



WHITE PAPER

**Compliance with FCC
Guidelines for Human Exposure to
Radio Frequency Electromagnetic
Fields**



Introduction & Executive Summary

It is vital to ensure that the emission levels of RFID equipment are measured to ensure compliance with FCC and FDA regulations and in particular with CFR 47 which regulates the Maximum Permissible Exposure (MPE) limits for human exposure to Radio Frequency Electromagnetic fields.

Magellan Technology wishes to endorse, most strongly, the requirement to include MPE limit compliance in all considerations of RFID platforms and standards.

This paper seeks to explain why MPE limit compliance is not only necessary but vital to the RFID industry and to customers who rely on the RFID industry to provide safe and not harmful equipment.

LF and HF RFID technology are well established and mature RFID technologies world wide and there is an extensive and well documented history and body of evidence to show that equipment operating at these frequencies can be safely deployed in the workplace and in places accessible to the general public. (Refer Magellan Note 1)

Magellan Note 1. As one example refer:

"Dosimetric Assessment of Contactless Identification Systems - Human Exposure". This is a report on HF RFID at 13.56 MHz commissioned by Siemens from the Institut für Mobil - und Satellitenfunktechnik GmbH (IMST) ©. Also see further papers at <http://www.imst.com/en/search.php>

No such history exists for RFID devices at UHF frequencies and yet UHF operates in the microwave region where there are well known and increasing concerns not only about the heating effects of microwave radiation on human tissue (the eye and the brain) but also new concerns about the effects of microwave radiation on cellular tissue.

This paper seeks to establish, primarily by reference to USA regulations (and not EU and ETSI regulations, which are even more stringent and must be considered for a global technology) the reasons why the RFID industry when seeking to define any new platform, protocol or standard should make absolutely sure that human exposure levels are properly considered.

Magellan asserts the RFID industry is obliged to ensure that no technology it is developing or considering for deployment should approach let alone exceed human exposure limits.

The primary reference used throughout this briefing paper is FCC CFR 47. This FCC document is long but, while it has technical content, it is written to also facilitate understanding by non technical persons. This briefing paper makes its various points by using excerpts from the CFR. These excerpts are necessarily selective but all excerpts are exact and are clearly shown in blue. The page number is also provided so readers can refer to the original complete document. (Refer Magellan Note 3)

Magellan Note 3.

Refer <http://www.fcc.gov/oet/info/rules/> These rules were updated on 1 Jan 2006 by a revised Supplement C.

Also refer <http://www.fcc.gov/oet/info/rules/part15/part15-2-1-06.pdf> These rules provide fine detail on intentional radiators (RFID antennas)

FCC Regulations

Introduction

In August, 1996, the Commission adopted a *Report and Order* in ET Docket 93-62 amending its rules for evaluating the environmental effects of radiofrequency (RF) electromagnetic fields. Specifically, the Commission adopted new guidelines and procedures for evaluating human exposure to RF emissions from FCC-regulated transmitters and facilities. (FCC Note 1) As a part of this proceeding, new limits were adopted for human exposure to RF emissions from certain mobile and portable devices. Two subsequent FCC Orders were issued to refine and clarify the decisions adopted in the original *Report and Order*. (FCC Note 2) A revised version of OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields" was also issued. (FCC Note 3) One of the areas discussed in Bulletin 65 is compliance with the limits adopted by the Commission for safe exposure to RF emissions due to mobile and portable devices such as non-fixed wireless transmitters and hand-held cellular telephones. The first edition of Supplement C (97-01) was released in 1997. The purpose of this revised supplement is to provide parties filing applications for equipment authorization with guidance on complying with the latest requirements using up-to-date test procedures.....

FCC Note 1 See *Report and Order*, in ET Docket 93-62, FCC 96-326, 11 FCC Rcd. 15123 (1996). The Commission's environmental rules for RF exposure are described in 47 CFR §1.1307(b).

FCC Note 2 See *First Memorandum Opinion and Order*, ET Docket 93-62, FCC 96-489, 11 FCC Rcd. 17512 (1997). See also *Second Memorandum Opinion and Order and Notice of Proposed Rule Making*, ET Docket 93-62, FCC 97-303, 12 FCC Rcd. 13494 (1997).

FCC Note 3 OET Bulletin 65, Edition 97-01, released August 25, 1997. This document can be downloaded from the FCC's World Wide Web Internet site: <http://www.fcc.gov/oet/>.

RF Exposure



The FCC guidelines differentiate between portable and mobile devices according to their proximity to exposed persons. For portable devices (47 CFR §2.1093), RF evaluation must be based on specific absorption rate (SAR) limits. Human exposure to RF emissions from mobile devices (47 CFR §2.1091) can be evaluated with respect to Maximum Permissible Exposure (MPE) limits for field strength or power density or with respect to SAR limits, whichever is most appropriate. Industry groups and other organizations have been working to develop standardized product test procedures to evaluate RF exposure compliance with SAR limits..... (FCC Note 4)

FCC Note 4 Standards Coordinating Committee 34, Subcommittee 2, of the Institute of Electrical and Electronics Engineers, Inc. (IEEE SCC-34/SC-2) has been developing recommended procedures for evaluating portable devices for compliance with SAR limits using experimental or numerical methods. Additional information is available at the IEEE Standards Association Internet Web Site: <http://standards.ieee.org/> and the SCC-34/SC-2 Web Site: <http://grouper.ieee.org/groups/sc34/sc2/>.

It needs to be pointed out that SAR limits (Specific Absorption Rate) have in the past been calculated with relationship only to the heating effects of RF energy on the human body. One example of the heating effects of microwave radiation is the Microwave Oven which uses UHF microwave energy to heat food. There is also, now however, a new concern about the other biological (non heating) effects of microwave (UHF) energy on the human body. Human cell tissue regeneration is a new and important area of topical interest. . (Refer Magellan Note 2 & 3)

Magellan Note 2: Refer simply as illustrative

http://www.fda.gov/cdrh/ost/reports/fy98/BIOEFFECT_R.HTM and

<http://www.fda.gov/cdrh/ost/reports/fy99/OSTfy99.pdf> (Page 78)

Magellan Note 3 Refer

http://www.goaegis.com/fda_letter0200.html

Also refer FCC Note 6 further below

.....FCC rules require applicants for equipment authorization of certain portable and mobile devices to include an affirmative statement of compliance attesting that the devices comply with FCC limits for RF exposure. The rules also require that technical information be provided upon request for supporting compliance.....

Customers of RFID systems, for the most obvious reasons, of worker and public safety, will unquestionably require the RFID industry to demonstrate compliance with MPE limits.



FCC rules for RF compliance of mobile and portable devices

As stated in the FCC rules, mobile and portable transmitting devicesare subject to routine environmental evaluation for RF exposure prior to equipment authorization or use. Portable devices operating in the Wireless Medical Telemetry Service (WMTS) and the Medical Implant Communications Service (MICS), authorized under Subparts H and I of Part 95 are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use. Unlicensed PCS, U-NII and millimeter wave devices authorized under Part 15 of FCC rules are also subject to routine environmental evaluation for RF exposure prior to equipment authorization or use. All other mobile and portable devices are categorically excluded from routine environmental evaluation for RF exposure. (FCC Note 5)

FCC Note 5. See 47 CFR §§ 1.1307(b)(1), 2.1091 and 2.1093 for details.

Mobile Devices

The FCC rules for evaluating mobile devices for RF compliance are found in 47 CFR §2.1091. For purposes of RF exposure evaluation, a mobile device is defined as a transmitting device designed to be used in other than fixed locations and to be generally used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structures and the body of the user or nearby persons. In this context, the term "fixed location" means that the device, including its antenna, is physically secured at a permanent location and is not able to be easily moved to another location. Examples of mobile devices, as defined above, would include cellular and PCS mobile telephones, other radio devices that use vehicle-mounted antennas and certain other transportable transmitting devices. Transmitters designed to be used by consumers or workers that can be easily relocated, such as a wireless modem operating in a laptop computer, are considered mobile devices if they meet the 20 centimeter separation requirement. These devices are normally evaluated for exposure potential with the MPE limits given in Appendix A. Mobile devices may also be evaluated with respect to the SAR limits given in Appendix A for RF exposure compliance, but in such cases it is usually simpler and more cost-effective to evaluate compliance with respect to MPE limits based on field strength or power density.

It would seem reasonable to include RFID POS terminals; long range UHF antenna and RFID hand held readers in this category as POS and other staff can often work well within 20 cm of the radiating antenna. This close proximity is not an issue with low power HF systems using magnetic induction. Close proximity, however, to a focusing UHF horn antenna, or to metal plates or bars intended to concentrate a UHF field, is an area where MPE limits need to be properly addressed.



Portable Devices

The FCC rules for evaluating portable devices for RF exposure compliance are contained in 47 CFR §2.1093. For purposes of RF exposure evaluation, a portable device is defined as a transmitting device designed to be used with any part of its radiating structure in direct contact with the user's body or within 20 centimeters of the body of a user or bystanders under normal operating conditions. This category of devices would include hand-held cellular and PCS telephones that incorporate the radiating antenna into the hand-piece and wireless transmitters that are carried next to the body. Portable devices are evaluated with respect to SAR limits for RF exposure. (FCC Note 6) The applicable SAR limit for portable transmitters used by consumers is 1.6 watts/kg, which is averaged over any one gram of tissue defined as a tissue volume in the shape of a cube.

FCC Note 6. Both the ANSI/IEEE and NCRP exposure criteria are based on a determination that potentially harmful biological effects can occur at a SAR level of 4.0 W/kg as averaged over the whole-body. Appropriate safety factors were then added to arrive at limits for both whole-body exposure (0.4 W/kg for "controlled" or "occupational" exposure and 0.08 W/kg for "uncontrolled" or "general population" exposure, respectively) and for partial-body exposure (localized SAR), such as might occur in the head of the user of a hand-held cellular telephone.

The point to be made here is that the FDA takes a very keen interest in the OH&S effects of UHF (microwave) radiation where it is not, as is the case with mobile phones, a voluntary exposure but is an exposure that is imposed on employees and the general public. Legal opinions and further detailed research are needed in this area of UHF.

GENERAL POPULATION / UNCONTROLLED EXPOSURE

The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity. Warning labels placed on low-power consumer devices such as cellular telephones are not considered sufficient to allow the device to be considered under the occupational/controlled category and the general population/uncontrolled exposure limits apply to these devices. (Refer page 6)

MPE Evaluation of Mobile Devices (Page 9)

Human exposure to RF emissions from mobile devices (47 CFR §2.1091) may be evaluated based on the MPE limits adopted by the FCC for electric and magnetic field strength and/or power density, as appropriate, since exposures are assumed to occur at distances of 20 cm or more from persons. (FCC Note 9) The 1992 ANSI/IEEE standard (See Reference [1]) specifies a minimum separation distance of 20 cm for performing reliable field measurements to determine adherence to MPE limits. (FCC Note 10) If the minimum separation distance between a transmitter and nearby



persons is more than 20 cm under normal operating conditions, compliance with MPE limits may be determined at such distance from the transmitter. When applicable, operation instructions and prominent warning labels may be used to alert the exposed persons to maintain a specified distance from the transmitter or to limit their exposure durations and usage conditions to ensure compliance. If the use of warning labels on a transmitter is not effective or desirable, the alternative of performing SAR evaluation with the device at its closest range to persons under normal operating conditions may be used.

The field strength and power density limits adopted by the FCC are based on whole-body averaged exposure and the assumption of spatially averaged RF field levels relate most accurately to estimating whole-body averaged SAR. (Refer page 9)

FCC Note 8. An example would be certain transmitters used at checkout stands.

FCC Note 9. The FCC adopted limits for field strength and power density that are generally based on Sections 17.4.1 and 17.4.2, and the time-averaging provisions recommended in Sections 17.4.1.1 and 17.4.3, of "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86 (1986), National Council on Radiation Protection and Measurements (NCRP). With the exception of the limits on exposure to power density above 1500 MHz and the limits for exposure to lower frequency magnetic fields, these MPE limits are also generally based on the guidelines contained in the RF safety standard developed by the Institute of Electrical and Electronic Engineers, Inc. (IEEE) and adopted by the American National Standards Institute (ANSI). See Section 4.1 of ANSI/IEEE C95.1-1992, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz".

FCC Note 10. Although ANSI/IEEE does not explicitly state when SAR measurements are preferable to MPE measurements, we believe that the 20 cm distance is appropriate based on Sec. 4.3(3) of ANSI/IEEE C95.1-1992.

If a transmitter is designed to operate next to the body of its user or at close proximity to persons, a RF evaluation may be requested according to 47 CFR §1.1307(c) and (d). These types of evaluations are typically limited to transmitters that are intended to operate in very close proximity to the body, using 0.5 watt of output power or more with a high signal transmitting duty factor, and which do not incorporate obvious effective means for users to meet RF exposure compliance. When RF evaluation is requested, the procedures described in this supplement for evaluating mobile and portable devices with respect to MPE or SAR limits may be used. (FCC Note 11-14) (Refer page 18)

FCC Note 11. See *Report and Order*, in ET Docket 96-8, FCC 97-114, Amendment of Parts 2 and 15 of Commission's Rules Regarding Spread Spectrum Transmitter.

FCC Note 12. Warning instructions and labels also include certain caution statements that are needed to ensure compliance. Warnings are typically used in situations where there could be imminent danger, such as exposing to the main beam of a high gain antenna operating at substantially high output power. Caution statements and labels are more appropriate for informing the users of most Spread Spectrum devices to follow specific installation and operating requirements to ensure compliance for all exposed persons.



FCC Note 13. Power density estimates based on simplified sources are different than the computational methods used in routine SAR evaluation where the test device and/or tissue models are constructed numerically to simulate the exposure conditions and to calculate power density or SAR.

FCC Note 14. Both conducted and radiated output power should be considered in near-field exposure conditions. The output indicated in the above (500 mW) is appropriate when the device and its antenna are both operating at more than 2.5 – 3.0 cm from a person's body, such as certain hand-held terminals. If a device, its antenna or other radiating structures are operating at closer than 2.5 cm from a person's body or in contact with the body, SAR evaluation may be necessary when the output is more than 50 – 100 mW, depending on the device operating configurations and exposure conditions.

Note the reference to near field in the above note.

Magellan Technology contends that MPE evaluation is mandatory for RF antenna at POS check out desks. This is particularly so for UHF antennas which need certain power levels to achieve penetration of mixed goods (liquids etc) and where the frequency of operation has pronounced effects on human tissue. This argument becomes even more compelling when it is considered that many POS workers will work an 8 hour shift within 20cm of the radiating antenna.

Protocol issues

For purposes of determining RF exposure, the transmission protocols used by certain spread spectrum transmitters may qualify the device for source-based time averaging. The applicable duty factor may be determined according to the RF output power "on" and "off" time durations, either as a signal with a repeatable duty cycle or by establishing a worst case duty factor using power off durations identified by the transmission protocol. Duty factors related to device usage, frequency hopping or other similar transmission conditions are normally not acceptable as source-based, time averaging factors for RF evaluations. (Page 19)

Note that certain protocols are Reader Talks First (RTF) thus the duty cycle is that the device is always on!

People near antenna

For transmitters that use external or remote antennas for indoor or outdoor operations, appropriate installation procedures should be provided to the installer to ensure the antenna is installed to provide the specified distance from nearby persons to satisfy compliance.....As is explained in the FCC's *Report and Order* in ET Docket 96-8 (FCC 97-114, Section 9), these are steps that can be taken by the responsible parties to ensure that these devices are operated in accordance with the RF guidelines for human exposure adopted by the Commission. The methods used to ensure compliance must be effective, and the installation, operation and warning instructions or warning labels should explain their purpose and provide appropriate means for satisfying compliance..... (Refer FCC Note 12 and page19)



Many UHF antennas are high gain aperture antennas as they are focusing antennas. It is mandatory that such antenna be installed with an appropriate safety distance.

As argued earlier in this paper it is not acceptable for an industry or user body to say "Well, the legal limit is 4W so we can use all of the 4W and all will be OK". The protective principle now being applied is called the ALARA principle. ALARA means As Low As Reasonably Achievable. This principle says that minimization of radiation is the new goal; not simply staying within the maximum power envelope. Environmental issues are highly topical and human exposure levels can be expected to be tightened and not relaxed over time. With regard to the possible roll out of a global technology it is suggested that the RFID Industry has, also, an obligation to support more environmentally friendly technologies that use less power and not more power to do the same job.

In factories and warehouses where the work force is trained and informed of the radiation hazards of the more powerful microwave electric "E" fields found in UHF RFID transmitters (as opposed to the more benign magnetic or H fields used in HF RFID transmitters) then fencing off antennas and antenna horns might be acceptable. Magellan doubts, however, that this will be a satisfactory answer for supermarkets as uninformed staff and members of the public will have occasion to walk past antenna apertures in their normal course of work and business. There is a strong argument for fencing off all high gain UHF transmitters anywhere near people.

RTF

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20 April 2006

Readers interested in furthering their general knowledge of RF are referred to <http://www.fcc.gov/oet/rfsafety/rf-faqs.html> which contains comprehensive FAQ about RF in general