A LOW-COST HIGH PERFORMANCE MV RMU WITH CIRCUIT BREAKERS FOR USE IN REMOTE CONTROLLED MV-LV SUBSTATIONS: FIRST RESULTS OF ENEL DISTRIBUZIONE EXPERIMENTATION

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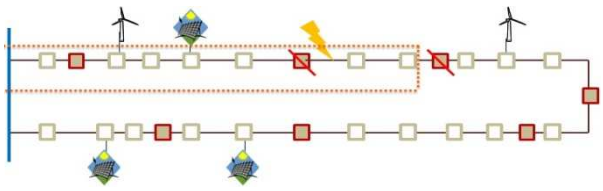
ABSTRACT

The high quality standards, set by the Italian Energy Market Regulatory Authority, have encouraged the adoption by Enel Distribuzione of innovative apparatus installed on its network since the beginning of 2008: high performance air insulated MV switchgear [1] [2], which has undergone constant improvements and upgrades in all its components throughout the years.
To achieve even higher quality of service results, Enel has specified, tested and adopted a new high performance gas insulated MV switchgear [3]. This new component has been designed to be installed in MV networks with high pollution, and is fully compatible with remote control smart units, therefore dramatically reducing installation costs, especially in the case of retrofitting. All the feedback data coming from the field are encouraging and completely in line with Enel first expectations.

CONTENT

We have been accustomed for a long time now to the rising attention that energy regulated markets are called to pay to 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 goal, 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 threshold 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 between 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 to 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 limitations of MV switchgears and the solution that has been proposed to overcome these obstacles.
Essentially, there are four limiting factors: switching time, making and breaking rated currents, the electrical and mechanical endurance of the switchgear and the pollution resistance.
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 available time 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 an earthed neutral Petersen coil, 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 break 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.
Maintenance costs of the equipment increase proportionally to the levels of the environmental pollution with a reduction of its expected lifespan.
Air insulated equipments have shown some limits which must be overcome in order to achieve higher quality of service levels.
For this reason, MV equipments must be more pollution-resistant, so we decided to adopt SF_6 insulation.

OBJECTIVE

Our goal is to make available to those who build, maintain and run the MV network, a new MV metal-enclosed switchgear and SF_6 insulated which could represent a good trade-off among the need for the expected performance, reliability and lifetime costs.
On the other hand, we also want to 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.
With this goal in mind, we have specified and adopted a new low cost, high performance MV RMU switchgear for use in automatic MV-LV substations.

REQUIREMENTS AND CONSTRAINTS

The new switchgear is intended for use in MV-LV substations and it is 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 switchgears 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 of 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 equipped with a circuit-breaker per each line combined with disconnector and grounding switch (referred to as 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 new device has 5 possible configurations: 2L+T, 3L+T, 4L+T and 3L, 4L; it cannot be extended by adding other lines.

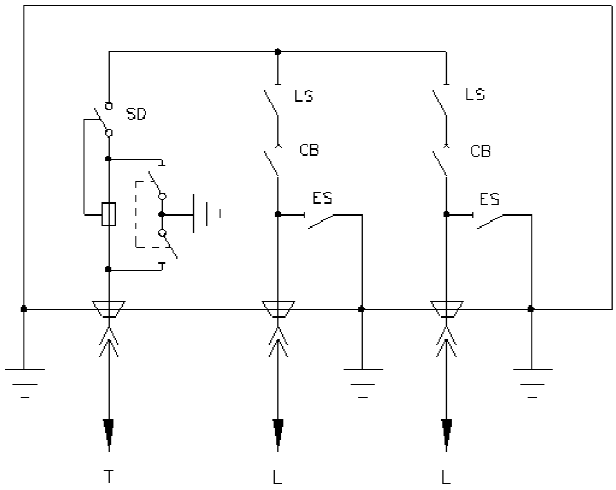


Fig.1 - First homologated devices

The 3L and 4L devices are designed to be used in plants with no transformer in order to connect MV customers, together with DY808, another new concept Enel apparatus, SF_6 insulated with current and voltage transformers inside.
DY900 and DY808 are underwater immersion resistant and will therefore answer to the needs of MV-LV and

MV customer connection substations in areas where only small spaces are available or where there is a high level of pollution and finally in areas at high risk of flood.

FIRST INSTALLATIONS

Enel Distribuzione bought one hundred of this new items at a very good price: up to 13% less than air insulation solution.
In these first batch installations we realized some MV-LV secondary substations of two MV lines in the Province of La Spezia in the Liguria region (Italy), in an area predominantly mountainous and entire MV-LV secondary substations of two MV lines in the province of Trapani in the Sicily region (Italy) in which water has a high salt content, using the DY900 switchgear.

Fig.2a – DY900 device

Chosen MV lines are named "CARRODANO" and "VARESE", from Primary Substation "VIZZA'" in Liguria region with the high flood risk and lines named "CASSIERE" and "SALINE" from Primary Substation "TRAPANI" in Sicily region with high salt pollution.

Fig.2b – DY900 devices

CONCLUSIONS

With this initial batch of installed devices it has been possible to appreciate the good results of our technical solution. They were installed used for a special project called Sche.Ma.: an innovative European Project for management and operation of a closed ring MV network [4].
The adoption of SF_6 insulated solution confirmed a high level of performance and economy, reliability and operational safety and last but not least our commitment to environmental issue.
During 2012 Enel Distribuzione installed more than 50 new RMU with circuit breaker, so 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 customers involved in the more extended phase of 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 15% - 20% and to a 40% reduction of the number of interruptions per customer, 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.
The new RMU has also proved to be truly pollution and underwater immersion resistant, reaching on the fields all our goals. In fact during a heavy flood episode, the new devices remained in service for 36 hours under water until the capillary penetration overcame the terminal degrees of protection (IP66).
Another important result from the field comes from DY808 device: it has allowed to offer reliable connection and fraud safe energy measurement for MV customers.

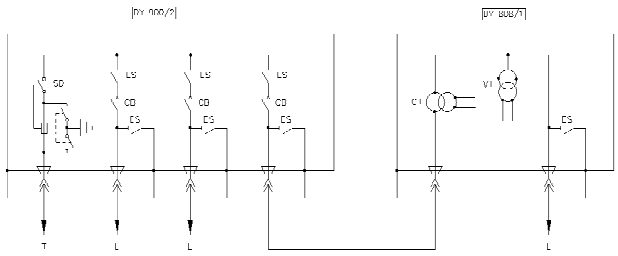


Fig.3 – MV Customer connection scheme

REFERENCES

[1] L. Giansante, C. Napoli, "A LOW-COST HIGH-PERFORMANCE MV SWITCHGEAR FOR USE IN

REMOTE-CONTROLLED MV/LV SUBSTATIONS", *Cired 2007, Vienna*

[2] L. Giansante, M. Dota, "A LOW-COST HIGH-PERFORMANCE MV SWITCHGEAR FOR USE IN REMOTE-CONTROLLED MV/LV SUBSTATIONS: FIRST RESULTS OF ENEL DISTRIBUZIONE EXPERIMENTATION*", Cired 2009, Prague*

[3] F. Giammanco, L. Giansante, "A LOW-COST HIGH PERFORMANCE MV RMU WITH CIRCUIT BREAKERS FOR USE IN REMOTE CONTROLLED MV-LV SUBSTATIONS", *Cired 2011, Frankfurt*

[4] S. Botton, L. Cavalletto, F. Marmeggi, "SCHEMA PROJECT–INNOVATIVE CRITERIA FOR MANAGEMENT AND OPERATION OF A CLOSED RING MV NETWORK', *Cired 2013, Stockholm*