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Environmental impact of electromagnetic radiation from the 10 kW medium wave transmitter of Weihai Broadcasting Station

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Abstract—The attenuation of electrical field intensity, E, from an electromagnetic source, with the reciprocal of distance, $1/r$, was studied using a theoretical calculation method and field simulation measurements. For a 10 kW medium wave length transmitter, the electrical field E near the ground (2m above the ground) is less than 25 V/m for $r>75$m from the transmitter, which is lower than the "Second Class Standard" of the State Standard, GB 9175-88. For $r>150$m, the electrical field E near the ground is less than 10 V/m, which is lower than the "First Class Standard". However, at places such as the platform on top of the buildings within 200m from the transmitter, the field intensity is so strong that it exceeds the state standard value and that injures to human bodies can be caused by metal structures poorly earthed due to induced charge and secondary radiation.

Keywords: environmental impact assessment; electromagnetic radiation; broadcasting station; electromagnetic pollution.

1 Introduction

According to the developing program of Weihai City, the transmitter antenna of Weihai Boradcasting Station (WBS) will be moved from Donglaotai to a new site in Huaiyun Village, since this potential moving should be in accordance with the Hygienic Standard of Environmental Electromagnetic Wave (GB 9175-88) issued by the Ministry of State Public Health in 1987, the authority of Weihai Environmental Protection Agency demanded an assessment on the environmental impact which may result from the electromagnetic radiation from the broadcasting station in new site. By desire, we have measured environmental electromagnetic radiation levels around both the present operating site and the projected site of the WBS and have worked out an assessment.

2 Measurement method of the field intensity of the environmental electromagnetic pollution

First of all, we examined the natural and social environment around the areas of the present operating site and the projected site of WBS (referred to as the operating site and new site respectively, hereafter) and collected public opinions and the data of the transmitter station, then specific methods for measuring the electromagnetic radiation level of the operating site and the background of electromagnetic radiation in the new site were chosen. Finally, simulated measurements and theoretical calculation were carried out to predict the environmental impact, which would happen if the transmitter was moved to the new site.

2.1 Allocation of the measurement locations

The operating site of WBS is in an open area that is topographically flat. There are three tower transmitter antennae (one with the power level of 10 kW and the other two 1 kW) with the same height of 87m, which are distributed apart nearly in a shape of an isosceles-triangle, as shown in Fig. 1. The antennae transmit electromagnetic wave in all directions. A counter-poise system was built in a depth about 0.5m under the ground (in a radial shape, with 60-80m copper wires arranged at an angle interval of 1.5°) to reduce current loss in earth, so the measurement locations were selected in a quincuncial way. The 10 kW-transmitter tower was taken as the center and the measurement points were located along eight directions with an angle separation of 45°. Along each direction, measurement points were set at 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 150, 180, 200, 250 and 300m from the center respectively. Therefore there were 144 measurement points at which 4320 data were obtained.

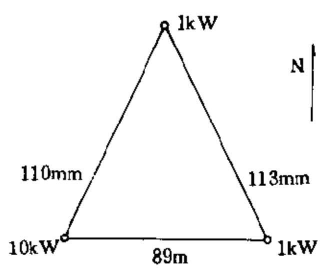

Fig. 1 Plain view schematic of the distribution of the three transmitter towers

As to the new site, the measurement points were selected emphatically in the radiosensitive areas. For instance, on the campus of Shandong University at Weihai (SUW), near the backyard wall of the dormitory of SUW, around the dormitory of the Construction Engineering Company of Weihai (CECW) and the area projected to build a middle school and a parking lot. In the above areas, 21 measurement points were selected and totally 420 measured data were obtained.

2.2 Measurement schedule

The measurements were carried out according to the schedule given as follows: 8:00-9:00am, 17:00-18:00pm , and 20:00-22:00 pm.

2.3 The instruments for the measurements and the time interval for observing and recording

A 701 3-axial field-intensity meter (produced by Wuhan 701 institute, ±1 db, calibrated by the institute before using) was settled approximately 2m above the ground. The time interval of observing and recording was taken as 15s. In each measurement routine, it was done once in the every 15s, so 10 measured data were taken from each measurement point. The average values obtained are tabulated in Table 1.

2.4 Theoretical calculation and simulated measurement

To estimate the environmental electromagnetic radiation level in the new site when transmitter antenna would be operating there, theoretical calculation and field simulated measurements

Table 1 Measured values of the electric field intensity in the operating site

Unit: V/m

r, m	5	10	15	20	30	40	50	60	70	80	90	100	120	150	180	190	200	250	300
NE	40.2	41.2	42.0	38.2	32.4	30.0	26.3	22.1	26.1	17.4	15.7	14.5							
N	71.4	51.4	42.0	38.4	31.8	26.6	22.2	18.3	17.4	15.8	13.7	13.0	10.9	9.8			10.2	9.0	5.0
NW	99.3	63.6	48.0	28.7	22.0	19.2	17.8	15.7	12.7	11.4	10.0								
W	116.4	64.2	46.8	37.6	26.5	20.9	19.8	17.6	16.0	14.5	13.3	12.6							
SW	135.6	62.8	50.0	37.7	29.1	25.2	22.3	20.2	18.2	16.1	14.8	13.5							
S	131.1	62.8	50.6	45.2	35.9	32.1	30.5	29.4	27.4	21.2	19.2	17.3	15.5	8.6	3.5	2.0			
SE	104.8	43.2	40.5	40.0	30.2	25.8	27.5	26.0	25.4	24.8	24.2	19.9	15.0	11.6				6.0	1.8

Note: r is the horizontal distance from the 10 kW transmi tter antenna. The receiving antenna of the electric field intensity meter is 2m above the ground. Absence of the data row for eastern direction and absence of the numerical in some columns of Table 1, are due to the obstacles which made the measurements at those points impossible.

were carried out. For a medium wave with wave length in the range of 200—2000m, the signals received for distance $r<150$ km depend entirely on the ground waves. If the surface of the ground is smooth and the dielectric constant and the conductivity of the ground are homogeneous, the electric field intensity can be given (Xie, 1962):

$$E = \frac{2.45 \times 10^2}{r} \sqrt{P \cdot D} \cdot W \ , \tag{1}$$

where E is in unit of V/m, P is transmitting power in unit of kW, D is a direction factor, r (in m) is the horizontal distance between the measurement point and the transmitter, and W is the attenuation factor, which depends on the electricity parameters of the ground, the wave length of the electromagnetic wave and the distance r. W can be written as:

$$W = \frac{2 + 0.3x}{2 + x + 0.6x^2}, \tag{2}$$

where x is an additional parameter called distance number, and it is given by

$$x = \frac{\pi r}{\lambda} \cdot \frac{\sqrt{(\varepsilon - 1)^2 + (60\lambda\sigma)^2}}{\varepsilon^2 + (60\lambda\sigma)^2}, \tag{3}$$

where λ is the wave length (m), ε(F/m) the dielectric constant and σ ($\Omega^{-1}m^{-1}$) is the conductivity. If $\varepsilon >> 1$ and $60\lambda\sigma >> \varepsilon$, x can be approximately given by

$$x = \frac{\pi r}{60\lambda^2\sigma}. \tag{4}$$

According to the realistic values of the parameters we used $\varepsilon = 10$ F. m^{-1}, $\sigma = 10^{-3}\Omega^{-1}$ m^{-1}, $D=1.5$ and $\lambda = 248$m, and for simplicity we just used $P=10$ kW in our calculation. The calculated results are given in Table 2, and the E versus r curve are shown in Fig. 2.

Table 2 The theoretical values of electrical field intensity

Unit: V/m

r, m	5	10	15	20	30	40	50	60	70	80	90	100	120	150	180	200	250	300	1000
E, V/m	189	94.6	63.0	47.2	31.3	23.4	18.7	15.5	13.3	11.6	10.2	9.2	7.6	6.0	5.0	4.4	3.5	2.9	0.7

Note: r is the horizontal distance from the 10 kW transmitter

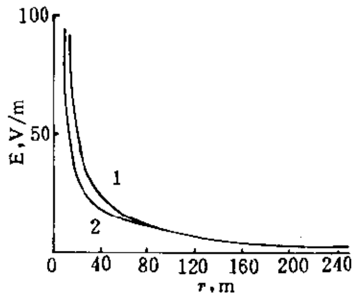

Fig. 2 Electrical field intensity as a function of distance Curve 1: theoretical result, Curve 2: measured result in the direction of northwest

For a specific area, it is found empirically that the theoretical results may differ from those of the experimental measurements since there are many factors, such as the electrical parameters of the soil, the topographic condition, the vegetation coverage and the buildings, etc. in the area which may affect the accuracy of the calculations (This agrees with the report given by a group in Beijing*). Therefore we have emphasized the measurements rather than the calculations.

The relative positions among the transmitter antenna and the surrounding buildings in the operating site and the new site are shown in Fig. 3 and Fig. 4, respectively.

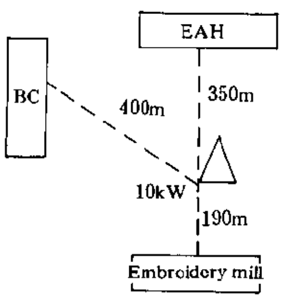

Fig. 3 The schematic of the relative position of the buildings around the operating site

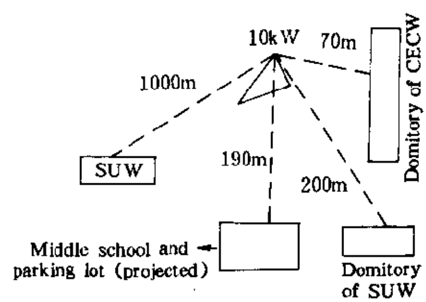

Fig. 4 The schematic of the relative position of the major-buildings around the new site

The two sites both locate on open plain and share considerably similar topographic features and land form. For this sake, it is reasonable to use the electromagnetic radiation data measured around the operating site to simulate the electromagnetic radiation level in the new site. Around the operating site the following points were selected: the building of an embroidery mill, the construction fields for a main building of the Bank of Communications (BC) and the Experts' Apartment House (EAH). In these buildings totally 40 measurement points were selected, from which 780 data were collected. The average values of the measurement results are given in Table 3 and Table 4.

* Studies of the electromagnetic radiation pollution in Beijing area, the electromagnetic pollution distribution and strategy for controlling the pollution, reported by the Electromagnetic Research Laboratory, Institute of Labor Protection, Beijing, and The Electromagnetic Research Laboratory, Research Center of Controls for Environmental Physics Pollutions, Beijing, February 1988.

Table 3 Measured values of the electric intensity, data obtained from the main building of the embroidery mill

Unit: V/m

Floor	Time	Measurement points					
		A		B		C	
		In	Out	In	Out	In	Out
1	Day	0.85	0.82	0.87	0.84	0.57	0.68
	Night	0.31	0.32	0.31	0.33	0.31	0.31
2	Day	0.41	1.1	0.39	0.89	0.38	0.86
	Night	0.76	2.6	0.70	2.5	0.78	2.6
3	Day	0.91	4.7	1.2	4.8	1.3	4.0
	Night	0.87	4.6	1.2	4.6	0.96	4.5
4	Day	0.36	3.4	0.36	3.7	0.19	3.7
	Night	0.33	3.5	0.32	3.6	0.18	3.6
Top	Day	8.8	22.6	9.6	23.4	9.3	23.1
Floor	Night		23.0	10.0	23.2	9.5	23.5
Top	Day		43.4				
Platform	Night		44.2				

Table 4 Measured values of the field intensity, data obtained from the buildings under construction for the Bank of Communications and for Experts' Apartment House

Unit: V/m

Floor	BC		EAH	
	am.	pm.	am.	pm.
1	0.19	0.39	0.61	1.27
2	1.04	1.23	0.43	0.82
3	1.30	2.04	0.19	0.97
4	0.99	3.47	0.18	0.99
5	0.78	6.50	0.28	1.60
6			0.34	7.60[a]

a: The top of the building is unfinished.

2.5 Special measurements for some high field-strength points

The workers who worked in the construction field near the transmitter told that they often got shocked and scalded as touching the hooks of the column cranes. Therefore, special measurements were done to obtain the field intensities near the surfaces of the hooks. The results are given in Table 5.

Table 5 Measured values of the electric field intensities near the hooks of the column cranes

Unit: V/m

No.	1			2			3	
Horizonal distance, m	0.7	1.0	1.7	0.7	1.0	1.7	0.05	0.2
Field intensity, V/m	>275	145	72.3	>275	103	43.6	2.35	0.19
Time of measurement	17:00			17:00			9:30	
Working status of the transmitter	on			on			off	

Note: Hook 1# was located 200m to the northwest of the transmitter in the construction field for the Bank of Communications. It was set 1.2m above the ground. Hook 2# was located 300m to the north of the transmitter in the construction field for the Experts' Apartments House, and was set 1.1m above the ground.

3 Data treatment

Through the field measurements, 5530 raw data were obtained. Those data were then statistically treated by computer and the final results are tabulated in Table 1, Table 3 and Table 4, respectively, which are drawn by using the data presented in Table 1. For comparison , the E vs. r curve obtained by the theoretical calculation is also shown in Fig. 2. For the high electric field points near the hooks of the column cranes, the electric field curves were drawn using the measured values of the electric field intensities, from which the extrapolated values of the electric field were obtained.

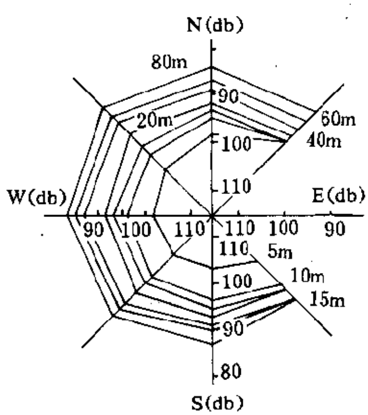

Fig. 5 The equidistance electric field intensity

4 Result analysis and assessment

(1) If we draw the E vs. r curves using the measured field intensity data in all the directions under study (Fig. 2 is only depicted as an example to show the E vs. r along the northwest direction) it can be found that the electric field intensity, E, decreases with the increase of distance r. The attenuation law of $E \propto 1/r$, especially for $r > 50$m, where the theoretical curve agrees with the measured one very well. However, because of the effects stemmed from the topographic features and the buildings, etc. , the equidistance field intensity appears not symmetric in different directions (Fig. 5). Nevertheless, the general attenuation law always holds true. It turns out to be a general feature that the electromagnetic pollution varies with distance: the nearer the heavier and the further the lighter.

According to the analysis given above and the data from the simulated measurements, we predict that when the transmitter antenna is moved into the new site, the electric field intensity near the ground (2m above the ground) will be higher than 25 V/m for distances $r < 75$m, which exceeds the stipulated value in the "Second Class (Grade) Standard" of hygiene, i. e. "State Standard GB 9175-88", and therefore it will be harmful to human health. For $r > 75$m, however, the value of the electric field intensity will be lower than the value claimed in the GB 9175-88. For distance $r > 150$m, the electric field E is lower than 10 V/m, which satisfies the requirement of the "First Class Standard". For example, on the campus of SUW ($r = 1000$) the electric field intensity given by the simulated measurements is less than 2 V/m. The theoretical calculation gives a value $E < 1$ V/m. Outside the backyard wall of the dormitory of SUW ($r = 200$m), the measured value of the electric field is $E = 0.3$-5 V/m, and the calculation predict an electric field $E = 4.5$ V/m. Furthermore, due to the shield of the walls of the buildings the field intensities inside the rooms of the buildings are even lower accordingly. Based on the measurement results reported above, it is clear that the protection radius of the transmitter antenna in the new site should properly set a value of $r = 150$m, and no less than 100m in any case.

(2) Outside the high buildings located with distances $r<200$m from the transmitter, for example, on platforms on top of the high buildings, the electric field can exceed the "Second Class Standard" (Table 3). Therefore severe electromagnetic pollution may exist on high floors of those buildings (e. g. up floor 5).

(3) The electromagnetic field intensity near the hooks of the column cranes in the construction fields (for the Bank of Communications and Experts' Apartment House) is so high that they enormously exceed the state standard. In fact the extrapolated value of the field intensity is 1000 V/m, which is much higher than the maximum reading range 275 V/m, of the field intensity meter used in the measurements. The strong field certainly has harmful effects on the health of the workers working nearby for long. The special high electromagnetic radiation is found to happen synchronically with the on-air time of the WBS, as indicated by the data in Table 5. This special high field caused by the secondary radiation from the metal hooks since the column cranes and their connected parts are found being poorly earthened. The high-frequency eddy induced in metal has electrical and thermal hazards to human health.

5 Conclusion remarks

In assessing the environmental effect associated with the moving project of the transmitter antenna of WBS, we have carried out field investigation, simulated measurements and theoretical calculations on the environmental impact of the electromagnetic radiation and the study of the attenuation law of the electric field intensity E, with the increase of the distance from the transmitter. The attenuation law predicted by the theoretical calculation agrees reasonably with that obtained by the field simulated measurements.

According to the requirements of the "State Standard GB 9175-88", which says: "The transmitters of the newly constructed, reconstructed or extended broadcasting stations, television stations and radar stations should meet the 'First Class Standards' their covering residential areas" ($E<10$ V/m for long, medium and short waves). We have worked out a protection radius based on our measurements. For a 10 kW medium wave transmitter, the protection radius for the local residents should be equal to 150m. In any case it should not be less than 100m.

Reference

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