Selecting the right cable system material is critical to offshore performance

By Keith Wells, CEO of SMI

Scientific Management International (SMI) supports the operating performance of offshore power generation platforms with 'fit and forget' cable systems built for hostile subsea environments.

You may well have heard of Ørsted's recent problem with its offshore windfarms. Subsea turbidity had been moving turbine cables across scour protection rocks surrounding their foundations. Through this, the cables were being damaged to the extent that they were expected to fail. The upshot for Ørsted is a £350m bill and a change in how it deploys subsea cables.

That a brilliant company such as Ørsted can suffer these issues underlines the relatively frontier nature of the engineering involved. We've manufactured cable solutions for the Royal Navy's submarine fleets for 30 years. Whatever the sea can do to a cable, we've seen it and engineered a solution. This experience informs the characteristics of the cable solutions we supply offshore power generation businesses.

The Ørsted situation has served to draw attention to the critical role of cables in offshore generation and the ways in which they can fail. Studies of subsea cable failures reveal that the materials and processes used to manufacture them are at the heart of most problems. Successful subsea cabling requires an understanding of the properties of materials, as well as specialist chemical and processing knowledge.

Subsea cable jackets are generally made from thermoplastics or rubbers. The majority of thermoplastic cables have either polyethylene (PE) or polyurethane (PU) jackets. Sometimes, cables are jacketed with a synthetic rubber, polychloroprene, better known as Neoprene. Each material has advantages and disadvantages.

DeltaStream on Pembroke Dock

POLYETHYLENE FOR SUSTAINED PERFORMANCE

As we can see from the plastic pollution found in the world's oceans, PE does not degrade over time. Cable-grade PE is effectively inert in the ocean. Processes such as oxidation, hydrolysis (chemical breakdown in water) and mineralisation are extremely slow. Crucially for cable jackets, PE does not absorb moisture over time as other materials do. PE also delivers orders of magnitude better insulation than other materials, and this performance does not degrade at higher temperatures.

However, PE is notoriously difficult to process, and its low surface energy means it doesn't easily bond to other materials. Nevertheless, advanced knowledge of its chemistry and compatible processing technology does exist to guarantee repeatable performance. If this knowledge is applied, exceptional bonding can be achieved between PE and metals or rigid polymers.

POLYURETHANE FOR TURBIDITY RESISTANCE

Thermoplastic polyurethane (TPPU) has greater elasticity than PE. This provides some outstanding properties as a cable sheathing. It is very flexible throughout a broad temperature range and is extremely wear-resistant and mechanically tough. It also has excellent resistance against environmental agents, including a wide range of chemicals and oils. A useful characteristic of TPPU as a sheathing material is its anti-kink property, making it ideal for flexible and retractable cables.

Again, no material is perfect. TPPU absorbs moisture, a propensity which increases as temperature rises. Moisture within cables degrades their performance. We have observed rapid degradation in ships' systems performance in the warm waters of the Gulf due to TPPU sheathed cables absorbing water. A commercial TPPU immersed for more than a year in sea water from 25°C to 120°C absorbs about 1.8% of water and will suffer from hydrolysis at high temperature.

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Series 80 Hybrid Wet Mate

POLYCHLOROPRENE (NEOPRENE) IS COMMONLY USED BUT IS NOT A LONG-TERM SOLUTION

I mention this synthetic rubber because it is widely used for low cost cable jackets. Neoprene is tough, flexible and bonds well to other materials but has low insulation performance and is only suitable for up to five years immersion. The oils used in the manufacture of rubber material can be attacked by subsea microbes and we have witnessed rapid degradation in operational performance, especially when operating in warm sea conditions. In terms of long-term subsea use in offshore generation platforms, attention is better directed at PE or PU as a jacketing material, or both of those materials in combination.

DUAL JACKETS PROVIDE THE BEST OF BOTH MATERIALS

Cable jacket selection has historically required a compromise between electrical performance and abrasion resistance. PE has great electrical performance but is not the best material for resisting the turbid subsea environment found around offshore generation platforms. The position of PU is the reverse. PU has greater resistance to turbidity than PE but lower electrical performance.

Increasingly dual jackets – an inner PE sheath, with an outer sheaf of PU on the same cable - are being specified to guarantee sustained performance and long life in service. However, it is not sufficient to simply have sheaths in PE and PU to realise the advantages of both materials, the jackets need to be water blocked and bonded.

BONDING AND AMALGAMATION ARE CRITICAL TO PERFORMANCE

To make informed decisions relating to cable systems in hostile environments, it is useful to understand the science of adhesion and polymer processing. Sealing is provided by the cable jacket and the termination moulding. Using the best materials and processing for both is fundamental to delivering long-life performance.

In addition to mechanical adhesion, which relies on roughening the adhering surface to increase surface area and interlocking, chemical bonding provides a very high strength union, guaranteeing the best long-term resistance to water penetration. Chemical bonding occurs when sufficient energy is applied to free electrons of materials being processed to encourage them to transfer to electron holes in the adjacent material. By definition, the bond will be stronger than the weaker of the two materials and orders of magnitude greater than any mechanical joint. High pressure and temperature in the thermoplastic moulding process provides the energy required for this bonding to occur.

Another important property of thermoplastics is that they can be re-melted. Heat is applied to plastic granules to transition them from solid to molten form, which is then injected under high pressure into a tool to manufacture a termination. The cable jacket is melted during this process and so all the materials mix and flow together, cooling into a homologous material. This amalgamation process is absolutely key to long-term sealing, as with no interface present, water can never enter a moulding at this critical junction.

MATERIAL SELECTION AND MANUFACTURING PROCESSES ARE KEY TO LONG-TERM, COST-EFFECTIVE PERFORMANCE

Our experience with the Royal Navy's submarine fleet has informed us of the extent to which the deployment of cables in turbid subsea conditions will challenge their integrity and therefore the long-term, sustained performance of dependent systems.

Ørsted's recent cabling issues are unlikely to be repeated by the company or, now, others. However, cable failures are likely to continue be a problem for the industry until material selection and processing techniques are more widely understood and standardised.

With offshore power generation, it's not only export and inter-array cables to consider, monitoring and control systems that have subsea elements also require appropriate cabling connections. Selecting the right materials, cable design and connector for all of these systems not only extends their life and reliability but also reduces marine logistics time and offers through-life economies.

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Keith Wells is a Fellow of the Institute of Mechanical Engineers and one of the founders of Scientific Management International. He is widely recognised as the UK's leading subject matter expert on thermoplastic moulding for hostile environments and in particular subsea applications.