ABSTRACT

The distribution network of Electrabel in Wallonia has been managed by five different zones. Each one was responsible for the choice of equipment, techniques, methods and operation of its network. There was no common strategy for the whole network (business unit).

With the creation of a centralized technical department for the whole business unit, a standardisation process was set up.

For control and protection of the MV network, standards and policy have been defined, bearing in mind simplicity and cost effectiveness.

When considering the protection of a feeder, a clear rule specifies the kind of protection scheme to use and the settings without any need for computation. The only important parameter is the architecture of the network.

For remote control, rules help to choose the stations that have to be controlled and which of their elements should be controlled.

To allow standardization of the hardware and of its integration, categories of protections and sizes of RTU’s are defined. For each one of these, standard wiring schemes are set up.

The goal of this paper is to present the standards and policy defined for control and protection of the MV network and their advantages.
POLITIQUE DE CONTRÔLE ET PROTECTION DU RÉSEAU MT
ASPECTS TECHNIQUES ET FONCTIONNELS

Y. Laperches - M. Braipson - P. Parent - R. Hatert

Electrabel Distribution Wallonie - Belgique

RESUME

Le réseau de distribution d'Electrabel en Wallonie était précédemment géré par cinq zones différentes. Chacune d'elle était responsable des choix en matière d'équipements, de technologies, de méthodes et d'exploitation de son réseau. Aucune stratégie commune pour l'ensemble du réseau wallon n'était établie.

Avec la création d'un département technique centralisé pour l'ensemble de la Wallonie, un processus de standardisation a été lancé.

Pour les aspects de contrôle et de protection du réseau MT, des standards et une politique ont été établis dans une optique de simplification et de réduction des coûts.

En matière de protection des feeders, une règle claire définit le schéma de protection à utiliser ainsi que les réglages à appliquer sans que des calculs ne soient plus nécessaires. Le seul paramètre à prendre en considération est l'architecture du réseau.

En télécontrôle, des règles spécifient quelle cabine de transformation et quels éléments de cette cabine il faut télécontrôler.

Afin de faciliter la standardisation du matériel et son intégration, des catégories de protections et des gabarits de postes subordonnés (RTU) sont établis. Pour chacun d'eux, un schéma de câblage standard est prévu.

Le but de cet article est de présenter les standards et la politique définis pour le contrôle et la protection du réseau MT et leurs avantages.
INTRODUCTION

The distribution network of Electrabel in Wallonia has been managed by five different zones. Each one was responsible for the choice of equipment, techniques, methods and operation of its network. There was no common strategy for the whole network (business unit).

As a legacy of the past, the existing network is controlled by different types of Remote Terminal Units (RTU), communicating with different protocols over different types of communication media. No common rule existed to choose which distribution station to equip with a RTU and what the latter should control.

The situation for protections was exactly the same: different relays were used with different functionalities and different settings. No common rule for protecting the network did exist.

With the creation of a centralized technical department for the whole business unit, a standardisation process was set up with the following objectives:

- make maintenance and installation easy for centralised teams;
- meet the obligation to buy the equipment through the procedure of European tenders;
- simplify the inventory of spare parts;
- cut the costs of investments and maintenance;
- have rules to justify the investment policy towards the future network regulator.

The goal of this paper is to present the standards and policy defined for control and protection of the MV network and their advantages.

The choices made are based on the experience acquired in the field throughout the years and aimed to get simple and cost effective rules and methods.

The MV network under consideration supplies 1.25 million customers. 50% of the network is composed of overhead lines. It is fed through 150 HV/MV substations and the LV network is fed through 25000 MV/LV transformer stations. Among these stations, 350 are remote controlled. The number of protection relays is 5000.

PROTECTION POLICY

The MV network in Wallonia is mostly radial with open loops. Only a small part is meshed. The neutral is mostly grounded through an impedance. Both urban (underground) and rural (overhead) networks are present.

For the sake of simplicity and partly because of a lack of data, the rules used in the policy are kept simple so as to limit the need for calculation.

The present state of the network protection is still very heterogeneous. The here defined policy aims to review and adjust the protection’s settings.

Underground Networks

For purely underground networks, an overcurrent protection is used.

The time-current characteristic used is constant time. The selectivity is chronometric, the time (t) being decreased by 0.3 seconds at each step of protection from the source to the end of the feeder. Usually the number of protection steps is limited to three.

The current setting (I>) is defined by the weakest cable portion to protect. The load capacity of this cable gives the setting.

Automatic reclosers are never used with underground networks.

The short circuit current setting (I>>>) of the relay is sometimes used when the section of the cables to protect is very small and the short circuit power is high. The use of this setting is limited to the first step of protection in order to avoid the need to change the relay’s settings when the structure of the network changes.

Overhead Networks

The network behind a breaker is considered to be overhead only if it doesn't contain more than one kilomètre of underground cable.

The protection used for this kind of network is a combination of an overcurrent and an earthfault
For the earthfault protection, a sensitive inverse curve is used (see figure 1).
The advantage of such a particular curve is that it allows tripping for very low values of the earth current while allowing a cascade of protections with a good selectivity.
Its major drawbacks are its cost and the need to place a dedicated sensor measuring the real earthfault current.
The selectivity is made by using a different curve for each protection step together with different current levels (see figure 2).

Due to the very sensitive tripping of this kind of protection, an automatic recloser is mandatory. The reclosing cycle is set to reclose two times after the first tripping: the first time after 0.4 second and the second after 30 seconds.

**Mixed Networks**

When overhead lines are mixed with more than one kilometre of cable, the network is said to be "mixed".

In this case, the same rule as for overhead networks is used (overcurrent and sensitive earthfault protection) if the length of underground cables behind the protection is not too important (a few kilometres).

When the cable portion becomes more important, the earthfault current is used with a constant time-current characteristic instead of an inverse characteristic. The reason is that the contribution to the capacitive zero sequence current of the cable portion can lead to untimely tripping when faults occur on neighbouring feeders.

The use of automatic reclosers with this kind of network is much debated. On the one hand, security reasons tend to forbid their use because of the presence of underground cables. On the other hand, operational reasons tend to impose them to avoid excessive interruption time due to the frequent fugitive faults on the overhead sections.

In the absence of rules on this matter, each case is individually considered and a compromise is made.
Benefits of this Policy

The advantages of such simple rules are:
• no need for computation when determining the settings;
• no need for resetting the relays when extensions of the networks are made;
• very simple maintenance (test of the relays) which can be done by less skilled technicians.

Selection of Relays

Because the range of needed protective functions cannot be covered by a single type of relay, five categories of relays have been defined:
• overcurrent relays without automatic recloser;
• overcurrent relays with automatic recloser;
• differential relays;
• directional relays;
• distance relays.

The use of categories allows the definition of a limited number of standard wiring schemes. It also helps to determine the required functions and range of setting of the relays when launching a tender.

The policy described above make use of the first two categories. The other three are used for less frequent protection schemes.

All the relays must be registered by Electrabel laboratories. This registration ensures that the chosen relays meet defined standards for performances, interface, endurance, electromagnetic compatibility (EMC), precision and are well documented.

REMOTE CONTROL POLICY

When considering the remote control of a network, two kinds of RTU’s can be defined. The first kind is the "classical" RTU used where there are sufficient devices to control, enough installation room and where the availability of the control is important. The second kind is the "small" RTU used where constraints of size and budget are important, where the number of devices to control is small and where availability is not so important. This paper deals only with the "classical" kind of RTU.

Dialog with the Control Centre

The existing RTU’s are communicating with four different protocols: TG800, TG065, Tracec, Modbus. Two media of communication are used: permanent lines or PSTN (switched telephone lines).

Due to its lack of availability, the PSTN mode of communication is only used for the smaller stations. No protocol has currently been standardized for this kind of media. Both TG800, Tracec and Modbus are employed.

For bigger stations, the TG800 protocol has been chosen as a standard and permanent lines are used.

Control Signals

Stations usually contain the same type of devices. Only the layout and the number of devices differ from one station to another.

For remote control purpose, standard cells have been defined:
• Switchgear without relay;
• Switchgear with relay (five types of cells based on the five relays categories);
• Common information;
• Transformer.

Each kind of cell uses a standard set of controls, digital and analog signals. Each one of these has a precise fixed short name. This allows the reported information from the stations to look all alike at the control centre. This standard serves also as a guideline when conceiving a remote control. Each device of the same type in all the stations will be controlled in a similar way.

As an example for a breaker with an earthfault protection and automatic recloser the standardized set is:
### Table

<table>
<thead>
<tr>
<th>Type of signal</th>
<th>Status</th>
<th># of bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td>Open/close</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Recloser inhibit</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Earthfault inhibit</td>
<td>2</td>
</tr>
<tr>
<td>Digital</td>
<td>Device's Position</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Recloser inhibit</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Earthfault inhibit</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Relay fault</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Fault detected</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Spring fault</td>
<td>1</td>
</tr>
<tr>
<td>Analog</td>
<td>Value of Current</td>
<td>--</td>
</tr>
</tbody>
</table>

In the above table, common information means that there is only one common information transmitted for all the cells of the station.

### Sizes of RTU’s

The suppliers often offer a range of RTU's depending on the size of the station to remotely control. To make it easier to choose the size of the RTU for a specific station, a classification depending on the size of the station has been set:

<table>
<thead>
<tr>
<th>Size</th>
<th>Number of cells in station</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>1 → 4</td>
</tr>
<tr>
<td>A2</td>
<td>5 → 8</td>
</tr>
<tr>
<td>B</td>
<td>9 → 16</td>
</tr>
<tr>
<td>C</td>
<td>17 → 25</td>
</tr>
</tbody>
</table>

The number of cells taken into account is the maximum number that the station can contain, including the unequipped cells. This avoids the need to replace the RTU when an extension of the station is made.

The size also defines the cubicle and its integration in the general layout of the station. This aspect is explained later.

### Rule for Remote Control

In order to give guidelines for the choice of controlling or not controlling a station, a rule has been defined. It is based on an economical balance between the cost of investment and maintenance of the remote control and the costs induced by the outages if no remote control is present.

There are two kinds of induced costs:
- penalties imposed by the regulator on the network manager for undelivered power;
- costs of on-site intervention to restore power.

The first kind is far more important than the second.

The economical balance yields a rule based on two criteria:
- the accessibility of the station (in hours);
- the power that can be immediately restored remotely (in MW).

If the accessibility and the restorable power are above the levels shown in figure 2, the station must be remotely controlled.

A complementary criteria is the presence of sensitive customers i.e. customers for whom the consequences of outages can endanger human health (e.g. hospitals) or lead to costs far above the penalties (e.g. industries with continuous process).

If a specific station falls in the "no remote control" area of the diagram and sensitive customers are present behind this station, it can be decided to remote control the station after all.

### INTEGRATION PRINCIPLES

The integration of the remote control and protections in a station is based on the use of a system of interconnected elements. These elements are: the remote control cubicle, the protection cubicle, the MV cells.

Each element is assembled by the supplier in his factory following standard guide schemes. The guide schemes are defined by Electrabel and are supplier independent.

For the remote control, the guide scheme imposes the overall organization of the cubicle in which the RTU and its auxiliary elements have to be installed. The cubicle is always pre-wired for the maximum capacity of the station, even if all the I/O cards are not present.

Depending on the type of cells in the station, the principle of integration of the protection relays is different. For metal enclosed cells, the relays are...
integrated in the LV closet of the cell. For open cells, relays are integrated in a cubicle. The integration of relays is done following guide schemes as for the remote control.

In order to optimise the space occupation in the station, remote control and protections are integrated in cubicles in a way depending on the station’s size:

- size A1, enclosed cells: mural box for the RTU;
- size A1 and A2, open cells: common cubicle for the RTU and the relays;
- other combinations: separate cubicles for RTU and relays.

On site, each element is interconnected with the others using standardized connectors. A simplified interconnection scheme is shown on figure 3.

![Figure 3 - Principle of interconnection.](image)

This system of interconnection allows to fully test each element in the factory before on-site assembly.

When testing a RTU in the factory, a breaker simulator is connected to the cubicle and all the tests of the interactions of the RTU and the cells (controls and signals) is made quickly and completely.

The same applies for the protections cubicle where simulators are also connected to allow the test of the protections.

The cubicles being completely tested in the factory, on-site tests limited.

During operation, thanks to the system of connectors, each element can be tested separately without the need to interrupt the service of the station.

Assembling in the station is also greatly simplified by the use of this technique.

CONCLUSIONS

With the policy outlined above, the control and protection of the network have been simplified and standardized.

When considering the protection of a feeder, a clear rule specifies the kind of protection scheme to use and the settings without any need for computation. The only important parameter is the architecture of the network.

For remote control, rules help to choose the stations that have to be controlled and which of their elements should be controlled.

Once these steps are done, the ordering of the hardware and its layout are very simple. The size of the station and the devices it contains automatically determine the hardware, its wiring and its settings.

The remaining tasks consist essentially in the factory and on-site reception of the hardware.

The standardization of the hardware and of its integration has been the basis of a technical specification for a European call to tender. This call to tender has been issued in fall 2000 and contracts should be awarded by mid-2001.

On the functional policy side, a general review of the entire network protections is taking place with a view to adapt the settings and to pinpoint the locations where investments should occur.

For remote control, the standardized control set has been used for 2 years with success. The rule for the choice of the to be controlled stations is still being tested.