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Chinese Transmission Lines' Icing Characteristics and Analysis of Severe Ice Accidents

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ABSTRACT

In China, atmospheric icing is of great danger to transmission lines. Taking as typical examples several severe ice accidents that have occurred in China in the past 20 years, this paper analyzes the causative reasons and conditions. Results of the analysis show transmission lines' icing characteristics: long duration, high frequency of occurrence, large coverage area and great losses to the national economy, among others. Based on the authors' long-term observations and research on the subject, this paper then categorizes the icing of Chinese transmission lines into 7 different types. In addition, it indicates that hard glaze and mixed rime cause the severe ice accidents.

INTRODUCTION

Accumulation of ice or snow is a normal natural phenomenon, but where transmission lines are concerned, such accumulation will lead to serious accidents.

China is one of the countries whose transmission lines suffer severe icing problems. Two of the features of China's energy-resources distribution is that hydroelectric resources are abundant in its western high-altitude and icing regions, and that 79% of the hydroelectric resources that can be exploited are in these regions (Sun et al., 2002). Due to the particular geographic positions and meteorological conditions, Chinese transmission lines' ice accidents, which mainly occur in the South where there is high moisture, are very serious. For instance, severe ice accidents have occurred in Yunnan Province and Guizhou Province, which lie in high-altitude regions, and such accidents have also occurred in Hubei Province, Hunan Province and Henan Province, which lie in hilly and plain regions in Middle China, respectively. In the past 20 years, numerous ice accidents have occurred on transmission lines, and they can be divided into the reduction of electric insulation strength of insulator strings caused by ice covering, and mechanical damages (such as tower collapse and conductor cut-off) due to excessive ice accumulation.

With the development of West China and the west-to-east power transmission, more and more EHV AC and DC transmission lines will be built to deliver great power from the western high-altitude regions to Middle China, East China and South China, where the economy is highly developed. Hence, the transmission lines in these districts will be confronted with the threat of severe icing problems. The icing will be one of the main factors that threaten the safe operation of transmission lines in China (Sun et al., 2002; Jiang et al., 2002; Wang, 1999; Wu et al., 2002). China began its research on transmission lines' icing in the 1950s and has shown great attention to this field, indicating that the research work has a prospect of important engineering applications. Some investigators have done much work in this field (Teng, 1959; Jiang et al., 2002).

Based on the analysis of severe ice accidents on Chinese transmission lines, this paper puts forward the characteristics of the ice accidents. Taking several ice accidents as typical examples, it analyzes the reasons and conditions that result in severe ice accidents. Long-term observation and significant research have particularly focused on the effect of icing types on ice accidents. We hope this will help reduce the number of accidents and the losses they cause.

ANALYSES OF SEVERE ICE ACCIDENTS OCCURRING ON CHINESE TRANSMISSION LINES

Severe Ice Accidents

The earliest recorded ice accident on transmission lines in China occurred in 1954 (Teng, 1959). In recent decades, severe ice accidents have endangered the safe operation of the power system. Here are several observed from 1987 to 2003:

(1) Two 500-kV AC transmission lines from the Gezhouba Hydro-Power Station to Wuhan cross the Han river at Zhongshankou, Zhongxiang County, Hubei Province, forming a 1600-m-long river span. On February 19–21, 1987, for the first time after the transmission lines were put in service in September 1986, a striking galloping caused by the transmission lines' conductor icing occurred at the overhead line of the large span. During this galloping, vibration could be felt in the towers, the cross-arms were seen swinging windward, and a huge sound from hardware fittings could be heard. All 6 phase conductors were galloping, and the peak value of the 2 upper-phase conductors' galloping, i.e., the amplitude of oscillation, reached 10 m. The same happened to the 500-kV transmission line from the Shuanghe Substation to the Fenghuang Substation. The galloping damaged many hardware fittings and protective conductors. Two of the 3 upper-phase subconductors suffered from abrasion. In that period, atmospheric temperature ranged from $-5°$ to $-3°$; wind speed was about 18 m/s; wind direction was from the north-northwest. Ice accreted on conductors appeared crescent (Fig. 1).

(2) In 1988, from 12:00 am on December 25 to 12:00 pm on December 26, the striking galloping on the overhead line of

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