Practical HV Cable Jointing and Terminations for Engineers and Technicians

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Technology Training that Works

Presents

Practical

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for Engineers and Technicians

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Overview

In this introductory chapter, we will discuss the need for power transmission and distribution through HV cables, their advantages and disadvantages compared to overhead power line. We will discuss about the different types of high voltage cables, the need for jointing/termination as well as various types of jointing/termination kits that are available in the market.

Learning objectives

- Need for high voltage cables
- Advantages of using cables over overhead transmission lines
- Disadvantages of cables
- Various types of high voltage cables
- Need for cable jointing
- Need for termination
- Various types of jointing kits and termination kits

1.1 Introduction

Utility companies produce power from electrical generators also sometimes called as alternators driven by prime movers. The prime movers that drive the generators are steam turbines in the case of thermal and nuclear power plants, water wheels and water turbines in the case of hydro power stations and wind turbines in the case of windmill generating stations. The power thus produced needs to be evacuated or sent to the users' factories or houses for their use / consumption. This is made possible by the use of overhead transmission lines or by the use of electric cables, which connect the utility station and the users' loads. Overhead transmission lines comprise an open system of conductors made of steel and aluminum or copper wires strung over porcelain or ceramic insulators. Figure 1.1 shows a typical high voltage overhead transmission line system terminating at a substation.

Figure 1.1
Typical view of an overhead transmission line terminating at a substation

Electric cables comprise copper or aluminum wires with layers of insulating materials over the conductors. Figure 1.2 shows a typical view of a high voltage cable for 33kV application.

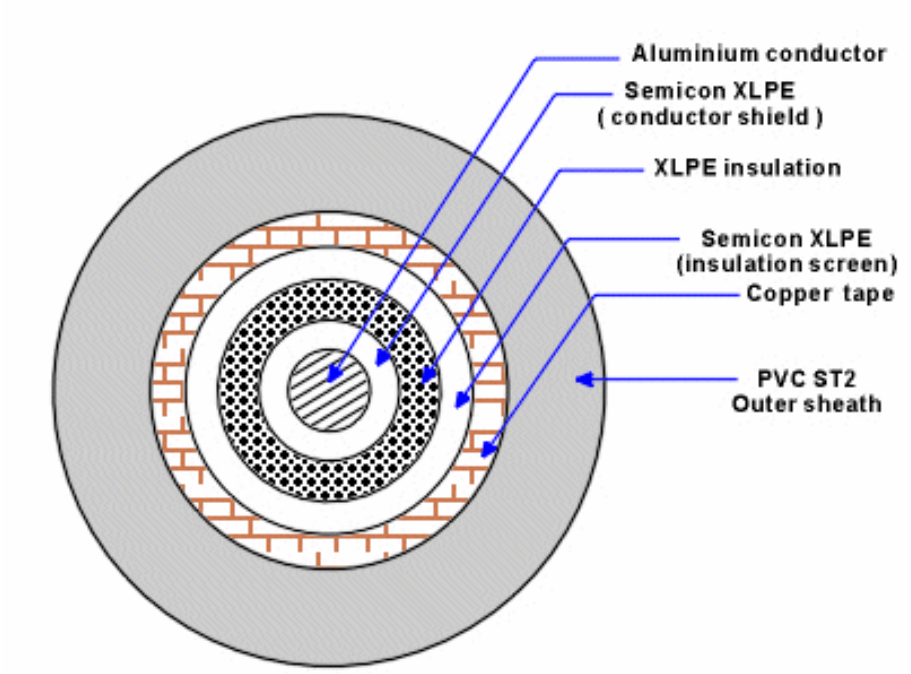

Figure 1.2
Typical view of a 33kV, Cross-linked polyethylene cable

Overhead transmission lines cannot be installed at all applications due to reasons attributable to environment, space requirement etc. Likewise, cables cannot be used in all applications due to reasons attributable to voltage level, distance etc

Cable manufacturers produce cables in standard lengths ranging from 300m to 1000m. The above length depends on the type and unit weight (kg/m) of the cable that is being manufactured. Hence, in case our requirement for cable exceeds such standard length, we have to use an additional length of cable, to complete our work. Here comes the need for joints. Cable joint as the name implies, join the tail end of the first cable and the head end of the second cable. Cable companies themselves or some other manufacturers who specialize only in joints offer "jointing kits". We have to use these kits whenever we need a joint.

Cables also need special kits for the purpose of their termination at sending end and at receiving end. These are called as "termination kits", which can be either procured from the cable manufacturers or from specialized manufacturers of jointing kits mentioned above, who also make the termination kits. Cables are to be installed with care as per manufacturer's recommendation and as per installation codes as per their voltage class. Cables are also to be jointed and/or terminated by skilled technicians who use standard jointing/termination kits.

1.2 Need for high voltage cables

Normally power produced by the generators at the utility stations vary from 6600V to about 15000V depending the output rating. Thus, power produced at the above voltage can be used at the same voltage level for consumers living in the same or nearby locality by the use of a properly designed distribution system. For

consumers living in far off places or for consumers situated in a huge well spread out factory such as an integrated iron and steel works, it is not economically possible to make the above connections (called transmission of power) at the generated voltage, due to increase in energy losses.

Transmissions at higher voltage say 33kV, 66kV, 110kV, 132kV, 220kV etc. mitigate above drawback and bring down the energy loss levels significantly. In order to achieve a higher transmission voltage level, the voltage level of the generated power is to be stepped up or increased using step-up transformers. At the consumer end, step-down transformers are used to bring back or change the voltage to a lower value suitable for the consumer.

In addition, loads such as electric motors operate at higher voltages at higher output ratings. In general, the following table gives the relation between motor ratings in kW and their voltage level of operation.

Table 1.1

Motor output and commonly used voltage rating

Motor rating in kw	***Operating voltages in Volts***
Up to 200kw	415V
Between 200 to 500kw	3300V
Between 500kw to 2500kw	6600V
Above 2500kw	11000V

From the above table it can be seen that large motors need power supply at higher voltages and hence call for the use of high voltage cables. There are other examples of loads, which would need operation at high voltage such as furnace transformers, electrostatic precipitators in dust control systems etc.

Thus, we see that for the basic needs of power distribution inside a factory or for transmitting to far off consumers, high voltage cables are needed.

1.3 Advantages over overhead transmission lines

In general, we can note that high voltage cables have the following advantages over the overhead transmission lines:

- In crowded metros, overhead transmission lines occupy large area apart from looking grotesque and posing safety problems. Requirement of large area calls for land space as well as clearances around the conductors calling for a power alley. This is becoming increasingly difficult to provide in today's crowded metropolitan cities and their satellite townships. In such cases, high voltages cables offer the advantage of installation in cable trenches or underground cable tunnels thus freeing valuable land space over ground. The cables can also be buried directly in ground preferably routed in the space provided along side the roads called as "berm". Freeing of land space has helped in the saving of cumbersome land acquisition procedures and associated litigation issues.
- Ecological restrictions as well as very high real estate costs favor the installation of high voltage cable systems. Sometimes, the objections include visual pollution of an area of natural scenic beauty or a historic site

by the incongruous transmission structures. Another problem is the high electromagnetic interference associated with exposed electrical lines.

- In areas prone to atmospheric lighting discharges, the overhead transmission lines would suffer frequent breakdown and cause power outages. High voltage cables are not affected by the above atmospheric discharges, as they are safe either buried in ground or routed inside a tunnel or trench.
- Due to higher surge impedance, high voltage cables offer increased protection from switching surges to various equipment mainly transformers in installations such as outdoor switchyards.
- For power supply to small islands, it is possible to transmit power only through underwater high voltage cables as overhead transmission lines are ruled out in such applications.

1.4 Disadvantages of cables in power transmission

While we saw high voltage cables score over overhead transmission lines in a few situations, they also suffer from a few disadvantages such as:

- Location of fault in a high voltage cable system is more difficult compared to an overhead transmission line system.
- High voltage cable systems are expensive in voltage levels higher than 33kV when compared to overhead transmission line systems either for the purpose of intra-plant distribution or for interplant transmission of power.
- High voltage cables of oil filled type call for monitoring and inspection schedules, which need to be implemented strictly. In case of overhead transmission lines, such schedules are less stringent and rectification, if needed, is easier in comparison to the cable systems.
- Cable joints and terminations are expensive and call for a factory trained and skilled technician for their installation. In comparison, jointing and termination in overhead transmission line systems are straightforward and simple.
- The joints and terminations in the high voltage cable system pose a cause for worry to the maintenance personnel since the above are the weakest links in the otherwise robust electrical system. This calls for constant monitoring of the joints and terminations.
- Testing of high voltage cable systems is a time consuming process compared to testing of overhead transmission line systems.

Thus, we can conclude that selection of transmission system needs an elaborate study and choice of high voltage cables or overhead system shall be made judiciously.

1.5 Various types of high voltage cables

We can classify high voltage cables broadly into different types based on the insulation medium used. These are:

- Low pressure oil filled cables
- High pressure oil filled cables
- Paper insulated cables
- Cross linked polyethylene (XLPE) cables

Cables can also be classified according to the voltage grades, such as low voltage cables, medium voltage cables, high voltage (HV) cables and extra high voltage (EHV) cables, which in turn is decided by the system voltage where a cable is used. In fact, the type of insulation discussed above is very much dependent on the voltage grade of the cable. The voltage grade based classification can however vary between different countries as no uniform classification is followed internationally. In the forthcoming chapters, we would learn more about the construction and use of these various cables. While MV and HV cables are very common in industrial plant applications, use of EHV cables is almost restricted only to utilities and that too in distribution circuits.

Power cables are also grouped according to the number of cores: such as single-core, 2-core, 3-core and so on. Multi-core cables are commonly used only up to MV levels. HV and EHV cables are always of single core type.

1.6 Need for cable jointing (splicing)

Cables are manufactured in standard lengths and delivered to the customers wound on drums. The weight of the cable drums is substantial and a typical drum with 500m of 3cx240 sq. mm. XLPE insulated cables can weigh up to 7500 kg. This introduces a bottleneck in terms of handling capacity at the cable factory. In addition, large unwieldy drums would pose problems during transportation and installation of the cables at site. Therefore, in order to install large lengths, one has to go in for joints. Also in the case of cable failure in an existing installation, it would be prudent to go in for removal of the damaged portion and replace this section with a new length by jointing with the healthy portions of the cables.

Every user would like to install their cables without joints but due to inevitable reasons explained above, cable joints become a necessity. In general, users feel that a cable joint is a weak point in the distribution chain. On the contrary, jointing kit manufacturers vouch that a properly made joint is as good as the original cable. In addition, joints are required when two cables of dissimilar construction are to be jointed. This happens when an expansion takes place in an existing factory. Likewise, “T” joints are required in certain distribution schemes. Another type of joint is the “branch Y joint which finds use in a few applications.

We can group the various types of joints broadly as:

- Straight through
- Branch Y joints
- T joints
- Transition joints

Depending on the type of insulation of the cable under use, there are further variations in the above types. Also sometimes distinction is made on the location where the joints are made, namely, indoor type or outdoor type. We can study the various types of jointing kits in the forthcoming chapters.

Figure 1.3 shows typical cable joints.

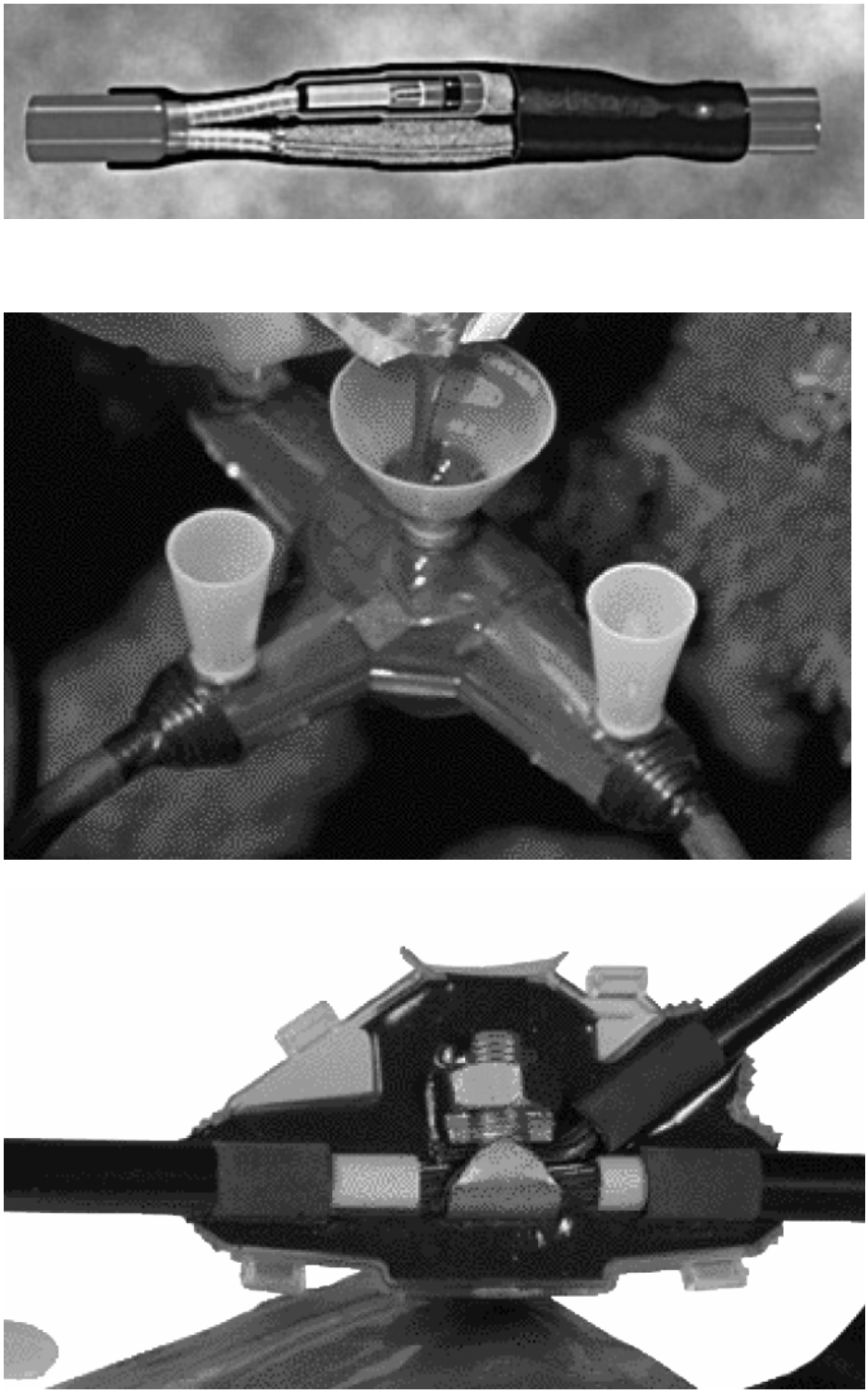

Figure 1.3
Various types of cable joints

1.7 Need for termination kits

Every cable, whether it is low-tension type or high-tension type, needs proper termination so that a cable run can be connected to a piece of equipment, usually a circuit breaker, a transformer, a motor and so on. There are basic requirements like cable boot, cable lugs and consumables like insulation tapes, cable glands used for low voltage cables etc. In the case of high voltage cables there are other accessories related to sealing, stress control etc. These aspects would be discussed in detail in the forthcoming chapters. In addition, basic types of termination kits vary with respect to their location – indoor or outdoor.

Proper termination kits with proven test results are of great importance in order to provide faultless terminations. An improperly made termination would result in heating of the joint and eventual flashover and outage in the systems.

The manuals supplied with the kits do give a systematic procedure for going ahead with the preparation and completion of the termination. Besides the manual, some amount of hands-on training also needed to carry out a sound job.

Figure 1.4 shows a typical high voltage cable termination arrangement.

Figure 1.4
Typical HV cable termination

We can group the various types of termination kits broadly as:

- Indoor termination kits
- Outdoor termination kits (the arrangement shown in the figure above)
- End sealing kits

The first two types explained above are for active terminations. The third type, namely, end sealing kit, is used whenever cable ends are to be left without use for a long time. We will study the various types of termination kits in later chapters.

1.8 Summary

High voltage cables play an important role in the power distribution in the modern world. There is continuous improvement in material science, which brings about better quality of the materials and accessories that go into the manufacture of cables and the various jointing kits and termination kits.

Over a period, overhead transmission lines would be eliminated in our cities for various reasons explained above and high voltage cables would replace them. Due to ecological restrictions, all outdoor substations would be converted into compact gas insulated indoor substations. In fact, all new substations would be indoor type in future. High voltage cables would play a crucial role in such cases i.e., for interconnections to and from indoor substations. Like cables, there is also a continuous improvement in the field of cable accessories such as jointing and termination kits. There are new composite type insulator designs, which have greatly reduced weights and provide extra creepage distances. These insulators are self-cleaning type with excellent properties in areas of fire resisting capability and UV radiation resisting capability. Testing is an important area once the cables are installed, jointed and terminated. Testing is crucial, as it would reveal the quality of work done. We would be dwelling upon above aspects in detail in the later chapters.

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