

INTERNATIONAL Ocean Systems

The Magazine for Ocean Professionals

May/June 2017



**CONNECTORS/CABLES/WINCHES;
OFFSHORE RENEWABLES/OFFSHORE TECHNOLOGY**

Power and precision

By Amy Brown, director of corporate communications, BIRNS, Inc., California, USA.

BIRNS' high voltage connectivity solutions

There are many advantages available today in new high voltage configurations for deep submergence subsea connectors and cable assemblies. There is increased flexibility and performance for a range of marine applications from these advanced connectivity solutions that can provide high voltage pins in close proximity to both optical fibres and coax conductors. Designing, producing and testing high voltage connectors and cable assemblies, however, has a tradeoff in difficulty for the performance advantages provided. BIRNS, Inc., an ISO 9001:2008 certified designer and manufacturer of high performance lighting and connector systems, has been serving the subsea market since 1954. The company launched its connector division in 1988, began developing high voltage connectors in 1998, and has been at the forefront of new technologies for working with high voltage ever since with its popular six-kilometre rated BIRNS Millennium connector series.

Although many industry connectors



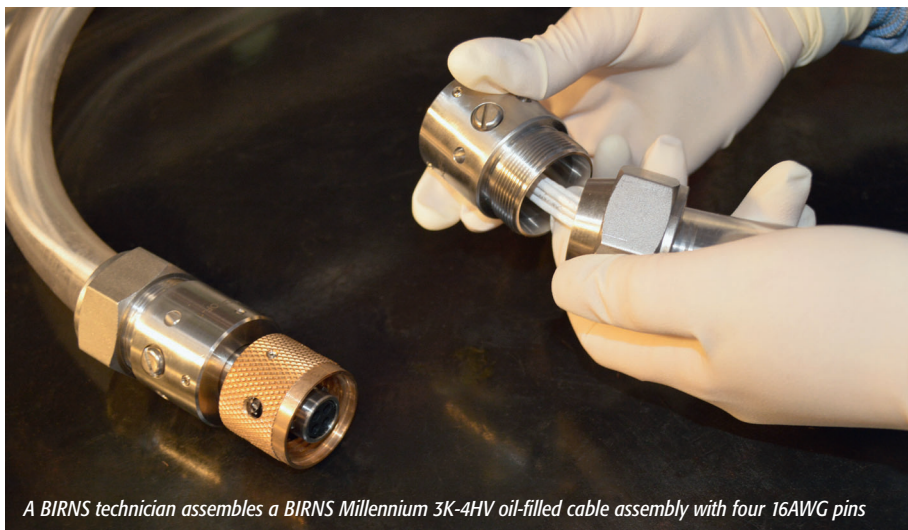
A six-kilometre rated BIRNS Millennium 30-4HV high voltage cable assembly with four 10AWG pins

cannot resist more than 2000-3000psi (1300-2000 metres) while mated to oil-filled cables, BIRNS Millennium connectors are open face rated to 6000 metres when used with oil-filled or moulded cables. Both series feature replaceable electrical inserts (for receptacles and plugs) to make them more user-friendly, and to allow for flexibility in future design changes for a system. The series' pins are constructed of C36000 copper and the sockets are made of heat-treated C17300H beryllium-copper to ensure spring strength and memory. This provides excellent contact engagement per MIL-STD-39029D. Plus, the solder pots are insulated to minimise EMI, noise and crosstalk. These robust connectors offer superior electrical contact,

and all contacts have 50µ of hard gold plating for excellent data transmission. The temperature limit of BIRNS Millennium connectors (approximately 165°C) is higher than that of commercially available wire insulation, so in actual fact the ampacity of the connectors is limited by that of the wire or cable attached to it. Also, for increased system safety, BIRNS contacts are larger than the wires put into them. For example, a 10AWG wire is defined as having a 5.26mm² cross-sectional area and its ampacity is typically rated at 30A, 35A or 40A (65°C, 75°C or 90°C insulation respectively). At 7.92mm², a BIRNS 10AWG pin is 50% larger in cross-sectional area than a 10AWG wire; it would normally be rated at 45A to 60A (65°C or 90°C wire insulation, respectively) yet BIRNS very conservatively rates its ampacity at 33A.

ENGINEERING CONSIDERATIONS

There are some important design considerations in working with connectors for voltages above 1kV. Factors like size constraints, the operating environment of the cable assembly and the operating voltage and current are primary concerns. As with most cable assemblies in the marine industry, there is a demand for smaller, lighter systems that provide increased operating parameters. However,



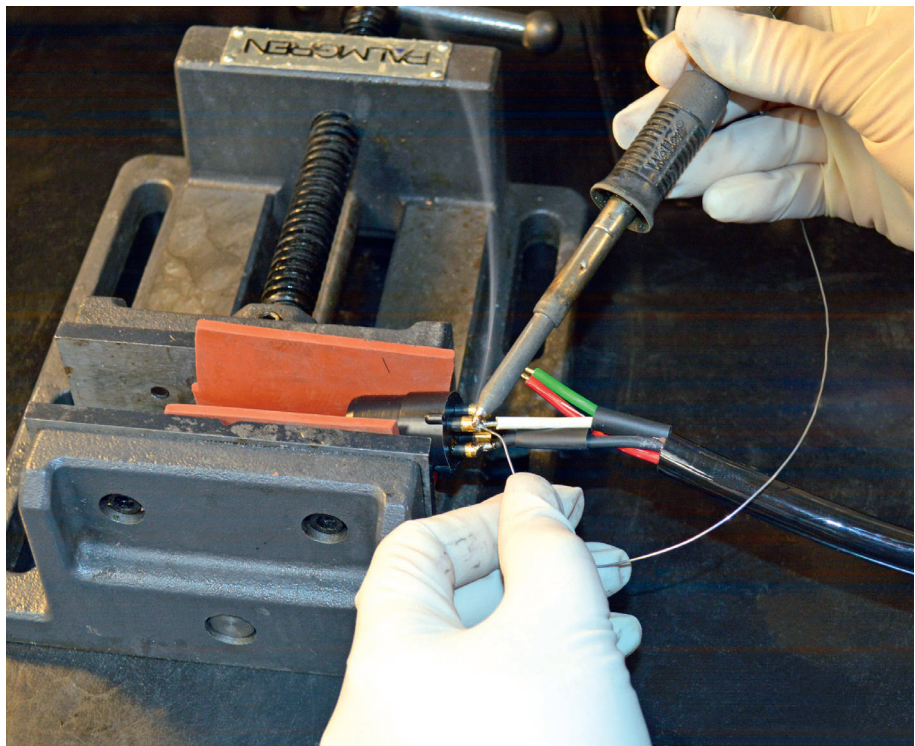
A BIRNS technician assembles a BIRNS Millennium 3K-4HV oil-filled cable assembly with four 16AWG pins

the designs must be developed in such a way as to minimise a number of inherent potential issues. Specifically, high voltages may create arcing between pins if not properly spaced or insulated. A solution to guard against such issues is providing adequate spacing (separation), to facilitate safety measures in creepage and clearance. Creepage is the distance that an arc might travel over a connector surface, whereas clearance is the distance that such an arc might travel through the air from one conductor to another. Since high voltages create unusually elevated levels of stress on all connection system components, designers of such assemblies must ensure that the necessary insulation is included. Naturally, insulating materials that are effective and safe at 500V might easily break down and fail at 3kV.

BIRNS protects against dielectric breakdown with high voltage conductors by including an arc prevention crown (APC) on the contacts in the form of a shelf, which provides a longer and more circuitous path for the electricity to run, greatly reducing the risk of arcing. The APC is at the base of each high voltage pin on the receptacle side of a connector pair, and has a corresponding deeper well,



The Millennium series has a wide range of high voltage options, including this 3O-9HV assembly, featuring five 10AWG high voltage pins and four 20AWG conductors



A BIRNS J-STD-001 Class 3 certified technician carefully terminates a high voltage connector insert; each insert's solder pot is covered part way with glass reinforced epoxy (GRE), providing additional insulation

an arc prevention recess (APR) on the cable plug side in each socket. The combination of the APC and the APR provide a dielectric insulated barrier (DIB) when mated together. In a recent set of testing protocols, BIRNS' Engineering Department took one 3kV rated BIRNS Millennium mated pair up to 9kV to prove that the DIBs perform as expected. The connector pair eventually failed at 9kV while mated, and failed at 6kV while unmated, proving that the DIB is functional and provides the expected insulation protection. Of course, the GRE moulding process itself must also be carefully controlled in order to ensure a dense, void-free moulded part which is also free of cracks, hairline folds and density discontinuities. Any of these issues could cause decrease in insulation resistance and resulting possible degradation and, ultimately, a voltage pathway.

FORM AND FUNCTION

High voltage connectors can be small while also by definition, mighty. For instance, BIRNS has several widely requested pin configurations in its Millennium series, two of which have inserts far smaller in diameter than a quarter. For example, the BIRNS Millennium 3K-4HV, which has an engaging nut diameter of 1.32 inches

(33.5mm), features four 16AWG high voltage pins, and is a robust, compact solution for a wide range of demanding applications. BIRNS was recently asked to provide such a compact high voltage cable assembly solution for a customer in the oil and gas sector. The end user needed a connector with four high voltage contacts with a minimum of 4A and 1750V for working pressure of 300 bar. The customer also specified a double barrier between seawater and electrical components, to ensure that if one barrier were to somehow fail, that the electrical parts would not come in contact with seawater. BIRNS provided a 3K-4HV-CP-OF cable assembly with corona-resistant 3kV wire (suitable for long-term immersion in oil) and both the termination in the cable plug and in the receptacle featuring solder pots that were insulated after termination with heat-shrink tubing with meltable inner wall, and epoxy-potted after termination.

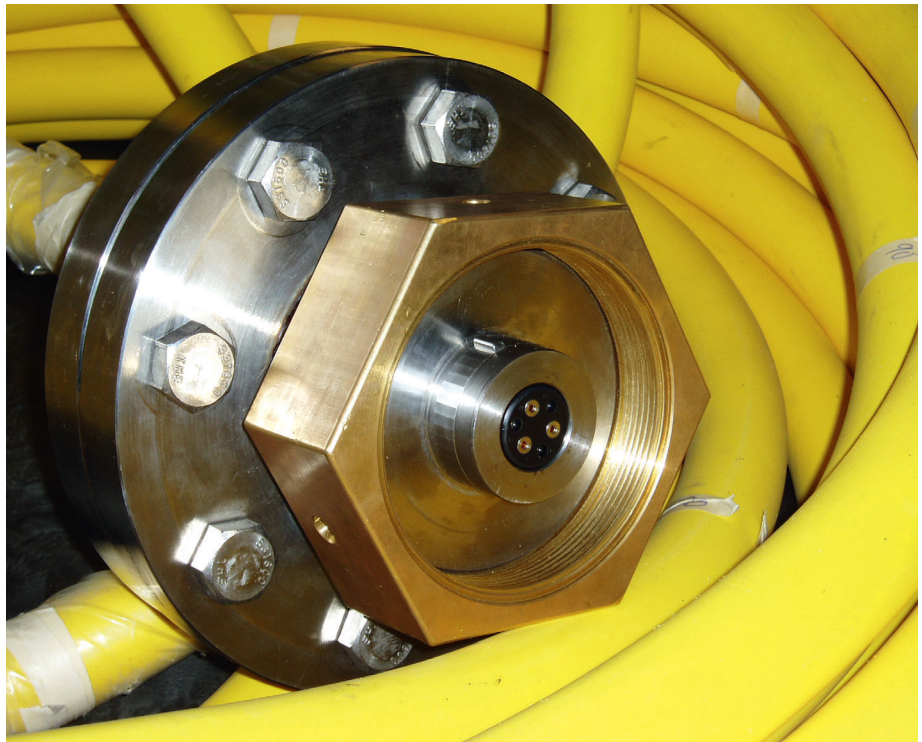
The 3G-2HV, with an engaging nut diameter of just 1.06 inches (26.9mm), is even smaller than the 3K, and features two 16AWG pins. Another slightly larger popular pin configuration is the 3O-9HV, which, comparatively, has a bulkhead receptacle (BR) body diameter of 1.62 inches (41mm), and a combination of five 10AWG high voltage pins and four 20AWG

Cables/Connectors

pins. A configuration that is in very high demand in the same shell size is the 3O-4HV, with four 10AWG pins. These four-pin high voltage configurations are popular for motors and HPUs (high power units) which typically run at 3kV and three-phase power. A still larger shell size is the 3T-2F12, with two optical fibres, eight 14AWG high voltage pins and four 22AWG conductors all in a compact connector with a two-inch (50.8mm) diameter.

TERMINATION PROTOCOLS

BIRNS Millennium electrical connectors are available in combinations of high and low voltage electrical configurations, high voltage and optical fibre hybrids, as well as high voltage, fibre and coax options. Therefore, terminating such complex high voltage systems can be a delicate and painstaking process. BIRNS connectors are designed without wings or other obstructions that might possibly limit soldering access. All of the solder pots are scalloped and face outward, and the inserts can be terminated outside the shell. These solder pots accept the largest stranding of any wire size per MIL-STD-39029D. Each solder pot is covered part way with glass reinforced epoxy (GRE), providing further insulation, while also providing the added advantage of making the solder pots easy to cover with heat-shrink tubing. Additional protection can be provided by back potting with epoxy after termination, and using a special high voltage rated heat shrink tubing.



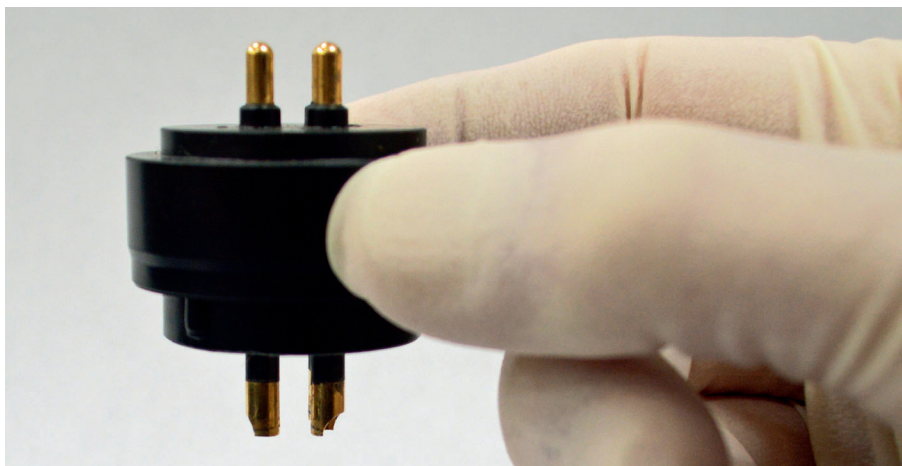
A massive hybrid high voltage cable assembly with three 3.6kV 10AWG conductors and three single mode optical fibres

TESTING

BIRNS' advanced electrical test system was custom-designed for the company and permits the simultaneous automatic testing of up to 16 electrical conductors at voltages up to 10kV, with up to 99 different programmable test sequences, all while subjected to hydrostatic and hydrodynamic pressure. Testing for electrical connectors, high voltage assemblies in particular, can include hipot (dielectric withstanding), insulation resistance (IR) and continuity testing. Hipot testing measures current leakage in amperes, which is gathered through charging an individual conductor with a strenuous voltage depending on the design specification, while the rest of the

conductors are left at low voltage to measure for arcing. IR testing determines the insulation resistance value in ohms through applying a specific test voltage to a conductor, while the other conductors in the assembly are not charged, and holding this charge for enough time to measure any loss of resistance (an average of one minute per conductor). Continuity testing is required to ascertain the expected flow of current through a circuit. BIRNS technicians test all electrical connectors to IAW MIL-STD-1344A, 'Test Methods for Electrical Connectors', Test Method 3003.1, 'Insulation Resistance', Test Condition 'I'. High voltage testing is done per IAW MIL-STD-1344A, 'Test Methods for Electrical Connectors', Test Method 3001.1, 'Dielectric Withstanding Voltage'.

BIRNS continually seeks new ways to innovate in this demanding industry, and is investing in even more advanced equipment, and is always developing new ways to increase the performance capabilities of high voltage connectors to meet market demand. The company has been receiving numerous inquiries for connector and cable assemblies with exponentially increasing voltage performance attributes, along with greater depth ratings, and looks forward to continue meeting these challenges with new elegant solutions.



BIRNS protects against dielectric breakdown by including an arc prevention crown (APC) on the contacts in the form of a shelf, which provides a longer and more circuitous path for the electricity to run, greatly reducing the risk of arcing