基于领结模型的电缆外护层缺陷风险分析

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摘　要：外护层是电缆的第一道防线，外护层的绝缘能力是电缆安全运行的重要保证。近年来广州地区存在大量外护层绝缘电阻偏低现象，因而有必要对外护层存在绝缘缺陷的电缆进行风险分析。建立了以外护层绝缘缺陷为关键事件的埋地电缆和金属支架电缆故障的领结模型，利用前因半领结模型进行原因分析，利用后果半领结模型进行风险分析。结果表明：以外力、固有老化、积水等原因为前因的电缆故障链发展缓慢；重度蚁害和金属护套接地环流异常为前因的电缆故障链发展速度相对较快，发生概率高，最终很可能引发电缆故障。最后，结合风险分析结果和状态评价标准，提出了电缆外护层绝缘缺陷运维策略。

关键词：电缆外护层；绝缘缺陷；领结模型；风险分析
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Risk Analysis of Cable Sheath Defects Based on Bow - tie Model

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Abstract: The outer sheath is the first line of defense of the cable, and the insulation ability of the sheath is an important guarantee for the safe operation of the cable. In recent years, there are a lot of transmission cables whose outer sheath insulation resistance is below standard in Guangzhou. Therefore, it is necessary to carry out the risk analysis of cables with insulation defects in the outer sheath. Bow - tie models of buried cable and metal support cable fault is established with the key event of outer insulation defect, then the causal analysis was conducted using the antecedent semi bow - tie model and the risk analysis was performed using the consequence bow - tie model. The results show that the development of cable fault chain caused by external force, inherent aging and water accumulation is slow, and the development of cable fault chain caused by severe ant damage and metal sheath grounding circulation is relatively fast, and the probability is high, which may eventually lead to cable fault. Finally, combined with the risk analysis results and the state evaluation criteria, the maintenance strategy of insulation defects of the cable outer sheath is proposed.

Keywords: cable sheath; sheath defects; bow - tie model; risk analysis

电力电缆的使用已有多年历史，有些电缆投运时间已接近其设计寿命 30 年，未来将会有越来越多的电缆进入其寿命中后期。近年来广州地区电缆线路外护层绝缘电阻试验分析表明[1]，有 62.7 % 的外护层绝缘电阻达不到规程要求，20.7 % 的绝缘电阻严重降低（绝缘电阻 < 0.01 MΩ · km），说明有较大一部分电缆存在外护层绝缘缺陷。外护层是电缆的第一道防线，其绝缘能力是电缆安全运行的重要保证，因而掌握外护层老化状态并对其进行风险分析，对电缆的正常运行具有重要意义。

应用于电气领域的传统风险分析方法主要是借助评价系统中元件的停运模型，利用一定的分析方法统计系统失效状态及其失效概率，并结合历史故

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