

US Exposures Limits A History of Their Creation

Comments and Explanations

Historical: [ANSI C95.1-1982 Exposure-Limit Standard](#)

Existing: [IEEE C95.1-1991 Exposure-Limit Standard](#)

Introduction

More than four years ago the World Health Organization (WHO) declared cellphone radiation is a Group 2B (possible) Human Carcinogen substantially based on scientific studies which found statistically significant risks of brain cancer and a hearing nerve tumor called an acoustic neuroma.

An industry consultant's response: "Dr. Meir J. Stampfer, a professor at the Harvard School of Public Health and a consultant to the cellphone industry. 'In science, unlike math, we can't have absolute certainty, but in the scheme of things, this is not a health risk I would be concerned about at all.'" [NY Times, June 6, 2011]

In 1985 the United States government adopted an exposure limit from the American National Standards Institute (ANSI-an industry & military organization), ANSI C95.1-1982 Exposure Limit Standard. In 1996 the U.S. government adopted (updated from the ANSI Standard) the IEEE C95.1-1991 Exposure Limit Standard. IEEE, the Institute of Electrical and Electronic Engineers is substantially an industry and military organization.

What follows is the history of how these two standards were created, based on the actual text of these two standards

The History

This page highlights important understandings gleaned from a review of the the [ANSI C95.1-1982 Standard](#) and [the IEEE C95.1-1991 Standard](#).

Summary of Key Findings (within ANSI and IEEE Standards):

- **The authors understood that the mean (average) SAR value ignored "hotspots"** which can be many-fold higher than the mean SAR.
- **The authors were aware of the existence of "modulation-specific effects,** such as efflux of calcium ions" (resulting in harmful effects on cells), but because the authors were mostly military and/or associated with corporations with a vested interest in promoting microwave radiation, they *chose*, in effect, to ignore these results.

- **The authors were aware that other characteristics of the exposure** such as modulation frequency and peak intensity may pose a risk to health.
- **There is no 5-fold “safety level” for the general public.** With the IEEE Standards, the general public’s exposure was reduced 5-fold compared to electrical workers. However, the allowed averaging time was increased 5-fold for the general public compared to electrical workers and the end result was that the *the total allowed absorbed radiation is identical*. In effect this change *negates* the so-called 5-fold “safety level” for the general public.

Part 1: Highlights from the [ANSI C95.1-1982 Exposure Limit Standard](#)

Note: Pdf Pages 2-8 are missing in the OCR (Optical Character Recognition) version.

[Pdf page 3](#) lists the “Co-Secretariat: Institute of Electrical and Electronic Engineers, US Department of the Navy (Naval Electronic Systems Command);

Pdf page 5 is a Forward. However it states: “This Forward is not part of ANSI C95.1-1982, American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz.”

It should be noted, in spite of its official sounding name, ANSI is not an governmental entity.

1. **1. No medical organizations were included (beyond the military) nor any public health agency.** Please note these Members of the Committee (a partial listing) which reviewed and approved this standard. (pdf page 6) :
 - American Petroleum Institute
 - DoD (Defense Nuclear Agency)
 - International Microwave Power Institute
 - Office of the Assistant Secretary of Defense
 - US Department of Commerce
 - US Department of the Air Force School of Aerospace Medicine
 - US Department of the Air Force Office of the Surgeon General
 - US Department of the Army, Army Material Command’
 - US Department of the Army, Army Environmental Hygiene Agency
 - US Department of the Navy Bureau of Medicine and Surgery
 - US Department of the Navy, Naval Sea System Command;

2. **Many Committee members were members of corporations and/or consultants to these corporations.** ([See ANSI pdf page 6](#) to read the full list of organizations and the name of person representing these organizations who reviewed and approved the standard. ANSI [Pdf page 7](#) names the members of the committee at the time the standard was approved.
3. **The mean (average) SAR value ignored “hotspots”** which can be many-fold higher than the mean SAR as noted by this statement.
 - “It is recognized, however, that a whole-body-averaged SAR is the mean of a distribution, the high side of which is an envelope of electrical hotspots.” (page 12)
4. **The exposure limit is based on an immediate (AKA acute) effect** where hungry rats trained to find food ceased looking for food. See the highlight below saying that a long-time (AKA chronic) exposure should be considered “an irreversible injury”.
 - “The assumption is that reversible disruption during an acute exposure is tantamount to irreversible injury during chronic exposure.” (Page 13)
5. **The authors were aware of “modulation-specific effects, such as efflux of calcium ions”** (resulting in harmful effects on cells), but because the authors were mostly military and/or associated with corporations with a vested interest in promoting microwave radiation, they *chose*, in effect, to ignore these results. Nevertheless, they felt obligated to report that *there were effects*. This is extraordinarily important.
 - “In addition, modulation-specific effects, such as efflux of calcium ions from brain materials were not considered adverse because of the inability of the subcommittee's members to relate them to human health. The narrow ranges of power density and the low and narrow range of modulation frequencies associated with field-induced efflux of calcium ions, and the authors' findings that the phenomenon is reversible, are factors that entered into the subcommittee's deliberations.” (Page 13, column 2)
6. **At a whole-body SAR_{WB}=4 W/kg, a potentially deadly, short-term (AKA acute) effect was found:** hungry rats trained to find food ceased eating. As noted above, a long-term (AKA chronic) exposure is “tantamount to irreversible injury.”
 - “**6.6 Safety Factor.** To ensure a wide margin of safety, an order-of-magnitude reduction in the permissible whole-body-averaged specific absorption rate (SAR) to 0.4 W /kg was invoked. This decision was nearly unanimous; one biological scientist dissented on the grounds that a specific justification should be given for the power-of-ten reduction. Different biological scientists offered different reasons, but beyond the need for a wide margin of safety, no quantitative justification was advanced. None of the members of the subcommittee offered an argument to widen the margin of safety [emphasis in original Pages 13-14].”

7. While it may appear that a 10-fold “Safety Factor” should be a sufficient reduction to provide protection against harm, Fig. A3 (page 24) contradicts this appearance. See below:

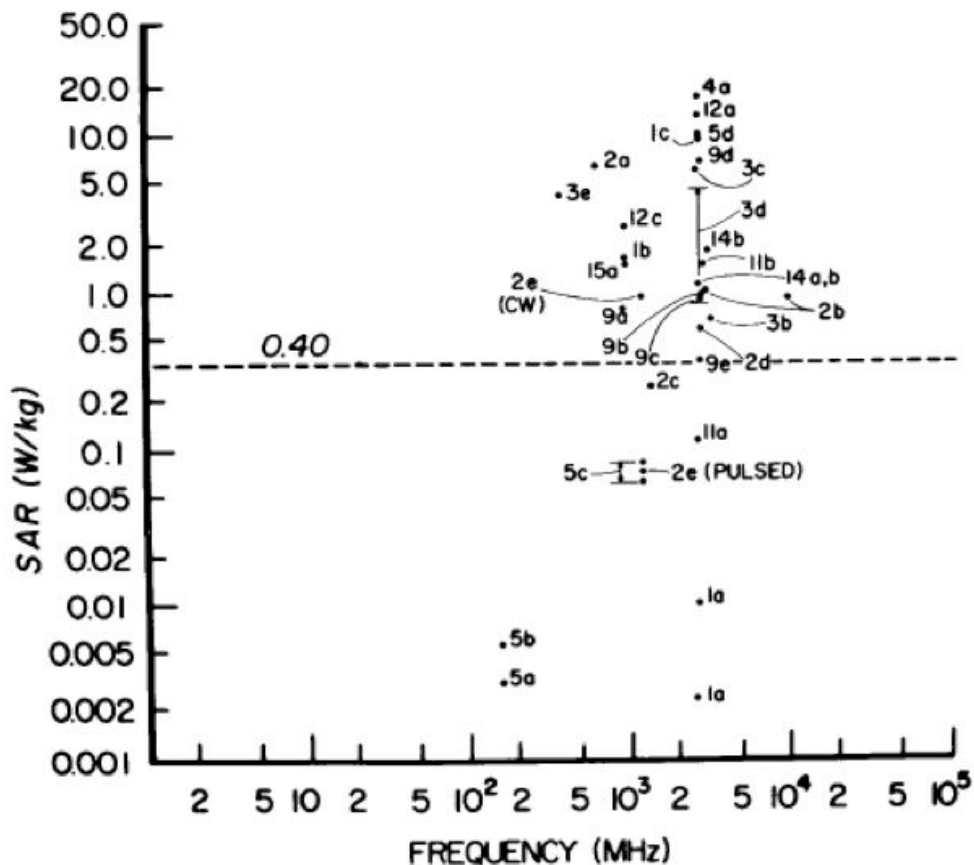


Fig A3
Whole-Body-Averaged SAR
Corresponding to Biological Effects Reported in
Various References of Appendix

- Fig A3 Explained (Page 24)
- The dashed line represents the 10-fold “safety” factor exposure level (SAR=0.40 W/kg) from the SAR=4W/kg whose long-term exposure is tantamount to an irreversible injury.
- The references in this figure refer to studies found in the Appendix (pages 17-19). For example: “4a” refers to “A4. Teratology BERMAN, E., KIN, J. B. and CARTER, H. B. Observations of Mouse Fetuses After Irradiation with 2.45 GHz Microwaves. Health Physics, 35, 1978, pp 791-801 on page 18; “9d” refers to the 4th study in the section “A9. Thermoregulation and Metabolism,” “LU, S. and T., LEBDA, N., MICHAELSON, S. M., PETTIT, S. and RIVERA, D. Thermal and

Endocrinological Effects of Protracted Irradiation of Rats by 2450 MHz Microwaves. Radio Science, 12(6S), 1977, pp 147-156.” Found on page 18.

- **Note that there are 8 references far below the “safety” factor, some of these studies had exposures 100 times lower than the “safety factor.** Reference 5 is one of these studies. Its title is: “Induction of Calcium-Ion Efflux from Brain Tissue by Radio-Frequency Radiation: Effects of Modulation Frequency and Field Strength.”
 - Calcium levels are critically important for the viability of human cells. Efflux is defined as “the flowing out of a particular substance or particle.”
 - The exposure level is on the order of a SAR=0.005 W/kg--8-fold lower than the “safety” factor (AKA limit). Why was the “safety” factor not set 10-times lower than the level where calcium flowed out of brain cells? That is, SAR=0.0005 W/kg?
- 8. Figure A3 shows that we knew *more than 34 years ago* that the “safety factor” does not protect us from biological effects!**
- As we see in Fig. A3, a SAR_{WB}=0.4 W/kg “safety” factor ignored studies which found adverse effects from below the “safety” factor established by ANSI-C95.1-1982.
- 9. The authors were aware that other characteristics of the exposure could be a health risk.**
- It is clearly stated that modulation frequency and peak intensity may pose a risk to health. See the quote below:
 - **Other Factors.** It was recognized by the subcommittee that the specific absorption rate (SAR), which provides the basis for limiting power densities, does not contain all of the factors that could be of importance in establishing safe limits of exposure. First, *other characteristics of an incident field such as modulation frequency and peak intensity may pose a risk to health* [emphasis in the original; emphasis added].” (Page 14, column 2)
- 10. It was well understood prior to 1982 that peak SARs can be far higher than averaged SARs.**
- “By implication and demonstration, peak SARs in a biological body can range *more than an order of magnitude above the average SAR over a limited mass of the exposed tissue.*” (Page 15, column 2, *emphasis added*)
- 11. The Committee retained 6 minutes of averaged exposure relying on the false assumption that the only adverse biological effects from exposure to non-ionizing radiation (NIR) is heating.**
- “**6.12 Time Averaging.** The subcommittee retained 0.1 h (6 min) as the significant period of time over which exposures, the values of specific absorption

rates (SAR) and input power are to be averaged.” (Page 16, column 2. **emphasis in the original**)

Part 2: Highlights From The IEEE C95.1-1991 Standard^{III}

1. **Language in the second paragraph found on [pdf page 2](#) is of interest as the “wholly voluntary” wording appears to absolve the IEEE from any consequences.**
 “Use of an IEEE Standard is *wholly voluntary*. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued [*emphasis added*].”
2. In essence IEEE took over from ANSI but the membership was nearly identical. See the Forward ([pdf page 3](#)) which states
 - Prior to 1988, C95 standards were developed by an accredited standards committee C95, and submitted to ANSI for approval and issuance as ANSI C95 standards. Between 1988 and 1990, the committee was converted to Standards Coordinating Committee 28 under the sponsorship of the IEEE Standards Board. In accordance with policies of the IEEE, C95 standards will be issued and developed as IEEE standards, as well as being submitted to ANSI for recognition.

Major Changes From the ANSI c95.1-182 Standard

A review of this document shows the following major changes (or lack of changes) from the previous ANSI C95.1-1982 standard were the following:

1. **The supposed creation of *two exposure limit values* has the end result of identical exposure limits in that the allowed Specific Absorption (SA)—in other words, despite the two types of limits- the total allowed radiation absorption—*is identical between electrical workers and the general public.***

How did this happen? Please note the following:

- As will be seen below, the general public’s exposure was reduced 5-fold compared to electrical workers. However, the allowed averaging time has increased 5-fold for the general public compared to electrical workers.
- The introduction of “spatial-peak SAR” (SAR_{sp}) was added in addition to the previous whole-body SAR (SAR_{wb}). The former occurs when the radiation source is close to the body such that only a portion of the body absorbed the radiation (e.g., holding a cellphone to the ear); the latter is when the radiation is far from the body such that the whole body absorbed the radiation (e.g., a cellphone tower).

- For both electrical workers and the general public the SAR_{ps} is 5-fold higher than the SAR_{wb} .
- For the general public the allowed $SAR_{wb}=0.08$ W/kg and the allowed $SAR_{sp}=1.6$ W/kg.

In other words, the brain (and other similarly sensitive tissues) is allowed to absorb 20 times more radiation than was allowed by the ANSI C 95.1-1982 Standard. In addition a new exposure limit for the hands, wrists, feet and ankles was defined.^[2]

Unlike the 1982 ANSI standard, this IEEE standard introduced the concept of Maximum Permissible Exposure (MPE). Because the MPEs do not directly refer to the Specific Absorption Rate (SAR), but list values for the electric field, magnetic field, and power density, we will only focus on the SAR values along with the two exposure limits.

Please note the following highlights from the text of the document.

“**Abstract:** IEEE C95.1-1991 gives recommendations to prevent harmful effects in human beings exposed to electromagnetic fields in the frequency range from 3 kHz to 300 GHz.^[3] The recommendations are intended to apply to exposures in controlled, as well as uncontrolled, environments.” (Page 1)

“Also, a distinction is made between controlled and uncontrolled environments relative to *safe exposure limits* [*emphasis added*].” (Page 4)

From the “Definitions” section:

“**continuous exposure.** Exposure for durations exceeding the corresponding averaging time. Exposure for less than the averaging time is called short-term exposure [**emphasis** in the original].”

“**controlled environment.** Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a *concomitant of employment* ... [**emphasis** in the original; *emphasis added*].”

Concomitant of employment is that worker must accept higher exposure if they want to work.

“**RF ‘hot spot’.** A highly localized area of relatively more intense radio-frequency radiation that manifests itself in two principal ways [**emphasis** in the original]:

- (1) The presence of intense electric or magnetic fields immediately adjacent to conductive objects that are immersed in lower intensity ambient fields (often referred to as re-radiation), and
- (2) Localized areas, not necessarily immediately close to conductive objects, in which there exists a concentration of radio-frequency fields caused by reflections and/or narrow beams produced by high-gain radiating antennas or other highly directional sources. In both cases, the fields are characterized by very rapid changes in field strength with distance. RF hot spots are normally associated with very nonuniform exposure of the body (partial body exposure). This is not to be confused with an actual thermal hot spot within the absorbing body.”

The reality that “hot spots” will exist is noted but it is interesting to note that no statement is made about exposure limits being applicable to “hot spot” regions.

“**4.2.1 Controlled Environment.** At frequencies between 100 kHz and 6 GHz, the MPE in controlled environments for electromagnetic field strengths *may be exceeded if*:

- (a) the exposure conditions can be shown by appropriate techniques to produce SARs below 0.4 W/kg as averaged over the whole-body and spatial peak SAR, not exceeding 8 W/kg as averaged over any 1 g of tissue (defined as a tissue volume in the shape of a cube), except for the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 20 W/kg, as averaged over any 10 g of tissue (defined as a tissue volume in the shape of a cube), ...

The SARs are averaged over any 6-min interval [**emphasis** in the original].” (Page 17)

The end result of these changes is that:

1. **The spatial-peak SAR hands, wrists, feet and ankles^[4] was increased by 250%** from $SAR_{sp}=8$ W/kg to 20 W/kg, and the tissue volume was increased 10-fold from 1 gram to 10 grams of tissue. Because a 10-gram SAR can be up to 3-times higher within any 1 gram of tissue, the effect was to *increase the spatial-peak SAR 7.5-fold* ($2.5 \times 3=7.5$). For electrical workers who concomitant to their employment must accept the 5-fold higher exposure.
2. **Uncontrolled environments allow a 5-fold lower exposure for the general public.**

- “**4.2.2 Uncontrolled Environments** At frequencies between 100 kHz and 6 GHz, the MPE in uncontrolled environments for electromagnetic field strengths *may be exceeded if*:
 - The exposure conditions can be shown by appropriate techniques to produce SARs below 0.08 W/kg, as averaged over the whole body, and spatial peak SAR values not exceeding 1.6 W/kg, as averaged over any 1 g of tissue (defined as a tissue volume in the shape of a cube), except for the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 4 W/kg, as averaged over any 10 g of tissue (defined as a tissue volume in the shape of a cube) ... [**emphasis** in the original; *emphasis* added].” (Page 17)
- However, like for electrical workers, the spatial-peak SAR for hands, wrists, feet and ankles^[5] was increased by 250% from SAR_{sp}=1.6W/kg to 4 W/kg, and the tissue volume was increased 10-fold from 1 gram to 10 grams of tissue. Because a 10-gram SAR can be up to 3-times higher within any 1 gram of tissue, the effect was to increase the spatial-peak SAR 7.5-fold.
 - The above limits are also applicable for the general public.
 - “For both pulsed and non-pulsed fields ... the SARs, as applicable, are averaged over any 6-min or 30-min period.” (Page 18)
 - As noted in the ANSI section above, because for electrical workers the 5-fold higher SARs are averaged over 6 minutes and for the general public the 5-fold lower SARs are averaged over a 5-fold longer time (30 minutes), *the total allowed absorbed radiation is identical*.
- 3. **The document states that *Non-thermal effects*, such as efflux of calcium ions from brain tissues, are mentioned as potential health hazards:**
 - “To some, it would *appear attractive and logical* to apply a larger, or different, safety factor to arrive at the guide for the general public. Supportive arguments claim subgroups of greater sensitivity (*infants, the aged, the ill and disabled*), potentially *greater exposure durations* (24-hr/day vs. 8-hr/day), *adverse environmental conditions* (excessive heat and/or humidity), *voluntary vs. involuntary exposure*, and psychological/emotional factors that can range from anxiety to ignorance. *Non-thermal effects*, such as efflux of calcium ions from brain tissues, are also mentioned as potential health hazards [*emphasis* added].” (Page 23)
- 4. **The document states that spatial peak SAR values can exceed a whole-body average value.**
 - “It has been established through *thermographic* analyses of models of rats and man, and cadavers of rabbits, that spatial peak SAR values can exceed a whole-body average value by more than a factor of 20. Comparable findings have

been reported. However, several factors preclude explicit use of peak SAR, such as the following:

- (1) The availability of data on distributive SARs is limited ... [*emphasis added*]” (Pages 24-25)
- “[T]hermographic” (i.e., temperature change) analyses show a 20-fold higher SAR underestimates the instantaneous SAR value. This is of critical importance, because virtually all adverse biological effects reported since 1991 are non-thermal effects [e.g., various human cancers, deleterious effects on sperm (in vitro, in vivo, and human epidemiological studies), double-strand DNA breaks (in vivo studies)].

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An industry consultant’s response: “Dr. Meir J. Stampfer, a professor at the Harvard School of Public Health *and a consultant to the cellphone industry*. ‘In science, unlike math, we can’t have absolute certainty, but in the scheme of things, this is not a health risk I would be concerned about at all.’” [NY Times, June 6, 2011]

^[1] This became ANSI/IEEE C95.1-1992. The only change was the American National Standards Institute (ANSI) ratified the IEEE C95.1-1991 Standard. In 1996, the Federal Communications Commission (FCC) substantially adopted the ANSI/IEEE C95.1-1992 as the U.S. Government’s exposure limit regulation.

^[2] Recently the FCC defined the ear (AKA pinna) as an extremity like hands, wrists, feet and ankles.

^[3] 3 kHz to 300 GHz is the IEEE definition of the radio frequency (RF) spectrum range. It is only a convenient definition for engineers. Per se, there is no biological meaning.

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