Design of noise Control Scheme for 500kV Substation

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Abstract. The noise of substation is generally generated by the main transformer, reactor, capacitor and other electrical equipment, in which the transformer is the main sound source equipment. Its spectrum characteristics are mainly low frequency noise, medium and high frequency noise as auxiliary. The noise band is wide, the wave grow is long, the attenuation is slow, and the penetration ability to the building structure is strong, which seriously affects the daily life of the residents. In this paper, the noise source of a 500kV substation with noise exceeding the standard is tested and analyzed first, then the noise reduction scheme design and sound field simulation calculation are carried out to verify the feasibility of the scheme.

1. Test of noise sources in stations

1.1. Main transformer test
The main transformer noise mainly includes body noise and fan noise. In this paper, the noise levels of two main transformers in the station are tested, and the noise frequency doubling spectral sound pressure levels of the No. 2 main transformer are measured. The test results are shown in tables 1, 2 and 3.

Table 1. Noise monitoring results of No. 1 main transformer (dB(A))

| Measuring point | A phase | A phase | A phase |
|-----------------|---------|---------|---------|
| 1               | 72.7    | 69.9    | 70.7    |
| 2               | 71.3    | 75.2    | 68.7    |
| 3               | 73.0    | 73.6    | 72.2    |
| 4               | 71.3    | 74.0    | 69.3    |
| average value   | 72.1    | 73.6    | 70.4    |

Table 2. Noise monitoring results of No. 2 main transformer (dB(A))

| Measuring point | A phase | A phase | A phase |
|-----------------|---------|---------|---------|
| 1               | 71.0    | 72.4    | 70.2    |
| 2               | 71.1    | 74.4    | 72.7    |
| 3               | 67.8    | 67.8    | 66.6    |
| 4               | 73.0    | 72.6    | 72.1    |
| average value   | 71.1    | 72.4    | 71.0    |
Table 3. The frequency doubling spectral pressure levels of the No. 2 main transformer (dB)

| Frequency (Hz) | Pressure level | Frequency (Hz) | Pressure level |
|----------------|----------------|----------------|----------------|
| 31.5           | 72.2           | 1000           | 66.6           |
| 63             | 74.0           | 2000           | 60.6           |
| 125            | 73.6           | 4000           | 55.4           |
| 250            | 72.8           | 8000           | 47.9           |
| 500            | 71.9           | 16000          | 40.2           |

1.2. Noise Test of High Voltage Reactor

The noise and spectrum characteristics of two groups of high-voltage reactors in the station are analyzed, and the results of the test are shown in Table 4, 5, 6 and 7.

Table 4. Noise monitoring results of No. 1 high-voltage reactor (dB(A))

| Measuring point | A phase | A phase | A phase |
|-----------------|---------|---------|---------|
| 1               | 72.5    | 74.0    | 69.3    |
| 2               | 76.7    | 77.3    | 71.8    |
| 3               | 73.0    | 76.4    | 70.6    |
| 4               | 77.5    | 79.4    | 73.6    |
| average value   | 75.5    | 77.2    | 71.6    |

Table 5. Noise monitoring results of No. 2 high-voltage reactor (dB(A))

| Measuring point | A phase | A phase | A phase |
|-----------------|---------|---------|---------|
| 1               | 69.3    | 70.0    | 71.1    |
| 2               | 73.9    | 76.0    | 76.2    |
| 3               | 66.0    | 71.5    | 67.7    |
| 4               | 74.2    | 70.8    | 74.3    |
| average value   | 72.0    | 72.8    | 73.4    |

Table 6. The frequency doubling spectral pressure levels of the No. 1 high-voltage reactor (dB)

| Frequency (Hz) | Pressure level | Frequency (Hz) | Pressure level |
|----------------|----------------|----------------|----------------|
| 31.5           | 69.1           | 1000           | 62.2           |
| 63             | 74.6           | 2000           | 58.9           |
| 125            | 77.5           | 4000           | 47.5           |
| 250            | 74.7           | 8000           | 45.3           |
| 500            | 74.0           | 16000          | 37.8           |

Table 7. The frequency doubling spectral pressure levels of the No. 2 high-voltage reactor (dB)

| Frequency (Hz) | Pressure level | Frequency (Hz) | Pressure level |
|----------------|----------------|----------------|----------------|
| 31.5           | 55.3           | 1000           | 57.2           |
| 63             | 68.7           | 2000           | 49.3           |
| 125            | 79.0           | 4000           | 42.7           |
| 250            | 72.8           | 8000           | 43.9           |
| 500            | 65.1           | 16000          | 40.6           |

2. Noise reduction scheme design

2.1. Noise reduction scheme for Main transformer

The semi-closed sound insulation barrier can effectively reduce the radiation propagation of the main transformer noise. As shown in Figure 1, at the north side of the main transformer C, the sound insulation barrier of the steel structure is set along the road edge at the distance of 7.5 meters from the main transformer. The total length of the sound insulation screen is 51.12 meters, the upright part of...
the sound insulation barrier is 8 meters high, and the eaves are extended for 2 meters. Since the north section sound barrier occupies the position of the road in the substation station, a sound insulation rolling gate of 6 m to 5 m is set at the position of the original road. At the same time, the sound-absorbing micro-perforated plate is laid on both sides of the firewall in order to avoid the mixed noise caused by the reflection of the firewall.

![Figure 1 Layout of main variable sound barrier](image)

2.2. Noise reduction scheme for high-voltage reactor

In order to reduce the influence of high voltage reactor noise on the factory boundary and sensitive points, a semi-closed sound barrier is set up on the basis of the original firewall, as shown in fig. 2 to fig.4. In order to ensure the sound absorption and insulation effect of the barrier, and to maintain a sufficient safe distance from the 500kV high voltage lead, as well as the requirements of ventilation and heat dissipation, the height of the sound barrier reaches to the bottom of the new casing of the reactor, and the bottom layer is the ventilation muffler layer. In order to ensure the convenience of maintenance of high voltage reactor, the sound barrier adopts detachable type. The bus reactor was not in operation during the test period. After investigation, the reactor is rarely put into operation, so the noise of the equipment is not considered for the time being.

![Figure 2 Schematic diagram of facade layout of high noise barrier](image)
Figure 3 Plane layout of high anti - noise barrier.

3. Simulation of noise reduction scheme by SoundPLAN
According to the actual situation on the spot, the parameters of the simulation are as follows: the ground of the resident residence is 10 meters higher than the transformer ground, the nearest distance between the transformer and the barrier is 7.5 m, and the nearest distance between the transformer and the resident residence is 40 m. The simulation of before and after the noise reduction measures are shown in figures 4 and 5.

The simulation results for setting different main variable sound barrier heights are shown in the following figure. It can be seen that after the sound insulation barrier is added, the plant boundary is up to the standard.
Figure 6 Noise Distribution Map of 500kV Substation before noise reduction

Figure 7 Noise Distribution Map of 500kV Substation after noise reduction with 8 m barrier

Figure 8 Noise Distribution Map of 500kV Substation after noise reduction with 9 m barrier

Figure 9 Noise Distribution Map of 500kV Substation after noise reduction with 10 m barrier

Table 8. Comparison of noise pressure levels after reducing measures (dB(A))

| Measuring point | Pre-governance test value | 8 m barrier | 9 m barrier | 10 m barrier |
|-----------------|--------------------------|-------------|-------------|--------------|
| 1               | 57.8                     | 42.5        | 42.4        | 42.4         |
| 2               | 58.9                     | 48.5        | 48.5        | 48.5         |
| 3               | 52.7                     | 46.0        | 46.0        | 46.0         |
| 4               | 56.5                     | 48.7        | 48.7        | 48.7         |
| 5               | 46.5                     | 45.3        | 45.3        | 45.3         |
| 6               | 52.9                     | 44.3        | 44.3        | 44.3         |
| 7               | 43.2                     | 36.3        | 36.3        | 36.3         |
| 8               | 42.4                     | 45.3        | 45.3        | 45.3         |
| 9               | 42.6                     | 46.7        | 46.7        | 46.7         |
| 10              | 48.9                     | 46.1        | 46.1        | 46.1         |
| 11              | 53.4                     | 50.2        | 49.4        | 48.5         |
| 12              | 45.3                     | 45.2        | 44.2        | 43.3         |
| 13              | 43.2                     | 44.6        | 43.7        | 43.0         |
| 14              | 50.8                     | 48.3        | 47.6        | 47.0         |
| 15              | 54.6                     | 49.1        | 47.5        | 46.0         |
| 16              | 55.1                     | 50.0        | 50.0        | 45.0         |

4. Conclusion

In this paper, the noise source of a 500kV substation with noise exceeding the standard is tested and analyzed first, then the noise reduction scheme design and sound field simulation calculation are carried out to verify the feasibility of the scheme. According to the simulation results, in order to ensure that the noise of the factory boundary reaches the second standard, the height of the barrier should reach more than 9 meters on the basis of 2 meters of eaves, otherwise, the noise reduction measures of the main transformer should be considered. Considering the possible errors, it is
suggested that there should be enough margin in the concrete implementation of the project to ensure the standard.

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