INCOMPATIBILITY BETWEEN MV SWITCHGEAR CONFORMING TO THE INTERNATIONAL STANDARDS AND THEIR USE IN DNO'S SUBSTATIONS

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ABSTRACT

MV switchgear installed on the distribution network of DNOs is subject to ageing and degradation, such as tracking and corrosion. Particularly MV switchgear for secondary distribution is mostly subject to more severe conditions than the normal service conditions as considered by IEC 62271-1 (common clauses). The degradation of the MV apparatus is accelerated by the combination of humidity, temperature and dielectric stress. Since a distribution network is mainly made up of underground cables, MV switchgear are subject to quite different operating conditions compared to tertiary or industrial applications. Checking the condition of the installed MV cables has to be easy, reducing the outage of the network to the minimum. Furthermore, the switchgear's connection has to be compatible with mechanical stresses applied by the MV cables.

On the other hand, MV switchgear design has to meet the requirements of the international standards. The insulation materials used are selected to meet the normal service conditions as mentioned in the standard, electrical fields are calculated through simulation for normal service conditions. The choice of material for the metallic parts is based on the same normal service conditions. Type tests and routine tests are performed on new specimens, disregarding their ageing after installation under real service conditions.

This paper aims to show which particularities should distinguish MV switchgear suited for distribution networks from MV switchgear for industry as well as the main requirements which should be considered in the standard to meet the requirements for use in distribution networks.

INTRODUCTION

The DNO's investments mainly consist in network equipment, essentially substations equipment, cables and accessories, whilst the investments in industrial and tertiary sector are focused on process equipment and/or infrastructure. The Belgian DNOs - Eandis, Ores and Sibelga - have encountered some "premature" failures related to the actual lifetime of the MV switchgear installed on their distribution network. Those MV apparatus, in service from 3 up to 20 years, were submitted to Laborelec for investigation in order to specify the requirements regarding the influence of the real on site conditions.

MV switchgear, used in a distribution network, has to meet the following criteria:

- It must comply with the network's real service conditions
- It must comply with the network use
- It must comply with load current carrying capability under various conditions of ambient temperature and load
- It must be reliable in order to minimize the possible network outages

INTERNATIONAL STANDARDS VERSUS DNO'S APPLICATION

General considerations

Because of the distribution network's history and the impact of public procurements, an increasing number of different types of MV switchgear is in service.

The performances of the network user's MV switchgear, connected on the public distribution network, have to be similar to the MV switchgear owned by the DNOs. As a consequence, a dysfunction related to the network user's MV switchgear will have a similar impact on the reliability of the distribution network.

Manufacturers have a major participation in normative works. This can be explained by the direct impact of the standards on their business. Consequently, the service conditions as prescribed in the standards often fail to reflect the actual service conditions experienced in the distribution network applications. This leads to numerous supplementary technical requirements in the DNO's particular specifications.

The switchgear has to comply with network real service conditions

MV switchgear for secondary distribution is mostly subject to more severe conditions than the normal service conditions as considered by IEC 62271-1.

Three modes of ageing affect the lifetime of metal-enclosed SF6 MV switchgear, used in those real service conditions:

- corrosion of metal parts under the influence of humidity and heat
- degradation of the insulating parts under the influence of moisture, heat and dielectric stress
- tightness of the vessel containing the insulation gas mainly influenced by the ambient and insulation gas temperature

Factors influencing the lifetime of metal-enclosed SF6 MV switchgear are service conditions (temperature and humidity and ventilation), the design of the MV switchgear and the applied maintenance.

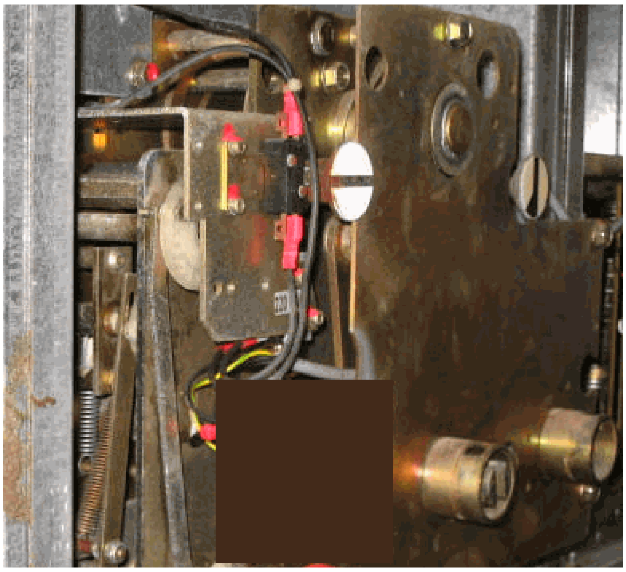

Figure 1: blocked mechanism after 10 years in a substation under severe conditions

The end of life is determined by:

- blocked mechanisms due to corrosion of metal or swelling of synthetic parts, disabling their manual or automatic operation (see figure 1)
- partial discharges and tracking currents leading to dielectric breakdown between phases or between phase and earth (see figure 2 and 3)
- loss of SF6 gas, the SF6 pressure reaching the minimum service pressure, possibly leading to an intrusion of air into the SF6 vessel which makes the MV switchgear dangerous to operate and to keep in service

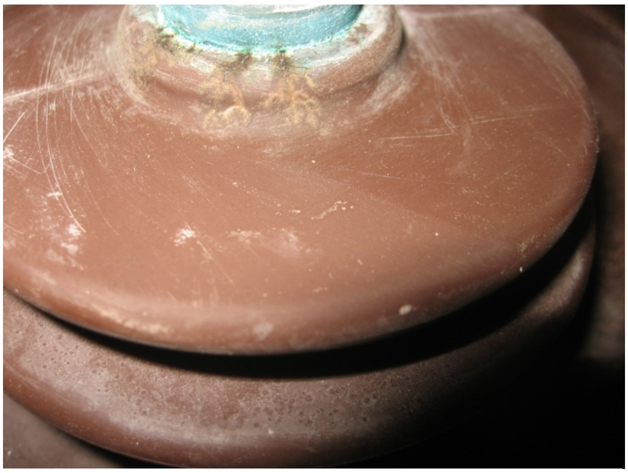

Figure 2: degradation due to tracking current on insulating parts

MV Switchgear is developed for a certain voltage and current range, but those ranges are often extended to the limit to increase the switchgear's application field. Approaching the dielectric limits, accessories like insulating plates or field deflectors are added or removed. Those changes can have a significant impact on the lifetime of MV switchgear placed in severe network conditions because of the possible increase of local electrical field gradients. This is a typical case for which tracking occurs.

Standards covering adequate tests exist to address those problems but are not mandatory in the common clauses according to IEC 62271-1 neither in the corresponding series 62271. The IEC/TS 62271-304 (test under severe conditions) is well mentioned but without correspondence with the service conditions. The requirement of the IEC 60587 for tracking current (see figure 3) on insulation parts should be addressed. The tightness test of the IEC 62271-1 does not take the real service conditions as encountered in a network substation into account.

Figure 3: tracking test according to IEC60587 for class 1A2,5 (at 2.5 kV) on polyurethane resin use for SF6 carters and MV instrument transformers.

Furthermore, MV switchgear can be subject to frost which can also lead to a blocked operating mechanism.

Secondary substations could be equipped with climate control in order to reduce above mentioned ageing modes. However, in practice, such a solution is neither technically nor economically feasible.

The MV switchgear has to comply with the network use requirements

MV switchgear is subject to quite different operating conditions compared to industrial or tertiary applications. Some features and functions are particularly important for the DNO's operators due to the complexity of the distribution network and the large number of substations present.
Those features are:

Operations
In a distribution network, MV switchgear is subject to a limited number of operations, sometimes no operation at all for several years. The requirements of the standards however address MV switchgear subject to numerous operations.

Service continuity
Maintenance is a difficult issue for the DNOs due to the large number of substations equipped with different types of MV switchgear. The distribution network never can be shut down, and if so, consequently costly operations have to be carried out, unlike the switchgear installed in industry which mostly can be put out of service during a programmed shut down related to the process maintenance schedule.

Pressure indicating device
MV switchgear is the main device to manage a distribution network. Hence, MV switchgear has to be extremely reliable as it has to be kept in service for a long time (more than 30 years) as explained in paper 0971. One of the main ageing reasons is an insufficient tightness of the vessel containing the insulation and arc quenching gas, i.e. SF6 gas. For this reason, an indicating device of the presence of SF6 gas is mandatory in order to avoid operation when the SF6 pressure is under the minimum service pressure. For load break switches, the remote control has to be locked-out when the SF6 pressure is lower than the minimum service pressure; for circuit breakers and switch-fuse combinations automatic tripping occurs when the minimum service pressure is reached. For those switching devices, it is important to monitor the SF6 pressure to avoid network outages.

Interlock
The torque to operate a switch differs from one switchgear type to another. The risk for an operator to perform a wrong operation and to exceed the mechanical resistance of the interlock increases. This risk is limited for an operator of an industrial site, confronted with a limited number of MV switchgear types. The second edition of the standard IEC 62271-200 takes this issue into account.

Maintenance
Preventive checks and condition based maintenance is carried out for primary substations, where more elaborated switchgear (equipped with withdrawable circuit breakers, double busbar system, etc…) is used. In metal enclosed MV switchgear, it is rather difficult to respect the safety rules of EN 50110-1 about Operation of electrical installations. To illustrate these difficulties, one can mention the access to the busbar disconnectors of MV switchgear with a double busbar configuration with the MV switchgear in service, and the difficulty to earth parts on both sides of the accessed object without being exposed to some possible risk.

Cable tests
Cable test and cable fault localization is one of the main operations to be realized in substations. Therefore, dedicated test points for cable tests have to be foreseen on the main circuit of MV switchgear dedicated to distribution network applications.

Testing of circuit breakers and protection relays
DNOs require accessible points to carry out a primary current injection as well as a method to perform the test of the complete protection chain without disconnecting the MV ring cables from the MV switchgear. Consequently, MV switchgear design shall meet this requirement.

The switchgear has to comply with load current carrying capability under various conditions of ambient temperature and load

Switch-fuse combination:
Switch-fuse combinations are often used in distribution networks for the protection of a distribution transformer. The opening time of the switch-fuse combination triggered by the striker of one of the MV fuses must be compatible with the arcing time of the fuses to avoid the switch interrupting a current higher than the transfer current. This need is under discussion in the relevant IEC working group.

Temperature rise
The temperature rise test is required in the standards of concern but the influence of the temperature on other network components is not taken into account. In an emergency situation, the core temperature of the cable connected to the switchgear can reach temperatures higher than 90°C or 110°C. This situation occurs when the cable ring is affected by a failure in one of its sections and the network configuration is consequently modified. In this case, the load of the MV cable connected on the switchgear can be near its limit and the above mentioned temperatures are reached. The ring current is also close to the rated

current of the switchgear. The actual temperature rise of the MV switchgear can be higher than the value obtained through a temperature rise type test as prescribed in the relevant standards. Furthermore, the mechanical stress on the connection points (isolators or bushings) can reach quite higher values than the values mentioned in the standard IEC 60137.

The switchgear has to be reliable

Internal arc fault

If an internal arc occurred, the network situation has to be re-established quickly. The consequences of an internal fault on the substation building, on other equipment present in the substation as well as on the other functional units that are part of the same MV switchboard shall be minimized. The configurations for the internal arc test cover most of the real configurations as found in substations. Nevertheless, these test configurations do not cover the RMU version with regard to the control of the gas exhaust in closed premises. Furthermore, arc suppressors are not addressed.

Consequences of lack of reliability of switchgear

The lack of reliability causes economical damage incommensurate with the damage to the MV switchgear itself as there are significant operation costs.

CONCLUSION

Manufacturers have a major participation in normative works. Hence, end users should be more involved. A higher degree of information exchange through forums concerning return of field experience and feedback of problems encountered could be beneficial.
The set-up of a collaborative platform between DNOs should allow consolidating their needs with regards to electrical network equipment. Such a platform existed till the end of the nineties in Unipede “HV Switchgear” where Distribution and Transmission Network Operators actively participated.
An equivalent working group like Network Substation Equipment of Eurelectric could also contribute to normative works. By doing so, MV switchgear, could much better meet the actual DNO’s technical requirements and needs.

MISCELLANEOUS

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