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长波远程导航台电磁辐射环境影响研究

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摘要 对我国首座长波远程导航台的脉冲长波天线周围电场强度进行测试和有关理论计算。结果表明。发射机房内一般电场强度在 $0.5-3.6~\mathrm{V/m}$,其相应脉冲峰值为 $38.5-276.9~\mathrm{V/m}$,距离发射天线 $850-1100~\mathrm{m}$ 的居住区内,场强为 $0.7-3.9~\mathrm{V/m}$,峰值为 $53.9-300.3~\mathrm{V/m}$;环境场强随与天线的距离增大而迅速衰减。在离天线 $1200~\mathrm{m}$ 以外,场强衰减到极小值。

关键调 电磁辐射,脉冲,长波,环境,电场强度。

我国 80 年代中期开始将长波远程导航技术应用于航海导航,为了解长波远程导航台环境电磁场分布规律和设置卫生防护带,笔者对国内首座脉冲-相位长波无线电导航(Loran-C, Long range navigation-C)系统进行了环境电场强度测定和分析。

1 方法

1.1 脉冲长波辐射源参数

Loran-C 系统的工作原理是基于测量主、副台脉冲到达时差和测量主、副台载频的相差,起到导航作用[1]。其发射天线为伞状无方向性脉冲组型,高度 247 m,发射频率 100 ± 10 kHz,组脉冲宽度 900 μ s,组重复周期 6.93 ms,占空比为 1.3×10^{-2} ,发射脉冲功率 2.2 MW,有效功率 1.6 MW。

1.2 测试仪器

美制 HI-3601 型射频测定仪,用以精确测量非正弦波形的均方根值(RMS),响应频率 2 -300 kHz,在 10-100 kHz 频段中,电场测量精度为±0.5 dB,在 2-10 kHz 和 100-300 kHz 范围内,测定精度为±2 dB。

1.3 测试及计算方法

分 3 个区域进行电场强度 RMS 测定。工作 区,在离发射天线 20 m 远的发射机房内各主要 工作位点取样。天线周边区,因 Loran-C 系统为

无方向性型辐射源,遂以发射天线为圆心,沿 850 m 外有人群居住的一侧。分别在半径为 100、150、200、300、400、500、750 和 850 m 的 地点测试。居住区,在离天线 850—1150 m 范围内的居室内外测试。

测试时,射频测定仪离开测试人 1 m,离地高度 1.7 m。

按下列公式[2]计算脉冲峰值场强:

$$P_{p} = P_{a} \cdot \frac{T_{g}}{\tau_{g}} \tag{1}$$

式中 P_p 为脉冲峰值场强(V/m); P_a 为 RMS 场强(V/m); T_g 为组重复周期(μs); τ_g 为组脉冲宽度(μs)。

2 结果

2.1 工作区电场强度分布

发射机房内一般场强在 0.5-3.6 V/m (RMS),其相应脉冲峰值为 38.5-276.9 V/m (见表 1)。但在电源前后,场强可达 12.0 V/m,峰值为 923.1 V/m。

2.2 天线周边区电场强度分布

如图 1 所示,在离发射天线 100 m 以外,场强随距离增大呈现线性衰减。

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表 1 长波脉冲导航台发射机房电场强度(V/m)

測定点	电场强度 (RMS)	脉冲峰值场强 (计算值)
空调机室门口	2. 4	184. 8
空调机室室内	0.5-0.8	38.5-61.6
控制室工作位	1.0	77. 0
时频基准机柜前	1.0-2.5	77.0-192.5
时频基准机柜后	0.8-0.9	61.6-69.3
时频基准机柜后泄漏处	1. 3	100.1
发射室	0.8 - 3.6	61.6 - 277.2
电源前后	12.0	924.0
配电室	0.8-2.2	61.6-169.4

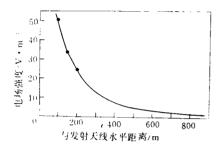


图 1 天线附近电场强度分布

2.3 居住区电场强度分布 结果见表 2。

表 2 长波脉冲导航台附近居住区电场强度(V/m)

测定点	与发射天线 水平距离 (m)	电场强度 (RMS)	脉冲峰值均强 (计算值)
蓝球场中心	850	3. 9	300. 3
1 号住房前	900	0.7	53. 9
1 号住房内		0.4	30.8
2 号住房前	950	0.8	61.6
2 号住房内		0.4	30.8
食堂前	1000	1.6	123. 2
3 号住房前	1100	1.0	77.0
3号住房内		0.3	23. 1
4 号住房内一楼	1150	未测出	
4 号住房内二楼1)		3. 2	246.4
4 号住房内二楼 ²		1.1	84.7

1) 打开朝天线方向钢窗 2) 关闭朝天线方向钢窗

从表 2 可知,居住区电场强度,住宅二楼比一楼高,住房外比住房内高;住宅内打开朝天线方向钢窗时比关闭时高。此外,食堂和 3 号住房与天线的距离虽比 1、2 号住房远,但前两座建筑前的场强却比后两座建筑前高。

3 讨论

由于长波脉冲发射机房内各种仪表、仪器、设备等电气装置较多,因此所测得的场强值实为 2 个以上场强矢量叠加的结果,场强幅值可增大或减小。在发射功率恒定的情况下,它主要取决于设备本身的性能状态。例如,在电源前后,场强高达 12.0 V/m(峰值 924.0 V/m)。此外,设备有无屏蔽措施,也是设备近旁场强高低的重要原因之一。时频基准机柜后泄漏处的场强比无泄漏处明显要高。

Loran-C 系统发射的长波有很好的沿地面表面传播性能。在传播过程中,电磁波不断被地面吸收而迅速衰减。这种衰减与地面的导电系数有关。该导航台附近 1000 m 方圆范围内场地开阔、平坦、种植庄稼,无成片树林、高层建筑和密集的输电线分布,因此呈现出良好的线性衰减。

居住区场强值较为离散,2层楼面比1层地面场强高,与长波的空间波传播形式有关。蓝球场中心测点场强较高。离天线较远的建筑物场强比离天线近的为高及住房内场强较低等现象,均与其周围住房的金属窗架反射有关。

一般认为,目前环境中长波辐射不致于形 成电磁污染, 尤其不会对机体产生明显不良影 响。前苏联的长波职业卫生标准规定的容许值 为 50 V/m, 公众暴露限值为 25 V/m [3]但这些 标准仅对连续波而言,并未考虑到长波脉冲的 作用。Loran-C系统信号由8个脉冲组成脉冲 组, 瞬时峰值场强很高。国内外关于微波辐射 的研究表明,脉冲波比连续波有着更强烈的生 物学效应[4]。为此,我国的微波职业卫生标准规 定,脉冲波和连续波的容许值分别为 25 μW/ cm² 或 50 μW/cm^{2[5]}, 前者的暴露限值比后者严 格 1 倍。微波辐射的这种脉冲-效应应答规律有 可能存在于长波辐射。对长波导航台作业人员 和附近居住区人员的体检发现,这些人员的白 细胞及其吞噬能力比对照组下降[6]。笔者建议 长波导航台在生活住宅和活动场所应采取适当 的屏蔽措施。 (下转第76页)

2.4 植物叶片吸附的铅尘

汽车废气对植物的铅污染,有附在叶面的粉 尘和吸收在叶内的可溶态2种形式。为了明确附

在叶面的粉尘铅含量,测定未经洗涤杨树、蔬菜叶片的铅含量,再减去洗涤后的样品铅含量,其 差值定为植物叶片吸附的铅,结果见表 6。

表 6 不同植物叶片吸附的铅量(干重, m	g/kg)
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植物种类	未洗样品	洗涤样品	叶片吸附铅	吸附百分率(%)
杨树	14. 38	7. 84	6. 54	45.5
芹菜	7.47	4. 68	2. 79	37. 3
包心菜	6.74	3. 77	2. 97	44.1
甘蓝	5. 43	3. 07	2. 36	43. 5
杨树	17.65	9. 14	8. 51	48. 2
	杨树 芹菜 包心菜 甘蓝	杨树 14.38 芹菜 7.47 包心菜 6.74 甘蓝 5.43	杨树 14.38 7.84 芹菜 7.47 4.68 包心菜 6.74 3.77 甘蓝 5.43 3.07	杨树 14.38 7.84 6.54 芹菜 7.47 4.68 2.79 包心菜 6.74 3.77 2.97 甘蓝 5.43 3.07 2.36

杨树叶吸附的铅最高,这是因为杨树枝叶分泌出粘着力较强的粘性物质,铅尘较难飞失和杨树紧靠路边之故。植物含铅量的增加,往往是环境污染所致[1],尽管植物叶片吸附的铅不被植物全部吸收,但从另一个方面说明了汽车废气对环境污染的程度和造成二次污染的可能性,提示植树造林是防治大气铅污染的有效途径。

3 结论

- (1) 西宁郊区公路两侧土壤中的铅比清洁对照区高 2.6-4.1 倍,随着偏离公路距离的增 ,加,铅含量逐渐降低,在 100 m 处趋于当地背景值,污染程度与范围取决于车流量和树木密度。
- (2) 公路边植物铅含量比清洁对照区高出: 杨树 3.0-4.1 倍; 小麦青苗 3.0-3.7 倍, 蔬菜

- 1.5-2.3 倍。农作物和树木在距公路 80 m 左右处,其铅含量通常降至该地区背景水平。
- (3) 用未经水洗样品与经水洗样品铅含量之差作为植物叶片吸附的铅。路边植物叶片吸附的铅。路边植物叶片吸附的铅占未经水洗样品铅含量的 37.3%—48.2%。路边较宽的树木林带,能有效地吸附铅尘和其它有害粉尘。

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根据本调研的结果分析,结合国内外有关电磁辐射生物效应研究报道和环境标准,功率在 1.5-2.0 MW(脉冲功率为 2.0-2.5 MW)或以上的 Loran-C 系统发射天线,宜设置一个500-1000 m 的卫生防护带。在这一区域内不应建造住宅,以免对长期居住和生活在该电磁辐射环境中的人群,包括婴儿、孕妇和老弱病残者带来潜在性不良影响。

由于长波脉冲强大的导航性能对促进航海、 外贸、捕鱼和国防事业的发展起到了重要的作 用,因此最近 5-10 年将在东北和沿海区域建 成多个更大功率的 Loran-C 导航台。这样,接触长波脉冲辐射的作业人员和居民会明显增加。因此,建议深入开展脉冲长波电磁辐射预防性卫生监督和卫生标准研究。

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tration increased; and the toxicity (EC₅₀, 96 h.) of rareearth elements on *Chlorella pyrenoides* was insequence as: Nd>Ce>Pr>La>mixture of them, but little difference

Key words: rare-earth element, *Chlorella pyrenoides*, effect on growth and reproduction.

Study on in-Bed Desulfurization within Fluidized Bed Coal Gasifier. Bu Xuepeng et al. (Beijing Research Institute of Coal Chemistry, Central Coal Mining Research Institute, Beijing 100013); Chin. J. Environ. Sci., 17 (2), 1996, pp. 39-41

The data obtained from the tests indicated that both limestone and dolomite can be used effectively for capturing sulfur during the gasification of high sulfur coals. Desulfurization efficiencies can be improved with increasing the Ca/S molar ratio, the efficiencies were maximum when the ratio was 3, or by increasing total sulfur in raw coals. The effect of operating pressure on desulfurization efficiency is determined by temperature and partial pressure of carbon dioxide. The desulfurization rate was range of 50% -85% under different conditions.

Key words: fluidized bed gasification, in-bed desulfurization, desulfurizaiton sorbent.

Mass Transfer-Reaction Process Mechanism of Wet Flue Gas Desulfurization with Lime. Wu Zhongbiao and Tan Tian'en (Dept. of Chem. Eng., Zhejiang University, Hangzhou 310027); Chin. J. Environ. Sci., 17 (2), 1996, pp. 42-44

By studying experimentally wet flue gas desulfurization with lime as absorbent and rotating-stream-tray scrubber as absorber, the mass transfer and reaction process on Ca(OH)₂ slurry absorbing SO₂ is analyzed. Furthermore, the process mechanism is proposed. According to the mechanism, the total reaction rate is controlled by SO₂ diffusion in gas phase and Ca(OH)₂ dissolution and diffusion in liquid phase. The reaction process can be divided into three stages, the stage controlled by gas phase resistance, by gas phase and liquid phase resistance, and by liquid phase resistance. The process mechanism has been verified by the experiment. These results will help to optimize the design and operation of the industrial installation of wet flue gas desulfurization with lime.

Key words: flue gas desulfurization, mechanism, mass transfer-reaction process, lime, wet.

Effects of Three Sorts of Anaerobic Promoter on Anaerobic Digestion of the Waste Liquor from Ammonium Sulfite Pulping of Straws. Zhang Renquan (Dept. of Resource and Environ. Sci., Hefei Univ. of Technol., Hefei 230009): Chin. J. Environ. Sci., 17(2), 1996, pp. 45-46

The effects of activated carbon, ferrous sulphate and bentonite on anaerobic digestion of the waste liquor from ammonium sulfite pulping of straws have been analysed on the basis of the experimental results of anaerobic batch assays with the waste liquor. The results indicate that, with a dose of 2.5 g/L, each sort of the anaerobic promoter can substantially promote anaerobic digestion of the waste liquor, which can increase 30 day total gas production of the anaerobic system by 16.1%, 13.9% and 26.1% respectively compared with the control. The ac-

tion mechanisms of the three sorts of anaerobic promoter have been discussed preliminarily.

Key words: anaerobic promoter, waste liquor from ammonium sulfite pulping of straws, anaerobic digestion, action mechanisms.

Using Hydra Reaggregations Evaluating the Safety of Two Kinds of Food Additives. Cheng Qinyao et al. (Dept. of Biology, Anhui University, Hefei 230039): Chin. J. Environ. Sci., 17(2), 1996, pp. 47–48 This paper studied the safety of two kinds of food additives using Hydra reaggregations. The results showed that both sodium benzoate and sodium nitrite inhibited the growth of reaggregations. The minimum effective concentrations were 34. 7×10^{-4} mol/L and 2. 9×10^{-3} mol/L respectively. In addition, the negative correlation existed between the depolymerization time of the reaggregations and the concentration of food additives. Therefore, Hydra reaggregations technique will be a rapid screening method for predicting the potential toxicity of food additives.

Key words: *Hydra* reaggregation, food additive, evaluation safety, rapid screening.

A Study on Long-wave Pulsed Electromagnetic Fields Around A Long Range Navigation Station. Yao Gengdong et al. (School of Public Health, Zhejiang Medical University, Hangzhou 310031): Chin. J. Environ. Sci., 17(2), 1996, pp. 49-50

A measurement and a theoretical calculation of long-wave pulsed electromagnetic fields (PEMF) around the antenna of the first long range navigation station in China were conducted. The results showed that the electric field intensities were 0. 5-3. 6 V/m (RMS) corresponding to peak values of 38. 5-276. 9 V/m in the PEMF generating room; in the residential area which is 850-1100 m away from the antenna, the electric fields were 0. 7-3. 9 V/m corresponding to peak values of 53. 9-300. 3 V/m; the PEMF decreased in environment with the distance away from the antenna and when the distance is over 1200 m from it, the fields tended towards minimum.

Key words: pulse, long-wave, environment, electric field intensity.

Determination of Hydraulic Load Cycle in Rapid Infiltration Treatment System of Waste Water. Wu Yongfeng et al. (Dept. of Environ. Sci., China University of Geosciences, Beijing, 100083): Chin. J. Environ. Sci., 17(2), 1996, pp. 51-53

Hydraulic load cycle is the most important operation parameter in rapid infiltration treatment system of waste water. The decrease curve and recovery curve of infiltration rate in flooding and drying periods are obtained from the in situ test with the area of 80 m² and flooded with brewery waste water. The curves can be expressed with exponential and logarithmic equations respectively. A quantitative method is proposed to determine the hydraulic load cycle with maximum hydraulic load. The calculated result is 1.78 days flooding and 2.77 days drying, very similar with the test results.

Key words: rapid infiltration, hydraulic load, hydraulic load cycle, infiltration rate.

A New Way to Accelerate the Start-up of UASB Reac-