Study Committee B1

Insulated Cables

Paper ID 10276

APPLICATION OF FAULT TREE ANALYSIS TO UNDERGROUND CABLE ACCESSORIES

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Motivation

- The increasing demand for reliable power combined with the attrition of experienced engineers leads to a need for better analysis of equipment failures
- Heat-shrinkable cable joints have been especially troublesome on ComEd's system and have required more detailed analysis than present practices allow

Method/Approach

- Fault tree analysis was proposed as a useful means to describe failure mechanisms
- It is also useful to evaluate the relative probability of different failures and the effectiveness of their countermeasures

Objects of investigation

- Fault tree analysis was applied to heat-shrinkable cable joints
- These joints have had frequent failures and many failed samples were available for evaluation

Experimental setup & test results

- A fault tree was developed for the heat-shrinkable joint based on major modes and causes of failure
- This tree was applied to existing failure histories and the analysis reports were mapped onto the fault tree
- The incidence of defects was scaled up from observations to give system probabilities of defects

Discussion

- Leading causes of failures were found to be water in cable, inadequate heat-shrinking, and mastics out of position
- These causes match the qualitative experience of the failure analysis engineers when examining failed joints in the laboratory
- The nature of fault tree analysis allows much more detail to be provided in the laboratory, but also by the initial fault reporter when fault tree analysis is used as a basis for the field reporting codes

Conclusion

- Fault tree analysis methods can be used to extend a limited set of laboratory observations to describe the state of the system in general
- Very precise causal factors can be identified with this method and then grouped for identifying preventive measures such as improvements to construction methods and training
- Rapid and systematic identification of failure causes makes reliability improvements with limited resources more practical, including changes to material and construction standards, employee training, and manufacturing practices.

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continued

Cable Joint Faults

- An example cable joint fault

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continued

Cable Splice Fault Tree

- This is the main fault tree used for failed cable joints as shown in the previous page
- Many causes have been omitted for space
- The cause of the illustrated fault (poor heat shrinking) can be traced up the tree from event G080 below