MV Insulated cables and screen arrangements: single-point bonding vs solid-bonding

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ABSTRACT

The distribution cables can be operated with their metallic screens in solid bonding (bonded and earthed at both ends) or in single-point bonding (bonded and earthed only at secondary station earthing grid). Each arrangement has pros and cons and the final choice depends upon the cable line length and the earth potential rise of the primary substation. If the distribution network is operated with neutral earthed by an arc suppression coil (or Petersen coil), a first phase-to-ground short circuit gives a low current value (depending on the degree of Petersen coil tuning). In these systems, the sound phases can experience high overvoltages during the fault clearing time so that a second phase-to-ground short circuit can occur in a different phase from the first faulted one. This occurrence is very redoubtable since the short circuit current can be several thousand of amps. The single-point bonding (if applicable) avoids that a great part of the screens is interested by high currents and by their associated I^2t. On the contrary, solid-bonded cables suffer from high double phase-to-ground short circuit currents, which could damage the outer jacket of the cables and lead to the failure with time.

KEYWORDS

Single-point bonding, Solid-bonding, Distribution cables, Double phase-to-ground short circuit, Arc suppression coil.

INTRODUCTION

Medium and low voltage insulated cables play a key role in the distribution network due to their great extension with respect to the overhead lines differently from HV and EHV cables [1-3]. In some Italian distribution grids (phase-to-phase voltages of 15 kV or 20 kV), the underground and aerial cable lines are more than 96 % of the entire network (a meaningful example is the distribution network around Roma). As an average value in Italy the distribution networks are composed of 45 % cable lines. This high consistency of cables justifies a great attention towards the endogenous causes of cable failures. Since the exogenous causes (third-party damages) can be partly avoided by adopting suitable mechanical protections (concrete slabs [4], etc.) together with warning tools (coloured tapes etc.), the internal causes of the power system deserve to be strongly investigated and studied. As it is well known, the failure of the insulating materials is almost always of permanent type differently from overhead lines where the fault can have a transient behaviour. Moreover, the cable time to repair can take several hours so jeopardizing the distribution network continuity of supply (these outages are strongly mitigated by the meshed structure of distribution network even if radially operated).

In Italian technical literature, a considerable effort has been produced to investigate the "cascade failures" during very hot weather (typically during July) [5-7]: the increase of soil thermal resistivity in concurrence with high loads (also due to increased cooling equipment power) can cause an early ageing of insulations. Differently, this paper investigates another possible cause of cable failures which could be mitigated with suitable arrangements of the metallic screens.as separators.

SINGLE POINT BONDING OR SOLID BONDING ARRANGEMENTS

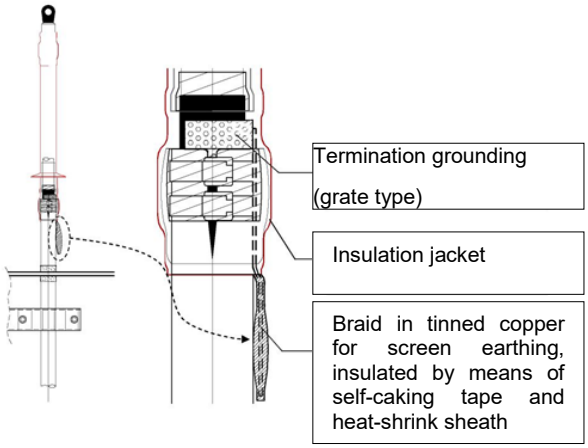

Fig. 1 Terminations with unearthed screens

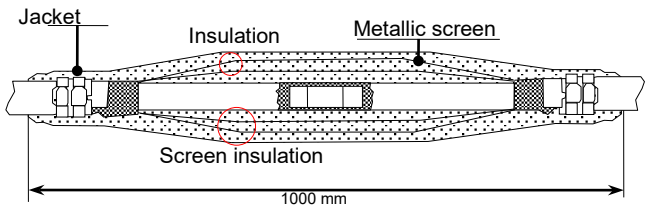

Fig. 2 Medium voltage joint with interrupted screens

When dealing with distribution cables, in the first instance, the solid bonding arrangement is often advocated to be the safer operation since, differently from single-point bonding, there is no floating screens with possible high-induced voltages (the induced voltages in the floating screen terminations depend on the cable length and on the inducing phase currents).

The disadvantage is that during steady-state operation there are induced currents in the screens with consequent power losses, which decrease the ampacity. In order to avoid induced currents in the screens it is possible to resort to the single-point bonding or to the cross-bonding.

Even if the cross-bonding would be the best solution since