Summary

Introduction

High and extra high voltage cables

- The evolution of HV and EHV cables with synthetic insulation
- An outline history of developments
- Project engineering for HV cable links
- Examples of the range of HV and EHV cables with synthetic insulation
- Production tools
- 420 kV cable technology
- Checks and tests
- References
- Accessories
- Services
Introduction

Position of Nexans Switzerland

Nexans Switzerland is Switzerland’s foremost cable maker and supplier. It manufactures, distributes, fits and installs a comprehensive range of products for underground, submarine and aerial installations:

- high, medium and low voltage power cables
- copper or optical fiber telecommunications cables
- special cables for many applications
- power and telecom accessories
- connection equipment.

Its services range from the supply of cables to the implementation of complex turnkey products, including development, engineering, construction work, system technology, laying, installation and project financing.

Nexans Switzerland supplies high and very high voltage power cables and accessories, optical fiber cables, optical waveguide and special cables for the international market.

Nexans Switzerland has three production centres:

- the Breitenbach site
- the Cortaillod site
- the Cossonay site.
The evolution of HV and EHV cables 
with synthetic insulation

The greater demand for energy requires the implementation of installations designed to support increasingly higher voltage and power levels. This is why Nexans Switzerland Ltd has developed cables with synthetic (or dry) insulation for voltages up to 420 kV and cross-sections that can be larger than 2000 mm².

Conductors

For conductor cross-sections larger than 1000 mm², segmented conductors must be produced to reduce considerably their resistance to alternating current by reducing the skin effect.

Insulation

Higher service gradients require better insulation qualities. These materials should be perfectly clean – this is particularly important, as their long-term performance can be considerably affected, even by micro-impurities. Precautions to ensure cleanliness should be taken both during the production of raw materials and throughout the entire cable fabrication process.

Sheaths

At high gradients, synthetic insulation is sensitive to the presence of moisture. It is therefore essential to avoid any contact with water or steam during fabrication processes and also during line operation. The cross-linking operation must be carried out in the absence of humidity, either on a catenary line in an inert atmosphere, or on a horizontal line (MDCV process).

For all cables, the external protection is provided by a polyethylene sheath. Over this insulation, the application of a waterproof metallic sheath, which also acts as a screen, is generally required.

This sheath can be made of unwelded extruded aluminum or lead, or of welded or glued copper or aluminum. Nexans Switzerland Ltd uses all these techniques with complete mastery.
An outline history of developments

Developments from 1973 to the present day

Since the introduction of cross-linkable synthetic insulation, production and control techniques have gone through a whole series of development steps.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Implementation of a cross-linking catenary line</td>
</tr>
<tr>
<td>1974</td>
<td>Delivery of the first HV cables with dry insulation</td>
</tr>
<tr>
<td>1976</td>
<td>Introduction of the triple-head extrusion process</td>
</tr>
<tr>
<td>1977</td>
<td>Delivery of the first 150 kV extruded insulation cable</td>
</tr>
<tr>
<td>1978</td>
<td>Modification of the catenary line for nitrogen cross-linking</td>
</tr>
<tr>
<td>1983</td>
<td>Delivery of the first 220 kV cable with XLPE insulation</td>
</tr>
<tr>
<td>1986</td>
<td>Construction and start-up of a laboratory for measuring partial discharges up to 480 kV</td>
</tr>
<tr>
<td>1987</td>
<td>Production of the first 275 kV cable with XLPE insulation</td>
</tr>
<tr>
<td>1989–1991</td>
<td>Implementation of a 2nd cross-linking line for large conductor cross-sections and thick layers of insulation</td>
</tr>
<tr>
<td>1996</td>
<td>Production of the first 400 kV cable with XLPE insulation abroad</td>
</tr>
<tr>
<td>1998</td>
<td>Delivery of the first 400 kV cable with XLPE insulation in Switzerland</td>
</tr>
<tr>
<td>2006</td>
<td>Production of the first XLPE Cable 220 kV with a cross-section of 2500 mm²</td>
</tr>
</tbody>
</table>
**Project engineering for HV cable links**

<table>
<thead>
<tr>
<th>Development plan</th>
<th>Cause and nature of operations</th>
<th>Effects</th>
<th>Intervening parties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>territorial planning</td>
<td>network plan</td>
<td>customer</td>
</tr>
<tr>
<td></td>
<td>increased demand</td>
<td>network calculation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>connection of heavy users</td>
<td>power flow determination</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pre-study plan</th>
<th>Cause and nature of operations</th>
<th>Effects</th>
<th>Intervening parties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>decision to reinforce network</td>
<td>choice of connection type: underground, overhead or mixed</td>
<td>customer</td>
</tr>
<tr>
<td></td>
<td>preliminary feasibility study</td>
<td>technical solutions</td>
<td>Nexans</td>
</tr>
<tr>
<td></td>
<td>pilot study</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Cause and nature of operations</th>
<th>Effects</th>
<th>Intervening parties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impact study</td>
<td>choice of connection type: underground, overhead or mixed</td>
<td>customer</td>
</tr>
<tr>
<td></td>
<td>collaboration with other departments: engineering offices, industrial departments, etc.</td>
<td>drawing up of specifications</td>
<td>Nexans</td>
</tr>
<tr>
<td></td>
<td>notice to municipal authorities and landowners</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project</th>
<th>Cause and nature of operations</th>
<th>Effects</th>
<th>Intervening parties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>choice of definitive run</td>
<td>preparation of contractor’s file</td>
<td>customer</td>
</tr>
<tr>
<td></td>
<td>definition of laying parameters</td>
<td></td>
<td>Nexans</td>
</tr>
<tr>
<td></td>
<td>measurement of line length</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Offers</th>
<th>Cause and nature of operations</th>
<th>Effects</th>
<th>Intervening parties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>definition of possible cable types or variants</td>
<td>preparation of requests for offers and contract tenders for materials and contractors</td>
<td>customer</td>
</tr>
<tr>
<td></td>
<td>calculation of the cross-section according to voltage, power and civil engineering parameters</td>
<td>cost of civil engineering work</td>
<td>Nexans</td>
</tr>
<tr>
<td></td>
<td>distribution of partial lengths</td>
<td>cost of installation and setup, schedule and details</td>
<td></td>
</tr>
<tr>
<td></td>
<td>grounding system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Authorizations</th>
<th>Cause and nature of operations</th>
<th>Effects</th>
<th>Intervening parties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>file for the authorities concerned</td>
<td>building authorization</td>
<td>customer</td>
</tr>
<tr>
<td></td>
<td>handling of possible objections</td>
<td></td>
<td>inspectors, Nexans</td>
</tr>
</tbody>
</table>
Examples of the range of HV and EHV cables with synthetic insulation

- 45 kV EPR insulation
- 60 kV XLPE insulation
- 150 kV XLPE insulation, 500 mm²
- 220 kV XLPE insulation, 2000 mm²
- 400 kV XLPE insulation, 800 mm²
Production tools

HV Extrusion line

Aluminium press

HV laboratory
420 kV cable technology

EHV cables with PPLP and XLPE insulation

For 420 kV cables, there are currently two alternatives to traditional fluid oil impregnated paper insulation:

- cables with PPLP insulation, consisting of three-layer laminated paper and polypropylene tapes, formed into ribbons and impregnated with oil.
- extruded cross-linked polyethylene (XLPE) insulation cables which, with the progress of the techniques used in the manufacturing of basic materials and above all for installation, have achieved the reliability level required for use in extra high voltage (EHV) networks.

For connection projects at 420 kV, exhaustive tests have been successfully carried out for both XLPE and PPLP cables. The main features of these two types of cables are compared below.

PPLP and XLPE insulation

PPLP Insulation

For extra high voltage (400 kV and higher), new types of tapes made of PPLP (Poly Propylene Laminated Paper) are used. They have the advantage of combining the traditional application technology used for impregnated paper cables with the excellent electrical and dielectric properties of synthetic insulators. PPLP is a three-layer insulation consisting of a polypropylene (PP) sheet laminated between two sheets of paper. PP improves the quality of the insulation, while the sheets of paper ensure the circulation of oil between the layers. Compared with paper insulation, PPLP has a higher breakdown strength and above all lower dielectric losses.

PPLP insulation, which was introduced at the end of the 80’s, is still limited to cables to be used at a voltage of 400 kV or higher. This is due on the one hand to its price, which is higher than the price of paper, and on the other to the increasingly generalized use of XLPE insulation for voltages up to 220 kV and 400 kV.

XLPE Insulation

Cross-linked polyethylene (XLPE) was introduced in the 70’s. It was initially used for medium voltage cables, but is now used as insulation for extra high voltage cables (EHV). Its use at voltage levels of 400 kV and higher requires, of course, sophisticated state-of-the-art technology. In particular, we should mention:

- the rigorous selection of insulating and semi-conducting materials, which must be of a very high purity level,
- the checking of filtering during application,
- three-layer extrusion (internal semi-conductor, insulation and external semi-conductor) using a single tool,
- the obtention of perfectly smooth insulation semi-conductor interfaces,
- protection of the insulation against the penetration of moisture,
- stringent electrical tests to detect any faults.
For all these tasks, reliable and fast measurement equipment is required. Considerable investments have been made to equip our materials test laboratories with the most modern equipment, such as thermal analysis instruments, tensile strength apparatus, optical microscopes, infrared spectrometer, chromatograph, among others. These exacting checks enable us to reduce to a minimum the presence of undesirable matter and to guarantee the quality of our cables.

... to electrical tests

The quality of high voltage cable links is highly dependent on the rigorous nature of the tests carried out on the cables and their accessories. The more stringent these tests are, the lower is the risk of failure during operation. The principal tests are as follows:

Routine tests
to evaluate production quality.

Type tests
to validate a type of construction, for either cables or accessories.

Special tests
undertaken in the case of major design changes.

After-laying tests
to check the quality of assembly of accessories after installation and to simulate cable operation and rapidly provide information on cable efficiency after prolonged periods of use.

Accelerated ageing tests
to simulate working life and to provide information within a short time frame on their behavior in long-term use.

Diagnostic tests
to highlight any degradation phenomena in the line in service and to provide information on the residual cable life.
Nexans Switzerland Ltd, manufactured and installed 9 x 400 m, 400 kV XLPE cables, 800 mm² with a corrugated aluminium sheath and accessories for connecting the three transformers located in the sublake to the switching station, across the Rhone river.

Through Nexans France, Nexans Switzerland has won a contract for the supply of 70 km of XKDAlT cable, 1 x 2000 mm², 161 kV for Taiwan Power, in Taiwan.

Nexans supplied and installed 5 XAluWT cable circuits, 1 x 400 mm² and 1 x 630 mm², 230 kV and 3 120 kV cable circuits on an industrial site in Dearborn in the United States.

Following a mechanical accident, the gas pressure cables of the 130 kV Foretaille – Chêne sublake linking section operated by Services Industriels de Genève, were damaged in November 1999. Nexans Switzerland replaced the sublake link with a length of 3200 m by cables of the XDAluT type in a record time of 3 months between the order and commissioning.

Following a fire in the access tunnel to the “El Cajon” power plant in Honduras, two oil-filled 220 kV cables were damaged. Nexans replaced 2 circuits with a length of around 1000 m by XAluWT cables 1 x 500 mm², 220 kV. This project was completed in just 3.5 months between the order date and commissioning.

Nexans Switzerland laid two sublake links for Società Elettrica Sopracenerina in Lago Maggiore. For each link with a length of 2200 m, three cables of the XDAuWET type, 1 x 300 mm², 60 kV were run in PE tubes previously installed on the lake bed.

Nexans completed a 230 kV (5,500 m of XAluWT, 1 x 4000 mm²) cable installation and a 132 kV installation (24 km of XDcuCuT, 1 x 630 mm²) for two customers in Spain.

When the extension of the Chicoasen power station near Tuxtla in Mexico was decided to add a further 3 generators (each of 310 MW) to the 5 generators already in service and bring the total capacity to 2430 MW (practically one third of the total production in Switzerland), Nexans developed, manufactured, installed and tested the 3x 400 kV cable links - 400 kV type PoAluWET 1 x 400 mm² Cu - from the transformer to the starting point of the overhead lines. With this project, Nexans once again confirms its high levels of expertise in project and installation engineering.

When Transellectrica (the national Romanian electricity transmission company) issued an international invitation for the restoration of a 220 kV circuit and a 400 kV circuit connected to the same transformer and building up a crucial part of the operating system of the “Portile de Fier” (doors of steel) power station, Nexans won the contract. In collaboration with a local company and within an ambitious completion date, Nexans removed the existing oil-filled cables and replaced them with synthetically insulated cables with a higher power rating – 400 kV type XDCuAluWET, 1 x 630 mm² Cu and 220 kV type XDKAlT-Tsc, 1 x 1000 mm² Cu.

Nexans Suisse began to expand into China in 1997, in partnership with an integrator, within the framework of the Da Yuan Du hydro-electric power station project in Hunan province, for which a system of 110 kV XLPE cables was supplied and installed. Further projects followed, in which Nexans Suisse had the same responsibilities for the supply of complete cabling systems and for on-site supervision of the installations: the first 220 kV XLPE cables for the Zheng Jiang power station were supplied in early 2003, and since 2005, almost 30 km of cables, in particular 220 kV cables with a copper cross section of 2500 mm², for the supply of sub-stations in Peking in anticipation of the 2008 Olympic Games. Over a period of 10 years, no fewer than 21 circuits in total have been installed throughout the country.
Accessories

Outdoor sealing ends with porcelain insulator

The concept of the sealing end with porcelain insulator has a long-term experience with paper insulated cables of more than 60 years. The sealing end includes a pre-molded slip-on stress cone.

Composite insulators for various applications

As an alternative, customers worldwide ask more and more for synthetic insulators.

Thousands of composite insulators have been installed since 1980 by our companies, some of them are in service under very severe conditions, at the full satisfaction of their users.

Special advantages are low weight, excellent seismic, mechanical and pollution performances as well as no explosion risk.

Dry type outdoor sealing ends

Since 20 years, Nexans offers slip-on dry type outdoor sealing ends, which don’t need any oil or gas filling.

A monobloc version available for voltages up to 145 kV, offers many additional advantages like:

- no risk of leakage;
- no environmental effect
- easy handling
- quick installation
GIS sealing ends / Transformer sealing ends

For the connection of HV cables to transformer or gas insulated switch-gears, Nexans manufacturing programme includes adequate terminations.

The GIS sealing ends are designed in accordance with IEC 60859 standard, either according to item 7.1 for fluid filled terminations or item 7.2, Type A for dry type terminations.

Joints

Nexans prefabricated high voltage joints (72 - 550 kV) are basically composed of a premolded elastomer joint body, and an outer casing.

For the 72 kV level, a cable joint with premolded, factory expanded joint body is available.

Outer protections for joints are available in different versions:

- **MOP**: Medium Outer Protection consisting of a synthetic, rigid cover.
- **LOP**: Light Outer Protection made of heat shrink components.

Nexans prefabricated high voltage joints (2 - 0 kV) are basically composed of a premolded elastomer joint body, and an outer casing.

- **HOP**: Heavy Outer Protection casing consisting of a strong copper tube and a robust PE covering. Shield brake facilities are integrated, factory made and factory tested.

Transition joints

When paper insulated HV cables have to be connected to synthetic insulated cables, a so called transition joint is needed.

Nexans has developed a concept which guarantees a high reliable and compact connection for HV cables of different technologies.

Various accessories and tools

Where special equipments are required for the proper installation of HV Power Accessories, Nexans offers such tools, as well as the various accessories to complete a cable installation, such as cable screen disconnecting systems, surge arrestors, cable clamps, etc.
Nexans Switzerland provides a wide range of services to its customers, extending from engineering to cable laying and installation.

Working to the instructions of experienced teams of engineers, highly qualified fitters install cable systems all over the world. Laying and installation materials which are optimized in every respect, together with measuring and testing instruments for every need, permit the implementation of all kinds of installations under the best possible technical and commercial conditions.

Cables delivered and installed by Nexans Switzerland guarantee a reliable service for many years.

Based on its extensive experience with low and medium voltage cables, Nexans Switzerland offers its clients an expert partnership to solve problems and implement practical solutions.