

LIFESPAN PROLONGATION OF MV SWITCHBOARDS OF MV/LV PUBLIC DISTRIBUTION SUBSTATIONS

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ABSTRACT

This article presents the step of lifespan prolongation of MV switchboards of MV/LV substations carried out by the distributor EDF, to avoid any renewal not justified. The stakes of this step are initially presented. The article approaches then the analysis of the experience feedback of EDF which resulted in identifying the ranges of MV switchboards likely to be the subject of these actions. Then it explains how, by a technical economic study, the choice of the equipment to be dealt with in priority was carried out. Lastly, it presents the cards written at the attention of the operators which synthesize the actions of lifespan prolongation to be carried out on each range of targeted MV switchboards.

INTRODUCTION

The opening of the markets and the deregulation lead the electric companies to optimise their investments in networks. In this context, the lifespan prolongation of equipment can be an alternative to the renewal of the equipment (limitation of costs by maintaining the functionalities of the network to identical) :

- either by carrying out operations of refurbishment at a level allowing to find normal conditions of operating, with a cost however definitely lower than that of a renewal,
- or by implementing a diagnosis, individualized or generic, to consider the residual lifespan of equipment, and thus to lengthen to the maximum periods between two interventions,
- or by combining the two approaches above.

EDF, like other distributors, uses this approach of lifespan prolongation for equipment, when it is considered to be technically and economically interesting.

STAKES

The experience feedback of MV switchboards makes it possible to highlight the problems encountered by each range of equipment. It is then a question of proposing suitable actions of refurbishment which at the same time make it possible to anticipate any breakdown likely to affect the equipment and to extend their lifespan.

Thus, while contributing to increase the technical expertise of the operators of the distributor, the actions of refurbishment make it possible to differ the renewal from

these equipment, and thus to better control the investments in networks.

To anticipate the problems of the equipment installed in operation by a suitable refurbishment which, as indicated previously, must be carried out when it is technically possible and economically interesting, such is the major stake of the step of lifespan prolongation of the equipment.

ANALYZE OF THE EXPERIENCE FEEDBACK OF EDF

The MV switchboards of the public distribution substations of EDF represent approximately 700 000 functional units, of generations, technical stages and different manufacturers. It is pointed out in particular that these equipment knew four successive technical stages, which coexist today on the MV networks of the distributor :

- 1968 : Arrival of an industrial prefabricated metal-enclosed product replacing the previous equipment of the open type,
- 1979 : Arrival of a stage more reliable technically with breaking in SF₆,
- 1993 : Confirmation of the good behaviour of the technical stage with breaking and insulation in SF₆ and generalization of the sure position of the switchgears by means of a mechanical indicator (suppression of the concept of visibility).
- 2002 : Evolution of the metal-enclosed equipment with generalization of the compact concept to modular (MV switchboards of the compact extensible type and units of extension which can be extensible).

The experience feedback of EDF on the whole of these equipment makes it possible to list the specific or generic problems encountered by each range of equipment. For this reason, one can quote in particular the presence of corona discharges as well as the wear or the gumming of operating mechanisms.

The experience feedback also makes it possible to capitalize the various solutions recommended within the framework of a step of lifespan prolongation to solve certain failures (solutions being able to call or not upon the manufacturers), or contrary to make the decisions of replacement which are essential when the step of lifespan prolongation is not applicable.

This knowledge led EDF in 2000 to recommend actions of lifespan prolongation for the MV switchboards of the first

technical stage (1968), which arrived at the end of their 30 years lifespan specified.

On the basis of the lessons of this experiment, EDF wonders today about the interest to renew actions of this nature for other technical stages.

A first analysis revealed two great potentially interesting families :

- four ranges of MV switchboards of the stage 1979

They are equipment presenting problems for which solutions simple to implement to prolong their lifespan can be recommended, the more so as their presence is still significant on the EDF park.

- MV switchboards of new generations (stages 1993 and 2002)

These equipment presented problems which were solved on a case-by-case basis with the manufacturers thanks to actions of refurbishment on the parks which were concerned. So these problems should not arise any more in principle.

Thus in first reading, it appears convenient to work on the 4 MV identified switchboards of stage 1979.

To validate this choice, a technical economic study was undertaken by EDF, taking into consideration representativeness and generated costs of the ranges concerned on the EDF park.

JUSTIFICATION OF THE ACTIONS BY A TECHNICAL ECONOMIC STUDY

The principle of such a study is to compare, for given equipment, the cost of its immediate renewal to that of an action of lifespan prolongation by making it possible to differ its renewal from a certain number of years, this one being specified with saying of experts.

To specify the cost related to this type of action, it is necessary to take into account :

- the cost of manpower which depends naturally on the time of intervention recommended (operations of switchboards cleaning in the case of corona discharges, interventions on the operating mechanisms in the case of wear or gumming...),
- the purchase cost of possible consumables,
- the cost of consignment of the switchboard or installation of an external power generator, according to whether these last can be carried out while the MV switchboard is energized or not.

The equipment selected to be the subject of these actions of lifespan prolongation are those for which the potential profits are considered to be consequent, by integrating their respective quantity on the EDF park, and the proportion

which will be dealt with.

The technical economic study thus carried out justified the interest to deal with the 4 ranges of the stage 1979 previously identified.

According to an estimate with saying of experts taking account of the experience feedback and the knowledge of the equipment, the lifespan prolongation of the switchboards varies between 10 and 15 years according to the type of equipment and the nature of the problem dealt with.

By considering that one annually deals with approximately 5% of the number of functional units of the park concerned with the step, which represents a few thousands of specimens, the distributor EDF estimates that the step of lifespan prolongation led to significant profits of several million euros.

DRAFTING OF THE CARDS INTENDED FOR THE OPERATORS

For each range retained by the preceding study, cards specifying the actions of maintenance to be applied to them were written.

They comprise in a first part a recall on the years of manufacture, technologies (breaking/insulation) and the quantities of current functional units.

Then they synthesize the encountered problems and respective measurements to take : actions of lifespan prolongation or replacement taking into account the criticality of the encountered problems.

Times of intervention and the conditions in which the operator must carry out these last actions are also specified (switchboard energized or not, therefore possible required external power generator), which allows the preparation upstream these actions.

And the actions themselves are described by illustrating the recommendations using photographs or other diagrams.

An application of these cards, directed like a help with the repairing service, was proposed at the attention of the operators. It brings to their attention simple methods of resolution which until there were not always known in a uniform way between operators, and thus ensures the sharing of information.

This application contributes to two aspects :

- to help the operator to intervene quickly, which has an obvious impact over the quality of supply and the unavailability time,

- to avoid failures of equipment caused by improvised operations of repairing.

The profits relating to this help with the repairing service are not quantified through the technical economic study mentioned previously.

Lastly, certain ranges meeting problems of identical nature such as the corona discharges, those are approached through dedicated cards.

This work finally led to the drafting of ten cards, designed in dialog with the operators to make sure of the good comprehension and applicability of the provided explanations.

RECALLS ON THE PHENOMENA OF CORONA DISCHARGES

The corona discharges are the sensitive effects of the dielectric rupture of the air in the immediate vicinity of a conductor or an insulator under the effect of intense electric fields.

Conditions of appearance

They are related on the one hand to the equipment :

- design of MV switchboard,
- design of MV terminals,

and in addition with its environment :

- wet ambient medium,
- condensation (important variation of temperatures),
- edge of sea,
- industrial pollution.

Consequences

The phenomenon of corona discharges will slowly degrade insulators until making lose their insulating characteristics. One will take the case of synthetic resin insulators whose phenomenon of progressive degradation is easily comprehensible.

The resin is containing hydrocarbon and it is charged with very fine silica to make volume (silica has a very weak cost compared to that of the resin).

Chalking and carbonisation

The heating of surface due to the corona discharges will start by degrading the surface of insulator while exposing silica : it is called chalking because silica has aspect of flour.

In the following stage, the resin is degraded in depth and started to be calcined while letting escape hydrogen and by

leaving carbon in position. Black spots start to appear.



Traces of chalking on an insulating bulb

Tree structures

In the following phase, lines of fields are established in a stable way by digging furrows in the resin which one calls tree structures. They lead to a premature ageing of insulators.



Traces of tree structure on a current transformer

When the distance between the end of the tree structures and the mass is not sufficient any more to withstand the voltage, there is absence of insulation which leads to the destruction of the equipment.

The diagnosis

These corona discharges result in :

- perceptible micro discharges in the darkness,
- a level of noise proportional to the disturbed surfaces,
- an ozone outburst (which leads to the corrosion of the metal parts),

- a progressive degradation of insulators.

The detection of partial discharges can thus be carried out in different ways :

- visual (traces of chalking, tree structures, micro discharges, corrosion),
- olfactive (presence of ozone),
- sound (perceptible noises with the ear or use of tools such as "DADEP 2000" used by EDF).



DADEP 2000

diagnosis and their resolutions.

It was done in dialog with the operators to make sure of the good comprehension and applicability of the provided explanations.

The only actions of lifespan prolongation (except repairing interventions), which allow to postpone renewal from 10 to 15 years, lead to significant profits of several million euros by considering that 5% of the concerned equipment are dealt with annually.

The distributor EDF must from now on specify the details of implementation of these actions.

Solutions

The solutions to be implemented are of three types :

- cleansing of the substation by removing the potential entries of moisture,
- reduction of ventilations of the substation in function of :
 - o the power of the MV/LV transformer,
 - o their orientation compared to the dominant winds,
 - o their orientation towards the MV switchboard,
- checking of the state of the interfaces between the cables and the MV switchboard.

CONCLUSIONS AND PROSPECTS

The work undertaken by EDF led to the drafting of ten cards which explain :

- actions of lifespan prolongation to be implemented for the ranges being of technical economical interest,
- simple methods of repairing service,
- generic phenomena such as the corona discharges or the wear of the operating mechanisms, their