NEW APPROACH FOR MV UNDERGROUND CONNECTION
NOUVELLES SOLUTIONS POUR LIAISONS SOUTERRAINES MT

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Résumé
Dans un monde industriel économique très tendu, toute évolution technique de produit et/ou de procédé qui présente un gain financier significatif doit être étudiée avec intérêt. Pour illustration, la conception et la réalisation des liaisons souterraines Moyenne Tension (MT) pourraient changer.
Un premier pas déjà réalisé, a vu l'introduction de critères fonctionnels dans les spécifications et normes [1]. Aussi, les nombreux acteurs engagés aujourd'hui dans la conception et la réalisation d'une liaison souterraine MT doivent partager l'ensemble des informations. Par conséquence, seule une approche globale permet de mieux identifier les postes économiques critiques.
Dans cette optique, nous proposons une analyse qualitative des coûts initiaux et en service d'une liaison souterraine MT sur le réseau de distribution français. Sur cette base, nous présenterons un nouveau type de câble à enterrabilité directe renforcée et une nouvelle jonction MT.

Mots-clés: MT, liaison souterraine, enterrabilité directe renforcée

Abstract
Nowadays, in a moving industrial world with rising economic pressure, the way of studying MV underground connections has to be totally changed. One way already used, is to introduce functional criteria in specifications and standards [1]. Consequently, the numerous actors involved in the design and making of an underground connection must share the necessary information. Obviously, this leads to a global approach of all the items included in a MV underground connection.
That is why we propose one qualitative analysis of the initial costs and the costs in service of a connection in the french MV grid.
Based on the obtained results, we described a new type of cable we called IMPB (Improved Mechanical Protection for cable Burying) and a new type of MV joint.

Keywords: MV, underground connection, improved cable burying, solution provider, cable system.

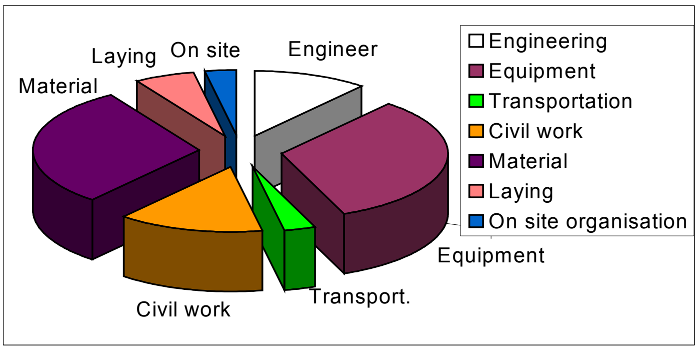
1 GLOBAL COST OF A MV UNDERGROUND CONNECTION

The global cost of a MV underground connection is mainly divided into two parts: the initial cost and the cost in service

1.1 Initial cost

A lot of different actors are involved in designing a Medium Voltage underground cable system : power utilities, electrical installers, civil workers, engineering company, cable makers, accessory makers.
Information has to be shared between people having slightly different point of view. One barrier is to gather a lot of figures coming from various sources and to complete an objective analysis.

However, it was made possible to identify the main initial costs items and, even if not exhaustive, the following sector sketch seems to be very representative in a french underground MV connection using traditional cables.



Initial cost repartition of a MV underground connection

First of all, based on the total power to transmit from one point to another, the study of the best route and the specification of equipment makes the first item called "**Engineering of the underground connection**".

Secondly, equipment (mainly cables and accessories) are purchased. This item is called "**Equipment**".

Thirdly, cables and accessories are transported to the site. This item is called "**Transportation**".

The fourth item is "**Civil Work**".

Fifthly, special raw material is used to backfill the trench : soft sand if needed, controlled backfill. This item is " **Material**".

Sixthly, cable laying and cable fitting with joints, terminations , … is making an item called "**Laying**".

Finally, on site organisation, final acceptance tests and commissioning are gathered in the last identified item called "**On site organisation**"

1.2 Costs in service

A power utility aims to get the best balance between initial costs and costs in service.

Main sources of costs during lifetime of the underground MV connection are losses (Joule losses, losses by Foucault current, eddy current in metallic screens, dielectric losses, …) and service unavailability (due to failures in equipment, to mechanical agression, …).

Nowadays, the only identified way to reduce significantly the losses is to enlarge the cable cross-section. But, as it causes a significant increase of the initial cost, it is rather difficult to share the right figures enabling to choose the best cable size.

Another way to reduce costs is to improve the service quality. It is well-known that joints can be weak points of an electrical connection because they are fitted in the field, involving uncertainty in the resulting equipment.

To reduce the potential risk of failures, it could be interesting to design and provide easy fitting joint with maximal integrated functions for better control efficiency.

At last but not least, another way to improve the service quality is to increase cable lengths in order to reduce the number of joints.

2 CABLE APPROACH (IMPROVED MECHANICAL PROTECTION for BURYING = IMPB)

2.1 Design of IMPB

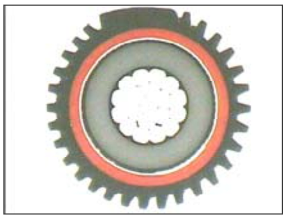
Using their know-how in designing, manufacturing or compounding special formulations, cable makers decided to study a reinforced protection for improved direct burying of cables (= IMPB).

Of course, it was necessary to keep in mind that the improvement of mechanical protection must not be balanced by an unacceptable difficulty to handle and to fit cable.
The solution described in this paper is based on an innovative sheath protection for each phase conductor.

The experience shows that care resistance to abrasion, to mechanical impact, to stamping at high temperature [2] increased through typical properties of thermoplastic compounds. On the other hand, absorption of mechanical impact energy and stress is ensured by combination of elastic compounds properties and the shape of the extruded sheath.

These two complementary properties lead to a thermoplastic rubber (TPR) compound combines with a grooved sheath.

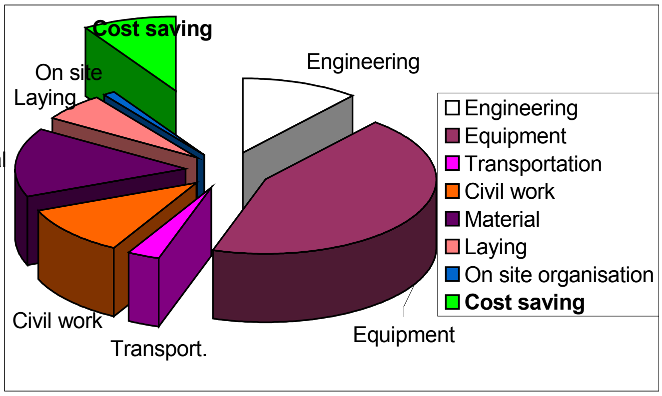
IMPB Cable design



Thanks to the elastic phase of TPR compound, the IMPB cable keeps an acceptable flexibility and the minimum allowable bending radius is maintained.
In order to make easier the work on the cable in the field, we designed compound and process so as to get a strippable sheath. So, to fit a joint or a terminal, one has just to remove the IMPB sheath at the distance from the cable end adapted to the accessory (using standard tools) and to follow the classical installation instructions with usual accessories.

2.2 Impact of IMPB on initial costs

We propose now to check item by item (see paragraph 1.1) the impact of IMPB cable on initial costs.



Initial cost repartition of a *IMPB* MV underground connection

It can be considered that items “**Engineering of the underground connection**” and “**Transportation**” remain unchanged.

Of course the item “**Equipment**” is increased by the use of IMPB cable.

We found one main consequence on item “**Civil work**” : it makes possible to reduce trench sizes (width and depth). With a classical cable, when directly buried in a hard soil, a minimum quantity of soft sand must be placed around the phase conductors leading to a wider and deeper trench than with IMPB cable. Indeed, thanks to improved resistance to abrasion, impact and stamping at high temperature of IMPB cables, burying can be made without soft sand bedding. Logically, the item “**Material**” is then significantly reduced because no sand bedding nor controlled filling-up is required. That means also that no transportation of sand and no clearing and tipping of excavating material are to be taken into account.

Maintaining an acceptable cable flexibility and ensuring a strippable protection, the item “**Laying**” is not really changed.

The item “**On site organisation**” is really different with IMPB cable. The use of “native” material in the trench instead of soft sand and controlled filling-up leads to an easier organisation with far less trucks traffic on site. No sand has to be stored, no loading of sand on laying machine makes the work easier, more continuous, so more productive and shorter.

These aspects could be checked on different occasions in the field.

2.3 Influence of IMPB on costs in service

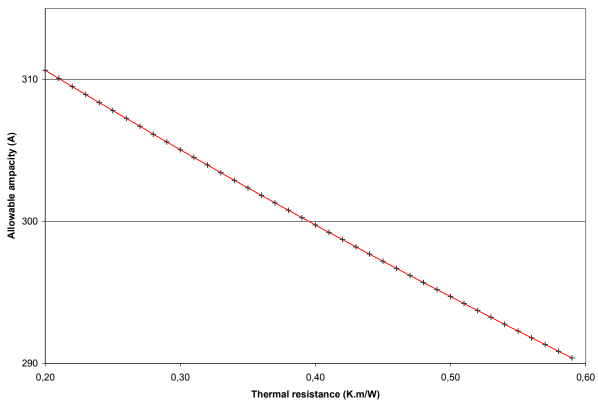
As seen before, the improvement of mechanical protection is provided by an additional protection sheath on a standard phase conductor. We must keep in mind that this additional sheath must not cause critical increasing of the losses in the cable during service.

First of all let us remind that MV cable for underground distribution grid has been in continuous evolution in France for about 4 years. One of the results is that the cable outer diameter is really lower than before.
For example, a 150 mm² 12/20 kV IMPB cable according to C 33-226 has an outer diameter very close to the former HN 33 S 23 cable. Consequently, the lengths for an IMPB cable on reels are slightly the same than with HN 33 S 23.
In addition, an opportunity is given to improve these lengths thanks to the allowable bending radius of IMPB cable which is adapted to a reduced reel drum diameter. Consequently, the number of joints is nearly the same with IMPB cable type C 33-226 than with HN 33 S 23 cable and in relation with paragraph 1.2, the service quality is not reduced.

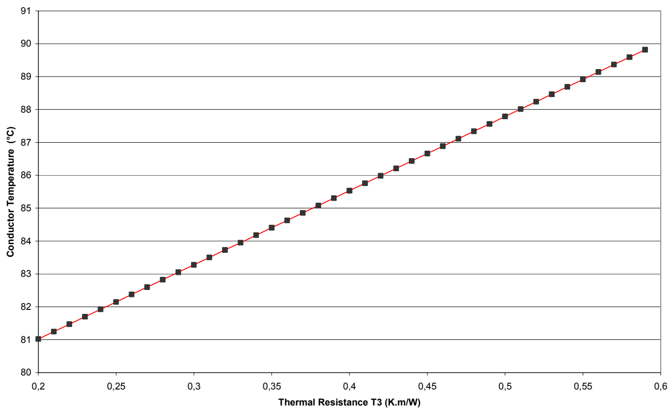
In a global approach, the opportunity to use single core cable instead of three-core bundled cable, leads to a real reduction of the number of joints. Of course, this solution needs a good preliminary analysis of the project involving all the concerned actors.

Furthermore, we checked that the innovative protection was not in measure to increase critically the thermal resistance of the cable sheathing system. This aims to keep constant the necessary cable cross-section for a given power to transmit and to limit the increase of conductor temperature for a constant current.

The below graph shows the evolution of allowable ampacity of a 150 mm² Aluminium cable according to the thermal resistance of the sheathing system with the following summer parameters [3] i.e. soil thermal resistivity of 1,2 K.m/W, surface temperature of 20°C for France.



The below graph shows the evolution of the conductor temperature versus thermal resistance of the sheathing system for a 150 mm² cable, the current being 200 Amp.



Based on these graphs, we see that with a thermal resistivity of the sheathing system ranging from 0,2 to 0,5 K.m/W, the current variation is below 5 % and the increase of the conductor temperature is less than 5K.

With the described protection called IMPB, the thermal resistance of the sheathing system is less than 0,4 K.m/W, so the current reduction is less than 5% and temperature rise of conductor for a given current is less than 5 K.

All the above calculation are made with the same thermal hypothesis than for a common cable laying with soft sand bedding. That means that the soil thermal resistivity value is taking into account a sand drying in the summer. Of course, this is a pessimistic hypothesis for allowable calculated current.

With IMPB cable, we do not need a bedding ("native" soil), so we should have calculated current with a lower soil thermal resisitivity. First studies lead to the conclusion that the allowable current on an IMPB without sand bedding is not lower that the allowable current of a standard cable laid with a sand bedding. Obviously, a parallel can be made about the conductor temperature leading to the same conclusions.

3 JOINTING APPROACH

3.1 Design of a cold shrink joint kit including clamp-in connectors

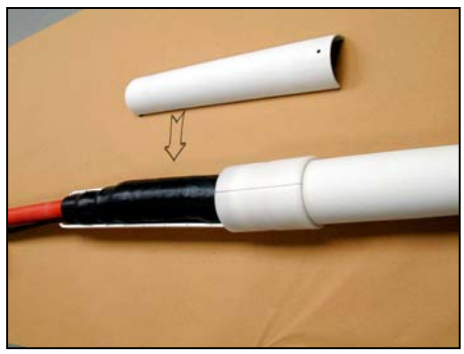
The update technology of design and manufacturing of MV joints is based on cold shrink components for dielectric insulation and mechanical protection. Thanks to continuous progress in designing, compounding and manufacturing MV accessories, it is now possible to pre-expand in factory almost all the components of a MV joint (dielectric insulation, metallic screening, watertightness, mechanical protection).

Combining two cold shrinking technologies, the proposed solution is carried out in two steps: firstly pre-shrink the centre of the joint in order to position it longitudinally and, secondly, complete the cold shrinking of the whole MV joint (see below).

Two step shrinkage of MV joint

Besides, this approach introduces multisection clamp-in connectors in the MV joint kit. This one contents every component necessary to make a joint in the field whatever are the cable cross-sections to be connected.

Moreover, in the case of improved direct burying, it is possible to ensure the joint mechanical protection by re-using the two shells which initially support the pre-expanded joint (see below).



IMPB for MV joint

3.2 Impact of cold shrink joint kit including clamp-in connectors on initial costs

With one kit adapted to a broad range of cable cross-sections, the material purchase becomes easier with only one reference including electrical, dielectric and mechanical components. Of course, the impact on the item “**Material**” is interesting, taking into account that no heavy machine nor tools have to be bought with clamp-in technology. This is a great evolution compared with classical technology as deep indent or crimping.

This has a second positive consequence on “**On site organisation**” : no heavy hydraulic nor electric pump is needed for connector compression.

The cold shrink joint described here leads to an easier and shorter fitting on site, making obvious the positive impact on item “**Laying**”.

3.3 Impact of cold shrink kit including clamp-in connectors on costs in service

This type of joint has two major consequences on the risk of failure due to a poor work on site. Firstly, the two stages of shrinking ensures a good positioning of the MV joint along the cable and this position may be easily controlled before final shrinkage. This is a strong improvement about the electric stress control along the joint and about the watertightness between the joint and the cable sheath. So the risks of breakdown due to Corona effect and to water ingress are strongly reduced.

Besides, we saw in paragraph 3.2 that no hydraulic nor electric pump is necessary when using clamp-in connectors. Consequently no maintenance on this type of equipment (and associated tools) is required. We know that compression with equipment suffering a lack of maintenance can lead to critical electrical failure with deep indent or crimping technology.

The above remarks inclines us to think that this type of joint increases the service quality.

4 CONCLUSION

Through this general cost analysis of a MV underground connection for the French MV grid, some technical solutions have been presented. Depending on requirements, these solutions may be adjusted for other European MV grids. Keeping in mind that each project is a single and particular one, a global approach is necessary to provide the best technical and economical cable design: single core or bundled, standard or IMPB, cross-section sizing,…
In addition, the more the information is shared between the different actors, the more the cable industry will develop and provide full-integrated innovated technical solutions.

5 REFERENCES

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