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EMF Exposure Evaluation for Manhole Type Base Stations

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Abstract

This paper presents the results of exposure evaluation for manhole-type small-cell base stations installed underground using a regulated measurement method basically applied to fixed radio sources installed above ground. The power densities from the manhole-type base stations with the transmission power normalized by the equivalent isotropically radiated power of 1 W per multiple-input multiple-output branch were measured.

1. Introduction

In tourist and scenic spots, there are cases where it is difficult to install even small-cell base stations because suitable installation locations for base stations are limited or there are local regulations making installation difficult. In such locations, a manhole-type base station where the antennas and transmitters are installed underground to create a terrestrial small cell is an effective solution. NTT DOCOMO developed manhole-type base station prototypes for 4G mobile communication networks and will consider applying the results of technical verification to 5G mobile communication networks [1].
In Japan, compliance assessment methods including the reference levels and evaluation methods for human exposure to electromagnetic fields (EMFs) from fixed radio sources are regulated by radio laws, and these laws are basically assumed to be applied to radio sources installed above ground [2]. This paper shows the results of exposure evaluation of manhole- type small-cell base stations installed underground using these evaluation methods.

2. Method

An overview of the structure and service area of the manhole-type base station in [1] is shown in Fig. 1, and the main specifications are given in Table 1. In this evaluation, the manhole-type base station was installed in an environment where occupational exposure conditions were applied.
Under radio law in Japan, the reference levels regarding human exposure to EMFs from mobile base stations are defined by the 6-minute average value of the electric field strength, the magnetic field strength, and power density [2].

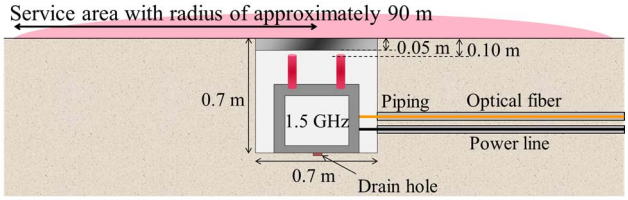


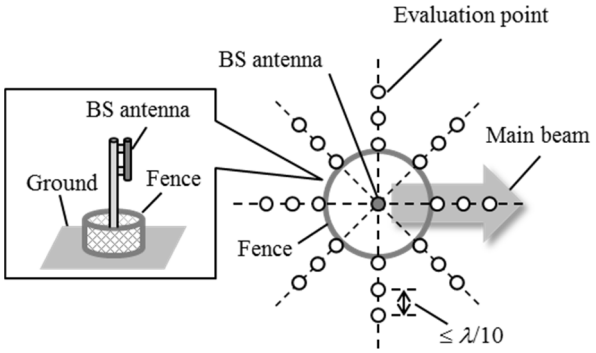
Figure 1. Overview of structure and service area for manhole-type base stations.

Table 1. Main specifications for manhole-type base stations.

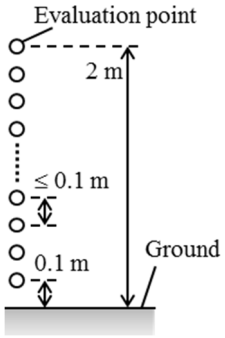
Items	Values
Wireless access system	FDD-LTE
Frequency	1.5-GHz band (Band 21)
Number of resource blocks	75 (15-MHz bandwidth)
Multiple-input multiple-output	2×2

These EMF strengths from the base station must be evaluated using a regulated calculation or measurement method, and comply with the reference level.
All the points to be evaluated are shown in Fig. 2. The evaluation points in the horizontal direction are defined radially at less than one wavelength/10 steps (approximately 20 mm at 1.5 GHz) around the wave source. The evaluation points in the vertical direction at a certain horizontal evaluation point are defined from 0.1 m to 2.0 m in height at intervals of 0.1 m or less (when the frequency is 300 MHz or higher) assuming the space occupied by a human body.
In the first step of the compliance assessment, it must be confirmed whether the maximum value of the EMF strength in the vertical direction is equal to or less than the normal reference level (10 W/m^2 at 1.5 GHz) at each evaluation point in the horizontal direction. If it exceeds the reference level and the human body is not uniformly exposed to a radio wave, it is needed to confirm whether the maximum value and the average value of the EMF strength in the vertical direction is equal to or less than the spatial maximum reference level (20 W/m^2 at 1.5 GHz) and the spatial average reference level (10 W/m^2 at 1.5 GHz), respectively.
The exposure evaluation of the manhole-type base station was carried out based on power density measurements. The measurement equipment, SRM-3006 (Narda-STS,

Germany), used in the evaluation incorporates isotropic sensitivity and frequency selectivity, which are required characteristics in the regulated measurement method.



(a) Top view of evaluation points in horizontal direction.



(b) Side view of evaluation points in vertical direction at certain evaluation point in horizontal direction.

Figure 2. All points to be evaluated for compliance assessment of human exposure to EMFs from base stations regulated in Japan.

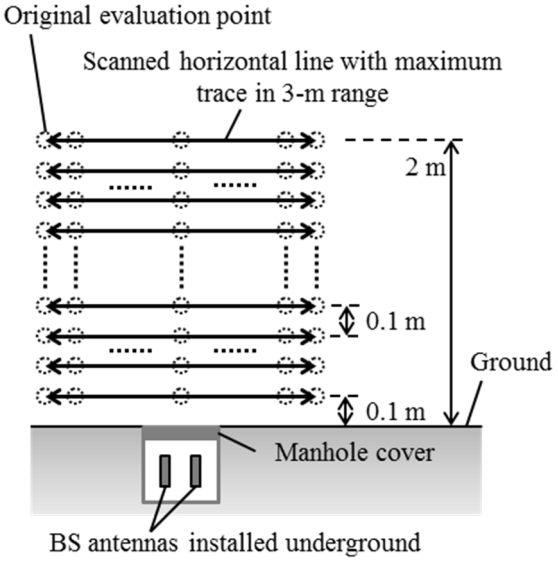


Figure 3. Scanned horizontal lines with maximum trace to reduce measurement time and obtain conservative evaluation results.

Although the reference levels are specified by the 6-minute average value as mentioned above, the power density assuming the maximum traffic was measured for conservative evaluation. Annex F.7 in IEC 62232: 2017 provides two types of measurement methods for the EMF strength assuming the maximum traffic for a frequency division duplex-long term evolution (FDD-LTE) base station under normal traffic conditions [3]. In the method using spectrum analyzers, the power density of the specified channels that regularly become the peak power for each resource element is measured using a zero span frequency under the condition that the resolution bandwidth is 1 MHz and the time resolution coincides with 1 symbol (approximately 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.

Since there are too many evaluation points in the horizontal direction for measurements, in order to reduce the measurement time and obtain a conservative evaluation result, 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 Fig. 3. The maximum value in the horizontal direction was measured at each evaluation point in the vertical direction. Furthermore, the maximum value in all horizontal directions at each height was obtained, and the maximum and the average values of those in the vertical direction were calculated.

3. Results

The vertical direction dependence of the maximum power density in all horizontal directions at each height normalized by the equivalent isotropically radiated power (EIRP) of 1 W per multiple-input multiple-output (MIMO) branch is shown in Fig. 4.

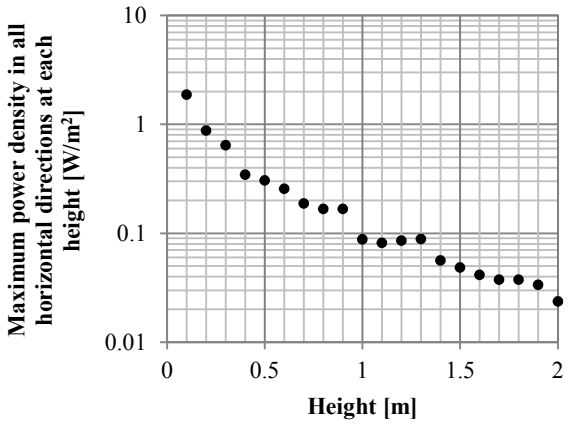


Figure 4. Vertical direction dependence of the maximum power density in all horizontal directions at each height normalized by the EIRP of 1 W per MIMO branch.

The maximum and average values of the points in the vertical direction are 1.9 W/m^2 and 0.27 W/m^2, respectively. These values are lower than both the normal reference levels, the spatial maximum reference level, and the spatial average reference level, respectively, regulated by the laws in Japan. Therefore, it was confirmed that the manhole-type base station complies with the regulations.

4. Conclusion

Exposure evaluation based on measurements of power densities for the manhole-type base station was carried out using regulated methods applied to radio sources installed above ground.
In the future, the validity of this evaluation will be confirmed based on EMF simulations and further measurements.

5. References

1. https://www.nttdocomo.co.jp/info/news_release/2018/04/11_00.html (in Japanese only).

2. http://www.tele.soumu.go.jp/e/sys/ele/body/index.htm.

3. 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,” Aug. 2017.