

THE STUDY OF ELECTRIC FIRE PROTECTION IN UNDERGROUND SPACE BUILDINGS

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SUMMARY OF THE THESIS

That the underground space buildings have particular characteristics, such as special underground circumstances and distinctive closed conditions, determine its dependence upon the guarantee of electricity, which becomes the most necessary and important energy source of the buildings. But in the meantime electricity will give rise to possible dangers of damages and disasters due to the wrong use of it. The disaster of electric fire is one of the great dangers. This thesis, combining theory with practice, is planned to analyse, study and inquire into the importance and the regularity of electric fire disasters and scientific means to prevent and control it so as to maintain the safety of the underground space buildings.

Nowadays we are in an age of electricity and electron. The development of power industry of our country is very rapid. In 1990, the total capacity of electric power equipments reached 135 millions kilowatts and the electric energy production reached 6150 billions degrees. Our country has been the fourth biggest nation in electric power, just following the United States, former Soviet Union and Japan. Electricity has dual nature. On one hand it is beneficial that it brings multiple material civilization to the humankind and great development to the society, which must be applied and developed at an accelerated pace; on the other hand it is harmful that it may bring dangers of disasters to us due to the wrong use of it by people, which must be restricted and weakened. Electric fires that happen to some architectures due to the wrong use of the power is a great disaster. According to the report of public police department, electric fire disasters occupy 16.1% of the overall fires that happen in the whole country per year, and the proportionality is still rising every year.

Now the living space of the humankind are developing to the three-dimensional space. The underground space building are one part of the development. It is the supplement, prolongation and enlargement of modern cities and is a valuable source to be used and developed. Underground space buildings are a new world of people in peace time, and in war time it is an important backing and engineering guarantee for the existence of the people and the preservation of the war ability. However, special underground circumstances and distinctive closed conditions will determine its dependence upon the guarantee of the electricity, which becomes the only necessary energy source of these buildings. But on the other hand underground space buildings have special bad circumstances which will lead to hidden dangers and threats to the safety of electricity. The probability of electric fire to happen in underground space buildings may be increased. This thesis will analyse,

study and inquire into the characteristics, regularity and protection of electric fire disasters at the point of electric safety technique, both in view of the possibility of the electric fire in the underground buildings and the reasonableness to convert danger into safety by the achievement of certain means.

1. THE IMPORTANCE OF FIRE PROTECTION AND CONTROL IN UNDERGROUND SPACE BUILDINGS

The electric fire disaster in underground space buildings happens from time to time. The damage and loss caused by the disaster are very severe. For examples:

(1) In January 21, 1984, there was a large fire disaster happened in Steel Milling Plant of Wu Yan Iron Company in Ping Ding Shan City. The fire was due to the short circuit in cables in underground transformer house. The economic loss caused by the disaster was 1,513,000 yuan in money, and the production was stopped for 120 days, the indirect loss of which couldn't be calculated.

(2) CCTV has reported one biggest fire disaster in underground buildings in our country. It happened at Fu Shan underground commercial centre of Nan Chang City Jiang Xi province in 1988. The total area of the center was over 7,800 square metres; it is a mainstay and window of civil air defence works. Because the insurance mechanism in the interior of a daylight lamp ballast did not work, a short-circuit was introduced. The short circuit current superheated the top board of the wooden cargo cabinet under the daylight lamp and the flammable cargoes piled on the cabinet. The wealth of 5 millions yuan in money was burnt away.

(3) In September 9, 1990, a fire burnt up all the decorative materials and high class stage lamps in Tong — tian Restaurant and Hotel of Snake Mountains of Wuhan City. The fire that burnt up all the organic materials as the veneer board, wood dragon spine and resinous adhesive materials in insufficient evaporated or dry condition was due to the high temperature of the radiation heat from a 200w lamp and the emergency extinction having been given not on time. The lamp was lean against a easy burning decoration plane near these easy burning materials as a temporary light during the stage of decoration. Moreover the electricians disobey the specification and connected electric wires at random without insurance installations. The fire spreaded all over the building and the economic loss caused by the disaster was 300,000 yuan.

All these examples are enough to show that the consequence of the fire disasters in underground space buildings are very severe and out of the ordinary. This is because compared with ground buildings underground buildings have its particular circumstances, which enlarges the danger and gravity of the consequence.

The specific particularities of the fire in underground buildings are as follows:

(1) The fire in underground buildings expands very quickly. Its spreading way and velocity are quite different from ground buildings. When a fire happens, the smoke and heat accumulate to make the ambient temperature rise very rapidly because of the closed conditions. Superheat will build up in some parts of the building and quickly reach 530° centigrade — the explosion point. Comparing with ground buildings, the time for heat to accumulate in underground buildings is earlier and faster, so as to create the so-called Explosion (FO) phenomenon in the field of fire protection. Once this phenomenon appears, the flammable materials in the building will explode to burn at once, and the fire expand all the way at the same time. It may not be the common fire that spreads excessively, as we have familiarized with.

(2) Heavy smoke and high temperature appear in underground buildings immediately. Because of the closed conditions, bad ventilization and lack of oxygen, smoke and heat cannot scatter in time and they are quickly full of the building. Along with the expanding of fire, temperature may rise to 800°-900° centigrade.

(3) Most civil air defence works may situate at people crowded region in order to hide people in war time. Therefore the limited ground space will put difficulties to the fire extinction. Meanwhile, in underground buildings the number of entrances and the ability of the passway are limited. The buildings may be situated in a definite depth and install slope, narrow and curved steps. All these conditions make it more difficult for the people to evacuate and for the firemen to put out the fire. Moreover, when the underground building is in fire, the heavy smoke and high temperature will resist the people to approach the fire. The direction of the population evacuation of ground buildings is downward, yet the direction of underground buildings is upward, the former on safe side and the latter on bad side. The fire smoke and heat of underground buildings are condensed at vertical holes—stairs and electric stairs coincide with the population evacuation current. It becomes even more difficult to do the fire fighting.

(4) If a fire happens in the underground space buildings, the amount of oxygen in air will reduce. The lack of oxygen in air will reduce people's ability to move. When oxygen in air drops to 15%, the muscle activity of human body begins to reduce; when drops to 10-15%, human body becomes weak; when drops to 6-10%, the human being falls in a faint. The above mentioned examples have stated that some people suffered from poisoning and stifling in fire. According to Japanese and English statistics on the causes of death in fire, the people died of poisoning CO or poisonous gases occupies 40-50% of the total number of deaths. So underground buildings must install smoke exhaust equipments that can exhaust most of the smoke and about 70-80% of the heat so as to control the spread and development of the fire.

(5) The technology of fire protection in underground buildings is extremely complicated and difficult. When fire happens in underground buildings, besides the above mentioned smoke exhaust equipments, water supply and drainage must be prepared and run without stop. Because the pressure of city water supply can not satisfy the pressure required by fire protection, it is necessary to increase the pressure in order to run the pumps. Meanwhile, water drainage can not be cut down so as to drain the increasing catchment caused by fire fighting. Therefore the drainage pump must work at the same time.

Underground buildings completely depend upon electric illumination. If fire happens, the light may disappear and darkness may surround you, you then can not even find your way. In addition, in order to avoid the secondary fire, the electric wire must be cut down. Therefore the ordinary working light is stopped and make it difficult to save the people and materials. The emergency light is then required. We can use storage batteries in the emergency light to reserve energy at normal time and to maintain the illumination in accident even if the power supply is cut off.

As for the fire protection means of the underground space buildings, appropriate fire fighting appliances, technical equipments and materials must be equipped. If it simply depends upon the technical equipments for ordinary ground buildings to fight the fire, sometimes we can do nothing about it. The fire protection struggle of the underground commercial center of Nan Chang City as mentioned above continued seventeen hours. So there is no example of fire protection in underground buildings can illustrated that the fire fighting had met with success smoothly.

2. THE REGULAR PATTERN OF FIRE DISASTERS IN UNDERGROUND SPACE BUILDINGS

That the underground space buildings is situated in a special environmental conditions not only add some difficulties to extinction works, but also bring bad

influences and severe attack to electric fire protection.

Underground space buildings situate beneath under the ground, sometimes even immersed in floor water and underwater. If it is dealt with not very well, it may produce water permeation, leak and soaking. On the other hand the temperature of the underground space buildings is close to the temperature of the underground stone and soil. So the difference between temperatures of the underground and above ground is very big. Especially in summer when temperature above ground is very high, the temperature difference is even bigger.

Under ventilation, large amount of freezing water then accumulates on the wall and various equipments, forming special wet and damp environment, which makes the insulator worse to produce short circuit. The short-circuit is proportional to the square of the current, i.e. $Q=I^2RT$. The heat is so great and the temperature may rise at such a rapid pace to make the electric wire melt away and the insulator burn down. Under suitable conditions, inflammables around may burn very easily. On the other hand, the joint point between wires and the contact point between wires and fixed terminals shall produce oxide, mildew and rot due to the wet and damp conditions, and copper green, aluminum mildew and steel rust shall be achieved. Therefore, the contact resistance enlarge obviously, even if electric spark will be produced. Then the insulator will burn down to cause a fire.

Because most insulators are made of flammable organic materials, such as textile of insulating oil, paper, silk, flax and cotton, and resin, asphalt, PVC plastics and rubber, etc. A few kinds of inorganic materials, such as ceramic, asbestos and mica, are the only exceptional examples. Short circuit, overloading and enlarged contact resistance shall make part or the whole of the circuit produce superheating to cause the insulator and flammable materials around to burn.

Because underground space buildings situate underneath, the equipments used for technical guarantee are more than ground buildings. There must be sewage pump, moisture reducing machine, air intake and exhaust machine, etc. The electric light can not leave the underground buildings for a moment. Electric lines and lamps must be in operation continuously. Lighting standard must be better, the number of the lamps must be larger and the time of power supply must be longer than in ground buildings. The high dependence upon electric guarantee and severe conditions of the underground buildings result that the probability of electric trouble, accident and hidden disaster is greater than ground buildings. We must have a clear recognition, scientific manner and rigid means to deal with these problems.

3. THE SCIENTIFIC MEANS OF ELECTRIC FIRE PROTECTION IN UNDERGROUND SPACE BUILDINGS

The so-called electric fire protection is to use modern electric technology in the ordinary fire protection and treatment, in the primary fire investigation and early warning, and in the steps and methods to fight against fire. It is an electric technical guarantee applied to the safety insurance of the underground space buildings. To manage well the electric fire protection, we must obey the scientific principles. At first, we must carry a valuable and practical advanced science of management—Total Quality Control—into the field of fire protection.

National Fire Protection Rules stipulates that the policy of fire fighting is : prevention to be the first and of the great significance, and then combining prevention with fighting; it is necessary to change from simply depending upon fire fighting department to the participation of all the staff; change from fighting after fire begins and defending afterwards to the comprehensive management of beginning with prevention and warning and then fighting.

The study of fire disaster can be divided into three parts: fire prevention, primary warning and fire fighting. In most cases, if an efficient primary reaction

has been established, danger will be turned into safety. So we must set up a convenient and efficient system to carry out the ideas of Total Quality Control. In my opinion, the following means must be put into effect in the field of electric fire protection of underground space buildings.

(1) The establishment of proper multiple-stage guarantee in power distribution system:

In the design and installation of power distribution system, it must establish proper multiple-stage gradient guarantee. We must make every stage of guarantee on duty to improve the sensibility, selectivity and reliability of the protectors so as to ensure the safety of the wire. Ordinarily, there may be three stages in the low voltage distribution. If a breakdown has happened in a certain loop, the failure current can be cut down rapidly. Not only are the influence and inspection area of the trouble reduced but also the protectors above this stage are saved. This is like a safety protective screen to control the failure current. The above example of Fu Shan Underground Centre shows that the light distribution system has incomplete points both in the three phases main current and in each branch line, which had not installed melting down articles.

(2) The improvement of artificial grounding protection system:

The relevant specifications in effect of our country stipulate that industry and civil low voltage power system uses natural or artificial grounding protection of three phases, four wires and neutral natural or artificial grounding which is the traditional single-phases two wire and three-phase four wires method of wire connection. In these connections, protective zero wire and working zero wire are the same line, as may cause the disadvantage of high level in safety guard. It is suggested to use special protective zero wire which is separated with neutral wire. The purpose to add special ground protection is to eliminate the current in protective wire, so as to eliminate contact potential. Once phase conductors touch with each other, the protector will work to cut off the power supply to ensure the safety. According to the specification, it may use conductors of different colours and its cross section may be 1.5mm^2 for copper branch wire and $2.5\text{--}4\text{mm}^2$ for main wire.

(3) The improvement of the protective ways:

Besides the above-mentioned protection, it may be considered to prevent the leakage current, the loss of phase in the three-phase motor, and thunder and static electricity. Moreover it must be suggested to install the protection of electric leakage automatic switch and protective articles in electrical series in a new design, or it may be completed these installations in the old design. That the three phase motors must be practiced the protection of phase cutting down may be a first technical step.

(4) The operation of the fireproof rolling curtain door:

According to the new fire protection specifications the underground buildings must be established the fireproof unit not exceeding 400 square meters in size. But in the large underground buildings it always remains big spaces in order to create a great architectural spaces, which exceed the size of fireproof unit. It is permitted to install rolling curtain of water protection, which is rooled above the door in peace time and shut down in accident. It becomes a moving wall between fireproof units. The curtain can resist high temperature and fire.

(5) The application of automatic wetting fireproof control and alarming equipments:

According to the requirements of the specifications in effect large underground buildings must install automatic wetting fireproof control and alarming equipments.

(6) The selection of combinational multipurpose plug-ins:

In order to avoid the misuse of the plug-ins, it is suggested to use fixed lines instead of temporary ones, and to set enough convenient plug-ins of general and

multiple-functional uses. This method can reduce the probabilities of the electric fires caused by the misuse of the plug-ins.

(7) The application of emergency light:

The specifications of fire protection stipulate that the walls of the underground buildings must be installed emergency waist or foot light at the height of 1 to 1.2m. These light will direct the way for the people lost in smoke and darkness to escape when a light curtain effect begins in the fire.

(8) The selection and laying of cables and wires:

Because the air in underground space buildings is relatively wet and damp, we must choose the copper cored leads as possible as we can. At the same time, it must be avoided to use copper-aluminium leads together with cables, because the electrization and erosion of the connectors of the copper-aluminium leads may enlarge the contact resistance to cause a rapid rise of temperature in some parts of the wires, which will introduce a fire. If the cables are installed in cable channel, it must be separated by fireproof partition wall or non-burning glass steel partition wall. As above mentioned example of the fire of Wu Yan Iron Company, the fire was due to the burning of the cables and the spreading of the fire along the channel.

(9) The methods to ensure the reliability of the power applied to fire fighting:

The equipments of fire fighting must make use of an independent power loop in order to ensure the continuity of the power in fire fighting. Meantime the feed cable and wire must have corresponding fireproof ability with metal protective outside tube or have been installed in non-burning materials.

(10) The preparation of equipments of fire fighting:

It must be installed the dry powder extinguishers which are not electric conductive and can operate with electricity or fire extinguishing agents being used to extinguish fire on equipments. It can not be used poisonous materials, such as CaCl_2 and CO_2 , etc. Otherwise, people may face the danger being stifled and poisoned.

Water is an ordinary fire fighting materials with low price and high efficiency. People always use water to eliminate fire with electricity, because water columns contain leakage current, which is favorable to use. But on the other hand water columns may introduce electricity to harm the operator. If we install a ground protector on the nozzle of the water gun, the danger will disappear.

(11) To observe specifications and regulations; To value experience and practice:

As electric technicians, we must understand, observe and use every specifications and regulations. At the same time, we must sum up our experience in practice to substantiate and develop the truth. The above example shows that the cause of the fire disaster of Tong-tian Restaurant and Hotel was due to disobey or to look down on the technical rule of science, then we had paid high price and unseemly punishment.

Now I shall finish my discussion about the study of electric fire protection in underground space buildings. I do not wish my opinion be considered as something of great significance, but I hope much more emphasises will be put on the electric safety in fire control, because it does be an very important topic. Let all of our electric technicians make a great effort to search for the regularity of electric safety. It is our glorious and sacred duty to maintain the safety of the underground space buildings and of our cities.