HVDC cable rating methodology: Thermal, electrical and mechanical constraints

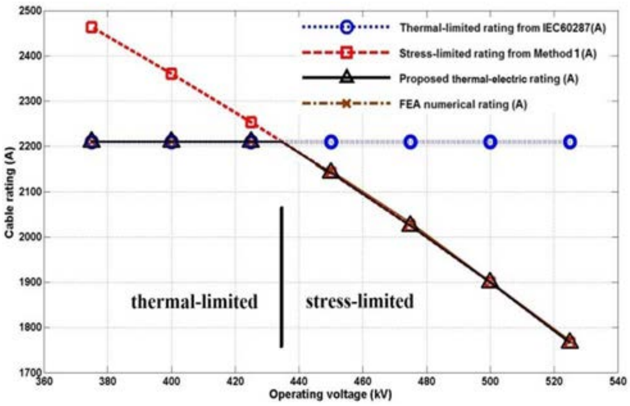
Ziyi **HUANG** (1), James A **PILGRIM** (1), Paul L **LEWIN** (1), Steve **SWINGLER** (1), G **TZEMIS** (2)

1 University of Southampton, Southampton, UK, zh2g09@soton.ac.uk
2 National Grid Plc, Warwick, UK, Gregory.Tzemis@nationalgrid.com

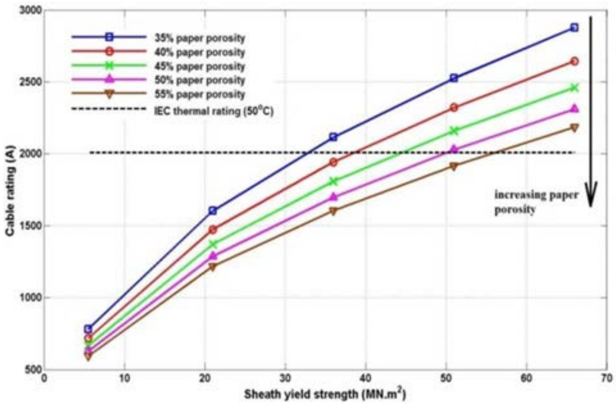
With the continuing growth in energy consumption worldwide, the move towards a European wide super grid will result in significant changes in how modern transmission and distribution networks are operated. As long-distance bulk power transmission between maritime nations is normally carried out through high voltage dc (HVDC) power cable circuits, fundamental to this is the need to accurately know or determine their available ampacity. Therefore, an accurate cable rating becomes paramount towards an efficient and safe operation of transmission networks.

Besides the standard IEC thermal-limited rating methodology which follows a maximum conductor temperature constraint to prevent excessive dielectric thermal ageing, HVDC applications impose extra physical constraints (i.e. electrical and mechanical) on the cable rating and are not thoroughly considered by standard rating approaches. Electrically, the dielectric field inversion under HVDC applications has its maximum electrical stress at the insulation screen, which increases with an increasing current loading. This means a dielectric electrical breakdown may occur before the normal upper thermal limit is exceeded. Thus a rating methodology limited by the maximum dielectric electrical stress is very useful. Mechanically, unacceptably high interfacial pressure changes are reported during loading cycles through thermal expansion or contraction. Consequently, plastic deformation of the cable sheath can occur and dielectric voids might be introduced. Therefore, a rating methodology which prevents internal mechanical damage is also of great value. Thermally, the analytical calculation loses its applicability for submarine cable crossing ratings as some idealistic assumption no longer holds (e.g. isothermal ground surface). Therefore, numerical modelling techniques become preferable for thermal rating calculations especially in complicated thermal environments.

This paper will firstly explain, in a comprehensive manner, the new rating methodology developments by the author to address these challenges. Subsequently, applications of a proposed modern HVDC cable rating methodology system are demonstrated. It is believed that this work provides an overall guideline for rating HVDC cables with appropriate methodology, which can be beneficial to both cable manufacturers and utilities.



Thermal rating vs Electrical stress-limited rating



Thermal rating vs Mechanical pressure-limited rating