

## Failures in underground power cables – return of experience

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### ABSTRACT

For many years, the DNV GL Energy branch on operational excellence (formerly known as KEMA), is performing failure analyses on all types of power equipment. On a regular basis also underground power cables are being investigated. An investigation is normally focused on finding the root cause of failure. An important outcome of the root cause analysis is the identification of required actions aiming to avoid future failures, like improving design, production, installation, testing or service circumstances. The investigation also gives insight in which other components might suffer from the same problem and may have to be replaced to prevent outages, related safety problems, costs and reputation issues. Failures as mentioned above, can be a full breakdown, but can also be a defect found by a diagnostic test. In this paper, common experiences as obtained by DNV GL with failure analyses over many years will be shared with the reader.

### INTRODUCTION

Due to the increasing demand for power, coupled with the geographical expansion of this need, we are more and more relying on the reliability of the grid. The amount of cable installations (both land and submarine) is growing rapidly around the world.

In case of a power failure, it is of crucial importance to know what is the root cause (or are the causes) of that failure. This is due to:

1. Technical reasons. There is a need to avoid a similar failure in the future. So where in the process from design, manufacturing, testing, installation and operation is improvement needed? Knowing the cause of failure is a crucial part in the feedback loop for improvement. Furthermore, knowing the root cause is necessary to assess the risk of failure in similar situations (e.g. same type of components).
2. Economical / political reasons. There can be major consequences for customers, as well as penalties, indirect costs, reputation damage, etc.
3. Insurance. The party responsible for the failure has to be identified.
4. Safety. Related to the chance of a similar failure in the future, what are the safety hazards in case of e.g. different circumstances?

In some cases the root cause of failure is obvious, like in case of digging activities. In many cases, however, a more extensive failure investigation is needed to find the root cause of failure.

In case of a failure investigation, there are often multiple stakeholders involved in the failure analysis, depending on the importance of the connection. Besides the owner of

the cable system (network owner) there is usually involvement of the manufacturer(s), the installer(s), representatives of the users of the connection, insuring companies, et cetera. Since all these stakeholders have different interests there is a clear need for a knowledgeable, independent and impartial party to lead the investigation and that is responsible for the validity of the outcome of the investigation.

DNV GL is fulfilling the role of independent and impartial party for many years already and has therewith built up a wealth of experience in failure investigations. These failure investigations got formalized in the late nineties into an official service called 'Power Failure Investigations'. These investigations are performed on all types of power components, such as transformers, switchgear, lines, isolators, bushings, rotating equipment, all kinds of station equipment, etc. DNV GL adapted a uniform method for such failure investigations and often multiple disciplines need to be combined together for more complex investigation (where multiple components are involved, which is quite regular, and/or network studies are needed). This paper is about the failure investigations on power cables.

Over the years a significant increase in the number of failure investigations on power cables per year is observed as depicted in Fig. 1. A total of approximately 170 individual cases have been recorded over the period from 1997 until the end of 2014. Relevant information from these investigations has been collected and used to create insight in many details, statistics, degradation and failure mechanisms of power cables all over the world.

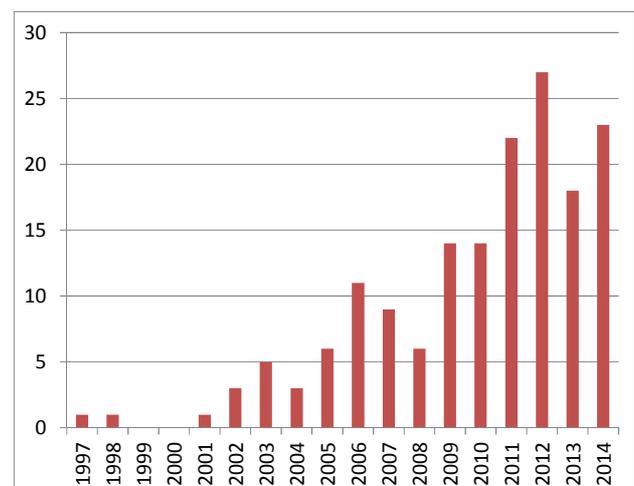


Fig. 1: the number of cable system related failure investigations per year

Due to high confidentiality of this information not everything can be shared in a paper like this. Information that can be traced back to the manufacturer, the network operator or any other involved party will obviously never