INSTALLATION CONDITIONS AND IMPROVED MV AIR INSULATED SWITCHGEAR ARE KEYS FACTORS FOR AN EXTENDED LIFE

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ABSTRACT

MV modular air insulated switchgear offer incomparable advantages in flexibility and cost to fulfill all varieties of applications.
The way switchgear is operated has a clear influence on the life span. However, the installation and environmental conditions play a key role.
The paper will show how important it is to analyze the installation conditions and its improvements. For this purpose three severity classes are set as "normal", "severe" and "aggressive" conditions.
After that the last action is to choose the right product following the severity classes : "normal" product or" reinforced" product.

INTRODUCTION

Indoor switchgear is generally designed assuming "normal service conditions" as defined in IEC standard 62271-1 [1]. The standard also includes a list of some "special conditions". However not all of them really reflect all the situations that can be found on site. And it is not easy to evaluate the influence on the service life of switchgear.

Quite often on site, environmental conditions are different from the "normal ones". It may be found an infinite number of combinations of special service conditions. In addition, how a switchgear is installed has different consequences on the real stresses that has to be withstood . The MV equipment can be exposed to degradations such as:
- fast metallic parts oxidations [figure 1]
- insulating part superficial degradation (linked to appearing corona effect) [figure 2]

Figure 1- Example of corrosion on metallic part of an RMU

Figure 2- Example of degradation due to corona effect on field distributor on AIS switchgear.

WHY A PRODUCT COULD BE SUBJECTED QUICK DEGRADATION

The MV switchgear degradation process

As explained in [2], a whole set of external parameters interact during the degradation process. On Figure 3, the bubbles represent these external parameters and in the box are shown the consequence on the degradation phenomena up to the flashover : final default for the MV product.

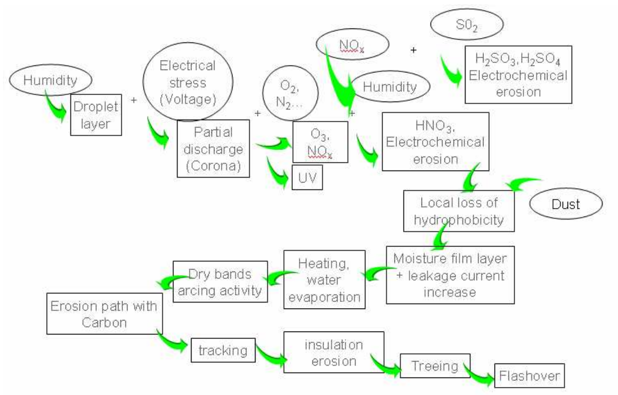

Figure 3- Degradation process

The analysis of this process highlight that 2 main origins impact the degradation: installation of the product (external factor to MV Switchgear) and the product itself [figure 4]

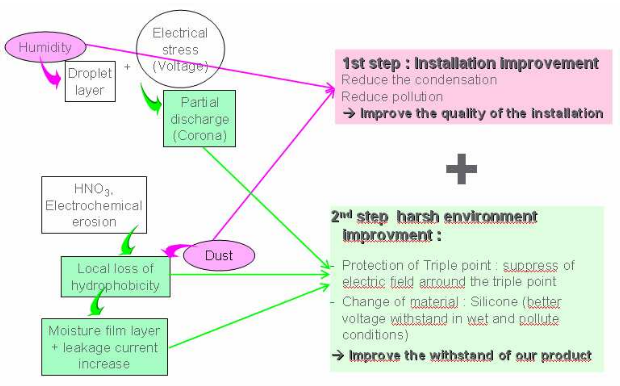

Figure 4- two origins for the degradation

Some figures from recorded installation conditions

A study has been conducted in some countries to determine mission profiles of MV switchgear during the whole life cycle including installation and operational life [3].
Among the results are:
- the average amplitude of temperature variations inside of substation is around 16,5°C.
- 48% of the substations contain water in cable trenches.
- 29% of the substations having water in the cable trenches have revealed corrosion issues on switchgear.
- dust & air pollution are also an important factor of deterioration (69% of equipment installed in China are exposed to dust & pollution).

First main parameter : Liquid Condensation

2 processes can lead to air saturation and condensation:
- at constant temperature, by carrying additional humidity,
- at constant humidity, through temperature variation.

The amount of humidity in the air is limited. The limitation is described by the "dew point" curve. Condensation appears as soon as the temperature is lower than the dew point. [Figure 5]

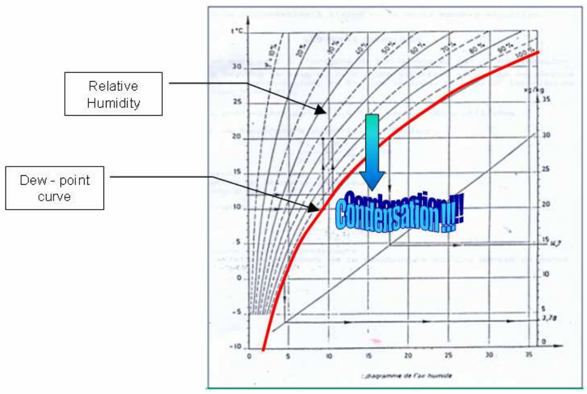

Figure 5- Humid air diagram (Mollier diagram - psychrometric diagram)

There are 3 main sources for humidity causing condensation as described in [4]:
- ambient air charged with humidity
- water leaks in the building or kiosk
- water presence in the cable trenches

Second main parameter : Pollution

Some areas are submitted to dusty environment because of industrialization and /or civilization of mankind (big cities) [4]. Without any precaution, dust and pollution will settle on insulating components.

HOW TO IMPROVE THE LIFE SPAN OF MV INSTALLATION

Improve the installation conditions

Definitions of conditions classes

Three classes of conditions are defined: normal conditions, sensitive conditions and aggressive conditions. A guide has been established to give recommendations on installation conditions.

The **"normal conditions class"** consists of "normal service conditions" according to standards, and favourable installation conditions such as:
- clean and dry trench;
- absence of dust or of any kind of remaining deposit. This is generally the case when the soils are not dusty , or when the equipment are not installed in an industrial area;
- stable temperature : no important ventilation, transformer in another room, no window, no metallic kiosk;
- no humidity: no vegetation around the substation, equipment not installed in a coastal area.

The **"severe conditions class"** includes some special service conditions plus controlled but less favourable installation conditions such as installation close to the sea, close to a dusty area, etc…

In "**the aggressive conditions class**", it is assumed that it is not possible to avoid poor installation conditions and a combination of special environmental conditions, such as:
- humidity and rapid changes of temperature generating condensation;
- presence of dust and/or other deposit;
- water in cable trenches;
- dusty, salty or polluted atmosphere, presence of water or heavy pollution.

Installation Diagnosis & Recommendations

The installations are divided in two categories : existing or new constructions. The diagnosis of installation will be different depending on the two types:
- for the new construction, the analysis will be visual and mainly focussed on the external environment: water presence, type of climatic conditions, dust presence,etc…
- for the existing one, the analysis will take into account the expected installed product in addition of external diagnosis.

Of course the visual diagnosis of product is important for the analysis of the situation: visible degradation will highlight the potential issue with installation. But it is possible to anticipate the visible degradation. As it is explained in Figure 3, the first phenomenon is the emergence of partial discharges. The “noise” of these phenomena can be measured with specific tools, including electrosonic sensor, before the apparition of visual degradation. This type of diagnosis allows taking measures to improve the installation before the final degradation of MV product.

Recommendations on installations are generally very simple and can be very easily implemented. A non exhaustive list of possible improvements includes:
- use of substation ventilation openings with **chevron-type baffles** to reduce the penetration of dust and pollution;
- keeping the **substation ventilation to the minimum required** for evacuation of transformer heat to reduce the penetration of pollution and dust;
- use of MV cubicles with a **sufficiently high degree of protection;**.
- use of **air conditioning systems with filters** to restrict entry of pollution and dust;
- regular **cleaning of all traces of pollution** from metal and insulating parts.

Choose the right product

The starting point of physical phenomena is the increase of dielectrical stress on the triple point at connection of epoxy, conductor, and air. Then, the solution is to reduce dielectric stresses at triple point.
The modification of field distributor to fully cover the triple point at connection is divided in two actions [figure 6] [figure 7]:
- protection against the worst parameters around the triple point as condensed water and dust locally change the field distribution;
- implementation of a physical barrier to modify the field distribution using a specific silicone device (better dielectric withstand in moist/wet, and pollute conditions).

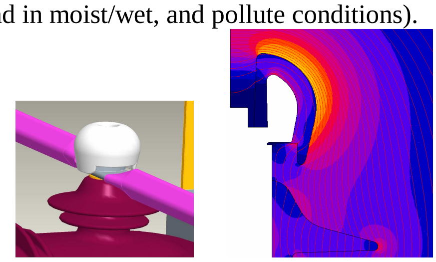

Figure 6- Field distributor for normal offer

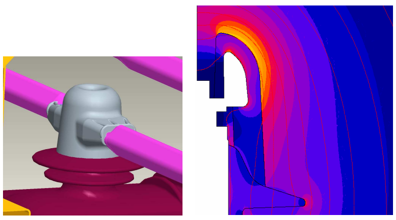

Figure 7- Field distributor with silicone device for triple point protection

PRODUCT VALIDATION PROCESS

Accelerated dielectric ageing tests were performed in test laboratory on a modified version of existing AIS switchgear of SM6 range

The SM6 cubicles have been submitted to severe environmental conditions during 3000h, in a climatic chamber, while being energized at the same time under rated voltage by a 3-phase high voltage source.

The test protocol is derived both from the standard IEC 62271-304 [5], and from our past experience. The expectation is to be representative of real harsh environment conditions that occur during the complete life of the equipment.

As it is defined in the standard IEC 62271-304 [5], the equipment is installed in the climatic test room and subjected to 2 hour damp heat cycles. During the whole test period, the temperature and humidity parameters are measured and controlled in the climatic chamber.

They are some important differences between the IEC standard 62271-304 [5] and our protocol:
- the ambient humidity is not only generated by a vapour flux injected inside the test chamber , but also by the pulverization of a thin heated water spray directly over the apparatus. The conductivity of the pulverized water is accurately adjusted and controlled during the test.
- the roof of the test object is removed and replaced by metal grids.

The water layer, deposited on the apparatus epoxy surface, is issued both from the condensation (from the vapour) and from the pulverisation effects. Our test protocol allows applying severe conditions on both lower and upper parts of the equipment:
- water condensation on the lower parts of the apparatus,
- stress increase on the upper part, because of the conductivity of the water sprayed.
Moreover, the ageing duration is also longer in comparison with IEC 62271-304.

The resulting test conditions are more severe than those defined in IEC standard, with the objective to simulate a real harsh environment. One main difference is the creation a surface conductivity on the apparatus, representing the effect of pollution such as dust, soot, or other deposit.

A clear difference has been noticed in the behaviour of switchgear including standard field distributor or reinforced protection of triple point. The solution including reinforced protection of triple point withstand the test conditions three times longer than the standard one.

The following [Figure 8] and [Figure 9] summarize the test conditions:

		IEC 304	**specific protocol**
Total ageing duration		1176 h	**Up to 3000 h**
Wet cycle :	Duration	**2 h**	
	Humidity (%HR)	95%	**90 %**
	Temperature	50°C	**40°C**
Dry cycle	Duration	**2 h**	
	Humidity (%HR)	70%	**70%**
	Temperature	30°C	**20°C**
Water pulverization, conductivity		None	**Fixed in the 100-300 µS.cm interval**

Figure 8- Climatic Cycle parameters

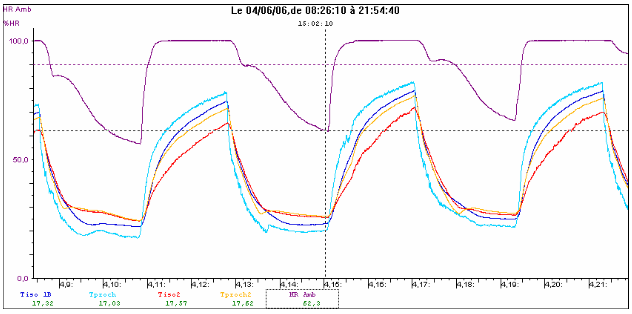

Figure 9- Climatic Cycle parameters

CONCLUSION

The life span of switchgear strongly depends on the environmental and site installation conditions.

It has been possible to define an analytic approach to ensure the longest possible life span which is always compromising installation conditions versus product.

In a first step, it is very important to analyse the environmental and site conditions. This will give a first visibility of severity class in existing or in a new construction, where the product will be installed.

In a second step, it has to be followed the installation diagnosis results with taking care of recommendations as much as applicable to have a better installation conditions. At this stage installation severity class is defined. For this purpose three severity classes have been set as “normal”, “severe” and “aggressive” conditions.

In a last step, it is time to choose the right product regarding the first two steps.

REFERENCES

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