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# HV CABLE JOINTING AND TERMINATIONS FOR ENGINEERS AND TECHNICIANS



## WHAT YOU WILL LEARN:

- Basic principles of cable jointing and terminations
- Construction of electrical power cables, different types of cables for various voltage ratings and manufacturing aspects
- Different types of connectors and connection methods
- Methods of cable terminations and jointing and choosing an appropriate type for every application
- Importance of stress control and methods of stress redistribution in joints and terminations
- Important installation aspects in cable joints and terminations
- International and national standards applicable
- Type testing and routine testing
- Failures, failure analysis and failure prediction
- Future trends in cable technology and cable accessories

## WHO SHOULD ATTEND:

- Consulting Engineers
- Electrical Engineers
- Project Engineers
- Maintenance Engineers
- Power System Protection and Control Engineers
- Building Service Designers
- Data Systems Planners and Managers
- Electrical and Instrumentation Technicians
- Master Electricians

## The Workshop

The range of voltage and capacity of power transmitted through cables has shown a steady increase over the years. Environmental concerns, aesthetic issues, lack of transmission corridors and difficulty in routing overhead lines in crowded human habitats are some of the reasons for the explosive growth of cable technology well into the extra high voltage range.

Due to physical limits on cable lengths for manufacturing and packaging, joints in cable become inevitable, particularly in the context of the utility sector. The cables also need to be terminated at sending and receiving end equipment, a very wide variety of them, in utility as well as industry applications and this calls for appropriate cable termination accessories. Cable terminations and joints form the weakest link in any distribution system. Also, a failed joint in an underground distribution system is much more difficult to locate and repair compared to any similar problem in overhead distribution systems. This means that we should do our utmost to achieve a good joint or termination, which can give years of trouble-free service.

The quality of a joint or termination depends to a large extent on the skill of cable joiner. The aim of a cable joiner must therefore obtain a joint whose electrical properties are as good as the original cable both in electrical and mechanical terms. The design of cable jointing and termination accessories is based on this perception. Dependence on operator-skill is sought to be reduced by good choice and quality of jointing materials, though such dependence cannot be totally eliminated.

We will discuss these issues in this course by looking at the fundamental aspects involved so that the importance of the correct execution of a termination or joint will be brought home to those who attend the workshop.

### Pre-requisites

Some working knowledge of basic electrical equipment is required, although this will be covered at the beginning of the course. Real-life experience with such equipment and hands-on testing will enable the workshop to be placed in context.

## The Program

### INTRODUCTION

- Need for cable joints and terminations
- Cables - types and historic perspective
- Types of insulation materials
- Basic types of terminations and joints
- Installation aspects - reducing the number of joints by proper planning
- Standards and testing
- Failures

### CABLES

- Basic construction
- Conductor materials and configurations
- Insulation materials for different applications and voltages: PVC, paper and XLPE
- Use of screen in HV cables
- Use of armour for earth continuity and mechanical protection
- Special aspects of single core cables
- Voltage rating of cables and impact of system earthing method on voltage rating
- Stress distribution in single core and multicore power cables
- Electrical breakdown of insulating materials
- HV cables using XLPE insulation
- Treeing in XLPE and need for end sealing of cables in storage
- Basic manufacturing process

### CABLE CONNECTORS

- Materials
- Types of connectors for cable terminations and joints
- Current path
- Method of connections: soldering, brazing, welding, crimping (compression) and bolting
- Comparison
- Contact resistance
- Preferred methods in practice for different cable ratings
- Contact of dissimilar materials and galvanic effects, use of bi-metal accessories

### JOINTS AND TERMINATIONS - THEORY

- Basic approaches
- Broad classification of joints/terminations approach: prefabricated and site fabricated from kits
- Comparative merits
- Prefabricated: pre-moulded (slip-on) and cold shrink
- Site fabricated: taped and compound sealed, taped and cast resin sealed and heat shrinkable
- Additional requirements of outdoor terminations
- Reconstitution of cable properties: insulating tape, semi conducting tape, high permittivity stress control tape and sealing against moisture
- Connectivity for cable screen and armour
- Mechanical protection of joints and terminations

### STRESS CONTROL

- Effect of joints and terminations on stress gradients
- Areas requiring stress control: terminations and joints
- Basics of stress control approach: geometric solutions, use of stress control tubes, cones, high permittivity solutions, use of stress control tapes

### JOINTING AND TERMINATION PRACTICE

- Kits for joints and terminations
- Shelf life issues
- Importance of matching diameter of insulated conductor with kit specifications in pre-fabricated kits
- Preparation of cable for termination and jointing
- Connection
- Reconstitution of cable properties
- Continuity and earthing aspects
- Sealing
- Healthiness of joint/termination
- Installation aspects for joints: buried joints and markers for identification, joints placed on cable structures with other cables-safety issues, access for repairs

### STANDARDS AND TESTING

- International/national standards
- Type tests
- Limitations
- Routine tests
- Training and certification of personnel

### TERMINATIONS TO EQUIPMENT

- Terminations to indoor switchgear: need for coordination with manufacturer of switchgear, issues arising from multiple terminations, design of switchgear terminals
- Terminations to electrical machines
- Terminations of outdoor HV installations
- Terminations to GIS installations
- Importance of correct orientation of terminations

### FAILURES AND ANALYSIS

- Reasons for failures
- Documentation of work
- Documentation of failures
- Analysis of failures
- Predictive approach: use of partial discharge detection

### NEW TRENDS

- Reasons for increasing preference to underground cables
- New technologies for very high capacities and voltages
- EHV XLPE
- High temperature superconductivity in cables and likely impact on current practices

### SUMMARY, OPEN FORUM AND CLOSING