LACK OF STANDARDIZATION CONCERNING INTERFACES BETWEEN NETWORK EQUIPMENTS

Yvan TITS
Laborelec – Belgium
yvantits@laborelec.com

Marc ARENS
Laborelec – Belgium
Marc.arens@laborelec.com

Alain FRANCOIS
Ores - Belgium
Alain.francois@ores.be

Wim DE MAESSCHALCK
Eandis – Belgium
Wim.demaesschalck@eandis.be

Marcel VAN DEN BERG
Sibelga – Belgium
Marcel.vandenberg@sibelga.be

ABSTRACT

Despite the use of modern network equipment, the number and severity of incidents does not decrease as might have been expected. This is due to some components less covered by standardization, i.e. interfaces between equipment.
The paper is focused on the problems which can be encountered during the lifetime of the network equipment because of the insufficient attention on the compatibility between them. Such problems could be solved advantageously through a increased consideration of the interfaces in the standardization. It describes some cases for which this lack of standardization can lead to a heavy impact on the network components leading to a decrease of reliability of the network. Normative works should consider the interface between network equipments. Either those topics should be included in the equipment standard, or dedicated standards related to these interfaces should be established. Furthermore, end users should be encouraged to participate more actively in this work.

INTRODUCTION

The brainteaser of technologists working for Distribution Network Operators is to write technical specifications assuring the compatibility of the electrical network equipment manufactured by different manufacturers according to the respective standards and how they have to be connected together.
Actually, the standards are written by working groups, essentially composed by manufacturers, mainly interested in their own markets, and trying to hold their equipment technically and economically competitive.
There are very few contacts between experts of different WG working on equipment which have to be connected together (e.g. cables vs. switchgear) because of different commercial interest.
The tests required are focused on the concerned equipment and not on the interface between two equipments described by two different standards, nor on the effect of one equipment on the other. In addition to this, there is less and less participation of experts from the user side for financial reasons.

The components of an electrical network have to be considered not only for their particular function but also with regard to their influence on the set of components combined to constitute the network arrangement. The design requirements and the type tests have to take into account the various interfaces, which are the weakest points of the network most of the time.

Unlike industrial networks, a public distribution network has to remain energized 365 days per year; it is a dynamic system which evolves during its life, allowing the connection of new users by adding derivations or reinforcing its ampacity. It is not accepted by network users to be put out of electric power supply for some days or some weeks in case the network owner has to carry out an intervention on the network, i.e. for an extension or refurbishment of the substation as well as maintenance of the equipment. If such interventions are not well anticipated, the cost often becomes prohibitive because of the need to keep the network energized. For this reason, manufacturers should take into account future network needs during development of products.

Each network component is compliant with its individual product standard. However, the network operator needs a complete solution for which the performances are in line with those of each network component. Standards are generally reviewed every 5 years, taking into account advances in technology, but technical experts are increasingly specialized in their own field, given the increasing complexity of the technique. This is why it becomes more and more difficult for them to take properly into account interfaces with other network components. This explains why the failures due to poorly adapted interfaces appear more often than before.

Furthermore, connecting those components together often results into a decrease of the global network characteristics, due to a lack of standardization concerning interfaces.

STANDARDISATION IMPROVEMENT FOR NETWORK EQUIPMENT INTERFACES

Connection of cables with large cross sections

On one hand, large currents yield heating, which leads to thermal expansion and possible longitudinal high mechanical stress on the switchgear cable connection point ; on the other hand, dynamic forces generated by short-circuit currents lead to lateral constraints. The way to fasten the cables inside or under the cable compartment has an important impact on the mechanical constraint to which the switchgear cable connection is submitted. Those constraints are particularly high for large cable sections. The IEC standards (particularly the IEC 62271-200 and IEC 60137) with its cantilever load withstand test) do not cover those mechanical constraints, depending on the connected cables.

Figure 1: Cable fixations under switchgear cubicles

Furthermore, the heat dissipated in the cables can lead to additional heat generated in the switchgear. This means that the operating temperature of the cable can be limited by the temperature limit of the switchgear cable connection point (90°C for bare copper), especially in emergency situation of the network for which higher temperatures of cables are allowed (120°C) in the cables standard (HD620).

Figure 2: Example of tin-coated cable shoes connected to a bare copper bar

Dielectric type test made on the cable compartments without cables or cables lugs

The space costs are important in the construction of a substation. Therefore the reduction of the switchgear footprint is a source of cost reduction. This leads to the use of compact gas insulated switchgear on one hand, and of insulating material on the other hand, reducing the needed distances between phases and between phases and earth.
The maximum cable section and their corresponding cable lugs as well as the allowed number of cables which can be connected to the switchgear should be mentioned in the installation guide. The dielectric type test should be realized with this onerous configuration (IEC 62271-200). Due to the cable connections, the test object has a high capacity which is mostly not compatible with the performance of the test bay. This inconvenience can be met by connecting the cable lugs without the cables provided that a simulation shows that the dielectric gradient along the cable terminal remains sufficiently low, avoiding flash over for the required dielectric test value. All the devices located in the cable compartment have to be taken into account including the moving parts (e.g. : earthing switch). The dielectric type test performed with connected cable lugs will guarantee the design of the cable compartment that is compatible with all other possible, less onerous, cable configurations.

Test voltages on cables : level and duration

Certain cable standards require a dielectric test on laid cables at a frequency of 0.1 Hz for 3U0 during 60 min. The proposed duration for the a.c. cable test in the switchgear standard is 1 min without defined level. Therefore, the indication of the cable test voltage on the rating plate wisely required by the new version of the MV metal enclosed switchgear standard (IEC 62271-200) is an important information to the user.

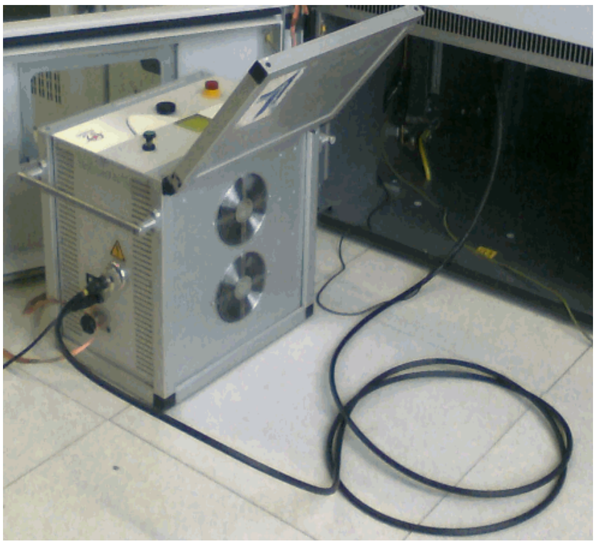

Figure 3: on-site 0.1 Hz cable test on newly installed MV cables, connected to the switchgear

Interface between network components and its network location

The standard IEC 62271-1 defines the normal service conditions for which the assigned characteristics of the switchgear for indoor use are guaranteed. However no type test is foreseen to verify the compliancy of this switchgear with defined service condition. No type test for this purpose is foreseen in this standard. Even the requirements for the highest class (ageing class 2) according to the 62271-304 (design classes for indoor enclosed switchgear to be used in severe climatic conditions) are not severe enough to demonstrate that the expected lifetime (30 years) of the equipment will be guaranteed under normal service conditions. A measuring campaign in a large number of substations on the Belgian MV grid shows that the real service conditions are mostly in line with the normal service conditions as defined in the above mentioned standard. A visual inspection of the condition was performed, on one hand, on various switchgear after this test for the class 2 of the IEC 62271-304 (7 weeks of 5 days cycles), and on the other hand, on switchgear submitted to real site conditions. One can conclude that the simulation made by the standard is equivalent with a 5 to 10 years real site condition lifetime, and particularly for air insulated switchgear. The challenge here is to develop a representative test of the conditions actually encountered in the network substations.

Interface between existing switchgear and their future extension

When installed switchgear is no longer available on the market, extension has to be done with another type of switchgear during the life of the substation. A dedicated interface panel for which the characteristics are generally not covered by an equipment standard is needed. Such a cubicle is never covered by type tests and is however a central part of the main circuit of the extended panel. This is typically an equipment situated between two manufacturers which at the present is not covered by a conformity assessment.

Interaction between fuses and its combined load break switch

Despite that technical requirements for fuses and the load break switch are covered by their dedicated component standards (IEC 60282-1 and IEC 62271-105), attention shall be paid to the correct choice of the fuse assuring the correct functioning of the combined load break switch under normal operating conditions (heat losses with possible de-rating) and faulty network conditions.

The correct choice of the time-current characteristic of the fuses has to be made. A too small opening time of the load break switch can lead to unacceptable transfer or take-over currents.

In the opposite case, the fuse might not melt properly when the opening time of the load break switch is higher than the arcing duration withstand of the fuses. The current limiting MV fuse standard requires an arcing duration withstand of the fuse of 100 ms, which does not guarantee the compatibility with the maximum opening time of the combined load break switch.

SUMMARY OF CONSEQUENCES

Interface	Incompatibility	Consequence
Connection of cables with large cross sections on switchgear	Effort on the connection due to expansion of the cables	Leakage of SF6 and internal arc
Dielectric type test made on the cable compartments without cables or cable lugs	Insulation between cable lugs	Internal arc in cable compartment in case of an overvoltage
Test voltages on cables connected on a switchgear	Level and duration : compatibility between switchgear and cables characteristics	Internal arc in the disconnector in case of cable test with simultaneous overvoltage on the busbar. Damage on switchgear and on test equipment.
Climatic conditions and switchgear	IEC 62271-1 normal conditions not tested	Internal arc after a certain lifetime due to tracking current
Interface between existing switchgear and their future extension	Difficulty to assure the characteristic of the adaptor cubicle	Risk of internal arc in the busbar especially in function of the climatic conditions
Interaction between fuses and its combined load break switch	Opening time of the switch and pre-arcing time withstand of the fuses	If the fuses are not correctly adapted to the combination, explosion of a fuse with consequently a possible internal arc and a incorrect protection of the transformer.

Conclusion

Nowadays, network managers specify their own requirements in order to solve accurately the problem encountered at the moment. As a consequence, network operators individually dedicate a considerable amount of time to complete the existing requirements, not or only partially covered by the individual equipment standards in order to avoid the problems as they arise, with more or less success. The topics of concern, mostly related to interfaces between network components, are seldom addressed by the DNOs, leading to troubles on the network.

If the DNOs do address them, the experience shows that it is difficult to get a solution related to interface problems.
A higher degree of information exchange through forums concerning return of field experience and feedback of problems encountered could be beneficial. Furthermore, a collaborative platform between DNOs should allow consolidating their needs.

Interaction between technical committees should take place through the set-up of joint working groups between working groups and maintenance teams depending on dedicated technical committees. Such working groups could fill the gaps mentioned above. This should be addressed by the Advisory Committee On Electricity Transmission And Distribution of IEC. ACTAD has to deal with all matters concerning electricity transmission and distribution which concern, or may potentially concern, more than one TC or SC.

REFERENCES

[1] M.Arens & Y.Tits, 2011, " Incompatibility between MV Switchgear conforming to the international standards and their use in DNO's substations *CIRED* 21st International Conference on Electricity Distribution paper 0950