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Electrical and Pressure Tests of
ALVIN's Electrical Through Hull Penetrators

by

H.H. Learnard, M.J. McCamis
and O.L. Swinhart

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ABSTRACT

Our objective was to investigate the mechanical and electrical integrity of the hull penetrator assembly, in its eighteen (18) ten (10) amp single lead configuration, as designed by Litton Industries for the ALVIN. The results indicated a few minor refinements must be made to the penetrator before final acceptance of this hardware.

1. Hardware:

One (1) hull penetrator, with the eighteen (18) ten (10) amp. lead configuration, figure 1, was used during our tests. This design was settled upon after much discussion between Woods Hole Oceanographic Institution (WHOI) and the Applied Science Division of Litton Systems, Inc. The penetrator hardware was then forwarded to Electro-Oceanics, for potting and final assembly. After preliminary pressure and electrical tests at Electro-Oceanics, the penetrators were shipped to WHOI, via Litton, for further testing. One (1) lead in one of the penetrators was grounded to its case, so this was the penetrator selected for our tests. The penetrator bodies had not been hardened as required by the design specifications 17-4PH, see figure 2, but this did not effect our results. Our test facility at WHOI is a 16 inch shell casing, for which we fabricated a special breech block, simulating ALVIN's hull, into which the penetrator could be fitted. The eighteen leads were arranged in circuits as follows. The eighteen external #18 insulated wires were connected in pairs, to one another, and these connections were potted to resist the pressures during the tests. The eighteen interior #16 insulated wires were connected across a load and a variable resistor in series, with eight leads connected to the negative side, and one pair connected individually across the load. The eight leads' pairs were connected to the positive side. The penetrator was mounted in the test block so that the end which would be external to the pressure hull was inside the test shell, and exposed to the pressures. The test medium was salt water.

2. Objectives:

We in the Deep Submergence Research Vehicle Group at WHOI desired to subject one penetrator to an exhaustive series of tests to investigate its properties under taxing conditions. This included exploring the wires' overload characteristics, repeating previous lead continuity and insulation checks, and examining closely the integrity of the penetrator's three pressure barriers; the exterior neoprene potting, the stainless steel header, and the interior epoxy potting.

3. Test Descriptions:

We ran continuity and ground checks in the penetrator, first in air and then in salt water, at atmospheric pressure. Then we put the penetrator in our test facility and pressurized to 10,000 psi. At this time we rechecked lead continuity and grounds. Then load

tests were run, at pressure, and the results recorded on the graphs 1 and 2. Next a load test was run on a single lead at 0 psi. to check its insulation and overload properties. Results were recorded on graph 3. Finally, we subjected the interior epoxy potting to 10,000 psi., by tapping a 1/8 inch diameter hole, as in figure 1. Care was taken to avoid the leader, and not to penetrate the epoxy.

4. Test Results:

a. Continuity and ground checks -- All readings were normal, with all ground resistance readings over 10,000 megohms, except the one grounded lead. This read 50,000 ohms. There was no difference between air and salt water readings.

b. 10,000 psi. load check -- The continuity and ground checks were no different from the previous readings. As graphs 1 and 2 indicate, various loads were applied, which caused significant temperature and pressure changes. Loads greater than 15 amps per load caused considerable temperature increase, indicative of a large IR drop, which we feel would lead to equipment failures due to low voltages. There were no penetrator leaks during this test.

c. Single lead load test -- Prior to making the destructive tests, a single lead load test was run, and the results recorded on graph 3. The lead started smoking at about 45 amperes.

d. Destructive test -- After tapping a hole in the penetrator body, figure 1, it was replaced in the pressure facility, and pressure was applied. At 2,000 psi. a leak check revealed a gradual seepage of salt water at the protruding end of the penetrator, and a slow pressure loss was noticeable, when attempting to hold pressure. At 3,400 psi., due to this seepage, the pressure could no longer be increased. The penetrator was removed from the test chamber, and a series of cuts through it, between the epoxy and the penetrator body, and a relatively low resistance of one hundred thousand ohms was recorded between the header pins and the header itself.

e. Temperature -- Temperature was taken in air outside pressure vessel at penetrator and 6 ft. from penetrator. Temperature at the penetrator was 15° cooler than temperatures shown on graphs.

5. Conclusions:

a. The exterior neoprene potting forms an excellent pressure barrier.

b. The leads showed excellent insulation and overload properties.

c. The header forms a good secondary pressure barrier. Salt water introduced at the header's inner surface undoubtedly contributed to the low pin ground readings in test d. The relatively small amount of pin insulation must be extended further down the pins, into the epoxy potting, to guard against this. This was done on penetrators used in the vehicle.

d. The epoxy is an adequate third pressure barrier. From these tests, its bonding to the penetrator body appears to be its weak link. In our estimation this was the path of the leak in test d, and contributed to the low pin ground readings. It is important to have better control of lead position in the epoxy potting to avoid grounds to the penetrator bodies.

6. Other Tests:

All of the hull electrical penetrators were pressure and electrically tested by Southwest Research Institute prior to installation in Hulls No. 1 and No. 2. See their report Project No. 03-1206 "ALVIN Hull Penetrator Test" dated February 1964 by E.M. Briggs and R.C. DeHart, and were further tested in the pressure hulls during pressure testing of them.

Footnote - Electro-Oceanics, San Diego, California has collaborated with USNEL on the TRIESTE project, handling most of the TRIESTE's wiring and potting problems.

Fig. 1 Penetrator Drawing

Fig. 2 Penetrator Photo

1) Hull Penetrator Load Test

2) Hull Penetrator Load Test

3) Single Lead Test at Zero Pressure