APPENDIX XVII

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May 10, 1995

TO: Prof. P. Jeff Fox, Chair - DEep Submergence Science Committee

FROM: Dudley Foster and Barrie Walden - WHOI

SUBJECT: ALVIN Batteries and Hydraulic system

Dear Jeff:

In response to questions raised at the December 1994 DESSC meeting concerning ALVIN batteries, charging cycles and bottom time we have provided the following information for evaluation by the committee. We feel that it is important to demonstrate to the committee and the community that we are tracking the submersible power issue. Realistically, however, there exists no panacea to this problem, and given the current fiscal climate it is extremely difficult for us to do more than what we have within the scope of our limited operational budget.

One question that was raised by the committee and various scientists at the meeting was how does the ALVIN group justify its battery voltage limits. The recommended low-voltage limits and capacity of Pb-acid batteries is available from most major manufacturers of this type of battery. We have tracked this issue carefully over the years and have stayed abreast of the most current recommendations as they relate to the batteries we purchase to build our battery packs. Several months of research on various Pb-acid cell types (flat and tubular plates), and their care and treatment, was re-done by our engineers about six years ago. This has been done several times in our 30 year history due to ALVIN battery configuration changes. The results of those studies have determined our present voltage cut-off limits.

There have been no significant developments in Pb-acid battery manufacturing that have provided any type of technological breakthrough which would be worth spending the time and money to redo those studies in an effort to gain power for ALVIN. The information does not show that any appreciable power-gain, over what we currently have, is possible with today's Pb-acid technology. At such a time that either Pb-acid technology breakthroughs arrive, or should the current testing of Ag-Zn or Fe-Ni batteries by other submersible operators show that these battery technologies could provide a reliable, cost-effective, and sustainable increase in available operational and science power, we would be the first to argue for funding to investigate the applicability of those power sources for ALVIN. As mentioned above, given the present funding climate we do not feel that we can make a strong case at this time for requesting additional funding to further research the submersible power issue, despite its clear importance and implications for the conduct of science while on the bottom. The ALVIN group will continue to monitor the Pb-acid technology and dialog with the other submersible operators to learn about their experiences with other power sources, and we will keep DESSC abreast of our findings at upcoming meetings.

As further background to the voltage cut-off limit we have recently been doing some testing of Pb-acid cells here at WHOI and have concluded that the at-sea operations group is running the batteries to about 70% discharge when they leave the bottom. The general guidelines throughout the Pb-acid battery industry is to not discharge below 80% of capacity for regularly used batteries, such as fork trucks, which is less severe service than we use for ALVIN. The net result is that ALVIN leaves the bottom with only 10% of the "usable" battery left to get to the surface, maneuver if required, and get secured in the hanger until external power is connected. Our experience and data show a significant imbalance in cell capacity

with usage, and running below 80% capacity risks permanent damage to the weakest cells.

The initial battery problem on the last Karson cruise (January - February 1995) is a good example of what can happen if a single cell in a battery is overly discharged. When the low-capacity ALVIN battery was removed in Barbados after that cruise, some of the individual cells showed "reverse polarity" damage on the initial test discharge, even though the overall battery voltage was satisfactory. These cells were likely the weakest ones in the battery pack. This type of problem can only be solved by throwing away the cell. Pressing the low voltage limit increases the risk of this kind of cell damage, resulting in permanent loss of the entire ALVIN battery capacity. The result is lost bottom time for future legs until the battery pack can be replaced.

In an effort to get the most power for the longest period of time from our batteries, we continually try to improve the way ALVIN battery packs are maintained, and we are currently testing electronic monitoring devices that will help us track battery performance. Part of this effort requires occasional changes to procedures, support hardware, and associated evaluation of results. The initial poor battery performance on the Karson cruise was due in part to changes in the battery charging hardware, internal component grounds, and a battery with some less-than-optimum cells. The time involved in recognition and evaluation of the results caused limited power on several dives. Because of the small incremental improvements we are trying to achieve, any changes realistically require 50 or more battery cycles (dives) to correctly evaluate the results. Because these "experiments" can only be evaluated in our operational environment the expected results will not be 100%. Unfortunately, a few users may, at times, be shorted on performance in the interest of long-term improvements for all ALVIN users.

We intend to present some historical data that we have compiled on bottom times for dives from 1985 to the present at the upcoming DESSC meeting and discuss the many variables involved with the issue of submersible power and bottom time with the committee.

Please let us know if you need further information on this topic or if there are questions on the issues we discuss above.

Sincerely,

(signed)

Barrie B. Walden

(signed)

Dudley B. Foster

cc: R. Pittenger WHOI - DSAC

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