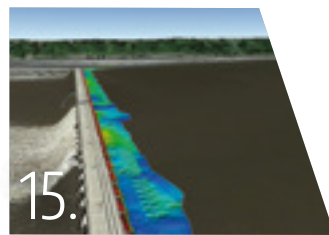




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# ELECTRIFYING SUBSEA OPERATIONS

Leon Adams, VP at Southwest Electronic Energy Corp

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**Onboard batteries are an enabling technology for underwater vehicles. They eliminate the need for a costly umbilical by putting electrical power where it is needed. The benefits extend beyond capex reduction into the world of performance improvement.**

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Power needs of underwater vehicles can range from short duration, high-power demand applications to long duration, low-power demand situations. The subsea industry is in the midst of an electric revolution and hydraulic power on underwater remote operated vehicles (ROVs) is on its way out in favor of electric power with support from on-board batteries.

Classic ROVs are powered by umbilicals, but long umbilicals are extremely heavy. If they become long enough and heavy enough, it can lead to a tail wagging the dog situation.

Preventing that scenario is straightforward: Electric thrusters and actuators with onboard battery power support. Work-class ROVs can rely on battery power to provide backup power in the case of an umbilical issue as well as deliver extra local peak power for electric manipulators, lights and high thrusts. Batteries can be charged topside or via umbilical at low power levels, enabling lighter weight, lower gauge copper power lines in the umbilical.

When it comes to hybrids, in which the ROV is driven by the pilot in ROV mode but autonomously navigates when in AUV mode, both modes use batteries for all power needs. Those needs may be for high-power bursts, such as using electric thrusters for urgent maneuvers, or to operate the manipulators, or to meet ongoing low-power requirements. Sensors, video cameras, LED lights, communications systems, guidance and control electronics are all examples of ongoing low-power needs.

Underwater vehicles require power for safe operations. The power unit should be high capacity and able to deliver higher power when bursts are needed. Other characteristic needs are for smaller and lighter battery units, longer life and high reliability.

An AUV needs a lighter weight battery that will allow it to perform longer survey runs and deeper dives. Beyond that of thrusters, the power needs of the robotics within the AUV are often longer duration, lower power, and variable based on equipment deployed. Such needs can be continuous demand of lower current or low to moderate voltage loads with peaks and dips on power demand. Such power needs include the control electronics and the communications systems between man and machine or machine- to-machine to issue commands, manually pilot robotics, or communicate feedback visually or via datacomm. Other demands include operating the small electric motors for

Courtesy of Southwest Electronic Energy Corp







Courtesy of Southwest Electronic Energy Corp

servo control and actuation of manipulators as well as running digital video and still cameras, plus lighting to enhance the imagery. Robotics require power for control processors and interface electronics, as well as sensors that carry out measurements and deliver feedback of node status information to the control processors.

Southwest Electronic Energy Corp's (SWE) SeaSafe batteries serve up the power that ROVs and AUVs require. SWE SeaSafe battery modules, typically 30 VDC or 24 VDC, can be configured in battery system matrices to deliver a wide variety of DC voltage and power size battery systems. Connecting modules in series provide DC voltage as required in 30 VDC or 24 VDC increments. For example, a 120 VDC battery would be achieved by connecting four of the 30 VDC SWE SeaSafe battery modules in series. Larger count module strings would achieve higher voltage. Parallel copies of the voltage strings provide higher capacity of amp hours or more watts of power. The parallel strings of same count modules are easily interconnected on output via SeaSafe Diode ORing Module for common output to the load.

These parallel strings also provide redundancy of power available at the DC voltage. Each Diode ORing battery string can provide stand-alone power at the DC voltage even if another string goes down. The max battery system capacity will be less than the total prior capacity from combined strings, but you still would have the same voltage to continue operations, even if at a reduced power level.

## ROV UNDER ICE

Woods Hole Oceanographic Institution (WHOI) found that tethers used for ROV operations from an icebreaker working in permanent moving ice faced a number of issues. First,

they were constrained by their tethers, and those tethers were vulnerable to ice damage. The vehicle with tether damage would switch to slow speed acoustic modem or beacon mode to "come home". Surface ships could not hold position, limiting the ability to work predictably in specific sea-floor locations with vehicles. Conventional Arctic ROV footprints of operations are small, about 500 meters, and the unit was under a ship that was moving with the ice.

The solution was enabled by recent advances in ROV tethering technologies that make real-time control over extended distances possible, which frees the vehicle from restrictions imposed by surface ice cover.

WHOI's battery requirement for the Nereid UI (nUI) included safe and reliable operation in water depths to 2000 meters, about 88 volts and 40 amps continuous, 100 recharge cycles, the ability to operate from -20 degrees Celsius to +50 degrees Celsius, 12 hours recharge time, at least 15 kWh in a space 36 inches by 24 inches by 12 inches, protection and balancing internally and diagnostic information logged externally.

WHOI selected the SWE SeaSafe lithium-ion battery, which comes with a patented Battery Management System (BMS) for safety and reliability, internal protection and balancing, and its ability to access battery status on demand and log the data externally. It operates in water depths to 6000 meters and temperatures of -40 degrees Celsius to +85 degrees Celsius. In the Nereid UI configuration, it delivers 87 V Nominal and 96 V Maximum along with 40 Amps continuous power. The SeaSafe can recharge more than 1000 times and takes less than 12 hours to recharge. The three SeaSafe battery pods in-

stalled in nUI deliver a total capacity of 18 kWh. Using onboard SWE SeaSafe batteries on the light-tethered nUI drove the ROV's footprint of operations up by 40x to about 20,000 meters.

## **PACKAGED POWER**

SWE SeaSafe, a pressure-tolerant lithium-ion polymer battery is ideal for subsea use, compared to traditional lead acid batteries. For starters, SWE SeaSafe lithium-ion battery delivers four times more energy density for its size and weight compared to standard lead acid batteries while providing discharge/charge cycle lives that are up to eight times more than their lead acid counterparts. The SeaSafe also performs 1.5 times better at the low temperatures of subsea than standard lead acid batteries. Standard lead acid batteries also outgas during charge, which can be hazardous due to ignitable hydrogen gas. This typically prevents subsea charging of lead acid batteries. SWE SeaSafe, by contrast, does not outgas during charge. In general, standard lead acid batteries are less durable than SWE SeaSafe potted lithium-ion polymer batteries. Finally, traditional lead acid batteries don't come with smart battery management systems or health and status reporting capabilities while SeaSafe comes with SWE's patented and user-friendly Battery Management System (BMS) to manage the battery safety and monitor the health of the battery.

In addition, the pressure tolerant feature of SWE SeaSafe eliminates the often heavy, expensive and implosion risky pressure vessel requirement for batteries. Examples include 18650 based lithium-ion, alkaline or primary lithium-based batteries when used in subsea applications.

The level of intelligence in these batteries is new to the subsea world. Because of the growing importance of condition-based monitoring, SWE developed the BMS to enable these smart batteries to provide data on demand, allowing condition-based monitoring of the batteries, which is crucial to maintaining reliable operations.

The integrated BMS automatically manages and tracks the safety, reliability, charge and discharge of the batteries and reports technical information on demand. These safe and smart batteries can take care of themselves, and the reporting communications capability makes the batteries more reliable than other battery systems because more information is available on demand.

SWE developed the SeaSafe pressure-tolerant lithium-ion polymer subsea battery pack in conjunction with WHOI, and the first SWE SeaSafe battery pack went to market in 2013. The original SeaSafe battery represented an efficient move away from the heavy sealed lead acid batteries toward using lighter, more powerful lithium-ion batteries, which take up less space. These batteries were easier to install than lead acid batteries, and while they don't require a pressure vessel, they did require a pressure balanced oil-filled container, since contacts are not sea-ready.

SWE SeaSafe represented a major breakthrough in subsea power operations because it was one-quarter the weight of the traditional sealed lead acid batteries, did not require a pressure vessel, and offered a longer service lifetime.

The second generation SWE SeaSafe II, released in 2017, incorporated lessons learned, reliability improvements and American Bureau of Shipping (ABS) Certification. Driven by customer request, the SWE SeaSafe Direct, which can be placed directly into the water without requiring a pressure vessel, was developed and has also been available since 2017. This ease of use convenience – direct-in-the-water use – eliminates the need for pressure balanced oil-filled case is growing trend in the industry.

Both SWE SeaSafe II and SWE SeaSafe Direct are ABS certified in various voltage size configurations. These batteries make it possible for underwater vehicle operators to squeeze more power and lifetime out of their battery packs to further their mission in unearthing the mystery of the deep sea.