A LOW-COST HIGH PERFORMANCE MV RMU WITH CIRCUIT BREAKERS FOR USE IN REMOTE CONTROLLED MV-LV SUBSTATIONS

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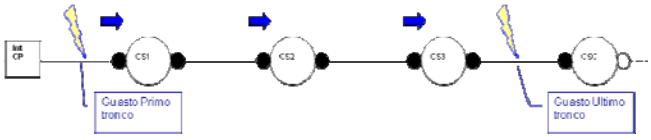
ABSTRACT

In order to achieve the quality of service aims set by the Italian energy market regulation authority, Enel Distribuzione has implemented an efficient and highly effective automatic fault detection system in its MV (Medium Voltage) network. Its performance and upgrade possibilities are influenced and sometimes limited by the characteristics of the switchgears currently installed in the network and by environmental pollution related problems. To overcome these limits, different network components are needed, hence the specification, test and adoption of a new high performance gas insulated MV switchgear.
These new switchgears have been conceived by Enel Distribuzione after the excellent feedback come from the field with same concept air insulated switchgears that are encouraging and completely in line with Enel Distribuzione first expectations.

CONTENT

Currently the energy regulated market is highly focused on quality of service and customer supply continuity. In Italy, the AEEG, Authority for Electric Energy and natural Gas, sets the rules for the energy market and controls the performance of the energy suppliers, enforcing the quality of service requirements by means of a fine-reward mechanism based on various key performance indicators (KPI). One of the most important KPIs used by the AEEG to assess the utilities' performance is the cumulative duration of long lasting supply interruption per LV customer and the number of interruptions per LV customers. The time limit for a supply interruption to be classified as "long" is currently set at 180 s. As a consequence, it is absolutely crucial to limit long duration supply interruption to the furthest possible extent and to limit the number of interruptions per LV customers.



To accomplish this, two simple strategies can be used: to reduce the time necessary to find and isolate the fault keeping it as short as the 180 s deadline and, once the fault is found, to minimize the number of customers affected by the fault, that is, roughly, to minimize the length of the network section that must be shut off to isolate the fault.

Those two strategies are reflected in the automatic fault detection system which Enel Distribuzione has implemented and has successfully been using for many years in its medium voltage network. Depending on whether the network has neutral ground or not, one among two comparatively simple algorithms is automatically operated thus allowing to detect and localize any fault within a single section of MV power line. Such a system has proved itself to be extremely effective, dramatically reducing the cumulative duration of customer supply interruptions per customer.
The second important issue, not be underestimated is the environmental one which has a significant impact on the quality of service, especially in coastal and industrial areas due to salt contamination and chemical pollution respectively.

TECHNOLOGICAL ISSUES

Despite the efficiency of this system, careful consideration must be placed on the distinctive nature of its network components which poses some limitations to its performance, and reliability, whilst restricting the opportunities for upgrades and evolutions.
We will focus on the characteristics and limitation of MV switchgears and the solution that has been proposed to overcome these obstacles.
Essentially, there are three limiting factors: switching time, making-and-breaking rated currents and the electrical and mechanical endurance of the switchgear.
The switching time, i.e. the interval between a command and the completion of the correspondent operation (opening or closing), limits the spatial resolution of the fault detection essentially to the ratio between the maximum time available for fault detection and isolation, and the switching time. Taking into account the limit set by AEEG for a long duration power shut off this time is 180 s, but the worst-case limit can be significantly lower: for example, if the network is run with a Petersen coil earthed neutral, the limit is essentially given by the withstand of the Petersen coil itself (approximately 20 s in Enel Distribuzione networks). The making and breaking ratings are related to the possibility of using procedures where it is required to make

or break fault currents. The extended endurance switches currently installed in Enel Distribuzione MV networks are tested to perform up to 5 short-circuit making operations, but cannot brake short-circuit currents, therefore it is necessary to operate the line circuit-breaker any time it is required to break the short-circuit current.
The electrical and mechanical endurance of the MV switchgears obviously determines the lifetime of the device: the higher the operation frequency the shorter the residual lifetime. Automatic operation implies higher usage ratios, thus decreasing the expected lifetime of the device and increasing the frequency of periodic replacement and, as a consequence, maintenance costs.
The maintenance costs of the equipment increase proportionally to the levels of environmental pollution with a reduction of its expected lifespan when the highest levels of pollution are reached.
In these cases the air insulated MV equipment have shown some limits which must be overcome if a high quality of service has to be achieved.

OBJECTIVE

To overcome these limits, and therefore open the way towards extended reliable network automation and new, faster and more efficient fault searching algorithms, in order to achieve quality of service results always in line with expectations, a network component with significantly higher and more trustworthy performances must be available: our goal is to make available to those who build, maintain and run the MV network, a new MV switchgears metal-enclosed and SF6 insulated which could represent a good trade-off between the need for the expected performance, reliability and lifetime costs.
With this goal in mind, we have specified and adopted a new low cost, high performance MV RMU switchgears for use in automatic MV-LV substations.

REQUIREMENTS AND CONSTRAINTS

The new switchgear is intended for use in MV/LV substations, built according to a standard incoming-outgoing electric scheme, so its basic performance consists of simple ordinary functions such as busbars disconnection and line grounding. In order to overcome the previously listed limitations, the additional obvious requirements that the new switchgear has to meet are fast switching time, short-circuit current making and breaking capability and extended mechanical and electrical endurance. All these characteristics must be implemented at the reasonably lowest cost possible. Besides, in order to minimize installation costs, this device must be dimensionally interchangeable with currently installed switchgear and fully compatible with the command and control interface of the remote control smart unit installed in MV/LV substations.

Of course, safety and environment protection are a major concern. Therefore this new device must guarantee the highest safety standards, in order to safeguard the health and safety of the community and the workers.

In order to reach this target the mechanical and electrical interlocks must avoid improper using, preventing the operator from performing dangerous operation. Moreover, the device is internal arc classified (16 kA for 0.5 s), according to IEC 62271-200. In comparison to the IEC 62271-200 test requirements, some special requirements have been added, in order to reproduce the actual operating conditions. In particular, special attention has been paid to the testing condition of this new switchgear because of its peculiar installation type and operating conditions.
The result of our specification is a compact Ring Main Unit with circuit-breaker per each line with disconnector and grounding switch (referred to DY900 from now on), a piece of equipment that is faster, more accurate, more reliable and easier to adapt into existing systems than previous generations of equipment for installation in MV/LV substations.
The first configuration of this new device consists of two lines equipped with a circuit breaker and a traditional protection transformer with fuses (2LEi+1T). The DY900 will be underwater immersion resistant and cannot be extended by adding other lines.

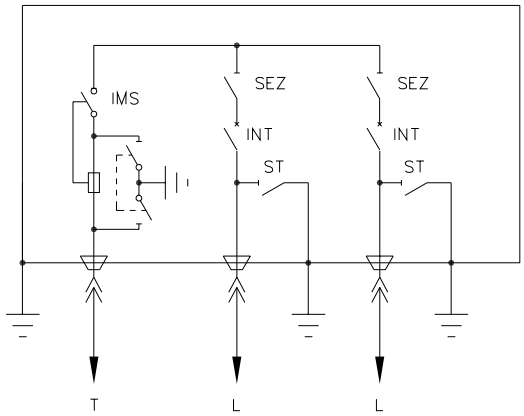


Fig.1 - First homologated devices

Such solution will respond to the demands of MV/LV substations in areas where only small spaces are available or where a high-level of pollution is present and finally in areas at high risk of flood.
The technical specifications of this new project of RMU with circuit breaker will be better defined in partnership with EdF and Endesa.

Enel Distribuzione tendered out a first experimental quantity of this new item which has been assigned to one manufacturer. In this experimentation we realized all MV/LV secondary substations of an entire MV line in a

particular location with heavy sea pollution, using the DY900 switchgear.

Fig.2 - First homologated devices

FEEDBACK FROM THE FIELD

With the initials batch of installed devices it has been possible to appreciate the good results of our technical solution.
The adoption of SF6 insulated solution confirms a high level of performance and economy, reliability and operational safety and last but not least our commitment to environmental issue.
Despite the brevity of the experimentation it has been possible to appreciate higher reliability of this device in comparison to a traditional motorized switch-disconnector.
The shorter switching time has allowed to increase the number of automated knots installed along a single line, in comparison to what was possible with the use of former traditional motorized switch-disconnector, thus reducing the number of clients involved in the more extended phase of the fault detection (i.e. the phase of manual operation).
Such a solution has led to a reduction of the cumulative duration of long lasting supply interruption per LV customer, which for the single line is about 10% - 15% and to a 40% reduction of the number of interruptions per customers, since neutral grounding and network automation in some cases allow (with single phase earthing fault on the last section of the line) the line to remain in operation, with the opening of the only automated switchgear before the faulty section.

NEXT STEPS

The good results obtained by the use of this new device have prompted us to develop two new projects:

- two additional configurations (3LEi+1T and 3LEi);
- a device for MV customer connection SF6 insulated with current e voltage transformer inside.

These new devices will enable Enel Distribuzione to connect the costumers reliably and reach an appreciable reduction of the number of interruptions whilst containing the effects of the faults caused by MV customers internal plant.

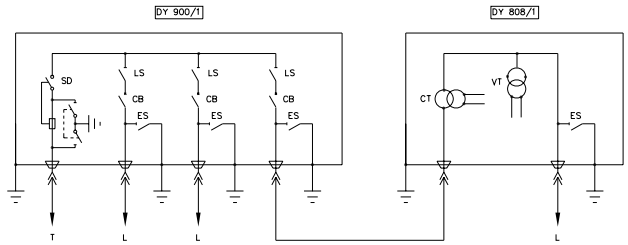


Fig.3 – Near future MV Customer connection scheme