

Maintenance Activity in 400 kV XLPE Power Cable System

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Abstract: This document outlines a general maintenance schedule of cross-linked polyethylene (XLPE) cable systems for voltage levels $U_m = 400$ kV. The general maintenance schedule relies on long operational experience with XLPE cable systems and is based on recommendations and specifications of technical CIGRE - brochure no. 194 and no. 279.

Keywords: Maintenance Activity, 400 kV, XLPE, Power Cable system

1. Introduction

This document outlines a general maintenance schedule of cross-linked polyethylene (XLPE) cable systems for voltage levels $U_m = 400$ kV. The general maintenance schedule relies on long operational experience with XLPE cable systems and is based on recommendations and specifications of technical CIGRE – brochure no.194 [01] and no.279 [02]. XPLE cable systems are designed for 40 years of operation and are generally very reliable.

The operator/utility shall ensure that during the operating lifetime of the cable system, the maximum operating values for voltage and current shall not exceed the design values. Moreover, the installation and environmental conditions that have been adopted in the design of the cable system were considered.

Maintenance procedures for extruded cable systems are usually limited to visual inspection of the cable, associated equipment, periodical checking of the integrity of the cable over the sheath and bonding system.

It is important that preventive maintenance is carried out by well-trained/experienced personnel who can carry out the maintenance works according to the relevant international standards and approved procedures/Method of Statement (MOS), after taking all necessary safety precautions.

Special Safety requirement for cables in tunnels:

As 400 kV XLPE power cables are usually installed underground through different installation conditions, our paper focuses on the 400 kV XLPE power cables laid in underground tunnels (Figure 1 A & B).

Specific safety precautions shall be considered and determined by the operator to ensure the safety of their staff prior to entering the tunnel, and shall not be limited to the below requirements:

- Only authorized and competent personnel are allowed to enter the tunnel
- Specific Permit to Work (PTW) to be issued by the operator prior to entering the tunnel.

- Environmental conditions inside the tunnel are suitable to perform the maintenance work such as:

○ Temperature inside tunnel $< 50^{\circ}\text{C}$.

Before any access, it is recommended to check the tunnel temperature and to confirm that it is lower than 50°C .

○ Electromagnetic field according to International guidelines, in our case we refer to the International Commission on Non-Ionizing Radiation Protection (ICNIRP-1998), the exposure guidelines are:

- Public exposure limits: $100\ \mu\text{T}$
- Occupational exposure limits: $500\ \mu\text{T}$

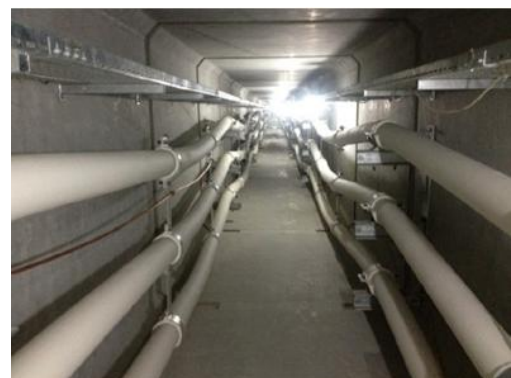
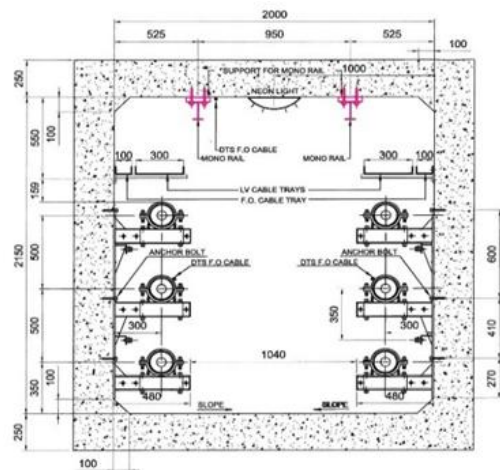


Figure 1 A: 400 kV Cable arrangement inside Tunnel

Volume 11 Issue 1, January 2022

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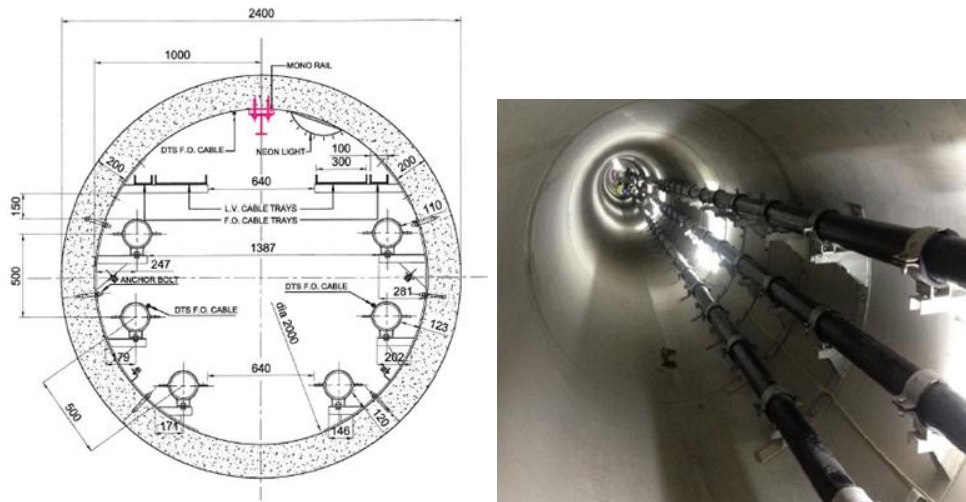


Figure 1 B: 400 kV Cable arrangement inside Micro Tunnel (Crossing the main road)

Maintenance Schedule

The frequency of the maintenance activities has to be proposed based on detailed study/analysis taking into consideration cable system manufacturer recommendation.

Reliability Centered Maintenance (RCM) methodology is one of the methodologies being followed by many utilities

recently to specify the maintenance activities and the frequency of these activities for all equipment.

1.1 Cable System General

The maintenance activities in Table-1 are commonly performed for 400 kV XLPE power cables, the frequency/requirement might be varied based on operator requirement and Manufacturer recommendation:

Table 1: Maintenance Activities for 400 kV XLPE Cable System

No.	Activity	Procedure	Requirement	Operating State	Measures in case of Deviations	Frequency	Work Duration	Personnel / Equipment
1	Cable route patrolling	Visual inspection	Prevent unauthorized works in the vicinity of cable route / tunnel	system on-line	Stop unauthorized works	daily	1 day	Technician/ vehicle
2	Inspection of cable tunnel	Visual inspection	no obvious damages to cables, accessories, additional equipment, steel construction	system on-line	Schedule rectification activity, Obtain Manufacturer recommendation if necessary.	twice yearly	1 day	Technician, Tool box
3	Outer sheath Direct Current (DC) test and Sheath Voltage Limiter (SVL) testing	sheath test	Direct Current (DC) test of outer sheath with 5 kV DC / 1 minute	system off-line	Schedule pinpointing/repairing activities	every 3 years	1 day	Technician, Direct Current (DC) testing kit, Tool box
4	Sheath fault locating and repairing (SFLR)	Sheath fault locating and repairing (SFLR)	Sheath with pinpointing kit	system off-line	Locating the Exact position of the damage and Repair the fault	When sheath fault detected	7 days	Technician, fault locating kit, Tool box, Repairing material
5	Partial discharge (PD) measurement for system inspection	synchronic PD-measurement at cable screen of each accessory	no internal PD with vertical and horizontal comparison of the accessories	system on-line	Obtain manufacturer/PD specialist recommendation	On-line system	On-line	On-line monitoring
6	Functional testing of Distributed Temperature Sensor (DTS)	Temperature at cable / inside the tunnel	Compare the temperature along other phases	system on-line	Inspect the high temperature zone, Obtain manufacturer recommendation,	On-line system	On-line	On-line monitoring
7	Inspection of oil level in termination	visual inspection	Oil pressure system reading as per O&M manual setting	system on-line	Schedule repairing activity, Obtain manufacturer recommendation if required	Monthly	1 day	Technician
8	Fire Alarm-Routine checking	inspection	Check the fire alarm system in the tunnel	system off-line	Schedule repairing activity, obtain manufacturer recommendation if required	Yearly	1 day	Technician, Tool box

9	Lighting and Emergency Lighting System-Routine checking	inspection	Check the lightings in the tunnel	system on-line	Schedule repairing activity,	Yearly	1 day	Technician, Tool box
10	Drainage Pump-Routine Checking	inspection	Check the drainage pumps, located at each low points of the circuits	system on-line	Schedule repairing activity, obtain manufacturer recommendation if required	every 2 years	1 day	Technician, Tool box
11	Tunnel-Minor water leakage inside the tunnel	inspection	no leakage	system on-line	Repair of detected water leakage in the tunnel	N/A	1 day	Technician, Tool box

Failure and Repair Plan

If failure or damage occurs, the repaired method might be varied based on the abnormality as per Table-2.

The repair time considers that all necessary spare materials are available on-site and the installation staff / manufacturer / supplier jointers including tools have arrived at the site.

1.2 Possible Troubles / Faults and Repair Concept

Skilled technicians, required tools, installations consumables as well as materials having limited shelf life to be maintained continuously.

After repair a test with U_0 for 24 hours duration is recommended (in accordance with IEC 62067) accompanied by a partial discharge measurement at each newly installed accessory.

Table 2: Failure and Repair Scenario for 400 kV XLPE Cable System

No.	Abnormality	Repair Concept	Repair Time	Personnel / Equipment
1	cable failure / damage	Replacement of the failed / damaged cable with new joint if cable loop is available. Replacement of the failed / damaged cable with new piece of power cable and two addition joints or one joint & one termination if cable loop is not available (depends on the location)	2 weeks-1 Month	Technician/ Supplier jointer & Repairing material
2	Joint failure / damage	Replacement of the failed / damaged joint with new joint if cable loop is available. Replacement of the failed / damaged joint with new piece of power cable and two new joints if cable loop is not available	2 weeks-1 Month	Technician/ Supplier jointer & Repairing material
3	Termination / Outdoor sealing End (ODSE) failure / damage	Replacement of the failed / damaged termination / Outdoor sealing End (ODSE) with new termination / ODSE if cable loop is available. Replacement of the failed / damaged termination with new piece of power cable and new termination and new joint if cable loop is not available	3 weeks-1 Month	Technician/ Supplier jointer & Repairing material

2. Spare Material

For the case of a failure / damage, Table-3 specifies the minimum required spare materials to be available in store.

However, associated consumables have to be checked and replaced periodically based on the maintenance manual of the manufacturer.

Table 3: Spare Material for 400 kV XLPE Cable System

No.	Equipment	Material					
		CABLE	Gas Insulated Switchgear (GIS) Termination	Outdoor Sealing End Termination	Joint	Link Box	Bonding Cable
1	400 kV XLPE power Cable System	3 Drums of the lengthy section to be maintained	One set of 3 Nos to be maintained	One set of 3 Nos to be maintained	2 set of joints (each set of 3 Nos) to be maintained	One Set of 2 Nos to be maintained	One drum (i.e. 500 meters) to be maintained

References

- CIGRE – brochure no.194 [01] and no.279 [02]
- ICNIRP – 1998