

## COLLECTIVE VERSUS INDIVIDUAL SCREENING OF “WET DESIGN” ( $U_m \leq 36$ kV) POWER CORES FOR MULTI-CORE CABLES

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### ABSTRACT

*This paper discusses basic functions and design of power core screening, with a main focus on submarine multi-core cables and power umbilicals. Required functionality of semi-conducting and metallic screens is well described by IEC 60502-2 for voltages up to 36 kV ( $U_m$ ). End users may specify detailed design solutions, specifically for metallic screening, that may not be in line with the basic functionality defined by IEC. Moreover, while variations in metallic screening of single-core cables are very limited, multi-core cables/umbilicals allow design optimization for reduced power loss and/or improved robustness.*

### KEYWORDS

Multi-core power cables, power umbilicals, wet design, metallic screens, semi-conducting screens

### INTRODUCTION

The main focus of this text is on submarine cables, but principles apply equally to underground cables. Currently there are no cable standards dedicated to submarine cables, so IEC standards are used although they may explicitly state that they do not cover special applications like submarine use. Common practice is to design power cores for submarine use in accordance with IEC, add measures specific to submarine use, and include additional testing in line with CIGRE recommendations.

Long, medium-voltage (here:  $7,2 \text{ kV} \leq U_m \leq 36 \text{ kV}$ ), multi-core submarine power cables and power umbilicals, typically for interconnecting offshore platforms (= cables) or for supplying subsea consumer(s) from a topside host (= umbilicals), are steadily increasing in numbers. It is also typical to connect the topside end of the power cores to special platform-type cables as close to hang-off as possible, as the submarine cable design will typically not comply with all topside requirements, e.g. resistance to chemicals or fire.

The term “wet design” is commonly used for cables without the “radial water impermeable barrier”, which is typically required at higher voltages – traditionally in the form of a lead sheath. Cables with rated voltage within the range covered by IEC 60502 [1] are most often “wet designs”. The electric field within the insulation is considered small enough to limit excitation of the ageing mechanism known as *water treeing* to acceptable levels. At higher voltages the electric stress is greater, and the traditional choice is to prevent water treeing by keeping the extruded insulation dry.

Design of the individual power cores (= insulated conductors) for submarine use is typically in compliance with IEC 60502-2, but with additional requirements for subsea application – e.g. conductor sealing. While few will question IEC’s specification of insulation thickness and maximum resistivity of semiconducting screens, there are

apparently diverging perceptions when it comes to functional requirements for *screening* – both metallic and semi-conducting – of multi-core cables. It is considered likely that some confusion originates from platform cable design practice, e.g. including metallic screening of individual cores *plus* a collective metallic screen.

This text firstly summarizes actual requirements defined by IEC 60502-2, and then proceeds by discussing additional submarine/subsea requirements. Examples of end user design requirements are also considered where relevant.

With cable/umbilical lengths extending up to several tens of kilometres, conditions during *voltage testing* becomes increasingly important. In fact, conditions at voltage testing may well become decisive with respect to the design of metallic screening.

### BASIC CABLE DESIGN REQUIREMENTS

In contrast to IEC standards for cables with rated voltages exceeding 36 kV ( $U_m$ ), IEC 60502-2 goes far in specifying design details – e.g. insulation thickness. However, design requirements with respect to *screens*, *sheaths*, and *armour* are kept on a functional level.

This text is focused on multi-core cables, and specifically on the following functional elements (referred paragraphs point to IEC 60502-2):

1. Semi-conducting screens (§7)
  - a) conductor screen
  - b) insulation screen
2. Metallic screens (§7/8/9/10)
  - a) individual
  - b) collective
3. Metallic armour (collective) (§13)
4. Non-metallic sheaths and tapes (§7/8/9/13/14)

Additional functions that must be incorporated in *any* power cable or umbilical include:

5. Safety of humans: it shall not be possible to make physical contact with high voltage without first penetrating, and thus making contact with, an earthed, metallic screen (§10).
6. Safety of equipment
  - a) protection against mechanical damage from external actions (§13)
  - b) passage of a pre-defined fault current shall not damage the cable – refer to IEC 60986 [2]
7. Conduct capacitive currents originating from each power core: