IMPROVEMENTS OF UNDERGROUND CABLE DISTRIBUTION SYSTEMS IN THE AREA OF MEXICO CITY

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ABSTRACT

Most of the distribution substations feeders in Mexico City have a 300 to 900 m underground link connected to an overhead distribution line. Feeder overloading and cable ageing have created critical conditions which require prompt attention. Thermal modeling should take into account soil conditions and the appearance of possible hot spots enhanced by climate changes during dry season. Modern EPR cables play an important role providing a safety margin. Real time monitoring temperature systems are of vital importance. The basis for the selection of the most suitable temperature monitoring system was also studied and is reported in this article.

KEYWORDS

Underground distribution cables, high temperature insulation, on line temperature measurement, load management

INTRODUCTION

Mexico City is one of the largest urban centers in the world with a high population density. In order to satisfy the electrical energy demands, a vast distribution system is required. The system is made of 96 substations fed with 85 kV transformers banks in the older substations and with 230 kV in those recently installed. The older substations are supplied at 85 kV with 30 MVA transformer banks, but as load demands grew up, 60 MVA transformer banks at 230 kV were required. The transformers reduced the voltage to 23 kV, which is used in the whole distribution system.

At this voltage level, there are two types of feeders, some of them use underground cables entirely, but others use a short underground cable transition from the substation, with a length that can vary from 300 to 900 m, which connects an overhead distribution line. As a general statement, it can be said that hybrid cable feeders have 5 times more failures than the ones where only underground cables are used.

The substations have an average of 9 to 12 feeders, with a current capacity that depends on the number of circuits per duct; when there is only one circuit, the current capacity is 472 A; with two circuits the current capacity is reduced to 402 A, and for three circuits the current capacity is limited to 374 A. Underground cables cross section is standardized to 240 mm^2 and cupper conductor is used exclusively. Current capacities were established in the Specification 40.143 [1], considering 90 ^{o}C-cm/W ground thermal resistivity and 100% load factor and 90 ^{o}C cable conductor temperature and XLPE cable insulation.

Regarding emergency overload conditions, the criteria was to limit current not exceeding 130 ^{o}C in the conductor in no more than 100 hours per year and 1500 hours during the entire useful cable life. It is important to clarify that in practice, when a feeder was out of service, the allowed load on the remaining feeders is the one corresponding to the remaining circuits. For instance, if three feeders are installed and one is out of service, the allowed emergency overload is the corresponding to two circuits. Although most of the distribution feeders are of radial type, the arrangement allows taking the load from an adjacent feeder during contingencies. This load interchange can be made in the substation or along the feeder length.

Up to the mid-eighties, self-contained oil impregnated paper cable insulation was widely used; to date many of these circuits are still in operation. Gradual retirement of skilled workers for oil/paper cables terminations and joints and the introduction of polymeric cables and accessories forced changes in this scenario. Therefore, it was decided to use XLPE cable insulation with standard polyethylene jacket and with no additional moisture barriers.

Regarding cable installation 3 inches internal diameter concrete ducts were generally used. Early this century, it was decided to use 4 inches cable ducts. Phase conductor arrangement and feeders' current capacity according to the circuit numbers [1] are shown in Fig. 1.

DISTRIBUTION SYSTEM FACED PROBLEMS

In recent years, the underground cables of the distribution system experienced a failure increase. There were up to 12 failures per year in the most critical period, in the worst substation. In the majority of the failures, the feeders had a transition to an overhead line. As previously mentioned, the arrangement of the conductors is not symmetrical, but still with a correct phase sequence, the current distribution was reasonable even. After a failure, the spare duct has to be used and with constant failures the arrangement was lost generating uneven overheating in some cables. There are a lot of circuits coming out of the substation in a relatively small area that produce mutual heating degrading the insulation by thermal effects.

Underground cables in hybrid feeders operate under adverse circumstances. The overhead line experience several failures caused by lightning overvoltages; torrential rain and wind; falling tree branches and foreign objects. All of these expose to frequent short circuit currents to the underground cable. Whenever there is a permanent failure, if the substation operator tries to reestablish the service and closes the circuit under fault conditions, the cables experience a short circuit current that contributes to cable insulation ageing.