B.3.4.

A multidiscipline 35 kV cable failure investigation

ORTON H., FURST G. & BATHO A., Orton Consulting Engineers International Ltd, Canada
RAO A., Powertech Labs, Canada
DE SALVIDAR C., Conductores Monterrey, Mexico
GOMES MORANTE M., Was with Hylsa, Mexico

Abstract

Cable failure investigations must evaluate all facets of cable technology to reach a complete understanding of why and how an underground power cable failed. This paper presents the salient points of a recent investigation into an in-service failure after only several weeks of operation.

Résumé

Les investigations concernant les claquages de câbles doivent prendre en compte tous les aspects de la technique pour obtenir une meilleure compréhension du pourquoi et du comment des défauts des câbles d'énergie souterrains. Cet article présente les points essentiels d'une investigation récente concernant un défaut après seulement quelques semaines de service.

Introduction

Several 35 kV, 500 mm^2 (1000 kcmil) cross-linked polyethylene, copper tape shield, PVC sheathed power cables feeding a new dc arc furnace at a Mexican industrial plant failed shortly after energization. The investigation followed a preliminary work plan and schedule that included a detailed analysis of cable manufacturing, installation, operation methods, failure events, power system topography, operation and power system protection. The work plan provided laboratory analysis to support all studies and conclusions. On site evaluations at both the cable manufacture facility and the industrial plant were carried out.

Electrical System Study

As part of the investigation into the cable failures, a system study was carried out to determine if overvoltages in the industrial distribution network could have been a contributory factor to the failure of the cables. An EMTP (Electro Magnetic Transient Program) study was performed simulating the 35 kV distribution network in detail, including harmonic filters and the step down transformers at the converters. Circuit breaker operations were simulated, and the effect of filters and possible harmonic resonance in the distribution network was examined. The results did not show any overvoltages that would endanger the insulation of the cables. Maximum overvoltages occurred during line-to-ground faults, which caused the sound phase voltages to increase to about the phase-to-phase voltage. This is normal and to be expected in similar systems and should not result in insulation failure. A maximum transient overvoltage found from the simulation was 65 kV peak which compares with the cable power frequency voltage withstand capability of 98 kV peak. The 35 kV system exhibited a natural resonant frequency between 120 and 180 Hz. Due the type of filters installed this is not likely to cause linear or ferro resonance. It is believed that dielectric stresses across the cable insulation did not contribute to the cable failures.

Figure 1 shows the fault current for a single line to ground fault. The current shown is about 1100 A r.m.s. close to the 1200 A recorded during the actual incidence. Figure 2 shows the voltages on phases B and C during the SLG fault on phase A. The voltage rise on the sound phases is 47 kVp, approximately the normal phase-to-phase voltage, 34.5 kV r.m.s.