MINIMISING LOSSES OF HV UNDERGROUND POWER TRANSMISSION CABLES

Underground power cable systems present unique design and installation challenges not found in the overhead power cable environment. Poor thermal dissipation, confined spaces, lack of visibility, more difficult fault diagnosis, circulating earth currents, and frequent joints in an unfriendly environment are all problems that cable engineering must overcome to deliver a reliable long term installation. A well designed cable system delivers maximum power and minimum losses within a small footprint.

The current rating of HV underground cable circuits is mainly influenced by environmental factors and cable losses. Specialised techniques are used to improve cable heat dissipation. Heat generated in cables is caused by electrical losses in insulation and metallic components. These are classified as current or voltage dependent losses.

Current losses are generated in cable conductors, metallic sheaths, armouring and piping designed to carry fault currents.

In a simplified cable system the three main loss generators are main conductors, insulation and metallic sheaths / wire screens.

VOLTAGE DEPENDENT LOSSES
Voltage dependent losses are caused by capacitive effects. The cable is effectively a large capacitor. Charging current and dielectric losses are dependent on dielectric constant (e), electrical resistance plus magnitude and frequency of applied voltage. Voltage losses are generated all the time the cable is grid connected.

CURRENT DEPENDENT LOSSES
Current dependent (conductor) losses are ohmic losses manifested as heat generated by current flowing in cable conductors. AC electrical resistance (Ω) is dependent on skin effect, proximity effect and temperature variation. Skin effect is caused by conductor self-inductance being greater at the centre than the periphery, which leads to current flow concentration at the surface. The proximity effect is generated by conductor current induced magnetic field (and other parallel conductor currents).

If the current in parallel conductors flows in the same direction the magnetic flux is higher on the inner parallel side, increasing AC resistance in this part of the conductor, so current density is greater in the external (remote) halves of the conductor.

Proximity effect is influenced by cable DC resistance, system frequency, cable spacing and cable diameter while skin effect is influenced only by resistance and frequency. This may be ignored for small conductors (say up to 800mm²) carrying low currents. The effects are significant for high rating cables with large conductors and it is essential to compensate for their effect by using “Milliken” or “Segmental” conductors of several alternated, insulated sector shaped strands.

SHEATH LOSSES
Sheath losses are generated in cable metallic sheaths by induced currents when load current flows in cable conductors. Sheath currents in single-core cables are induced by “transformer” principles; by the magnetic field of current flowing in the cable conductor which induces voltages in the cable sheath and other parallel conductors. Sheath induced electromagnetic forces generate two types of losses: circulating current and eddy current losses.

Eddy currents are generated by similar principles to skin and proximity effects. Eddy currents are generally smaller than circuit (circulating) currents of solidly bonded cable sheaths and may be neglected except for very large segmental conductors.

A circulating current is induced in the sheath by the conductor current’s electromagnetic forces if the sheath is double bonded to form a closed loop via earth or a return conductor.

These losses are determined by the magnitude of current in the cable conductor, frequency, mean diameter and resistance of the cable sheath and the distance between single-core cables; ie the mutual inductance. Sheath losses can be significantly reduced or eliminated by applying special sheath bonding systems in conjunction with cable transposition at joint bay positions.

A cross bonding link box is used at every splice point or joint bay to transpose cable sheaths to balance cable sheath impedances.

The bonding system may include several alternatives such as single-point bonding, continuous bonding or the classic bonding of a series of consecutive 3 (three) minor cable sections.

Surge voltage limiters or arrestors are routinely used between sheaths and earth at each link node to limit induced voltage spikes that may occur during transient and fault conditions.

RELIABILITY IN HOSTILE ENVIRONMENTS
Environmental considerations are very important in reliable link box design. A box should be capable of withstanding fire and flood. This means it should be explosion proof in the event of an internal fault and withstand deep water immersion indefinitely. Naturally, robust corrosion resistant material is mandatory. Ease of access for installation, maintenance and system troubleshooting is very important, as well as a robust and reliable joint sealing system.

SUMMARY
Cross bonding and single point bonding link boxes in a well designed underground power transmission cable system will minimise current losses and thermal problems, allowing the cable system’s ampacity to be uprated by as much as 40 percent.
HV Power Cable Earth System Link Boxes

AEM’s HV POWER CABLE LINK BOX FAMILY is a complete solution for:

// Minimising circulating earth current losses
// Enhancing system reliability, availability and safety
// Simpler and quicker project installation and commissioning
// Easy, visible cable testing

- UK EA C55/4 COMPLIANT
- FITS 70 MM² – 300 MM² CABLES
- UP TO 330 kV SYSTEM VOLTAGE
- IP67 ENCLOSURE

- CAPTIVE, SELF CENTRING, SELF ALIGNING FASTENER SYSTEM
- ANY SIDE HINGE, FIELD CONFIGURABLE FOR EASY ACCESS
- 250 kPa INTERNAL EXPLOSION RESISTANCE

DESIGNED & MANUFACTURED IN AUSTRALIA