

## Photographers journal: A day with Sean Kelley, pilot and electronic lead, Alvin Submarine

### Application Note

#### Testing Functions Case Study

By Louis Fliger, Senior Photographer, Fluke Corporation



**Tools:** Fluke 27 Analog/Digital Multimeter, Fluke 77 IV Series Digital Multimeter, Fluke 87 Digital Multimeter

**Operator:** Sean Kelley, Pilot and Electronic Lead, Alvin Submarine, Woods Hole Oceanographic Institution (WHOI)

**Measurements:** Voltage, continuity and other operational tests on electronic science equipment and submarine systems; tracking battery power during dives

It was a thrill to spend a day with Sean Kelley, one of the elite group of pilots of the Alvin, the best-known and most-accomplished research submarine in history. The 16-ton deep ocean research submersible is owned by the United States Navy and operated by Woods Hole Oceanographic Institution (WHOI) in Woods Hole, Massachusetts. Sean let me go down into the submarine to check out the conditions experienced by the pilot and two passengers during a mission. The outside dimensions of Alvin are 23 feet 4 inches long, 11 feet 10 inches high and 8 feet 6 inches wide but much of that space is occupied by the hull, mechanical systems, and other equipment, so it's very cramped inside. Alvin has a six mile range, a cruising speed of one knot and a maximum speed of two knots. It is propelled by electric motors and features an electrical system powered by lead-acid batteries. Alvin is launched from the submersible support vessel Atlantis which is also owned by the Navy and operated by WHOI.

Since it was launched in 1964, Alvin has taken a pilot and two passengers, who are normally scientists, on over 4,000 dives for up to nine hours at depths up to 4500 meters (15,000 feet). In 1966, Alvin was used to help locate and retrieve a hydrogen bomb that had been lost after an American B-52 and a tanker collided over the Mediterranean Sea. Alvin

sunk in 1968 in 1500 meters (5000 feet) of water while it was being transported with the hatch open. Fortunately, the three crew members on board escaped without injuries. The submarine was recovered 10 months later, overhauled and put back into service. Most famously, Alvin carried Dr. Robert Ballard and two companions as they explored the wreckage of the Titanic in 1986. Alvin and a small remotely operated vehicle named Jason Jr. was used to provide detailed photographic and video surveys of the wreckage that have since appeared in many publications and television shows.

Alvin's most noteworthy scientific achievement was its use by researchers from the Scripps Institution of Oceanography to discover the first hydrothermal vents in the Pacific Ocean off the coast of the Galapagos Islands. These vents, which are commonly called black smokers, emit black smoky water that is superheated to temperatures of around 400 °C (750 °F) but is prevented from boiling by the intense pressure at the floor of the ocean. Since then, Alvin has located more than 24 hydrothermal sites in the Atlantic and Pacific Oceans at typical depths of 2100 meters. While life is normally rare at these depths, black smokers form the center of ecosystems that differ dramatically from all others on earth or in the ocean. Conventional life forms are based on photosynthesis which converts sunlight into chemical energy.

Black smoker ecosystems are based on converting heat, methane, and sulfur compounds into energy through a process called chemosynthesis. Researchers have already discovered about 300 new species in the neighborhood of black smokers.

Kelley belongs to an elite fraternity of only 34 men and 1 woman who have piloted the Alvin. Only 26 years old, Kelley has already piloted Alvin on over 60 dives. For comparison, over 75 men and women have piloted the space shuttle. Kelley has an engineering degree like most Alvin pilots and has received special training from the Navy. He can, among things, swim for miles and repair nearly anything in the boat's hydraulic, ballast, mechanical, electrical and electronics systems. His additional responsibility as the electronics lead puts him in charge of Alvin's critical electronics systems.

Alvin uses a series of rechargeable lead-acid forklift batteries. Four 26 V dc/dc converters provide the main power source for equipment inside the hull as well as outside the hull. On a typical dive, Alvin sources around 30 amps from the dc/dc converters. Alvin is also equipped with an inverter to supply 120 V ac power to a forward looking sonar as well as any equipment such as a laptop that might require the ac power. All of these power sources are fed from Alvin's main batteries, which supply 120 V dc power.

All of Alvin's electrical systems must be ungrounded to limit the chance for corrosion of structural parts in the event of inadvertent grounding of any conductor. Alvin's electrical systems are frequently checked for grounds during each dive.

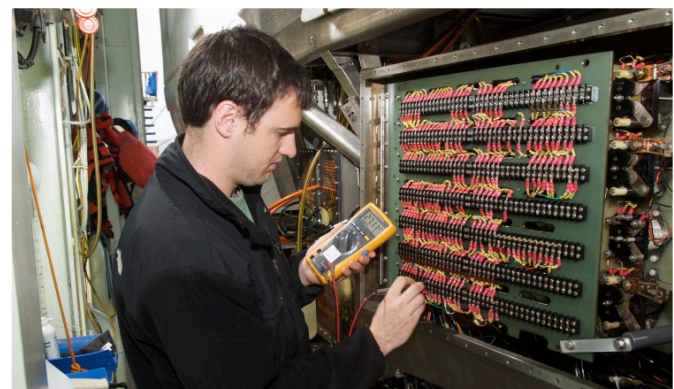
Kelley is very busy while living on the Atlantis during a mission. While Alvin is on a mission, five hours of maintenance and inspection is performed every day on the boat's critical electrical, electronic and mechanical systems. Every day Kelley gets up before dawn and tests the boat's radios, temperature gauges, depth-readers, video cameras, video recorders, and other electronic equipment. Scientific equipment requires particular testing because it is frequently swapped in and out for specific missions. Instruments are housed in 35 inches of standard 19 inch rack space.

A pool of various Fluke digital multimeters (DMMs) are used on board the Alvin. Kelley primarily uses the Fluke 27 waterproof DMM and the Fluke 77 IV DMM when he is checking the sub out between missions. He uses the DMMs to check the continuity of wiring of the boat's electrical systems and electronic equipment such as video cameras and recorders and scientific instruments that have been installed for the specific mission.

A separate Fluke 77-II DMM is mounted in the control panel of the Alvin and used to track battery power while Alvin is submerged. As soon as the sub is launched, the crew performs "water dive checks"—checking the condition of the weight dropper solenoids and explosive bolts. The pilot uses the DMM mounted in his control panel to check continuity on the bolts and solenoids and to check for grounds. If any one of them checks bad, the pilot has to bring the sub back on deck immediately and fix the problem. As Kelley said to me, "People's lives literally depend on that multimeter working every day that we dive."



Sean Kelley stands just in front of the Alvin's pilot port hole, where he has controlled the sub on more than 60 dives.



Kelley measures across electrical connections in the 26 V dc electrical distribution panel on the exterior of the sub. This panel is sealed by an acrylic cover and then filled with mineral oil to compensate for the extreme pressure of deep water.





Sean Kelley switches through the various electrical systems aboard the sub, and compares the analog meters against the Fluke 77 DMM mounted in the control panel.

After every 25 to 30 dives, which are normally completed within three months, Alvin goes back to its base in Astoria, Oregon for maintenance and inspection. I spent a day with Kelley in port at Astoria, while the ship was refitting in between missions to study black smokers in the Pacific Ocean. Kelley spent the day I was with him supervising maintenance work on key electrical systems. As I followed Kelley, he would often stop and pick up a bundle of wires and check their voltages with his Fluke 27 DMM.

With three lives depending on Alvin's performance, not to mention a mission cost of \$40,000 per day, failure is not an option.

Kelley said that Fluke instruments' ruggedness and reliability makes them ideal for use on missions where there's no chance of getting repairs or replacements until the boat comes back to port three months later. He said that the critical nature of the work means that all instruments used for work on the Alvin must have a current certification by an independent laboratory. After spending a day with Kelley, it was obvious that the men and women who ride on the Alvin are well justified in putting their confidence in pilots like Kelley to take them to the bottom of the ocean and bring them back safely again.



Sean Kelley at the bench in Alvin's work shop. He's troubleshooting an electrical problem on a 26 V dc video controller that is very valuable to each dive but is vulnerable to conditions on the sub.



Kelley double checks the continuity of a video camera connector that was just installed on the sub's top side, before the access panel is closed back up.

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