The Weakest Link in Underground MV Networks

Joint failure modes and why interfaces matter most

Introduction

Underground medium-voltage (MV) networks are designed for long service life, even in moist soil conditions.
Yet when outages occur during or after flooding, failures are disproportionately concentrated at cable accessories, especially joints.
This is not a coincidence. A joint is where materials, geometries and interfaces come together, making it the most complex and therefore most vulnerable part of the system.
This extract explains the most common joint failure modes under wet conditions and why interfaces, not bulk materials, typically define reliability.

Why joints are more vulnerable than cables

MV cables are continuous systems with insulation layers engineered to tolerate long-term exposure to moisture and submersion.
A joint is different: it introduces transitions between conductive elements, insulation systems, housings and sealing layers in a confined space.
Those transitions create multiple potential entry points for moisture, especially when networks face standing water, high groundwater or hydrostatic pressure.
Because of this complexity, joint reliability becomes a system-critical factor under wet operating conditions, not a secondary detail.

The typical failure chain after moisture ingress

When water enters a joint, it rarely causes immediate catastrophic breakdown. More often, it initiates a sequence of degradation mechanisms that accumulate over time.
Common effects observed and described in post-event analyses include:

- reduced insulation resistance
- increased dielectric losses (tan δ)
- initiation of partial discharge
- water treeing and progressive insulation damage
- accelerated thermo-electrical ageing at interfaces

This is why many flooding-related joint failures appear as delayed outages: the root cause is moisture ingress, but the failure occurs after degradation has progressed.

Failure mode 1: Interface leakage (the most common pathway)

In practice, water ingress in MV joints occurs predominantly along interfaces rather than through bulk material.
Interfaces can include transitions between polymeric cable sheaths, housings and metallic elements, where even small discontinuities can form a preferential pathway.
Under hydrostatic pressure, water will exploit:

- imperfect wetting during installation
- micro-gaps caused by dimensional tolerances
- local debonding over time
- ageing-related changes at material boundaries

Engineering implication: interface sealing performance is often the defining factor for wet-environment reliability.

Failure mode 2: Voids and unfilled gaps (initiation points for degradation)

Void-free encapsulation is critical because air pockets and unfilled interfacial gaps become initiation sites for pressured-driven water ingress and partial discharge.
Even small voids can concentrate electrical stress and create conditions where partial discharge begins, especially as moisture increases conductivity along local paths.
In wet service conditions, the combination of voids and water exposure accelerates the degradation chain described earlier (dielectric loss rise, PD inception and ageing at interfaces).

Engineering implication: filling behaviour, wetting and the elimination of voids matter as much as the nominal insulation design.

Failure mode 3: Ageing-related cracking and loss of sealing continuity

Repeated thermal cycling, soil movement, vibration and long service time impose mechanical stress on the joint body and its sealing layers.
If the outer sealing system becomes brittle or develops microcracks, those defects can become preferential pathways for water ingress under pressure.
Investigations in repeatedly flooded environments frequently identify insufficient sealing, poor adhesion and ageing-related cracking as leading contributors to outages.

Engineering implication: long-term crack resistance and stable mechanical integrity are essential for wet-environment performance, not optional features.

Failure mode 4: Loss of adhesion (sealing mechanism breaks down)

A joint's sealing capability is often adhesion-driven. Strong adhesion to cable jackets, housings and metallic elements blocks longitudinal water migration along interfaces.
When adhesion is weak, degraded or inconsistent, water can track along the interface even if the bulk material remains intact.
This is one reason why joints can fail under wet conditions even when the main insulation material is theoretically "water resistant."

Engineering implication: interface bonding quality is a dominant reliability variable in flooded environments.

What this means for transition joints and mixed materials

Transition joints combine different cable constructions or sheath materials, increasing the number and complexity of interfaces in a single assembly.
More interfaces mean more potential pathways for moisture migration and more locations where long-term ageing effects can accumulate.
For transition applications, reliability depends strongly on:

- consistent interface wetting during installation
- durable adhesion across different substrate types
- stable mechanical integrity under service stresses

Conclusion
In wet and flooded conditions, MV joint failures are usually driven by interfaces: leakage paths, micro-voids, cracking and loss of adhesion. Water rarely needs to penetrate bulk

material to cause damage; it exploits discontinuities at boundaries and initiates a degradation chain that often results in delayed outages. Improving joint reliability therefore starts with controlling interfaces, eliminating voids and maintaining sealing continuity over the full service life.

Continue exploring

On the main page, you can explore practical design principles for flood-resilient joints (including resistance to hydrostatic pressure), along with selection criteria that help engineers and asset managers choose solutions for water-logged areas and complex transition applications.