ПРАКТИЧЕСКОМУ ЗДРАВООХРАНЕНИЮ

DOI: https://doi.org/10.31089/1026-9428-2020-60-9-597-599

Sergey Yu. Perov[1], Olga V. Belaya[1], Quirino Balzano[2], Nina B. Rubtsova[1]

The problems of mobile communication electromagnetic field exposure assessment today and tomorrow

[1]Izmerov Research Institute of Occupational Health, 31, Budyonnogo Ave., Moscow, Russia, 105275;
[2]University of Maryland, Electrical and Computer Engineering, Kim Building, College Park, Maryland, USA, 20742

New and necessary improvements of electromagnetic exposure assessment principles and methods are considered and presented. The electromagnetic field exposure assessment is the physical basis for hygienic and biological research and needs s to consider the new technological features of emerging 5G mobile systems in addition to existing 2-4G systems. The new generation of telecommunication networks will cause significantly novel electromagnetic field exposure, in particular for time-frequency and spatial parameters. A complex exposure assessment based on refined broadband measurements seems to be the proper and necessary approach to the enhancement of Russian EMF assessment guidelines. Simple broadband EMF measurements are the common approach for present exposure assessment and cannot be used any longer as the only measure for multiple 5G sources exposure evaluation. Then again broadband measurements are the simple and practical approach for mm wave *in-situ* exposure assessment. Frequency-selective and code-selective measurements provide detailed EMF level distribution in separate frequency channels, telecommunication services or sources and are a promising approach for objective exposure assessment.

Key words: *electromagnetic field; radiofrequency; human exposure assessment; mobile communication; 5G NR*
For citation: Perov S.Yu., Belaya O.V., Balzano Q., Rubtsova N.B. The problems of mobile communication electromagnetic field exposure assessment today and tomorrow. *Med. truda i prom. ekol.* 2020; 60(9). https://doi.org/10.31089/1026-9428-2020-60-9-597-599
For correspondence: *Sergey Yu. Perov*, head. The laboratory of electromagnetic fields, Research Institute of Occupational Health, Dr. of Sci. (Biol.). E-mail: perov@irioh.ru; perov1980@mail.ru
Information about authors:
Perov S.Yu. https://orcid.org/0000-0002-6903-4327 Belaya O.V. https://orcid.org/0000-0003-3937-4950
Balzano Q. https://orcid.org/0000-0002-4384-8402 Rubtsova N.B. https://orcid.org/0000-0001-6306-777X
Funding. The study had no funding.
Conflict of interest. The authors claim no conflict of interest.
Received: 15.06.2020 / Accepted: 12.08.2020 / Published: 07.10.2020

УДК 614.875;654.165
Перов С.Ю.[1], Белая О.В.[1], Балзано К.[2], Рубцова Н.Б.[1]

Проблемы оценки электромагнитных полей от систем мобильной связи сегодня и завтра

[1]ФГБНУ «Научно-исследовательский институт медицины труда им. академика Н.Ф. Измерова», пр-т Буденного, 31, Москва, Россия, 105275;
[2]Университет Мэриленда, Кафедра Электрической и компьютерной инженерии, здание Кима, Колледж-Парк, 20742, Мэриленд, США

Рассмотрены и представлены необходимые направления совершенствования принципов и методов оценки экспозиции электромагнитными полями. Оценка воздействия электромагнитного поля (ЭМП) является физической основой при проведении гигиенических и медико-биологических исследований и требует соответствия технологическим особенностям новых систем мобильной связи поколения 5G в дополнение к существующим системам поколений 2-4G. Внедрение беспроводных сетей нового поколения приведет к значительному изменению условий экспозиции электромагнитным полем, в частности по частотно-временным и пространственным параметрам. Комплексная оценка воздействия, основанная на уточнении широкополосных измерений, представляется подходящим и необходимым подходом к совершенствованию российских нормативно-методических документов по оценке ЭМП. В современной практике оценки экспозиции ЭМП простые широкополосные измерения являются общепринятым подходом и не могут больше использоваться в качестве единственного метода оценки условий экспозиции от нескольких источников, в том числе и поколения 5G. Кроме того, широкополосные измерения являются простым и реализуемым на практике подходом для натурных исследований уровней ЭМП в диапазоне мм-волн. С помощью частотно-селективных и кодо-селективных измерений можно получить детальные данные об уровнях ЭМП в отдельных частотных каналах, для выбранных стандартов связи или источников, что представляет многообещающие возможности для объективной оценки условий экспозиции в настоящем и будущем.

Ключевые слова: *электрическое поле; радиочастотный диапазон; оценка экспозиции человека; мобильные средства связи; 5G NR*
Для цитирования: Перов С.Ю., Белая О.В., Балзано К., Рубцова Н.Б. Проблемы оценки электромагнитных полей от систем мобильной связи сегодня и завтра. *Мед. труда и пром. экол.* 2020; 60(9). https://doi.org/10.31089/1026-9428-2020-60-9-597-599
Для корреспонденции: *Перов Сергей Юрьевич*, зав. лаб. электромагнитных полей ФГБНУ «НИИ МТ», д-р биол. наук. E-mail: perov@irioh.ru; perov1980@mail.ru
Финансирование. Исследование не имело спонсорской поддержки.
Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.
Дата поступления: 15.06.2020 / Дата принятия к печати: 12.08.2020 / Дата публикации: 07.10.2020

Nowadays, new wireless telecommunication and next generation mobile networks are coming into the international wireless technology mainstream. The development and applications of 5G/IMT2020 mobile systems involve various economy sectors: industry, transport, healthcare, media, smart environments and others [1]. The new telecommunication systems utilize the radiofrequency electromagnetic energy in ways different from current mobile systems: a new spectrum range, broader channel bandwidth, dynamic and more localized energy spatial distribution. Therefore, the 5G systems integration with current 2-4G mobile networks will change and significantly complicate occupational and general public radiofrequency electromagnetic fields (EMF) exposure. This electromagnetic safety problem is a great concern for modern society and is addressed by occupational and public health authorities. EMF exposure assessment, the physical/technical ground for hygienic, medical and biological research, needs to adapt to the technological features of emerging EMF sources by means of appropriate measurement methods and equipment. Therefore the principles and methods of current Russian EMF exposure assessment guidelines [2, 3] require enhancements concerning the main aspects of 2–5G cellular technologies.

While the 2–4G mobile system, emit signals in 450–2700 MHz

frequency range, the 5G mobile systems may occupy 410–7125 MHz and 24,25–52,6 GHz frequency ranges [4] (table). At present, two frequency bands, 4800–4990 MHz and 25,25–29,5 GHz, are allocated for 5G trials in Russia. Thus, the 5G network deployment will cause new EMF exposure conditions with wide-band signals that may lead to unique or unanticipated biological effects.

Another important characteristic of 5G mobile systems is the application of advanced antenna technologies with dynamic radiation pattern scanning and beamforming. Multi-elements antenna systems of the massive multiple input multiple output (mMIMO) type provide adaptive control of the beam gain, number and direction depending on terminal space distributions, locations and traffic loads. These aspects will form a new spatiotemporal structure of 2–5G mobile networks EMF exposure. So, the EMF exposure assessment for modern telecommunication systems should include the frequency, time and spatial parameters of electromagnetic field dynamics of the base stations and the subscriber phones.

Conventional constant EMF exposure assessment is based on broadband and selective measurements [5]. The broadband measurements are the simple and common approach for *in-situ* EMF exposure assessment and cover levels from all sources in the measured frequency range. However, complicated broadband EMF signaling cannot provide simple, definite frequency bandwidth data, which are most important in multiple source environments, as well as the physical foundation of biological effect research and epidemiological studies. The selective EMF measurements are more sophisticated and allow to separately summarize exposure levels into individual frequency ranges (frequency-selective measurements) or individual services (code-selective measurements). This approach is important for mobile system exposure assessment particularly to evaluate the different cellular standards and operators input. Furthermore, the rapid EMF exposure time variation from base station traffic load can be solved by means of selective measurements.

The international EMF exposure assessment approach [6, 7] uses selective measures with pilot and control channels from base stations and extrapolate these data to the worst exposure conditions — the actual or possible maximum exposure levels. The simplicity and practical use of in-situ selective EMF measurements are limited by available handheld measurement equipment and its frequency ranges. Today, these devices' (measurement tools) frequency range is not over the entire 3–6 GHz band and doesn't cover the full 5G spectrum. The available measurement equipment of spectrum analyzer type covers the mm wave range, but is complex to use and is intended for a laboratory environment only. Today the broadband measurements are the simple and practical approach for mm wave *in-situ* exposure assessment.

Table / Таблица

Mobile systems operating bands
Рабочие диапазоны частот мобильных систем связи

Mobile systems generation	Operating frequency band, MHz	Channel bandwidth, MHz
2G (GSM 900, GSM 1800)	890 – 960 1710 – 1880	0,2
3G (UMTS)	890 – 2170	5
4G (LTE)	453 – 2690	1,4 – 20
5G NR	410 – 7125	5 – 100
	24250 – 52600	50 – 400

In fact, broadband measurements are the only practical EMF exposure assessment approach in Russia. There are no generally accepted frequency-selective and code-selective methodologies considered in current national guidelines [2, 3] in contrast to international standards and practices [6–10]. That is why the alternative to broadband measurements is of significant importance at this stage of new wireless systems deployment. Selective EMF exposure measurements are promising for objective exposure assessment in addition to broadband measurements, in particular for full spectrum of 2-5G telecommunication services.

Conclusion. *A complex exposure assessment based on broadband and selective measurements seems to be the objective and necessary approach for Russian EMF assessment guidelines enhancement in line with existing and emerging mobile systems deployment and operation. The successful implementation of a comprehensive method for cellular communication systems, including 5G, EMF exposure evaluation, will ensure an adequate assessment of their impact on the general public and will help to address future issues of electromagnetic safety.*

REFERENCES

1. Pujol F., Manero C., Carle B., Remis S. 5G *Observatory Quarterly Report 7 Up to March 2020.* Available at: http://5gobservatory.eu/wp-content/uploads/2020/04/90013-5G-Observatory-Quarterly-report-7-updated-16-04-2020.pdf
2. MUK 4.3.1677–03. *Determination of electromagnetic field levels created by the radiating technical means of television, FM broadcasting and land mobile radiocommunications base stations: Methodical instructions.* Moscow: Russian Federation Ministry of Health; 2003 (in Russian).
3. MUK 4.3.1167–02. *Determination of electromagnetic field power flux density at locations of radio systems operating in the 300 MHz-300 GHz band: Methodical instructions.* Moscow: Russian Federation Ministry of Health; 2002 (in Russian).
4. ETSI TS 138 104 V15.5.0. *5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104 version 15.5.0 Release 15, 2019-05).* https://www.etsi.org/deliver/etsi_ts/138100_138199/138104/15.05.00_60/ts_138104v150500p.pdf
5. Barnes F. S., Greenebaum B. eds. Bioengineering and Biophysical Aspects of Electromagnetic Fields. 3th ed. Boca Raton: Taylor & Francis Group, LLC; 2006.
6. IEC 62232-2017. *Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure.* Geneva: International Electrotechnical Commission; 2017.
7. TR 62669-2019. *Case studies supporting IEC 62232 — determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure.* Geneva: International Electrotechnical Commission; 2019.
8. Aerts S. et al. In-Situ Measurement Methodology forthe Assessment of 5G NR Massive MIMO Base Station Exposure at Sub-6 GHz Frequencies. *IEEE Access.* 2019; 7: 184658-167. https://doi.org/10.1109/ACCESS.2019.2961225
9. Keller H. On the Assessment of Human Exposure to Electromagnetic Fields Transmitted by 5G NR Base Stations. *Health Phys.* 2019; 117 (5): 541–5. https://doi.org/10.1097/HP.0000000000001089
10. Electromagnetic Field (EMF) measurements near 5G mobile phone base stations. Technical Report, Ofcom, 2020. https://www.ofcom.org.uk/__data/assets/pdf_file/0015/190005/emf-test-summary.pdf

СПИСОК ЛИТЕРАТУРЫ

1. Pujol F., Manero C., Carle B., Remis S. 5G *Observatory Quarterly Report 7 Up to March 2020.* Available at: http://5gobservatory.eu/wp-content/uploads/2020/04/90013-5G-Observatory-Quarterly-report-7-updated-16-04-2020.pdf
2. МУК 4.3.1677–03. *Определение уровней электромагнитного поля, создаваемого излучающими техническими средствами телевидения, ЧМ радиовещания и базовых станций сухопутной подвижной радиосвязи: Методические указания.* Москва: Минздрав России; 2003.
3. МУК 4.3.1167–02. *Определение плотности потока энергии электромагнитного поля в местах размещения радиосредств, работающих в диапазоне частот 300 МГц-300 ГГц: Методические указания.* Москва: Минздрав России; 2002.
4. ETSI TS 138 104 V15.5.0. *5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104 version 15.5.0 Release 15, 2019–05).* https://www.etsi.org/deliver/etsi_ts/138100_138199/138104/15.05.00_60/ts_138104v150500p.pdf

5. Barnes F. S., Greenebaum B. eds. Bioengineering and Biophysical Aspects of Electromagnetic Fields. 3th ed. Boca Raton: Taylor & Francis Group, LLC. 2006.
6. IEC 62232-2017. *Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure*. Geneva: International Electrotechnical Commission; 2017.
7. TR 62669-2019. *Case studies supporting IEC 62232 — determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure.* Geneva: International Electrotechnical Commission;2019.
8. Aerts S. et al. In-Situ Measurement Methodology forthe Assessment of 5G NR Massive MIMO Base Station Exposure at Sub-6 GHz Frequencies. *IEEE Access.* 2019; 7: 184658-167. https://doi.org/10.1109/ACCESS.2019.2961225
9. Keller H. On the Assessment of Human Exposure to Electromagnetic Fields Transmitted by 5G NR Base Stations. *Health Phys.* 2019; 117 (5): 541-5. https://doi.org/10.1097/HP.0000000000001089
10. Electromagnetic Field (EMF) measurements near 5G mobile phone base stations. Technical Report, Ofcom, 2020. https://www.ofcom.org.uk/__data/assets/pdf_file/0015/190005/emf-test-summary.pdf