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Supporting Capacity-Building Project Characteristics Test of Zhoushan Multi-Terminal HVDC Flexible Demonstration Project

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Abstract: In this paper, a flexible Zhoushan multiterminal HVDC test demonstration projects supporting capacity-building project for the study, the DC cables through the flexible testing ground field measurements of its surrounding environment, the DC cables of a flexible environment affect the characteristics of the test site. The results show: the project on the surrounding environment has little effect of electromagnetic radiation, which affect the field strength generated by the project on the environment is negligible, the project generated frequency electric field, power frequency magnetic fields, DC magnetic field, radio interference strength, noise are smaller than the corresponding standard limits.

Keywords: Flexible DC Transmission, Environmental Impact, Electric Field, Magnetic Filed, Radio Interference, Noise

1. Introduction

The flexible direct current transmission technology is a new generation of DC transmission technology featuring fully controlled power electronics, voltage source converters and new modulation technologies. Compared with traditional DC transmission technologies, it has no need for reactive power compensation and no phase change. Failure problems, simultaneous adjustment of active power and reactive power, and low harmonic levels are suitable for the construction of multi-terminal DC systems and other obvious advantages [1]. They are widely used in grid-connected renewable energy, isolated islands, urban power supply, and wind power generation. Measure the weather and choose sunny weather [2-3].

This article selects Zhoushan multi-port flexible HVDC transmission demonstration project supporting test capacity construction project as the research object, and through the field measurement of the surrounding environment of the flexible DC cable test site, the environmental impact characteristics of the flexible DC cable test site are discussed.

2. Overview of Supporting Experimental Capacity Building Project of Zhoushan Multi-Station Flexible HVDC Transmission Demonstration Project

Zhoushan ±200kV five-terminal flexible DC transmission project is the first five-terminal flexible DC transmission project that has been successfully put into operation in the world. It is also the world's most flexible, direct-current DC project with the highest voltage rating, the largest number of terminals, and the largest single-ended capacity. The research object belongs to Zhoushan ±200kV five-terminal flexible DC transmission engineering technology reserve project. At present, the first DC 200kV flexible DC cable pre-assessment test has been carried out in the flexible DC test site of the Zhoushan multi-terminal flexible DC transmission demonstration project. The test aims to strengthen the islands under the jurisdiction of electrical contacts, enhance the structure of the grid, improve the reliability of power supply, solve the flexible access of new energy such as offshore wind power, cable charging power and impact stability and power quality problems.

The main equipment in the test field of flexible DC cables is one set of 1200kV/50mA DC high voltage test equipment. It is mainly used for power cable type test, pre-qualification test, polarity reversal test and DC superimposed impulse voltage test, which can be 500kV and below. DC power transmission equipment withstand voltage test to provide power; Another thermal cycle system 1 set, can provide heating power for the cable system, mainly used for the heating of the cable sample conductor core. Among them, the 1200kV/50mA DC generator bears the heavy responsibility of providing test line voltage, it will be used for testing the corona characteristics and environmental impact of the line segment, as well as the on-line assessment of some equipment. It is one of the key test equipments for the base. The corona of the DC generator itself is closely related to the accuracy of future experimental results. The intensity of the corona depends directly on the surface field distribution of the generator components [4].

3. Engineering Environmental Impact Monitoring

3.1. Environmental Background Value

The monitoring results of the maximum synthetic field intensity in this project are 0.25-0.45kV/m, the 80% synthetic field monitoring results are 0.19-0.36kV/m, the DC magnetic field strength is between 48.1-49.4μT, and the radio interference frequency is 0.5MHz. The value is 39.4~52.4dB(μV/m) [5].

3.2. Measurement Items

This study selected power frequency electric field, power frequency magnetic field, synthetic field strength, DC magnetic field, radio interference, and noise as measurement items.

3.3. Measuring Instruments

Measurement instruments and corresponding technical parameters are shown in Table 1.

Table 1. *Measuring instruments and corresponding technical parameters.*

measuring instrument	Instrument model	Measuring range
Power frequency field analyzer	EFA300	Power frequency electric field:0.7V/m~200kV/m; Power frequency magnetic field:4nT~87mT
Interference field strength meter	PMM9010/RA-01	0~134dB(μV/m)
Synthetic field strength meter	HDEM-01	-100kV/m~100kV/m
Vector fluxgate magnetometer	FVM-400	-100μT~100μT
Sound level meter	AWA6270+	35dB (A) ~130dB (A)

3.4. Measurement Points

Table 2. *Measurement points.*

Measurement items	Flexible DC Cable Test Site
Power frequency electric field, power frequency magnetic field, synthetic field strength, DC magnetic field	5m outside the wall of the flexible DC cable test site
Radio interference	20m outside the wall of flexible DC cable test site
noise	Placement of 1m outside the wall of the flexible DC cable test site

3.5. Equipment Operation Conditions During Measurement

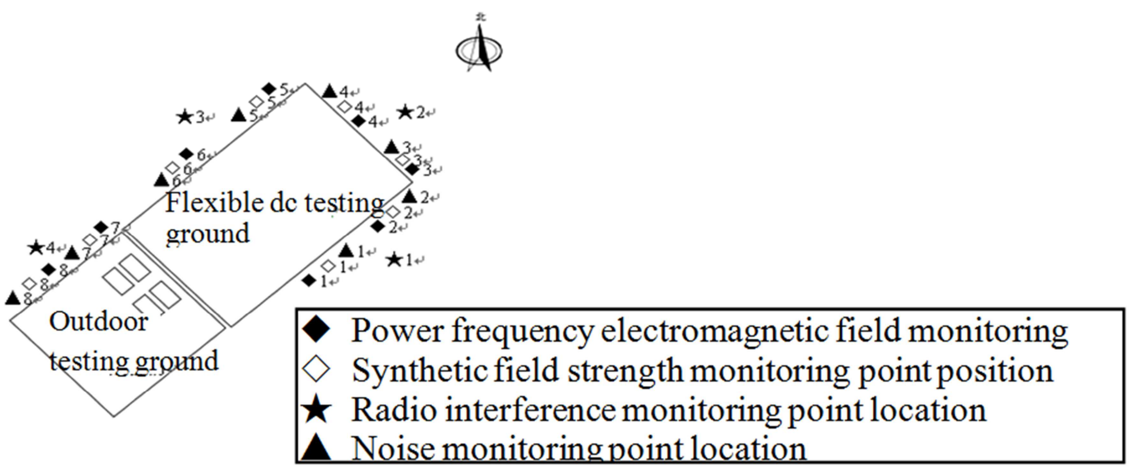

Figure 1. *Schematic diagram of measurement point distribution of flexible cable test field.*

Table 3. *Operating conditions.*

equipment	Primary input voltage (V)	Primary input current (A)	High voltage output voltage (kV)	High voltage output current (mA)
1200kV/50mA DC voltage test device	251.1~259.0	3.9~4.1	-304.0~-294.0	-1.40~-1.20

Table 3. *Continued.*

equipment	Circuit 1 current (A)		Circuit 2 current (A)		Circuit 3 current (A)		Circuit 4 current (A)	
	Test cable	Analog cable	Test cable	Analog cable	Test cable	Analog cable	Test cable	Analog cable
Thermal cycling equipment	751.6~814.4	747.7~810.2	576.1~650.7	580.8~653.9	564.6~633.32	564.1~636.0	762.7~885.2	761.4~886.1

3.6. Measuring Weather Conditions

Choose good weather measurement in sunny days to avoid the influence of strong wind, rain, snow, hail and other weather [6].

3.7. Measurement Results

Table 4. *Power frequency electric field intensity and magnetic field strength measurement results.*

Numbering	Point name	Power frequency electric field strength(kV/m)	Power frequency magnetic field strength(μT)
1	5m east-southeast	0.018	0.174
2	5m to the southeast middle point	0.017	0.237
3	5m to the east of the northeast	0.028	0.153
4	5m northeast of the northeast	0.018	0.251
5	5m to the northwest	0.018	0.236
6	5m to the southwest	0.018	2.75
7	5m to the northwest side of the outdoor test site	0.018	4.11
8	5m to the southwest side of outdoor test field	0.017	2.12
9	Corresponding standard limit requirements	4	100

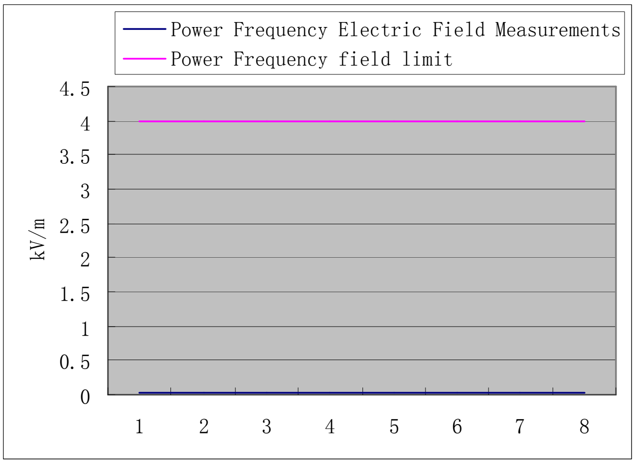

Figure 2. *Power Frequency Electric Field Measurements, Limits.*

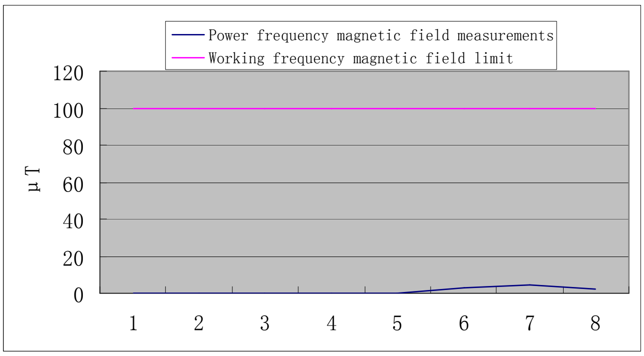

Figure 3. *Power frequency magnetic field measurement, limit value.*

Table 5. *Synthetic field strength monitoring results.*

Numbering	Point name	Synthetic field strength(kV/m)	
		80%	Maximum
1	5m east-southeast	-0.30	-0.30
2	5m to the southeast middle point	0.10	0.15
3	5m to the east of the northeast	-0.10	-0.15
4	5m northeast of the northeast	-0.10	-0.15
5	5m to the northwest	-0.15	-0.20
6	5m to the southwest	0.05	0.10
7	5m to the northwest side of the outdoor test site	0.10	0.10
8	5m to the southwest side of outdoor test field	0.05	0.10
9	Corresponding standard limit	15	25

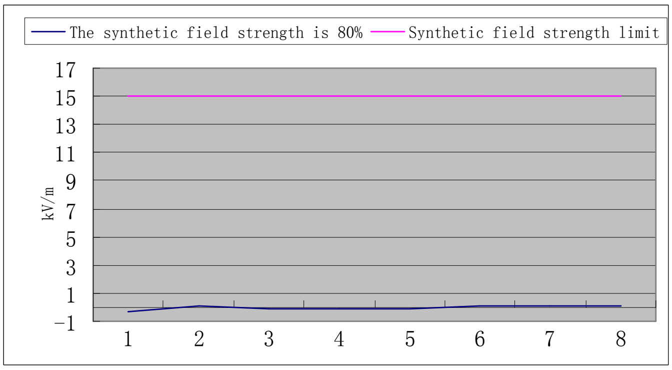

Figure 4. *Synthetic field strength 80% measurement value, limit value.*

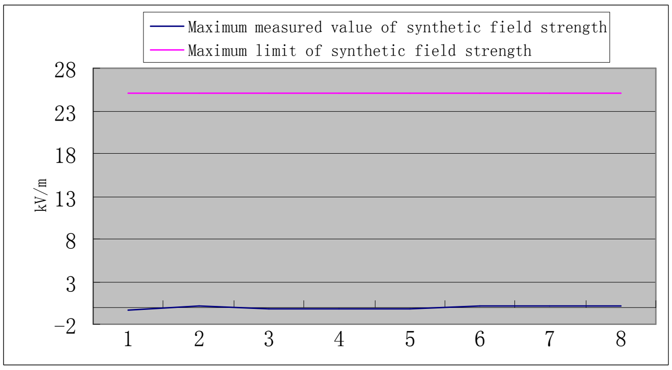

Figure 5. *Synthetic field strength maximum measurement value and limit value.*

Table 6. *DC magnetic field strength monitoring results.*

Numbering	Point name	DC magnetic field strength(μT)
1	5m east-southeast	43.5
2	5m to the southeast middle point	43.5
3	5m to the east of the northeast	44.5
4	5m northeast of the northeast	44.6
5	5m to the northwest	50.2
6	5m to the southwest	48.6
7	5m to the northwest side of the outdoor test site	50.5
8	5m to the southwest side of outdoor test field	48.2
9	Corresponding standard limit	10000

Table 7. *Radio Interference Monitoring Results.*

Numbering	Point name	frequencyMHz	Radio interference field strength dB(μV/m)
1	20m away from the southeast wall	0.5	43.8
2	20m away from the northeastern wall	0.5	42.9
3	20m to the northwest	0.5	40.8
4	Outdoor test site 20m away	0.5	48.8
5	Corresponding standard limit requirements	0.5	53

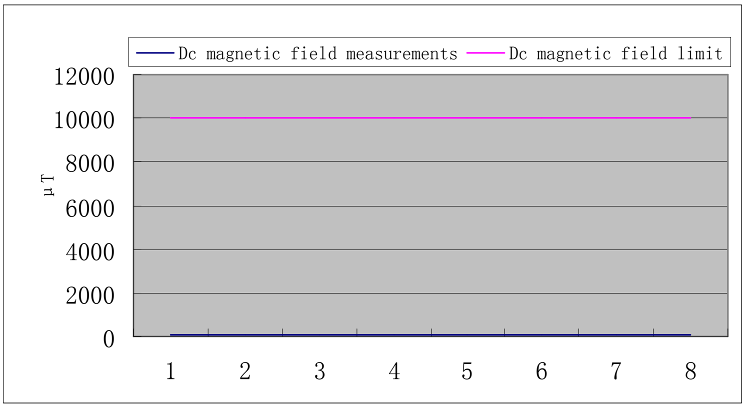

Figure 6. *DC magnetic field measurements, limits.*

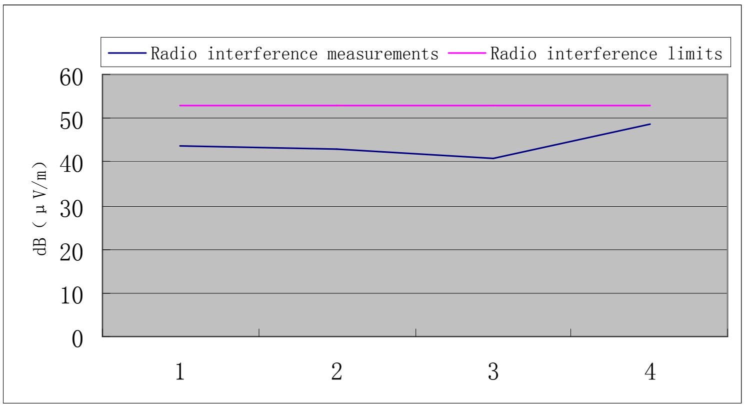

Figure 7. *Radio interference measurements, limits.*

Table 8. *Noise Monitoring Results.*

Numbering	**Point name**	**Noise dB(A)**	
		Daytime noise	**Night noise**
1	1m east-southeast	44.8	40.2
2	1m southeast of the middle point	45.2	40.9
3	1m to the east of the northeast	52.5	43.9
4	1m northeast of northeast	54.6	44.0
5	1m to the northwest	61.5	49.8
6	1m to the southwest	57.4	49.2
7	1m to the northwest side of the outdoor test site	55.4	48.2
8	1m on the southwest side of the outdoor test site	56.7	49.0
9	Corresponding standard limit requirements	65	55

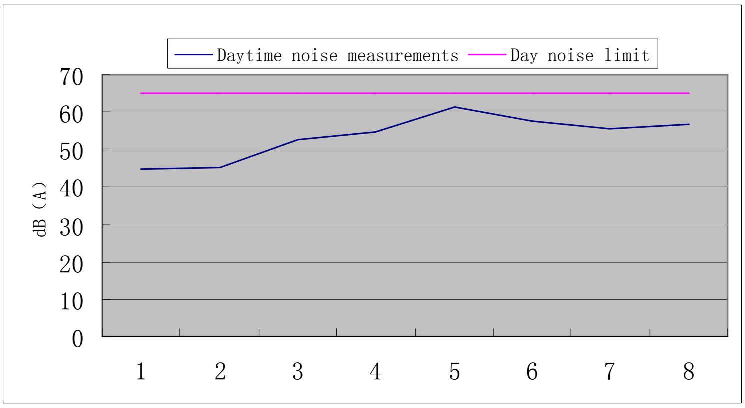

Figure 8. *Daytime noise measurements, limits.*

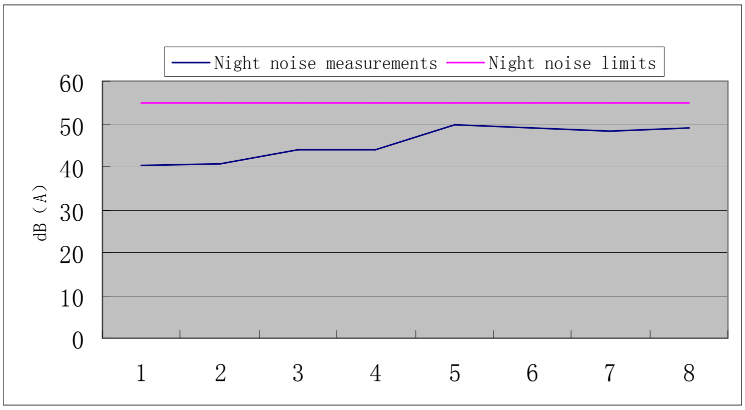

Figure 9. *Night noise measurements, limits.*

3.8. Summary Analysis of Monitoring Results

From Table 4 to Table 8, Figure 2 to Figure 9, it can be seen that the strength of the composite

Field around the test field of the flexible DC cable is basically the same as the background value of the environment.

The power frequency electric field, power frequency magnetic field, DC magnetic field strength, radio interference intensity and noise around the test field of the flexible DC cable are all less than the corresponding standard limit requirements [7-10].

4. Conclusion

As the first pre-qualification test of flexible DC cables in China, the results obtained from the actual measurement of the surrounding environment of the flexible DC test site in the supporting experimental construction project of the Zhoushan multi-terminal flexible HVDC transmission demonstration project show that:

The flexible DC test field has less influence on the surrounding electromagnetic radiation environment. The influence of the synthetic field intensity generated by the project on the surrounding environment is negligible; the power frequency electric field, power frequency magnetic field, DC magnetic field, radio interference intensity, and noise generated by the project are much smaller than the corresponding standard limit values.

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