Safe discharge of high cable capacitances under HV DC Stress

Ulf **GUSTKE**, Gunnar **STEIN;** Megger – Hagenuk KMT GmbH; Radeburg; Germany
ulf Gustke@megger.com, gunnar.stein@megger.com

ABSTRACT

Growing demand of electrical energy in every place of the world was leading to various structures of power generating solutions and thus ongoing development. Such as well-known, regular power plants onshore (e.g. fossil firing based) and modern clusters of windmills offshore installations. All of that energy must feed and safely operated in the Transmission Grids. Typical designs for power distribution and transmission systems are overhead power lines and/ or more and more insulated power cables with increasing length. The intrinsic property of these mostly polymeric insulated cables is their much higher capacitance per kilometer compared to overhead lines of about factor 300-500. Charging these cables for testing, diagnoses and/or cable fault location leads to a pre-calculable amount of stored electrical energy in this feeder cable capacitance. The effect of charge accumulation under HV DC Stress requires a controlled discharge process to avoid damages of the insulation. But a very important safety aspect as well is to protect the operator and the Test equipment. The high amount of stored energy must be handled and discharged in a safe way during and in every status of the cable maintaining process. This contribution describes the way of design such discharge device and "how is the workflow" aspects for that discharge and grounding module and the procedure of operation in modern high voltage energy cable infrastructures.

KEYWORDS

Charged cable, stored energy, safe discharge, field proof applicability

INTRODUCTION

The proportion of high voltage cables in electrical network structures is increasing. It replaces overhead line constructions more and more. For example in Germany the amount of cables in the energy network was increasing in the period from 1993 to 2013 by app. 20% in the medium voltage (MV) network, in the high voltage (HV) and extra high voltage (EHV) segment much smaller, app 3% in HV-network and only 0.3% in EHV - network [1] in the same period. Further demands on growing mainly XLPE insulated AC and DC cable structures are reported on other platforms [2].

Capacitances of cables in HV transmission grids are typically at a value of app. 0,21 µF/km.

It is a focus in general to save installation costs on these transmission projects. Therefore the design of such new cable feeders will be in some projects without interrupters in line. That means it will be not possible to separate cable segments for fault location purposes. Related to the current and planned transmission grid long cable routes with capacitances up to app. 75 µF – 180 µF will be built.

When a high voltage cable failed under service conditions, for different reasons the outage time needs to be as minimized as possible. A Cable failure must be located and repaired in a certain minimized timeframe.

MAIN FAULT LOCATING PROCEDURES AND THE CHALLENGE FOR SAFETY AND OPERATOR CONVINIENCE

The fault location process on a cable is well known over decades. Main principles are taking place under "offline conditions" on the cable, the cable is de-energized.

Typical procedure steps for fault locating are:

1) Check the condition of the cable (e.g. Insulation resistance measurement; check for breakdown voltage)
2) Identify significant characteristics in the cable feeder line by performing TDR measurement (e.g. cable end, number and location of joints)
   Compare TDR traces with finger print TDR traces and between healthy and faulty cable cores to locate low resistive faults
3) In case of high restive faults try to re-ignite the fault
   a. Step one) by charging high voltage on to the cable
   b. Step two) by capturing TDR Traces while fault is ignited during an physically existent plasma channel (e.g. measuring ARM Traces)

After step 2 or 3 was successfully performed

4) "Thump" on to the cable and its fault – by discharging a DC - charged high voltage capacitor (surge wave generator)

Step 3 is called fault "pre-location" and step 4 is called fault "pinpointing" in this terminology.

To charge the cable with a high voltage generator, two modes are beneficial:

1. Mode A:
   Direct applying DC Voltage up to an defined level
2. Mode B:
   Charge an HV- capacitor (integrated in the system) to a certain level and discharge the capacitor cyclically into the cable, with certain repetitions. When the voltage level increase (stepwise)

These two modes are procedures where the cable capacitance will be charged with high voltage to a certain energy level stored in its dielectric. When the defined voltage value is reached and no breakdown occurs at the fault point, a high energy (Joules) level is stored in the cable dielectric.