Mobile emergency air exhaust device for GIS equipment room and its application

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Abstract. This paper introduces a mobile ventilation device that does not require construction and installation. It can be used in electrical equipment studios such as Gas Insulated Switchgear (GIS) filled with sulfur hexafluoride (SF6) gas. In the fault state of the ground exhaust device, the mobile ventilation device can quickly complete emergency forced ventilation and gas purification, and it can also be used for forced ventilation in laboratories, operating rooms and other places without preset ventilation systems. The mobile emergency air exhaust device can be placed at any time and in any place where ventilation is required, and it is inexpensive, safe, efficient, and versatile. In the SF6 leakage condition of the GIS equipment room, the ventilation efficiency can be increased over 97% in 10 minutes, and the adsorption removal rate of harmful components in the operating gas is higher than 90%.

1. Introduction
SF6 gas is a synthetic gas with excellent electrical insulation performance and arc extinguishing performance. It is widely used in Gas Insulated Switchgear (GIS) and SF6 circuit breaker, sulphur hexafluoride transformer, sulphur hexafluoride closed high voltage transmission line combined electrical equipment and other equipment. The density of SF6 gas is about 6.16 g / L, which is five times as the density of air. When it leaked, it will accumulate in the ground area, causing safety problems such as operator suffocation. There is a ground exhaust system between the GIS equipment, which can quickly discharge the leaked SF6 gas to ensure the safety of operators. In the event of an exhaust system failure, to replace the ground exhaust device, an emergency ventilation device that can be quickly placed in the fault location is required. Focus on emergency ventilation requirements between GIS equipment, the main functions of the mobile ventilation device include: (1) The position of the suction port is close to the ground and the air volume of the fan is moderate, so the leaked SF6 gas can be discharged quickly and efficiently; (2) the suction pipe is provided with a filter layer filled by sorbents which absorb harmful SF6 produced during operation, guarantees personal and environmental safety; (3) it can be quickly and conveniently moved and positioned; (4) The air duct is folded and can be easily took into the box when it is idle, which is convenient and neat.

2. Structure and function of mobile ventilation
The structure of the mobile emergency ventilation device is as shown in FIG.1, which includes a power switch installed outside of the ventilation device body, a louver vent, an exhaust duct collection room, an exhaust duct and a silent fan installed inside the ventilation device body, and mute wheels
placed at the bottom of the ventilation device. There are lockout device on the mute wheels for easy movement and placement. The vent is located at the lower end, outside of the ventilating device body for the ground exhaust. It can be used not only for indoor ventilation, but also for special complicated conditions such as the exhaust air has higher density than the air or the gas concentration near the ground is higher than the upper space. The exhaust duct is about 6-10m, which is folded and stored in the air duct collection room for convenience. The material of shell is ABS engineering plastic and stainless steel, that can be beautiful and firm at the same time.

While using, first, open lockout device on the mute wheels, place the device in the room that needs ventilation, lock the lockout device; then open the folded exhaust pipe collection room door, pull out the pipe, and place the exhaust port outdoor. Then turn on the power switch to start forced ventilation. After using, fold exhaust duct, close the folding exhaust duct collecting room door, unlock the lockout device, place the moving ventilation device in a proper position, and then locked lockout device.

3. Effect test
Verification tests were conducted in the GIS equipment room. The GIS equipment room area is about 160m², the floor height is 5.2m, and the indoor effective volume is about 832 m³. According to the characteristics of the operator's activity range, the height is divided into three levels of 0.4m, 1.5m and 2.5m. 20 measuring points are evenly arranged in the grid shape shown in Fig.2. The ambient temperature is 20-25 °C, the pressure of SF₆ gas is adjusted to 130 kPa, and the flow rate is 3.0L/min. The indoor airing time is determined as needed, and the doors and windows are closed. After finishing aeration, wait for 2-10 minutes to get equilibrium. Then measure the concentration of SF₆ at each point, and the three-dimensional distribution state of the indoor gas concentration is obtained. Pump a higher amount of sulfur hexafluoride close to the ground and let it flow into the room, a wait for 2 minutes to get equilibrium, then tested immediately. The mobile ventilation device is located in the middle position of the GIS room. After 10 minutes of ventilation, the concentration of SF₆ gas in the room after ventilation is measured according to the measurement point of Figure 2. As a result, the effect of the mobile ventilation device as emergency ventilation is investigated.
Equipment like GIS will generate harmful gases such as SO2 and H2S during operation. Leakage in the air will be harmful to operator and pollute the environment. So it needs to be purified before being discharged outside. This mobile ventilator is equipped with a dedicated sorbent filter to remove harmful gases. The harmful gas removal efficiency is regulated by supplying standard gas and detecting the concentration of harmful gases entering and exiting.

The test instrument adopts HNP5000 type SF6 gas quantitative leak detector, whose range is 0-1500ppmv, and sensitivity is 1ppmv; and the HNPZH-90 type SF6 gas comprehensive measuring instrument whose range is 0-100μL/L.

Three concentration values were continuously tested at each sample point, and the average value was taken as the final detection result at that point.

4. Test results and analysis

4.1 SF6 gas concentration distribution state in the state of leakage

After the SF6 gas was charged indoor, it was kept for 5 minutes to get equilibrium, and the concentration of SF6 gas in the room became stable. The concentration of SF6 gas at a horizontal elevation of 0.4m, 1.5m, and 2.5m was detected at each position of Fig.2, and a state distribution model of the concentration of SF6 gas in Fig.3 was obtained. It can be seen that the concentration near the ground is the highest. Therefore, the data of 0.4m measurement points from the ground are taken for subsequent experiments.
4.2 Mobile ventilation device for the effect test of conventional ventilation equipment

To simulate the general pollution situation in the room, the mobile ventilation device is located in the middle position in the laboratory. After 10 minutes’ ventilation, the concentration of SF6 gas at each point is detected according to the position of the measurement point in Fig.2, and the ventilation effect of the mobile ventilation device is calculated. The result is shown in Fig.4.

4.3 Mobile ventilation device for emergency ventilation test

In order to simulate the sudden occurrence of SF6 gas leakage, an indoor environment with a higher concentration of sulphur hexafluoride gas is created. A higher amount of SF6 gas was placed close to the ground and filled into the room, it was kept for 5 minutes to get equilibrium and then tested immediately. The mobile ventilation device is located in the middle of the laboratory. After 10 minutes, the concentration of SF6 gas in the room after ventilation is measured according to the measurement points of Fig.2, to investigate the effect of the mobile ventilation device as an emergency ventilation. The result is shown in Fig.5.

4.4 Harmful gas adsorption test

The sulphur hexafluoride gas purification function of the mobile emergency ventilation device is verified by supplying the standard gas. The SF6 standard gas which contains SO2 20 μL/L and H2S 10μL/L is directionally discharged into the suction port of the ventilation device, and the concentration of SO2 and H2S at the outlet of the discharge pipe of the ventilation device is measured. When the harmful gas removal rate of the device is detected, the average of the three tests is SO2 1.91 μL/L and H2S 0.92μL/L.
5. Conclusion

(1) After the mobile emergency ventilation device was used for 10 minutes, the average removal rate of sulphur hexafluoride gas in the room was 95.1%. So it can be used as a conventional ventilation device in places such as laboratories to replace fixed ventilation equipment.

(2) Under the circumstance of high SF$_6$ concentration and high gradient difference, after the mobile ventilation device is ventilated for 10 minutes, the indoor sulphur hexafluoride gas removal rate is about 96.7%. It proves that the mobile ventilation device can exert a good ventilation effect in a local high concentration non-uniform pollutant leakage environment, and clean the air indoor in a short time.

(3) After the harmful gas is absorbed by the sorbent, the removal efficiency is about 90%, thus it completed the task of safety disposal of toxic gases in SF$_6$ decomposition products effectively.

Reference

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