

Modification to Add Lightning Protection Device to the Chimney Flowmeter of the Nuclear Auxiliary Building of a Nuclear Power Plant

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Abstract: In view of the problem that the lightning protection terminal of the stack air flowmeter (DVN001/002MD) of the nuclear auxiliary plant in a certain nuclear power station is easily damaged by lightning, the actual situation is analysed, and the Reform measures of lightning protection device are put forward to solve the problem of the flash alarm of the KCS cabinets in the lightning strike, to improve the anti-lightning interference ability of the stack air flow signal and to reduce the risk of shutdown due to the lightning signal, resulting in burnout of KCS cabinets and interference signal.

Keywords: Lightning Protection Device; Interference Signal; Analysis of Lightning Strike Accidents.

1. Introduction

With the continuous improvement of the automation level of the nuclear power industry, the application of DCS and various intelligent instruments is becoming more and more common. The two line system of 4 to 20mA is widely used in the transmission mode of the instrument and control signal, and the power supply voltage is 24V, which is easily disturbed by thunder and lightning during the thunderstorm season [1]. Nuclear power unit involves nuclear safety. When the control loop is suddenly struck by lightning, it will cause incalculable danger and loss to the unit. During the two thunderstorm attacks of a certain nuclear power base in May 2012 and July 2014, the electromagnetic interference produced by the inductive thunder was introduced into the protection group cabinets by the stack air flowmeter (DVN001/002MD) signal cable of the nuclear auxiliary plant to cause the burning of the card and the related alarm.

2. The Necessity of the Reform

2.1. A Brief Introduction of DVN001/002MD Instrument and Control System

DVN001/002MD used to measure the air flow of the stack by annubar sensor, whose differential pressure output is connected to two Rosemount 3051 transmitters through the guide tube, and the transmitter is at the height of 53.8m on the stack operating table. The transmitter uses the IE shielded cable, the transmitter itself is grounded and the shield layer DCS side is single end, and the 4 ~ 20mA signal of the two 3051 transmitter is sent to the security level DCS (KCS) protection group cabinets respectively [2].

2.2. Analysis of Lightning Strike Accidents at a Nuclear Power Plant Site

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When there is a large common mode voltage (ground potential difference) between the terminals at both ends of the shield, a large additional current I_f is formed in the shielding layer, and the direction of the current depends on the direction of the ground potential difference. If one of the ground ends is located at the downline of the stack, the lightning current is 100kA, the grounding resistance is 1 Ω , the electric current is the current source, so the ground potential will increase 100kV; if the potential of another location of the shielding layer is 0V, the potential difference will produce a large additional current of I_f in the shielding layer, and the additional current I_f will return to the core line. The induction current can be generated in sufficient equipment damage [4].

The main reason for the lightning strike in a certain base is that the instrument side and the KCS side use double end grounding to connect the downline of the stack arrester and the stack's guardrail on the same place, and the shielding layer of the signal shielded cable is connected with the stack's guardrail on the side of the differential pressure transmitter, while the signal shields the cable shield. The other side is located on the side of the KCS cabinets in the room. Because the site is far away from the stack, the ground potential can be approximately zero when the lightning strikes, which is due to the great potential difference between the ends of the shield layer. A large additional current I_f is formed in the shielding layer, and the additional current I_f produces a large induction current in the core circuit, which makes acquisition card of DVN001/002MD burn down to affect the protection group cabinets.

2.3. Safety Analysis of Lightning Strike in a Certain Nuclear Power Station

Although the nuclear power station uses the single end grounding of the KCS side cabinets, the lightning rod and the instrument box may produce overvoltage when the lightning rod is struck by lightning. If the external insulation of the signal line in the instrument side CR box is not good, it may produce breakdown. If the interference along the measuring cable to the side of the KCS cabinets may interfere with other

important signals, it may even damage the KCS plate, which affects the availability of the important security level channels of the cabinets.

From the operation experience of a nuclear power station and other power stations, a single lightning protection measure, such as single end grounding or double end grounding of cable shielded line, cannot be effectively prevented by using a single lightning protection measure in outdoor and high position measuring instrument, because the lightning interference source and the interference way are complex and the intensity is different, so many kinds of lightning protection should be taken. Measures are carried out for comprehensive lightning protection. The measures to increase the lightning protection device for such equipment can effectively improve the lightning protection effect.

3. Reform Scheme

3.1. Reform Measures

The overall scheme solves the problem of lightning

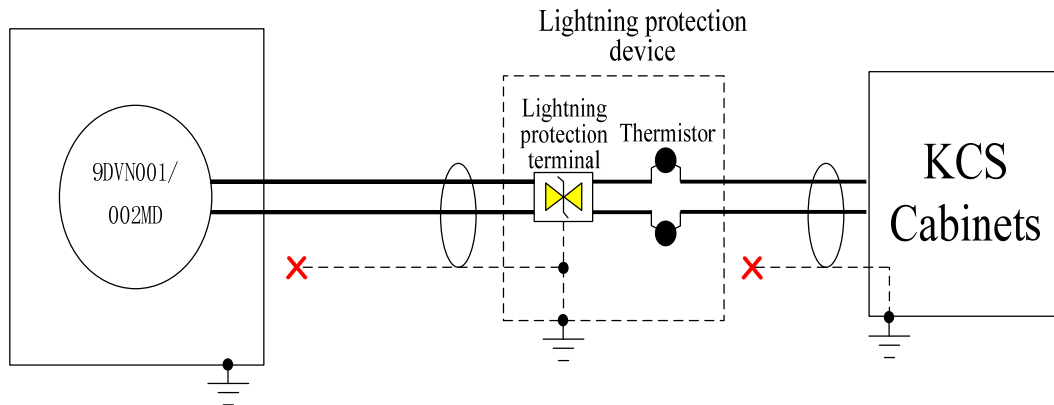


Fig 1. A schematic diagram of an increase in lightning protection device

There are two functions of the lightning protection device.

(1) Discharge. The invasion of lightning current is diverted to the ground, so that most of the energy of lightning can be released into the earth, so that the lightning electromagnetic pulse cannot reach or only a small part reaches the electronic equipment.

(2) Limit pressure. When the lightning overvoltage passes through the power line, the voltage (residual pressure) is maintained at both ends of the surge protector, and the voltage limit is acceptable to the electronic equipment. The two functions at the same time, that is to achieve voltage limit in the process of shunting, so that the electronic devices are protected.

3.2. Grounding Mode of Cable Shielding

According to Article 6.3.1 of the technical code for protection of building electronic information system against lightning, the shielding layer should be connected at least at the two ends when the shielded cable is used. When the system requires only an equipotential connection at one end, two layers of shielding should be used, and the shielding of the outer layer is handled according to the previous requirements [5].

According to the provisions of article 3.6.8 of the code for design of cables of electric works, the grounding mode of controlling the metal shielding of cables shall comply with the following provisions [6]:

(1) The analogue signal loop of the computer monitoring system and the shielding layer of the control cable shall not

interference by adding lightning protection devices in the measurement loop of 9DVN001/002MD. The specific installation position is at the junction of the lightning protection area at the LPZ0 (outside the building) and LPZ1 (inside the building and the cable slot box with Faraday cage structure). The ZKHBJ-SPD type lightning protection device is made.

Usually, surge protective devices should be installed at the boundary of different lightning protection zones. Therefore, after the transformation, the new box is arranged in the NB725 room, the tray is across the entrance of the workshop, and the two box boxes belong to the different protection groups, and the installation interval is at least 1m. The wiring diagram between sensor, lightning protection device and KCS cabinet is shown in Fig. 1.

constitute two points or multi point grounding.

(2) In addition to (1) the control cable shielding layer which needs a little grounding, when the interference of electromagnetic induction is larger, it is appropriate to use two points to connect the ground; the interference of the electrostatic induction is larger, and a bit of grounding can be used. Double shields or composite shields should be divided into two points, one is internal and external shielding, and the other is two point grounding.

The shielding way adopted by DVN001/002MD is two layers of shielding. The shielding layer of the inner cable is a single end grounding, which conforms to the analog signal circuit of the computer monitoring system of the GB 50217-1994[7], which controls the single end grounding requirements of the cable, and the outer cable bridge is multipoint grounding, which is in line with the design code for the lightning protection of the GB50057-2000[8] buildings and the design of the GB50343-2012 power engineering cable. The specification is required to shield the ground with multiple points.

Adding surge protection device does not change the two layer shielding principle. The cable shielding layer is still single ended grounded, and the outer cable bridge is multi-point grounding mode. The measuring cable between the instrument box and the lightning protection device is connected to the single end of the lightning protection device. The measuring cable between the lightning protection devices in the KCS cabinet is used in the single end of the KCS cabinet. The shielding points, protected areas and signals of

lightning protection devices are connected to the nuclear island grounding system and reinforcing bar. In order to prevent the lightning interference to the maximum extent, the instrument side outlet to the measuring tray, the cable added protection casing, the protection sleeve to the single end ground to the pallet grounding wire.

3.3. Kelvin Connection Method

When installing lightning protection devices, must be noted:

According to Clause 1 of Article 6.5.1 of the Technical Code for Lightning Protection of Building Electronic Information Systems (GB50343-2012): the connecting conductors of surge protective devices (SPDs) at all levels shall be short and straight, and their length shall not exceed 0.5 m. [8] When the lightning protection device is connected to the protected equipment, the final effective protection level $U_{p/f}$ is:

$$U_{p/f} = U_p + \Delta U$$

where: ΔU — is the induced voltage drop across the connecting conductors at both ends of the SPD.

$$\Delta U = \Delta U_{l1} + \Delta U_{l2} = (l_1 + l_2) L \frac{di}{dt}$$

where: L — is the self-inductance of the two conductor segments ($\mu H/m$);

l_1, l_2 — is the length of the two conductor segments;

$\frac{di}{dt}$ — is the rate of rise of the lightning current flowing into the SPD. When a partial lightning current flows through the SPD, it may be assumed $\Delta U = 1kV/m$, or a 20% margin may be considered. When the SPD circuit adopts Kelvin Connection Method, $l_1 = l_2 = 0$, the line residual voltage can be neglected.

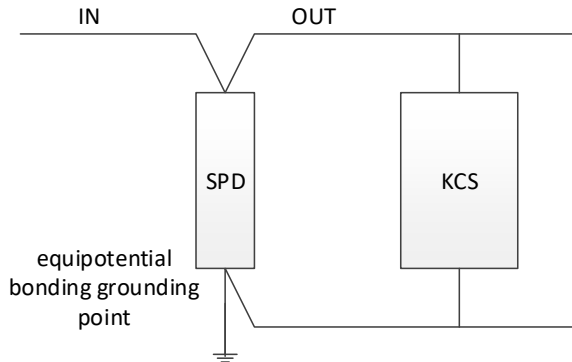


Fig 2. Kelvin Connection Method

In this retrofit, the lightning protection wiring adopts a method similar to Kelvin Connection Method. The difference

is that the KCS-side grounding does not change the original KCS design requirements, thereby minimizing the line residual voltage.

4. Summary

This reform aims at improving the lightning protection measures between DVN001MD/002MD and KCS cabinets, and the new lightning protection equipment is used to suppress the surge and Transient Overvoltage on the signal line and overcurrent on the discharge line, thus avoiding the damage of the KCS cabinet card of the measuring signal in the thunderstorm weather, or other safety grade letters in the same cabinets. The reliability and safety level of the reactor protection system in A certain nuclear power station is greatly improved, and the safe and stable operation of the unit is ensured.

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