HARMONISING MV CABLE SYSTEM DESIGN

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ABSTRACT

The efforts made by utilities and manufacturers for improved performances and cost reduction led to highly optimised cable systems. Distributing energy seems to be a basic task, but the degree of complexity of a European supply is still very high. After a brief description of the current situation, the paper deals with the stakes of harmonisation and points out the involved parameters according an experience with functional analysis and rationalisation. The approach is illustrated with the results of the recent EuroMVcable Project.

CURRENT SITUATION

Some noticeable improvements

Extruded medium voltage cables have now given more than twenty years of satisfactory experience, as against the early products of the sixties that gave poor performance. Improved conductors and insulation semiconducting screens, cross-linking technology, metallic radial water tightness barriers or better grades of polymer compounds with higher water-treeing resistance, have contributed to enhance reliability.

A wide diversity

The efforts made by utilities and manufacturers for improved performances and cost reduction led to highly optimised cable systems. However, the number of rationalised products is still very high: for example, the current harmonising document HD 620 [1], produced by the Cenelec TC20, is over 1000 pages long! This compendium of national standard referencing describes 84 basic cable models with 49 possible options. It explains the high degree of complexity of a European supply, in spite of an apparently simple common function, which entails distributing energy.

STAKES OF HARMONISING

Mutual benefits

The stakes are important. In principle, it would seem interesting for utilities to install a single cable on the networks, in order to produce a slightly greater grouped volume of sales. On the other hand, the suppliers would rationalise their developments, qualifications, industrial plants, etc, with harmonised systems.

Beyond optimisation

Harmonising may begin with an economical paradox because utilities generally made an advanced optimisation of their cable, or designed it with safety margins for their strictly own use. The use of a common system extended to other networks implies that the system takes into account any specificity of these networks. This requirement may lead, according to a "common denominator" principle, to an oversized product, which is therefore more expensive. This over cost has to be compensated by savings from a greater volume of purchase, mutualisation of development and qualification costs, etc.

Fig.1: Optimisation of French cable from 1999 to 2002

For example, the EDF product (NF C 33-226) seems to be technically completed, and a very few changes may be expected in the medium term. Today the construction of this cable is very close to the economic optimum in relation to:

- the requirement of EDF distribution networks,
- cable manufacturing technology,
- the number of suppliers which is sufficient for exposure to competition.

However, they considered how a common cable would be designed for the EDF group companies, at a European scale. The work consisted in listing existing disparities between models and requirements within various utilities, but also convergence criteria for possible common solutions.

A former and best example is surely the EuroMVcable Project [3] concluded in 2004, and described in a further section of this paper.

Harmonised products and methods

Harmonising in not only the search of a unique common product. This is the development of a common industrial basis. The cable engineer offers rationalised subcomponents for a given function, and the final product can be assembled from this modular scheme (a well-known process in the car industry…). Therefore, harmonising includes also shared testing protocols.

In this framework, the EuroMVcable was an encouraging success.

A MORE FUNCTIONNAL APPROACH BEYOND NATURAL RELUCTANCE

The engineer often relies on descriptive specifications or standards, with variable levels of detail. It can be explained as a way to protect oneself against early and unexpected ageing. This natural reluctance reveals the difficulty to give up some designs or testing methods in which the engineer has confidence. Descriptive methods are sometimes the result and the pragmatic answer to successive experiences. The functional analysis has sometimes to override this heritage and to start from scratch. But it is not really applicable. The best compromise is to open the specification as far as possible, and to keep descriptive requirements when they cannot be avoided. For example, the French standard NF C-33-226 does not set insulation or semiconducting thickness: maximum electrical field values are specified, and the manufacturer can adapt the accessories.

A functional analysis begins with a systematic check on all the variables that may affect the cable system throughout its life cycle. Then, the model is widened to include the various views and experiences. The contributors to EuroMVcable made the description of such a work in a Jicable paper [2].

The proposal of the harmonising document may also face possible trends to national market protectionism.

ANALYSIS OF PARAMETERS FOR RATIONALISATION

Legal constraints

The first major constraint is connected with legal measures. If the evolution of a company specification or of an international standard may be a very long process, the modification of a law can't be seriously considered. Legal measures imply safety issues for which the electrical utility is one of several actors who are operating in the same environment.

For example, the French Technical Decree dated May 2001 imposes considerable constraints, in particular the protection of third parties. It does not leave much space for a technological abrupt change.

Operating constraints

Operating rules may determine the sizing of equipment. Some crippling disparities can be observed between utilities and prevent from using a common cable system:

- the voltage level,
- the way how the network is neutrally compensated,
- the short-circuit characteristics and the protection rules.

The insulation thickness and the metallic screen design may be highly affected by these features.

For example, the French 20 kV cable includes a thin laminated aluminium screen (0.15 to 0.20 mm) bonded to a polyethylene protective covering. The service experience is excellent, especially because of its radial watertightness property. However, it is not designed, neither the screen connections, to withstand a maintained fault, operated by some utilities.

Interoperability of accessories, connector technology problems

The life expectancy of electrical equipment is of several decades. Many technologies of products, with a different degree of sophistication according the ages, are operated together. Any change made to the cable requires that its impact be checked over the whole system (interconnection of generations of equipment found on the network, interoperability of accessories). Let us quote a few examples:

- Compatibility of materials (copper conductor – aluminium conductor – adhesion of external coverings),
- Compatibility of sizing (reduction in insulation thickness),
- Fitting and installation.

Fig.2: Special care is taken with accessories and optimised design cable

The engineer has to define an acceptance level of interoperability. This level influences the range of accessories (with a possible extra cost).

Overall cost of a link

Harmonisation is mainly motivated by cost reduction. It is important for any benchmarking to check how accurate assumptions are. The comparative elements of the price must be based on common criteria and an overall cost assessment system:

- Initial cost of investment in components,
- Fitting and installation costs,
- Present value of the cost of losses, taking into account

the annual discounting rates over the economic cable life,

- Rate of failure and cost of repairs,
- Logistic costs,
- Costs generated in the qualification of assembly teams.

In terms of a project that aims at rationalising cable purchases, it is important to discuss overall costs rather than stop at the only element to be optimised. The costs induced by adapting other components to the network are factors to be taken into account.

Moreover, the cost of a system has to be assessed according to the provided services. For example, a cable can include a longitudinally watertight conductor. This additional function can naturally increase the cost of the initial investment for the distribution line, but it may ensure a longer service life, postponing its replacement costs.

The purchasers have to take into account possible exogenous costs in their forecasts. The substantial increase in the rate of copper in the last two years has spectacular consequences. The current running-up prices of oil are leading to increases in raw material rates (such as PE and PVC).

Technological limits

Paths for improvement must take into account the limits imposed by extrusion techniques (excentration, manufacturing tolerances, etc.) or even through material knowledge.

The thickness of insulation may therefore not fall below a minimum (guaranteed at any point) directly related to the performances of the material and those of manufacturing processes.

Market

Cable factories are quite specialised in terms of suppliers, and generally cover a geographical area whose perimeter is optimised. This production capacity is therefore calculated so as to be able to provide a determined quantity of cables to utilities and the suppliers of these utilities.

If unforeseen events take place, suppliers adapt temporarily so that they can deal with high demand. They are not necessarily ready to invest to increase their production capacity for markets which are often short term (two to three years – even if technological steps are longer). Suppliers cannot therefore be guaranteed to hold a share of the market which allows them to amortise investments made.

Human-related limitations

Changes made to cables inevitably lead to questions from the man in the fields. It is therefore necessary to plan:

- Operator training,
- Monitoring during the deployment of the new technology.

The culture and training of assembly teams varies from country to country. Facing the event of an assembly error, it would be, for example, absolutely unthinkable to use certain tools in an area, even if they are however currently used in another country.

THE EUROMVCABLE PROJECT

Contributors and objectives

The EuroMVcable project was launched in 2001 and concluded in April 2004, included in the Fifth Framework Programme of the European Community for Research, Technological Development and Demonstration Activities: http://ec.europa.eu/research/fp5.html.

Electricity companies and cable manufacturers were seeking to rationalise the design of medium voltage cables in Europe. The project aimed to demonstrate the performances of optimally insulated cables, and propose pre-compliance procedures. From a comparative analysis of models, tests, operating requirements and operating practices in Europe, four cable designs were proposed, allowing the majority of the European market to be covered.

Four models and tests with prototypes

Prototypes have been manufactured and a set of investigation tests has been performed, mainly focussed on high gradient cables. Cable systems have been exposed to long-term tests in water as many utilities do in Europe, and to long-term tests directly buried as EDF France is used to carry out.

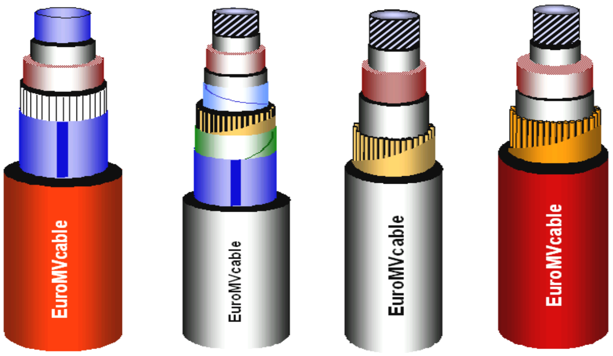

Fig.3: Four EuroMVcable designs retained

The main technical challenge focused on assessing an optimal insulation thickness (testing both 20 kV and 33 kV cables with high electrical field values). Long-term test procedures covered both thermomechanical and water treeing phenomena. Such testing and comparison of performance in a number of designs had not been undertaken previously (interest of the cross validation). They were successful.

The expected result from this work is a proposal for a basis to discuss possible harmonising (with validated data, comparative analysis and testing campaigns).

CONCLUSION AND PROSPECTS

Harmonising cable systems is made easier with a more functional approach instead of a frame of descriptive references. It is often illusory to hope to converge on a unique optimised solution.

The good degree of rationalisation should not involve encouraging the production of a single identical model by all manufacturers. On the contrary, it seems preferable to produce a specification that allows each manufacturer to rationalise, for its different customers, their manufacturing methods, production tools and raw materials. The four "special models" from EuroMVcable would more or less mean an outcome of this idea in Europe, which has already been applied in France, successfully, in the C 33-226 process [4].

The example of the EuroMVcable Project is interesting. The expected result from this work and continuation is a proposal for the introduction of four models into the Compendium HD 620. This basis could be discussed within WG9 of Cenelec for example, and find adjustments.

REFERENCES

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