'
30%	58.5	74.3’	408’	780’
40%	68.5	85.6’	471’	900'
50%	76.5’	96.0’	526’	1005’
60%	84.0’	105’	577'	1100'
70%	90.7’	114’	625’	1190'
80%	97.0’	121’	666'	1160'
90%	103’	129’	707’	1275’
100%	108’	136’	745'	1420’

Exceeds the BioInitiative Recommendation of 0.1 uW/cm2 at this distance (in feet)

Electrical Safety Authority

Electrical Safety Authority Directs Local Distribution Companies to Replace and Discontinue Use of Specific Model of Electrical Meter

Affected meters represent only one tenth of one per cent of meters in Ontario

MISSISSAUGA – January 22, 2015 – The Electrical Safety Authority (ESA) has directed Ontario's Local Distribution Companies (LDCs) to replace and discontinue use of the *iConA™ Generation 3.2 remote disconnect meters* manufactured by Sensus (typically referred to as the *Sensus 3.2 with remote disconnect*.) This is a direct result of a due diligence review after reports of safety incidents involving meters in Saskatchewan.

There have been no serious safety events reported in Ontario with the Sensus 3.2 with remote disconnect meters, however as a preventative step ESA is directing LDCs to remove these meters from service no later than March 31, 2015. ESA has concluded that this model is susceptible to a specific type of failure: arcing within the components if water/moisture and other contaminants get into the meter.

ESA is acting according to its powers and responsibilities under the Electricity Act and Ontario Regulation 22/04 Electrical Distribution Safety.

There are a reported 5,400 Sensus 3.2 with remote disconnect meters in Ontario, based on information from the Ontario Energy Board. This is one tenth of one per cent of the 4.8 million meters in the province. ESA's bulletin does not apply to the Sensus 3.2 meter without the remote disconnect feature, which has a different component design and therefore is not susceptible to the same type of failure.

"Although there were no serious incidents reported in Ontario involving these meters, when we learned of the events in Saskatchewan we undertook a due diligence safety review to determine if there were any implications for Ontario," said David Collie, ESA's President and CEO. "Even though the probability of a serious event in Ontario is low, nonetheless we have taken the proactive and prudent step and directed LDCs to remove these meters from service in order to eliminate any risk."

Homeowners and business owners should never attempt to remove, touch or alter a meter. Only personnel authorized by an LDC should remove or change meters.

About the Electrical Safety Authority (ESA)

The Electrical Safety Authority's (ESA) role is to enhance public electrical safety in Ontario. As an administrative authority acting on behalf of the Government of Ontario, ESA is responsible for administering specific regulations related to the Ontario Electrical Safety Code, the licensing of Electrical Contractors and Master Electricians, electricity distribution system safety, and electrical product safety. ESA works extensively with stakeholders throughout the province on education, training and promotion to foster electrical safety.

More information on the Electrical Safety Authority can be found at www.esasafe.com, through Twitter @homeandsafety and on Facebook at www.facebook.com/ElectricalSafetyAuthority.

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For further information:
Electrical Safety Authority Media Relations
905-712-7819 or Media.ESA@electricalsafety.on.ca

http://www.stcatharinesstandard.ca/2015/01/22/thousands-of-smart-meters-ordered-removed#channel=f2ed8ee2a32b4c4&origin=http%3A%2F%2Fwww.stcatharinesstandard.ca

Thousands of smart meters ordered removed in Ontario

By Antonella Artuso, Queen's Park Bureau Chief
Thursday, January 22, 2015 4:33:56 EST PM

There are almost 4.8 million residential and small businesses with smart meters in Ontario. (Toronto Sun files)

TORONTO - ***Have you been notified that your smart meter will be removed? We want to hear from you. Call 416-947-2211 or e-mail antonella.artuso@sunmedia.ca***

Several thousands smart meters have been ordered removed from Ontario properties over concerns they could start fires.

David Collie, president and CEO of the Electrical Safety Authority (ESA), said their experts found similarities between the structure of 5,400 Sensus Generation 3.2 remote disconnect meters installed in Ontario and a similar model used in Saskatchewan that was implicated in a number of fires.

Collie said there have been no serious incidents reported in Ontario, and the risk of fire is considered very low, but one meter was found to have failed.

“We watched these incidents very carefully that were taking place in Saskatchewan,” Collie said Thursday.

“When the engineer report came out, we went and did our own homework and due diligence here in Ontario and determined that this could happen here.” The ESA listed 11 local distribution companies (LDCs) that have installed the devices — Bluewater Power Distribution, Waterloo North Hydro, Kitchener-Wilmot Hydro, EnWin Utilities, Greater Sudbury Hydro, Brant County Power, Lakefront Utilities, Canadian Niagara Power, Norfolk Power Distribution, Oakville Hydro, and Algoma Power.

If moisture or another contaminant comes into contact with the meters, there could be arcing within the components, potentially starting a fire.

One LDC turned in a meter with evidence of arcing but the ESA refused to identify its location.

Property owners will be notified by their LDC if they have a suspect meter.

Authorized personnel will be sent out by the LDC to remove the meter, a task homeowners should not attempt themselves, the ESA says.

LDCs have until March 31 to remove the meters but some have already taken them out, Collie said.
There are 4.8 million smart meters installed in Ontario under orders of the Liberal provincial government to allow for time-of-use electricity pricing, but the safety issue only concerns one particular type of unit used sparingly in the province.
Energy Minister Bob Chiarelli’s office issued a statement in response to the ESA’s safety bulletin, telling LDCs that it expects them to quickly comply with the order.
“The safety of all Ontarians is the number one priority of our government,” Chiarelli said. “While there have not been any reported incidents with this particular model of smart meter in Ontario, we thank the Electrical Safety Authority for their comprehensive review and proactive recommendations to ensure the safety of Ontarians.” NDP MPP Peter Tabuns said the Ontario government has a lot of explaining to do to the many citizens already upset at the cost of the smart meter program who now find some of the devices pose a threat to their safety.
The NDP raised this issue with the government last summer after Saskatchewan ordered 105,000 Sensus meters removed following a number of suspicious fires, Tabuns said.
At the time, Sensus had issued a statement saying that its site inspections pointed to “external factors,” such as water intrusion due to holes in meter boxes, as a cause for the problems rather than a flaw in the product.
The Ontario energy ministry reported back that the Ontario Energy Board (OEB) had found none of the units used in Saskatchewan in place in this province, Tabuns said.
“Don’t worry, be happy, go home,” Tabuns said. “Happily the ESA actually looked at the problem, realized it wasn’t just one make of meter, that there was a larger problem, and they’re taking action.
“The government should have recognized last August that it couldn’t just dismiss the problem.”
Ontario NDP MPP Lisa Gretzky demanded action on the smart meters last August, saying the government should treat them like they “could be ticking time bombs attached to people’s homes.”

http://www.sunnewsnetwork.ca/sunnews/politics/archives/2015/01/20150122-130118.html

Thousands of smart meters to be replaced in Ontario because of fire concerns

1:01 pm, January 22nd, 2015

ONTARIO AUDITOR GENERAL BONNIE LYSYK
Credits: FILE PHOTO/Dave Thomas/Toronto Sun/QMI Agency

ANTONELLA ARTUSO | QMI AGENCY

TORONTO — Several thousand smart meters have been ordered removed from Ontario properties over concerns they could start fires.

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Collie said there have been no serious cases reported in Ontario, and the risk of fire is considered very low, but one meter was found to have failed.

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If moisture or another contaminant comes into contact with the meters, there could be arcing within the components, potentially starting a fire.

One LDC turned in a meter with evidence of arcing but the ESA refused to identify its location.

Each LDC will send out authorized personnel to remove the problematic meters — a task homeowners should not attempt themselves, the ESA says.

LDCs have until March 31 to remove the meters.

There are 4.8 million smart meters installed in Ontario under orders of the Liberal government to allow for time-of-use electricity pricing, but the safety issue only concerns one particular type of unit used sparingly in the province.

Energy Minister Bob Chiarelli's office issued a statement in response to the ESA's safety bulletin, telling LDCs that it expects them to quickly comply with the order.
"The safety of all Ontarians is the No. 1 priority of our government," Chiarelli said.
NDP MPP Peter Tabuns said the Ontario government has a lot of explaining to do, especially since many citizens were already upset about the cost of the smart meter program, now they learn some of the devices pose a threat to their safety.
The NDP raised the issue with the government last summer after Saskatchewan ordered 105,000 Sensus meters removed following some suspicious fires, Tabuns said.
At the time, Sensus issued a statement saying its site inspections pointed to "external factors," such as water intrusion due to holes in meter boxes, as a cause for the problems rather than a flaw in the meters.
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HUMAN AUDITORY PERCEPTION OF PULSED RADIOFREQUENCY ENERGY

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Running title: Auditory Perception of RF Pulses

ABSTRACT

Human auditory perception of pulses of radiofrequency (RF) energy is a well-established phenomenon that is dependent upon the energy in a single pulse and not on average power density. RF-induced sounds can be characterized as the perception of subtle sounds because, in general, a quiet environment is required for the sounds to be heard. The sound is similar to other common sounds such as a click, buzz, hiss, knock or chirp. Effective radiofrequencies range from 216 to 10,000 MHz, but an individual's ability to hear RF-induced sounds is dependent upon high-frequency acoustic hearing in the kHz range. The fundamental frequency of RF-induced sounds is independent of the radiofrequency but dependent upon head dimensions. The detection of RF-induced sounds is similar to acoustic sound detection once the cochlea is stimulated; however, the site of conversion of RF energy to acoustic energy is peripheral to the cochlea. The thermoelastic expansion theory explains the RF hearing phenomenon. RF-induced sounds involve the perception, via bone conduction, of thermally generated sound transients, that is, audible sounds are produced by rapid thermal expansion resulting from only a 5×10^{-6} ^{o}C temperature rise in tissue at the threshold level due to absorption of the energy in the RF pulse. The experimental weigh-of-evidence excludes direct stimulation of the central nervous system by RF pulses. The perception of RF-induced sounds near the threshold exposure level is considered to be a biological effect without an accompanying health effect. This conclusion is supported by a comparison of pressures induced in the body by RF pulses and by clinical ultrasound procedures.

Key Words: RF hearing, microwave, thermoelastic

INTRODUCTION

In their review article on the radiofrequency (RF) hearing phenomenon, Chou et al. (1982) wrote:

> "The earliest report we have found on the auditory perception of pulsed microwaves appeared in 1956 as an advertisement of the Airborne Instruments Laboratory in Vol. 44 of the *Proceedings of the IRE.* The advertisement described observations made in 1947 on the hearing of sounds that occurred at the repetition rate of a radar while the listener stood close to a horn antenna. When the observers first told their coworkers in the Laboratory of their hearing experiences, they encountered skepticism and rather pointed questions about their mental health."

The skepticism surrounding early reports of RF hearing, such as the one quoted above, was based on our understanding of human hearing. The ear was known to be exquisitely sensitive to pressure waves and, at that time, to have no sensitivity to electromagnetic waves at microwave frequencies (300 MHz – 300 GHz). The skepticism helps to explain why the first systematic study of this phenomenon by Frey (1961) did not appear until many years after the development of radar in the early 1940's. Frey described the perception of transient buzzing sounds by human subjects exposed to RF radiation from a rotating radar antenna. The apparent location of the sound, which was described as a short distance behind the head, was the same regardless of the body's orientation to the radar (Frey, 1961). In later reports (Frey, 1962, 1963), RF hearing was described as a "buzz, clicking, hiss or knocking" sound. Table 1 contains descriptions of these and other sounds reported by human beings exposed to pulsed RF fields. When a metal shield of aluminum flyscreen was placed between the subject and the radar, no RF sounds were heard (Frey and Messenger, 1973). The sensitive area for detecting RF sounds was described as a region over the temporal lobe of the brain, because the placement of a small piece of metal screen (5 x 5 cm) over this area completely stopped the sound (Frey, 1962). The subjects in Frey (1961) reported an increase in the RF sound level when earplugs were used to reduce the ambient noise level, an observation confirmed by others (Guy et al., 1975).

The "sound was something like that of a bee buzzing on a window, but with, perhaps, more high frequencies" according to Ingalls (1967) who used two radars like those described in Frey (1961). The sound seemed to come from about a meter or two above the head. In another report (Constant, 1967), the RF sound was described as being in the area of the ear on the side opposite to the one that was irradiated. All subjects experienced a buzzing sensation at a pulse repetition rate (PRR) greater than 100/s, whereas individual pulses were heard at a PRR below 100/s. Cain and Rissmann (1978) reported that human subjects heard distinct clicks either inside the head or behind the head when exposed to pulsed fields. Individual pulses were heard as distinct and separate clicks, and short pulse trains as chirps with the tone pitch corresponding to the PRR by two of the study investigators in Guy et al. (1975). The RF-induced sound appeared to originate from within or near the back of the head. This report also included the note that transmitted digital codes could be accurately interpreted by the subject when the pulse generator was keyed manually. Two reports from Russian scientists described the perception of pulsed RF signals as polytonal sounds and tinnitus (Tyazhelov et al., 1979; Khizhnyak et al., 1980).

These studies show that human perception of pulsed RF radiation, resulting in sounds that vary with modulation of the signal, is a well-established phenomenon. The following sections describe the effective radiation parameters including thresholds for RF hearing, the dependence of RF hearing on acoustic hearing, the mechanism responsible for human perception of pulsed RF fields, and a discussion of the significance of the effect. Additional information is available in reviews by Chou et al. (1982); Elder (1984); Lin (1978, 1989, 1990, 2001); Postow and Swicord (1996) and Stewart (2000).

EFFECTIVE RF RADIATION PARAMETERS

A summary of RF radiation parameters used in human studies is shown in Table 1. The parameters include frequency, PRR, pulse width, peak power density, average power density, and energy density/pulse. Threshold values for RF hearing have been reported in several studies and these are shown in the table also.

RF hearing has been reported at frequencies ranging from 216 to 10,000 MHz (see Table 1). Although Ingalls (1967) mentioned 10,000 MHz as an effective frequency, other investigators found that lower frequencies (8900 and 9500 MHz) at very high exposure levels did not induce RF sounds. For example, the frequency of 8900 MHz was not effective at an average power density of 25 mW/cm^2 and peak power density of 25,000 mW/cm^2 (Frey, 1962). At 216 MHz, the lowest effective frequency reported in the literature, the average power density threshold was 4 mW/cm^2 and the peak power density was 670 mW/cm^2 (Frey, 1963). The lowest threshold value expressed in units of average incident power density is 0.001 mW/cm^2 (Cain and Rissmann, 1978). This low value was due to the slow PRR of only 0.5/s (Table 1) because, for a given peak power, average power density depends on the pulse repetition rate. The hearing phenomenon, however, has been shown to depend on the energy in a single pulse and not on average power density. Guy et al. (1975) found that the threshold for RF hearing of pulsed

2450-MHz radiation was related to an energy density of 40 μJ/cm^2 per pulse, or energy absorption per pulse of 16 μJ/g, regardless of the peak power of the pulse or the pulse width (less than 32 μs); calculations showed that each pulse at this energy density would increase tissue temperature by about 10^{-6} ^{o}C.

A review of the table reveals that many of the threshold values were determined in a very quiet environment or subjects used earplugs or earmuffs to decrease the ambient noise level. As mentioned in the Introduction, earplugs were used by the subjects in Frey's first report in 1961. Thus, investigators were generally aware that a quiet environment was required because, in many cases, the normal noise levels in laboratory and outdoor environments masked the perception of RF sounds. In Guy et al. (1975), for example, the threshold value cited above was obtained in a very quiet environment having a background noise level of only 45 dB. When earplugs were used, the threshold level for one subject decreased from 40 to 28 μJ/cm^2. The threshold for a subject with a hearing deficit was much higher, approximately 135 μJ/cm^2.

DEPENDENCE OF RF HEARING ON ACOUSTIC HEARING

The advertisement from Airborne Instruments Laboratory (1956) stated that two persons with hearing loss above 5 kHz did not perceive RF sounds as well as did observers with normal hearing up to 15 kHz. Later studies provided more information on the relationship between acoustic and RF hearing. Frey (1961) reported that a necessary condition for perceiving the RF sound was the ability to hear audiofrequencies above approximately 5 kHz, although not necessarily by air conduction. This conclusion was based on results with subjects with normal or defective hearing. One subject with normal air-conduction hearing below 5 kHz failed to hear the microwave pulses; the person was subsequently found to have a substantial loss in bone-conduction hearing. Another subject with good bone-conduction hearing but with poor air-conduction hearing perceived the RF sound at approximately the same power density that induced threshold perception in subjects with normal hearing. In a later study, humans were shown to match sounds caused by repetitive exposure to a pair of RF pulses in the MHz range to acoustic frequencies near 4.8 kHz (Frey and Eichert, 1985).

In addition to determining standard audiograms that measure hearing thresholds for air conduction at acoustic frequencies of 250 to 8000 Hz and for bone conduction to 4000 Hz, Cain and Rissmann (1978) measured the hearing ability of eight subjects over the frequency range of 1 to 20 kHz. They found that although there was no apparent correlation between the ability to perceive pulsed RF fields at 3000 MHz and hearing ability as measured by standard audiograms, there was a strong correlation between the RF-hearing threshold and thresholds to air-conducted acoustic signals above 8 kHz. For example, three of the subjects who had normal hearing below 4 kHz, but a hearing deficit at frequencies above 8 kHz, could not hear RF sounds under conditions in which the other subjects could perceive RF sounds. The studies by Frey (1961), Frey and Eichert (1985) and Cain and Rissmann (1978) show RF hearing to depend on high-frequency hearing in the range of about 5 to 8 kHz and bone-conduction hearing at lower acoustic frequencies. Calculated values of fundamental frequencies of RF sound in the human head based on animal data or models are somewhat similar, e.g., 7-10 kHz (Chou et al., 1977), 13 kHz (Lin 1977) and 7-9 kHz (Watanabe et al., 2000); the results of these three studies are described in more detail below.

SIMILARITY OF AUDITORY RESPONSE TO MICROWAVE AND CONVENTIONAL ACOUSTIC STIMULI

The auditory pathway by which acoustic waves detected by the ear become interpreted as sound in the brain is known in some detail and several studies have been done to determine if the electrophysiological response of the auditory pathway to RF pulses is similar to the response to acoustic stimuli. The first stage of sound transduction is mechanical distortion of cochlear hair cells that result in cochlear microphonics, electrical potentials that mimic the sonic waveforms of acoustic stimuli. Subsequent to the detection of sound by the cochlea, electric potentials associated with the detection of sound may be recorded by electrodes placed in neurons at various locations along the auditory pathway.

In 1962, Frey proposed that RF hearing might be a result of direct cortical or neural stimulation but the results of later studies described in this review showed that Frey's theory was incorrect. His proposal was based, in part, on his failure to demonstrate that RF pulses stimulate the cochlea, that is, cochlear microphonics were not recorded at power densities much higher than those required to elicit auditory nerve responses (Frey, 1967). Guy et al. (1975) also failed to measure cochlear microphonics but determined that the failure was due to insufficient absorption of RF energy. In 1975, Chou et al. reported their success in overcoming the technical problems that had prevented investigators from recording cochlear microphonics from RF-exposed animals. The results showed that pulses of RF energy activated the cochlea because cochlear microphonics were recorded that were similar to those evoked by acoustic stimuli. The demonstration that RF sounds are perceived by the normal auditory system via the cochlea provided evidence against the proposal that RF pulses directly simulated the central nervous system.

Taylor and Ashleman (1974) and Guy et al. (1975) showed the importance of the cochlea by finding that destruction of the cochlea abolished RF-evoked potentials recorded at higher levels in the auditory pathway. These results indicated that the locus of the initial interaction of pulse-modulated microwave energy with the auditory system is peripheral to the cochlea.

In cats with an undamaged cochlea, Taylor and Ashleman (1974) measured the electrophysiological response in three successive levels of the cat auditory nervous system (eighth cranial nerve, medial geniculate nucleus, and primary auditory cortex) to both acoustic and pulsed-microwave (2450-MHz) stimuli. They found similar responses to microwave stimuli and conventional acoustic stimuli. Lebovitz and Seaman (1977a,b) reached the same conclusion based on the similar response of single auditory neurons in the cat to pulsed 915-MHz fields and acoustic clicks. The detection of these electric potentials in auditory neurons was expected based on the results of studies that demonstrated subjective auditory perception (Frey, 1962), auditory evoked potentials (Taylor and Ashleman, 1974), and cochlear microphonics (Chou et al., 1975).

It is known that acoustic stimuli can cause evoked potentials, called “cross-modal” responses, in central nervous system sites outside the auditory pathway. Similar “cross-modal” responses due to the auditory response to RF pulses were recorded by Guy et al. (1975). This finding indicated that electric potentials recorded from any CNS location could be misinterpreted as a direct interaction of RF energy with the particular neural system in which the recording was made, as reported by Frey (1967).

In an experiment in which the thresholds of evoked electrical responses from the medial-geniculate body in the auditory pathway in cats were determined as a function of background noise, Guy et al. (1975) found that as the noise level (50- to 15,000-Hz bandwidth) increased from 60 to 80 dB, there was only a negligible increase in the threshold for microwave stimuli, a moderate increase in the threshold for a piezoelectric bone-conduction source, and a large increase in the threshold for loudspeaker-produced stimuli. The finding that the evoked response to microwave stimuli did not increase in relation to background noise, which included acoustic frequencies to 15,000 Hz, indicated that pulsed RF energy interacted with the high-frequency portion of the auditory system.

Additional support for the dependence of RF hearing on high-frequency hearing was provided by theoretical analysis of acoustic vibrations induced in the heads of animals and humans based on thermal expansion in spheres exposed to pulses of RF energy (Lin, 1977). The frequency of the induced sound was found to be a function of head size and of acoustic properties of brain tissue; hence, the acoustic pitch perceived by a given subject is the same regardless of the frequency of RF radiation. The calculations of Lin show that the fundamental frequency predicted by the model varies inversely with the radius of the head, i.e., the larger the radius, the lower the frequency of the perceived RF sound. The estimated fundamental frequency of vibration in guinea pigs, cats, and adult humans were 45, 38, and 13 kHz, respectively; the frequency for an infant human head was estimated to be about 18 kHz. These calculations provide further evidence that a necessary condition for auditory perception by adult humans is the ability to hear sound waves at frequencies above about 5 kHz (Frey, 1961; Rissmann and Cain, 1975).

The results of Lin (1977) appear to be in good agreement with the measurements of Chou et al. (1975), who found cochlear microphonics of 50 kHz in guinea pigs exposed to RF pulses. In a later report, Chou et al. (1977) found the frequency of cochlear microphonics in guinea pigs and cats to correlate well with the longest dimension of the brain cavity and, based on these data, estimated the frequency of the microwave-induced cochlear microphonics in human beings to be between 7 and 10 kHz.

Gandhi and Riazi (1986) calculated RF hearing thresholds at 30-300 GHz, but there is little if any physiological significance of these calculations to RF hearing because a) the fundamental frequencies in the head are on the order of several hundred kilohertz, well above the maximum acoustic frequency of 20 kHz for human hearing, and b) there are no reports of human perception of RF pulses at frequencies higher than 10 GHz (see Table 1).

The results of the above studies of evoked electrical potentials in the auditory system, including the demonstration of pulsed-RF-evoked cochlear microphonics, strongly indicate that the detection of RF-induced auditory sensations is similar to that of acoustic sound detection, the site of conversion from RF to acoustic energy is peripheral to the cochlea, the fundamental frequency of RF sound is independent of the radiofrequency but dependent upon the dimensions of the head, and the pulsed RF energy interacts with the high-frequency portion of the auditory system. To hear RF sounds, one must be exposed to pulses of RF energy in the MHz range and be capable of hearing acoustic waves in the kHz range.

MECHANISM OF RF HEARING: THERMOELASTIC EXPANSION

One of the first challenges to Frey's proposal of direct neural stimulation (Frey, 1961, 1962) came from Sommer and von Gierke (1964) who suggested that stimulation of the cochlea through electromechanical field forces by air or bone conduction appeared to be a more likely explanation of the RF hearing phenomenon. Other scientists who helped lay the foundation for identifying the mechanism are White (1963) and Gournay (1966). White (1963) showed that pressure waves could be detected in water exposed to pulses of RF energy and his analysis of waves in this system predicted that, as a result of thermal expansion, the resulting temperature gradient would generate stress waves that propagate away from the site of energy absorption. Gournay (1966) extended White's analysis to show that for single long pulses, the induced stress wave is a function of peak power density and, for shorter pulses, the stress wave is a function of the peak power density and pulse width (or energy density per pulse).

Foster and Finch (1974) extended Gournay's analysis to a physiological solution exposed to RF pulses similar to those that produce sounds in humans. They showed both theoretically and experimentally that pressure changes would result from the absorption of RF pulses which could produce significant acoustic energy in the solution. They concluded that audible sounds were produced by rapid thermal expansion, resulting from only a 5×10^{-6} °C temperature rise in the physiological solution, due to absorption of the energy in the RF pulse. This conclusion led to their proposal that thermoelastic expansion is the mechanism for RF hearing. This mechanism is consistent with the following results.

1) RF pulses that would elicit sounds perceived by a human produced acoustic transients recorded with a hydrophone immersed in a solution (0.15 N KCl) having an electrical conductivity similar to that of tissue. In addition, acoustic transients were detected in blood, muscle, and brain exposed *in vitro* to pulses of RF energy.

2) The RF-induced pressure wave generated in distilled water inverted in phase when the water was cooled below 4 °C, and the response vanished at 4 °C, in agreement with the temperature dependence of the thermoelastic properties of water.

3) The thermoelastic theory predicts that the maximal pressure in the medium is

4) proportional to the total energy of the pulse for short pulses and is proportional to the peak power for long pulses. The relationship between pulse width and the RF-generated acoustic transient in the KCl solution was consistent with the theory.

Based on these findings, Foster and Finch concluded that RF-induced sounds involve perception, via bone conduction, of the thermally generated sound transients caused by the absorption of energy in RF pulses. The pulse can be sufficiently brief (50 μs) such that the maximum increase in tissue temperature after each pulse is very small (<10^{-5} ^{o}C). The peak power intensity of the pulse, however, must be moderately intense (typically 500 to 5000 mW/cm^2 at the surface of the head). These values are within the range of effective peak power intensities of 90-50,000 mW/cm^2 in the human studies shown in Table 1.

A year before the thermoelastic theory was proposed by Foster and Finch (1974), Frey and Messenger (1973) published the results of a human study that are in agreement with the theory. That is, the loudness of the RF hearing sensation in the human subjects depended upon the incident-peak-power density for pulse widths <30 μs; for shorter pulses, their data show that loudness is a function of the total energy per pulse. The threshold dependence on pulse width reported by Chou and Guy (1979) is in agreement with the predictions of the thermoelastic mechanism. They showed that the threshold for RF hearing in guinea pigs, as measured by auditory brainstem-evoked electrical responses, is related to the incident energy per pulse for pulse widths <30 μs and is related to the peak power for longer pulses.

The results on threshold and loudness may be summarized as follows. The energy in the first 30 μs or so of the pulse determines the threshold and loudness levels regardless of pulse widths greater than about 30 μs. For wider pulses (>90 μs), loudness is related to peak power rather than energy because the energy associated with the first 30 μs of the pulse increases directly with peak power. Thus, if sufficient energy is deposited within a 30-μs period, an RF-induced sound will result without regard to pulse width. And, for pulses >30 μs, loudness increases with an increase in peak power. Thus, the auditory response undergoes a gradual transition from an energy-related effect at pulse widths <30 μs to an effect dependent on peak power at pulse widths >90 μs (Frey and Messenger, 1973; Chou and Guy, 1979).

A psychophysical experiment with 18 subjects examined the adequacy of the thermoelastic hypothesis and the perceptual qualities of RF-induced sounds (Tyazhelov et al., 1979). Audiofrequency signals were presented alternately to or concurrently with microwave pulses (see Table 1) under conditions in which the subject could adjust the amplitude, frequency, and phase of the audio signal. Long pulses (~100 μs) resulted in a lower pitch of the RF sound and two subjects who had a high-frequency auditory limit of 10 kHz could not hear short RF pulses but could hear long pulses. These observations on human perception of long pulses are consistent with the results of electrophysiological responses in cats, that is, long pulses of 250 to 300 μs led to a decrease in sensitivity of high-frequency auditory responses (Lebovitz and Seaman 1977). Tyazhelov et al. (1979) concluded that the thermoelastic hypothesis adequately explained some of their findings for RF pulses of high peak power and short width (<50 μs), but they questioned the applicability of the hypothesis to some observations involving near-threshold pulses of low-power, long-duration, and high-repetition rate [see Chou et al. (1982) for a critique of Tyazhelov et al. (1979)]. In a subsequent paper, Tyazhelov and colleagues suggested that the thermoelastic theory accounted for the low frequency, but not the high frequency, RF sounds (Khizhnyak et al., 1980); however, no other reports have been found that support their proposed model for high frequency RF sounds.

Other animal studies, in addition to those already discussed, support and extend our understanding of RF hearing and the thermoelastic mechanism. Several investigators have determined the threshold for the RF-induced auditory sensation in laboratory animals (Table 2). In cats exposed to pulses of 918- and 2450-MHz radiation, the threshold was related to the incident energy density per pulse. The cat's threshold energy density per pulse was about one-half of the human threshold (Guy et al., 1975). The thresholds in Cain and Rissmann (1978) are in general agreement with the results in Guy et al. (1975), but a lower threshold was reported by Seaman and Lebovitz (1989). At higher frequencies between 8670 and 9160 MHz, Guy et al. (1975b) found that the threshold values of power density and of energy density per pulse were an order of magnitude higher than those at 918 and 2450 MHz (Table 2), but it is noted that no auditory response was obtained at the two higher frequencies unless the brain was exposed by removing part of the skull.

In guinea pigs, the threshold dependence on pulse width was found to be in agreement with the predictions of the thermoelastic expansion mechanism; that is, the threshold was related to the incident energy per pulse for short pulse widths (<30 μs) and was related to the peak power for longer pulses. At the shortest pulse width (10 μs), the threshold was about 6 μJ/g (Chou and Guy, 1979).

Chou et al. (1985) documented the dose response relationship of the auditory brainstem-evoked response (BER) in rats exposed to pulses of 2450 MHz fields in circularly polarized waveguides. The results were consistent with the thermal expansion theory because the same BER response was evoked when the incident energy density or absorbed energy density per pulse was the same, regardless of pulse width.

By measuring acoustic pressure waves with a miniature hydrophone transducer implanted in the brains of rats, cats and guinea pigs exposed to pulses of RF energy, Olsen and Lin (1983) confirmed earlier theoretical predictions of pressure waves in the head. In later work, Lin et al. (1988) observed that the speed of RF-induced pressure waves in the cat brain was similar to that of conventional acoustic wave propagation. These results support the thermoelastic expansion theory.

The hypothesis of Foster and Finch (1974) predicts that the RF hearing effect is related to thermoelastically induced mechanical vibrations in the head. Vibrations of this type can be produced by other means, such as by a laser pulse or by a pulsed piezoelectric crystal in contact with the skull (Chou et al., 1976). Frey and Coren (1979) used a holographic technique to test whether the skull and the tissues of the head of an animal have the predicted vibrations when exposed to a pulsed RF field. No displacements were recorded, but a subsequent paper by Chou et al. (1980) demonstrated that the holographic technique used by Frey and Coren (1979) did not have the sensitivity to detect displacements related to vibrations from microwave-induced thermoelastic expansion in biological tissues.

Wilson *et al.* (1980) described an autoradiographic technique in which [^{14}C]2-deoxy-D-glucose was used to map auditory activity in the brain of rats exposed to acoustic stimuli and to pulsed- and continuous-wave radiation. With this technique, *in vivo* determination of metabolic activity (i.e., glucose utilization and associated functional activity in the brain) can be visualized. Prior to exposure to the acoustic stimuli or to microwaves, one middle ear was ablated to block detection of sound waves in one side of the head. The expected bilateral asymmetry of radioactive tracer uptake in the auditory system of rats exposed to acoustic clicks or weak background noise was demonstrated. In contrast, a symmetrical uptake of tracer was found in the brain of animals exposed to pulsed radiation. These autoradiographic results confirmed the finding that RF hearing does not involve the middle ear (Frey, 1961; Chou and Galambos, 1979). Unexpectedly, Wilson et al. (1980) found similar patterns of radioactive tracer uptake in the auditory system of rats exposed to continuous wave radiation and to pulsed radiation. These results with a continuous wave field, however, have not been independently replicated and there are no known reports of continuous wave signals causing RF-induced sound in humans or experimental animals.

In summary, evidence from both human and laboratory animal studies indicates that thermoelastic expansion is the mechanism that explains the RF hearing phenomenon. The evidence includes measurements of acoustic transients in water, physiological (KCl) solution, and tissues (Foster and Finch, 1974) as well as in muscle-simulating materials (Olsen and Hammer, 1980); the relationship of the threshold value to pulse duration (Foster and Finch,1974; Frey and Messenger, 1973; Chou and Guy, 1979); the characteristics of the RF-induced cochear microphonics in laboratory animals (Chou et al., 1975, 1977) and calculations of the fundamental frequencies in the human head (Lin 1978; Chou et al., 1977) that correlate well with the perception of high frequency sounds in the kHz range.

SIGNIFICANCE OF RF HEARING

The potential for human exposure to pulsed fields that could induce RF hearing raises two questions in regard to the significance of the effect. One, what is the psychological impact of RF sounds? Two, aside from the perception of sounds, what is the physiological significance of exposure to pulsed RF radiation at intensities at and above the threshold for hearing?

The perception of RF sounds at threshold exposure levels is considered to be a biological effect without a health effect and, therefore, is not an adverse effect.[1] This conclusion is based on the following points. The sounds associated with RF hearing are not unusual but are similar to other common sounds such as a click, buzz, hiss, knock or chirp (see Table 1). Furthermore, RF hearing can be characterized as the perception of subtle sounds because, in general, a quiet environment is required for the sounds to be heard. It was noted in this review that most of the human subjects in the studies listed in Table 1 used earplugs to create conditions sufficiently quiet to hear RF sounds. The apparent location of the sounds, however, may vary from within, behind or above the head. Under some exposure situations that may lead to prolonged periods of RF sounds, the sounds might become an annoyance but our knowledge of the effective exposure conditions is sufficient to develop measures to eliminate RF sounds determined to be annoying. One solution is to move farther away from the source. A review of the human studies in Table 1 reveals that most of the studies were done in laboratory settings in which the subjects were a few feet from the RF antenna. In three of the four field studies, the distance of the subjects from the radar ranged from about six feet up to several hundred feet. Such close proximity was needed to achieve the effective, moderately high, peak power intensities ranging from 90-50,000 mW/cm^2 (see Table 1). This information on distance and effective exposure levels indicates that anyone

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[1] An adverse effect is a biological effect characterized by a harmful change in health. For example, such changes can include organic disease, impaired mental function, behavioral dysfunction, reduced longevity, and defective or deficient reproduction. Adverse effects do not include: 1. Biological effects without a health effect. 2. Changes in subjective feelings of well-being that are a result of anxiety about RF effects or impacts of RF infrastructure that are not related to RF emissions. 3. Indirect effects caused by electromagnetic interference with electronic devices. These indirect effects are covered by other standards. (This definition was developed by the IEEE CES SCC28/SC4 Revision Working Group.)

reporting RF hearing would be relatively close to a pulsed source operating in the 216 –10,000 MHz range (Table 1). If it is not possible to increase the distance from the source, remediation measures could include metal shielding and changes in the operating procedure of the RF device.

Aside from the perception of sound, it is important to address the physiological significance of exposure to RF pulses at the threshold for hearing. One approach is to compare the magnitude of the pressure of the RF-induced acoustic wave in the head to pressures from other sources. Based on calculated pressures resulting from the absorbed energy of 915-MHz pulses in human head models, Watanabe et al. (2000) found the RF-induced pressure at the hearing threshold to be only 0.18 Pa. This threshold value is more than 42,000X lower than ultrasound-induced pressure (7700 Pa, spatial peak temporal average) during medical diagnosis, which includes exposure of the fetus; the factor would be much greater if the comparison was to the higher spatial peak temporal power of the ultrasound pulses. Another comparison shows that the pressure at the RF hearing threshold is 1,000,000X lower than the pressures at the surface of the brain that produce changes in the EEG and moderate brain damage (1.5×10^5 Pa and 3×10^5 Pa, respectively) based on studies of traumatic head injury (see Raslear et al., 1993, p. 476). When compared to pressures exerted by medical ultrasound exposure and traumatic injury, it is highly unlikely that the RF hearing effect at the threshold level is hazardous with regard to the strength of the pressure waves, the dominant force in comparison to electrostrictive force and radiation pressure (see Guy et al., 1975; Gandhi and Riazi, 1986). The comparison with ultrasound pressures suggests that RF-induced pressures would have to be several orders of magnitude greater than the pressure at the hearing threshold to cause adverse effects.

Very high intensity RF pulses will induce adverse effects such as convulsions and a state of unconsciousness (stun effect) as demonstrated by Guy and Chou (1982). These authors determined the threshold for these effects in rats exposed to a single, high intensity, 915-MHz pulse that caused an elevation in brain temperature of 8 ^{o}C resulting in petit or grand mal seizures lasting for one minute after exposure, followed by a four-to-five-minute unconscious state. The brain temperature returned to normal within five minutes after exposure and the animals began moving when the brain temperature returned to within 1 ^{o}C of normal. Limited histopathological examination of four exposed rats revealed significant changes including neuronal demyelination at one day after exposure and brain swelling at one month after exposure. The threshold for the stun effect was 680 J, regardless of peak power and pulse width, or about 28 kJ/kg, expressed in terms of peak specific absorption. The stun threshold, a clearly adverse effect, is about 100,000X higher than the thresholds for auditory responses in rats (5-180 mJ/kg) and humans (16 mJ/kg) (Guy et al., 1975).

Small but significant changes in the otoacoustic emissions from the cochlea may serve as an indicator of outer hair cell subclinical or clinical pathology. A recently published paper found no functional changes in otoacoutic emissions of RF-exposed rats at average SARs in the head of 0.2 (950 MHz) and 1 W/kg (936 and 950 MHz) (Marino et al., 2000). Although the field was not pulsed and RF sounds would not occur, this report is important because it addresses potentially functional effects in the auditory system of exposed animals.

CONCLUSIONS

Human perception of pulses of RF radiation is a well-established phenomenon that is not an adverse effect. RF-induced sounds are similar to other common sounds such as a click, buzz, hiss, knock or chirp. Furthermore, the phenomenon can be characterized as the perception of subtle sounds because, in general, a quiet environment is required for the sounds to be heard.

The detection of RF-induced auditory sensations is similar to acoustic sound detection once the cochlea is stimulated; however, the site of conversion from RF to acoustic energy is peripheral to the cochlea. To hear the sounds, individuals must be capable of hearing high-frequency acoustic waves in the kHz range and the exposure to pulsed RF fields must be in the MHz range. The effective radiofrequencies reported in the literature range from 216 to 10,000 MHz.

The hearing phenomenon depends on the energy in a single pulse and not on average power density. Guy et al. (1975) found that the threshold for RF-induced hearing of pulsed 2450-MHz radiation was related to an energy density of 40 $\mu J/cm^2$ per pulse, or energy absorption per pulse of 16 $\mu J/g$.

The thermoelastic expansion theory explains the phenomenon, that is, audible sounds are produced by rapid thermal expansion, resulting from only a 5×10^{-6} ^{o}C temperature rise in tissue due to absorption of the energy in the RF pulse. The experimental weight-of-evidence does not support direct stimulation of the central nervous system by RF pulses. No published reports support the suggestion by Tyazhelov et al. (1979) that the theory does not explain all characteristics of RF hearing.

A comparison with routine ultrasound pressures during medical diagnosis, including exposure of the fetus, suggests that RF-induced pressures more than about five orders of magnitude greater than the pressure at the hearing threshold would be unlikely to cause significant biological effects.

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Table 1. Summary of Human Studies Describing Auditory Effects of Pulsed RF Radiation

Effect	Comment	Number of Subjects	Exposure Conditions: Frequency (MHz)	Pulse Repetition Rate (s^{-1})	Pulse Width (us)	Peak Power Density (mW/cm^2)	Av. Power Density (mW/cm^2)	Energy Density Per Pulse ($\mu J/cm^2$)	Noise Level (dB)	Reference
RF hearing: heard repetition rate of radar as "high frequency components"		Not given	1,300	600	2	(peak power ~0.5 MW)				Airborne Instruments Lab (1956)
RF hearing: "distinct" clicks	Threshold Values	8	3,000	0.5	5 10 15	2500 225-2,000 300-1,000	0.006 0.001-0.01 0.002-0.007	12.5 2.3-20.0 4.5-15.0	45 (+plastic foam earmuffs)	Cain and Rissmann (1978); Rissmann and Cain (1975)
RF hearing: buzz heard at PRR>100; individual pulses heard at PRR<100		3	3,000 6,500	<100-1,000 <100-1,000	1-2 1-2	2,500-50,000 2,500-50,000	5 5	40		Constant (1967)
No auditory response			3,000 6,500	<100-1,000 <100-1,000	0.5 0.5	10,000-100,000 10,000-100,000	5 5			
No auditory Response			9,500	<100-1,000	0.5-2	2,500-100,000	5			
RF hearing: "buzz, clicking, hiss, or knocking"	Threshold values	Not given	216 425 425 425 425	- 27 27 27 27	- 125 250 500 1,000	670 263 271 229 254	4.0 1.0 1.9 3.2 7.1		70-90 (+ear stopples)	Frey (1962,1963)
No auditory Response			8,900	400	2.5	25,000	25		70-90 (+ear stopples)	Frey (1962)
RF hearing: Matched RF sound to 4.8 kHz acoustic sounds	Subjects were trained musicians	3	1,200		12.5-50		<0.5			Frey and Eichert (1985)
RF hearing: "buzzing sound"		4	1,245 1,245	50 50	10 70	370 90	0.19 0.32			Frey and Messenger (1973)
RF hearing: "clicks, chirps"	Threshold values	2	2,450	3	1-32	1,250-40,000	0.1	40*	45	Guy *et al.* (1975)
RF hearing: Buzz	Threshold values (not at 10 GHz)	Not given	1,310 2,982 10,000	244 400 -	6 1 -	(12 v/cm) (18 v/cm)	0.3 0.18 -			Ingalls (1967)
RF hearing: "tinitus"		Not given	-	100-20,000	10-160	-	-			Khizhnyak et al. (1980)
RF hearing: polytonal sound		18	800	1,000-1,200	10-30	>500	-	-	40 (+ear stopples)	Tyazhelov *et al.* (1979)

*Calculated peak-absorbed-energy density per pulse is 16 mJ/kg.

Table 2. Summary of Studies Concerning Threshold Values for Auditory-Evoked Potentials in Animals

Effect	Species (n)	Exposure Conditions: Frequency (MHz)	Repetition Rate (s^{-1})	Pulse Width (µs)	Peak Power Density (mW/cm^2)	Av. Power Density (mW/cm^2)	Energy Density Per Pulse ($\mu J/cm^2$)	Peak Absorbed Energy y Density Per (µJ/g)	Reference
Response obtained with scalp electrodes	Cat (2) [also dog and chinchill a]	3000	0.5	5 10 15	2,200, 2,800 1,300 580		11, 14 13 8.7		Cain and Rissmann (1978); Rissmann and Cain (1975)
Response obtained from round window with carbon lead	Guinea pig (5)	918	100	1-10	*	*		20	Chou *et al.* 1975)
Response obtained with carbon-loaded Teflon electrodes	Guinea pig (n not given)	918	30	10-500	62-156	0.02-1.4	1.56-46.8	6-180	Chou and Guy (1979)
Electrode implanted in brain stem	Cat (11)	1200-1525	12-130	10	60	0.03			Frey (1967)
Response obtained from medial geniculate with glass electrode	Cat (2)	918 2450 8,670-9,160	1 1 1	3-32 0.5-32 32	800-5,800 600-35,6000 14,800-38,800	0.017-0.028 0.015-0.047 0.472-1.24	17.4-28.3 15.2-47.0 472-1,240	12-3-20.0 8.7-26.7	Guy *et al.* (1975)
Response obtained from individual auditory neurons with glass electrode	Cat (n not given)	915	<10	25-250	-	1.0	-	4-40	Lebovitz and Seaman (1977)
Neuronal action potentials in cochlea	Cat	915		20-700				0.6	Seaman and Lebovitz (1989)

*Direct comparison of power density in the circular waveguide exposure system to free-field power density is improper because the efficiency of energy coupling is 10 times higher than for free-field exposure (See Chou et al. 1975, p. 362).

Wi-Fi –
A Thalidomide in the Making.
Who Cares?

Barrie Trower

September 2013

With Deference to all Scientists: this Research Report has been written for all students and non-scientists to understand.

2013

1

= 400,000 FOLLICLES
= 400 TO MATURE
= 14 EACH CYCLE TO PRODUCE EGG(S) WHICH CAN BE FERTILIZED

CHILD 'A' 5-16 YEARS EXPOSED TO WI-FI IN SCHOOL
Possible damage to first and subsequent generations.

Microwave irradiation can cause oxidative and nitrosative stress to mitochondria - this DNA is 10x more susceptible to low level chronic microwave radiation than other DNA.

Low histone protein content i.e. mitochondropathy N_2 O_2 is essential for brain / immune system, any DNA damage is irreparable and can pass to every female hence forth.

57.7%

2

* PHOTOSENSITIVE GANGLIONS ABSORB RAD: EFFECT BODY FUNCTIONS → *40d = Eye

CHILD 'B' FOETUS FROM CHILD 'A' NOW AS A PREGNANT STUDENT/ADULT
With possible DNA damage

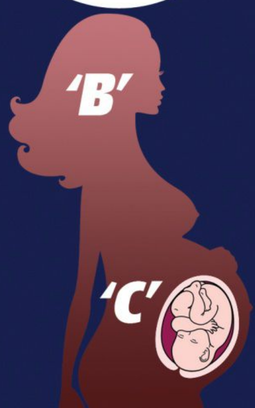
- 100 days for follicles to form: no definite structure thence 150+120 d. to mature
- No protein 53 (x4) to fight radiation
- No nuclear core complex (x30) proteins for defence
- No factor 1 protein* (apoptosis)
- Of 100,000 protein structures only 600 are known

7d = 100 Cells
28d = Heart
*40d = Eye
47d = fingers / toes

Body is initially inside out, i.e. major organs are the most irradiated

Woman may not know she is pregnant at this stage: Hence no precautions taken

3



CHILD 'B' IS NOW PREGNANT CHILD 'C'
Adult Child C may already have been irradiated

- Every aspect of Child 'C''s life has been at maximum risk from stages 1,2 & 3.
- The greatest risk is yet to come. Biggest danger from school wi-fi irradiation on students and teachers

1st 56 days is when all embryos are most vulnerable. During the first 4-6 weeks, the mother may not know she is pregnant, therefore will not shield the embryo from radiation

25+ years

Wifi – a Thalidomide in the Making – Who Cares?

Professor John R Goldsmith, International / Advisor Consultant for R.F. Communication, Epidemiology and Communications Sciences Advisor to the World Health Organisation, Military and University Advisor, Researcher; wrote concerning the low level exposure of microwave irradiation (below thermal level) incident upon women:

> "*Of the microwave-exposed women, 47.7% had miscarriages prior to the 7th week of pregnancy....*"(1)

The level of irradiation incident upon the women was stated, as from, five microwatts per centimetre squared. This level of irradiation may seem meaningless to a non-scientist; however, when I say that it is below what most schoolgirls will receive in a classroom of wi-fi transmitters, from the age of approximately five years upwards, this level becomes more meaningful.

A distinction here must be made and a very important one: schoolgirls are not women. Schoolgirls are children and children are both neurologically and physiologically different from adults. A child's brain tissue / bone marrow has different electrical conductivity properties than adults due to the higher water content (2) (this renders the Specific Absorption Rate obsolete). Children's absorption of microwave radiation can be ten times higher than adults. Permanent low-level microwave exposure can induce chronic nitrosative and oxidative 'stress' thence, damage the cellular mitochondria (mitochondropathy). This 'stress' can cause irreversible mitochondrial DNA damage (mitochondrial DNA is ten times more susceptible to oxidative and nitrosative 'stress' than the DNA in the cell nucleus). Mitochondrial DNA is irreparable due to its low histone protein content, therefore any damage (genetic or otherwise) can be transmitted to all successive generations through the maternal line. (3)

Hence, we are subjecting each successive female generation to harm. Whether these two ten-fold increases 'merge' to become 57.7% or are additional, thence equal 67.7% of those to suffer, is a moot point. Either way we are facing the equivalent of a pandemic. I was invited to present a lecture at Brighton University recently and one Doctor commented on a +60% foetal birth rate damage from exposed farm animals. All mammalian species will of course suffer the same consequence resulting from low-level microwave irradiation. There is very little difference 'biologically' between our embryonic cells.

I invite the Reader to peruse my diagram and / or read my simple explanation concerning the microwaving of the ovarian follicles in schoolgirls.

Simple Explanation

Imagine you are five years old, in school and sitting with a wi-fi laptop near your abdomen. Theoretically, your ovaries can become irradiated until you leave school at aged 16-18 years old. When you become pregnant, every one of your follicles (to become eggs) will have been microwaved. Hence, you may or may not deliver a healthy child.

Should you become a pregnant as a student, your embryo (for its first 100 days – if it is female) is producing approximately 400,000 follicles (within its ovaries) for future child-birth.

The problem is that these developing follicle cells do not have the cellular protection of mature adult cells. Consequently your 'Grandchild' may have had every single follicle cell irradiated and damaged prior to its conception. Therefore when your child becomes an adult (with its irradiated follicles) there is a greater likelihood of its child (your Grand-daughter) suffering the ailments previously mentioned, during conception / embryonic and foetal development stages.

Beyond Belief

The shocking truth is, not only was all of this known and documented long before wi-fi was ever put in front of children, but the dangerous biological effects were concealed (as they are to this day) from the general public, in order to protect the industries profit.

Professor Goldsmith writes:

> "*.....effects from exposure to RF radiation in certain populations: reproductive effects.....increased spontaneous abortion.....increased incidence of childhood and other cancers.....*" (1)

Confirming this with more than 2000 references is the Naval Medical Research Institute in their document: 'Bibliography of Reported Biological Phenomena (Effects) and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation' highlight '......Altered Menstrual Activity / Altered Foetal Development.....' (4)

The World Health Organization's 'International Symposium' Research Agreement No. 05-609-04 'Biological Effects and Health Hazards of Microwave Radiation' emphasizes in its 350 pages: Biological effects, health and excess mortality from artificial irradiation of Radio Frequency Microwaves. Section 28 deals with problems concerning Reproductive Function.

This document was classed as 'Top Secret' and its contents withheld by WHO and ICNIRP (International Commission on Non-Ionizing Radiation Protection). (5)

Eldon Byrd, a scientist for the Naval Surface Weapon Centre of the US Navy, in one of his 1986 lectures on the effects of low-level microwaves, is referenced as stating:

> '*.....we can alter the behaviour of cells, tissue.....cause up to six times higher foetus mortality and birth defects....*'. (6)

Finally, the Mobile Telecommunications Industry carried out a very thorough and exhaustive scientific study on its own product. This industries conclusion was:

> Sec. 7 "*.....it can be concluded that electro-magnetic fields with frequencies in the mobile telecommunications range do play a role in the development of cancer.*"
>
> "*.....Direct damage on the DNA as well as influences on the DNA synthesis and DNA repair mechanisms.....*" (7)
> (Note I have underscored the relevant words here.)

Note: DNA synthesis is essential for healthy embryonic / foetal / child's growth.

With these few of the roughly 8000 research articles showing this phenomena; in order to protect this industries' profit, the United States Defence Intelligence Agency sent a 'document' to 'advanced nations' describing the problem and suggesting 'how to deceive the public'.

It read:

> "*.....if the more advanced nations of the West are strict in the enforcement of stringent exposure standards, there could be unfavourable effects on industrial output.....exposed to microwave radiation below thermal levels experience more.....*" (8)

NB: Industrial output is of course...profit. A very relaxed exposure standard also makes it very difficult to take the industry to court.

This (and two other documents with ref. 8) then continues to list many physiological and neurological dangers from low-level: below thermal, microwave irradiation inc: blood disorders, heart problems, psychiatric symptoms and 'menstrual disorders'.

<u>Wi-fi is of course, below thermal low-level microwave irradiation.</u>

In order to appease the US Government, some Governments adopted the ICNIRP guideline, whereby, the only safety limit is just six-minutes of warming. Which means: if you do not feel too warm in six minutes, wi-fi is deemed to be safe.

No consideration at all has been given to the published 'below thermal' cellular interaction as listed by several countries including the United States; which were (and are) known to cause: cancer, severe neuropathological symptoms, foetal defects and literally hundreds of illnesses related to cellular disorders.

Countries following ICNIRP continue to argue that their six minute warming effect is all that is required regarding microwave irradiation.

Should the Reader be wondering whether I am 'as mad as a box of frogs' and thinking 'no government would ever harm its citizens for money, especially pregnant women'; I invite the Reader to investigate Government decisions behind: smoking, asbestos, BSE (mad-cow disease), lead in petrol, experiments on 20,000 UK serving military personnel serving in the 1960's, thalidomide and of course Agent Orange sprayed over the food crops in Vietnam. To this day, many global birth defects stem from these Government / Government Scientific / Military decisions: <u>with industrial advisors</u>.

If further evidence is required, I invite the Reader to read documents released under the Freedom of Information Act; namely, Operations: Pandora, MK Ultra, MK Chaos, Cointelpro, MK Delta, MK Naomi, MK Search, Bluebird, Artichoke, Chatter, Sleeping Beauty and Grill Flame.

Here, secret experiments carried out by the Military / Government scientists upon unsuspecting civilians, namely: students, servicemen, psychiatric patients, poor, children over the age of 4 years, pregnant women, Muslims, Catholics, prisoners, handicapped, deaf, blind, homosexuals, single women, elderly, school children, 'marginal groups' and dissidents; served to increase their knowledge and understanding of; what is commonly known as...Stealth Warfare.

Progress on the study of illnesses caused by low-level microwave irradiation continues to this day. One current study on cancer and neurological harm continues until 2018 and involves women who could be pregnant. (9)

Progress Reports are also fed back to Governmental Scientists:

> "*.....students will understand the nature of RF...bioeffects research, including human / animal studies.....students will become familiar with current state of knowledge on potential health effects RF, such as cancer, memory loss, and birth defects.*" (10)

NB: RF has become a generic term (Radio Frequency) to avoid using the term 'microwave'. It poses less 'safety queries' as the word 'radio' itself, which used to refer to 'long wave radio' was domestically non threatening.

Intentional Ignorance

Governmental Intransigence forces a moratorium upon the risks of exposure to future generations. Both the Communications Industry and Governmental studies have proved that protein synthesis (the using of chemical structures to 'build' the roughly 4050 foetal and 4500 adults designated biological / neurological structures) can be influenced by low-level microwave irradiation. This moratorium seems to spread to organizations either relying on Governmental funding, or for whatever reason; acquiescence. However, not all research departments suppress the truth.

A brilliant paper published by Dundee University confirms that low-level microwave irradiation, unable to cause any heating (thermal) effect, can affect cellular signalling processes. (11)

The Main Risks to Children

These biological processes described as being 'influenced' by low-level microwave irradiation may not just damage foetal growth; relying on the same biological processes are:

> <u>Blood Brain Barrier</u> – requires 18 months to form and protects the brain from toxins. It is known to be effected.
> <u>Myelin Sheath</u> – requires 22 years to build its 122 layers. It is responsible for all thinking, organ and muscle processes.
> <u>Brain</u> – requires 20 years to develop (I can assure you, cell phones do not help in its development).
> <u>Immune System</u> – requires 18 years to develop. Bone marrow and Bone Density are known to be affected by low-level microwaves as are the immune systems' white blood cells.
> <u>Bones</u> – requires 28 years to develop – as mentioned the moisture content of children makes both the 'soft bones' and marrow particularly attractive to microwave irradiation. Bone marrow produces blood cells.

Clearly, our decision makers are overlooking a child illness pandemic hitherto unknown in our 40,000 generations of civilization; which can involve over a half of the World's exposed mothers / children.

The Very Sad Truth

I have been very honoured to address approximately 40 Royals, Governments, Leaders of Governments, Leaders of Peoples and Government Officials over the years.

My address (text) to one King concerning the numbers of ill children was placed on the internet. (12)

I referenced over 200 cancer / leukaemia clusters in schools (up to the time of data collection) from low level microwave transmitters in schools. There were many different types of cancers, leukaemias, miscarriages and breast cancers of staff. These continue, mostly only recorded locally, to this day.

When this was discussed in the English Parliament (as one of the EU Countries involved), a Minister dismissed it and lied to the House of Commons. My request to prove this lie was denied.

Possibly, the most respected children's charity in the World: UNICEF, joined forces with the World's leading authority on the effects of harm from low-level microwave irradiation:

The Russian National Committee on Non-Ionizing Radiation Protection: in their research document 'Health Effect on Children and Teenagers' found;

> 85% increase in Central Nervous System Disorders
> 36% increase in epilepsy
> 11% increase in mental retardation
> 82% increase in blood immune disorders and <u>Risk to Foetus</u>. (13)

NB. The Reader may think that the cell phone irradiation is different from wi-fi as it has more power. In fact wi-fi can be <u>more</u> harmful because of its lower power! Low power can enter the body and cause harm. All electromagnetic waves are accumulative. If they are <u>below</u> the body's threshold to cause activation of the necessary proteins required to defend and repair tissues, the damage accumulates very slowly and is undetectable like a cancer. Think of sunbathing on a cloudy day, you can still burn your skin.

The Good Guys

I have a list of nine countries (some of whom I am working with) who are actively, either taking wi-fi out of schools or in the legal argument-stage of this process. I decline to publically name these countries as my actions may interfere with their legal negotiations.

The Parliamentary Assembly (Assemblee Parlimentaire) Council of Europe Document 12608, published on 6.5.2011 in section 8.3.2. states:

> *'.....ban all mobile phones, DECTphones or Wi-Fi or WLAN systems from classrooms and schools.....'*

For legal reasons this had to be changed to a 'wired system is preferred'. However, the meaning is clear.

In a translated document, Professor Yuri Grigoriev of the Russian Committee for Non Ionizing Radiation Protection wrote on 19.6.2012

> *'.....recommend the use of wired networks and not networks using the wireless broadband access systems, including wi-fi, in schools and educational establishments.'*

A document dated 25.3.2013 (updated from 19.3.2013) by the Executive Committee of the American Academy of Environmental Medicine wrote a letter to the Los Angeles Unified School District with the following recommendation:

> *'.....do not add to the burden of public health by installing blanket wireless internet connections in Los Angeles Schools.'*

Just prior to this in December 2012 the American Academy of Pediatrics (representing 60,000 Paediatricians) wrote to Congress requesting more protection from low-level microwave irradiation for children and pregnant women: with regard to wi-fi in schools, they write:

> *'.....this is an unprecedented exposure with unknown outcome on the health and reproductive potential of a generation.'* (14)

In 2002, 36,000 Physicians and Scientists etc. signed the 'Freiburg Appeal'. Ten years hence, it has been re-launched. It specifically warns against the use of Wi-fi and the irradiation of children, adolescents and pregnant women. 'Freiburg' is an International Doctors' Appeal.

The Reader will appreciate that collectively there are approximately 100,000 of the World's most knowledgeable professionals expostulating this same warning.

As an aside, should the Reader be wondering why I have not mentioned school-boys and whether they can be affected in a similar way to girls: the answer is 'yes'.

DNA sperm fragmentation from wi-fi levels of irradiation, have been published. (15) It would require many more pages to comment upon this phenomenon and there is already a plethora of data both available and published.

Pulsing / Modulations

During the ‘Cold War’ conflict, whilst I was collating effects from microwave pulses / modulations caused by brain entrainment, resonance (both cyclotronic and circadian), rectification (at boundaries within the body) generated by electrically induced phase transition; it came to my attention that a list needed to be published for all microwave communication systems. (16)

In this Open Letter, I list 1 to 40 Hz (pulses / modulations per second) and their corresponding neurological / physiological response.

In his most explanatorily descriptive paper, Dr. Andrew Goldsworthy writes.....

> ‘*.....For example, Grigoriev et. Al. (2010) showed that 30 days exposure to unmodulated 2450 MHz microwave radiation triggered a small but significant increase in anti-brain antibodies in the blood of rats.....which could then result in an auto immune attack on the brain and / or nervous system. An example of an auto immune disease of the brain is Graves disease in which the pituitary gland (at the base of the brain) is affected.*’ (17)

NB. 2450 M Hz is the wi-fi frequency.

If you add the pulse / modulation frequency to the above; fatigue, depression, psychiatric problems (such as anger), loss of appetite and problems with movement can also be induced.

The Bad Guys

With gargantuan profits to be made, it is of no surprise that the English Parliamentary system choose to follow ICNIRP and their well established ‘Active Denial’ policy.

I became familiar with our ‘corruption’ when during the late 60’s – 70’s, I was commissioned to investigate (under a programme initiated by Sir William Melvin (1911)) corruption within the hierarchy of the London Metropolitan Police and the non-elected Members of the English Parliament. Should the Reader be dismissive of such actions, I suggest looking at any of our Sunday newspapers over the past 45 years, including now.

When a Reverend lady wrote to a Minister, Nick Gibb MP, concerning Wi-fi in schools, his standard reply (which I have seen many times) stated:

“*.....advice given.....by UK Health Protection Agency..... ‘There is no consistent evidence of health effects from RF exposures below guideline levels and no reason why schools and others should not use Wi-fi equipment.*” (18)

This letter is designed to deceive (and it is very successful). Look to the words 'no consistent evidence'. Let me explain please.

If I were to carry out an experiment on every single person who went through the doors of your main airport on any busy day and told them that they must drink one pint of beer and smoke ten cigarettes a day forever; some would react immediately, especially children. Others would react over days, weeks, months and years (many years in some cases). Then there would be those who would thoroughly enjoy the experiment and probably never be ill. That does not mean that alcohol and cigarettes are safe. It shows that people are not homogenous (all alike / identical). In other words, the conclusion of my experiment would be that there is: '<u>no consistent evidence</u>'.

Other Ministerial letters usually say: "*most of our research*" or "*most of our scientists*" – both of which are equally meaningless.

What they never say is: Wi-fi is safe.

It will come as no surprise to the Reader to learn that I have been refused permission to have a face-to-face meeting with my MP, Mr Mel Stride. Hence my Member of Parliament has successfully brought the 'shutters down' on any access I may have had to Government. This act by Mr Stride became a 'feature' in our West Country newspaper by leading Journalist Paul James. (19)

During my last attempt to contact my MP, his Secretary, Dominic just hung-up the telephone on me.

Years ago, when I started to 'advise caution' re microwaving children / pregnant women; the Academic Registrar of my own University (Exeter) forbade me from ever communicating with it, ever again. A similar message came from Dr. Jamie Harle of the Open University (Medical Physics), who said: "*Your work is too political.*"

Clearly in England, some universities and some parliamentary persons are more afraid of governmental 'reprisals' than telling the truth. Regardless of the consequences.

<u>Two Womens' Stories</u>

<u>The Real Price of Intentional Ignorance and Greed. Those Consequences.</u>

Ten telephone calls a day would not be unusual for me. I even receive calls Christmas Day / Easter Sunday. Two calls which summarize those from women are illustrated below. Both are actual conversations.

i) ".....my daughter had just died. I am holding her hand. She has just had her 11^{th} birthday and she was number 11 to die since the transmitter for Wi-fi was put near her and others' desk....."

ii) "*.....my child is one of several with cancer / birth genetic problems. These only started after the transmitter was turned on. My worries are two-fold and take every second of my life. Will my child ever marry or find a partner and be happy? What will happen when I die? I know I will die worrying. Regardless of who is to blame, it is me, the Mother who carries guilt and responsibility.....*" (20)

I Ask for Readers' Help, Please.

Imagine 57.7% of all of the schoolgirls with Wi-fi in their classrooms: all day – all year – all through their school career, in every country using it, in the World!

In just two generations we could have more dead / sick infants than resulted from both World Wars. And, these are not my figures, they come from Government advisors / research.

Advanced requests for this 'Paper' have been received from Royalty, Governmental Officers (outside of the UK) and people I will describe as 'interesting'.

As shutters fall blocking every direction I try to turn, I ask: "*Can the Reader succeed in preventing this 'Pandemic' where I will fail?*"

I have two requests:

i) Would a Royal or Leading Governmental Official please ask the British Prime Minister, face to face, why he told my MP, Mr Stride, that he is 'too busy' to see me for just one hour to discuss this issue.

ii) If every Reader sends just two copies of this Paper to people who may be able make a decision (preferably influential women); with mathematical progression – the original 100 advanced requests will soon land on a desk of somebody who can make a difference.

International Challenge

When I am invited to speak in countries, I invariably end up on the radio / TV news / documentary channels. Thence, I issue a challenge:

I ask for any scientist(s) from industry / government to 'humiliate' me live 'on-air' with their expert knowledge by answering one question:

"*What is the safe level of microwave irradiation for the ovarian follicles during the first 100 days development of the embryo?*"

To date, not a single scientist will appear and face me.

I mention this because it is a question the Reader can ask any decision maker, school Principal / Governor etc.

Should any person provide the answer, the next statement is:

"*Fine – we will send it to a Leading Scientific Journal for independent Peer Review.*" (With your research). (21)

The Solution

Education need not suffer if Wi-fi is withdrawn world-wide. We have telephone lines – fibre-optic cable.

The argument against these options is the cost. Compared to the future medical costs (forgetting the human cost), phone / fibre-cable shows to be a very cheap option.

Thank you.

Barrie Trower
3 Flowers Meadow
Liverton
Devon TQ12 6UP
United Kingdom

In UK - 01626 821014
World – 00 44 1626 821014

One Reader may be the person who achieves more to help humanity than any other modern day individual.

September 1st 2013

Epilogue

Please note – I have always worked free of charge and will represent any person in the world without cost.

PLEASE SEE ADDENDUM

Addendum – Recent Publications

Professors' / Doctors' Panagopoulos, Johnasson and Carlo describe in their (June 2013 Published) Paper – how man-made electromagnetic waves (as used in the communications industry) can cause interference, hence induced oscillations, from these polarized waves. This in turn, can induce biological alterations and render the SAR (Specific Absorption Rate) obsolete.

They write:

- *Man-made electromagnetic waves...they are polarized...*
- *....can produce interference effect...This induced oscillation will be most intense on the free particles which carry a net electric charge...a part of its energy...is transferred to the charged / polar molecules of the medium...within biological tissue there will be additional energy absorption by the water dipoles...proteins, lipids or nucleic acids, which will also be forced to oscillate by the applied field.*
- *...man-made EMF's can produce severe biological alterations such as DNA damage without heating the biological tissue...may lead to cancer, neurodegenerative deceases, reproductive declines or even heritable mutations...conductivity varies for different tissues and different field frequencies..The relative permittivity of an adult brain is calculated to be around 40 while the corresponding value for a young child's brain is between 60 and 80 resulting in almost double the radiation absorption and SAR...*
- *...SAR offers no information at all with respect to frequency, waveform or modulation...* (Ref (22))

Dr Dimitris Panagopoulos, Dep. of Biology, University of Athens also writes in his 2013 paper: Electromagnetic Interaction Between Environmental Fields and Living Systems Determines Health and Well Being:

- *Disturbances in the communication between individual body clocks can desynchronize the circadian system, which in turn may lead to unwellness, chronic fatigue, decreased performance, obesity, neuropsychiatric disorders, and the development of different diseases...*

- *...endogenous electrical balance in living organisms cannot occur in the presence of unnatural – man-made – electromagnetic pollution..... GSM mobile phone radiation is found to cause DNA damage on insect reproductive cells (gametes) and adversely affect reproduction for intensities down to 1 microwatt per centimetre squared after only a few minutes exposure.....* (Ref (23))

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DD4 5EH UK

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2013

Editors M.H Kwang and S.O Yoon

2013 Nova Sciences Publishers, Inc

Pages – i) 20   ii) 35

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http://www.activistpost.com/2013/10/34-scientific-studies-showing-adverse.html

34 Scientific Studies Showing Adverse Health Effects From Wi-Fi

Wednesday, October 30, 2013

Here is an excellent collection of scientific papers finding adverse biological effects or damage to health from Wi-Fi signals, Wi-Fi-enabled devices or Wi-Fi frequencies (2.4 or 5 GHz), complied by campaign group WiFi In Schools.

The papers listed are only those where exposures were 16V/m or below. Someone using a Wi-Fi-enabled tablet computer can be exposed to electromagnetic fields up to 16V/m. Papers are in alphabetical order. A file of first pages, for printing, can be found here.

If you feel like sending a copy of this collection to the local schools in your area, you can search for them here and either print out this article to post or email the link.

Wi-Fi papers

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With thanks to WifiInSchools.

This first appeared at Stop Smart Meters!