Demonstration and Optimization of Floor Height of 220kV GIS Room in the Indoor Substation

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Abstract. With the development of cities, the construction of indoor substations and the use of gas insulated switchgear (GIS equipment) are becoming more and more widespread. In this paper, the height of 220kVGIS room in the indoor substation is demonstrated and optimized. On the basis of the collection and analysis of the basic data of each major equipment manufacturer, the height of GIS room is analysed from the expansion, maintenance needs and pressure test, which are two limiting factors. Finally, the optimal height of 220kVGIS room is determined.

1. Introduction
Indoor substations are more and more widely used in urban construction and development because of their advantages of land saving and a building's appearance in harmony with its surroundings[1-2].

At present, in the design scheme of indoor substation with 220kV and below voltage level, the height of GIS room is usually about 9m, which generally needs to occupy two floors of the main factory building. If the height of the GIS room is optimized, it can be effectively lowered to make full use of the space above the GIS room, which is of great significance to reduce the construction area and floor area of the substation and reduce the project investment.

The floor height of GIS room should consider the following two factors: (1) GIS expansion and maintenance needs[3-5]; (2) GIS pressure test. The following is an optimization of the height of GIS room based on the collection and analysis of basic data of each major equipment manufacturer.

2. The height of GIS equipment
In order to determine the height of GIS room, first of all, it is necessary to make clear the height of GIS equipment. In this paper, the equipment data of 220kV GIS major manufacturers are statistically analysed, as shown in Table 1.

Table 1. 220kV GIS equipment data statistics of main manufacturers.

| The serial number | The manufacturer name         | Interval height/m |
|-------------------|------------------------------|-------------------|
| 1                 | PG Toshiba                   | 3.2               |
| 2                 | Shanghai Siemens             | 3.3               |
| 3                 | Xindongbei Electric          | 3.2               |
| 4                 | Shandong Taikai              | 3.3               |
| 5                 | Beijing Beikai Electric      | 3.3               |
According to the analysis of the equipment specifications of the above manufacturers, the following data is determined as the basic information for layout optimization: The height of the interval equipment is not greater than 3.3 meters.

3. Study and optimization of floor height of 220kV GIS room
The following two constraints of GIS height are considered respectively.

3.1. Height requirements for GIS expansion and maintenance
According to the investigation of GIS manufacturers and operation units, the fault probability of GIS equipment is very small, and the general fault can be solved by on-site debugging or local replacement of faulty parts. If there is a need to return to the plant for overhaul, the SF6 gas can be evacuated completely, and then the GIS can be divided into parts for shipment intervals using the same transportation method as the expansion[6].

Expansion and maintenance can be carried out in three ways:

- The external wall of the equipment room adopts detachable lightweight composite wall panel, and the whole wall can be detachable to realize GIS integral interval transportation. Lifting and maintenance can be achieved through the detachable wallboard as a whole, and lifting in the GIS room is no longer considered. However, the late expansion construction of this way is complex, which affects the bearing capacity and durability of the wall, and its reliability needs to be investigated.
- Increase the longitudinal size of the GIS room, widen the transportation channel, ensure the maximum unit transportation at the expansion or maintenance interval, and realize the installation of the expansion equipment in place. The height of the GIS room can be reduced, but the GIS area needs to be increased.
- Use the hook of GIS room to lift the expansion or maintenance interval equipment to the expansion position across the interval.

In order to achieve long-term development, it is necessary to reduce the footprint and make full use of space. It is recommended to use cross-interval lifting to meet the height requirements of expansion and maintenance.

Considering cross-interval lifting, the height requirement of GIS room is:
The height requirement of GIS room =3.3m + 3.3m + 0.4m (construction margin) = 7m.

Generally speaking, the spacing equipment is dismantled into small components for hoisting. Therefore, the floor height of GIS room is set at 7 meters to meet the requirements of expansion and maintenance.

3.2. Height requirements of GIS pressure test
For GIS equipment, the following voltage test methods for connecting cables are generally adopted:

- Add test air casing (220kV casing height is 2.5m). In this way, due to the need to consider the distance between the air casing and the surrounding walls and the top plate is not less than 1.8 meters[7-8], the height of the pressure test is:

  The height of the pressure test=3.3m+2.5m +1.8m =7.6m.

- If the GIS room space is insufficient, the GIL branch bus can also lead out the outdoor to test, without increasing the height of the GIS room because of the test. However, the GIL branch bus must be provided by GIS manufacturers in this way, which increases the equipment cost, is not convenient for bidding and procurement, and the utilization rate is low.

- GIS equipment manufacturers can also provide a fully closed test casing, using this equipment can not only achieve the local pressure test, but also to solve the problem of small space caused by the optimization of equipment plant. However, the test device has some problems,
such as the small capacity of the equipment, and only 1 ~ 2 phases in a single interval can carry out the withstand voltage test at the same time. At present, it is still in the research and development stage of related technologies and products, and it is not mature.

- If there is still a large space margin in the GIS room (for example, the construction scale of this period is only part of the equipment interval), the test casing should be placed horizontally or tilted during the pressure test, as shown in Figure 1. During the expansion, if there are too many intervals or insufficient space in this period and the safety distance requirements for horizontal or inclined placement of the test casing are not met, the voltage withstand test in special cases can be carried out by renting GIS electromagnetic voltage transformer with power output (PTV equipment).

![Figure 1. Schematic diagram of horizontal or inclined placement of test casing.](image)

The principle of PTV method is to apply a low voltage on the secondary side of PT, and a high voltage is induced on the primary side of PT and applied to the GIS switch, so as to provide high voltage for the field GIS switch withstand voltage test. In this way, the demand for pressure test equipment can be greatly reduced in the field, and the occupation of the test casing to the height can be avoided, so as to achieve a significant reduction in the height.

In addition, the PVT can be directly used as a voltage transformer in the interval of GIS equipment after the completion of the voltage withstand test, so it has high practicability. The real picture is as follows:

![Figure 2. PTV real picture.](image)

The height of the 220kV GIS room is limited by the pressure test, which is 0.6m higher than the height required for expansion and maintenance. When space is sufficient, the test casing can be tilted or placed horizontally. And because the PVT technology has been relatively mature, it has been
widely used in foreign countries, and the rental price is low. Through technical and economic comparison, if the space is not enough to meet the safety distance requirements of tilted or horizontal placement of the test casing, the pressure test can be carried out by leasing PTV equipment.

Therefore, it is recommended to use this pressure test method to reduce the height requirement to less than 7m.

Therefore, considering GIS maintenance and expansion, pressure test and other factors, it is recommended that the floor height of 220kV GIS room be no less than 7 meters.

4. conclusion
In this paper, based on the analysis of the data of major GIS equipment manufacturers, comprehensive consideration of GIS maintenance and expansion and pressure test and other factors, through the use of spare space, horizontal or tilted placement of test casing and the use of new PVT equipment, the 220kV GIS room height requirement is optimized to no less than 7 meters. This is of great significance to reduce the building area and floor area of the indoor substation and reduce the project investment.

The suggestion of floor height of 220kV GIS room in this paper has guiding significance to the construction of indoor substation.

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