

Grace under pressure

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

The development and testing path of BIRNS ABS-approved man-rated penetrators

BIRNS, Inc. is an ISO 9001:2008-certified global leader in the design and manufacturing of high-performance lights, connectors and custom cable assemblies. Since the company's inception in 1954, it has provided unique solutions trusted in some of the planet's most demanding environments – from deep-ocean and marine applications to defence systems and nuclear power facilities.

All of BIRNS's technologically advanced products are relied upon to perform under pressure – whether they contribute to the success of thousands of hours of project research, priceless technical equipment or an underwater vehicle with personnel aboard. All applications are critically important, so from design to development to meticulous testing, BIRNS exceeds industry standards – in none more so than the development and testing protocols for its American Bureau of Shipping (ABS)-approved man-rated penetrators. These robust penetrator systems safely and reliably transmit electrical power or signal through pressure boundaries and are widely used on diving bells, submarines



BIRNS P38100-24-RA-LS penetrator insert is mated to custom fixture for helium pressure testing

and submersibles. Penetrators decrease the complexity of electrical systems and reduce dependence on operator skill – in fact, thanks to their rugged design and performance attributes, they require minimal maintenance and are engineered for long-term deployment under incredibly rigorous conditions.

A longtime BIRNS customer, AC Plus Marine, a complete ship systems maintenance and equipment company in

Kentucky, USA, specialising in commercial saturation diving systems, recently had an order for 24 BIRNS penetrators – a variety which included BIRNS model P38100-24-RA-LS (P38: UTS [United Thread Standard] shell size; 100: mm shaft length; 24: number of electrical conductors; RA: right angle; LS: LSZH cable). AC Plus needed them for a three-man, 300-metre rated submersible saturation diving chamber application for the main and emergency



Twenty-four cable conductors are soldered to inboard and outboard sides of the penetrator's insert

power and the system's communication systems. BIRNS delivered all 24 penetrators, complete with ABS witnessing and approval, in just five weeks.

SETTING AND RAISING THE BAR

BIRNS began developing penetrators in 1999, and quickly developed industry-leading engineering and testing procedures which resulted in the company receiving coveted ABS Product Design Assessment (PDA) certification for all electrical penetrators and cable assemblies for underwater vehicles, systems and hyperbaric facilities. Thus, ABS has now approved BIRNS's design, drawing and test procedures for these intricate systems. BIRNS sets the bar high for its field-proven and ABS-approved penetrators, using the highest quality components, starting with

316 Stainless Steel shells, as this rugged material is the most seawater corrosion resistant of all stainless steel alloys. These shells are passivated per American Society for Testing and Materials (ASTM) A967-05, using a new environmentally-friendly citric acid passivation method. Polyurethane moulding on the outboard side

provides maximum resistance to harsh marine elements, and is longer lasting than neoprene rubber. Plus, all BIRNS penetrator contacts are gold plated copper alloy for supreme electrical performance, and insulated with glass reinforced epoxy (GRE) for superior dielectric characteristics, and solid construction throughout is engineered with exclusive potting and bonding techniques, along with durable O-ring seals.

All BIRNS penetrators meet or exceed stringent ABS and DNV requirements when fabricated with low smoke zero halogen (LSZH) cables inboard – BIRNS's standard for PVHO (pressure vessels for human occupancy) use. In fact, BIRNS's special blue LSZH cable has substantial insulation, and is made especially for BIRNS in Europe, with a higher stranding (27 strands per cable) and slighter larger than

16 American wire gauge (AWG), making the wire more flexible and with 33% greater ampacity than other LSZH cables on the market. LSZH is a type of cable jacketing composed of compounds that emit limited smoke and no halogens when exposed to high levels of heat. Thus, in the case of fire, LSZH cable greatly reduces the amount of toxic or corrosive gases, which is why so many authorities, such as ABS and DNV, require LSZH for PVHO use.

INSERTS PUT TO THE TEST

Now, like all BIRNS penetrators, the BIRNS P38-100-24-RA-LS for AC Plus is tested per BIRNS's ABS-approved test procedure ETP-6510-101 (electrical penetrators – submersible and non-submersible PVHO). This exhaustive testing sequence simulates both extremes of inboard and outboard pressures that the penetrators might encounter in use. BIRNS does all penetrator testing in-house, witnessed and certified by ABS officials on site, and thanks to its high volume, highly specialised testing systems, is the only company in the industry capable of offering inclusive ABS lead times and pricing for penetrators – as the historical market alternative for end users was to have a private test by an outside agency or lab witnessed by ABS at lengthy, uncertain lead times and great expense. "Being able



Left: Continuity and insulation resistance testing of entire penetrator. Right: Multiple penetrators in tanks for six-cycle saltwater hydrostatic pressure testing at 1250psi, with concurrent IR testing

to get the penetrators pre-tested, certified and ready to go, takes a lot of paperwork and headaches off our shoulders, as many manufacturers can't provide that service," says Jason Hammonds, an electrical engineer for AC Plus.

In fact, BIRNS tests to ABS and DNV certifications specs, whether the customer specifies it or not, using a state-of-the-art, high-performance three-channel hydrostatic pressure testing system, with a range of vessels rated to 20,000psi, 10,000psi, 5000psi and 1000psi. Another pressure test system includes a robust, high-volume helium testing capability, exceeding stringent ABS/DNV requirements. The facility provides an enhanced, streamlined, efficient means with which to test a wide range of products for both rigorous safety and demanding performance requirements. Helium testing is more rigorous than similar tests with air, as the helium atoms are far smaller and move faster than oxygen molecules – ergo, helium diffuses through solid materials three times faster than air.

For AC Plus's order, and any penetrator from BIRNS, the testing sequence begins during the manufacturing segment. First, the penetrators' inserts are subjected to a helium pressure test, where the inserts are fastened to a custom pressure fixture, put in a special hydro tank and submerged for ten minutes. The inboard sides are subjected to 1000psi of helium during the test. Any sign of leakage (in the form of bubbles) would result in immediate rejection if evidenced. After the successful helium testing phase, the cable conductors are soldered to both inboard and outboard sides of the insert by J-STD-001 Class 3 and WHMA-A-620-A Class 3 certified technicians. The insert assemblies are then inspected per J-STD-001, Class 3.

Next, the insert assemblies undergo rigorous continuity and insulation resistance (IR) testing procedures, with BIRNS's automated Kikusui 16-channel Hi-Pot and IR testing system. The IR testing requires that all 24 conductors be individually tested at a test voltage of 500V DC for interference between one another

and the penetrator shell – a minimum reading of 200M Ω is required to pass. Once that test is successful, the shell is attached to the penetrator, which is then overmoulded, and then the entire penetrator tested for continuity and IR once again, prior to formal ABS witness acceptance testing.

MAKING THE GRADE

The thorough testing continues with the complete penetrator undergoing a dielectric withstanding voltage (Hi-Pot) test – where each conductor is tested at 1480V DC for 60 seconds, before automatically moving to the subsequent channel, with a reading below 29 μ A required to pass. Once that test is successful, a six-cycle saltwater hydrostatic test is performed, wherein the outboard side of the penetrator is held to pressure of 1250psi. The first five cycles are held for one minute each at a pressure of 1250psi, with the sixth cycle held for 20 minutes. During this sixth cycle, the entire penetrator is given another IR test for the 24 conductors. A final helium test is carried out for the completed penetrator, with its inboard side inserted into a ten-foot (three-metre) long helium test fixture and pressurised to 1000psi of helium to check for any leakage using a MIL-L-25567 compliant gas leak detector. A final hydrostatic test sequence follows, subjecting the penetrator to 1250psi, and a final IR test at 500V DC is then performed.

After all of these steps in sequence are successfully completed, the penetrator is turned over for a complete visual inspection by J-STD-001, Class 3 certified inspectors to ensure that no physical damage



ABS in-house to witness BIRNS' man-rated penetrator acceptance testing

was incurred during the rigours of the previous testing procedures. BIRNS has an incredibly high pass rate – in fact, in 2010 the company had 100% success rate of all in-house penetrator tests – thanks to the careful engineering and manufacturing procedures backed up by ABS approval of BIRNS's design and testing procedures. ■



Final helium pressure testing with MIL-L-25567 compliant gas leak detector