UNIVERSITY OF CALIFORNIA, SAN DIEGO

Investigations into the Effects of Long-Term Seawater Exposure on Graphite/Epoxy Composite Materials

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Oceanography

by

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ABSTRACT OF THE DISSERTATION

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The investigations documented here were intended to determine whether graphite-fiber-reinforced plastics can survive the highly aggressive seawater environment when used as structural materials in advanced ocean engineering designs. Two general effects of seawater exposure were identified as potentially life-limiting phenomena. The first effect is a weakening of the fiber-to-matrix bond caused by exposure of the interface to moisture. The second effect is the establishment of an electrolyte (seawater) around the conductive graphite fibers, thus allowing electrochemical reactions to take place. (The effects of static pressure, solar radiation and biological activity were not included in the present investigation).

The fiber/matrix interface bond is weakened as a result of exposure to a moist environment. However, for graphite/epoxy composites the bond does not generally fail in the absence of applied loading. When loads are applied the local effect is for the fiber to de-bond from the matrix. However, the effects on a larger scale are more complex, and may not be intuitive. For example, in the present study it was found that the weakened fiber/matrix bond actually increased the resistance of the material to fatigue and fracture.

Electrochemical degradation can occur as the result of stray-current corrosion or galvanic coupling. Stray-current damage is rapid, involves dissolution of the graphite reinforcing fibers, and can occur under relatively low current conditions. Galvanic coupling damage is a subtle localized corrosion phenomenon involving chemical attack of the polymer resin. Electrochemical damage is the result of interaction with species which form as intermediates in the oxygen reactions on the anode and cathode.