EMERGENCY KITS FOR MV DISTRIBUTION NETWORK

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ABSTRACT

The purpose of this paper is to share the experience of EDP Distribuição on technical solutions regarding the mitigation of the consequences of major failures on the medium voltage network. We will present three solutions that were planned, developed and implemented by the company: Emergency Pole Kit, Emergency Cable Kit and LV/MV Mobile Generator. These three solutions were mainly thought to be used in crisis situation, even though they can also be used in scheduled maintenance interventions.

INTRODUCTION

EDP-Distribuição, as the main Portuguese DSO, is continuously making reflections on the best way to act on crisis situations, such as heavy storms, to avoid that consumers have long power interruptions. In the last revision of EDP's Operation Plan and Procedures for Crisis Situations (POAC) some solutions were identified with the purpose of reducing the interruption time.
Multitask investigation teams were created and, in partnership with EDP's service providers, several emergency kits were developed, tested and acquired.

EMERGENCY POLE KIT

This solution was thought to quickly replace damaged poles and also allows the provisional repair of concrete poles that break at 2/3 above ground level.
As request for this solution is the need to be very flexible, easy to store and transport and should allow assembly without the use of heavy machinery. It must also allow easy transportation by hand or using a small pick-up to reach the assembly site. The kit must also allow a wide range of electrical conductors with cross section of up to 160mm^2 and respect national standard EN 50341.
At the end of this project remained three different solutions: Steel Pole Solution, Gantry Solution and the Broken Concrete Poles Extension.

The Steel Pole Solution is a modular pole composed of 3 meters welded construction parts that can be put together enabling a maximum height of 18 meters, supporting a global 1000daN horizontally and 1200 daN of vertical effort. The pole can be used with a maximum angle of 15º.
The pole was designed to be mounted horizontally and then vertically placed. A hinged base with 2 rotation axes was created (Figure 1) to allow the pole to be mounted in a tilted surface.

Figure 1 – Steel Pole and Gantry solution hinged base

To keep the pole vertical it has to be guyed in four points and each cable can have traction from 1 to 5 kN.
To place the pole in vertical position in remote locations sometimes we cannot use a crane so this solution allows the poles to be placed vertically using one auxiliary steel rod which is then be pulled by a tirfor or a winch (Figure 2).

Figure 2 – Pole being raised by tirfor

The final result is shown in Figure 3.

Figure 3 – Steel Pole on design stage (left), example of final steel pole solution (right)

On the **Gantry Solution** we have used similar design and construction from the Steel Pole Solution. The Gantry Solution was thought to replace angled poles with a maximum angle of 45º and also support a 2500daN of global horizontal force.
We achieved this result by using two modular poles like the previous solution with an upper connection between the poles (Figure 4).

Figure 4 – Gantry solution upper connection

The pole uses the same hinged base and it also needs to be guy-wired. It also has a maximum height of 18 meters and supports electrical conductor with cross-section up to 160 mm^2.

This Gantry can be vertically placed using the same previously described methods. In Figure 4 the pole is being placed on vertical position using two tirfors simultaneously.

Figure 4 – Gantry solution being **vertically** placed

The **Broken Concrete Poles Extension** is a modular structure that suits different pole dimensions which enables the pole extension when it breaks on the upper end. It allows an extension of 6 meters from breaking point and can be used with electrical conductors with cross-section up to 160mm^2 and supports a global 1000daN horizontally force and 1200 daN of vertical effort.

Figure 5 – Example of broken concrete poles extension solution

The emergency pole kit is stored on shelves and there is one box for each pole with all the accessories needed to assemble the pole on site (Figure 7). To assemble one of these solutions all we need is one box and the number of elements required to achieve the desired height.

Figure 6 – EPK storage.

In total, EDP Distribuição has put together three Emergency Pole Kits, spread across Portugal, in three strategic locations to be used on emergencies or scheduled jobs.

EMERGENCY CABLE KIT

One of the solutions intended to reduce the impact of the long power cuts is the **Emergency Cable Kit (ECK)**.
This kit was envisioned, designed and acquired as a reliable and robust solution to bypass medium voltage faulted circuits (either underground cables or overhead lines) thus quickly restoring the power to the distribution substations affected by the fault. Once established, this temporary bypass allows the definitive repair to carry on without customer outages.
This solution is intended to be installed and ready to use in a short period of time, possibly replacing the extended

time and the considerable costs of generators.

The most important component of the ECK is the cable, which is used for both establishment options available for the kit (as depicted in Figure):

- **Laying directly on the floor;**
- **Aerial establishment in wooden poles.**

Figure 8 – Installation options: laying on the floor (left) and aerial establishment (right)

The cable used has an EPR insulation – which makes it more flexible to handle – and a copper conductor with a cross-section of 95mm^2. It is designed for voltages up to 30kV, and it has a 310A current rating.
The cable is rolled in three-phase cable drums, each containing 3x250m of cable. The kit has four such cable drums, which means that the total maximum length of the bypass created with the ECK is 1000m. The number of used cable drums depends on the length of the required bypass, which can therefore be of 250m, 500m, 750m or 1000m.

To allow this cable to be connected to different installations of the MV grid, the kit also has four types of 10m terminal cables, suitable for all the MV distribution substations connections as well as for connection to an overhead line. The connection scheme is depicted in Figure 9. This fact provides the ECK with both a flexibility of use and a guarantee of compatibility.

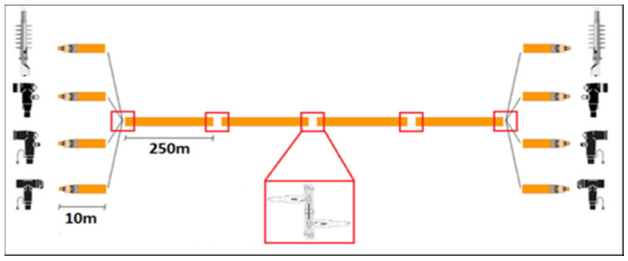

Figure 9 – ECK connection scheme

At each end of the long main cables and at one of the ends of the terminal cables we have premolded reusable separable connectors, which are coupled with a coupling reusable connector. This coupling is set in a plastic pallet, to protect the connection from external damages. The fitting of the connectors is simple and robust and can simply be untied when the bypass is withdrawn, for use in the following kit installation.

Apart from the cables, the ECK also comprises a significant amount of equipment, for both installation options.

Laying the cable directly on the floor is an appropriate solution for use in cities, along sidewalks and across streets and roads.
In installations in urban areas the main concern is not only to ensure the safety of the people and the goods but also to minimize the impact on populations of the presence of the cable.
Hence, the ECK has two kinds of cable protectors:

- For vehicle crossing – to lie across a road;
- For pedestrian crossing – to install along a sidewalk to allow the circulation of pedestrians on foot or in wheelchairs.

The kit also has cable blocks, to fix the cable along its track as well as red plastic safety barriers, to signal the presence of the cable, confine its path and prevent contact with pedestrians, as illustrated in Figure 10.

Figure 10 – Pedestrian crossing cable protectors (left) and safety barriers along the cable (right)

The **aerial establishment** is fit for use mainly in rural areas. This setting uses 8m wood poles, at the top of which a tensioned steel wire is mounted. This steel wire holds metal clip-on ring supports, through which the cable is passed, as seen in Figure 11. The maximum recommended distance between the poles is 40m.
The wood poles are set in metal bases (shown in Figure 11), fastened to the floor by steel anchor bars and stabilized with guy-wires also fixed to the floor by anchor bars.
This configuration can also be used in urban areas to transpose road crossings, in which case the base of the pole can be fixed using a concrete block.

Figure 11 – Ring supports with cable (left) and metal pole base (right)

The ECK is stored in two 20 feet containers, making it easier to carry them to a fault location. The equipment of the kit is stored so that each container is dedicated to one of the installation options: one for the direct laying on the floor and the other for the aerial setting. The containers hold inside the proper respective equipment for the installation as well as two cable drums and some handling devices, such as cable drum jack and shafts and a hand pallet truck. Each container weighs around 10 tons and is intended to be transported with a crane truck.
The only equipment of the ECK not stored in the containers are the wood poles and the safety barriers.

The ECK hence provides a turnkey solution, as all the components necessary to apply the solution are included in the containers.

In total, EDP Distribuição has put together three Emergency Cable Kits, spread across Portugal, in three privileged locations. The fact that these ECK are similar to each other makes it possible to assemble the kits and set a bypass up to 3000m long, if there is a need.

LV/MV Mobile Generator

The LV/MV Mobile Generator (Figure 12) was designed in order to provide EDP Distribuição with technical resources that enable the company to have a better response in crisis situations in the MV Network.

Figure 12 – LV/MV Mobile Generator

The most common solution used to mitigate the impact of faults in MV Network is the use of small generators connected directly to the LV side of secondary substations, that is, one generator feeds one secondary substation. What if there is a major fault that causes a severe outage of a group of secondary substations? And, what if the fault is so severe that a long time will be needed to fix the failure? Looking at these aspects EDP Distribuição developed a solution, as it couldn't be found in the market: the LV/MV Mobile Generator.

In the LV/MV Mobile Generator some equipment was added to a LV Diesel Generator: one MV/LV Transformer (working as an elevator – LV/MV), a MV switch gear, 3x50 meters MV cables, a 40 ft cargo container and one semi-trailer. The general working principle of the LV/MV Mobile Generator is to produce energy with the LV generator, elevate the voltage in the transformer from LV to MV and then inject the energy directly in the MV network. This way, instead of allocate one LV generator, connected in the LV side of each outage secondary substation, we will connect the LV/MV Mobile Generator to the MV network and feed a group of secondary substations affected by the failure (as shown in Figure 13).

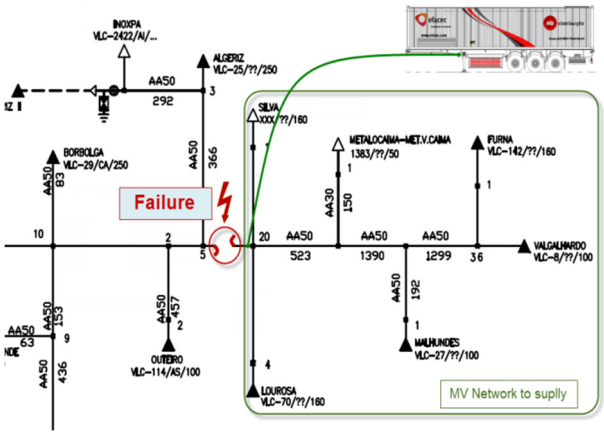

Figure 13 – Example of Mobile Generator installation

The designed solutions took into account the following:

- Power to supply
- Medium Voltage Levels
- Dimension of the equipment

Power to supply – two solutions were designed, one with a 630 kVA and other with 1250 kVA transformer. In this case the criteria is related only with the cost of the central that is, the decision is purely financial. Obviously the 1250 kVA Mobile Generator is more expensive than the 630 kVA, because of the generator and the transformer. However in some cases the decision can also take into account technical reasons, for instance the dominance of loads of a determined area of the network.

Medium voltage levels – EDP Distribuição has three different medium voltage levels: 10, 15 and 30 kV. Therefore, there were designed solutions that would allow that each Mobile Generator can be connected to two different MV levels. Transformers with two levels in the MV side were used.

Dimension of the equipment – in the design of the Mobile Generator, the dimension of the equipment was only an issue for the 30 kV voltage level, as the equipment is bigger and the area is limited by the size of the 40 ft container.

Three solutions were designed and built:

- 630 kVA – 10/15 kV
- 630 kVA – 15/30 kV
- 1.250 kVA – 10/15 kV

The choice of the three different typologies was made by analyzing the proximity of the three voltage levels networks that in crisis situations may need to be supplied. As in most of the network the 30 kV is not near the 10 kV, the 10/30 kV solution was not considered.

The disposition of the equipment inside the container is made always in the same way, as shown in the Figure 14.

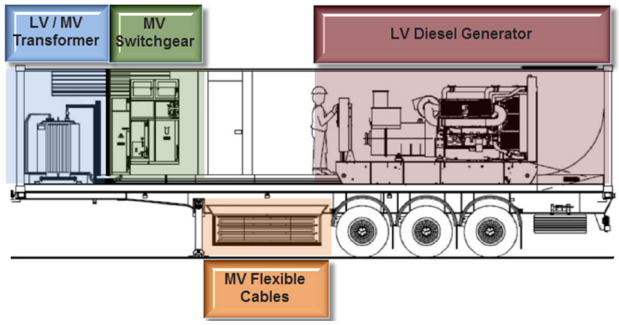

Figure 14 – Disposition of the equipment

The line diagram is as follows (Figure 15):

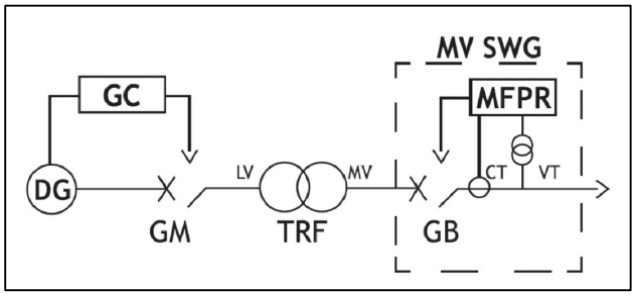

Figure 15 – Line diagram

DG – Diesel Generator
GC – Generator Control
GM – Generator Master Cut
TRF – Elevator Transformer
MV SWG – MV Switchgear
MFPR – Multi Function Protection Relay

The central main features are:

- MV/LV Transformer (connected as elevator) with mineral oil insulation:
- MV switchgear with vacuum breaker;
- Isolated neutral in the MV;
- Protection Relay with the following features: Under/Overvoltage, Under/Overfrequency, Neutral voltage displacement, Instantaneous phase overcurrent, etc.;
- Mechanical interlocking between switchgear, generator and transformer compartment;
- 8 hours full load autonomy for 630 kVA units and 4 hours for 1250 kVA.

CONCLUSIONS

All technical solutions that can minimize the outage time of a Medium Voltage Network in crisis situations, such as heavy storms, are of extreme importance, therefore EDP Distribuição have made in the past years a huge effort on developing the described "tools": Emergency Pole Kit, Emergency Cable Kit and LV/MV Mobile Generator. Besides the cost of the equipment itself a lot of engineering time was used to achieve balanced solutions such as the presented.
One of the main concerns of the design and acquisition of this equipment was the ease of handling and installation, which are often critical aspects of the repairs in emergency situations.
EDP Distribuição is convinced that in case of need this equipment will help the teams in the terrain to have more solutions on failures repair and minimize the outage.

It should be noted that all the field tests and the applications of these solutions in real emergency situations were very successful. This fact, together with the positive reaction of our service providers, shows the ultimate success of all the hard work carried out by EDP Distribuição of designing, specifying and implementing these solutions.

REFERENCES

[1] Manual utilização PowerPuc – EFACEC
[2] JJTomé, 2013, "ECK user guide", JJTomé Manual
[3] Metalogalva, 2014, "EPK user guide"