EFFECTS ON THE QUALITY OF SERVICE OF CHANGING THE NEUTRAL GROUNDING OF MV NETWORKS

Miguel LOURO
EDP Distribuição – Portugal
miguel.louro@edp.pt

José CUNHA ABREU
EDP Distribuição – Portugal
jose.cunhaabreu@edp.pt

FILINTO DUARTE
EDP Distribuição – Portugal
filintofilipe.duarte@edp.pt

Manuel MARTINS
EDP Distribuição – Portugal
manuelnunes.martins@edp.pt

Rui FITEIRO
EDP Distribuição – Portugal
ruimiguel.fiteiro@edp.pt

Filipe VALE
EDP Distribuição – Portugal
filipe.vale@edp.pt

ABSTRACT

In Portugal, for historic reasons, two main grounding practices for medium voltage (MV) neutrals have subsisted until now: grounding reactance; and isolated neutral.
However, the Quality of Service indicators have been worse (on average) in the areas where the MV neutral was isolated. The reader must also consider that line construction; cable construction and maintenance practices were different.
There are also several bibliographic references that indicate that isolated neutral substations do not have a good performance in certain circumstances. This subject is addressed to explain the decision to switch from isolated neutral to grounding reactance.
With the aim of improving the quality of service and creating uniform practices, thus reducing operational costs, EDP has begun a process of installing grounding reactances in the isolated neutral substations.
The aim of this paper is to present the Quality of Service improvements after changing the grounding system of 12 substations (EDP has about 400 substations, 60 of which are still in isolated neutral). In some substations there were significant reductions in interruption times and number of faults in a surprisingly short amount of time.

INTRODUCTION

Due to historical reasons there were two main MV grounding practices in Portugal in early 2008: isolated neutral; and grounding through a reactor. The isolated neutral substations were fewer than their neutral grounding reactor counterparts. In late 2009 some isolated neutral substations were equipped with neutral grounding reactances.
The reasons for changing neutral grounding practices are explained. Quality of Service improvements in 12 substations in which the neutral grounding was changed from isolated to grounding reactor are presented.

REASONS FOR THE CHANGING NEUTRAL GROUNDING PRACTICES

The two main MV neutral grounding practices in Portugal are isolated neutral and grounding through a reactor. However, the Quality of Service of isolated neutral substations has been inferior to the ones with a neutral reactor.
In the course of finding new strategies to improve the Quality of Service, EDP decided to review its MV grounding practices. During this process the internal report [1] was written. This report is mainly based on [2], [3] and several EMTP simulations. The conclusions of [1] state that the network's capacitive contribution for the earth fault current should not exceed 10A (optimistic hypothesis) for the arcing faults to be self-extinguished in isolated neutral. These results were obtained considering Portuguese networks.
A re-occurring arcing fault can, transiently, lead to a high phase-to-ground voltage in the healthy phases and thus stress the network's insulation. This can lead to a "cross-country" fault were an initial phase-to-ground fault causes a high transient voltage in the healthy phases which, in turn, causes another phase-to-ground fault somewhere in the network in one of the previously healthy phases. The result is a phase-to-phase fault through the ground. The fault current of a "cross-country" fault is usually large. Some of the substations in isolated neutral had a high rate of "cross-country" faults.
Most of the substations operating in isolated neutral did not comply with the 10A criterion. This was mainly because of network growth over the years.
In the beginning of 2009 there were about 400 substations in Portugal and only 20% of these had isolated neutral. This situation was not optimal in terms of network operation and maintenance because it involved having different procedures for the 20% isolated neutral substations.
For these reasons EDP decided to install neutral grounding reactors in 12 isolated neutral substations. The objective was to assess the improvements in Quality of Service. The substations were selected to minimize investment cost and therefore implied selecting the most recent substations or the substations where the protection system had recently been changed. The older protection systems cannot operate with a neutral grounding reactance and replacing them is expensive.

RESULTS

In late 2009 eleven substations changed their neutral grounding from isolated to grounding reactor. One substation had already undergone that transformation in May 2009.

Three of these substations were relatively new and had been operating in isolated neutral for less than a year. Therefore, there wasn't enough data for a realistic comparison of Quality of Service.

In the beginning of 2008 EDP changed its geographical division of Portugal and introduced a new incident handling software by the end of the year. To ensure that results could be subject to comparison an observation period of two years was selected. However, substations SS4, SS6 and SS8 were completed in the end of 2008, therefore, there is only one year of data for the isolated neutral period.

The abbreviation SS is used for substation in the figures.

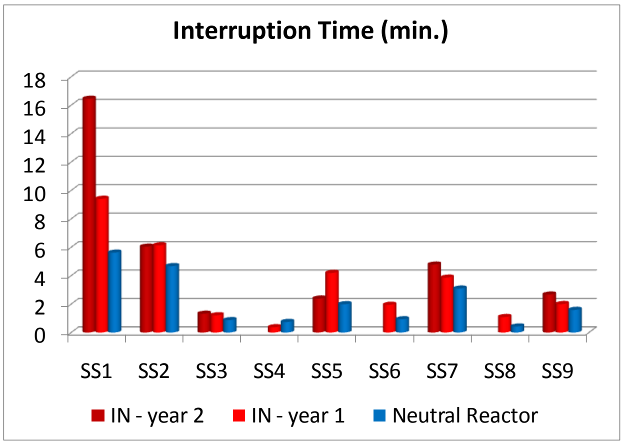

Fig.1 – Comparison between the interruption time in isolated neutral and with neutral reactor

From figure 1 it is possible to conclude that the interruption time decrease for all substations except substation 4. This was probably caused by the increase of network connected to substation 4 during 2009.

There are large reductions in interruption time, most noticeably in SS1, SS5 and SS6.

The interruption time presented in figure 1 does not take in to account occurrences caused by extreme weather conditions (ex.: 200 km/h winds). The time (expressed in minutes) is dependent of the region were the substation is located and should not be use to make comparisons between substations.

The total number of incidents in the network decreased in all substations except for SS4 and SS8 (see figure 2). Again, this increase can be explained by the growth of network in these substations. Both of these began operating with a fraction of the planned network. The network connection projects were completed in mid 2009.

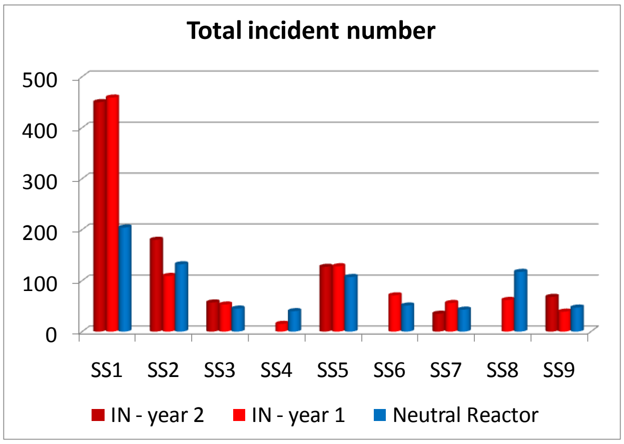

Fig.2 – Comparison between the total incident number in isolated neutral and with neutral reactor

The largest gain was seen in SS1 and was mainly caused by the sudden decrease in the number of "cross-country" faults immediately after the neutral grounding change.

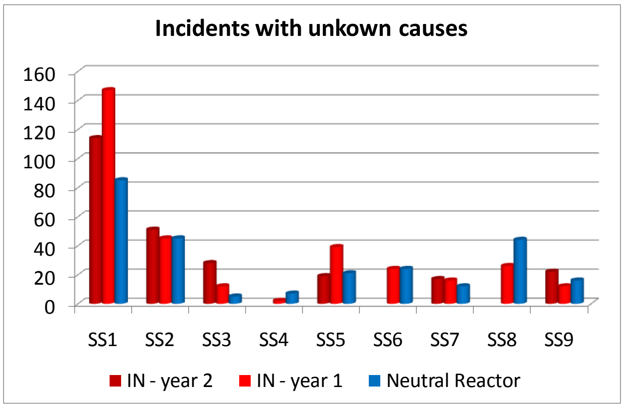

Fig.3 – Comparison between the number of incidents with unknown cause in isolated neutral and with neutral reactor

Sometimes, after a trip, a fault is not found in the network, it is then marked as an unknown fault. This is typically the case with successful automatic reclosures.

Figure 3 shows that the number of unknown faults was reduced, on average, after the neutral grounding reactance installation. SS1 and SS3 have the largest decrease. The exceptions are SS4 and SS8 for the previously stated reasons.

The most noticeable aspect of changing the neutral grounding was the decrease in the network equipment failure. All substations showed improvements in this category even SS4 and SS8. It is probably because of the magnitude reduction of the voltage transients in the healthy phases during a phase-to-ground fault.

In SS1 the reduction was of 85%.

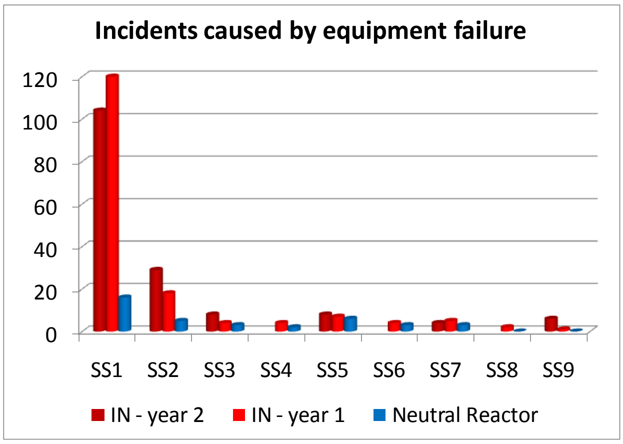

Fig.4 – Comparison between the incidents caused by equipment failure in isolated neutral and with neutral reactor

CONCLUSION

Changing the neutral grounding from isolated to reactor grounding improved Quality of Service by reducing the interruption time and the number of network incidents in the monitored substations. In two of these substations there was reduction of Quality of Service but this was probably due to a significant network increase that occurred in the middle of the isolated neutral observation period.

The improvements were most noticeable in the substation that presented the worst Quality of Service indicators at the start.

Equipment failures were greatly reduced in all monitored substations. In the case of SS1 this reduction was of 85%.

Following these improvements in Quality of Service, EDP is currently changing its entire substations neutral grounding to grounding reactor. This process is expected to be concluded in the end of 2012.

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