CONNECTION TO MV CABLE ALUMINIUM SCREEN

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ABSTRACT

*French medium voltage XPLE cable is designed with a longitudinally applied aluminium foil screen bonded to the oversheath. A specific device, called "**screen plate**" has been developed to interconnect the screens.*
A first test has been realized to evaluate the real performances of the screen plates in function of different parameters. Results show a limit at 10 amps for PVC oversheath, which satisfies the needs of MV links with rated current under and up to 400 A. For PE oversheath, the limit could be reach 30 amps, but others investigations have been instigated to validate this value [3]. A new test has been realized to evaluate different installation methods with collar-ties or roll-springs. Analyses are in progress.

INTRODUCTION

Cable and device presentation

Earth connection system

ERDF (French DSO) earthing system for medium voltage network is based on impeding neutral. Moreover, the screens of the 3 phases are always interconnected in accessories (Fig.1) and terminations of the link, except for big cross-sections (630 and 1200 mm²). In this case, the 3 screens are interconnected and single-point bonded to limit the screen current.

Fig. 1: Interconnection of the screens

MV Cable design

For 30 years, French medium voltage XPLE cable is designed with a longitudinally applied aluminium foil screen bonded to the oversheath.
At the same time, a specific device, called "***screen plate***" or "cheese grater", has been developed to interconnect the screens.
Today, screen plates are described by the French standard NF C 33-014 [1] and included in all accessories.

The device is based on a tinned copper plate with pikes, which exists in 3 sizes (Fig. 2), to cover all the cross-section range (25 to 1200 mm²). The pikes are designed to ensure the contact of the screen plate with the aluminium foil screen.
A tinned copper braid has to be welded on the screen plate to realise the interconnection and/or the screen continuity with the second cable.

Fig. 2: Different models of screen plate

Installation

The connection steps include:
- Making longitudinal cuts of the aluminium laminated screen and the oversheath,
- Opening out the aluminium screen bounded to the oversheath,
- Inserting the screen plate under the aluminium screen,
- Closing the oversheath on the screen plate,
- Tightening the oversheath on the screen plate with 2 non-magnetic stainless steel collar-ties (Fig. 3).

Fig. 3: Screen plate installed on the cable

Evolution of the system

Since polymeric cables are used in France, medium voltage cables have undergone evolutions, both in the design and the cross-section conductor range, to increase the reliability of the network or to optimise the MV links:
1994: Removal of shield bonding lead and increasing of screen thickness (100 → 200 µm),
1999: For 150 & 240 mm², reduction of insulation thickness (5,5 mm → 4,5 mm),
2002: Move on functional standard with polyethylene oversheath instead of PVC oversheath,
2004: Use of 240 mm² copper, for voltage drops,
2009: Use of 240 mm² copper for independent power producer links (40 MVA links).

Fig 4: MV cables (NF C 33-223, NF C 33-226)

Screen plates, which allow continuity of the screen in accessories and earthing connection, have never been modified since the first edition of the standard: HN 68-S-04 in 1983.
The actual design has a good field experience, because the main part of MV links is limited to 400 amps. So, the calculated screen current is around 10 amps, for a 240 mm² aluminium cable.
Furthermore, for the 240 mm² copper cable, the nominal currents have been limited (winter: 570 amps; summer: 490 amps) to respect a maximum screen current value of 20 amps (cf. last French cable standard NF C 33-226 [2]).
Today, the connection of independent power producers (wind or photo-voltaic farms) to the MV network requires using the full capability of the 240 mm² copper cable (around 630 amps) or 630 mm² aluminium cable (around 830 amps). In this case, the screen current could be reached respectively 27 and 35 amps, even more in function of installation (layer or clover). Moreover, these links could be submitted to fast high-level variations of load, depending on climatic conditions.
In this case, the device could be unsuitable. Only 2 models of screen plate are impacted. The smaller one, used for smaller cross-sections (50 and 95 mm²) is not study because current are less than 10 amps and the field experience is right.
The device is based on a tinned copper plate with pikes, which exists in 3 sizes (Fig. 2), to cover all the cross-section range (25 to 1200 mm²). The pikes are designed to ensure the contact of the screen plate with the aluminium foil screen.
A tinned copper bread has to be welded on the screen plate to realise the interconnection and/or the screen continuity with the second cable.

Works

In 2010, a Working Group Manufacturers/Customer has been launched within the French Standardisation National Committee (UTE):
- To withdraw the 10 Amps limitation and validate the maximum allowable current into screen plate in continuous operation,
- To improve the installation of the screen plate on cables,
- To precise the technical definition of the screen plate,
- To review the national standard NF C 33-014 to take into account new test results and conclusions.

FIRST EVALUATION TEST

Protocol

A test protocol has been established to carry out tests on 240 and 630 mm² loops, based on methods described by the standard IEC 61238-1 (electrical ageing test) [4].
The main parameters influencing the behaviour of the screen contact have been identified regarding the state of the art and the knowledge of the profession:
- Quality of the pikes of screen plates,
- Quality of installation (tightening pressure),
- Types of cables (thickness of screen: 150/200 µm; oversheath material: PVC/PE)

To estimate the importance of each parameter, all combinations have been realised except the PVC-150 µm case, which doesn't exist on the network, as shown below.

Fig. 4: Roll spring installed instead of collar-tie

First conclusions

Short-circuits have a temporary beneficial effect on the behaviour of the screen contact.
For the cables with PVC oversheath and with screen foil thickness of 200 µm (previous French cables), the maximum allowed screen current is 10 amps. This value satisfies the needs of MV links with rated current under and up to 400 A.
For the cable with PE oversheath, the maximum allowed screen current is higher, but the limit is not reach today. At this time, 30 amps seems to be acceptable, but only if screen plate and installation are achieved with good level of quality.
It could be necessary to investigate to another device (collar-tie and tool) for the installation of the screen plates to equilibrate the contact and to limit the effect of the jointer (pressure) during the installation.
It should be necessary to integrate in the future standard element to verify or describe the quality of the screen plates, in particular the pikes.

RECENT WORKS

All new investigations have been realized on 240 mm² cable with PE oversheath and 150 µm aluminium screen thickness, and with "good" screen plate.

Installation investigations

The target of these investigations was to find **new installation methods less sensitive to the jointer**.
In first, manipulations to find different installation methods and to test different existing tools and materials (any development) have been realized.
These investigations have shown the **efficiency and the utility of the roll-tool** (Fig. 6), used to close the oversheath on the screen plate, but all tool have not the same effect on the contact.

Fig. 5: Closing oversheath on the cupper plate with a roll-tool

At the end of these investigations, 2 approaches have been identified:
- Roll-springs instead of collar-ties (Fig. 4),
- Automatic tool to tighten collar-ties.

Investigation test

To select the best installation methods, an accelerated ageing test has been realized before a new electrical ageing test (similar to the first investigation).
This investigation permits for the next step:
- To limit the number of configuration,
- To increase the number of samples per configuration.

Materials, tools and methods tested

4 models of roll-springs (Fig. 6) with different dimensional characteristics (given in the table below) and different load have been tested.

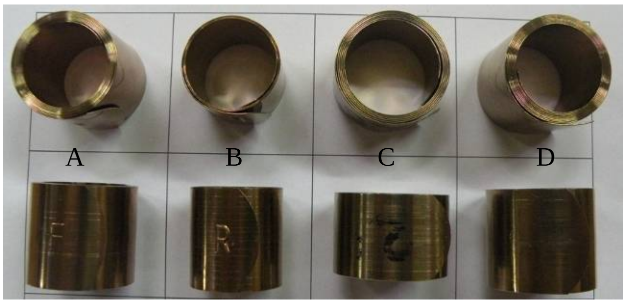

Fig. 6: Tested roll-springs

Model	Length (mm)	Width (mm)	Internal diameter (mm)	Thickness (mm)
A	700	25	22	0,30
B	230	25	22	0,30
C	500	20	25	0,40
D	662	25	22	0,33

To install them, we have tested two techniques:
- passing roll-tool on the roll-spring,
- passing the roll-tool directly on the oversheath.

3 models of roll-tools have been tested.

To tighten the collar-ties, 2 tools have been used:
- Actual tool without control,
- New tool with automatic release.

At last, several persons installed the different configurations to verify the influence of the jointer.

Test

All installation methods have been tested with 4 samples (only 2 samples in the first test), in a climatic device.
The test consisted to apply high and rapid variations of temperature on the material to accelerate the ageing (Fig. 8).

Parameters were:
- High temperature: 80°C (high value for stick of the screen)
- Low temperature: - 20°C
- Time per cycle: 2h

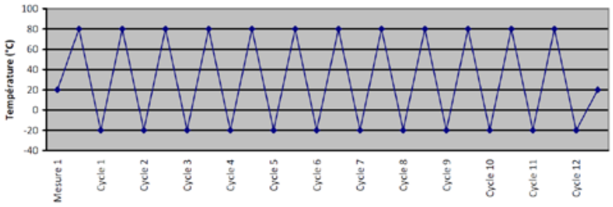

Fig.8: heating/cooling sequence

Contact resistance value was measured all 12cycles (24h). Materials have been tested during 360 cycles.

Results and observations

Generality

On the whole, results for collar-ties are better than results for roll-springs.
For all configurations, the perforation due to the pikes of the screen plates, are not uniform on the sectors of oversheath, especially on the central sector.

Collar-ties

For the collar-ties, perforations are more visible under the collar-ties, and the first line is often missing (Fig. 9). The position of the screen place against the cutback of the oversheath (20 mm) seems to be an influencing parameter. Moreover, perforations in the middle of the central sector are less marked than on the external sides.

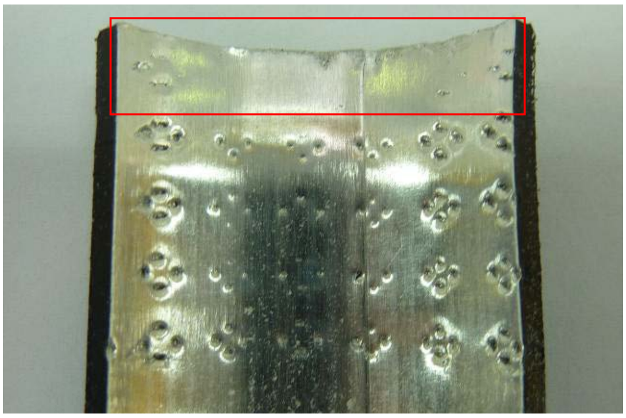

Fig. 9: Central sector - missing perforation on the first line

One roll-tool gives poor results and seems to be unsuitable. One other seems to be very efficient. It could be necessary to not turn around the sheath but only apply it on the screen plate to obtain a better contact.
Automatic and manual tool to tighten the collar-ties give similar results but for the automatic one, they are more reproducible. Automatic tool seem necessary to guaranty the quality of the contact. Perhaps, it could be necessary to modify it to obtain more tightening.

Roll-springs

For the roll-springs, perforations are missing in the middle on the central sector (Fig. 10)., at the place of the screen recovering

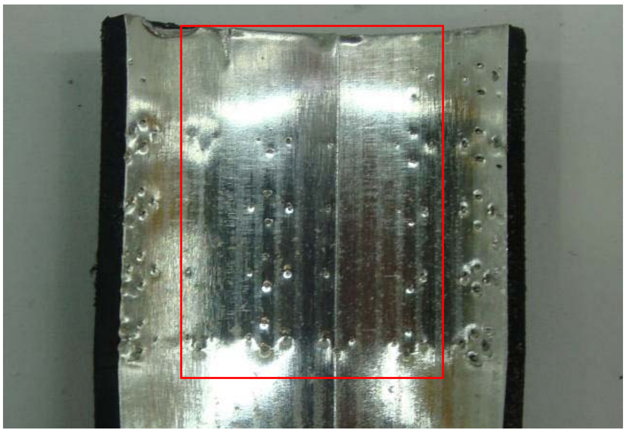

Fig. 10: Central sector - missing perforation in the middle

For roll-springs, 2 models seem to be unsuitable. The behavior of the twice other is better, especially if the roll-tool is used before their installation.
The length and the tightness of the roll-springs seem to be influencing parameters, but all examinations are not completed yet.

NEXT STEP

The following of the works should be dedicated:
- To finalize examinations of screen plates tested,
- To define the optimal way to install the 2 non-magnetic stainless steel-ties or other device, or roll-spring,
- To test several methods and configurations according to first electrical test sequence with ageing cycles,
- To finalize the revision of the national standard NF C 33-014 already started.

REFERENCES

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[3] C. Tourcher, 2011, "*Connection to MV cable aluminium screen*", Jicable 2011

[4] IEC, 2003, *IEC 61238-1: Compression and mechanical connectors for power cables for rated voltages up to 30 kV (U_m = 36kV) – Part 1: Test methods and requirements*, IEC, Geneva, Switzerland.