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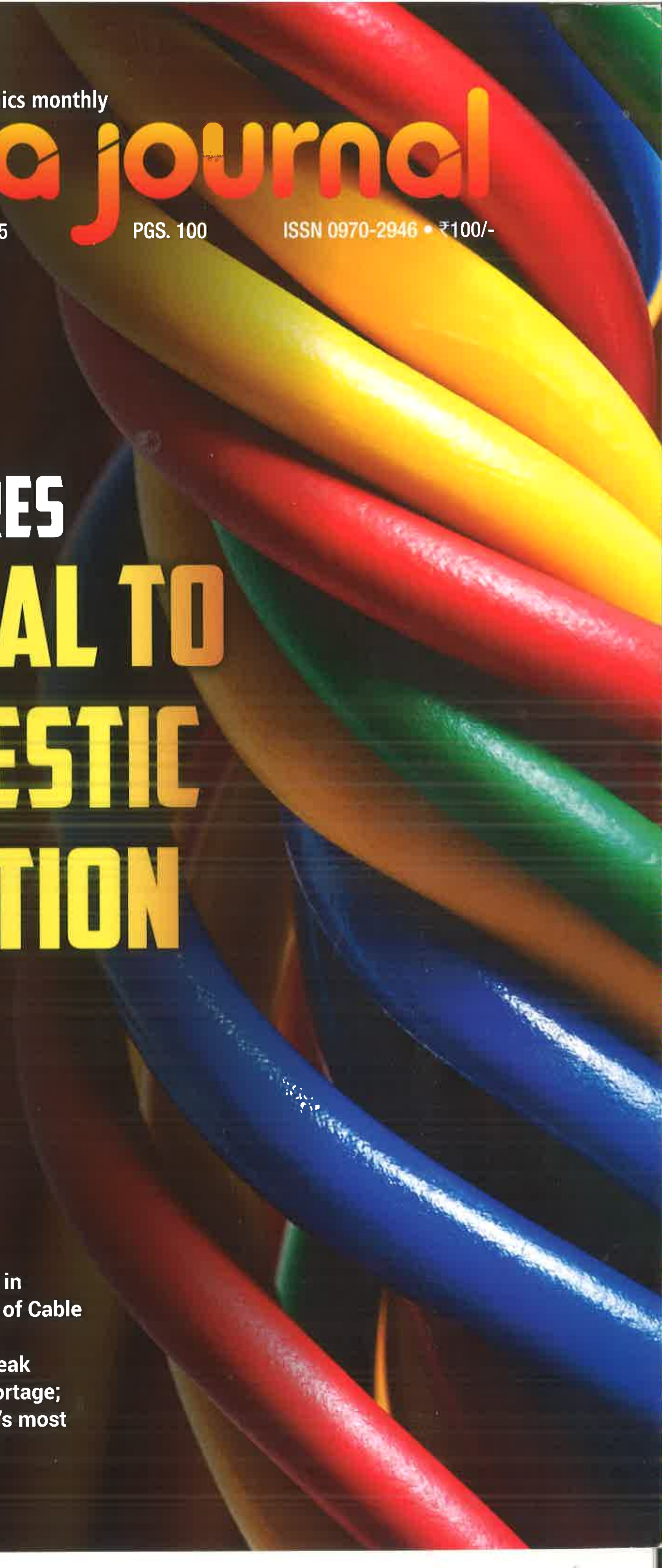

CABLES & WIRES

POTENTIAL TO 4x DOMESTIC PRODUCTION

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Enhancing Cable System Integrity: Root Cause Analysis of Joint Failures

Root cause analysis can help in preventing future failures and improving maintenance and procurement practices, which increases reliability of the cable network, says **Dr. Nitin Shingne, Head of Advanced Materials, Electrical Research and Development Association (ERDA), Vadodara.**

Cable networks are increasingly vital for power transmission and distribution, largely due to right-of-way constraints and aesthetic considerations. However, failure in cables can disrupt services. Furthermore, in case of underground cables, finding the fault location can be challenging, leading to longer disruption of power transmission and distribution and costly repairs. Thus, root cause analysis (RCA) is crucial for understanding why the failure happened. RCA can help in preventing future failures and improving maintenance and procurement practices, thus helping increase the reliability of the cable network.

A typical cable network comprises cables and their accessories, such as joints and terminations. Studies by CIGRE (Le Conseil international des grands réseaux électriques or The International Council on Large Electrical Systems) highlight that cable accessories are a significant weak point. CIGRE Technical Brochure 379 reported that more than 60 percent of internal faults in cross-linked polyethylene (XLPE) insulated land cables with a voltage rating of 60 kV and above are linked to accessories [1]. A subsequent survey by CIGRE Working Group B1.57 indicated an even higher failure rate for accessories in XLPE cables [2].

Cable accessories are designed to minimise high electrical stresses, which require precise material selection and skilled personnel for installation. Poor workmanship during jointing operations is a primary cause of immediate failures in cable accessories after installation [3] – this is the reason high rate of cable failures are attributed to cable accessories. Some examples of poor workmanship leading to failure of cable joint and terminations are discussed in this article.

Failure in 33 kV Cables Joint

Figure 1 shows 33 kV failed cable joint. The joint failed after a service life of less than one year. The failure was observed in the form of puncture and overheating marks on the outer sheath of joint.

When the joint was opened for post-mortem analysis, the problem was observed at the conductor joint as shown in Figure 2. The conductor connector

Figure 1: a) Failed 33 kV cable joint, b) Puncture on the joint, c) Outer sheath showing indications of overheating.

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When the joint was opened for post-mortem analysis, the problem was observed at the conductor joint as shown in Figure 2. The conductor connector or lug was improperly placed and bend near the XLPE insulation on one side; on the other side, there was sufficient gap between the insulation and lug. The XLPE insulation was improperly cut, and blade marks were still visible on the insulation. Improper crimping and sharp edges of the lug were touching the XLPE insulation, which led to localised heating and progressive degradation of XLPE insulation, resulting in failure of the cable joint.

Figure 1: a) Failed 33 kV cable joint, b) Puncture on the joint, c) Outer sheath showing indications of overheating.

Figure 2: Cable conductor joint with visible melting of aluminium lug on and burned XLPE insulation.

Figure 3: Failed part of the 66-kV cable joint.

Figure 4: Connection of the earthing continuity wires with aluminium sheath.

Failure in 66 kV Cables Joint

A 66-kV cable joint failed after a service life of seven months. The failed cable joint was used for jointing 66 kV XLPE insulated single core cable that was laid underground. The cable had corrugated aluminium sheath covered by bitumen compound for protection against water and corrosion. The outer sheath was made up of HDPE to protect all inner components from the environment. The total length of failed joint received at ERDA was 187 cm; the failure was observed at one end of the joint as shown in Figure 3. At the failure end, the outer sheath was covered with sand due to melting of the sheath. The XLPE insulation was punctured in the joint, where the earth continuity copper wires from the joint were connected with cable aluminum sheath.

Post-mortem analysis of the coble joint showed a change in XLPE insulation colour to light yellow up to 5 cm from puncture location. This indicated prolong overheating of the insulation before puncture. Dissection of the other end of the cable joint revealed improper jointing of the ground continuity wire connections on the aluminium sheath as shown in Figure 4. Before connecting the copper earth wires, the aluminium sheath was not properly cleaned, bitumen was still present, and black mastic tape was placed between the copper mesh and earthing wires. This resulted in localised contact resistance for the flow of sheath current, resulting in localised heating of the insulation when sheath current was high in the cable. This led to progressive degradation of XLPE and failure.

Summary

To improve reliability of cable network, here are some recommendations suggested:

- Use of skilled and certified cable jointers for cable termination and jointing.
- Cable joint and terminations to be tested in laboratory as per IS 13573 to verify their performance and workmanship.
- Videography of the cable jointing process, including joint identification, is essential for identifying errors and implementing future corrective actions.
- Making sure earth connections are proper, and earth resistance is minimum.

References

[1] CIGRE TB 399 "Update of Service Experience of HV Underground and Submarine Cable System" Working Group B1.10, April 2009.

[2] CIGRE TB 815 "Update of Service Experience of HV Underground and Submarine Cable System" Working Group B1.57, September 2020.

[3] Nitin R Shingne, Gaurav S Dhiman, Uday N Puntambekar, Satish H Chetwani, "Analysis of Failed Cable Termination: Role of Workmanship and Electrical Stresses", CIGRE Session 2022, Paper No. B1-10443.