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SERIES K: PROTECTION AGAINST INTERFERENCE

ITU-T K.91 – Supplement on radiofrequency exposure evaluation around underground base stations

ITU-T K-series Recommendations – Supplement 20

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Supplement 20 to ITU-T K-series Recommendations

ITU-T K.91 – Supplement on radiofrequency exposure evaluation around underground base stations

Summary

Measurement and computation methods of human exposure to electromagnetic fields (EMFs) from fixed radio sources like mobile base stations have been standardized and published as ITU-T K-series Recommendations and IEC 62232. These also include methods prescribed in Japanese regulation and have been basically assumed to be applied to radio sources installed above the ground.

Underground base stations for use in small cells of fourth generation (4G) mobile networks are installed underground to construct service areas above the ground.

Supplement 20 to ITU-T K-series Recommendations contains the measurement results of radio frequency exposure from underground base stations, to evaluate the exposure from these base stations.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K Suppl. 20	2020-05-20	5	11.1002/1000/14317

Keywords

RF exposure evaluation, underground base station.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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Supplement 20 to ITU-T K-series Recommendations

ITU-T K.91 – Supplement on radiofrequency exposure evaluation around underground base stations

1 Scope

This supplement contains the measurement results of radio frequency exposure from underground base stations using the measurement methods introduced in [ITU-T K.91], to evaluate the exposure from these base stations.

2 References

[ITU-T K.52] Recommendation ITU-T K.52 (2018), *Guidance on complying with limits for human exposure to electromagnetic fields*.

[ITU-T K.61] Recommendation ITU-T K.61 (2018), *Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations*.

[ITU-T K.70] Recommendation ITU-T K.70 (2018), *Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations*.

[ITU-T K.83] Recommendation ITU-T K.83 (2020), *Monitoring of electromagnetic field levels*.

[ITU-T K.91] Recommendation ITU-T K.91 (2020), *Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields*.

[ITU-T K.100] Recommendation ITU-T K.100 (2019), *Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service*.

[IEC 62232] 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*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 antenna [ITU-T K.70].

3.1.2 base station [ITU-T K.100].

3.1.3 electric field strength (E) [ITU-T K.83].

3.1.4 electromagnetic field (EMF) [ITU-T K.91].

3.1.5 equivalent isotropically radiated power (EIRP) [ITU-T K.52].

3.1.6 exposure [ITU-T K.52].

3.1.7 exposure level [ITU-T K.52].

3.1.8 power density (S) [ITU-T K.52].

3.1.9 radio frequency (RF) [ITU-T K.70].

3.1.10 reference levels [ITU-T K.70].

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

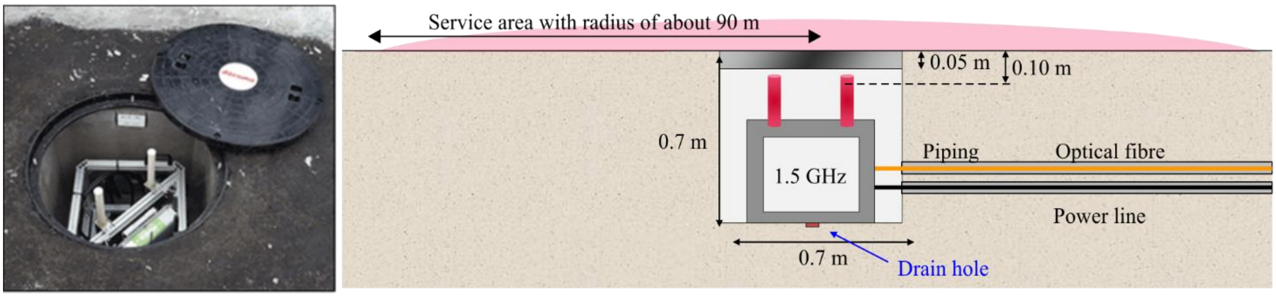
4G	Fourth Generation
EIRP	Equivalent Isotropically Radiated Power
EMF	Electromagnetic Field
FDD	Frequency Division Duplex
ICNIRP	International Commission on Non-Ionizing Radiation Protection
LTE	Long-Term Evolution
MIMO	Multiple Input Multiple Output
RF	Radio Frequency

5 Conventions

None.

6 Overview of underground base station

Underground base stations are for use in small cells of 4G mobile networks. They have been developed to secure communication areas mainly in locations where there are no suitable places for installation of antennas such as tourist spots and scenic spots. An overview of their structure and service area is shown in Figure 1. The main specifications are given in Table 1.



a) Photo

b) Structure and service area

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Figure 1 – Overview of structure and service area of underground base stations

Table 1 – Main specifications of underground base stations

Item	Value
Wireless access system	FDD-LTE
Frequency	1.5 GHz band (BAND 21)
Frequency bandwidth	15 MHz
MIMO	2×2

7 Measurement points and spatial averaging

The spatial averaging methods defined in [IEC 62232] and [ITU-T K.61] introduced in [ITU-T K.91] were used for the whole-body human exposure evaluation because the underground base station forms non-uniform field distributions. The 20-point method was used among several spatial averaging methods because the same spatial averaging method is stipulated by national regulations in Japan for the compliance assessment of EMF human exposure to mobile base stations [b-MIC].

All the points to be evaluated are shown in Figure 2. The evaluation points in the horizontal direction are defined by [b-MIC], and the points in the vertical direction for spatial averaging are defined by [IEC 62232], [ITU-T K.61] and [b-MIC].

The evaluation points in the horizontal direction are defined radially at less than wavelength/10 (approximately 20 mm at 1.5 GHz) steps around the wave source as shown in Figure 2(b). The evaluation points in the vertical direction at a certain horizontal evaluation point are defined from height 0.1 m to 2.0 m at intervals of 0.1 m or less (when the frequency is 300 MHz or higher) assuming the space occupied by a human body as shown in Figure 2(c).

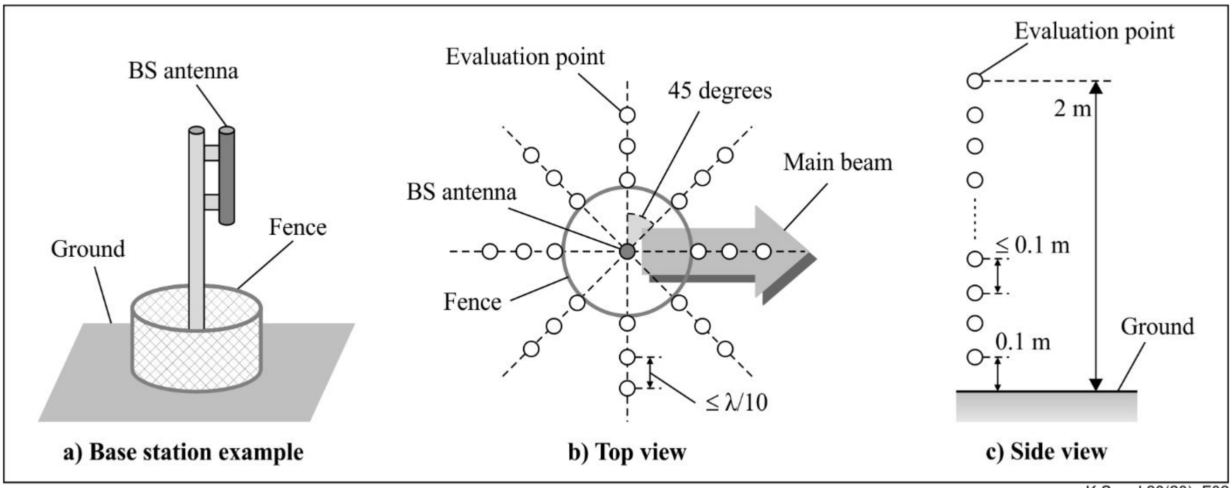

Figure 2– All measurement points for spatial averaging

8 Reference levels

Reference levels for compliance assessment defined in [b-MIC] were used because these levels are almost the same as those given in [b-ICNIRP] introduced in [ITU-T K.91]. The reference levels are regulated by a 6-minute averaged value of the electric field strength, the magnetic field strength and power density (when the frequency is 300 MHz or higher). The reference levels in the 1.5-GHz band in [b-MIC] are 10 W/m^2 for spatial averaging and 20 W/m^2 for the spatial maximum.

9 Frequency selective measurement

Frequency selective measurement methods defined in [IEC 62232] introduced in [ITU-T K.91] were used for more accurate exposure evaluation. In this case, since there were no other base stations in the vicinity using the same frequency, it was possible to obtain the power densities of only the underground base station.

Furthermore, the measurement method for the FDD-LTE base station using a spectrum analyzer given in [IEC 62232] was applied to obtain the power densities equivalent to the maximum traffic. In the method, the power densities of the resource blocks that regularly become the peak power are measured with zero span frequency under the condition that the resolution bandwidth is 1 MHz and the time resolution coincides with 1 symbol (about 71 μs) of the FDD-LTE signal. The obtained measurement value is extrapolated by the ratio of the number of resource blocks corresponding to the employed bandwidth to the number of measured resource blocks.

The SRM-3006 (Narda) analyser was used as measuring equipment. It has isotropic sensitivity and frequency selectivity. However, the minimum time resolution that can be set in the isotropic axis mode of this equipment is greater than 1 symbol. Therefore, the detector and the trace were set to maximum so that they are not underestimated. The set parameters of the measuring equipment for this evaluation are given in Table 2.

Table 2 – Set parameters of SRM-3006 for this evaluation

Item	Value
Axis	Isotropic
Resolution bandwidth	1 MHz
Video bandwidth	100 kHz
Result (Detector)	Max
Trace	Max

Since there is an excessive number of evaluation points in the horizontal direction for measurements, in order to reduce the measurement time and obtain conservative evaluation results, the sensor scanned slowly in the horizontal direction in the range of 3 m around the base station, maintaining a constant height while repeatedly sweeping with the maximum trace, as shown in Figure 3. The maximum value in the horizontal direction was measured at each evaluation point in the vertical direction. Furthermore, the maximum value was obtained in all horizontal directions at each height, and the maximum and the averaged value of those in the vertical direction were calculated.

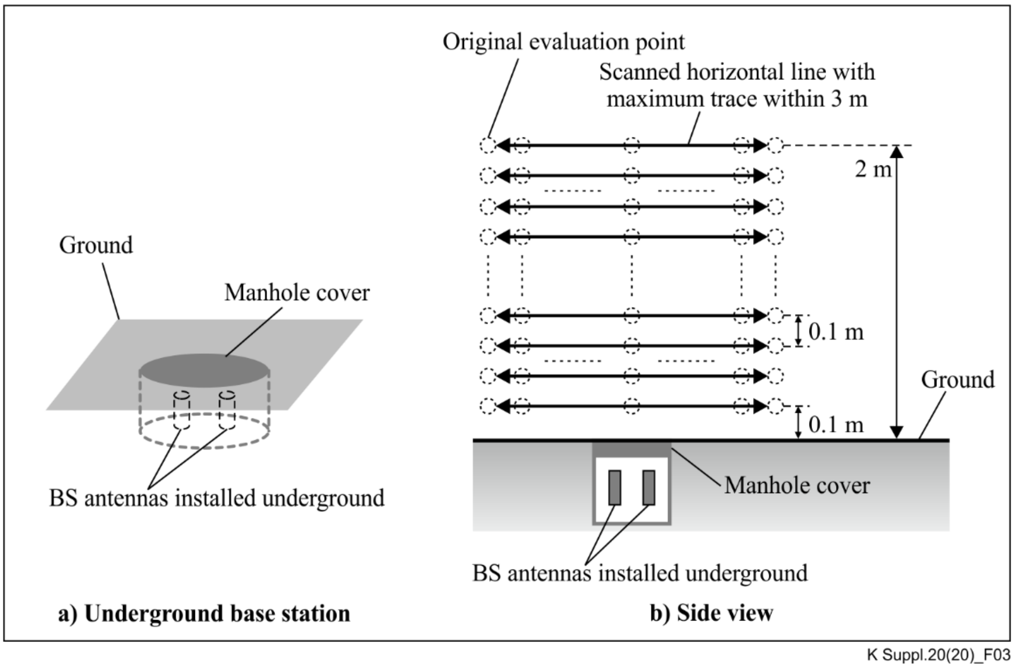

Figure 3 – Scanned horizontal lines with maximum trace to reduce measurement time and obtain conservative evaluation results

10 Results

The vertical direction dependence of the maximum power density in all horizontal directions at each height normalized by the EIRP of 1 W per MIMO branch is shown in Figure 4. The maximum value and the averaged value of those in the vertical direction are 1.9 W/m^2 and 0.27 W/m^2, respectively. These values are lower than both the spatial maximum reference level, and the spatial average reference level regulated by [b-MIC].

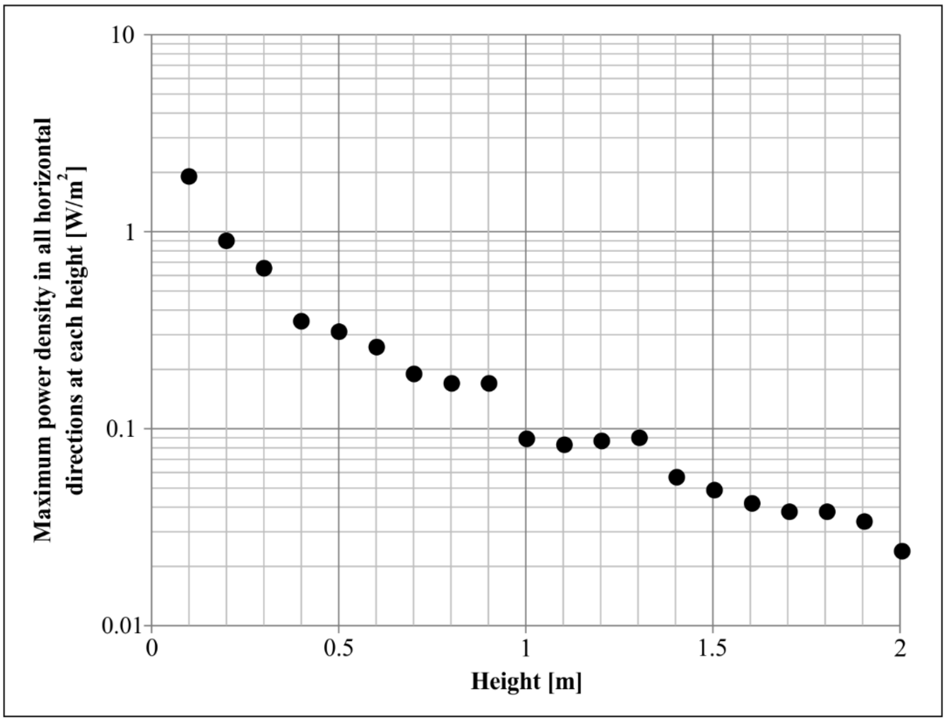

Figure 4 – Vertical direction dependence of the maximum power density in all horizontal directions at each height normalized with EIRP 1 W per MIMO branch

11 Conclusion

Exposure evaluation based on the measurements of power densities for the underground base station was carried out using the measurement method defined in [IEC 62232], [ITU-T K.61] and [b-MIC] introduced in [ITU-T K.91]. The maximum power density normalized by EIRP 1 W per MIMO branch was lower than the reference levels for spatial averaging defined in [b-MIC], which are almost the same as those given in [b-ICNIRP].

Bibliography

[b-ICNIRP] ICNIRP (1998), *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*, Health Physics, vol. 74, pp. 494-522.

[b-MIC] The Ministry of Internal Affairs and Communications, *Possible Health Effects on the Human Body from Radio Wave Exposure*, https://www.tele.soumu.go.jp/e/sys/ele/body/index.htm

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