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Failure analysis on collapsed towers of overhead electrical lines in the region Münsterland (Germany) 2005

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ABSTRACT

End of November 2005 strong south-west wind and heavy snowfall were predominant in the region Münsterland, north-western part of Germany. This led to accretion of a considerable quantity of wet snow to overhead electrical lines in form of snow rolls on the conductors. Eighty-two transmission towers failed catastrophically, most of them by buckling, however some by brittle fracture. As a consequence nearly 250,000 people have been cut off from electrical power supply for several days with major media attention.

This paper describes the forensic analysis in order to investigate the failure cause. Therefore extensive materials investigations, mechanical testing of original components and specimens thereof, estimations for the real wind and snow loads and their combinations, structural analyses as well as detailed evaluations on the basis of previous investigations, literature and regulations were conducted. It was revealed that some of the examined components were manufactured from Thomas steel which was partially in embrittled condition. The investigated towers fulfilled the design codes valid at the time of erection. However the present line loads of the wet snow rolls on the conductors exceeded by far the ones given in the design codes valid at that time.

The load case leading to failure was reconstructed by the derived positions of loads mainly caused by unequal and asymmetric distribution of snow rolls on left and right electrical system. The loads and corresponding stresses acting on the structure before failure were estimated. By comparison with the fracture forces from mechanical testing of original members of the collapsed tower the component that primarily failed was localised. The primary fracture occurred on a diagonal member under tension made of Thomas steel which was weakened by embrittlement. The failure cause was a combination of heavy weather conditions (storm, approx. 0 °C and wet snowfall leading to heavy snow rolls on conductors), asymmetric loading conditions and the usage of Thomas steel which was partially embrittled. Finally, recommendations for avoiding future failures are given.

1. Introduction, failure background, aims of the investigation

On November 25th/26th, 2005 strong south-west wind with storm force (8 Bft. ≈ 18 m/s) and heavy snowfall at a temperature of approx. 0 °C were predominant in the region Münsterland, Germany. Due to these weather conditions wet snow rolls formed around the conductors of several overhead transmission lines. This led to excessive line loads of approx. 5 kg/m, Fig. 1. Some of the covered conductors were sagging to the ground. Eighty-two tension and suspension towers of five different, 110 kV overhead electrical lines collapsed mostly by buckling, e.g. failed catastrophically, Fig. 2. As a consequence nearly

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