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Review of the Research on the Identification of Electrical Fire Trace Evidence

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Abstract

In this paper, we review the research results about the identification of the electrical fire trace evidence and the fire reason recognition. We point out the existing problems and put forward the corresponding suggestions to promote the development of the cause of the fire investigation and make it better to serve for the work of fire investigation.

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Keywords: electrical fire, trace evidence, fire investigation

1. Introdution

With the development of science and technology, the application of electric power is more and more extensive. It doesn't only provide a convenient and comfortable living environment for people, but also become the main energy of power, lighting, heating, control, signal and communication. However, everything has its dual attributes. Fire accidents caused by the electrical hazards and illegal use show a rising trend. According to statistics, from 1993 to 2007, about 373700 electrical fires occurred nationwide. It occupied 24.5% of the total fires on average. From 1997 to 2007, 1324 catastrophic electrical fires occurred nationwide. The direct property losses were about 1.56 billion. They accounted for 31.5% and 44.3% of all major fires respectively. Electrical fires occupied the first place of all types of fires. Electric lines are the main fire sources (almost 50%) in the electrical fires. Secondly, the use of electrical appliances, electrical equipment and electrical facilities is also an important cause of electrical fires. In addition, the lighting apparatus is also very prominent. The main cause of electrical fires is the short circuit fault (about 51%). In the face of severe electrical fire situation, the focus of fire investigation and fire-prevention work is to identify the failure modes and the cause of the fire, to take measures to prevent similar incidents from happening again, to protect people's lives and safety, to reduce the loss of social property [1].

In the remaining traces of the fire scenes, besides the residues produced directly by electrical reasons, in the process of occurrence and spread of fire caused by non-electrical reasons, electrical facilities are in high flame temperature effect, electrical insulation is destroyed, induced electrical accidents such as short circuits continue to occur on the live lines which will leave corresponding residue traces. Therefore, in the process of scene investigation, to find and extract these traces accurately and correctly, to distinguish and identify these traces are very important to determine the cause of fire. This paper mainly summarizes the research results of the cause identification of electrical fire trace evidence in recent years. Some advices are also proposed in this paper in order to promote the development of the actual fire investigation work to some extent.

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2. Research on the trace evidence identification

2.1. Short circuit trace

In fire investigation, we separate short circuit into two types: first short circuit and second short circuit. First short circuit is also called short circuit before fire. It means a short circuit caused by wire due to its own fault before the fire. Second short circuit is also called short circuit during the fire. It means a short circuit caused by electric wire insulation fault under the effect of external flame or high temperature. After a short circuit, all kinds of traces will appear at the short circuit point and around the short circuit point. These traces are called short circuit traces. The common traces include short circuit bead, pit like fuse trace, splash bead, tip fuse trace and fusing trace. Wang Liantie and others produced metallographic samples through simulation test method, and conducted analysis and summarization by means of macroscopic analysis and metallographic analysis. They concluded the trace characteristic rules when short circuit fault happened.

Through the research on the fault mode of the AC (Alternating Current) and DC (Direct Current) power supply line, it is found that the trace characteristic distinction between AC and DC is very obvious: The metallographic structure of first short circuit on the direct current line is mainly based on the fine columnar crystal which has fewer holes. There are two transition regions between the matrix and the end of the fuse trace on the metallographic structure of the circular fuse trace. They exist between the matrix and the fine columnar crystal and between the fine columnar crystal and the coarse columnar crystal. This kind of feature is seldom seen in the structure of first short circuit fuse trace of the AC line. Another obvious distinction is that the metallographic structure of first short circuit fuse trace in the DC line has more dendrite and broken crystal, and very few in the AC line. The macro characteristics and the fuse trace structure caused by second short circuit are basically consistent in both AC and DC lines. The insulation layer at the short circuit point has been totally carbonized. Because of the serious fire, the carbonization degrees of the internal and external layer are basically consistent. Most of the shapes of the fuse trace are circular. The transition region between the fuse bead and the wire is very obvious. The structure of the fuse trace is in the shape of coarse columnar crystal and more irregular holes. There are just more holes inside the second short circuit trace in the AC line.

2.2. Overloaded trace

Overloaded wire will lead to overloaded trace in the whole loop. It is quite different from the short circuit fuse trace at the short circuit point. The temperature will rise when the wire is overloaded. The crystal configuration inside will have a change. The metallographic structure is changed from the original deformed grains to the equiaxed grains. Thus, metallographic structure intensity is greatly reduced. The phenomenon of scarring will appear on the copper wire. The phenomenon of uniform section breaking will appear on the aluminum wire.

The wire where insulation layer exists (often seen below 3 times of the rated current) can be judged whether the heat come from inside or outside through the internal and external surface carbonization discoloration of the insulation layer, through the distribution of grains in the metallographic structure (especially 1.0mm wire). Accordingly, we can judge whether electricity current happens. We can determine the multiples of the overcurrent according to the depth and discoloration of the carbonization, the grain size and the distribution law of the grain and the distribution law of the electric current. As to the sample where fuse traces come into being (Greater than 5 times of the rated current), we can judge whether the trace is caused by the overcurrent or not according to the structure form and the grain size around the transition regions. As to the sample where the insulation layer has been totally burned up, but the fuse trace hasn’t been formed in the line core. A short section of the wire is analyzed, no difference is found between the external heating and the internal current heating. So we cannot identify it. But we can determine whether overcurrent phenomenon exist according to the structure change in the different positions of the same wire [2]. (The overcurrent trace characteristics remain the same across all the line. However, external fire heating trace will make different positions have different characteristics due to different temperature in different positions)

2.3. Poor contact trace

Qi Zibo, Zhang Ming and others conducted experiments of the sockets in the situation of static contact area decrease and contact vibration. They concluded the fire risk of the sockets in the forms above. On the basis of simulation experiments, they analyzed and summarized the extracted poor contact trace using technical methods such as macro analysis, micro morphology analysis, surface composition analysis, metallographic analysis. They put forward the identification technical methods and the criterion for the socket poor contact trace. They come up with the following conclusions: the poor contact of the sockets would bring about great fire risks; the macro characteristics of the malfunction sample were obvious; the