BEFORE THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH

NEW DELHI

OA NO. 557 OF 2022

IN THE MATTER OF ::

Gaur Atulyam Apartment Owners Association

...Applicant

VERSUS

Greater Noida Industrial Development Authority &ors

...Respondents

N.D.O.H:- 24.11.2022

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Through

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DELHI
DATED 23.11.2022

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Reply on behalf of the respondent No. 3 to the Application under Section 14 of the National Green Tribunal Act.

Respectfully Showeth :

The respondent No. 3 most humbly submits as under:-

1. That the above titled Application is pending before this Hon'ble Court and fixed for hearing on24.11.2022.

2. That the present Application preferred by the Applicant has impleaded Department of Telecommunications as respondent No. 3 by this Hon'ble Court.

3. That the present Application is not maintainable and is liable to be dismissed as the Applicant has no right or locus standi to file the present Application against the answering respondent No. 3. It is submitted that the averments made in the Application regarding installation of a mobile tower without necessary permissions, bypassing building byelaws and without following safety norms lies outside the purview of work assigned to respondent No. 3.**Permission/Clearance for erection of tower is regulated by the State Government, Municipal Corporation, Local Bodies as per their Building Bye-Laws. In this regard, the respondent No. 3 has also issued an advisory guideline for State Governments for issuance of clearance for installation of mobile towers.**

4. That the averment made in the subject Application in respect of **hazard of electromagnetic radiation from mobile tower** is devoid of merit as the same is based on unsubstantiated claims and unfounded worries. These averments are factoid sans fact and mere repetition of truthiness divorced from truth.

5. That at the outset it is submitted that the Hon'ble NGT (Principal Bench) dismissed OA No. 139 of 2015 and other cases on 15-09-2015 taking the view that **radiation i.e. emission of electromagnetic waves from the towers constructed by the respective respondents does not fall within the ambit, scope and jurisdiction vested in the Tribunal under the provisions of the NGT Act with reference Environment (Protection) Act, 1986**. The relevant portion of the Judgement is as follows:

> *"33. In view of the above discussion, we are of the considered view that radiation i.e. emission of electromagnetic waves from the towers constructed by the respective respondents does not fall within the ambit, scope and jurisdiction vested in this Tribunal under the provisions of the NGT Act with reference Environment (Protection) Act, 1986.*
> ...
> *36. Thus, we dismiss all these applications while holding that the Tribunal has no jurisdiction to entertain these applications. We dismiss all the applications, however, without any order as to costs."*

6. That it is also submitted that the permission/clearance for erection of telecom tower (interchangeably referred as mobile phone tower, cell phone tower, mobile tower or simply as tower) is regulated by the State Government, Municipal Corporation, Local Bodies as per their Building Bye-Laws. In this regard, Department of Telecommunication (**DoT**) has issued an advisory

guideline for State Governments for issuance of clearance for installation of telecomtowers. Also, in exercise of the powers conferred by sub-section (1) and clause (e) of sub-section (2) of section 7 read with sections 10, 12 and 15 of the Indian Telegraph Act, 1885(13 of 1885), the DoT/ Central Government issued the Indian Telegraph Right of Way (**ITRoW**) Rules, 2016 to regulate underground and overground infrastructure.**As per the advisory guideline and the ITRoW Rules, there is no restriction for the installation of telecomtower in any specific area including residential area.** A Copy of the Advisory Guidelines is annexed herewith as **Annexure-R-1** and a Copy of the consolidated **ITRoW Rules** (including amendments upto August-2022)is annexed herewith as **Annexure-R-2**.

7. That it is submitted that Telecommunications has been recognized the world-over as an important tool for socio-economic development of a nation. It has become core infrastructure required for rapid growth and modernization of various sectors of the economy. There has been a phenomenal growth of the telecom sector in terms of subscribers and usage over the past two decades in India. Today, India is amongst top

three of the largest and one of the fastest growing telecom markets in the world. The Indian telecom industry has grown from a tele-density of 3.58% in March 2001 to 84.88% in March, 2022. This great leap in both the number of subscribers and usage from telecom services has contributed significantly to the growth in GDP and employment.

8. That it is submitted that the current information revolution has been brought through the use of mobile broadband/ internet. However, the penetration of mobile internet is very low in country in comparison to other nations. Large investments and efforts from industry as well as Government are required to expand the mobile telephony related infrastructure, which includes telecom towers, with a view to expand the mobile telephony based services and take these to rural and remote areas. This needs to be done, so that the dream of broadband for all can be realized and benefit of this technology can be reaped by all sections of society. According to various reports, there is a direct correlation between increase in penetration of broadband and the GDP of a country.

9. That it is also submitted that telecom towers are critical installations on which the backbone of mobile communication rests. These are essential for realizing the vision of inclusive

growth. The success of initiatives like Digital India, Smart Cities and right to Broadband, which the Government intends to implement in mission mode, depends on this critical and essential infrastructure. Mobile communication plays important role in social and economic growth and disaster management for which telecom towers are a pre-requisite. A robust and scalable mobile infrastructure, including towers, is must for universal access to communication, effective delivery of services to citizens and financial inclusion. Realizing the significance of mobile towers, Government of India has included it in the harmonized list of infrastructure vide its Gazette notification dated 27-03-2012. Government has announced a new National Digital Communications Policy 2018 with an objective to prepare the country and its citizens for the future and seeks to unlock the transformative power of digital communications networks i.e. to achieve the goal of digital empowerment and improved well-being of people of India and towards this end, attempts to outline a set of goals, initiatives, strategies and intended policy outcomes. One of the strategies includes facilitating the establishment of telecom tower Infrastructure by way of extending incentives and exemptions for the construction of telecom towers.

10. That It is submitted that section 4 of Indian Telegraph Act, 1885 describes the privileges and powers of the Government in respect of telegraphs and power to grant licenses. Para 4(1) of Section 4 of Indian Telegraph Act, 1885 is reproduced below:

4(1) – *"Within India, the Central Government shall have the exclusive privilege of establishing, maintaining and working telegraphs:*

Provided that the Central Government may grant a license, on such conditions and in consideration of such payments as it thinks fit, to any person to establish, maintain or work a telegraph within any part of India."

11. That It is submitted that Department of Telecommunications, Government of India, has thus granted licenses, under Section 4 of Indian Telegraph Act, 1885, for Cellular Mobile Telephone Service (CMTS), Unified Access Service (UAS), etc. to Indian registered companies to establish, maintain and work on telegraph for providing mobile telephone services in the licensed area. Under these licenses, the Telecom Service Providers (**TSPs**) are establishing telecom towers to provide the coverage of mobile services in their service area.

12. That It is further submitted that to support the faster growth of telecom infrastructure including telecom tower,

Department of Telecommunications (**DoT**) has also created a separate registration category known as Infrastructure Providers Category-I (**IP-I**). The Infrastructure Provider-I registered companies are permitted to create passive infrastructure such as tower, dark fibre, duct space etc. and provide the same to licensed telecom service providers.

13. That It is submitted that as per Clause 41.6 of the terms and conditions of UAS license, the Licensee is required to ensure that the Telecommunication installation carried out by it should not become a safety hazard and is not in contravention of any statute, rule or regulation and public policy.

14. That It is submitted that as per terms and conditions of the CMTS / UAS/ UL license and IP-I registration, the responsibility of obtaining Permission/ Right of Way for establishing telecom towers lies with the TSPs/ IP-I companies.

15. That It is submitted that for providing the mobile services in the country, the telecom service providers have to establish Base Transceiver Stations (**BTS**), at suitable locations, as per their Radio Frequency (RF) Network Planning for proper coverage of the area. Prior to installation of telecom towers, the telecom service providers have to obtain Site clearance from

Standing Advisory Committee on Frequency Allocation (SACFA) of Department of Telecommunications (DoT) for every site from the point of view of interference with other wireless users, aviation hazards and obstruction to any other existing microwave links. The IP-I / TSPs have also to obtain necessary clearances from concerned local authorities such as municipal corporation, Gram Panchayat etc before installation of telecom tower.

16. That It is submitted that, with regard to health hazard from the radiations of telecom towers/networks, several studies have been conducted in different countries, under the aegis of World Health Organization (WHO). There is no conclusive scientific evidence of adverse health effects due to low level RF emission from telecom towers. WHO has referred to approximately 25,000 studies, published around the world over past 30 years, and based on an in-depth review of scientific literature, has concluded: "current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields". Since the effects on human beings are to be studied over a long period of time, further studies are going on around the world.

17. That It is submitted that with reference to Electromagnetic Field (**EMF**) radiation emanating from cellular telecom towers,

World Health Organization (WHO) in its Fact Sheet No. 304, May 2006 on Electromagnetic Fields and Public Health (Base Stations and Wireless Technologies) has concluded that "*considering the very low exposure* levelsand *research results collected to date, there is no convincing* scientific *evidence that the weak RF Signals from base stations and wireless networks caused adverse health effects. From all evidence accumulated so far, no adverse short or long term health effects have been shown to occur from the RF Signals produced by base stations.*" (Copy of Fact Sheet No. 304, May 2006 is placed as **ANNEXURE-R-3)**

18. That It is also submitted that in September 2013, WHO in online question and answers have mentioned that "Studies *to date provide no indication that environmental exposure to RF fields, such as from base stations, increases the risk of cancer or any other disease.*"

19. That It is submitted that as part of its charter to protect public health and in response to public concern over health effects of EMF exposure, the World Health Organization (WHO) established the International EMF Project in 1996 to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz. The EMF Project

encourages focused research to fill important gaps in knowledge and to facilitate the development of internationally acceptable standards limiting EMF exposure.

20. That It is submitted that, since the commencement of the EMF Project, over 50 national authorities have been involved. Apart from the national authorities the project is overseen by 8 international organizations and independent collaborating institutions and together they review scientific information related to public and occupational health, and environmental management of the EMF issue. It is pertinent to note that many of these studies have been going on for years so as to understand the effect of EMF over the period of time and these studies are not specific to developed countries alone. While summarizing the key points on health effect of EMF radiation, WHO website mentions the following:

"...WHO's International EMF Project was launched to provide scientifically sound and objective answers *to public concerns about possible hazards of low level electromagnetic fields.*

Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health..."

21. That in February, 2020, the WHO, in Q&A session on "5G mobile networks and health" again clarified that "To date, and after much research performed, no adverse health effect has been causally linked with exposure to wireless technologies.", (https://www.who.int/news-room/q-a-detail/radiation-5g-mobile-networks-and-health).

22. That It is also submitted that WHO has recommended in above mentioned fact sheet No. 304, May 2006 that "National authorities should adopt international standards to protect their citizens against adverse levels of RF fields. They should restrict access to areas where exposure limits may be exceeded." WHO has referred to the international Exposure Guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in same fact sheet No. 304, May 2006.

23. That It is submitted that ICNIRP, in its report of April 1998, has prescribed the following levels, limiting EMF emission from Base Transceiver Stations (BTSs) as safe for general public:

Frequency Range	Power Density (Watt/Sq. Meter)
400MHz to 2000MHz	f/200
2GHz to 300GHz	10

(f is the frequency of operation in MHz)

24. That ICNIRP has reviewed the radiofrequency EMF part of the 1998 Guidelines again in the year 2020 and summarized that "The only substantiated adverse health effects caused by exposure to radiofrequency EMFs are nerve stimulation, changes in the permeability of cell membranes, and effects due to temperature elevation. There is no evidence of adverse health effects at exposure levels below the restriction levels in the ICNIRP (1998) guidelines and no evidence of an interaction mechanism that would predict that adverse health effects could occur due to radiofrequency EMF exposure below those restriction levels." (https://www.icnirp.org/cms/upload/publications/ICNIRPrfgdl2020.pdf).

25. That It is submitted that ICNIRP guidelines of April 1998 states that, epidemiological studies on exposed workers and the general public have shown no major health effects associated with typical exposure environments. The studies have yielded no convincing evidence that typical exposure levels lead to adverse reproductive outcomes or an increased cancer risk in exposed individuals. A copy of ICNIRP guidelines of April 1998 is enclosed herewith and marked as **ANNEXURE-R-4**. Further ICNIRP in its Statement on the **"GUIDELINES FOR LIMITING**

EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHZ)" published in 2009 reiterated that "it is the opinion of ICNIRP that the scientific literature published since the 1998 guidelines has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high frequency electromagnetic fields. Therefore, ICNIRP reconfirms the 1998 basic restrictions in the frequency range 100 kHz–300 GHz until further notice".

26. That It is submitted that Government of India adopted the above mentioned ICNIRP guidelines in the year 2008 for basic restriction levels of EMF radiation from telecom towers and inserted the additional clause in the Access Service Licenses vide its amendment letter dated 4/11/2008. A copy of letter dated 4.11.2008 is enclosed herewith and marked as **ANNEXURE-R-5**.

27. That It is also submitted that DoT vide letter No. 800-15/2010-VAS dated 8th April 2010 directed all CMTS/UAS licensees for compliance of the reference limits/ levels

prescribed by ICNIRP by way of self-certification of their BTS for meeting the EMF radiations norms. A copy of DoT letter no. 800-15/2010-VAS dated 8th April 2010 is enclosed herewith and marked as **ANNEXURE-R-6.**

28. That as per the directions issued vide letter dated 8th April, 2010, all BTSs should be ICNIRP guidelines compliant and all BTSs should be self-certified as meeting the radiation norm. Self-certification is submitted to respective License Service Area (**LSA**) field unit of DoT.

29. That all new BTS sites starts radiating commercially only after self-certificate has been submitted to relevant LSA field unit of DoT.

30. That the LSA field unit of DoT tests up to 5% of total BTS sites randomly. Additionally, the BTS sites against which there are public complaints are also tested by LSA field units of DoT. The testing is done as per procedures prescribed by Telecom Engineering Centre (**TEC**) from time to time. TEC has published the Test Procedure for measurement of EMF from BTSs, latest being document no. TEC 13019:2021.

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31. That if a site fails to meet the EMF radiation criterion, in case of a shared site, a penalty of Rs.20 lakh per BTS per incidence has been prescribed to be imposed on rogue BTS(s) (BTS whose exposure ratio/index is more than '1') if the site becomes compliant after removing contribution of that rogue BTS(s). However, if the site is not compliant even after removing the contribution of that rogue BTS (s), then a penalty in proportion to the exposure ratio (Rs.20 lakh x Exposure Ratio) is prescribed to be imposed on all the remaining participating BTSs. In addition to levy of financial penalty as mentioned above, if the BTS is not made compliant to the EMF radiation norms within 30 days by the erring TSP, the same is required to be shut down as per prescribed procedure.

32. That It is submitted that based on media reports and public concerns an Inter-Ministerial Committee (**IMC**) consisting of officers from DoT, Indian Council of Medical Research (Ministry of Health), Department of Biotechnology and Ministry of Environment and Forest was constituted on 24.08.2010 to examine the effect of EMF Radiation from base stations and mobile phones. The IMC in its report has examined the environmental and health related concerns and has indicated

that most of the laboratory studies were unable to find a direct link between exposure to radio frequency radiation and health; and the scientific studies as yet have not been able to confirm a cause and effect relationship between radio frequency radiation and health. The effect of emission from telecom towers on human health is not known yet with certainty.

33. That It is submitted that, based on the recommendations by IMC, norms for exposure limit for the Radio Frequency Field (Base Station Emissions) have been made further stringent and reduced to $1/10^{th}$ of the existing limits prescribed by International Commission on Non Ionizing Radiation Protection (ICNIRP). Directions in this regard has been issued to the Operators on 30.12.2011 and amendment in the license in this regard has been issued on 10.01.2013. It has been further revised vide Letter No. 800-15/2010-VAS dated 26.06.2013. A copy of the latest letter is enclosed herewith and marked as **ANNEXURE-R-7.** As per latest letter dated 26.06.2013, the present EMF exposure limits/levels in respect of Power density are reproduced as detailed below:

Frequency Range	Power Density (Watt/Sq.Meter)
400MHz to 2000MHz	**f/2000**
2GHz to 300GHz	**1**

(f = frequency in MHz)

34. That It is submitted that DOT, vide letter dated 23.08.2012, has issued guidelines for issue of clearance for telecom tower installation and the same has been forwarded to the Chief Secretaries of all State Governments and Union Territories. The above said guidelines have been further revised with effect from 01.08.2013. A copy of the revised guideline is enclosed herewith and marked as **ANNEXURE-R-1**.

35. That It is submitted that as per clause 4. A (IV) of the above guidelines for obtaining clearance from local bodies / state governments for installation of mobile towers, the TSPs/ IPs-I are to submit, inter alia, copy of structural stability certificate for ground based tower. In case of roof top BTS towers, structural stability certificate is required for the building and tower based on written approvals of any authorized Structural Engineer of state/local bodies/Central Building Research Institute (CBRI), Roorkee/ IIT/NIT or any other agency authorized by local body.

36. That Department of Telecom (DoT), Ministry of Communications has launched Tarang Sanchar, a web portal for Information sharing on telecom towers and EMF Emission Compliances, with a view to generate confidence and conviction with regard to safety and harmlessness from telecom towers, clearing any myths and misconceptions. The portal can be accessed at www.tarangsanchar.gov.in. The Portal provides a public interface where an easy map-based search feature has been provided for viewing the mobile towers in vicinity of any locality. By click of a button, information on EMF compliance status of telecom towers can be accessed. Detailed information about any tower site, if requested, will be sent on email to the users. Additionally, any person can request for EMF emission measurement at a location by paying a nominal fee of Rs.4000/- online. LSA field unit of DoT will conduct the test (the requestor can be present, if he so desires) and the test reports will be provided. The portal also has 'EMF Overview' and 'Learn' Sections, which provide numerous articles, booklets and videos, to further educate the citizens about EMF and coverage of telecom services. Public can also access the 'DoT Initiatives' section which has information on various leaflets, articles and Frequently Asked Questions. The portal has the collated

technical details of over 23 lakh base stations (BTSs) spread across the country of all technologies (2G, 3G, 4G etc.) and of all Telecom Service Providers (TSPs).

37. That It is submitted that Hon'ble High Court Allahabad, Lucknow bench in a Writ Petition No. 11275 (M/B) of 2010 filed by Shri Ram Singh Jauhari Vs UOI &Ors has given direction vide its order dated 10.01.2012 to the Government of India to constitute a Committee consisting of five Members of Electrical Engineering Department of the IITs Kharagpur, Kanpur, Delhi, Roorkee, Bombay including Prof (Dr.) Girish Kumar and four other prominent persons of other scientific institutions of the country like AIIMS (Delhi), Indian Council of Medical Research, etc to submit a report so that the Government of India may take necessary precaution while granting permission for establishment of telecom towers as well as to regulate sale of mobiles with necessary precautions. The committee's report has been filed in the Hon'ble High Court of Allahabad, Lucknow Bench and has been taken on record on 10.02.2014. The Committee has decided that the Department of Telecom has already prescribed stricter precautionary limits for EMF radiation from telecom tower as well as from mobile handset/phones applicable as on date.

38. That After due consideration of the human health concerns on account of EMF radiation being raised in public and the Report of the Committee, the Government has decided in February 2014 that the present prescribed precautionary EMF safe exposure limits are adequate and need no further change at this stage. The decisions taken by the Government have been conveyed vide OM no. 17-63/2011/CS-III dated 27-02-2014, enclosed and marked as **ANNEXURE -R-8**.

39. That It is submitted that Hon'ble High Court of Orissa, on **12.09.2022**, disposed of WP C No. 4307 of 2018 filed by Kambhu Behera Vs. Union of India and Ors. with following order:

"1. If there is any violation of any Regulations or Guidelines then the Petitioner has to be specific as to which of those guidelines has been violated. Secondly, if there is any health risk to the villagers, the Petitioner has to be specific what type of health risk has been caused on account of the Mobile Tower being erected in the land of Opposite Party No.9. The petition does neither.

2. Consequently, the Court is not inclined to interfere at this stage in the present form of the petition. The Petitioners are nevertheless permitted to agitate their grievance in proper manner first to the authorities and then after following up on such grievance to seek appropriate remedies in accordance with law."

40. That It is submitted that in the W.P. No 2242 of 2021 dated 4.2.2021, Hon'ble High Court of Madras has conveyed that *"no one can be prevented from erecting the cellphone towers on a mere apprehension about the effect of radiation from the cellphone tower. The apprehension does not have scientific backing. Till a positive finding is given in this regard, cell phone towers cannot be prevented to be installed on mere apprehensions"*.

41. That Hon'ble Madurai Bench of Madras High Court in a WP(MD) No 9854 of 2021 filed by M/s ATC Telecom Infrastructure Pvt Ltd (Registered Infrastructure Provider Category -I *company* vs The Superintendent of Police, District Police, Nagercoil, Kanyakumari District & Ors has made the following observations in its order dated 10.06.2021:

"2...The petitioner Company is carrying the business of operation and maintenance of mobile phone towers across India for all the mobile phone operators/service providers, who got licence from the Government under Section 4 of the Indian Telegraph Act, 1885. The petitioner Company obtained IP-1 category license from the Department of Telecommunication, Government of India, to provide passive infrastructure to telecom service providers. All the towers are erected and installed upon private property, after obtaining permission in the form of lease from the respective property owners. The Government of Tamil Nadu has exempted the mobile phone tower service providers from getting building plan approval

from all Corporations, Municipalities and Panchayats videG.O.Ms.No.177 and G.O.Ms.No.302. As per Government Orders, the Company need not obtain any specific permission or No Objection Certificate from any local authorities. However, as per the order of this Court in W.P.No.7544 of 2017 and W.P.No.15144 of2019 and W.P.(MD)No.15974 of 2017, the petitioner Company has to send permission/requisition letter to the District Collector to erect transmission cell phone towers and the District Collector shall pass orders in accordance with the Rules and the order should be passed not later than three weeks from the date of application from the mobile phone tower operators.

7. As rightly pointed out by the learned counsel for the petitioner, erection of cell phone towers to connect India through its length and breadth is absolute need of the hour. We have close to nearly for 16 months so far, due to the prevailing pandemic situation, not in a position to move, interact and do our regular business freely. The situation is that the students are being taught only through online education. Business transaction and official meeting are being held through video conferencing. In fact, the conduct of Court proceedings are being done through video conferencing. Therefore, it is necessary that the information and communication technology network should be expanded for meeting the growing need. Installation and erection of cell phone towers is one of the necessary steps to be taken for the effective and robust communication network."

42. That **Hon'ble Kerala High Court** in the case of **Reliance Infocom Ltd. Vs. Chemanchery Grama Panchayat** and Ors., reported in **AIR 2007 Kerala 33** has observed on **12-10-2006** that the surveys conducted in proximity to the base stations indicated that the public was exposed to extremely low intensity

RF fields in the *environment* and all the evidences indicated that they were unlikely to pose the risk to health. Observations of Division bench of the Kerala High Court, as contained in para 5 of the judgment are as follows:

"5. We have already found that RF exposures from Mobile Base Stations are much less than from radio, Fm radio and television transmissions and that the consensus of scientific community is that the radiation from Mobile Phone Base Stations is far too low to produce health hazards if people are kept away from direct access to the antenna and the overall evidence indicates that they are unlikely to pose a risk to health. The strength of radio frequency fields in front of the antennae varies with the distance. Persons standing directly in front of the antennae in these high density zones will get higher exposures. We have also found that the height of Mobile Base Station antennae is normally 36 metres and the effect of radio waves depends on the distance from the base stations since the antennae are directed horizontally with a 5 degree downwards tilt. Human studies pertaining to base stations conducted by Santini R et al (2002), Bortkiewicz et al (2004) & Hutter & Kundi et al (2006) do not report any quantitative parameters related to health hazards. Therefore, it can safely be concluded that the permission granted for installation of Mobile Base Station by the Panchayat would not cause as such any health hazards nor will it affect the fundamental rights guaranteed to citizens under Article 21 of the Constitution. Right to life enshrined under Art.21 includes all those aspects of life which make life meaningful, complex and worth living. Development of technology has its own ill-effects on human beings, but, at times people will have to put up with that at the cost of their advantages. Petitioner and others for installing towers will have necessarily to comply with the statutory provisions contained in Chapter XIX of the Kerala Municipal Building Rules, 1999 which permits construction of telecommunication towers over buildings. Petitioner has submitted that it has already satisfied all those conditions and in such circumstance, Panchayat has granted the licence."

43. That **WP(C) No. 4282 & 7127 of 2009 filed** in **Kerala High Court** have been dismissed vide Judgement dated **09-07-2009.** The relevant excerpts of the Judgement is as follows:

"In their counter affidavit, the 4th respondent would also take the contention that the reason for cancellation of the permit that the tower is a health hazard to the public has already been found unsustainable by this Court in Reliance Infocom Ltd., v.Chemanchery Grama Panchayat, 2006(4) KLT 695."

44. That **W.P. (C) No. 6433 of 2010** filed in **Kerala High Court** have been dismissed vide Judgement dated **08-04-2010.** The relevant excerpts of the Judgement is as follows:

"In the instant cases, there is absolutely no question of any pollution and there is no pleading or proof as to any such instance and the only apprehension is with regard to the 'health hazards' likely to be created by the 'EMR'. As mentioned already, the Radio frequency waves are non-ionizing radiation, which cannot emit any electrons, unlike 'X-rays' and that apart, no Scientific Committee Report has been procured or produced to controvert the findings rendered by the Division Bench in Reliance's case 2006 (4) K.L.T. 695.

45. That **WP(C) No. 24569 of 2012** filed in **Kerala High Court** have also been dismissed vide Judgement dated **09-07-2013.** The relevant excerpts of the Judgement is as follows:

"The writ petition was filed as early as on b16.10.2012. None of the respondents have filed any counter affidavit in this writ petition. The matter was heard. Whether the commissioning of a telecommunication tower would affect the health of the people of the area is an issue which is still being debated among the scientist communities all over the world. This Court has, in two decisions, held that there is no evidence that the same will affect the health of the people. Whether it will affect the health of the people or not, it is an undisputed fact that we are bound to live for the rest of our lives with mobile phones in our pockets. The statute prescribes certain licenses and permits for erecting telecommunication towers. All what we can ensure is that such requirements are complied with in the erection and operation of the tower.

In the above circumstances, if the petitioner has obtained necessary permits and licenses, nobody can prevent them from erecting and commissioning telecommunication towers. Therefore, we dispose of the writ petition with a direction to respondents 1 and 2 to see that the petitioner is not prevented from commissioning the telecommunication tower already erected, if they have all W.P. the permits and licences to operate the telecommunication tower."

46. That **Hon'ble Allahabad High Court** has dismissed **PIL No.-40535 of 2013** on **26-07-2013**filed by **Sh. Ashwani Vs. State of U.P.** stating:

"Till a proper research is made and conclusively it is shown that Mobile Towers in residential areas are a definite health hazard, it will not be proper to ask for removal of such towers from the residential areas, which is not prohibited under any law or executive decisions of the State. Petitioner has failed to properly research and has not stated that this issue has not been determined authentically."

47. That **PIL 48084 of 2015** along with 15 other petitions filed in **High Court of Allahabad** have been disposed of vide Judgement dated **12-04-2016.** The relevant excerpts of the Judgement is as follows:

"We felt constrained to burden this judgment with various extracts of the findings and recommendations of DOT, the Parliamentary Standing Committee as well as the WHO in order to establish that a plethora of material gathered by experts clearly negatives the perceived and alleged imminent threat and danger to health as was sought to be canvassed before us. ***All the experts have unanimously voiced their opinion that the present body of scientific research does not justify the threat to health and life as is sought to be portrayed by some quarters including the petitioners before us.***

On the above state of the record we find no merit in the challenge raised by the petitioners on this score. Bearing in mind the present conclusions and findings on the subject as expressed by experts across the board we find that there exists no justification for the submission of a present and imminent danger or threat to human health from the radiation emitted by mobile towers and BTS's. We further note that the studies undertaken both in India as well as by other international organizations have unanimously opined that the emissions from these equipments are minuscule and do not warrant the anxiety or fear which is sought to be generated in this batch of petitions. Our conclusion so recorded is of course not intended to relieve DOT or the Union Government from its obligation of continuing a scientific review of the subject."

48. That **CWP No. 12047 of 2013** filed by **Sh. Dhup Singh Vs. Union of India**, Hon'ble **High Court of Punjab & Haryana** dismissed the petition on **09-07-2014** stating:

"In view of the fact that Union of India had taken steps as mentioned in their detailed reply, no ground is made out for restraining the official respondent from installing mobile tower in residential area."

49. That **SCA No. 16307 of 2013** filed by Indus Towers Limited in **High Court of Gujarat** have been allowed vide Judgment dated **15-07-2014** stating that **asking** the petitioner to produce NOC from the residents of the society is beyond authority and power of respondent Nagarpalika.The relevant excerpts of the Judgement is as follows:

"7. In the circumstances, the present petition stands allowed in terms of Para Nos.19(A) and 19(B) quashing and setting aside the notice dated 30.08.2013 asking the petitioner to produce 'No Objection Certificate' from the residents of the society as beyond authority and power of the respondent Nagarpalika. The petitioner is permitted installation of the subject mobile tower and the respondent Nagarpalika shall not hamper or object the installation, functioning and operation of mobile tower in any manner. However, it goes without saying that the petitioner shall take note of the precautionary measures as laid down by the guidelines issued by the Department of Telecommunications, Ministry of Communications and IT, Government of India. Rule is made absolute."

50. That Based the judgment of Division bench of the Hon'ble Kerala High Court, mentioned above, the Hon'ble **High Court of Gujarat at Ahmadabad** has rejected**SCA No. 5548 of 2014**, CA no. 5597 of 2014 and CA No. 5159 of 2014. Hon'ble High Court has also mentioned:

"27. ...the radio frequency waves used for mobile phones are not covered under the definition of "radiation" as given in the Atomic Energy Act, 1962 and the non-ionizing radiations do not have the capability to ionize the matter with which they interact. The Radiation Protection Division (NRPB) of the U.K. Health Protection Agency in the year 2000 has reported that the balance of evidence indicates that there is no general risk to the health of the people living near the base stations on the basis that the exposures are expected to be small fractions of guidelines."

51. That **Hon'ble Madras High Court** dismissed the petition **W.P. no. 27956/2014** on **27-10-2014** stating:

"2. If we have to accept the aforesaid plea of the petitioner, then we would have to shut down mobile services practically throughout Tamil Nadu. In Chennai, most areas would be thickly populated and if this test is applied, then there would be no mobile services available in Chennai.

3. Whether the society should live with or without mobile services or with other subject matters of perceived development, are matters relating to the policy decision of the Governments, which are elected by the people. It is not permissible for each individual to canvass his thinking on such issues and seek judicial restraint orders."

52. That **Hon'ble Madras High Court** disposed of about 50 petitions along with **W.P. No. 24976 of 2008 on 05-03-2015** stating:

"10. We are, thus, of the view that in a judicial proceeding these aspects cannot be analysed. There being no materials atleast as on date, which can finally suggest any health hazards from these towers and the solution thereof, the Court would not venture into unchartered territory of technical expertise to determine the area

where it should be installed. The Court, at best can place this matter before the appropriate Committee to look into this matter which the Kerala High Court already did and we have the benefit of the conclusion arrived at in those proceedings, as noticed above.

11. We are of the view that no further directions are required in these matters, other than to say that the concerned authorities would continue to analyse the materials as and when it emerges to look into the concern raised by the petitioners, especially, in view of the fact that there is no final view as yet on these aspects. Science grows and evolves and one does not know what may happen tomorrow. It is, in this context, we have made these observations"

53. That **CRL.O.P.(MD) Nos. 6885 and 6895 of 2015** and **WP.(MD) Nos. 5249 of 2010 along with 11 other petitions** filed in **Madurai Bench of Madras High Court** have also been dismissed vide Judgment dated **15-04-2015** and **22-04-2015** respectively on the basis of the Judgment of Madras High Court in W.P.Nos.24976 of 2008 on 05-03-2015.

54. That **WP (C) No. 8661 of 2015** filed in Hon'ble **High Court of Delhi** seeking a mandamus to the Union of India (UOI) to make proper amendments and issue new advisory guidelines incorporating the Recommendation No.13 of the IMC report of the year 2010-2011, of imposing restrictions on installation of mobile phone towers near high density residential areas, schools, playgrounds and hospitals has been dismissed by the Hon'ble court on **09-09-2015** stating:

"...

This Court cannot, upon being approached by residents or by association of residents, interfere with the works undertaken in accordance with the prevalent policy.

...

I am of the opinion that the said matters fall in the domain of policy making and the Courts, neither have the jurisdiction to nor where-with-all to take a call thereon. The appropriate authority has made the policy and while framing such policy, the report of the IMC has been duly considered. It is not for the Court to enter into the arena of finding out, whether the policy made by the expert body constituted, for going into the said question, is correct or not and that too on the basis of an opinion of some persons in the process of such decision making. It is the settled position in law (see Surgical Electronics Vs. Union of India 60 (1995) DLT 359 (DB) and Rajinder Kumar Khatri Vs. Delhi Development Authority MANU/DE/4005/2011) that such comments / opinions during the decision making process cannot form the basis of the challenge to the ultimate decision, even if contrary to the opinion at one level in the decision making process.....The Inter-ministerial Committee and its recommendations are but a stage in the making of the policy aforesaid."

The Hon'ble court also took notice of several judgments of the Kerala High Court viz. *M/s. Essar Telecom Infrastructure (P) Ltd. Vs. C.I. of Police, Angamali Police Station* MANU/KE/2780/2010 (FB), *Indus Towers Ltd. Vs. The Sub Inspector of Police* MANU/KE/1308/2014 (DB) and *Sudevan Vs. Mundur Grama Panchayat* MANU/KE/0839/2013, holding that **mobile phone towers do not pose any health hazard and stated:**

"Citizens not wanting to give up use of cell phones cannot approach the Court to push the towers and antennas essential for use thereof, from their own door steps to another person's door step; if at all they feel that the technology is harmful for them, all they have to do to give up the use of the same and in which case there would also be no need for towers and antennas required to be installed for enabling use thereof."

55. That **WP(c) 5550 of 2015** filed in **High Court of Delhi** have been dismissed vide Judgment dated **26-04-2016.** The relevant excerpts of the Judgment is as follows:

"12. In view of the above, it is clear that there is no scientific data available to show that installation of mobile phone towers and the emission of the waves by the said towers is in any way harmful for the health or hazardous to the health of citizens. There is no conclusive data to the said effect. The petitioner has not been able to produce any data whatsoever showing any such harmful effects on the health of human beings. The petitioner has also not been able to show violation of any norms by the respondent."

56. That **WP(c) 6525 of 2012** filed in **High Court of Delhi** have also been dismissed vide Judgment dated **05-05-2016** on the basis of the above mentioned Judgment of Delhi High Court dated 26-04-2016.

57. That **CWP 8283 of 2012** along with CWP No. 5282, 9747 of 2014 and 3287 of 2015 filed in **High Court of Himachal Pradesh, Shimla** have been dismissed vide Judgment dated **30-11-2015** stating that they find no merit in these petitions. In its Judgment, Hon'ble Court has discussed judgments of various High Courts on the similar matter in detail and stated:

"It is evident from the aforesaid precedents that there appears to be broad consensus amongst all the High Courts save and except Rajasthan High Court, suggesting that radiation being emitted from the Mobile Base Stations do not cause serious risk on the health of the people living near these base stations."

....

"At thisstage, it would be pertinent to note here that the aforesaid judgment of Rajasthan High Court is not only subjudice, but even the substantive direction ordering removal of towers have been stayed by the Hon'ble Supreme Court.

In so far as the recommendations of the Inter Ministerial Committee are concerned, which in fact formed the basis of the judgment of the Rajasthan High Court, the same have now been adopted as stricter norms for emission from the base stations being 1/10th of the limit prescribed by the ICNIRP..."

Hon'ble High Court has also quoted and discussed the entire write-up provided on the website of DoT under the section "A Journey for EMF" and stated that:

"The Department of Telecommunication (Ministry of Communication and Information Technology) has published on its website very instructive information regarding the health effect due to EMF"

After detailed discussion of the available materials, the Hon'ble Court has *concluded* that:

"17. It is evident from the perusal of the aforesaid reports that the exposures to electromagnetic fields (EMF) do not have any notable effect on the health of human beings. Evidently, the studies conducted till date by the two premier organizations i.e. WHO and SCENIHR go to indicate that despite a large number of studies having been carried out for the last two decades to assess the potential health risk on account of emission of EMF, no major adverse health effect has been noticed.

18. What in fact emerges is that radio frequency radiation from the mobile towers and phones are in minuscule range and is lakhs of time weaker than X-rays or UV rays or even normal visible light. In fact, so low that they simply cannot cause any disturbance of electrons in the basic atoms of matter or living tissue and hence classified as "non-ionising radiation".

19. Radiation in itself is nothing new and has been there since life began on earth three and a half billion years ago. Radiation is all around us and we are all actually submerged in naturally occurring ionizing radiation reaching us from the outer space, even *from the radioactive elements and materials around us. Sun shine in itself is a familiar form of radiation.*

20. We in view of the overwhelming material are of the considered view that as of now there is no cause of alarm with regard to the possible ill-effect on human health by electromagnetic Field (EMF radiation) from mobile phone towers and mobile phones because the limits adopted in India cannot have any biological effect on human. In fact, the limits set by India are much lower than the internationally adopted recommendations of the International Commission of Non-Ionizing Radiation Protection (ICNIRP) which account for thermal and non thermal effect.

21. There is no conclusive evidence as on date which may have found any adverse health effect by EMF radiation from the mobile tower or mobile hand set by the WHO or SCENIHR and so long as EMP radiation power level in vicinity of Mobile Base Stations is below the prescribed limits, there should not be any cause or concern for adverse thermal effect on human beings living close to Mobile Base Station or in the nearby vicinity.

22. Now in teeth of the report submitted by the WHO and another report submitted by the SCENIHR, the individual opinions relied upon by the petitioners to claim that the EMF radiations from the Mobile Base Stations are source of health hazard, for the time being, can conveniently be brushed aside as having no scientific backing whatsoever and therefore, any such reports relied upon by the petitioners shall have to give way to the opinion rendered by the WHO and SCENIHR. However, it appears that some myths are being spread and circulated simply in order to create fear amongst the people, but then as aptly said by Nobel laureate Marie Curie that "Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less." "

58. That**Conclusion: EMF radiations from a mobile tower, which are below the safe limits prescribed by ICNIRP and recommended by WHO, have no convincing scientific evidence of causing adverse health effects. Department of**

Telecommunications have prescribed stricter precautionary norms for exposure limit for the Radio Frequency Field (Base Station Emissions) which is ten times more stringent than the existing limits prescribed by ICNIRP and recommended by WHO. Also, there is no separate norm for special localities like schools, hospitals and residential areas. Further, Government of India has taken adequate steps to ensure that Telecommunications Service Providers strictly adhere to these prescribed norms.

59. Thatall the other individual paras are not related to DoT as such, comments against each para is neither required nor being given and hence without entering into para-wise reply of the petition, the answering respondent meeting only those averments which have a bearing on the issues involved. However, the answering respondent craves leave of the Hon'ble Court to file a para-wise reply, if and when required.

60. That while deciding the case on merit the above facts, reasons, and circumstances stated in the preceding paragraphs may be considered by the Hon'ble Court.

61. That the Applicant has filed above titled suit on false and fictitious ground against the respondent No. 3. It is submitted that the

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Applicant has no cause of action to file the present litigation against the respondent No. 3. The alleged cause of actions is totally false, fabricated, frivolous and manipulated.

62. That an affidavit in support of this reply is also attached here with.The undersigned has been authorized by the respondent No. 3 to file this reply on his behalf

PRAYER

In view of the above facts and circumstances, it is therefore, most respectfully and humbly prayed that this Hon'ble Court may kindly be pleased to:

i. Dismiss the Original Application of the Applicant against the respondent No. 3; and

ii. Pass any such or further orders as may deem fit and proper in the facts and circumstances of the present case, in the interest of justice.

For the respondent No., 3

Union of India, Department of
Telecommunications, New Delhi.

Director (Admin)
O/o Advisor, Delhi LSA
Ministry of Telecommunications
Department of Telecommunications
Nehru Place, New Delhi-19

(37)

Through

GIGI.C.GEORGE

ADVOCATE

STANDING COUNSEL(UOI)

Chamber No.457, Delhi High Court

New Delhi

Mob- 9810625315

Email- gigicgeorge.adv42@yahoo.in

DELHI

DATED 23.11.2022

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BEFORE THE NATIONAL GREEN TRIBUNAL PRINCIPAL BENCH

NEW DELHI

OA NO. 557 OF 2022

IN THE MATTER OF ::

Gaur Atulyam Apartment Owners Association

...Applicant

VERSUS

Greater Noida Industrial Development Authority &ors

...Respondents

AFFIDAVIT

I, Sandeep Kumar S/o Shri Rati Ram aged about 49 years working as Director in the office of Advisor Delhi LSA , Department of Telecommunications, Union of India, do hereby solemnly affirm and declare as under:-

1. That the deponent is the employee of the respondent No. 3 and is fully conversant with the facts and circumstances of the case as per the records maintained by the department and is competent to swear this affidavit.

2. The deponent has been authorized by the respondent No. 3 to file this reply on its behalf.

The Seal of the Oath Commissioner
Sl. No.-30/2021
MINATI MURARI
App By
Period
to 11/04/2023
Saket Distt. Court, New Delhi

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3. That the contents of the accompanying Reply have been drafted by our counsel under our instructions and the same are true to my personnel knowledge derived from records and are based on legal advice received and believed to be correct.

I Identify the Executant/Deponent who has signed in my presence.

DEPONENT

Director (Admin)
O/o Advisor, Delhi LSA
Ministry of Telecommunications
Department of Telecommunications
Nehru Place, New Delhi-19

VERIFICATION:

23 NOV 2022

Verified at New Delhi on this day of November , 2022 that the contents of the above affidavit are true and correct to the best of my knowledge and belief.

CERTIFIED THAT THE DEPONENT
Shri / Smt. / Km.......Sandeep Kumar
S/o, W/o, ...
R/o..........
Identified by Shri / Smt.......
has Solemnly affirmed before me
Delhi.......... Sl. No......
that the contents of the affidavit which
have been read & explained to him are
True and correct to the Knowledge.

Oath Commissioner, Delhi
MINATI MURARI

The Seal of the Oath Commissioner
Sl. No.-30/2021
MINATI MURARI
App. By Delhi High Court
Period 12/04/2021
to 11/04/2023
Saket Distt. Court, New Delhi

DEPONENT

Director (Admin)
O/o Advisor, Delhi LSA
Ministry of Telecommunications
Department of Telecommunications
Nehru Place, New Delhi-19

23 NOV 2022

Annexure - R - 1

(40)

DEPARTMENT of TELECOMMUNICATIONS
ADVISORY GUIDELINES FOR STATE GOVERNMENTS FOR ISSUE OF CLEARANCE FOR INSTALLATION OF MOBILE TOWERS
(Effective from 01.08.2013)

1. The Indian telecom sector has witnessed phenomenal growth and mobile telephony in particular has revolutionized in the country over the past decade. Providing telephone coverage across the country has been one of DoT's top priority areas. Out of 921 million connections, 891 million are wireless, as on May 2013. The popularity of cell phone and wireless communication devices has resulted in a proliferation of cell towers across the country.

2. Fixation of standards for exposure limits of radio frequency field emissions from mobile base stations, monitoring their compliance, all radiation related technical issues, issues of Access Service Licence / Infrastructure Provider registration and SACFA clearance for frequency allocation at any location are dealt with by DoT.

3. India has adopted strict limit for radiation from Base Transceiver Station (BTS), as below, which is $1/10^{th}$ of the International norms (ICNIRP):

Frequency in MHz	Power density limit
900	0.45 watt/m^2
1800	0.9 watt/m^2
2100 and above	1 watt/m^2

4. Broad guidelines for issue of clearance for installation of mobile phone towers were issued on 23.08.2012 and later modified on 26.03.2013. Subsequently, on the basis of feedback received after deliberations made with the state government officials and various stake holders on 16.04.2013 and holding further consultations thereafter, the guidelines have been finalized for the state governments. These are detailed in A and B below. ***These guidelines are issued in supersession of all earlier guidelines on the subject.***

A. Documents to be submitted by Telecom Service Providers/ Infrastructure Providers for obtaining clearance from local bodies / state governments for installation of mobile towers:

I. Copy of relevant license / Infrastructure Provider Registration Certificate from Department of Telecommunications.

II. Data Sheet

a) Name of Service/Infrastructure Provider
b) Location
c) Tower Reference:
i) Height, ii) Weight iii) Ground/Roof Top iv) Pole/wall mounted v) Number of antennae

III. Copy of SACFA clearance / copy of SACFA application for the said location submitted to WPC wing of DoT with registration number as

WPC acknowledgement along with undertaking that in case of any objection/ rejection, TSPs/ IPs will take corrective actions / remove the tower.

IV. Copy of structural stability certificate for ground based tower. In case of roof top BTS towers, structural stability certificate for the building and tower based on written approvals of any authorized Structural Engineer of state/local bodies/Central Building Research Institute (CBRI), Roorkee/ IIT/NIT or any other agency authorized by local body.

V. Copy of the type test certificate issued by Automotive Research Association of India (ARAI) to the manufacturers of the Diesel Generator (DG) Sets.

VI. Copy of clearance from Fire Safety Department only in case for high rise buildings where Fire Clearance is mandatory.

VII. For forest protected areas, the copy of clearance from State Environment & Forest Department, if applicable.

VIII. The local bodies may also seek submission of the copy of No Objection Certificate (NOC) from Building Owner / entities having roof top rights or roof top tenants in case of roof based tower/ land owner in case of ground based tower, as the case may be. As per their rules in force, State Governments, at their discretion, may seek fresh NOC at the time of renewal of site (tenancy) contract for mobile tower.

IX. Acknowledgement receipt issued by TERM Cells (DoT) of the self-certificate submitted by Telecom Service Provider/ Infrastructure Provider in respect of mobile tower/ BTS (ground based/ roof top/ Pole/ wall mounted) in the format as prescribed by TEC, DoT, establishing / certifying that all General Public areas around the tower will be within safe EMR exposure limit as per peak traffic measurement after the antennae starts radiating.

B. Action by State government/Local body

I. Nominal one time Administrative Fee as may be decided by the State Government to recover its costs on the issue of permission for installation of Tower.

II. Single Window Clearance may be provided in a time bound manner to telecom service provider / infrastructure provider by the local body / State Government. This will ensure issuance of faster clearances.

III. Telecom towers have been given infrastructure status by Government of India vide gazette notification no 81 dated 28.03.2012. All benefits, as applicable to infrastructure industry, should be extended. **Electricity connection may be provided to BTS site on priority.**

IV. Telecom installations are lifeline installations and a critical infrastructure in mobile communication. In order to avoid disruption in mobile communication, an essential service, sealing of BTS

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towers / disconnection of electricity may not be resorted to without the consent of the respective TERM Cell of DoT in respect of the EMF related issues.

V. State Governments along with DoT may organise public awareness programmes involving civil society members.

VI. In order to effectively address **Public Grievances** relating to installation of towers and issues related to telecom infrastructure, State Governments may setup:

- State Level Telecom Committee (STC) consisting of officers from TERM Cells, State Administration, representative(s) of concerned Telecom Service Provider(s) and eminent public persons etc.
- District Level Telecom Committee (DTC) consisting of officers from District Administration, representative(s) of concerned Telecom Service Provider(s) and eminent public persons etc.

C. Action by DoT/ TERM Cells

I. Public awareness programme (Through DoT web portal / Govt. Publication).

II. a) For all the existing as well as new BTSs / Towers, Telecom Service Providers are required to submit self-certificates periodically in the format as prescribed by TEC, DoT, in order to ensure that normally all general public areas around the site are within the safe EMR exposure limits. Any violation noticed attracts heavy penalties on Telecom Service Provider(s) and may also lead to shut down of BTS in case the violation persists.

b) The TERM Cells have been given clear instructions with regard to the technical audit of BTS, including for radiation from towers within safe limits. These include roof top/ ground based/ pole mounted/ wall mounted towers. They will also verify antenna orientation, safe distance from the tower (exclusion zone) etc. Installation and augmentation of BTS and antenna is a continuous process. DoT is organizing frequent workshops for these officers to ensure observance of the latest guidelines issued by DoT on the subject of EMF radiation and public safety. Additional Guidelines for TERM Cells as follows:

(43)

Additional Guidelines to TERM Cells for auditing BTS For EMF radiation

(Effective from 01.08.2013)

****

1. Instructions/guidelines have been issued to the TERM Cells for auditing the RF radiations from BTS for compliance to the prescribed norms. Following are additional guidelines to TERM Cells in the matter.

2. With a view to strengthen monitoring and compliance of safety aspects / provisions in regard to radio frequency emissions from mobile towers, TERM Cells may take the following also into account while conducting their audits for the purpose of ensuring that all general public areas are within safe EMF exposure limits as prescribed by DoT.

   - In case of both ground based towers & roof top towers, there shall be no building right in front of the antenna(e), of equivalent height taking into account the tilt of the lowest antenna on tower as per details in the table below. Further, the antennae at the same height only are to be counted, as the beam width of the mobile antennae, in the vertical direction, is very narrow.

Number of antenna(e) pointed in the same direction	Building/Structure safe distance from the antenna(e) at the same height (in meters)
1	20
2	35
4	45
6	55

   - The distance figures in the above table are based on empirical estimation considering that all the antennae are emitting at their maximum RF power of 20 Watts and exactly in the same direction with same height (a worst case scenario). In practice, the values of safe distance of buildings will depend upon actual deployment scenarios and mostly, may be far less than depicted above.

3. <u>Wall Mounted/Pole mounted Antenna:</u>

   - Wherever the antennae are mounted on the wall of building or pole on/along the road, their height should be at least 5 meters above ground level /road level. However, such installations will have to comply with the radiation limits.
   - As far as safe distance of buildings from antenna is concerned, guidelines as given above will apply.

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Annexure-R-2

(94)

The Indian Telegraph Right of Way Rules, 2016

[As amended from time to time (in 2017, 2021 and 2022)]

GOVERNMENT OF INDIA

MINISTRY OF COMMUNICATIONS

(Department of Telecommunications)

NOTIFICATION

New Delhi, the 15th November 2016

G.S.R. 1070(E). — In exercise of the powers conferred by sub-section (1) and clause (e) of sub-section (2) of section 7 read with sections 10, 12 and 15 of the Indian Telegraph Act, 1885(13 of 1885), the Central Government hereby makes the following rules to regulate underground infrastructure and overground infrastructure, namely: -

CHAPTER I

PRELIMINARY

1. **Short title and commencement.** -(1) These rules may be called the Indian Telegraph Right of Way Rules, 2016.

(2) They shall come into force on the date of their publication in the Official Gazette.

2. **Definitions.** -(1) In these rules, unless the context otherwise requires, -

(a) "Act" means the Indian Telegraph Act, 1885 (13 of 1885);

(b) "appropriate authority" means the Central Government, respective State Governments, local authority or such authority, body, company or institution incorporated or established by the Central Government or the State Government, in respect of property, under, over, along, across, in or upon which underground or overground telegraph infrastructure, is to be established or maintained, vested in, or under, the control or management of such appropriate authority;

(c) "State Government" means the State Government having jurisdiction, and includes the administration of a Union territory;

(d) "licensee" means any person holding a licence issued under sub-section (1) of section 4 of the Act;

(e) "overground telegraph infrastructure" means a telegraph or a telegraph line established over the ground and includes posts or other above ground contrivances, appliances and apparatus for the purpose of establishment or maintenance of the telegraph or the telegraph line;

(f) "rule" means the Indian Telegraph Right of Way Rules, 2016.

(g) "underground telegraph infrastructure" means a telegraph line laid under the ground and includes manholes, marker stones, appliances and apparatus for the purposes of establishment or maintenance of the telegraph line.

(h) "Schedule" means a Schedule appended to these rules.".

(2) Words and expressions used and not defined herein but defined in the Act shall

have the meaning assigned to them in the Act.

3. **Applicability.** - The appropriate authority shall exercise the powers under these rules on an application for establishment and maintenance of underground or overground telegraph infrastructure by any licensee on whom the powers of the telegraph authority have been conferred by notification under section 19B of the Act, subject to any conditions and restrictions as may be imposed in such notification.

4. **Nodal officer to be designated by local authority, etc.**-(1) Every appropriate authority shall designate a nodal officer for the purposes of these rules.

(2) Every application for permission under these rules shall be made by the licensee on an electronic portal developed by the Central Government.

CHAPTER II

ESTABLISHMENT AND MAINTENANCE OF UNDERGROUND TELEGRAPH INFRASTRUCTURE

5. **Application by a licensee.** — (1) A licensee shall, for the purposes of establishment of telegraph infrastructure under any immovable property vested in or under the control or management of any appropriate authority, make an application, supported by such documents, to that authority in such form and manner as may be specified by that appropriate authority.

(2) The information along with supporting documents to be provided by the licensee in the application made under sub-rule (1) shall include-

(i) a copy of the licence granted by the Central Government;

(ii) the details of underground telegraph infrastructure proposed to be laid;

(iii) the mode of and the time duration for, execution of the work;

(iv) the time of the day when the work is expected to be done in case the licensee expects the work to be done during specific time of the day;

(v) the details of expenses that such appropriate authority will necessarily be put in consequence of the work proposed to be undertaken by the licensee;

(vi) the inconvenience that is likely to be caused to the public and the specific measures proposed to be taken to mitigate such inconvenience;

(vii) the specific measures proposed to be taken to ensure public safety during the execution of the work;

(viii) any other matter relevant, in the opinion of the licensee, connected with or relative to the work proposed to be undertaken; and

(ix) any other matter connected with or related to the work as may be specified, through a general or special order, by the Central Government or appropriate State Government or appropriate local authority:

Provided that the licensee shall, while making the application, give a specific commitment on whether he undertakes to discharge the responsibility for restoration, to the extent reasonable and prudent, of the damage that the appropriate authority shall necessarily be put in consequence of the work proposed to be undertaken.

(3) Every application under sub-rule (1) shall be accompanied with such fee to meet administrative expenses forexamination of the application and the proposed work as the appropriate authority may, by general order, deem fit:

Provided that such fee to meet administrative expenses shall not exceed the amount specified in Part-I of the Schedule.

6. **Grant of permission by appropriate authority.** - (1) The appropriate authority shall examine the application with respect to the following parameters, namely: -

(a) the route planned for the proposed underground telegraph infrastructure and the possible interference, either in the establishment or maintenance of such telegraph infrastructure, with any other public infrastructure that may have been laid along the proposed route;

(b) the mode of execution;

(c) the time duration for execution of the work and the time of the day that the work is proposed to be executed;

(d) the estimation of expenses that the appropriate authority shall necessarily be put in consequence of the work proposed to be undertaken;

(e) the responsibility for restoration of any damage that the appropriate authority may necessarily be put inconsequence of the work proposed to be undertaken;

(f) assessment of measures to ensure public safety and inconvenience that the public is likely to be put to in consequence of the work proposed and the measures to mitigate such inconvenience indicated by the licensee;

(g) any other matter, consistent with the provisions of the Act and these rules, connected with or relative to the establishment or maintenance of underground telegraph infrastructure, through a general or special order, by the Central Government, appropriate State Government or the appropriate local authority.

(1A) The area of the underground telegraph infrastructure proposed to be established shall be the length of duct multiplied by the diameter of the duct multiplied by the number of the ducts.

Explanation. - "duct" means a pipe, permanently lubricated or of any other kind, used as underground cable conduit for telegraph line.

(1B) The appropriate authority shall be entitled to receive such compensation from the licensee, not exceeding the amount specified in Part-III of the Schedule, for the use of the property under which the underground telegraph infrastructure is proposed to be established, as may be determined by the appropriate authority.

(2) The appropriate authority shall within a period not exceeding sixty days from the date of application made underrule 5-

(a) grant permission on such conditions including, but not limited to, the time, mode of execution, measures to mitigate public inconvenience or enhance public safety and payment of restoration charge, not exceeding the amount specified in Part-II of the Schedule:

Provided that where horizontal directional digging technology is used for establishing underground telegraph lines, restoration charges shall be levied for pits only; or

(b) reject the application for reasons to be recorded in writing:

Provided that no application shall be rejected unless the applicant licensee has been given an opportunity of being heard on the reasons for such rejection:

Provided further that the permission shall be deemed to have been granted if the appropriate authority fails to either grant permission under (a) or reject the application under (b); and the same shall be communicated in writing to theapplicant not later than five working days after permission is deemed to have been granted.

(3) Where the appropriate authority accepts the undertaking by the licensee to discharge the responsibility to restorethe damage that such appropriate authority shall necessarily be put in consequence of the work, the appropriate authority,while granting permission under clause (a) of sub-rule (2), may seek a bank guarantee for an amount, not exceeding the amount specified in Part-II of the Schedule, in lieu of expenses for restoration of such damage, as security for performance in the discharge of the responsibility.

(4) The appropriate authority shall not charge any fee and compensation other than those prescribed under sub-rule (3) of rule 5, sub-rule (1B) and clause (a) of sub-rule (2) from the licensee for establishing, maintaining, working, repairing, transferring or shifting underground telegraph infrastructure.

7. Obligations of licensee in undertaking work. -(1) The licensee shall make the payment of expenses or submit the bank guarantee as determined by the appropriate authority within a period of thirty days from the date of grantof permission and prior to the commencement of work of laying the underground telegraph infrastructure:

Provided that the appropriate authority may, at its discretion, extend the said period for payment of expenses orsubmission of bank guarantee on an application made by the licensee seeking such extension.

(2) The licensee shall ensure that –

(a) prior to the commencement of work of laying the underground telegraph infrastructure and at all times during the execution of work, the measures to mitigate public inconvenience and provide for public safety are implemented; and

(b) the work of laying underground telegraph infrastructure is carried out in accordance with the conditionsspecified in the grant of permission by the appropriate authority.

(3) The licensee shall ensure provision of positional intelligence, through appropriate technology, of all underground telegraph infrastructures to enable the appropriate authority to obtain real time information on its location.

8. **Powers of appropriate authority to supervise the work.** -(1) The appropriate authority may supervise the execution of work to ascertain if the conditions imposed in the grant of permission under clause (a) of sub-rule (2) of rule6 are observed by the licensee.

(2) The appropriate authority may, on the basis of such supervision, impose such other reasonable conditions as it may think fit.

(3) If the appropriate authority comes to the conclusion that the licensee has willfully violated any of the conditionsfor grant of permission under clause (a) of sub-rule (2) of rule 6, it may forfeit, in full or in part, the bank guarantee submitted by the licensee and withdraw the permission granted to the licensee, for reasons to be recorded in writing:

Provided that no action shall be taken under this sub-rule unless the licensee has been given an opportunity ofbeing heard.

CHAPTER III

ESTABLISHMENT OF OVERGROUND TELEGRAPH INFRASTRUCTURE

9. **Application by a licensee.** — (1) A licensee shall, for the purposes of establishing overground telegraph infrastructure, upon any immoveable property vested in or under the control or management of any appropriate authority,make an application, supported by such documents, to that appropriate authority in such form and manner as may be specified by that appropriate authority.

(2) The information along with supporting documents to be provided by the licensee in the application made under sub-rule (1) shall include-

(i) a copy of the licence granted by the Central Government;

(ii) the nature and location, including exact latitude and longitude, of post or other above roundcontrivances proposed to be established;

(iii) the extent of land required for establishment of the overground telegraph infrastructure;

(iv) the details of the building or structure, where the establishment of the overground telegraph infrastructure, isproposed;

(v) the copy of approval issued by the duly authorised officer of the Central Government for location of theabove ground contrivances proposed to be used for the

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transmission of Radio waves or Hertzian waves;

(vi) the mode of and the time duration for, execution of the work;

(vii) the inconvenience that is likely to be caused to the public and the specific measures proposed to be taken tomitigate such inconvenience;

(viii) the measures proposed to be taken to ensure public safety during the execution of the work;

(ix) the detailed technical design and drawings of the post or other above ground contrivances;

(x) certification of the technical design by a structural engineer attesting to the structural safety, of the overgroundtelegraph infrastructure;

(xi) certification, by a structural engineer, attesting to the structural safety of the building, where the post or other above ground contrivances is proposed to be established on a building;

(xii) the names and contact details of the employees of the licensee for the purposes of communication in regard tothe application made;

(xiii) any other matter relevant, in the opinion of the licensee, connected with or relative to the work proposed to beundertaken; and

(xiv) any other matter connected with or relevant to the work as may be specified, through a general orspecial order, by the Central Government or appropriate State Government or appropriate local authority.

Provided that the documents mentioned in clauses (ii), (iii), (v) (ix), (x) and (xi) shall not be required in case of application made for establishment of overground telegraph line—:

Provided further that the documents related to route plan for establishment of overground telegraph line shall be required to be provided by the licensee with the application made for establishment of overground telegraph line:

(3) Every application under sub-rule (1) shall be accompanied with such fee to meet administrative expenses for examination of the application and the proposed work as the appropriate authority may, by general order, deem fit:

Provided that the one-time fee, to meet administrative expenses, accompanying every application shall notexceed the amount specified in Part-I of the Schedule.

10. Grant of permission by appropriate authority. -(1) The appropriate authority shall examine the application with respect to the following parameters, namely: -

(a) the extent of land required for the overground telegraph infrastructure;

(b) the location proposed;

(c) the approval issued by the duly authorised officer of the Central Government for location of the aboveground contrivances proposed to be used for transmission of Radio waves or Hertzian waves;

(d) the mode of and time duration for execution of the work;

(e) the estimation of expenses that the appropriate authority shall necessarily be put in consequence of the work proposed to be undertaken;

(f) assessment of the inconvenience that the public is likely to be put to in consequence of the establishment or maintenance of the overground telegraph infrastructure, and the measures to mitigate such inconvenience indicated by the licensee;

(g) certification of the technical design by a structural engineer attesting to the structural safety of theoverground telegraph infrastructure;

(h) certification, by a structural engineer, of the structural safety of the building on which the post or otherabove ground contrivances is proposed to be established;

(i) any other matter, consistent with the provision of the Act and these rules, connected with or related to the laying of overground telegraph infrastructure, through a general or special order or guidelines by the Central Government, appropriate State Government or the appropriate local authority:

Provided that the parameters mentioned in clauses (a), (b), (c), (g) and (h) shall not be necessary for examination of the application made for establishment of overground telegraph line:

Provided further that the appropriate authority shall examine the route plan for the proposed overground telegraph line and the possible interference in regard to the establishment or maintenance of such overground telegraph line with regard to any other public infrastructure that may have been laid along the proposed route: —

(1A) The area of the overground telegraph infrastructure (mobile tower) proposed to be established shall be the area occupied by the mobile tower and the supporting infrastructures, such as base transceiver station, engine alternator, etc. at the ground.

(2) Where the establishment of the overground telegraph infrastructure renders the immoveable property, vested in the control or management of any appropriate authority over which such overground telegraph infrastructure is established, unlikely to be used for any other purpose, the appropriate authority shall be entitled to compensation for the value of the immoveable property, either once or annually, assessed on such rates as that appropriate authority may, by general order, specify.

Provided that the compensation payable for the immovable property for the establishment of poles for installation of small cells and telegraph line shall not exceed the amount specified in Part-III of the Schedule.

(3) The appropriate authority shall, within a period not exceeding sixty days from the date of application made under rule 9 -

(a) grant permission on such conditions including, but not limited to, the time, mode of execution, measures to mitigate public inconvenience or enhance public safety or structural safety and payment of restoration chargenot exceeding the amount specified in

Part-II of the Schedule, or compensation, as specified in sub-rule (2); or

(b) reject the application for reasons to be recorded in writing:

Provided that no application shall be rejected unless the applicant licensee has been given an opportunity ofbeing heard on the reasons for such rejection:

Provided further that the permission shall be deemed to have been granted if the appropriate authority fails to either grant permission under clause (a) or reject the application under clause (b) and the same shall be communicated in writing to the applicant not later than five working days after permission is deemed to have been granted.

(4) The appropriate authority shall not charge any fee and compensation other than those mentioned under sub-rule (3) of rule 9, sub-rule (2) and clause (a) of sub-rule (3) from the licensee for establishing, maintaining, working, repairing, transferring or shifting overground telegraph infrastructure.

(5) For the purposes of this rule, and rule 10B and the Schedule, the expression, -

(a) "mobile tower" means any above-ground contrivance for carrying, suspending or supporting a telegraph and does not include pole;

(b) "pole" means any above-ground contrivance of height not exceeding eight meters for carrying, suspending or supporting a telegraph and does not include mobile tower;

(c) "small cell" means a low powered cellular radio access node that has a coverage of distance from ten meters to two kilometers.".

10A. Usage of street furniture for installation of small cells and telegraph line.-(1) A licensee shall for the purpose of installation of small cell and telegraph line submit an application, along with details of street furniture and a copy of certification by a structural engineer authorised by appropriate authority, attesting to the structural safety of the street furniture where installation of small cells and telegraph line is proposed to be deployed, to the appropriate authority for permission to use street furniture for installation of small cells and telegraph line.

(2) The application under sub-rule (1), shall be accompanied with such fee as may be determined by the appropriate authority to meet administrative expenses for examination of the application, which shall not exceed the amount specified in Part-I of the Schedule.

(3) The appropriate authority shall, within a period not exceeding sixty days from the date of application made, grant permission or reject the application for reasons to be recorded in writing:

Provided that no application shall be rejected unless the applicant has been given an opportunity of being heard on the reasons for such rejection:

Provided further that the permission shall be deemed to have been granted if the appropriate authority fails to either grant permission or reject the application.

(4) The appropriate authority shall be entitled to receive such compensation from the licensee, not exceeding the amount specified in Part-III of the Schedule, for use of street furniture for installation of small cells and telegraph line, as may be determined by the appropriate authority.

(5) The appropriate central authority may permit installation of small cells on their buildings and structures.

(6) For the purposes of sub-rule (5), the "appropriate central authority" means the Central Government or the authority, body, company or institution, incorporated or established by the Central Government, in respect of property, under, over, along, across, in or upon which underground or overground telegraph infrastructure, is to be established or maintained, vested in, or under, the control or management of such Government, authority, body, company or institution.

10B. Establishment of telegraph infrastructure over private property. - Where the licensee proposes the establishment of overground telegraph infrastructure over any private property, the licensee shall not require any permission from the appropriate authority:

Provided that in case of establishment of mobile tower or pole over a private building or structure, the licensee shall submit an intimation, in writing, to the appropriate authority, prior to commencement of such establishment:

Provided further that along with the intimation, he shall also submit the details of the building or structure, where the establishment of mobile tower or pole is proposed, and a copy of certification by a structural engineer, authorised by the appropriate authority, attesting to the structural safety of the building or structure, where the mobile tower or pole is proposed to be established.

11. Obligations of licensee in undertaking work. — (1) The licensee shall ensure that -

(a) prior to the commencement of establishment and maintenance of overground telegraph infrastructure and at all times, the measures to mitigate public inconvenience and ensure public safety, including structural safety of such overground telegraph infrastructure are implemented;

(b) the work of establishment and maintenance of overground telegraph infrastructure is carried out in accordance with the conditions specified in the grant of permission by the appropriate authority.

12. Powers of appropriate authority to supervise the work. — (1) The appropriate authority may supervise the establishment and maintenance of overground telegraph infrastructure to ascertain if the conditions imposed in the grant of permission under clause (a) of sub-rule (3) of rule 10 are observed by the licensee.

(2) The appropriate authority may, on the basis of such supervision, impose such other reasonable conditions, as it may think fit.

(3) If the appropriate authority comes to the conclusion that the licensee has willfully violated any of the conditionsfor grant of permission under clause (a) of sub-rule (3) of rule 10, it may withdraw, for reasons to be recorded in writing, the permission granted to the licensee:

Provided that no action shall be taken under this sub-rule unless the licensee has been given an opportunity of being heard.

CHAPTER IV

RIGHT OF APPROPRIATE AUTHORITY TO SEEK REMOVAL OF UNDERGROUND OR OVERGROUNDTELEGRAPH INFRASTRUCTURE

13. **Right of appropriate authority to seek removal, etc.**—(1) Where the appropriate authority, having regard to circumstances which have arisen since the establishment of any underground or overground telegraph infrastructure under, over, along, across, in or upon, any immoveable property vested in or under the control or management of that appropriate authority, considers that it is necessary and expedient to remove or alter such telegraph infrastructure, it shall issue a notice to the licensee, being the owner of such telegraph infrastructure, to remove or alter its location.

(2) On receipt of the notice under sub-rule (1), the licensee shall, forthwith and within a period of thirty days, proceed to submit, to the appropriate authority, a detailed plan for removal or alteration of such telegraph infrastructure.

(3) The appropriate authority shall, after examination of the detailed plan submitted by the licensee under sub-rule (2), pass such orders as it deems fit:

Provided that the appropriate authority shall, having regard to emergent and expedient circumstances requiring the removal or alteration of such telegraph infrastructure, give a reasonable time of not less than ninety days to the licensee for removal or alteration of such telegraph infrastructure:

Provided further that the responsibility and liability, including the cost thereof, for removal or alteration of suchtelegraph infrastructure shall be borne by the licensee.

CHAPTER V

DISPUTE RESOLUTION

14. **Disputes between licensee and appropriate authority**. — (1) Any dispute arising between a licensee and the appropriate authority in consequence of these rules, shall be referred to the officer designated by the Central Government.

(2) The Central Government shall designate, by notification, officers with such jurisdiction as may be mentioned in the notification, for the purpose to referring disputes under sub-rule (1).

(3) The officer designated by the Central Government shall determine the disputes referred to in sub-rule (1) withina period not exceeding sixty days in such manner as may be specified by the Central Government from time to time.

THE SCHEDULE

[See rules 5 (3), 6 (1B), 6 (2) (a), 6 (3), 9 (3), 10 (2), 10 (3) (a), 10A (2), 10A (4)]

Rule	Item	Amount
(1)	(2)	(3)
Part-I Fee		
5(3)	For establishment of underground telegraph infrastructure	One thousand rupees per kilometer.
9(3)	For establishment of overground telegraph infrastructure	(i) Ten thousand rupees for establishment of mobile towers (ii) One thousand rupees per kilometer for establishment of overground telegraph line. (iii) Nil for establishment of poles, for installation of small cells and telegraph line, on the immovable property vested in, or under control or management of appropriate central authority (iv) One thousand rupees per pole for establishment of poles, for installation of small cells and telegraph line, on the immovable property vested in, or under control or management of appropriate authority, other than appropriate central authority.
10A (2)	For installation of small cells and telegraph line using the street furniture	Nil.
Part-II Charges for restoration		
6(2)(a)	Establishment of underground telegraph infrastructure where undertaking is not given by the licensee to discharge the	Sum required to restore immovable property as per the rate prescribed by central public works department for that area or as per the rate prescribed by state public works department for that area, if no rate has been

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	responsibility to restore the damages	prescribed by central public works department for that area.
6(3)	Bank guarantee as security for performance in case of establishment of underground telegraph infrastructure where undertaking is given by the licensee to discharge the responsibility to restore the damages	20% of the sum required to restore immovable property as per the rate prescribed by central public works department for that area or as per the rate prescribed by state public works department for that area, if no rate has been prescribed by central public works department for that area.
10(3)(a)	Establishment of overground telegraph infrastructure	Sum required to restore immovable property as per the rate prescribed by central public works department for that area or as per the rate prescribed by state public works department for that area, if no rate has been prescribed by central public works department for that area. Further, licensee shall restore the damage incurred in case of establishment of poles for installation of Small Cells and telegraph line.
Part-III Compensation		
6(1B)	Establishment of underground telegraph infrastructure	Nil.
10(2)	Establishment of poles for installation of small cells and telegraph line	Nil
10A (4)	Usage of street furniture for installation of small cells and telegraph line	(i) For installation of small cells: Three hundred rupees per annum for urban area and one hundred and fifty rupees per annum for rural areas per street furniture. (ii) For installation of telegraph line: One hundred rupees per annum per street furniture.

Note: The principal rules were published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (i) *vide* notification number G.S.R. 1070 (E), dated the 15th November, 2016 and subsequently amended *vide* G.S.R. 407 (E), dated the 21st April, 2017, G.S.R. 749 (E), dated the 21st October, 2021 and G.S.R. 635 (E), dated the 17th August, 2022.

Annexure - R - 3

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Electromagnetic fields and public health

Base stations and wireless technologies

World Health Organization

Fact sheet N°304
May 2006
http://www.who.int/mediacentre/factsheets/fs304/en/index.html

Mobile telephony is now commonplace around the world. This wireless technology relies upon an extensive network of fixed antennas, or base stations, relaying information with radiofrequency (RF) signals. Over 1.4 million base stations exist worldwide and the number is increasing significantly with the introduction of third generation technology.

Other wireless networks that allow high-speed internet access and services, such as wireless local area networks (WLANs), are also increasingly common in homes, offices, and many public areas (airports, schools, residential and urban areas). As the number of base stations and local wireless networks increases, so does the RF exposure of the population. Recent surveys have shown that the RF exposures from base stations range from 0.002% to 2% of the levels of international exposure guidelines, depending on a variety of factors such as the proximity to the antenna and the surrounding environment. This is lower or comparable to RF exposures from radio or television broadcast transmitters.

There has been concern about possible health consequences from exposure to the RF fields produced by wireless technologies. This fact sheet reviews the scientific evidence on the health effects from continuous low-level human exposure to base stations and other local wireless networks.

HEALTH CONCERNS

A common concern about base station and local wireless network antennas relates to the possible long-term health effects that whole-body exposure to the RF signals may have. To date, the only health effect from RF fields identified in scientific reviews has been related to an increase in body temperature (> 1 °C) from exposure at very high field intensity found only in certain industrial facilities, such as RF heaters. The levels of RF exposure from base stations and wireless networks are so low that the temperature increases are insignificant and do not affect human health.

The strength of RF fields is greatest at its source, and diminishes quickly with distance. Access near base station antennas is restricted where RF signals may exceed international exposure limits. Recent surveys have indicated that RF exposures from base stations and wireless technologies in publicly accessible areas (including schools and hospitals) are normally thousands of times below international standards.

In fact, due to their lower frequency, at similar RF exposure levels, the body absorbs up to five times more of the signal from FM radio and television than from base stations. This is because the frequencies used in FM radio (around 100 MHz) and in TV broadcasting (around 300 to 400 MHz) are lower than those employed in mobile telephony (900 MHz and 1800 MHz) and because a person's height makes the body an efficient receiving antenna. Further, radio and television broadcast stations have been in operation for the past 50 or more years without any adverse health consequence being established.

While most radio technologies have used analog signals, modern wireless telecommunications are using digital transmissions. Detailed reviews conducted so far have not revealed any hazard specific to different RF modulations.

Cancer: Media or anecdotal reports of cancer clusters around mobile phone base stations have heightened public concern. It should be noted that geographically, cancers are unevenly distributed among any population. Given the widespread presence of base stations in the environment, it is expected that possible cancer clusters will occur near base stations merely by chance. Moreover, the reported cancers in these clusters are often a collection of different types of cancer with no common characteristics and hence unlikely to have a common cause.

Scientific evidence on the distribution of cancer in the population can be obtained through carefully planned and executed epidemiological studies. Over the past 15 years, studies examining a potential relationship between RF transmitters and cancer have been published. These studies have not provided evidence that RF exposure from the transmitters increases the risk of cancer. Likewise, long-term animal studies have not established an increased risk of cancer from exposure to RF fields, even at levels that are much higher than produced by base stations and wireless networks.

Other effects: Few studies have investigated general health effects in individuals exposed to RF fields from base stations. This is because of the difficulty in distinguishing possible health effects from the very low signals emitted by base stations from other higher strength RF signals in the environment. Most studies have focused on the RF exposures of mobile phone users. Human and animal studies examining brain wave patterns, cognition and behaviour after exposure to RF fields, such as those generated by mobile phones, have not identified adverse effects. RF exposures used in these studies were about 1000 times higher than those associated with general public exposure from base stations or wireless networks. No consistent evidence of altered sleep or cardiovascular function has been reported.

Some individuals have reported that they experience non-specific symptoms upon exposure to RF fields emitted from base stations and other EMF devices. As recognized in a recent WHO fact sheet "Electromagnetic Hypersensitivity", EMF has not been shown to cause such symptoms. Nonetheless, it is important to recognize the plight of people suffering from these symptoms.

From all evidence accumulated so far, no adverse short- or long-term health effects have been shown to occur from the RF signals produced by base stations. Since wireless networks produce generally lower RF signals than base stations, no adverse health effects are expected from exposure to them.

PROTECTION STANDARDS

International exposure guidelines have been developed to provide protection against established effects from RF fields by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998) and the Institute of Electrical and Electronic Engineers (IEEE, 2005).

National authorities should adopt international standards to protect their citizens against adverse levels of RF fields. They should restrict access to areas where exposure limits may be exceeded.

PUBLIC PERCEPTION OF RISK

Some people perceive risks from RF exposure as likely and even possibly severe. Several reasons for public fear include media announcements of new and unconfirmed scientific studies, leading to a feeling of uncertainty and a perception that there may be unknown or undiscovered hazards. Other factors are aesthetic concerns and a feeling of a lack of control or input to the process of determining the location of new base stations. Experience shows that education programmes as well as effective communications and involvement of the public and other stakeholders at appropriate stages of the decision process before installing RF sources can enhance public confidence and acceptability.

CONCLUSIONS

Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects.

WHO INITIATIVES

WHO, through the International EMF Project, has established a programme to monitor the EMF scientific literature, to evaluate the health effects from exposure to EMF in the range from 0 to 300 GHz, to provide advice about possible EMF hazards and to identify suitable mitigation measures. Following extensive international reviews, the International EMF Project has promoted research to fill gaps in knowledge. In response national governments and research institutes have funded over $250 million on EMF research over the past 10 years.

While no health effects are expected from exposure to RF fields from base stations and wireless networks, research is still being promoted by WHO to determine whether there are any health consequences from the higher RF exposures from mobile phones.

The International Agency for Research on Cancer (IARC), a WHO specialized agency, is expected to conduct a review of cancer risk from RF fields in 2006-2007 and the International EMF Project will then undertake an overall health risk assessment for RF fields in 2007-2008.

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FURTHER READING

ICNIRP (1998) www.icnirp.org/documents/emfgdl.pdf
IEEE (2006) IEEE C95.1-2005 "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz"

RELATED LINKS

- Base stations & wireless networks: Exposures & health consequences
- Fact sheet: Electromagnetic fields and public health: Electromagnetic Hypersensitivity
- WHO handbook on "Establishing a Dialogue on Risks from Electromagnetic Fields"
- 2006 WHO Research Agenda for Radio Frequency Fields
  pdf, 100kb

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Annexure R-4

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INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP GUIDELINES

FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

PUBLISHED IN: **HEALTH PHYSICS 74 (4):494-522; 1998**

ICNIRP PUBLICATION – 1998

GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

International Commission on Non-Ionizing Radiation Protection*†

INTRODUCTION

IN 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR), which examined the problems arising in the field of protection against the various types of NIR. At the IRPA Congress in Paris in 1977, this working group became the International Non-Ionizing Radiation Committee (INIRC).

In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO's Environmental Health Criteria Programme, sponsored by the United Nations Environment Programme (UNEP). Each document includes an overview of the physical characteristics, measurement and instrumentation, sources, and applications of NIR, a thorough review of the literature on biological effects, and an evaluation of the health risks of exposure to NIR. These health criteria have provided the scientific database for the subsequent development of exposure limits and codes of practice relating to NIR.

At the Eighth International Congress of the IRPA (Montreal, 18–22 May 1992), a new, independent scientific organization—the International Commission on Non-Ionizing Radiation Protection (ICNIRP)—was established as a successor to the IRPA/INIRC. The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, develop international guidelines on NIR exposure limits, and deal with all aspects of NIR protection.

Biological effects reported as resulting from exposure to static and extremely-low-frequency (ELF) electric and magnetic fields have been reviewed by UNEP/WHO/IRPA (1984, 1987). Those publications and a number of others, including UNEP/WHO/IRPA (1993) and Allen et al. (1991), provided the scientific rationale for these guidelines.

A glossary of terms appears in the Appendix.

PURPOSE AND SCOPE

The main objective of this publication is to establish guidelines for limiting EMF exposure that will provide protection against known adverse health effects. An adverse health effect causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect.

Studies on both direct and indirect effects of EMF are described; direct effects result from direct interaction of fields with the body, indirect effects involve interactions with an object at a different electric potential from the body. Results of laboratory and epidemiological studies, basic exposure criteria, and reference levels for practical hazard assessment are discussed, and the guidelines presented apply to occupational and public exposure.

Guidelines on high-frequency and 50/60 Hz electromagnetic fields were issued by IRPA/INIRC in 1988 and 1990, respectively, but are superseded by the present guidelines which cover the entire frequency range of time-varying EMF (up to 300 GHz). Static magnetic fields are covered in the ICNIRP guidelines issued in 1994 (ICNIRP 1994).

In establishing exposure limits, the Commission recognizes the need to reconcile a number of differing expert opinions. The validity of scientific reports has to be considered, and extrapolations from animal experi-

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ments to effects on humans have to be made. The restrictions in these guidelines were based on scientific data alone; currently available knowledge, however, indicates that these restrictions provide an adequate level of protection from exposure to time-varying EMF. Two classes of guidance are presented:

- Basic restrictions: Restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects are termed "basic restrictions." Depending upon the frequency of the field, the physical quantities used to specify these restrictions are current density (**J**), specific energy absorption rate (SAR), and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.
- Reference levels: These levels are provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded. Some reference levels are derived from relevant basic restrictions using measurement and/or computational techniques, and some address perception and adverse indirect effects of exposure to EMF. The derived quantities are electric field strength (**E**), magnetic field strength (**H**), magnetic flux density (**B**), power density (**S**), and currents flowing through the limbs (I_L). Quantities that address perception and other indirect effects are contact current (I_C) and, for pulsed fields, specific energy absorption (SA). In any particular exposure situation, measured or calculated values of any of these quantities can be compared with the appropriate reference level. Compliance with the reference level will ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded. However, whenever a reference level is exceeded it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary.

These guidelines do not directly address product performance standards, which are intended to limit EMF emissions under specified test conditions, nor does the document deal with the techniques used to measure any of the physical quantities that characterize electric, magnetic, and electromagnetic fields. Comprehensive descriptions of instrumentation and measurement techniques for accurately determining such physical quantities may be found elsewhere (NCRP 1981; IEEE 1992; NCRP 1993; DIN VDE 1995).

Compliance with the present guidelines may not necessarily preclude interference with, or effects on, medical devices such as metallic prostheses, cardiac pacemakers and defibrillators, and cochlear implants. Interference with pacemakers may occur at levels below the recommended reference levels. Advice on avoiding these problems is beyond the scope of the present document but is available elsewhere (UNEP/WHO/IRPA 1993).

These guidelines will be periodically revised and updated as advances are made in identifying the adverse health effects of time-varying electric, magnetic, and electromagnetic fields.

QUANTITIES AND UNITS

Whereas electric fields are associated only with the presence of electric charge, magnetic fields are the result of the physical movement of electric charge (electric current). An electric field, **E**, exerts forces on an electric charge and is expressed in volt per meter (V m^{-1}). Similarly, magnetic fields can exert physical forces on electric charges, but only when such charges are in motion. Electric and magnetic fields have both magnitude and direction (i.e., they are vectors). A magnetic field can be specified in two ways—as magnetic flux density, **B**, expressed in tesla (T), or as magnetic field strength, **H**, expressed in ampere per meter (A m^{-1}). The two quantities are related by the expression:

$$\mathbf{B} = \mu \mathbf{H}, \quad (1)$$

where μ is the constant of proportionality (the magnetic permeability); in a vacuum and in air, as well as in non-magnetic (including biological) materials, μ has the value $4\pi \times 10^{-7}$ when expressed in henry per meter (H m^{-1}). Thus, in describing a magnetic field for protection purposes, only one of the quantities **B** or **H** needs to be specified.

In the far-field region, the plane-wave model is a good approximation of the electromagnetic field propagation. The characteristics of a plane wave are:

- The wave fronts have a planar geometry;
- The **E** and **H** vectors and the direction of propagation are mutually perpendicular;
- The phase of the **E** and **H** fields is the same, and the quotient of the amplitude of E/H is constant throughout space. In free space, the ratio of their amplitudes E/H = 377 ohm, which is the characteristic impedance of free space;
- Power density, **S**, i.e., the power per unit area normal to the direction of propagation, is related to the electric and magnetic fields by the expression:

$$\mathbf{S} = \mathbf{EH} = E^2/377 = 377H^2. \quad (2)$$

The situation in the near-field region is rather more complicated because the maxima and minima of E and H fields do not occur at the same points along the direction of propagation as they do in the far field. In the near field, the electromagnetic field structure may be highly inhomogeneous, and there may be substantial variations from the plane-wave impedance of 377 ohms; that is, there may be almost pure E fields in some regions and almost pure H fields in others. Exposures in the near field are

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Table 1. Electric, magnetic, electromagnetic, and dosimetric quantities and corresponding SI units.

Quantity	Symbol	Unit
Conductivity	σ	siemens per meter (S m^{-1})
Current	I	ampere (A)
Current density	**J**	ampere per square meter (A m^{-2})
Frequency	f	hertz (Hz)
Electric field strength	**E**	volt per meter (V m^{-1})
Magnetic field strength	**H**	ampere per meter (A m^{-1})
Magnetic flux density	**B**	tesla (T)
Magnetic permeability	μ	henry per meter (H m^{-1})
Permittivity	ϵ	farad per meter (F m^{-1})
Power density	**S**	watt per square meter (W m^{-2})
Specific energy absorption	SA	joule per kilogram (J kg^{-1})
Specific energy absorption rate	SAR	watt per kilogram (W kg^{-1})

more difficult to specify, because both E and H fields must be measured and because the field patterns are morecomplicated; in this situation, power density is no longer an appropriate quantity to use in expressing exposure restrictions (as in the far field).

Exposure to time-varying EMF results in internal body currents and energy absorption in tissues that depend on the coupling mechanisms and the frequency involved. The internal electric field and current density are related by Ohm's Law:

$$\mathbf{J} = \sigma \mathbf{E}, \tag{3}$$

where σ is the electrical conductivity of the medium. The dosimetric quantities used in these guidelines, taking into account different frequency ranges and waveforms, are as follows:

- Current density, **J**, in the frequency range up to 10 MHz;
- Current, *I*, in the frequency range up to 110 MHz;
- Specific energy absorption rate, SAR, in the frequency range 100 kHz–10 GHz;
- Specific energy absorption, SA, for pulsed fields in the frequency range 300 MHz–10 GHz; and
- Power density, **S**, in the frequency range 10–300 GHz.

A general summary of EMF and dosimetric quantities and units used in these guidelines is provided in Table 1.

BASIS FOR LIMITING EXPOSURE

These guidelines for limiting exposure have been developed following a thorough review of all published scientific literature. The criteria applied in the course of the review were designed to evaluate the credibility of the various reported findings (Repacholi and Stolwijk 1991; Repacholi and Cardis 1997); only established effects were used as the basis for the proposed exposure restrictions. Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF. In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide a basis for setting exposure restrictions, although epidemiological research has provided suggestive, but unconvincing, evidence of an association between possible carcinogenic effects and exposure at levels of 50/60 Hz magnetic flux densities substantially lower than those recommended in these guidelines.

In-vitro effects of short-term exposure to ELF or ELF amplitude-modulated EMF are summarized. Transient cellular and tissue responses to EMF exposure have been observed, but with no clear exposure-response relationship. These studies are of limited value in the assessment of health effects because many of the responses have not been demonstrated *in vivo*. Thus, *in-vitro* studies alone were not deemed to provide data that could serve as a primary basis for assessing possible health effects of EMF.

COUPLING MECHANISMS BETWEEN FIELDS AND THE BODY

There are three established basic coupling mechanisms through which time-varying electric and magnetic fields interact directly with living matter (UNEP/WHO/IRPA 1993):

- coupling to low-frequency electric fields;
- coupling to low-frequency magnetic fields; and
- absorption of energy from electromagnetic fields.

Coupling to low-frequency electric fields

The interaction of time-varying electric fields with the human body results in the flow of electric charges (electric current), the polarization of bound charge (formation of electric dipoles), and the reorientation of electric dipoles already present in tissue. The relative magnitudes of these different effects depend on the electrical properties of the body—that is, electrical conductivity (governing the flow of electric current) and permittivity (governing the magnitude of polarization effects). Electrical conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the applied field. Electric fields external to the body induce a surface charge on the body; this results in induced currents in the body, the distribution of which depends on exposure conditions, on the size and shape of the body, and on the body's position in the field.

Coupling to low-frequency magnetic fields

The physical interaction of time-varying magnetic fields with the human body results in induced electric fields and circulating electric currents. The magnitudes of the induced field and the current density are proportional to the radius of the loop, the electrical conductivity of the tissue, and the rate of change and magnitude of the magnetic flux density. For a given magnitude and frequency of magnetic field, the strongest electric fields are induced where the loop dimensions are greatest. The exact path and magnitude of the resulting current induced in any part of the body will depend on the electrical conductivity of the tissue.

The body is not electrically homogeneous; however, induced current densities can be calculated using anatomically and electrically realistic models of the body and computational methods, which have a high degree of anatomical resolution.

Absorption of energy from electromagnetic fields

Exposure to low-frequency electric and magnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to electromagnetic fields at frequencies above about 100 kHz can lead to significant absorption of energy and temperature increases. In general, exposure to a uniform (plane-wave) electromagnetic field results in a highly non-uniform deposition and distribution of energy within the body, which must be assessed by dosimetric measurement and calculation.

As regards absorption of energy by the human body, electromagnetic fields can be divided into four ranges (Durney et al. 1985):

- frequencies from about 100 kHz to less than about 20 MHz, at which absorption in the trunk decreases rapidly with decreasing frequency, and significant absorption may occur in the neck and legs;
- frequencies in the range from about 20 MHz to 300 MHz, at which relatively high absorption can occur in the whole body, and to even higher values if partial body (e.g., head) resonances are considered;
- frequencies in the range from about 300 MHz to several GHz, at which significant local, non-uniform absorption occurs; and
- frequencies above about 10 GHz, at which energy absorption occurs primarily at the body surface.

In tissue, SAR is proportional to the square of the internal electric field strength. Average SAR and SAR distribution can be computed or estimated from laboratory measurements. Values of SAR depend on the following factors:

- the incident field parameters, i.e., the frequency, intensity, polarization, and source–object configuration (near- or far-field);
- the characteristics of the exposed body, i.e., its size and internal and external geometry, and the dielectric properties of the various tissues; and
- ground effects and reflector effects of other objects in the field near the exposed body.

When the long axis of the human body is parallel to the electric field vector, and under plane-wave exposure conditions (i.e., far-field exposure), whole-body SAR reaches maximal values. The amount of energy absorbed depends on a number of factors, including the size of the exposed body. "Standard Reference Man" (ICRP 1994), if not grounded, has a resonant absorption frequency close to 70 MHz. For taller individuals the resonant absorption frequency is somewhat lower, and for shorter adults, children, babies, and seated individuals it may exceed 100 MHz. The values of electric field reference levels are based on the frequency-dependence of human absorption; in grounded individuals, resonant frequencies are lower by a factor of about 2 (UNEP/WHO/IRPA 1993).

For some devices that operate at frequencies above 10 MHz (e.g., dielectric heaters, mobile telephones), human exposure can occur under near-field conditions. The frequency-dependence of energy absorption under these conditions is very different from that described for far-field conditions. Magnetic fields may dominate for certain devices, such as mobile telephones, under certain exposure conditions.

The usefulness of numerical modeling calculations, as well as measurements of induced body current and tissue field strength, for assessment of near-field exposures has been demonstrated for mobile telephones, walkie-talkies, broadcast towers, shipboard communication sources, and dielectric heaters (Kuster and Balzano 1992; Dimbylow and Mann 1994; Jokela et al. 1994; Gandhi 1995; Tofani et al. 1995). The importance of these studies lies in their having shown that near-field exposure can result in high local SAR (e.g., in the head, wrists, ankles) and that whole-body and local SAR are strongly dependent on the separation distance between the high-frequency source and the body. Finally, SAR data obtained by measurement are consistent with data obtained from numerical modeling calculations. Whole-body average SAR and local SAR are convenient quantities for comparing effects observed under various exposure conditions. A detailed discussion of SAR can be found elsewhere (UNEP/WHO/IRPA 1993).

At frequencies greater than about 10 GHz, the depth of penetration of the field into tissues is small, and SAR is not a good measure for assessing absorbed energy; the incident power density of the field (in W m^{-2}) is a more appropriate dosimetric quantity.

INDIRECT COUPLING MECHANISMS

There are two indirect coupling mechanisms:

- contact currents that result when the human body comes into contact with an object at a different electric potential (i.e., when either the body or the object is charged by an EMF); and
- coupling of EMF to medical devices worn by, or implanted in, an individual (not considered in this document).

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The charging of a conducting object by EMF causes electric currents to pass through the human body in contact with that object (Tenforde and Kaune 1987; UNEP/WHO/IRPA 1993). The magnitude and spatial distribution of such currents depend on frequency, the size of the object, the size of the person, and the area of contact; transient discharges—sparks—can occur when an individual and a conducting object exposed to a strong field come into close proximity.

BIOLOGICAL BASIS FOR LIMITING EXPOSURE (UP TO 100 KHZ)

The following paragraphs provide a general review of relevant literature on the biological and health effects of electric and magnetic fields with frequency ranges up to 100 kHz, in which the major mechanism of interaction is induction of currents in tissues. For the frequency range >0 to 1 Hz, the biological basis for the basic restrictions and reference levels are provided in ICNIRP (1994). More detailed reviews are available elsewhere (NRPB 1991, 1993; UNEP/WHO/IRPA 1993; Blank 1995; NAS 1996; Polk and Postow 1996; Ueno 1996).

Direct effects of electric and magnetic fields

Epidemiological studies. There have been many reviews of epidemiological studies of cancer risk in relation to exposure to power-frequency fields (NRPB 1992, 1993, 1994b; ORAU 1992; Savitz 1993; Heath 1996; Stevens and Davis 1996; Tenforde 1996; NAS 1996). Similar reviews have been published on the risk of adverse reproductive outcomes associated with exposure to EMF (Chernoff et al. 1992; Brent et al. 1993; Shaw and Croen 1993; NAS 1996; Tenforde 1996).

Reproductive outcome. Epidemiological studies on pregnancy outcomes have provided no consistent evidence of adverse reproductive effects in women working with visual display units (VDUs) (Bergqvist 1993; Shaw and Croen 1993; NRPB 1994a; Tenforde 1996). For example, meta-analysis revealed no excess risk of spontaneous abortion or malformation in combined studies comparing pregnant women using VDUs with women not using VDUs (Shaw and Croen 1993). Two other studies concentrated on actual measurements of the electric and magnetic fields emitted by VDUs; one reported a suggestion of an association between ELF magnetic fields and miscarriage (Lindbohm et al. 1992), while the other found no such association (Schnorr et al. 1991). A prospective study that included large numbers of cases, had high participation rates, and detailed exposure assessment (Bracken et al. 1995) reported that neither birth weight nor intra-uterine growth rate was related to any ELF field exposure. Adverse outcomes were not associated with higher levels of exposure. Exposure measurements included current-carrying capacity of power lines outside homes, 7-d personal exposure measurements, 24-h measurements in the home, and self-reported use of electric blankets, heated water beds, and VDUs. Most currently available information fails to support an association between occupational exposure to VDUs and harmful reproductive effects (NRPB 1994a; Tenforde 1996).

Residential cancer studies. Considerable controversy surrounds the possibility of a link between exposure to ELF magnetic fields and an elevated risk of cancer. Several reports on this topic have appeared since Wertheimer and Leeper reported (1979) an association between childhood cancer mortality and proximity of homes to power distribution lines with what the researchers classified as *high current configuration*. The basic hypothesis that emerged from the original study was that the contribution to the ambient residential 50/60 Hz magnetic fields from external sources such as power lines could be linked to an increased risk of cancer in childhood.

To date there have been more than a dozen studies on childhood cancer and exposure to power-frequency magnetic fields in the home produced by nearby power lines. These studies estimated the magnetic field exposure from short term measurements or on the basis of distance between the home and power line and, in most cases, the configuration of the line; some studies also took the load of the line into account. The findings relating to leukemia are the most consistent. Out of 13 studies (Wertheimer and Leeper 1979; Fulton et al. 1980; Myers et al. 1985; Tomenius 1986; Savitz et al. 1988; Coleman et al. 1989; London et al. 1991; Feychting and Ahlbom 1993; Olsen et al. 1993; Verkasalo et al. 1993; Michaelis et al. 1997; Linet et al. 1997; Tynes and Haldorsen 1997), all but five reported relative risk estimates of between 1.5 and 3.0.

Both direct magnetic field measurements and estimates based on neighboring power lines are crude proxy measures for the exposure that took place at various times before cases of leukemia were diagnosed, and it is not clear which of the two methods provides the more valid estimate. Although results suggest that indeed the magnetic field may play a role in the association with leukemia risk, there is uncertainty because of small sample numbers and because of a correlation between the magnetic field and proximity to power lines (Feychting et al. 1996).

Little is known about the etiology of most types of childhood cancer, but several attempts to control for potential confounders such as socioeconomic status and air pollution from motor vehicle exhaust fumes have had little effect on results. Studies that have examined the use of electrical appliances (primarily electric blankets) in relation to cancer and other health problems have reported generally negative results (Preston-Martin et al. 1988; Verreault et al. 1990; Vena et al. 1991, 1994; Li et al. 1995). Only two case-control studies have evaluated use of appliances in relation to the risk of childhood leukemia. One was conducted in Denver (Savitz et al. 1990) and suggested a link with prenatal use of electric blankets; the other, carried out in Los Angeles (London et al. 1991), found an association between leukemia and children using hair dryers and watching monochrome television.

The fact that results for leukemia based on proximity of homes to power lines are relatively consistent led the U.S. National Academy of Sciences Committee to conclude that children living near power lines appear to be at increased risk of leukemia (NAS 1996). Because of small numbers, confidence intervals in the individual studies are wide; when taken together, however, the results are consistent, with a pooled relative risk of 1.5 (NAS 1996). In contrast, short-term measurements of magnetic field in some of the studies provided no evidence of an association between exposure to 50/60 Hz fields and the risk of leukemia or any other form of cancer in children. The Committee was not convinced that this increase in risk was explained by exposure to magnetic fields, since there was no apparent association when exposure was estimated from magnetic field meter readings in the homes of both leukemia cases and controls. It was suggested that confounding by some unknown risk factor for childhood leukemia, associated with residence in the vicinity of power lines, might be the explanation, but no likely candidates were postulated.

After the NAS committee completed its review, the results of a study performed in Norway were reported (Tynes and Haldorsen 1997). This study included 500 cases of all types of childhood cancer. Each individual's exposure was estimated by calculation of the magnetic field level produced in the residence by nearby transmission lines, estimated by averaging over an entire year. No association between leukemia risk and magnetic fields for the residence at time of diagnosis was observed. Distance from the power line, exposure during the first year of life, mothers' exposure at time of conception, and exposure higher than the median level of the controls showed no association with leukemia, brain cancer, or lymphoma. However, the number of exposed cases was small.

Also, a study performed in Germany has been reported after the completion of the NAS review (Michaelis et al. 1997). This was a case-control study on childhood leukemia based on 129 cases and 328 controls. Exposure assessment comprised measurements of the magnetic field over 24 h in the child's bedroom at the residence where the child had been living for the longest period before the date of diagnosis. An elevated relative risk of 3.2 was observed for $>0.2\ \mu T$.

A large U.S. case-control study (638 cases and 620 controls) to test whether childhood acute lymphoblastic leukemia is associated with exposure to 60-Hz magnetic fields was published by Linet et al. (1997). Magnetic field exposures were determined using 24-h time-weighted average measurements in the bedroom and 30-s measurements in various other rooms. Measurements were taken in homes in which the child had lived for 70% of the 5 y prior to the year of diagnosis, or the corresponding period for the controls. Wire-codes were assessed for residentially stable case-control pairs in which both had not changed their residence during the years prior to diagnosis. The number of such pairs for which assessment could be made was 416. There was no indication of an association between wire-code category and leukemia. As for magnetic field measurements, the results are more intriguing. For the cut off point of 0.2 μT the unmatched and matched analyses gave relative risks of 1.2 and 1.5, respectively. For a cut off point of 0.3 μT, the unmatched relative risk estimate is 1.7 based on 45 exposed cases. Thus, the measurement results are suggestive of a positive association between magnetic fields and leukemia risk. This study is a major contribution in terms of its size, the number of subjects in high exposure categories, timing of measurements relative to the occurrence of the leukemia (usually within 24 mo after diagnosis), other measures used to obtain exposure data, and quality of analysis allowing for multiple potential confounders. Potential weaknesses include the procedure for control selection, the participation rates, and the methods used for statistical analysis of the data. The instruments used for measurements took no account of transient fields or higher order harmonics. The size of this study is such that its results, combined with those of other studies, would significantly weaken (though not necessarily invalidate) the previously observed association with wire code results.

Over the years there also has been substantial interest in whether there is an association between magnetic field exposure and childhood brain cancer, the second most frequent type of cancer found in children. Three recent studies completed after the NAS Committee's review fail to provide support for an association between brain cancer and children's exposure to magnetic fields, whether the source was power lines or electric blankets, or whether magnetic fields were estimated by calculations or by wire codes (Guénel et al. 1996; Preston-Martin et al. 1996a, b; Tynes and Haldorsen 1997).

Data on cancer in adults and residential magnetic field exposure are sparse (NAS 1996). The few studies published to date (Wertheimer and Leeper 1979; McDowall 1985; Seversen et al. 1988; Coleman et al. 1989; Schreiber et al. 1993; Feychting and Ahlbom 1994; Li et al. 1996; Verkasalo 1996; Verkasalo et al. 1996) all suffer to some extent from small numbers of exposed cases, and no conclusions can be drawn.

It is the view of the ICNIRP that the results from the epidemiological research on EMF field exposure and cancer, including childhood leukemia, are not strong enough in the absence of support from experimental research to form a scientific basis for setting exposure guidelines. This assessment is also in agreement with recent reviews (NRPB 1992, 1994b; NAS 1996; CRP 1997).

Occupational studies. A large number of epidemiological studies have been carried out to assess possible links between exposure to ELF fields and cancer risk among workers in electrical occupations. The first study of this type (Milham 1982) took advantage of a death certificate database that included both job titles and

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information on cancer mortality. As a crude method of assessing exposure, Milham classified job titles according to presumed magnetic field exposure and found an excess risk for leukemia among electrical workers. Subsequent studies (Savitz and Ahlbom 1994) made use of similar databases; the types of cancer for which elevated rates were noted varied across studies, particularly when cancer subtypes were characterized. Increased risks of various types of leukemia and nervous tissue tumors, and, in a few instances, of both male and female breast cancer, were reported (Demers et al. 1991; Matanoski et al. 1991; Tynes et al. 1992; Loomis et al. 1994). As well as producing somewhat inconsistent results, these studies suffered from very crude exposure assessment and from failure to control for confounding factors such as exposure to benzene solvent in the workplace.

Three recent studies have attempted to overcome some of the deficiencies in earlier work by measuring ELF field exposure at the workplace and by taking duration of work into consideration (Floderus et al. 1993; Thériault et al. 1994; Savitz and Loomis 1995). An elevated cancer risk among exposed individuals was observed, but the type of cancer of which this was true varied from study to study. Floderus et al. (1993) found a significant association with leukemia; an association was also noted by Thériault et al. (1994), but one that was weak and not significant, and no link was observed by Savitz and Loomis (1995). For subtypes of leukemia there was even greater inconsistency, but numbers in the analyses were small. For tumors of nervous tissue, Floderus et al. (1993) found an excess for glioblastoma (astrocytoma III–IV), while both Thériault et al. (1994) and Savitz and Loomis (1995) found only suggestive evidence for an increase in glioma (astrocytoma I–II). If there is truly a link between occupational exposure to magnetic fields and cancer, greater consistency and stronger associations would be expected of these recent studies based on more sophisticated exposure data.

Researchers have also investigated the possibility that ELF electric fields could be linked to cancer. The three utilities that participated in the Thériault et al. (1994) study of magnetic fields analyzed electric field data as well. Workers with leukemia at one of the utilities were reported to be more likely to have been exposed to electric fields than were control workers. In addition, the association was stronger in a group that had been exposed to high electric and magnetic fields combined (Miller et al. 1996). At the second utility, investigators reported no association between leukemia and higher cumulative exposure to workplace electric fields, but some of the analyses showed an association with brain cancer (Guénel et al. 1996). An association with colon cancer was also reported, yet in other studies of large populations of electric utility workers this type of cancer has not been found. At the third utility, no association between high electric fields and brain cancer or leukemia was observed, but this study was smaller and less likely to have detected small changes, if present (Baris et al. 1996).

An association between Alzheimer's disease and occupational exposure to magnetic fields has recently been suggested (Sobel and Davanipour 1996). However, this effect has not been confirmed.

Laboratory studies. The following paragraphs provide a summary and critical evaluation of laboratory studies on the biological effects of electric and magnetic fields with frequencies below 100 kHz. There are separate discussions on results obtained in studies of volunteers exposed under controlled conditions and in laboratory studies on cellular, tissue, and animal systems.

Volunteer studies. Exposure to a time-varying electric field can result in perception of the field as a result of the alternating electric charge induced on the body surface, which causes the body hairs to vibrate. Several studies have shown that the majority of people can perceive 50/60 Hz electric fields stronger than 20 kV m^{-1}, and that a small minority can perceive fields below 5 kV m^{-1} (UNEP/WHO/IRPA 1984; Tenforde 1991).

Small changes in cardiac function occurred in human volunteers exposed to combined 60-Hz electric and magnetic fields (9 kV m^{-1}, 20 μT) (Cook et al. 1992; Graham et al. 1994). Resting heart rate was slightly, but significantly, reduced (by 3–5 beats per minute) during or immediately after exposure. This response was absent on exposure to stronger (12 kV m^{-1}, 30 μT) or weaker (6 kV m^{-1}, 10 μT) fields and reduced if the subject was mentally alert. None of the subjects in these studies was able to detect the presence of the fields, and there were no other consistent results in a wide battery of sensory and perceptual tests.

No adverse physiological or psychological effects were observed in laboratory studies of people exposed to 50-Hz fields in the range 2–5 mT (Sander et al. 1982; Ruppe et al. 1995). There were no observed changes in blood chemistry, blood cell counts, blood gases, lactate levels, electrocardiogram, electroencephalogram, skin temperature, or circulating hormone levels in studies by Sander et al. (1982) and Graham et al. (1994). Recent studies on volunteers have also failed to show any effect of exposure to 60-Hz magnetic fields on the nocturnal melatonin level in blood (Graham et al. 1996, 1997; Selmaoui et al. 1996).

Sufficiently intense ELF magnetic fields can elicit peripheral nerve and muscle tissue stimulation directly, and short magnetic field pulses have been used clinically to stimulate nerves in the limbs in order to check the integrity of neural pathways. Peripheral nerve and muscle stimulation has also been reported in volunteers exposed to 1-kHz gradient magnetic fields in experimental magnetic resonance imaging systems. Threshold magnetic flux densities were several millitesla, and corresponding induced current densities in the peripheral tissues were about 1 A m^{-2} from pulsed fields produced by rapidly switched gradients. Time-varying magnetic fields that induce current densities above 1 A m^{-2} in tissue lead to neural excitation and are capable of producing irreversible biological effects such as cardiac fibrillation (Tenforde and Kaune 1987; Reilly 1989). In a study involving electromyographic recordings from the human arm (Polson et al. 1982), it was found that a pulsed field with dB/dt greater than 10^4 T s^{-1} was needed to stimulate the median nerve trunk. The duration of the magnetic stimulus has also been found to be an important parameter in stimulation of excitable tissues.

Thresholds lower than 100 mA m^{-2} can be derived from studies of visual and mental functions in human volunteers. Changes in response latency for complex reasoning tests have been reported in volunteers subjected to weak power-frequency electric currents passed through electrodes attached to the head and shoulders; current densities were estimated to lie between 10 and 40 mA m^{-2} (Stollery 1986, 1987). Finally, many studies have reported that volunteers experienced faint flickering visual sensations, known as magnetic phosphenes, during exposure to ELF magnetic fields above 3–5 mT (Silny 1986). These visual effects can also be induced by the direct application of weak electric currents to the head. At 20 Hz, current densities of about 10 mA m^{-2} in the retina have been estimated as the threshold for induction of phosphenes, which is above the typical endogenous current densities in electrically excitable tissues. Higher thresholds have been observed for both lower and higher frequencies (Lövsund et al. 1980; Tenforde 1990).

Studies have been conducted at 50 Hz on visually evoked potentials that exhibited thresholds for effects at flux densities of 60 mT (Silny 1986). Consistent with this result, no effects on visually evoked potentials were obtained by either Sander et al. (1982), using a 50-Hz, 5-mT field, or Graham et al. (1994), using combined 60-Hz electric and magnetic fields up to 12 kV m^{-1} and 30 μT, respectively.

Cellular and animal studies. Despite the large number of studies undertaken to detect biological effects of ELF electric and magnetic fields, few systematic studies have defined the threshold field characteristics that produce significant perturbations of biological functions. It is well established that induced electric current can stimulate nerve and muscle tissue directly once the induced current density exceeds threshold values (UNEP/WHO/IRPA 1987; Bernhardt 1992; Tenforde 1996). Current densities that are unable to stimulate excitable tissues directly may nevertheless affect ongoing electrical activity and influence neuronal excitability. The activity of the central nervous system is known to be sensitive to the endogenous electric fields generated by the action of adjacent nerve cells, at levels below those required for direct stimulation.

Many studies have suggested that the transduction of weak electrical signals in the ELF range involves interactions with the cell membrane, leading to cytoplasmic biochemical responses that in turn involve changes in cellular functional and proliferative states. From simple models of the behavior of single cells in weak fields it has been calculated that an electrical signal in the extracellular field must be greater than approximately 10–100 mV m^{-1} (corresponding to an induced current density of about 2–20 mA m^{-2}) in order to exceed the level of endogenous physical and biological noise in cellular membranes (Astumian et al. 1995). Existing evidence also suggests that several structural and functional properties of membranes may be altered in response to induced ELF fields at or below 100 mV m^{-1} (Sienkiewicz et al. 1991; Tenforde 1993). Neuroendocrine alterations (e.g., suppression of nocturnal melatonin synthesis) have been reported in response to induced electrical fields of 10 mV m^{-1} or less, corresponding to induced current densities of approximately 2 mA m^{-2} or less (Tenforde 1991, 1996). However, there is no clear evidence that these biological interactions of low-frequency fields lead to adverse health effects.

Induced electric fields and currents at levels exceeding those of endogenous bioelectric signals present in tissue have been shown to cause a number of physiological effects that increase in severity as the induced current density is increased (Bernhardt 1979; Tenforde 1996). In the current density range 10–100 mA m^{-2}, tissue effects and changes in brain cognitive functions have been reported (NRPB 1992; NAS 1996). When induced current density exceeds 100 to several hundred mA m^{-2} for frequencies between about 10 Hz and 1 kHz, thresholds for neuronal and neuromuscular stimulation are exceeded. The threshold current densities increase progressively at frequencies below several hertz and above 1 kHz. Finally, at extremely high current densities, exceeding 1 A m^{-2}, severe and potentially life-threatening effects such as cardiac extrasystoles, ventricular fibrillation, muscular tetanus, and respiratory failure may occur. The severity and the probability of irreversibility of tissue effects becomes greater with chronic exposure to induced current densities above the level 10 to 100 mA m^{-2}. It therefore seems appropriate to limit human exposure to fields that induce current densities no greater than 10 mA m^{-2} in the head, neck, and trunk at frequencies of a few hertz up to 1 kHz.

It has been postulated that oscillatory magnetomechanical forces and torques on biogenic magnetite particles in brain tissue could provide a mechanism for the transduction of signals from ELF magnetic fields. Kirschvink et al. (1992b) proposed a model in which ELF magnetic forces on magnetite particles are visualized as producing the opening and closing of pressure-sensitive ion channels in membranes. However, one difficulty with this model is the sparsity of magnetite particles relative to the number of cells in brain tissue. For example, human brain tissue has been reported to contain a few million magnetite particles per gram, distributed in 10^5 discrete clusters of 5–10 particles (Kirschvink et al. 1992a). The number of cells in brain tissue thus exceeds the number of magnetite particles by a factor of about 100, and it is difficult to envisage how oscillating magnetomechanical interactions of an ELF

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field with magnetite crystals could affect a significant number of pressure-sensitive ion channels in the brain. Further studies are clearly needed to reveal the biological role of magnetite and the possible mechanisms through which this mineral could play a role in the transduction of ELF magnetic signals.

An important issue in assessing the effects of electromagnetic fields is the possibility of teratogenic and developmental effects. On the basis of published scientific evidence, it is unlikely that low-frequency fields have adverse effects on the embryonic and postnatal development of mammalian species (Chernoff et al. 1992; Brent et al. 1993; Tenforde 1996). Moreover, currently available evidence indicates that somatic mutations and genetic effects are unlikely to result from exposure to electric and magnetic fields with frequencies below 100 kHz (Cridland 1993; Sienkiewicz et al. 1993).

There are numerous reports in the literature on the *in-vitro* effects of ELF fields on cell membrane properties (ion transport and interaction of mitogens with cell surface receptors) and changes in cellular functions and growth properties (e.g., increased proliferation and alterations in metabolism, gene expression, protein biosynthesis, and enzyme activities) (Cridland 1993; Sienkiewicz et al. 1993; Tenforde 1991, 1992, 1993, 1996). Considerable attention has focused on low-frequency field effects on Ca^{++} transport across cell membranes and the intracellular concentration of this ion (Walleczek and Liburdy 1990; Liburdy 1992; Walleczek 1992), messenger RNA and protein synthesis patterns (Goodman et al. 1983; Goodman and Henderson 1988, 1991; Greene et al. 1991; Phillips et al. 1992), and the activity of enzymes such as ornithine decarboxylase (ODC) that are related to cell proliferation and tumor promotion (Byus et al. 1987, 1988; Litovitz et al. 1991, 1993). However, before these observations can be used for defining exposure limits, it is essential to establish both their reproducibility and their relevance to cancer or other adverse health outcomes. This point is underscored by the fact that there have been difficulties in replicating some of the key observations of field effects on gene expression and protein synthesis (Lacy-Hulbert et al. 1995; Saffer and Thurston 1995). The authors of these replication studies identified several deficiencies in the earlier studies, including poor temperature control, lack of appropriate internal control samples, and the use of low-resolution techniques for analyzing the production of messenger RNA transcripts. The transient increase in ODC activity reported in response to field exposure is small in magnitude and not associated with *de novo* synthesis of the enzyme (unlike chemical tumor promoters such as phorbol esters) (Byus et al. 1988). Studies on ODC have mostly involved cellular preparations; more studies are needed to show whether there are effects on ODC *in vivo*, although there is one report suggesting effects on ODC in a rat mammary tumor promotion assay (Mevissen et al. 1995).

There is no evidence that ELF fields alter the structure of DNA and chromatin, and no resultant mutational and neoplastic transformation effects are expected. This is supported by results of laboratory studies designed to detect DNA and chromosomal damage, mutational events, and increased transformation frequency in response to ELF field exposure (NRPB 1992; Murphy et al. 1993; McCann et al. 1993; Tenforde 1996). The lack of effects on chromosome structure suggests that ELF fields, if they have any effect on the process of carcinogenesis, are more likely to act as promoters than initiators, enhancing the proliferation of genetically altered cells rather than causing the initial lesion in DNA or chromatin. An influence on tumor development could be mediated through epigenetic effects of these fields, such as alterations in cell signalling pathways or gene expression. The focus of recent studies has therefore been on detecting possible effects of ELF fields on the promotion and progression phases of tumor development following initiation by a chemical carcinogen.

Studies on *in-vitro* tumor cell growth and the development of transplanted tumors in rodents have provided no strong evidence for possible carcinogenic effects of exposure to ELF fields (Tenforde 1996). Several studies of more direct relevance to human cancer have involved *in-vivo* tests for tumor-promoting activity of ELF magnetic fields on skin, liver, brain, and mammary tumors in rodents. Three studies of skin tumor promotion (McLean et al. 1991; Rannug et al. 1993a, 1994) failed to show any effect of either continuous or intermittent exposure to power-frequency magnetic fields in promoting chemically induced tumors. At a 60-Hz field strength of 2 mT, a co-promoting effect with a phorbol ester was reported for mouse skin tumor development in the initial stages of the experiment, but the statistical significance of this was lost by completion of the study in week 23 (Stuchly et al. 1992). Previous studies by the same investigators had shown that 60-Hz, 2-mT field exposure did not promote the growth of DMBA-initiated skin cells (McLean et al. 1991).

Experiments on the development of transformed liver foci initiated by a chemical carcinogen and promoted by phorbol ester in partially hepatectomized rats revealed no promotion or co-promotion effect of exposure to 50-Hz fields ranging in strength from 0.5 to 50 μT (Rannug et al. 1993b, c).

Studies on mammary cancer development in rodents treated with a chemical initiator have suggested a cancer-promoting effect of exposure to power-frequency magnetic fields in the range 0.01–30 mT (Beniashvili et al. 1991; Löscher et al. 1993; Mevissen et al. 1993, 1995; Baum et al. 1995; Löscher and Mevissen 1995). These observations of increased tumor incidence in rats exposed to magnetic fields have been hypothesized to be related to field-induced suppression of pineal melatonin and a resulting elevation in steroid hormone levels and breast cancer risk (Stevens 1987; Stevens et al. 1992). However, replication efforts by independent laboratories are needed before conclusions can be drawn regarding the implications of these findings for a promoting effect of ELF magnetic fields on mammary tumors. It should also be noted that recent studies have found no evidence for a significant effect of exposure to ELF magnetic fields on melatonin levels in humans (Graham et al. 1996, 1997; Selmaoui et al. 1996).

Indirect effects of electric and magnetic fields

Indirect effects of electromagnetic fields may result from physical contact (e.g., touching or brushing against) between a person and an object, such as a metallic structure in the field, at a different electric potential. The result of such contact is the flow of electric charge (contact current) that may have accumulated on the object or on the body of the person. In the frequency range up to approximately 100 kHz, the flow of electric current from an object in the field to the body of the individual may result in the stimulation of muscles and/or peripheral nerves. With increasing levels of current this may be manifested as perception, pain from electric shock and/or burn, inability to release the object, difficulty in breathing and, at very high currents, cardiac ventricular fibrillation (Tenforde and Kaune 1987). Threshold values for these effects are frequency-dependent, with the lowest threshold occurring at frequencies between 10 and 100 Hz. Thresholds for peripheral nerve responses remain low for frequencies up to several kHz. Appropriate engineering and/or administrative controls, and even the wearing of personal protective clothing, can prevent these problems from occurring.

Spark discharges can occur when an individual comes into very close proximity with an object at a different electric potential, without actually touching it (Tenforde and Kaune 1987; UNEP/WHO/IRPA 1993). When a group of volunteers, who were electrically insulated from the ground, each held a finger tip close to a grounded object, the threshold for perception of spark discharges was as low as 0.6–1.5 kV m^{-1} in 10% of cases. The threshold field level reported as causing annoyance under these exposure conditions is about 2.0–3.5 kV m^{-1}. Large contact currents can result in muscle contraction. In male volunteers, the 50th percentile threshold for being unable to release a charged conductor has been reported as 9 mA at 50/60 Hz, 16 mA at 1 kHz, about 50 mA at 10 kHz, and about 130 mA at 100 kHz (UNEP/WHO/IRPA 1993).

The threshold currents for various indirect effects of fields with frequencies up to 100 kHz are summarized in Table 2 (UNEP/WHO/IRPA 1993).

Table 2. Ranges of threshold currents for indirect effects, including children, women, and men.

Indirect effect	Threshold current (mA) at frequency: 50/60 Hz	1 kHz	100 kHz
Touch perception	0.2–0.4	0.4–0.8	25–40
Pain on finger contact	0.9–1.8	1.6–3.3	33–55
Painful shock/let-go threshold	8–16	12–24	112–224
Severe shock/breathing difficulty	12–23	21–41	160–320

Summary of biological effects and epidemiological studies (up to 100 kHz)

With the possible exception of mammary tumors, there is little evidence from laboratory studies that power-frequency magnetic fields have a tumor-promoting effect. Although further animal studies are needed to clarify the possible effects of ELF fields on signals produced in cells and on endocrine regulation—both of which could influence the development of tumors by promoting the proliferation of initiated cells—it can only be concluded that there is currently no convincing evidence for carcinogenic effects of these fields and that these data cannot be used as a basis for developing exposure guidelines.

Laboratory studies on cellular and animal systems have found no established effects of low-frequency fields that are indicative of adverse health effects when induced current density is at or below 10 mA m^{-2}. At higher levels of induced current density (10–100 mA m^{-2}), more significant tissue effects have been consistently observed, such as functional changes in the nervous system and other tissue effects (Tenforde 1996).

Data on cancer risk associated with exposure to ELF fields among individuals living close to power lines are apparently consistent in indicating a slightly higher risk of leukemia among children, although more recent studies question the previously observed weak association. The studies do not, however, indicate a similarly elevated risk of any other type of childhood cancer or of any form of adult cancer. The basis for the hypothetical link between childhood leukemia and residence in close proximity to power lines is unknown; if the link is not related to the ELF electric and magnetic fields generated by the power lines, then unknown risk factors for leukemia would have to be linked to power lines in some undetermined manner. In the absence of support from laboratory studies, the epidemiological data are insufficient to allow an exposure guideline to be established.

There have been reports of an increased risk of certain types of cancer, such as leukemia, nervous tissue tumors, and, to a limited extent, breast cancer, among electrical workers. In most studies, job titles were used to classify subjects according to presumed levels of magnetic field exposure. A few more recent studies, however, have used more sophisticated methods of exposure assessment; overall, these studies suggested an increased risk of leukemia or brain tumors but were largely inconsistent with regard to the type of cancer for which risk is increased. The data are insufficient to provide a basis for ELF field exposure guidelines. In a large number of epidemiological studies, no consistent evidence of adverse reproductive effects have been provided.

Measurement of biological responses in laboratory studies and in volunteers has provided little indication of adverse effects of low-frequency fields at levels to which people are commonly exposed. A threshold current density of 10 mA m^{-2} at frequencies up to 1 kHz has been estimated for minor effects on nervous system functions. Among volunteers, the most consistent effects

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of exposure are the appearance of visual phosphenes and a minor reduction in heart rate during or immediately after exposure to ELF fields, but there is no evidence that these transient effects are associated with any long-term health risk. A reduction in nocturnal pineal melatonin synthesis has been observed in several rodent species following exposure to weak ELF electric and magnetic fields, but no consistent effect has been reported in humans exposed to ELF fields under controlled conditions. Studies involving exposures to 60-Hz magnetic fields up to 20 μT have not reported reliable effects on melatonin levels in blood.

BIOLOGICAL BASIS FOR LIMITING EXPOSURE (100 kHz–300 GHz)

The following paragraphs provide a general review of relevant literature on the biological effects and potential health effects of electromagnetic fields with frequencies of 100 kHz to 300 GHz. More detailed reviews can be found elsewhere (NRPB 1991; UNEP/WHO/IRPA 1993; McKinlay et al. 1996; Polk and Postow 1996; Repacholi 1998).

Direct effects of electromagnetic fields

Epidemiological studies. Only a limited number of studies have been carried out on reproductive effects and cancer risk in individuals exposed to microwave radiation. A summary of the literature was published by UNEP/WHO/IRPA (1993).

Reproductive outcomes. Two extensive studies on women treated with microwave diathermy to relieve the pain of uterine contractions during labor found no evidence for adverse effects on the fetus (Daels 1973, 1976). However, seven studies on pregnancy outcomes among workers occupationally exposed to microwave radiation and on birth defects among their offspring produced both positive and negative results. In some of the larger epidemiological studies of female plastic welders and physiotherapists working with shortwave diathermy devices, there were no statistically significant effects on rates of abortion or fetal malformation (Källen et al. 1982). By contrast, other studies on similar populations of female workers found an increased risk of miscarriage and birth defects (Larsen et al. 1991; Ouellet-Hellstrom and Stewart 1993). A study of male radar workers found no association between microwave exposure and the risk of Down's syndrome in their offspring (Cohen et al. 1977).

Overall, the studies on reproductive outcomes and microwave exposure suffer from very poor assessment of exposure and, in many cases, small numbers of subjects. Despite the generally negative results of these studies, it will be difficult to draw firm conclusions on reproductive risk without further epidemiological data on highly exposed individuals and more precise exposure assessment.

Cancer studies. Studies on cancer risk and microwave exposure are few and generally lack quantitative exposure assessment. Two epidemiological studies of radar workers in the aircraft industry and in the U.S. armed forces found no evidence of increased morbidity or mortality from any cause (Barron and Baraff 1958; Robinette et al. 1980; UNEP/WHO/IRPA 1993). Similar results were obtained by Lillienfeld et al. (1978) in a study of employees in the U.S. embassy in Moscow, who were chronically exposed to low-level microwave radiation. Selvin et al. (1992) reported no increase in cancer risk among children chronically exposed to radiation from a large microwave transmitter near their homes. More recent studies have failed to show significant increases in nervous tissue tumors among workers and military personnel exposed to microwave fields (Beall et al. 1996; Grayson 1996). Moreover, no excess total mortality was apparent among users of mobile telephones (Rothman et al. 1996a, b), but it is still too early to observe an effect on cancer incidence or mortality.

There has been a report of increased cancer risk among military personnel (Szmigielski et al. 1988), but the results of the study are difficult to interpret because neither the size of the population nor the exposure levels are clearly stated. In a later study, Szmigielski (1996) found increased rates of leukemia and lymphoma among military personnel exposed to EMF fields, but the assessment of EMF exposure was not well defined. A few recent studies of populations living near EMF transmitters have suggested a local increase in leukemia incidence (Hocking et al. 1996; Dolk et at. 1997a, b), but the results are inconclusive. Overall, the results of the small number of epidemiological studies published provide only limited information on cancer risk.

Laboratory studies. The following paragraphs provide a summary and critical evaluation of laboratory studies on the biological effects of electromagnetic fields with frequencies in the range 100 kHz–300 GHz. There are separate discussions on results of studies of volunteers exposed under controlled conditions and of laboratory studies on cellular, tissue, and animal systems.

Volunteer studies. Studies by Chatterjee et al. (1986) demonstrated that, as the frequency increases from approximately 100 kHz to 10 MHz, the dominant effect of exposure to a high-intensity electromagnetic field changes from nerve and muscle stimulation to heating. At 100 kHz the primary sensation was one of nerve tingling, while at 10 MHz it was one of warmth on the skin. In this frequency range, therefore, basic health protection criteria should be such as to avoid stimulation of excitable tissues and heating effects. At frequencies from 10 MHz to 300 GHz, heating is the major effect of absorption of electromagnetic energy, and temperature rises of more than 1–2 °C can have adverse health effects such as heat exhaustion and heat stroke (ACGIH 1996). Studies on workers in thermally stressful environments have shown worsening performance of simple tasks as body temperature rises to a level approaching physiological heat stress (Ramsey and Kwon 1988).

A sensation of warmth has been reported by volunteers experiencing high-frequency current of about 100–200 mA through a limb. The resulting SAR value is unlikely to produce a localized temperature increment of more than 1°C in the limbs (Chatterjee et al. 1986; Chen and Gandhi 1988; Hoque and Gandhi 1988), which has been suggested as the upper limit of temperature increase that has no detrimental health effects (UNEP/WHO/IRPA 1993). Data on volunteers reported by Gandhi et al. (1986) for frequencies up to 50 MHz and by Tofani et al. (1995) for frequencies up to 110 MHz (the upper limit of the FM broadcast band) support a reference level for limb current of 100 mA to avoid excessive heating effects (Dimbylow 1997).

There have been several studies of thermoregulatory responses of resting volunteers exposed to EMF in magnetic resonance imaging systems (Shellock and Crues 1987; Magin et al. 1992). In general, these have demonstrated that exposure for up to 30 min, under conditions in which whole-body SAR was less than 4 W kg^{-1}, caused an increase in the body core temperature of less than 1°C.

Cellular and animal studies. There are numerous reports on the behavioral and physiological responses of laboratory animals, including rodents, dogs, and non-human primates, to thermal interactions of EMF at frequencies above 10 MHz. Thermosensitivity and thermoregulatory responses are associated both with the hypothalamus and with thermal receptors located in the skin and in internal parts of the body. Afferent signals reflecting temperature change converge in the central nervous system and modify the activity of the major neuroendocrine control systems, triggering the physiological and behavioral responses necessary for the maintenance of homeostasis.

Exposure of laboratory animals to EMF producing absorption in excess of approximately 4 W kg^{-1} has revealed a characteristic pattern of thermoregulatory response in which body temperature initially rises and then stabilizes following the activation of thermoregulatory mechanisms (Michaelson 1983). The early phase of this response is accompanied by an increase in blood volume due to movement of fluid from the extracellular space into the circulation and by increases in heart rate and intraventricular blood pressure. These cardiodynamic changes reflect thermoregulatory responses that facilitate the conduction of heat to the body surface. Prolonged exposure of animals to levels of microwave radiation that raise the body temperature ultimately lead to failure of these thermoregulatory mechanisms.

Several studies with rodents and monkeys have also demonstrated a behavioral component of thermoregulatory responses. Decreased task performance by rats and monkeys has been observed at SAR values in the range 1–3 W kg^{-1} (Stern et al. 1979; Adair and Adams 1980; de Lorge and Ezell 1980; D'Andrea et al. 1986). In monkeys, altered thermoregulatory behavior starts when the temperature in the hypothalamic region rises by as little as 0.2–0.3°C (Adair et al. 1984). The hypothalamus is considered to be the control center for normal thermoregulatory processes, and its activity can be modified by a small local temperature increase under conditions in which rectal temperature remains constant.

At levels of absorbed electromagnetic energy that cause body temperature rises in excess of 1–2°C, a large number of physiological effects have been characterized in studies with cellular and animal systems (Michaelson and Elson 1996). These effects include alterations in neural and neuromuscular functions; increased blood-brain barrier permeability; ocular impairment (lens opacities and corneal abnormalities); stress-associated changes in the immune system; hematological changes; reproductive changes (e.g., reduced sperm production); teratogenicity; and changes in cell morphology, water and electrolyte content, and membrane functions.

Under conditions of partial-body exposure to intense EMF, significant thermal damage can occur in sensitive tissues such as the eye and the testis. Microwave exposure of 2–3 h duration has produced cataracts in rabbits' eyes at SAR values from 100–140 W kg^{-1}, which produced lenticular temperatures of 41–43°C (Guy et al. 1975). No cataracts were observed in monkeys exposed to microwave fields of similar or higher intensities, possibly because of different energy absorption patterns in the eyes of monkeys from those in rabbits. At very high frequencies (10–300 GHz), absorption of electromagnetic energy is confined largely to the epidermal layers of the skin, subcutaneous tissues, and the outer part of the eye. At the higher end of the frequency range, absorption is increasingly superficial. Ocular damage at these frequencies can be avoided if the microwave power density is less than 50 W m^{-2} (Sliney and Wolbarsht 1980; UNEP/WHO/IRPA 1993).

There has been considerable recent interest in the possible carcinogenic effects of exposure to microwave fields with frequencies in the range of widely used communications systems, including hand-held mobile telephones and base transmitters. Research findings in this area have been summarized by ICNIRP (1996). Briefly, there are many reports suggesting that microwave fields are not mutagenic, and exposure to these fields is therefore unlikely to initiate carcinogenesis (NRPB 1992; Cridland 1993; UNEP/WHO/IRPA 1993). By contrast, some recent reports suggest that exposure of rodents to microwave fields at SAR levels of the order of 1 W kg^{-1} may produce strand breaks in the DNA of testis and brain tissues (Sarkar et al. 1994; Lai and Singh 1995, 1996), although both ICNIRP (1996) and Williams (1996) pointed out methodological deficiencies that could have significantly influenced these results.

In a large study of rats exposed to microwaves for up to 25 mo, an excess of primary malignancies was noted in exposed rats relative to controls (Chou et al. 1992). However, the incidence of benign tumors did not differ between the groups, and no specific type of tumor

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was more prevalent in the exposed group than in stock rats of the same strain maintained under similar specific-pathogen-free conditions. Taken as a whole, the results of this study cannot be interpreted as indicating a tumor-initiating effect of microwave fields.

Several studies have examined the effects of microwave exposure on the development of pre-initiated tumor cells. Szmigielski et al. (1982) noted an enhanced growth rate of transplanted lung sarcoma cells in rats exposed to microwaves at high power densities. It is possible that this resulted from a weakening of the host immune defense in response to thermal stress from the microwave exposure. Recent studies using athermal levels of microwave irradiation have found no effects on the development of melanoma in mice or of brain glioma in rats (Santini et al. 1988; Salford et al. 1993).

Repacholi et al. (1997) have reported that exposure of 100 female, *Eμ-pim1* transgenic mice to 900-MHz fields, pulsed at 217 Hz with pulse widths of 0.6 μs for up to 18 mo, produced a doubling in lymphoma incidence compared with 101 controls. Because the mice were free to roam in their cages, the variation in SAR was wide (0.01–4.2 W kg^{-1}). Given that the resting metabolic rate of these mice is 7–15 W kg^{-1}, only the upper end of the exposure range may have produced some slight heating. Thus, it appears that this study suggests a non-thermal mechanism may be acting, which needs to be investigated further. However, before any assumptions can be made about health risk, a number of questions need to be addressed. The study needs to be replicated, restraining the animals to decrease the SAR exposure variation and to determine whether there is a dose response. Further study is needed to determine whether the results can be found in other animal models in order to be able to generalize the results to humans. It is also essential to assess whether results found in transgenic animals are applicable to humans.

Special considerations for pulsed and amplitude-modulated waveforms

Compared with continuous-wave (CW) radiation, pulsed microwave fields with the same average rate of energy deposition in tissues are generally more effective in producing a biological response, especially when there is a well-defined threshold that must be exceeded to elicit the effect (ICNIRP 1996). The "microwave hearing" effect is a well known example of this (Frey 1961; Frey and Messenger 1973; Lin 1978): people with normal hearing can perceive pulse-modulated fields with frequencies between about 200 MHz and 6.5 GHz. The auditory sensation has been variously described as a buzzing, clicking, or popping sound, depending on the modulation characteristics of the field. The microwave hearing effects have been attributed to a thermoelastic interaction in the auditory cortex of the brain, with a threshold for perception of about 100–400 mJ m^{-2} for pulses of duration less than 30 μs at 2.45 GHz (corresponding to an SA of 4–16 mJ kg^{-1}). Repeated or prolonged exposure to microwave auditory effects may be stressful and potentially harmful.

Some reports suggest that retina, iris, and corneal endothelium of the primate eye are sensitive to low levels of pulsed microwave radiation (Kues et al. 1985; UNEP/WHO/IRPA 1993). Degenerative changes in light-sensitive cells of the retina were reported for absorbed energy levels as low as 26 mJ kg^{-1}. After administration of timolol maleate, which is used in the treatment of glaucoma, the threshold for retinal damage by pulsed fields dropped to 2.6 mJ kg^{-1}. However, an attempt in an independent laboratory to partially replicate these findings for CW fields (i.e., not pulsed) was unsuccessful (Kamimura et al. 1994), and it is therefore impossible at present to assess the potential health implications of the initial findings of Kues et al. (1985).

Exposure to intense pulsed microwave fields has been reported to suppress the startle response in conscious mice and to evoke body movements (NRPB 1991; Sienkiewicz et al. 1993; UNEP/WHO/IRPA 1993). The threshold specific energy absorption level at midbrain that evoked body movements was 200 J kg^{-1} for 10 μs pulses. The mechanism for these effects of pulsed microwaves remains to be determined but is believed to be related to the microwave hearing phenomenon. The auditory thresholds for rodents are about an order of magnitude lower than for humans, that is 1–2 mJ kg^{-1} for pulses <30 μs in duration. Pulses of this magnitude have also been reported to affect neurotransmitter metabolism and the concentration of the neural receptors involved in stress and anxiety responses in different regions of the rat brain.

The issue of athermal interactions of high-frequency EMF has centered largely on reports of biological effects of amplitude modulated (AM) fields under *in-vitro* conditions at SAR values well below those that produce measurable tissue heating. Initial studies in two independent laboratories led to reports that VHF fields with amplitude modulation at extremely low frequencies (6–20 Hz) produced a small, but statistically significant, release of Ca^{++} from the surfaces of chick brain cells (Bawin et al. 1975; Blackman et al. 1979). A subsequent attempt to replicate these findings, using the same type of AM field, was unsuccessful (Albert et al. 1987). A number of other studies of the effects of AM fields on Ca^{++} homeostasis have produced both positive and negative results. For example, effects of AM fields on Ca^{++} binding to cell surfaces have been observed with neuroblastoma cells, pancreatic cells, cardiac tissue, and cat brain cells, but not with cultured rat nerve cells, chick skeletal muscle, or rat brain cells (Postow and Swicord 1996).

Amplitude-modulated fields have also been reported to alter brain electrical activity (Bawin et al. 1974), inhibit T-lymphocyte cytotoxic activity (Lyle et al. 1983), decrease the activities of non-cyclic-AMP-dependent kinase in lymphocytes (Byus et al. 1984), and cause a transient increase in the cytoplasmic activity of ornithine decarboxylase, an essential enzyme for cell proliferation (Byus et al. 1988; Litovitz et al. 1992). In contrast, no effects have been observed on a wide variety of other cellular systems and functional end-points, including lymphocyte capping, neoplastic cell transformation, and various membrane electrical and enzymatic properties (Postow and Swicord 1996). Of particular relevance to the potential carcinogenic effects of pulsed fields is the observation by Balcer-Kubiczek and Harrison (1991) that neoplastic transformation was accelerated in C3H/10T1/2 cells exposed to 2,450-MHz microwaves that were pulse-modulated at 120 Hz. The effect was dependent on field strength but occurred only when a chemical tumor-promoter, TPA, was present in the cell culture medium. This finding suggests that pulsed microwaves may exert co-carcinogenic effects in combination with a chemical agent that increases the rate of proliferation of transformed cells. To date, there have been no attempts to replicate this finding, and its implication for human health effects is unclear.

Interpretation of several observed biological effects of AM electromagnetic fields is further complicated by the apparent existence of "windows" of response in both the power density and frequency domains. There are no accepted models that adequately explain this phenomenon, which challenges the traditional concept of a monotonic relationship between the field intensity and the severity of the resulting biological effects.

Overall, the literature on athermal effects of AM electromagnetic fields is so complex, the validity of reported effects so poorly established, and the relevance of the effects to human health is so uncertain, that it is impossible to use this body of information as a basis for setting limits on human exposure to these fields.

Indirect effects of electromagnetic fields

In the frequency range of about 100 kHz–110 MHz, shocks and burns can result either from an individual touching an ungrounded metal object that has acquired a charge in a field or from contact between a charged individual and a grounded metal object. It should be noted that the upper frequency for contact current (110 MHz) is imposed by a lack of data on higher frequencies rather than by the absence of effects. However, 110 MHz is the upper frequency limit of the FM broadcast band. Threshold currents that result in biological effects ranging in severity from perception to pain have been measured in controlled experiments on volunteers (Chatterjee et al. 1986; Tenforde and Kaune 1987; Bernhardt 1988); these are summarized in Table 3. In general, it has been shown that the threshold currents that produce perception and pain vary little over the frequency range 100 kHz–1 MHz and are unlikely to vary significantly over the frequency range up to about 110 MHz. As noted earlier for lower frequencies, significant variations between the sensitivities of men, women, and children also exist for higher frequency fields. The data in Table 3 represent the range of 50th percentile values for people of different sizes and different levels of sensitivity to contact currents.

Table 3. Ranges of threshold currents for indirect effects, including children, women, and men.

Indirect effect	Threshold current (mA) at frequency: 100 kHz	1 MHz
Touch perception	25–40	25–40
Pain on finger contact	33–55	28–50
Painful shock/let-go threshold	112–224	Not determined
Severe shock/breathing difficulty	160–320	Not determined

Summary of biological effects and epidemiological studies (100 kHz–300 GHz)

Available experimental evidence indicates that the exposure of resting humans for approximately 30 min to EMF producing a whole-body SAR of between 1 and 4 W kg^{-1} results in a body temperature increase of less than 1 °C. Animal data indicate a threshold for behavioral responses in the same SAR range. Exposure to more intense fields, producing SAR values in excess of 4 W kg^{-1}, can overwhelm the thermoregulatory capacity of the body and produce harmful levels of tissue heating. Many laboratory studies with rodent and non-human primate models have demonstrated the broad range of tissue damage resulting from either partial-body or whole-body heating producing temperature rises in excess of 1–2°C. The sensitivity of various types of tissue to thermal damage varies widely, but the threshold for irreversible effects in even the most sensitive tissues is greater than 4 W kg^{-1} under normal environmental conditions. These data form the basis for an occupational exposure restriction of 0.4 W kg^{-1}, which provides a large margin of safety for other limiting conditions such as high ambient temperature, humidity, or level of physical activity.

Both laboratory data and the results of limited human studies (Michaelson and Elson 1996) make it clear that thermally stressful environments and the use of drugs or alcohol can compromise the thermoregulatory capacity of the body. Under these conditions, safety factors should be introduced to provide adequate protection for exposed individuals.

Data on human responses to high-frequency EMF that produce detectable heating have been obtained from controlled exposure of volunteers and from epidemiological studies on workers exposed to sources such as radar, medical diathermy equipment, and heat sealers. They are fully supportive of the conclusions drawn from laboratory work, that adverse biological effects can be caused by temperature rises in tissue that exceed 1°C. Epidemiological studies on exposed workers and the general public have shown no major health effects associated with typical exposure environments. Although there are deficiencies in the epidemiological work, such as poor exposure assessment, the studies have yielded no convincing evidence that typical exposure levels lead to adverse reproductive outcomes or an increased cancer risk in exposed individuals. This is consistent with the results of laboratory research on cellular and animal models, which have demonstrated neither teratogenic nor carcinogenic effects of exposure to athermal levels of high-frequency EMF.

Exposure to pulsed EMF of sufficient intensity leads to certain predictable effects such as the microwave hearing phenomenon and various behavioral responses. Epidemiological studies on exposed workers and the general public have provided limited information and failed to demonstrate any health effects. Reports of severe retinal damage have been challenged following unsuccessful attempts to replicate the findings.

A large number of studies of the biological effects of amplitude-modulated EMF, mostly conducted with low levels of exposure, have yielded both positive and negative results. Thorough analysis of these studies reveals that the effects of AM fields vary widely with the exposure parameters, the types of cells and tissues involved, and the biological end-points that are examined. In general, the effects of exposure of biological systems to athermal levels of amplitude-modulated EMF are small and very difficult to relate to potential health effects. There is no convincing evidence of frequency and power density windows of response to these fields.

Shocks and burns can be the adverse indirect effects of high-frequency EMF involving human contact with metallic objects in the field. At frequencies of 100 kHz–110 MHz (the upper limit of the FM broadcast band), the threshold levels of contact current that produce effects ranging from perception to severe pain do not vary significantly as a function of the field frequency. The threshold for perception ranges from 25 to 40 mA in individuals of different sizes, and that for pain from approximately 30 to 55 mA; above 50 mA there may be severe burns at the site of tissue contact with a metallic conductor in the field.

GUIDELINES FOR LIMITING EMF EXPOSURE

Occupational and general public exposure limitations

The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to EMF. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure. It is these considerations that underlie the adoption of more stringent exposure restrictions for the public than for the occupationally exposed population.

Basic restrictions and reference levels

Restrictions on the effects of exposure are based on established health effects and are termed basic restrictions. Depending on frequency, the physical quantities used to specify the basic restrictions on exposure to EMF are current density, SAR, and power density. Protection against adverse health effects requires that these basic restrictions are not exceeded.

Reference levels of exposure are provided for comparison with measured values of physical quantities; compliance with all reference levels given in these guidelines will ensure compliance with basic restrictions. If measured values are higher than reference levels, it does not necessarily follow that the basic restrictions have been exceeded, but a more detailed analysis is necessary to assess compliance with the basic restrictions.

General statement on safety factors

There is insufficient information on the biological and health effects of EMF exposure of human populations and experimental animals to provide a rigorous basis for establishing safety factors over the whole frequency range and for all frequency modulations. In addition, some of the uncertainty regarding the appropriate safety factor derives from a lack of knowledge regarding the appropriate dosimetry (Repacholi 1998). The following general variables were considered in the development of safety factors for high-frequency fields:

- effects of EMF exposure under severe environmental conditions (high temperature, etc.) and/or high activity levels; and
- the potentially higher thermal sensitivity in certain population groups, such as the frail and/or elderly, infants and young children, and people with diseases or taking medications that compromise thermal tolerance.

The following additional factors were taken into account in deriving reference levels for high-frequency fields:

- differences in absorption of electromagnetic energy by individuals of different sizes and different orientations relative to the field; and
- reflection, focusing, and scattering of the incident field, which can result in enhanced localized absorption of high-frequency energy.

Basic restrictions

Different scientific bases were used in the development of basic exposure restrictions for various frequency ranges:

- Between 1 Hz and 10 MHz, basic restrictions are provided on current density to prevent effects on nervous system functions;
- Between 100 kHz and 10 GHz, basic restrictions on SAR are provided to prevent whole-body heat stress and excessive localized tissue heating; in the 100 kHz–10 MHz range, restrictions are provided on both current density and SAR; and
- Between 10 and 300 GHz, basic restrictions are provided on power density to prevent excessive heating in tissue at or near the body surface.

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In the frequency range from a few Hz to 1 kHz, for levels of induced current density above 100 mA m^{-2}, the thresholds for acute changes in central nervous system excitability and other acute effects such as reversal of the visually evoked potential are exceeded. In view of the safety considerations above, it was decided that, for frequencies in the range 4 Hz to 1 kHz, occupational exposure should be limited to fields that induce current densities less than 10 mA m^{-2}, i.e., to use a safety factor of 10. For the general public an additional factor of 5 is applied, giving a basic exposure restriction of 2 mA m^{-2}. Below 4 Hz and above 1 kHz, the basic restriction on induced current density increases progressively, corresponding to the increase in the threshold for nerve stimulation for these frequency ranges.

Established biological and health effects in the frequency range from 10 MHz to a few GHz are consistent with responses to a body temperature rise of more than 1°C. This level of temperature increase results from exposure of individuals under moderate environmental conditions to a whole-body SAR of approximately 4 W kg^{-1} for about 30 min. A whole-body average SAR of 0.4 W kg^{-1} has therefore been chosen as the restriction that provides adequate protection for occupational exposure. An additional safety factor of 5 is introduced for exposure of the public, giving an average whole-body SAR limit of 0.08 W kg^{-1}.

The lower basic restrictions for exposure of the general public take into account the fact that their age and health status may differ from those of workers.

In the low-frequency range, there are currently few data relating transient currents to health effects. The ICNIRP therefore recommends that the restrictions on current densities induced by transient or very short-term peak fields be regarded as instantaneous values which should not be time-averaged.

The basic restrictions for current densities, whole-body average SAR, and localized SAR for frequencies between 1 Hz and 10 GHz are presented in Table 4, and those for power densities for frequencies of 10–300 GHz are presented in Table 5.

REFERENCE LEVELS

Where appropriate, the reference levels are obtained from the basic restrictions by mathematical modeling and by extrapolation from the results of laboratory investigations at specific frequencies. They are given for the condition of maximum coupling of the field to the exposed individual, thereby providing maximum protection. Tables 6 and 7 summarize the reference levels for occupational exposure and exposure of the general public, respectively, and the reference levels are illustrated in Figs. 1 and 2. The reference levels are intended to be spatially averaged values over the entire body of the exposed individual, but with the important proviso that the basic restrictions on localized exposure are not exceeded.

For low-frequency fields, several computational and measurement methods have been developed for deriving field-strength reference levels from the basic restrictions.

Table 4. Basic restrictions for time varying electric and magnetic fields for frequencies up to 10 GHz.[a]

Exposure characteristics	Frequency range	Current density for head and trunk (mA m^{-2}) (rms)	Whole-body average SAR (W kg^{-1})	Localized SAR (head and trunk) (W kg^{-1})	Localized SAR (limbs) (W kg^{-1})
Occupational exposure	up to 1 Hz	40	—	—	—
	1–4 Hz	40/f	—	—	—
	4 Hz–1 kHz	10	—	—	—
	1–100 kHz	f/100	—	—	—
	100 kHz–10 MHz	f/100	0.4	10	20
	10 MHz–10 GHz	—	0.4	10	20
General public exposure	up to 1 Hz	8	—	—	—
	1–4 Hz	8/f	—	—	—
	4 Hz–1 kHz	2	—	—	—
	1–100 kHz	f/500	—	—	—
	100 kHz–10 MHz	f/500	0.08	2	4
	10 MHz–10 GHz	—	0.08	2	4

[a] Note:
1. f is the frequency in hertz.
2. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm^2 perpendicular to the current direction.
3. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by $\sqrt{2}$ (~1.414). For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$.
4. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.
5. All SAR values are to be averaged over any 6-min period.
6. Localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.
7. For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$. Additionally, for pulsed exposures in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed 10 mJ kg^{-1} for workers and 2mJ kg^{-1} for the general public, averaged over 10 g tissue.

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Table 5. Basic restrictions for power density for frequencies between 10 and 300 GHz.[a]

Exposure characteristics	Power density (W m^{-2})
Occupational exposure	50
General public	10

[a] Note:
1. Power densities are to be averaged over any 20 cm^2 of exposed area and any $68/f^{1.05}$-min period (where f is in GHz) to compensate for progressively shorter penetration depth as the frequency increases.
2. Spatial maximum power densities, averaged over 1 cm^2, should not exceed 20 times the values above.

The simplifications that have been used to date did not account for phenomena such as the inhomogeneous distribution and anisotropy of the electrical conductivity and other tissue factors of importance for these calculations.

The frequency dependence of the reference field levels is consistent with data on both biological effects and coupling of the field.

Magnetic field models assume that the body has a homogeneous and isotropic conductivity and apply simple circular conductive loop models to estimate induced currents in different organs and body regions, e.g., the head, by using the following equation for a pure sinusoidal field at frequency f derived from Faraday's law of induction:

$$J = \pi R f \sigma \mathrm{B}, \qquad (4)$$

where B is the magnetic flux density and R is the radius of the loop for induction of the current. More complex models use an ellipsoidal model to represent the trunk or the whole body for estimating induced current densities at the surface of the body (Reilly 1989, 1992).

If, for simplicity, a homogeneous conductivity of 0.2 S m^{-1} is assumed, a 50-Hz magnetic flux density of 100 μT generates current densities between 0.2 and 2 mA m^{-2} in the peripheral area of the body (CRP 1997). According to another analysis (NAS 1996), 60-Hz exposure levels of 100 μT correspond to average current densities of 0.28 mA m^{-2} and to maximum current densities of approximately 2 mA m^{-2}. More realistic calculations based on anatomically and electrically refined models (Xi and Stuchly 1994) resulted in maximum current densities exceeding 2 mA m^{-2} for a 100-μT field at 60 Hz. However, the presence of biological cells affects the spatial pattern of induced currents and fields, resulting in significant differences in both magnitude (a factor of 2 greater) and patterns of flow of the induced current compared with those predicted by simplified analyses (Stuchly and Xi 1994).

Electric field models must take into account the fact that, depending on the exposure conditions and the size, shape, and position of the exposed body in the field, the surface charge density can vary greatly, resulting in a variable and non-uniform distribution of currents inside the body. For sinusoidal electric fields at frequencies below about 10 MHz, the magnitude of the induced current density inside the body increases with frequency. The induced current density distribution varies inversely with the body cross-section and may be relatively high in the neck and ankles. The exposure level of 5 kV m^{-1} for exposure of the general public corresponds, under worst-case conditions, to an induced current density of about 2 mA m^{-2} in the neck and trunk of the body if the E-field vector is parallel to the body axis (ILO 1994; CRP 1997). However, the current density induced by 5 kV m^{-1} will comply with the basic restrictions under realistic worst-case exposure conditions.

For purposes of demonstrating compliance with the basic restrictions, the reference levels for the electric and magnetic fields should be considered separately and not additively. This is because, for protection purposes, the currents induced by electric and magnetic fields are not additive.

For the specific case of occupational exposures at frequencies up to 100 kHz, the derived electric fields can be increased by a factor of 2 under conditions in which adverse indirect effects from contact with electrically charged conductors can be excluded.

At frequencies above 10 MHz, the derived electric and magnetic field strengths were obtained from the whole-body SAR basic restriction using computational and experimental data. In the worst case, the energy coupling reaches a maximum between 20 MHz and several hundred MHz. In this frequency range, the derived reference levels have minimum values. The derived magnetic field strengths were calculated from the electric field strengths by using the far-field relationship between E and H (E/H = 377 ohms). In the near-field, the SAR frequency dependence curves are no longer valid; moreover, the contributions of the electric and magnetic field components have to be considered separately. For a conservative approximation, field exposure levels can be used for near-field assessment since the coupling of energy from the electric or magnetic field contribution cannot exceed the SAR restrictions. For a less conservative assessment, basic restrictions on the whole-body average and local SAR should be used.

Reference levels for exposure of the general public have been obtained from those for occupational exposure by using various factors over the entire frequency range. These factors have been chosen on the basis of effects that are recognized as specific and relevant for the various frequency ranges. Generally speaking, the factors follow the basic restrictions over the entire frequency range, and their values correspond to the mathematical relation between the quantities of the basic restrictions and the derived levels as described below:

- In the frequency range up to 1 kHz, the general public reference levels for electric fields are one-half of the values set for occupational exposure. The value of 10 kV m^{-1} for a 50-Hz or 8.3 kV m^{-1} for a 60-Hz occupational exposure includes a sufficient safety margin to prevent stimulation effects from contact currents under all possible conditions. Half of this value was chosen for the general public reference levels, i.e.,

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Table 6. Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength (V m^{-1})	H-field strength (A m^{-1})	B-field (μT)	Equivalent plane wave power density S_{eq} (W m^{-2})
up to 1 Hz	—	1.63×10^5	2×10^5	—
1–8 Hz	20,000	$1.63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—
8–25 Hz	20,000	$2 \times 10^4/f$	$2.5 \times 10^4/f$	—
0.025–0.82 kHz	$500/f$	$20/f$	$25/f$	—
0.82–65 kHz	610	24.4	30.7	—
0.065–1 MHz	610	$1.6/f$	$2.0/f$	—
1–10 MHz	$610/f$	$1.6/f$	$2.0/f$	—
10–400 MHz	61	0.16	0.2	10
400–2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2–300 GHz	137	0.36	0.45	50

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width, does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. Electric shock from low impedance sources is prevented by established electrical safety procedures for such equipment.

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength (V m^{-1})	H-field strength (A m^{-1})	B-field (μT)	Equivalent plane wave power density S_{eq} (W m^{-2})
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4{,}000/f$	$5{,}000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

5 kV m^{-1} for 50 Hz or 4.2 kV m^{-1} for 60 Hz, to prevent adverse indirect effects for more than 90% of exposed individuals;

- In the low-frequency range up to 100 kHz, the general public reference levels for magnetic fields are set at a factor of 5 below the values set for occupational exposure;
- In the frequency range 100 kHz–10 MHz, the general public reference levels for magnetic fields have been increased compared with the limits given in the 1988 IRPA guideline. In that guideline, the magnetic field strength reference levels were calculated from the electric field strength reference levels by using the far-field

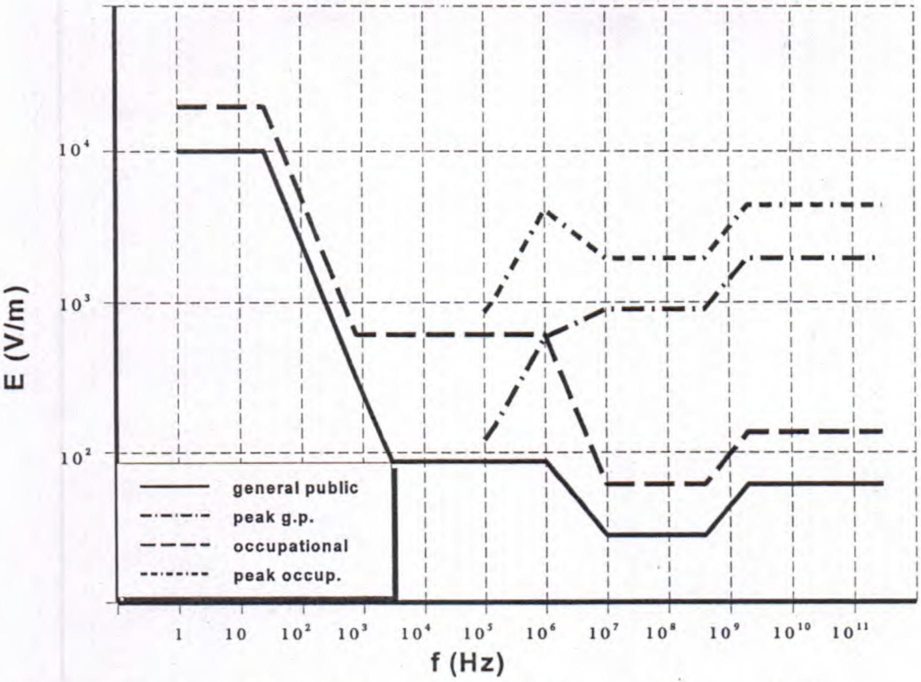

Fig. 1. Reference levels for exposure to time varying electric fields (compare Tables 6 and 7).

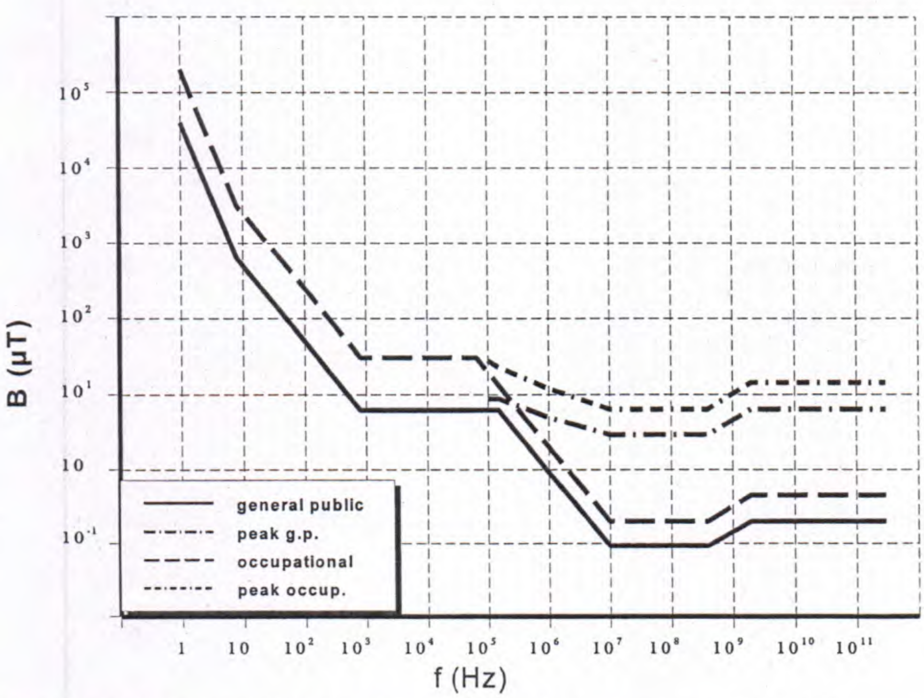

Fig. 2. Reference levels for exposure to time varying magnetic fields (compare Tables 6 and 7).

formula relating E and H. These reference levels are too conservative, since the magnetic field at frequencies below 10 MHz does not contribute significantly to the risk of shocks, burns, or surface charge effects that form a major basis for limiting occupational exposure to electric fields in that frequency range;

- In the high-frequency range 10 MHz–10 GHz, the general public reference levels for electric and magnetic fields are lower by a factor of 2.2 than those set for occupational exposure. The factor of 2.2 corresponds to the square root of 5, which is the safety factor between the basic restrictions for occupational exposure and those for general public

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exposure. The square root is used to relate the quantities "field strength" and "power density;"

- In the high-frequency range 10–300 GHz, the general public reference levels are defined by the power density, as in the basic restrictions, and are lower by a factor of 5 than the occupational exposure restrictions;
- Although little information is available on the relation between biological effects and peak values of pulsed fields, it is suggested that, for frequencies exceeding 10 MHz, S_{eq} as averaged over the pulse width should not exceed 1,000 times the reference levels or that field strengths should not exceed 32 times the field strength reference levels given in Tables 6 and 7 or shown in Figs. 1 and 2. For frequencies between about 0.3 GHz and several GHz, and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion the specific absorption from pulses must limited. In this frequency range, the threshold SA of 4–16 mJ kg^{-1} for producing this effect corresponds, for 30-μs pulses, to peak SAR values of 130–520 W kg^{-1} in the brain. Between 100 kHz and 10 MHz, peak values for the field strengths in Figs. 1 and 2 are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz.
- In Tables 6 and 7, as well as in Figs. 1 and 2, different frequency break-points occur for occupational and general public derived reference levels. This is a consequence of the varying factors used to derive the general public reference levels, while generally keeping the frequency dependence the same for both occupational and general public levels.

REFERENCE LEVELS FOR CONTACT AND INDUCED CURRENTS

Up to 110 MHz, which includes the FM radio transmission frequency band, reference levels for contact current are given above which caution must be exercised to avoid shock and burn hazards. The point contact reference levels are presented in Table 8. Since the threshold contact currents that elicit biological responses in children and adult women are approximately one-half and two-thirds, respectively, of those for adult men, the reference levels for contact current for the general public are set lower by a factor of 2 than the values for occupational exposure.

For the frequency range 10–110 MHz, reference levels are provided for limb currents that are below the basic restrictions on localized SAR (see Table 9).

SIMULTANEOUS EXPOSURE TO MULTIPLE FREQUENCY FIELDS

It is important to determine whether, in situations of simultaneous exposure to fields of different frequencies, these exposures are additive in their effects. Additivity should be examined separately for the effects of thermal and electrical stimulation, and the basic restrictions below should be met. The formulae below apply to relevant frequencies under practical exposure situations.

For electrical stimulation, relevant for frequencies up to 10 MHz, induced current densities should be added according to

$$\sum_{i=1\ \mathrm{Hz}}^{10\ \mathrm{MHz}} \frac{J_i}{J_{L,i}} \leq 1. \qquad (5)$$

For thermal effects, relevant above 100 kHz, SAR and power density values should be added according to:

$$\sum_{i=100\ \mathrm{kHz}}^{10\ \mathrm{GHz}} \frac{SAR_i}{SAR_L} + \sum_{i>10\ \mathrm{GHz}}^{300\ \mathrm{GHz}} \frac{S_i}{S_L} \leq 1, \qquad (6)$$

where

J_i = the current density induced at frequency i;
$J_{L,i}$ = the induced current density restriction at frequency i as given in Table 4;
SAR_i = the SAR caused by exposure at frequency i;
SAR_L = the SAR limit given in Table 4;
S_L = the power density limit given in Table 5; and
S_i = the power density at frequency i.

For practical application of the basic restrictions, the following criteria regarding reference levels of field strengths should be applied.

Table 8. Reference levels for time varying contact currents from conductive objects.[a]

Exposure characteristics	Frequency range	Maximum contact current (mA)
Occupational exposure	up to 2.5 kHz	1.0
	2.5–100 kHz	0.4*f*
	100 kHz–110 MHz	40
General public exposure	up to 2.5 kHz	0.5
	2.5–100 kHz	0.2*f*
	100 kHz–110 MHz	20

[a] *f* is the frequency in kHz.

Table 9. Reference levels for current induced in any limb at frequencies between 10 and 110 MHz.[a]

Exposure characteristics	Current (mA)
Occupational exposure	100
General public	45

[a] Note:
1. The public reference level is equal to the occupational reference level divided by $\sqrt{5}$.
2. For compliance with the basic restriction on localized SAR, the square root of the time-averaged value of the square of the induced current over any 6-min period forms the basis of the reference levels.

(80)

For induced current density and electrical stimulation effects, relevant up to 10 MHz, the following two requirements should be applied to the field levels:

$$\sum_{i=1\text{ Hz}}^{1\text{ MHz}} \frac{E_i}{E_{L,i}} + \sum_{i>1\text{ MHz}}^{10\text{ MHz}} \frac{E_i}{a} \leq 1, \qquad (7)$$

and

$$\sum_{j=1\text{ Hz}}^{65\text{ kHz}} \frac{H_j}{H_{L,j}} + \sum_{j>65\text{ kHz}}^{10\text{ MHz}} \frac{H_j}{b} \leq 1, \qquad (8)$$

where

E_i = the electric field strength at frequency i;
$E_{L,i}$ = the electric field reference level from Tables 6 and 7;
H_j = the magnetic field strength at frequency j;
$H_{L,j}$ = the magnetic field reference level from Tables 6 and 7;
a = 610 V m^{-1} for occupational exposure and 87 V m^{-1} for general public exposure; and
b = 24.4 A m^{-1} (30.7 μT) for occupational exposure and 5 A m^{-1} (6.25 μT) for general public exposure.

The constant values a and b are used above 1 MHz for the electric field and above 65 kHz for the magnetic field because the summation is based on induced current densities and should not be mixed with thermal considerations. The latter forms the basis for $E_{L,i}$ and $H_{L,j}$ above 1 MHz and 65 kHz, respectively, found in Tables 6 and 7.

For thermal considerations, relevant above 100 kHz, the following two requirements should be applied to the field levels:

$$\sum_{i=100\text{ kHz}}^{1\text{ MHz}} \left(\frac{E_i}{c}\right)^2 + \sum_{i>1\text{ MHz}}^{300\text{ GHz}} \left(\frac{E_i}{E_{L,i}}\right)^2 \leq 1, \qquad (9)$$

and

$$\sum_{j=100\text{ kHz}}^{1\text{ MHz}} \left(\frac{H_j}{d}\right)^2 + \sum_{j>1\text{ MHz}}^{300\text{ GHz}} \left(\frac{H_j}{H_{L,j}}\right)^2 \leq 1, \qquad (10)$$

where

E_i = the electric field strength at frequency i;
$E_{L,i}$ = the electric field reference level from Tables 6 and 7;
H_j = the magnetic field strength at frequency j;
$H_{L,i}$ = the magnetic field reference level from Tables 6 and 7;
c = $610/f$ V m^{-1} (f in MHz) for occupational exposure and $87/f^{1/2}$ V m^{-1} for general public exposure; and
d = $1.6/f$ A m^{-1} (f in MHz) for occupational exposure and $0.73/f$ for general public exposure.

For limb current and contact current, respectively, the following requirements should be applied:

$$\sum_{k=10\text{ MHz}}^{110\text{ MHz}} \left(\frac{I_k}{I_{L,k}}\right)^2 \leq 1 \quad \sum_{n=1\text{ Hz}}^{110\text{ MHz}} \frac{I_n}{I_{C,n}} \leq 1, \qquad (11)$$

where

I_k = the limb current component at frequency k;
$I_{L,k}$ = the reference level of limb current (see Table 9);
I_n = the contact current component at frequency n; and
$I_{C,n}$ = the reference level of contact current at frequency n (see Table 8).

The above summation formulae assume worst-case conditions among the fields from the multiple sources. As a result, typical exposure situations may in practice require less restrictive exposure levels than indicated by the above formulae for the reference levels.

PROTECTIVE MEASURES

ICNIRP notes that the industries causing exposure to electric and magnetic fields are responsible for ensuring compliance with all aspects of the guidelines.

Measures for the protection of workers include engineering and administrative controls, personal protection programs, and medical surveillance (ILO 1994). Appropriate protective measures must be implemented when exposure in the workplace results in the basic restrictions being exceeded. As a first step, engineering controls should be undertaken wherever possible to reduce device emissions of fields to acceptable levels. Such controls include good safety design and, where necessary, the use of interlocks or similar health protection mechanisms.

Administrative controls, such as limitations on access and the use of audible and visible warnings, should be used in conjunction with engineering controls. Personal protection measures, such as protective clothing, though useful in certain circumstances, should be regarded as a last resort to ensure the safety of the worker; priority should be given to engineering and administrative controls wherever possible. Furthermore, when such items as insulated gloves are used to protect individuals from high-frequency shock and burns, the basic restrictions must not be exceeded, since the insulation protects only against indirect effects of the fields.

With the exception of protective clothing and other personal protection, the same measures can be applied to the general public whenever there is a possibility that the general public reference levels might be exceeded. It is also essential to establish and implement rules that will prevent:

- interference with medical electronic equipment and devices (including cardiac pacemakers);

- detonation of electro-explosive devices (detonators); and
- fires and explosions resulting from ignition of flammable materials by sparks caused by induced fields, contact currents, or spark discharges.

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APPENDIX

Glossary

Absorption. In radio wave propagation, attenuation of a radio wave due to dissipation of its energy, i.e., conversion of its energy into another form, such as heat.

Athermal effect. Any effect of electromagnetic energy on a body that is not a heat-related effect.

Blood-brain barrier. A functional concept developed to explain why many substances that are transported by blood readily enter other tissues but do not enter the brain; the "barrier" functions as if it were a continuous membrane lining the vasculature of the brain. These brain capillary endothelial cells form a nearly continuous barrier to entry of substances into the brain from the vasculature.

Conductance. The reciprocal of resistance. Expressed in siemens (S).

Conductivity, electrical. The scalar or vector quantity which, when multiplied by the electric field strength, yields the conduction current density; it is the reciprocal of resistivity. Expressed in siemens per meter (S m^{-1}).

Continuous wave. A wave whose successive oscillations are identical under steady-state conditions.

Current density. A vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor. Expressed in ampere per square meter (A m^{-2}).

Depth of penetration. For a plane wave electromagnetic field (EMF), incident on the boundary of a good conductor, depth of penetration of the wave is the depth at which the field strength of the wave has been reduced to 1/e, or to approximately 37% of its original value.

Dielectric constant. See permittivity.

Dosimetry. Measurement, or determination by calculation, of internal electric field strength or induced current density, of the specific energy absorption, or specific energy absorption rate distribution, in humans or animals exposed to electromagnetic fields.

Electric field strength. The force (E) on a stationary unit positive charge at a point in an electric field; measured in volt per meter (V m^{-1}).

Electromagnetic energy. The energy stored in an electromagnetic field. Expressed in joule (J).

ELF. Extremely low frequency; frequency below 300 Hz.

EMF. Electric, magnetic, and electromagnetic fields.

Far field. The region where the distance from a radiating antenna exceeds the wavelength of the radiated EMF; in the far-field, field components (E and H) and the direction of propagation are mutually perpendicular, and the shape of the field pattern is independent of the distance from the source at which it is taken.

Frequency. The number of sinusoidal cycles completed by electromagnetic waves in 1 s; usually expressed in hertz (Hz).

Impedance, wave. The ratio of the complex number (vector) representing the transverse electric field at a point to that representing the transverse magnetic field at that point. Expressed in ohm (Ω).

Magnetic field strength. An axial vector quantity, H, which, together with magnetic flux density, specifies a magnetic field at any point in space, and is expressed in ampere per meter (A m^{-1}).

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Magnetic flux density. A vector field quantity, B, that results in a force that acts on a moving charge or charges, and is expressed in tesla (T).

Magnetic permeability. The scalar or vector quantity which, when multiplied by the magnetic field strength, yields magnetic flux density; expressed in henry per meter (H m^{-1}). *Note:* For isotropic media, magnetic permeability is a scalar; for anisotropic media, it is a tensor quantity.

Microwaves. Electromagnetic radiation of sufficiently short wavelength for which practical use can be made of waveguide and associated cavity techniques in its transmission and reception. *Note:* The term is taken to signify radiations or fields having a frequency range of 300 MHz–300 GHz.

Near field. The region where the distance from a radiating antenna is less than the wavelength of the radiated EMF. *Note:* The magnetic field strength (multiplied by the impedance of space) and the electric field strength are unequal and, at distances less than one-tenth of a wavelength from an antenna, vary inversely as the square or cube of the distance if the antenna is small compared with this distance.

Non-ionizing radiation (NIR). Includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than about 12 eV, wavelengths greater than 100 nm, and frequencies lower than 3×10^{15} Hz.

Occupational exposure. All exposure to EMF experienced by individuals in the course of performing their work.

Permittivity. A constant defining the influence of an isotropic medium on the forces of attraction or repulsion between electrified bodies, and expressed in farad per metre (F m^{-1}); *relative permittivity* is the permittivity of a material or medium divided by the permittivity of vacuum.

Plane wave. An electromagnetic wave in which the electric and magnetic field vectors lie in a plane perpendicular to the direction of wave propagation, and the magnetic field strength (multiplied by the impedance of space) and the electric field strength are equal.

Power density. In radio wave propagation, the power crossing a unit area normal to the direction of wave propagation; expressed in watt per square meter (W m^{-2}).

Public exposure. All exposure to EMF experienced by members of the general public, excluding occupational exposure and exposure during medical procedures.

Radiofrequency (RF). Any frequency at which electromagnetic radiation is useful for telecommunication. *Note:* In this publication, radiofrequency refers to the frequency range 300 Hz –300 GHz.

Resonance. The change in amplitude occurring as the frequency of the wave approaches or coincides with a natural frequency of the medium; whole-body absorption of electromagnetic waves presents its highest value, i.e., the resonance, for frequencies (in MHz) corresponding approximately to $114/L$, where L is the height of the individual in meters.

Root mean square (rms). Certain electrical effects are proportional to the square root of the mean of the square of a periodic function (over one period). This value is known as the effective, or root-mean-square (rms) value, since it is derived by first squaring the function, determining the mean value of the squares obtained, and taking the square root of that mean value.

Specific energy absorption. The energy absorbed per unit mass of biological tissue, (SA) expressed in joule per kilogram (J kg^{-1}); specific energy absorption is the time integral of specific energy absorption rate.

Specific energy absorption rate (SAR). The rate at which energy is absorbed in body tissues, in watt per kilogram (W kg^{-1}); SAR is the dosimetric measure that has been widely adopted at frequencies above about 100 kHz.

Wavelength. The distance between two successive points of a periodic wave in the direction of propagation, at which the oscillation has the same phase.

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Note

Equation 11 in this publication (Health Physics, 1998) was subsequently amended by the ICNIRP Commission in the 1999 reference book "Guidelines on Limiting Exposure to Non-Ionizing Radiation", a reference book based on guidelines on limiting exposure to non-ionizing radiation and statements on special applications. R. Matthes, J.H. Bernhardt, A.F. McKinlay (eds.) International Commission on Non-Ionizing Radiation Protection 1999, ISBN 3-9804789-6-3. The amended version is available below.

"For limb current and contact current, respectively, the following requirements should be applied:

$$\sum_{k=10MHz}^{110MHz}\left(\frac{I_k}{I_{L,k}}\right)^2 \le 1 \qquad \sum_{n=1Hz}^{10MHz}\frac{I_n}{I_{C,n}} \le 1 \qquad \sum_{n=100kHz}^{110MHz}\left(\frac{I_n}{I_{C,n}}\right)^2 \le 1 \qquad (11)$$

where
I_k is the limb current component at frequency k
$I_{L,k}$ is the reference level of limb current (see Table 9)
I_n is the contact current component at frequency n
$I_{C,n}$ is the reference level of contact current at frequency n (see Table 8).

The above summation formulae assume worst-case conditions among the fields from the multiple sources. As a result, typical exposure situations may in practice require less restrictive exposure levels than indicated by the above formulae for the reference levels."

Ref: Excerpt from "Guidelines on Limiting Exposure to Non-Ionizing Radiation", a reference book based on guidelines on limiting exposure to non-ionizing radiation and statements on special applications. R. Matthes, J.H. Bernhardt, A.F. McKinlay (eds.) International Commission on Non-Ionizing Radiation Protection 1999, ISBN 3-9804789-6-3.

Annexure - R-5

(90)

Government of India
Ministry of Communications and IT
Department of Telecommunications
(AS-II Cell)
Sanchar Bhavan, 20, Ashok Road, New Delhi-110117

No.842-998/2008-AS-IV 114

Dated: 4th Nov., 2008

To

All Cellular Mobile Telephone Service Licensee(s) to whom CMTS Licenses issued in 2001 or thereafter

Subject: Amendment to the Cellular Mobile Telephone Service Licence Agreement issued in 2001 or thereafter

In exercise of the power vested in the Licensor under clause 5.1 of Cellular Mobile Telephone Service (CMTS) Licence issued in 2001 and thereafter, inter-alia, reserving the right to modify at any time the terms and conditions of the LICENCE, in public interest, security of the nation or proper conduct of the SERVICE, the Licensor hereby inserts after clause 46.5 of the said Licence Agreement, with immediate effect, the following clause, namely:-

"46.5A. Licensee shall conduct audit and provide self certificates annually as per procedure prescribed by Telecommunication Engineering Centre (TEC)/or any other agency authorized by Licensor from time to time for confirming to limits/levels for antennae (Base Station Emissions) for general public exposure as prescribed by International Commission on Non-Ionizing Radiation Protection (ICNIRP) from time to time. The present limits/levels are reproduced as detailed below:

Frequency Range	E-Field Strength (Volt/Meter (V/m))	H-Field Strength (Amp/Meter (A/m))	Power Density (Watt/Sq.Meter (W/Sq.m))
400MHz to 2000MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	f/200
2GHz to 300GHz	61	0.16	10

(f = frequency in MHz)

Note: The compliance in the form of Self Certificate shall commence six months after the date of issue of prescribed test procedure by TEC or any other agency authorized by Licensor."

4.11.2008

(B.L. Panwar)
Asstt. Director General (VAS-II)
Tel:23710506

Copy to:

1. Secretary, TRAI, New Delhi
2. Wireless Advisor, WPC Wing, New Delhi
3. Sr.DDG,TEC,New Delhi: A detailed test procedure may kindly be issued on priority
4. Sr.DDG(WPF), DoT, New Delhi
5. DDG(Security), DDG(AS-I), DDG(LF), DoT, New Delhi
6. DDG(C&A), DoT for posting on the DoT website

Annexure - R-6

32/C

(91)

No: 800-15/2010-VAS
Government of India
Ministry of Communication & IT
Department of Telecom
Access Services Cell
Sanchar Bhawan, Ashoka road New Delhi

Date: 8th April, 2010

To

All CMTS/ UAS Licensees

Sub: Instructions to Service Providers on implementation of radiation norms on EMF exposure by Base Transceiver Stations (BTSs)

This is with reference to conditions of the License Agreement amendment dated 4th November 2008, regarding implementation of ICNIRP guidelines regarding the emission by Base Transceiver Stations (BTSs) as below:

"Licensee shall conduct audit and provide self certificates annually as per procedure prescribed by Telecommunication Engineering Centre (TEC)/or any other agency authorized by Licensor from time to time for confirming to limits/levels for antennae (Base Station Emissions) for general public exposure as prescribed by International Commission on Non-Ionizing Radiation Protection (ICNIRP) from time to time. The present limits/levels are reproduced as detailed below:

Frequency Range	E-Field Strength (Volt/Meter (V/m))	H-Field Strength (Amp/Meter (A/m))	Power Density (Watt/Sq.Meter (W/Sq.m))
400MHz to 2000MHz	$1.375f^{½}$	$0.0037f^{½}$	f/200
2GHz to 300GHz	61	0.16	10

(f = frequency in MHz)

Note: The compliance in the form of Self Certificate shall commence six months after the date of issue of prescribed test procedure by TEC or any other agency authorized by Licensor."

2 TEC has since issued the test procedure No. TEC/TP/EMF/001/01.SEP-2009 which has been intimated to the Licensees vide letter dated 09.11.2009.

3. In view of the above, following instructions are issued for meeting the ICNIRP guidelines:

(i) All existing BTSs should be ICNIRP guidelines compliant by 08.05.2010 as the TEC test procedure has been circulated on 09.11.2009. Therefore, all BTSs should be self certified as meeting the radiation norm. Self certification should be submitted to respective Telecom Enforcement Resource & Monitoring (TERM) Cells of DOT by 15.05.2010.

199/DC(T)
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(ii) All new BTS sites should start radiating only after self certificate has been submitted to relevant TERM Cells.

(iii) The TERM Cell will test up to 10% of new BTS sites randomly at its discretion. Additionally, the BTS sites against which there are public complaints, shall also be tested by TERM Cell. The testing shall be done as per procedures prescribed by Telecom Engineering Center (TEC) from time to time.

(iv) The cost of test for audit of EMF exposure from BTS shall be borne by the Mobile Service Operator, which shall be Rs. 10, 000 (Rs. Ten Thousands only) for one site/per Service Provider.

(v) Tools and equipments for testing would be provided by the concerned Mobile Service Provider to the TERM cell.

(vi) If a site fails to meet the EMR criterion, a penalty of Rs. 5 lakh shall be levied per BTS per service provider. Service providers must meet the criterion within one month of the report of TERM cell in such cases, after which the site will be shut down.

(vii) The BTS site details would be hosted on Telecom Engineering Center (TEC) website on submission of self test and registration with TERM cell, giving the test result and mentioning that the BTS site is self certified by the service Providers. Nature of compliance will be mentioned against each BTS i.e. self certified, TERM certified and not certified. After the BTS site has been tested by TERM cell, status of the BTS site will be changed to be "TERM certified".

(viii) The service providers also have the option of getting all the BTS sites tested from TERM cell by paying the requisite fee. TERM cell will test such sites at their discretion depending upon the availability of resources with them. If they are not able to test such sites either the test fee shall not be accepted or will be refunded within a month's time, if a commitment to test the site within next 6 months is not given.

4. The Mobile Service Providers are advised to adopt following ten best practices in regard to guidelines for public exposure of Electromagnetic Fields for Base Transceiver Stations:

(i) Include ICNIRP compliance as recommended by the TEC in their planning exercise for radio base station.

(ii) Assess all radio base stations for international (ICNIRP) compliance as recommended by the TEC for public exposure.

(iii) Produce a programme for this compliance as recommended by the TEC for already existing sites also.

(iv) Provide a database of information, which is available to the public on radio base stations.

(v) Respond to complaints and enquiries about radio base stations, within ten working days.

(vi) Financially support the Government's independent scientific research programme on mobile communications health issues.

(vii) Develop clear standards and procedures on the issue after consultation with local communities and other stakeholders.

(viii) Participate in pre-rollout and pre-application consultation with local planning authorities.

(ix) Publish clear, transparent and accountable criteria and cross-industry agreement on site sharing, which should be updated and published regularly.

(x) Establish professional development workshops on technological developments within telecommunications for public and other stake holders.

(Vinod Kumar) 8/4/10
Director (AS-II)

Copy to:

1. Wireless Advisor, WPC Wing, DoT, New Delhi
2. Sr. DDG, TEC, DoT, New Delhi
3. Sr. DDG (WPF), DoT, New Delhi
4. DDG (Security-TERM))/ DDG (Security)/ DDG (LF), DoT, New Delhi
5. DDG (C&A) for posting on DOT website.

Annexure R-7

(94)

Government of India
Department of Telecommunications
(Access Services Cell)
Sanchar Bhawan, 20, Ashoka Road New Delhi - 110 001

File No: 800-15/2010-VAS **Dated:** 26 .06.2013

To

All Cellular Mobile Telephone Service Licensee(s) to whom CMTS License were issued in 2001 or thereafter

Subject: Corrigendum to amendment dated 11.01.2013 to the Cellular Mobile Telephone Service Licence Agreement issued in 2001 or thereafter.

In this office letter of even number dated 10.01.2013 pertaining to Electromagnetic Radiations from antennae (Base Stations), the amended clause 46.5A may be read as under:

*"Licensee shall conduct audit and provide self certificates **after every two year** as per procedure prescribed by Telecommunication Engineering Centre (TEC)/or any other agency authorized by Licensor from time to time for conforming to limits/levels for antennae (Base Station) Emissions for general public exposure as prescribed by Licensor from time to time. The present limits/levels are reproduced as detailed below:*

Frequency Range	*E-Field Strength (Volt/Meter (V/m))*	*H-Field Strength (Amp/Meter (A/m))*	*Power Density (Watt/Sq.Meter (W/Sq.m))*
400MHz to 2000MHz	*0.434f ½*	*0.0011f ½*	*f/2000*
2GHz to 300GHz	*19.29*	*0.05*	*1*

(f = frequency in MHz)"

(P.C.Sharma)
Director(AS-II)

Copy to:

1. Secretary, TRAI
2. Sr. DDG, TEC
3. Sr. DDG (TERM). DoT
4. DDG (CS), DoT
5. All DDsG TERM.
6. Director (AS-I)/ Director (AS-III)/ Director (AS-IV), DoT

Annexure R-8

(95)

Govt. of India
Ministry of Communications & IT
Department of Telecommunications
713, Sanchar Bhawan, 20-Ashoka Road, New Delhi-110001.
(Carrier Services Cell)

No. 17-63/2011-CS-III

Dated: 27.02.2014

OFFICE MEMORANDUM

Subject: Report of the Committee constituted in compliance to the directions of the Hon'ble High Court, Allahabad, Lucknow Bench on issues relating to Electromagnetic Field (EMF) radiation --- Acceptance and decisions regarding:

In compliance to the directions of Hon'ble High Court, Allahabad, Lucknow Bench vide its order dated 10th January, 2012, the Committee was setup by the Government which has submitted its Report on 17.01.2014 on issues relating to EMF radiations from cell phone towers and mobile handsets. In consideration to the Report of the Committee, the following decisions are hereby conveyed:-

1) The present prescribed norms for the EMF radiation limits are as follows:

a) **Limits/levels for antennae (Base Station) EMF Emissions for general public exposure :**

Frequency Range	E-Field Strength (Volt/Meter (V/m))	H-Field Strength (Amp/Meter (A/m))	Power Density (Watt/Sq.Meter (W/Sq.m))
400MHz to 2000MHz	$0.434f^{1/2}$	$0.0011f^{1/2}$	f/2000
2GHz to 300GHz	19.29	0.05	1

(f = frequency in MHz)

The above prescribed limits for EMF radiations from Base Station in India are one-tenth (1/10th) of internationally prescribed limits (ICNIRP).

(i)

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b) **For Mobile Phones:**

Specific Absorption Rate (SAR) levels for mobile handsets adopted in India are 1.6 Watt/Kg averaged over a mass of 1gram of human tissue.

The Department of Telecom has already prescribed stricter precautionary limits for EMF radiation from mobile tower as well as from mobile handset/phones applicable as on date.

After due consideration of the human health concerns on account of EMF radiation recently being raised in public and the Report of the Committee, it has been decided that the present prescribed precautionary EMF safe exposure limits are adequate and need no further change at this stage.

2) Department of Telecom has already taken adequate steps in regard to granting of permission for siting of mobile towers in its recent guidelines to State governments and Telecom Enforcement, Resource & Monitoring (TERM) cells in different licence service areas effective from 01-08-2013. In order to make the deterrence stronger, the penalty for violation of prescribed stricter EMF norms from BTS tower by telecom service providers has been increased from Rs. 5 Lakhs to Rs. 10 Lakhs per BTS, per incidence per operator w.e.f. 20th November, 2013.

In order to ensure compliance to the prescribed stricter precautionary norms of EMF from BTS tower, the extensive audit of comprehensive self-certificates and sites for compliance to EMF radiations safe limits being submitted by telecom service providers shall be carried out by TERM Cells of DoT for the purpose of limiting the EMF radiation exposure and keeping general public areas in the vicinity of towers safe, as per the procedure prescribed from time to time in their respective License Service Areas.

3) The Department of Science and Technology and Indian Council of Medical Research (ICMR) shall carry out / facilitate extensive studies, on the Indian conditions with special focus on prolonged use of mobile phone, to conclusively determine sensitivity of EMF Radiation / possible health hazard risk of EMF radiation, which at present is not proven. These Indian specific scientific studies should aim at generating scientifically credible data and evidences by involving Ministry of Science and Technology, ICMR, Ministry of Environment & Forest, DoT and other relevant organisation. The Government of India shall make available funds to ensure

(ii)

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extensive long term/short term research and studies on possible health effects of EMF radiation on life (Human, Living organism, Flora & Fauna & Environment).

4) Concerned departments of Government like Department of Telecom, Health, Environment etc. shall step up efforts to spread public awareness on EMF and above precautions regarding mobile phones (Handsets) to allay undue apprehensions in regard to possible health effects of EMF radiation largely caused due to misinformation being peddled by certain sections in public. This can be done through print media/electronic media and other communications channels and tools along with conducting market research / survey, workshops and seminars etc.

5) Annual discussion, meetings/seminars shall be conducted by the Government by inviting experts from various academic and research institutions for continual evaluation of scientific evidence published worldwide with an aim to monitor the progress in research on the effects of EMF radiation.

6) In order to get latest updates on EMF radiation related issues, DoT will actively participate in the deliberations of various International standards bodies, including WHO, involved in the study of EMF radiation.

7) Department of Telecom will create national EMF web portal to provide public access to the status of compliance, of the prescribed EMF norms, of all BTSs/ mobile towers in the country and related relevant information.

This issues with the approval of MOC&IT.

27/2/14

(Sanjeev Kumar Sharma)
Director (CS-III)

Copy to:

I) PS to Hon'ble MOC&IT
II) PS to Hon. MOS (C&IT)-D
III) PS to Hon. MOS (C&IT)-P
IV) PPS to Secretary (T), DoT
V) PSs to Member (T)/Member (F)/ Member (S)
VI) PS to Addl. Secy.
VII) Advisor (Technology)

(iii)

(98)

VIII) Sr.DDG (TERM)/Sr. DDG (TEC)/ DDG (AS-I)/ JS(A)/ DDG (CS)/ DDG (PG)/ Wireless Adviser, WPC, DoT for taking necessary action.

Copy for action as appropriate to:

I) Secretary, Ministry of Environment & Forests
II) Secretary, Department of Science & Technology
III) Secretary, Department of Health & Family Welfare
IV) Director General, Indian Council of Medical Research

(iv)

Gmail Proof of Service

Dheeraj Singh <dheeraj.adv001@gmail.com>

Reply on behalf of the Respondent No.3

Dheeraj Singh <dheeraj.adv001@gmail.com> 23 November 2022 at 14:34
To: "info@maestrolegal.in" <info@maestrolegal.in>

Dear Sir,
I am annexing Reply on Behalf of the Respondent No.3 in Case title Gaur Atulyam Apartment Owners Association Versus Greater Noida Industrial Development Authority & Ors

Thanks & regards
Dheeraj Singh, Adv
Junior of Gigi.C.George,Adv
Ch.No.336, Lawyers Chamber Block,
Saket District Court, New Delhi
Mob-9810625315

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