Trends in the cable industry: HVAC and HVDC

Brief overview of the 51st CIGRE session

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In the last week of August 2026, a CIGRE session was held in Paris, France, which included an exhibition of new products and technologies, as well as numerous conferences and working group meetings on various topics (high-voltage and control equipment, power transmission lines, network management, etc.). The large CIGRE session is held every 2 years and is a significant event for the global electric power industry. Although CIGRE deals with a wide range of issues, in this overview we will only touch on what seemed interesting in the field of power cable lines.

Introduction

CIGRE is the International Council on Large Electric Systems. The organization is well known to experts, partly due to the publications (technical brochures (TB) and Electra magazine) that are published on completely different topics related to the electric power industry. Currently, CIGRE's main activities are divided into areas, and one or another study committee or working group is responsible for each of them (for example, study committee B1 deals with cable lines, and B2 deals with overhead lines). Every engineer in the world can become a member of CIGRE by contacting its national representative (please visit website Cigre.org).

The overview of the CIGRE 2026 session will focus only on the cables (B1) and, above all, on the product samples presented by the factories. Let us divide the overview into categories:

- HVAC cables.
- HVDC cables.
- Cable fastening/fixing systems.
- Smart link-boxes for cross-bonding of cable screens.

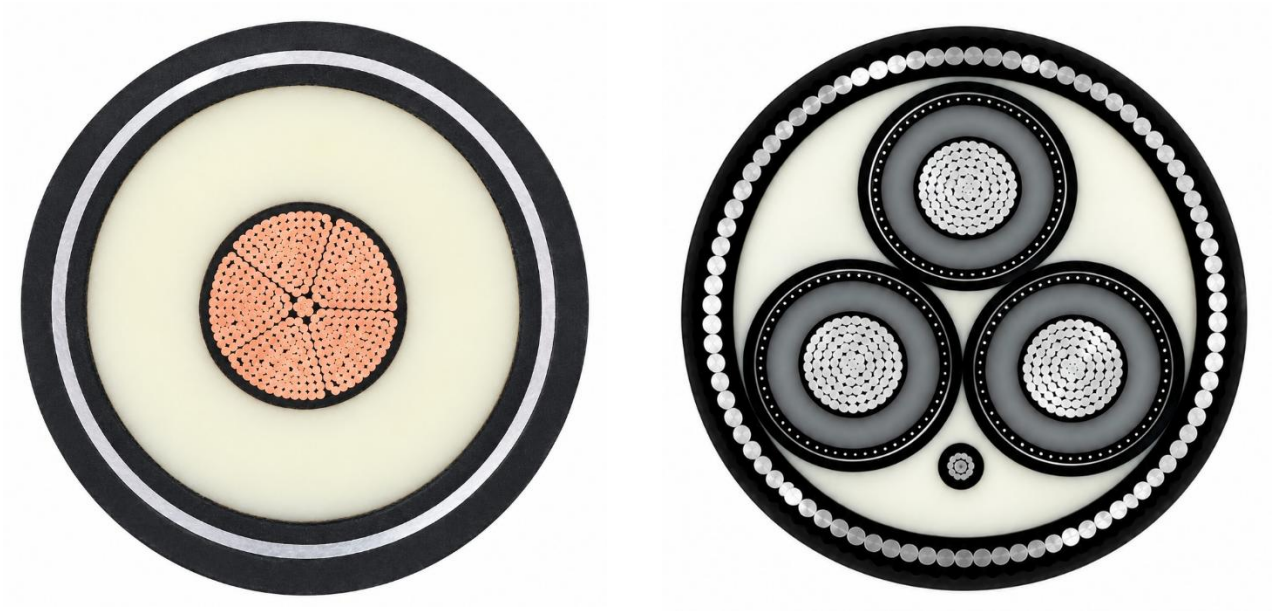
Many of the product samples seemed interesting and even inspiring, but there were also some that could be called as "experimental", not ready for full-fledged operation.

HVAC cables

After visiting the exhibition, there was a strong impression that cable factories compete with each other in terms of their ability to produce power cables of increasing rated voltage and conductor cross-section, while no one seemed to be interested in the real need for such "super cables". As an example, Figure 1a shows a cable of voltage class 750 kV ("conductor-screen" voltage is 435 kV), and, frankly, it is not entirely clear where exactly such a cable can be used in practice, and how reliable insulation is, operating at the limit of its capabilities. Interestingly, this cable was presented by one of the Chinese factories, and in general, the trends are such that the share of Chinese enterprises at European events is constantly increasing from year to year.

The conductor of the cable shown in Figure 1a is a standard "Milliken" consisting of a central circular element and 5 sectors placed around it. In general, according to established practice, Milliken-type conductors are typical for all HVAC cables if their cross-section is:

- for copper conductor: more than 1000 mm^2;
- for aluminium conductor: more than 1200 mm^2.



(a) – 750 kV, 1x2500 mm^2, Milliken **(b)** – 66 kV, 3x800 mm^2

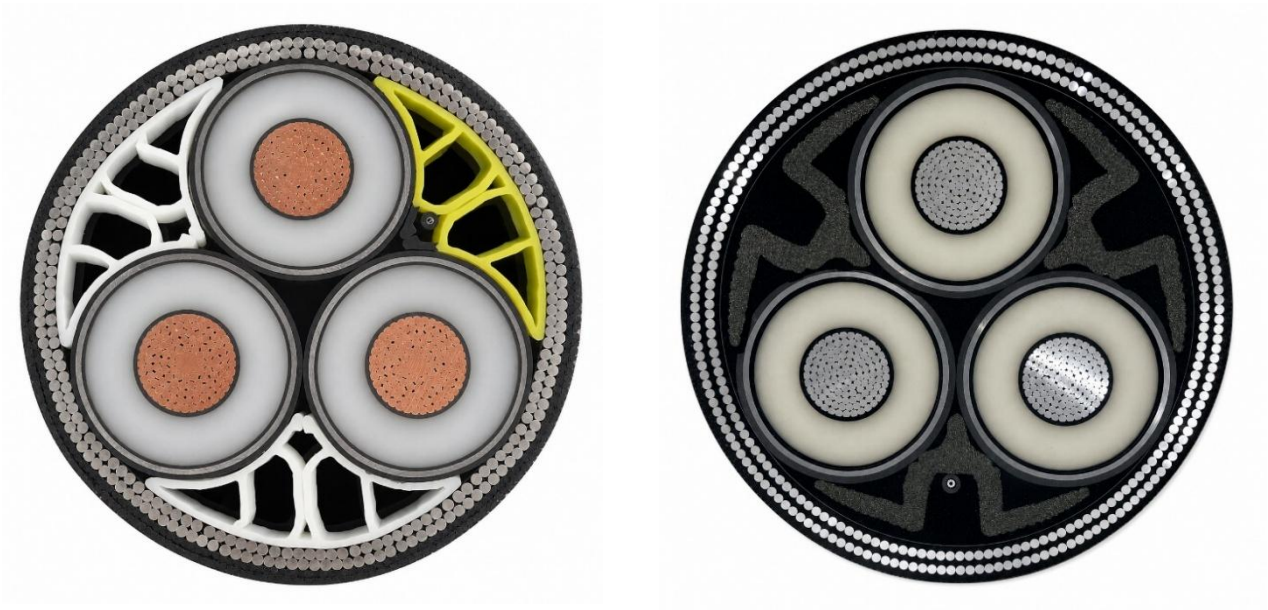
Figure 1 – Examples of typical design of HVAC cables.

To further illustrate this well-known rule, Figure 1b also shows a cable with an aluminium conductor of a cross-section of only 800 mm^2, and it can be seen that the conductor design here is really an ordinary multi-wire, and not Milliken at all, used only for conductors with a cross-section of more than 1000-1200 mm^2. However, after a careful study of all the cable options presented on CIGRE exhibition, it turned out that in fact the use of Milliken type conductors is subject to more complex rules, which most cable engineers probably do not even suspect. So, let us turn to Figure 2, which shows HVAC cables with a conductor cross-section of 2000 mm^2, made of copper (a) or aluminium (b).

Despite the significant cross-section of the conductor, the HVAC cables in Figure 2 do not have Milliken, which can be confusing, because with alternating current (frequencies 50 or 60 Hz) for such conductors, the skin-effect is already noticeable, and the current does not occupy the entire cross-section of the conductor, but only its outer part, making the central part "useless".

Communication with specialists from factories producing cables of the type shown in Figure 2 made it possible to clarify the situation. It turns out that it is extremely important for submarine cables to ensure the maximum degree of longitudinal sealing of the conductor, and this cannot be achieved for Milliken-type conductors. Thus, for submarine HVAC cables, when choosing between solving the problem of skin-effect in the conductor (Milliken is good here) and solving the problem of sealing (on the contrary, Milliken should be abandoned), factories

are more interested in providing sealing, i.e. in abandoning Milliken. Of course, this leads to inefficient use of the cross-section of the conductor of such submarine cables, to a decrease in the permissible current (ampacity) of the cable line and increased losses of active power. One of the ways to resolve these contradictions related to Milliken is to switch from HVAC technology to HVDC, where there are no problems with the skin-effect in the conductor, and when designing the cable, we should only deal with sealing problems.



(a) – 420 kV, 3x2000 mm^2 **(b)** – 500 kV, 3x2000 mm^2

Figure 2 – Examples of typical design of submarine HVAC cables.

HVDC cables

Figure 3 shows examples of modern submarine HVDC cables. It can be seen that the conductor design differs markedly from the previously discussed options typical for HVAC. This is not a stranded multi-wire conductor or a Milliken-type, but a very compact one in which, due to the special shape of the wires, they are tightly adjacent to each other – this conductor design is called as "Keystone". Such a conductor has not only increased longitudinal tightness, but also high compactness, which is important for reducing cable diameter, weight and cost.

Figure 3 is also interesting because the cross-sections of the conductor depicted on it are world record holders for the modern cable industry and amount to:

- for copper conductor: 4000 mm^2;
- for aluminium conductor: 5000 mm^2.

These cable samples were presented by Chinese companies, and it is not yet clear whether they are experimental products or are already finding their practical application. Nevertheless, to show the seriousness of intentions to put into practice such cables with a large conductor cross-section, next to the cable samples, one could also find a mock-up of a cable joint for their connection, shown in Figure 4. Most likely, it is a mock-up, since usually the joint of submarine cables is made in a special protective housing, massive and it has a length of up to 3-5 meters.

To be fair, it should be said that the first company to produce a cable of 4000 mm^2 copper conductor was Prysmian, headquartered in Italy, and Chinese companies are not the first ones. But still, the scale of the industry's transformation is obvious – if earlier a large conductor cross-section was considered 1000 mm^2, then 2500 mm^2, now there are already implemented projects with cables with a cross-section of 3000, 3200, 3500 mm^2, and requests for 4000-5000 mm^2 began to appear. Of course, cables of these conductor cross-sections are exclusively submarine HVDC cables that do not have any problems with skin-effect and are delivered to the installation site on special cable vessels.

Looking at the emerging trend of increasing conductor cross-sections over 2500 mm^2, industry experts realized that there are a significant number of unresolved issues here, such as mechanical and electrical calculations, as well as cable testing issues. For example, there are not many serial devices and techniques that could accurately measure the resistance of a conductor if it has such a significant cross-section. To address all these issues, a new CIGRE working group was created, which received the number B1.102.



(a) – ± 525 kV, 1x 4000 mm^2 **(b)** – ± 525 kV, 1x 5000 mm^2

Figure 3 – Submarine HVDC cables with conductors of a Keystone type.



Figure 4 – A joint for connecting cables shown in Figure 3.

Having considered the design features of the conductor of modern HVAC and HVDC cables, we can conclude that there are 2 main rules here. The first is that the Milliken conductor is used only for HVAC cables (as only they have a skin-effect). The second rule is that of all the HVAC cable options (underground and submarine), the Milliken conductor is normally used only for underground cables.

Understanding rules 1 and 2, which were formed in the cable industry and which are followed by most modern cable factories in the world, it should be recognized that among the cable samples presented at CIGRE 2026, there was found a cable sample showing a violation of both (!) of these rules at the same time – see Figure 5.

Figure 5 shows a submarine HVDC cable with a residential Milliken-type conductor, which, by its design, contradicts both rule 1 (do not use Milliken for HVDC) and rule 2 (do not use Milliken for submarine). Most likely, this cable appeared due to the production restrictions that a particular manufacturer had.



Figure 5 – Non-typical submarine HVDC cable.

Cable fastening systems

Most of the cable samples presented by the CIGRE participants can be attributed to high- and extra-high voltages of 300-500 kV, alternating current (HVAC) or direct current (HVDC), with an emphasis on subsea HVDC cables. This gave the impression that the problems of the cable industry in the "traditional" AC 6-220 kV networks had already been solved and no longer deserved attention. However, fortunately, there were also those stands that focused on 6-220 kV, which are of interest to the widest audience of engineers. Among these stands, two completely different approaches to fixing cables when laying them along structures (in tunnels, etc.) should be noted – they are reflected in Figure 6.

Figure 6a shows well-known conventional metal structures that are made of steel and equipped with horizontal support platforms (consoles) for laying and fastening cables on them. There are three types of cable cleats available:

- polyamide (including reinforced with steel tape);
- metal for rigid fastening;
- metal for flexible fastening, allowing the movement of the cable, which may be necessary when changing the length of the cable due to fluctuations in its temperature.



(a) – standard supports (metal) and cable cleats (metal or plastic)

(b) – special supports (insulated metal) and cable cleats/belts (made of Kevlar)

Figure 6 – Examples of fastening cables to supporting structures.

Figure 6b seems very similar to Figure 6a, but actually represents a different approach to cable laying and fastening. Among the features of Figure 6b:

- supports and platforms/consoles are made not as conductive but as insulating;
- cleats are made of Kevlar belts (not polyamide or steel).

The developers of this approach refer to operational experience, according to which, when cables are laid on conventional metal structures and there is a short circuit, short-circuit currents often pass from inside the cable to outside and then through an electric arc onto the metal of the supporting structures, simultaneously burning through the cleats holding the cable. In turn, this leads to the destruction of cleats and even the fall of the cable, complicating and making it more expensive to repair cable line. To reduce the risk of these effects, it is proposed to cover metal structures (in the factory, not on site) with a thick layer of a specialized polymer, which is not

only a good dielectric, but also resistant to fire. That is why in Figure 6b the supports, although they are metal from the inside, are coated with a bright red dielectric from the outside – the short-circuit current will not be able to escape from the cable to such structures and, therefore, there is no risk of burning out the cable cleats. As for the Kevlar belts (instead of metal, etc.), it most likely allows to additionally isolate the cables from the structures.

"Smart" link-boxes

Another group of CIGRE stands associated with traditional AC lines of classes 6-220 kV refers to link boxes for the cross-bonding of cable screens. The fact is that, obviously, there is a tendency to try to equip such link-boxes with systems for monitoring both the boxes themselves and the cable line on which they are installed.

The parameters that manufacturers of boxes, based on their experience, consider useful and possible for monitoring are listed below:

- induced voltages on the cable screens;
- induced currents in the cable screens;
- the presence of water/moisture in the box;
- the condition of the box lid (open/closed);
- the condition of Sheath Voltage Limiters (SVL) installed in the box;
- the level of partial discharges (PD) in the cable joints.



(a) – option with control cables **(b)** – option with control and 220 V cables

Figure 7 – Examples of "smart" link-boxes for cross-bonding of cable screens.

To control these parameters (or at least some of them), instrumental voltage and current measuring transformers, various sensors, as well as communication systems (between the box and the ends of the cable line) should be provided for the link box. This increases the cost and complicates the design, and, for example, from Figure 7 it can be seen that on the surface of the box there are now not only power cables for connecting the box to three cable joints of the main cable line and a ground contour, but also communication lines and low-voltage power cables.

In order for the specified equipment to function fully, a power of up to 100 Watts per link-box is required, and the question arises where to get this power from? It turned out that the box manufacturers propose using a low-voltage 220 V cable, which should be connected to the source of power in one of the two following ways:

1) by laying along the high-voltage cable line to its nearest end (to the control room of the station or substation);
2) by laying towards the closest available local 220 V network located near the link-box.

Both these ideas show that the link-box developers are not fully aware of the problems of electromagnetic compatibility. For example, it is well known that laying low-voltage and high-voltage cables along each other is dangerous due to the induced voltages and currents that occurs on a low-voltage cable during switching or short-circuit in a high-voltage network. As for the case of power supply from a 220 V local network, there are risks of bringing a high potential of the high-voltage cable line (with a short circuit on it) out of the link-box into a local low-voltage network – to protect against this, it becomes necessary to use isolation transformers and other complex and expensive measures.

Thus, it should be recognized that interesting idea for creating a "smart link-box" will not yet be widely implemented due to the lack of a safe solution for powering these boxes. It can be said that "a smart box needs smart power supply".

Conclusion

Even if we talk only about power cables, the CIGRE session is an interesting event, many times more ambitious than the individual topics that have been highlighted in this brief overview. For example, the overview did not include such important issues as the gradually increasing use of polypropylene-insulated cables (HVAC and HVDC), which, unlike crosslinked polyethylene, is recyclable. Also, there were not included the topics of using DC cables for medium voltage (not HVDC), which finds application in networks of renewable energy sources and data centres. Separately, progress should be noted in monitoring of HVAC and HVDC lines (by measuring cable temperature, vibration, and other parameters), as well as in advanced modelling of cable lines and calculating their long-term permissible current and overload capacity.