Discussion on Substation Noise Control Target and Simulation Analysis

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Abstract. Substation noise engineering control is an important environmental protection content of current power grid companies. How to ensure the effectiveness of noise control and reduce environmental complaints and disputes has become an important subject for engineering and technical personnel. This paper analyzes and discusses the "Environmental Noise Emission Standards for Industrial Plants" (GB 12348-2008), and uses the simulation calculations and analysis cases of typical substation noise control to propose the principles and principles of sensitive targets and station boundaries in substation noise control. The analysis method in substation noise control provides reference and reference for the revision of substation noise engineering control technology and related standards.

1. Introduction
In order to meet the rapid development of China's economy, more and more urban substations are built. At the same time, in order to alleviate the environmental protection pressure caused by complaints and disputes caused by substation noise, there are more and more control projects for substation noise in recent years.

The investigation found that some problems have been exposed in the substation noise engineering control: Due to the misunderstanding of the standard, the substation noise control target is vague, resulting in poor project treatment effects and even false high project costs[1]. Before 2000, environmental disputes caused by substation noise were exceedingly rare. The main reason is that the sensitive points are far away from the substation and there are few high-rise buildings nearby. As long as the station boundary reaches the standard, the sensitive buildings can usually reach the standard, which has become people's mindset. Over the past ten years, great changes have taken place around the substation. Not only are the sensitive buildings getting closer to the substation, but there are also more and more tall buildings around. Substation boundary reaches the standard but the sensitive buildings do not reach the standard are a frequent occurrence[2].

At present, sound insulation control technology is still the most widely used method in substation engineering treatment[3-5]. As the environment of the substation is more complex, the location of sensitive points is closer and higher. And the difficulty of treatment becomes more and more difficult. A simple sound barrier cannot control the noise alone. And a complex combination of sound barriers is required to achieve the control effect[6-12]. This will inevitably enhance the difficulty of predicting the effectiveness of noise control. In this paper, the noise control effect of complex combined sound barrier is analyzed accurately by means of the simulation software SENCS[13]. And the control
method and effect are demonstrated by an engineering example. Provide reference for more substation noise engineering control.

2. Substation noise control targets
The principles of formulating noise standards are to prevent and control noise pollution in industrial enterprises, protect sensitive people and improve the quality of the acoustic environment. The formulation of standards must conform to the national conditions of China and be economically reasonable. The formulation of standards has certain actual effect. It needs constant revision and refinement. There are two main noise control targets of substation: The sensitive targets around the substation and station boundary reaching standard in noise control of substation. According to the current situation of China. In order to protect sensitive people, it is a common understanding and a basic requirement to ensure that all the sensitive target noise around the substation reach the standard. The noise environmental quality requirements of non-residential areas outside the station should comply with China's national conditions and the principle of economic rationality. The requirements can be relatively loose.

The noise control of substations is mainly carried out according to the standards for quality of sound environment (GB3096-2008) and environmental noise emission standards for industrial enterprises (GB12348—2008). Especially the latter standard, so the following will discuss the related issues of this standard in substation noise control.

1) In the past, most of the sensitive targets around the substation were a small house with a relatively small area, which could be represented by a measuring point in noise monitoring or prediction. But now a sensitive target around the substation may be one or more high-rise buildings and their adjacent courtyard dams and gardens, the scope is relatively large, the environment is more complex. The monitoring site should be more, the forecast analysis should be more precise and comprehensive.

2) According to clause 5.3.3.1 of GB 12348-2008, when the station boundary is surrounded by a wall and the noise-sensitive building. The measuring point should be located 1 m outside the station boundary and 0.5 m above the wall. On the other hand, when there is no noise-sensitive building around the station boundary. It should be carried out according to the regulation of 5.3.2, that is, the measuring point should be selected located 1 m outside the station boundary, 1.2 m above the station boundary, and not less than 1 m from any reflection surface. In fact, this is based on the situation that both inside and outside the station are at the same level. Two "above", in fact, is to give a standard range of height. If the location of the External Acoustic Environment is higher than the level of the substation. The height of the station boundary measuring point will not be "1.2 m above". But may be "3 m above" or higher, so as ensuring that the actual noise level outside the station can be reached. When the environment outside the station is lower than the level of the substation. The position of the measuring point can be lower. Making it easier for the station boundary to reach the standard.

3) The survey found that the necessary link between meeting the station boundary and ensuring that sensitive targets outside the station are met no longer exists. Therefore, when there are sensitive buildings outside the substation wall, it is no longer meaningful to fix the measuring point above 0.5 m. The environmental noise emission standard for industrial enterprises (GB 12348-2008) has been published for more than 10 years. And many articles cannot meet the requirements of environmental protection. Therefore, it is suggested that the outside noise should be handled flexibly and treated differently under the premise that the sensitive targets around the substation will not exceed the emission noise standard. If it is a public activity place, such as park, square and so on. It is necessary to ensure that the substation above the level of this area 3 m floor height measurement point discharge noise all reach the standard. If the area outside the station is farmland, fishponds, unclaimed land and rivers with low or no special noise requirements. There is no need to spend a lot of money to ensure that the station boundary meets the standards. Neither conforms to the standard formulation should follow the principle of economic rationality, but also deviates from the people-oriented goal of noise control.
3. Case analysis of sound control in substation

3.1. Combination of sound barriers
If the sensitive point has a single target, it can be solved by a simple sound barrier. If the sensitive point is large or the range is large, it needs to be treated by a combined sound barrier or acoustic enclosure. Combined sound barrier has better noise reduction effect. For outdoor noise source equipment, in order to ensure the ventilation and heat transfer during the operation of the equipment, the use of full-enclosed acoustic enclosure is avoided as far as possible. If full-enclosed acoustic enclosure must be used, ventilation and heat transfer should be fully considered in the design of acoustic enclosure, and the calculation of ventilation and heat transfer efficiency should be strengthened.

3.2. Engineering case analysis
In a 110kV open substation, except for two main transformers, all other electrical equipment are indoors. The substation is located in the urban area. With the development of the city, high-rise residential buildings have been built outside the substation. The category f acoustic environment functional area where the substation is located is Category II.

In order to accurately understand the distribution of noise in the substation. Based on the site investigation and collection of various data. The substation is modeled and simulated by using SENCS software.

3.2.1. Simulation analysis before treatment.
In the modeling, take the substation plane as the benchmark, adjust by 0 m. The size of the scene is 156 m×155 m. The building inside the substation is the distribution room. And the starting coordinates in the scene are (76.73,69.04). The ending coordinates are (76.81,24.65). The height is 8 m. The width is 8.92 m. The firewall nears the main transformer is 8 m high and 11 m long. The ground of the residential area is 2.3 m higher than the substation plane. And the wall height of the residential area is 2.3 m. The starting coordinates of the residential buildings around the substation are (123.25,120), (66.56,115.23), (17.72,59.94), (17.95,138.32). The ending coordinates are (146.23,120), (90,115.23), (40.92,59.94), (40.88,138.32). The width is 19 m, 18.4 m, 23.3 m, 18.4 m. The height is 60 m.

The main sound sources in the substation are two 220 kV transformers. The coordinates of 1/2 main transformer in the scene are (124.59,127.09,2), (104.11,124.35,2). And the sound pressure level is 73.1 dB (A) and 73.2 dB (A) respectively.
Figure 3. 2D noise distribution of 3.8m height plane

Figure 4. 2D noise distribution of 45m height plane

After the model is built, the two-dimensional simulation analysis before the treatment is carried out by the software. Through the 2D distribution of the noise of 1.5 m, 3 m, 3.8 m and 45 m plane height in the figure, it can be seen that not only the station boundary of the substation has exceeded the standard, but also the surrounding residential buildings and districts have exceeded the standard. As shown in Figure 1-4.

Figure 5. elevation noise distribution map of 1 #, 2 #, 3 # residential building

Figure 6. 3D isosurface diagram before treatment

Figure 5 is the elevation noise distribution map of the 1 #, 2 # and 3 # residential buildings facing 1 m from the side of the substation. From the figure, it can be seen that the range of the height exceeding the standard of the 1 # residential building is approximately 5-60 m. The range of the height exceeding the standard of the 2 # residential building is approximately 4-60 m. And the range of the height exceeding the standard of the 3 # residential building is approximately 42-60 m. This is consistent with the simulation results of two-dimensional plane with different heights.

Figure 6 is a three-dimensional noise isosurface analysis diagram of the substation. The noise magnitude of the isosurface is 50 dB (A). It can be seen that some station boundaries have exceeded the standard, which is consistent with the result of two-dimensional analysis.
3.2.2. simulation analysis after treatment:
Through the above analysis and combined with the actual situation of the substation, the use of "semi-enclosed acoustic enclosure combination" for noise control. The starting coordinates of the semi-enclosed acoustic enclosure 1 and 2 in the scene are (81,68.02), (81,54.4), (92.55,68.02), (92.55,54.4). The height is 11 m. The width is 2 m. The sound barrier is constructed over the wall on the side near the distribution room. In the scene, the starting coordinates are (81,69.11). The ending coordinates are (81,36.61). The height is 3 m. The front of 1, 2 # main transformers is the sound barrier. The height is 3.5 m. The bottom is hollowed out 0.5 m. Some of the parameters are described in detail in Figure 7.

![Figure 7. 3D dimensional diagram of treatment scheme](image)

The two-dimensional simulation analysis of noise control is performed by software. As can be observed in Figure 8 and Figure 9, the analysis of 1.5 m and 3 m floor height shows that the 50 dB red line does not exceed the station boundary. Therefore, the station boundary will not exceed the standard after treatment. As can be seen from Figure 10, the ground level detection value of 3.8 m floor height representative residential area is less than 50 dB and will not exceed the standard. Figure 11 represents the noise analysis of the 45 m floor height of the space. The four residential buildings do not exceed the standard.

![Figure 8. 2D noise distribution of 1.5m height plane](image)

![Figure 9. 2D noise distribution of 3m height plane](image)
Figure 10. 2D noise distribution of 3.8m height plane

Figure 11. 2D noise distribution of 45m height plane

Figure 12 is the elevation noise distribution map of the 1 #, 2 #, and 3 # residential buildings facing 1 m from the side of the substation. From the figure, it can be observed that the noise of the 1, 2, and 3 # residential buildings does not exceed 50 dB, so they all meet the requirements of environmental protection standards. Figure 13 is the result of the elevation analysis. It can be observed that all four residential buildings have reached the standard, which is consistent with the result of the previous plane analysis. It is proved that after the substation adopts the above-mentioned semi-enclosed acoustic enclosure to reduce noise, it has shown that substation boundaries and sensitive points have achieved the goal of reaching the standard.

Figure 12. elevation noise distribution map of 1 #, 2 #, 3 # residential building

Figure 13. 3D contour map after treatment

Figure 13 is a three-dimensional noise isosurface analysis of the substation with semi-enclosed acoustic enclosure. The noise of isosurface is 50 dB (A) and the height of isosurface is 0-64 m. From Figure 13, it can be observed that the 1, 2, 3, 4 # residential buildings after treatment all meet the requirements of environmental protection standards, which is also consistent with the results of two-dimensional analysis.
4. Conclusion

Based on the discussion of noise control targets of substations and the two-dimensional and three-dimensional simulation analysis of engineering examples, the following conclusions are drawn:

1) In the noise control of substations, it is necessary to ensure that the noise emitted by the main noise source equipment will not cause all the sensitive targets around the substations to exceed the standard.

2) In order to ensure that the noise level of the station boundary reaches the standard under the current environmental protection standard, the level of the noise monitoring point should be considered at the level of the area outside the station and the level of the substation. And put forward reasonable suggestion for standard revision.

3) By analyzing classic cases of substation noise control, the basic process of substation boundary noise and sensitive targets reaching the standard is fully demonstrated through the analysis of two-dimensional and three-dimensional noise before and after treatment. It can be used for reference in substation noise engineering control.

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