

A unique dry 145 kV prefabricated one-piece self-supporting outdoor cable-termination

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ABSTRACT

Historically, the design of terminations for power cables has been based on insulating fluids. However, over the last decades there is a strong trend toward dry technologies replacing the fluid filled designs. Dry designs are today mature and dominating for cable terminations for connection to GIS and transformers up to 550 kV. For air insulated cable terminations, e.g. outdoor terminations, dry designs are mature and dominating for voltages up to about 145 kV. However, for the highest voltages, dry designs are still less common than the fluid filled ones. This paper discusses a unique dry design for outdoor terminations where the conventional insulating fluid is replaced with a soft cured rubber (gel). The novelty with the design is that the termination is prefabricated. That is, the insulation system is manufactured as a one-piece component in the factory. Thus, there is no filling procedure needed in the field. The termination was commercially introduced in 2012. At the time of writing over 1400 units have been delivered worldwide without a single reported failure.

INTRODUCTION

Historically, the design of terminations for power cables has been based on insulating fluids. However, over the last decades there is a strong trend toward dry technologies replacing the fluid filled designs. In this context dry normally means that there is no insulating fluid, i.e. oil. However, dry may also mean that there is no gas other than air, e.g. SF₆,

Dry designs are today mature and dominating for cable terminations for connection to GIS and transformers up to 550 kV. For air insulated cable terminations, e.g. outdoor terminations, dry designs are mature for voltages up to about 145 kV. However, for the highest voltages, dry designs are far less common than the fluid filled ones. Cost is arguably the main reason for this. The difference in cost between a dry and a fluid filled design is far greater with air insulated cable terminations than with GIS and transformer terminations for the highest voltages.

Drivers for dry designs are environmental, safety and technical aspects such as oil leakage during installation and operation, reduced risk of spreading fire in case of damage, no burning oil in trenches or spread out in switchyards or at switchgears, reduced risk of external secondary damage due to explosion shatter, reduced risk of faults in the installation procedure due to easier installation when having pre-tested and fewer parts, possibility to install in any direction, and improved mechanical performance in terms of mechanical load at the connection point. The dry design shall result in a safe, long life time and reliable operation with reduced maintenance cost.

In 2012 a novel type of dry cable termination was introduced. The termination is qualified according to IEC 60840 up to a rated voltage of $U_0/U (U_m)$ 76/132-138 (145) kV. The design is based on a conventional self-supporting fluid filled outdoor cable termination where the fluid is

replaced with a soft rubber (gel). The unique feature of the design is that a hollow core polymeric composite insulator, stress-relief cone and soft rubber are pre-fabricated as a one-piece unit. That is, the insulation system is delivered as one pre-fabricated component. Thus, the termination offers a simpler, safer and faster installation compared with a conventional cable termination. After the cable is prepared, the complete insulation system is installed in one single push-on operation. There is no filling at site. The installation time can be reduced by several hours compared with that of a conventional oil (or gel) filled termination.

This paper discusses various dry-type accessory design-concepts for cables with extruded insulation, e.g. XLPE. The focus is on dry outdoor cable terminations. The unique dry prefabricated one-piece self-supporting outdoor cable termination is described in detail. The paper also reports on six years of problem-free service experience with a total of over 1400 delivered units.

CABLE ACCESSORY TYPES

Cable accessories can be broadly categorized into joints and terminations. Cable terminations can be divided into cable connectors to GIS and transformers and outdoor (and indoor) cable terminations. The latter is also referred to as air insulated type. Figure 1.

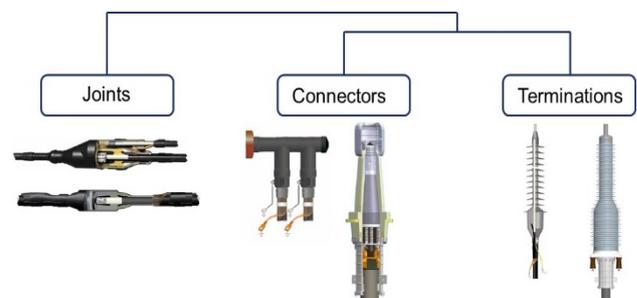


Figure 1. Cable accessories may be classified as joints, connectors and terminations.

Concerning joints, suffice it to say that they are dry technology.

For cable terminations connecting to GIS and transformers, the overwhelming market is now dry technology. For the very highest voltages, the fluid filled type is still (more) common.

For voltages above 123-170 kV, the fluid filled type outdoor cable termination is dominating the market. For the lower voltages, the dry types are dominant.

CABLE ACCESSORY DESIGN TYPES

There are various design technologies for dry terminations. Two major categories are referred to as inner and outer cone type design, respectively. This is true for both cable