Power cables and accessories survey – learnings from type tests, tests after installation and in-service failures

Peter **VAN DER WIELEN**; DNV GL and TU Eindhoven, (The Netherlands), Peter.vanderWielen@dnvgl.com
Hong **HE**, Bernd **VAN MAANEN,** Edwin **PULTRUM**; DNV GL, (The Netherlands), Hong.He@dnvgl.com, Bernd.vanMaanen@dnvgl.com, Edwin.Pultrum@dnvgl.com

ABSTRACT

The failure statistics of pre-qualification, type testing and testing after installation of power cables and accessories from DNV GL's KEMA laboratories are evaluated in order to provide the statistics and learnings. Furthermore, statistics and learnings from failure investigations are provided and the combination of these statistics is being evaluated. The results provide insight into the need for such testing and investigations as well as the difference in performance of these types of components. Comparison is made between cables, accessories, various voltage classes as well as underground vs. submarine cables. Furthermore, insight in the distribution of failure causes is obtained.

KEYWORDS

Power cable; Power cable accessories; Pre-qualification test; Type test; Test after installation; In-service failures; Power failures; Failure investigations; Failure rate.

INTRODUCTION

For power cables, like other components, the life cycle involves engineering, design, manufacturing, testing, transportation, installation, operation and replacement (preceded by failure or not). During these phases, much (inevitable) effort is spent to avoid in-service failures. Next to the various more general quality control and assurance activities, that can be applied during all phases, there are the various testing opportunities. As the various power cable standards recommend, such testing opportunities involve e.g. pre-qualification (PQ) testing and type testing (TT), where mainly the manufacturer's capability (related to quality) and design are tested, routine and sample testing, where mainly the production quality is tested, and testing after installation, where mainly the transportation and installation quality are tested. For submarine cables additional testing, such as harbor testing can be added to this list.

Failures to meet the requirements (like actual breakdowns or other non-conformities; in this paper both called failures) during testing often cause project delays and considerable additional costs (on top of the costs associated with the repetition of the testing itself). Therefore, one tries to avoid these failures during testing as much as possible. This, together with the fact that today, there is a considerable amount of experience with producing power cables and accessories, one might assume that the amount of failures during testing is negligible by now, fading away the need for such testing and reclassifying it as not more than a formality. This is one of the reasons DNV GL's KEMA laboratories nowadays keep track of the number of tests performed, differentiated to voltage class, standard, component type and more, as well as the ratio of successfully tested components, i.e. the ratio of test programs that were passed initially (without non-conformities or failures). Although the confidentiality standard for such tests is very high, revealing overall statistics over the many years of testing can be done in order to share these results and learnings.

Testing after installation (TAI) for power cable systems is getting more and more acknowledged and performed, as one identifies the added value of such testing. It is well known that the insulation system of cable systems (i.e. the cables together with their accessories), considering the accessories, is for the majority constructed in the field during installation. Only a part of the accessory sub-components can be tested in the factory beforehand, but the overall insulation system can only be tested after being constructed/installed in the field. This makes the testing after installation the primary testing to verify the accessory installation (and partly also production) quality. The number of tests, per voltage class, as well as the failure ratio of such testing after installation is revealed in this paper.

Despite all the quality assurance and control activities, like the previously mentioned testing programs, failures in the field are inevitable. Sometimes the root cause of the problem is clear from undisputable evidence, like failures immediately after invoking external damage. Also known ageing mechanisms or previously identified design issues may be known, eliminating the need for further investigation (although in many cases it was worth checking to verify that indeed the new case is alike this previously identified ageing or design issue, as the presumption has been shown to be incorrect various times). In many other cases it is worth performing a (power) failure investigation (PFI) to reveal the root cause of the failure, mainly for three categories of reasons.

The first category of reasons is to identify the party (or person) responsible for the failure, for the purpose of:

- claims (repair costs, indirect costs, penalties, injuries), in relation to insurances, legal cases or not,
- preventing reputation damage (for any involved party: owner, installer, manufacturer, advisor, etc.).

The second category of reasons is a possible obligation of the local or national (often governmental) regulator to have such an investigation being carried out. This can be an economically (market), politically or safety driven institute or administration demanding from one (or all) of the parties to have an independent failure investigation being performed. Regularly, parties order the execution of a failure investigation by an independent party in order to be prepared for one of these first two categories mentioned.

However, there is another, possibly even more important, category of reasons to have a good failure investigation being performed. This third category of reasons has everything to do with the essence of having a learning and quality improving company, set of processes and system. To enable this learning process, one has to monitor the performance (overall, or partly) of the previous set of