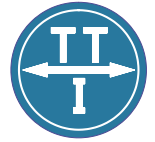
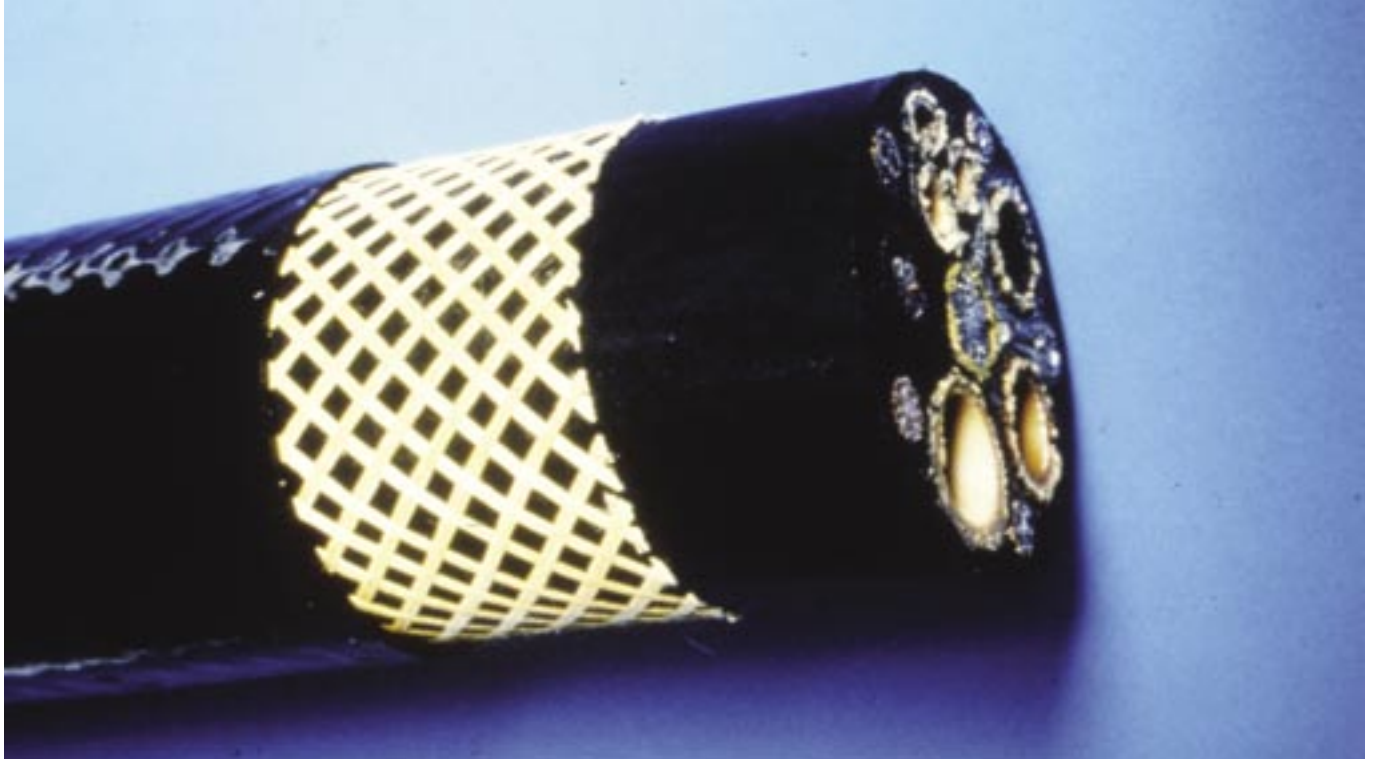


# ELECTRO-MECHANICAL CABLES



Cable design and application services

Technical Notes 03, January 2005



**ELM (electro-mechanical) cables push design engineering to the limit. These cables operate in the severest environments in defense and offshore applications, yet they have to be small to fit into the limited space allocated for them. For example on frigates and submarines, winches have to be squeezed between other vital equipment. Consequently, the sonar cable not only has to have the lowest possible diameter but also is deployed from a small winch drum. The same applies to ROV (remote operated vehicle) umbilicals and tethers, to seismic cables and the myriad other ELM cables.**

There are no national or international standards that govern the design of ELM cables, which generally operate far outside the design norms for other cables. The voltage stress on power

conductors is typically around 2kV/mm, cable jackets are just a few mm's thick, extra high tensile wire or high strength aramids are used for the strength member. Since, these cables are often operated with multiple layers on a winch, heat builds up. This can lead to the power conductor insulation melting and a catastrophic short circuit failure. ROV umbilicals and tethers run on small winches, where the conductors are prone to 'Z' kinking. This causes a loss of copper section and local overheating in power conductors, followed by melting and a short circuit.

Signal conductors and coaxes within the umbilical often work at the limit of data transmission. They have to be designed to have the right capacitance, characteristic impedance and low attenuation. These components are not robust and tend to be the first to fail.

Optical fibres are increasingly important in this market sector, replacing fragile signal conductors. Properly designed, these fibres packages can be very robust and provide exceptional service.

Standard high pressure hoses can be large and drive up the overall diameter of the umbilical. In these cases, hoses should be designed specifically to meet the operational requirement

Torque imbalance can cause cables to form loops which, on reloading, tighten to hockles and irreversible damage along the length of cable. Small diameter umbilicals are particularly prone to this type of failure. Part of the solution is to ensure that the cable is as nearly torque balanced as possible. This is not simple. Under load the cable core is compressed by the strength member and load is shifted from one layer of

the cable to the other. The solution is a complex iterative calculation.

Terminations are a vulnerable part of the cable. Generally, they must have the strength of the cable, have an effective bend limiter and remain sealed at depth, with a pressure resistance up to 600 Bar in extreme cases. These terminations often run over pulleys and have to be as small as possible or even articulated. Special techniques are required to capture the strength member over a short length. Pressure resistance is obtained through a combination of pressure compensation and multiple 'O' rings. Close liaison is required with the electrical and optical connector manufacturer.

## TTI'S CAPABILITIES

### Power Conductor Design

#### Voltage Stress

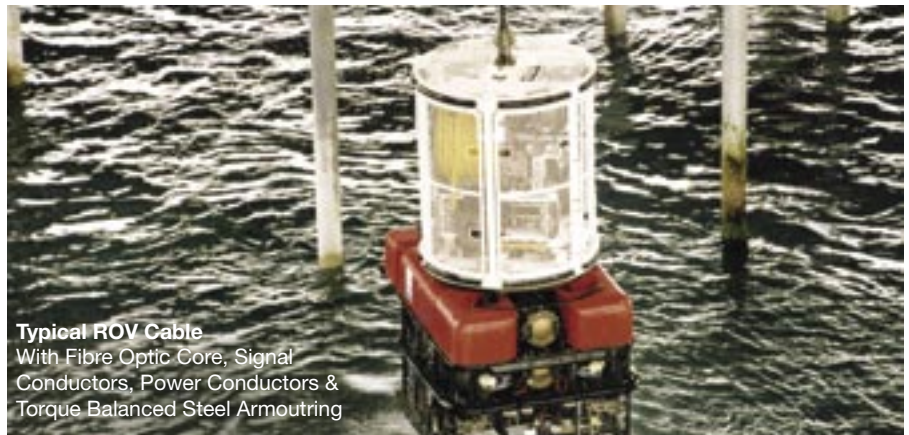
- Cables such as ROV umbilicals use small conductors which concentrate the voltage stress at the conductor – insulation boundary. The voltage stress calculation takes this into account

#### Voltage Drop

- The cable's resistance increases with temperature and this is allowed for in the calculation of voltage drop

#### Power

- The power available is also reduced by internal cable heating



**Typical ROV Cable**  
With Fibre Optic Core, Signal  
Conductors, Power Conductors &  
Torque Balanced Steel Armouring

#### Heating

- The cable's capacity to dissipate heat reduces when operated from a winch. With more layers, the internal heating can increase substantially, even leading to insulation melting and cable failure.

#### Signal Conductor Design

- Small changes to signal conductor design, the size of the conductor and insulation and the presence of screening affect the Capacitance, Attenuation and Characteristic Impedance

#### High Pressure Hose Design

- The strength member should be applied neutral angle of 54.7°. Small changes to this angle can balance the changes in length and diameter with pressure of the hose.

#### Strength Member Design

- Strength, low rotation and low

residual torque are essential properties to ensure that the cable has a long life and will work well over pulleys and on winches

#### Termination Design

- The termination needs to capture the strength of the cable and at the same time maintain water tightness at the cable's operating depth.

#### Supervision of Cable Testing and Qualification

- Testing is important to ensure that the cable will do the job required of it. Consequently, it is vital to ensure the test programme is relevant, practical and affordable.

#### Liaison with Classification Societies

- Since these cable are not governed by accepted norms, it is important to present data to the classification societies that will enable approval to be given.

**For further information on TTI's experience in Yarn Testing and its interpretation contact:**

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