Strategies for maintenance and repair of EHV cable systems

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ABSTRACT

One of the main challenges regarding the use of 380 kV cable systems is longer out-of-service times in case of failures compared to the one of overhead lines. Additionally, focus has to be laid on maintenance of cable systems. In the best case, some failures can be avoided or detected in an early stage before breakdowns happen.

In this paper, practical issues are addressed for repair and maintenance strategies of 380 kV cable systems, taking into account grid operation. The paper presents recommendations on measures to minimize the out-of-service times and maintenance aspects.

KEYWORDS

Extra High Voltage Cables, Failure, Repair, Maintenance, Monitoring, Strategy, Reduction out-of-service Time.

INTRODUCTION

In 2011, three grid operators started a joint 380 kV cable research program after receiving common questions about partially integrating 380 kV cable systems in an existing 380 kV overhead line grid without affecting the overall reliability of the grid. Under this cooperation topics such as “Reduction of out-of-service time” and “Quality aspects from cable system point of view” were investigated.

One of the main challenges for 380 kV cable systems is the longer out-of-service times in case of failures compared to the one of overhead lines. In theory, many options exist to minimize out-of-service times in case of cable failures. Practical experience, however, still sometimes show long out-of-service times due to various reasons. This concerns, in particular, repair works on fluid-filled cables as the available knowledge, available skilled personnel and availability of spare parts decline. This situation is unlikely to improve since the use of fluid-filled cables in new installation decreases, because mainly XLPE cables are used.

Besides repair activities, focus has to be laid on maintenance for cables as well. In the best case, certain failures can be avoided or detected in an early stage before breakdowns happen. This eases planning of repair work and can reduce repair times drastically. It seems that in past years, the maintenance aspects for cables were neglected. However, the importance and value of maintenance have risen significantly in recent years.

In this paper, practical issues are addressed for repair and maintenance strategies of 380 kV cable systems, taking into account grid operation. Additionally, focus is laid on the importance of being “best-prepared” for failures. Conclusions are drawn for minimizing out-of-service times and maintenance aspects are presented.

GENERAL ASPECTS

Grids with fully or partially underground cables (UGC) can be less reliable compared to the equivalent fully overhead lines (OHL) networks, mainly due to a possible longer outage time in case of failures.

A previous publication [1] shows that the mean outage time in XLPE UGC systems can be 100 time larger than those in OHL systems (Table 1). (*Note: failure statistics for 380 kV cables are vague due to little available data. Furthermore, certain failures are not included in current statistics.*)

EHV Component	Failure Frequency *[100circuit-km/yr and 100components/yr]*		Mean outage times *[hours]*
	High	Low	
OHL	0.220	-	8
Cable	0.120	0.079	730
Joint	0.035	0.016	
Termination	0.168	0.092	

Table 1 Failure statistics and Outage time UGC vs OHL systems [1]

Hence, when integrating more cables into the grid, considerations shall be given to identify a sound design as well as mitigating measures to minimize such outage time.

Theoretically, the failure frequency of only a UGC without its accessory is somewhat smaller than that for OHLs. However, in practice, the combination of cable system components (e.g. cable sections, joints, terminations) and specific configurations of the circuits may lead to a mean failure frequency, which is larger than equivalent OHL circuits. Hence, incorporating UGCs can influence the grid availability of the transmission system.

The main grid goals of a Transmission System Owner (TSO) are safety and supply of energy. This means that restoring a sufficient reliable 380 kV grid is of utmost importance. Hence, the minimization of the outage time is key and appropriate mitigation measures must be in place. Furthermore, possible risk factors need to be assessed.

To study the effect of adopting partially 380 kV UGC and the mitigation of possible negative effects, practical and academic research were started in 2011. The academic research focused on typical overall grid phenomena like transient behavior, compensation methods, resonance phenomena and proposing mitigation measures based on failure statistics [1],[2],[3],[4]. The practical investigation