A STUDY ON ELASTOMER/METAL BONDS APPLICABLE IN UNDERSWATER SONAR SYSTEMS

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Recent emphasis on the long-term performance of sonar systems requires that investigations be carried out to improve the durability of elastomer-to-metal adhesive bonds in water. A screening test of some commercially available adhesive systems was performed. ASTM-D429 test methods using both conical button specimens and peel-strips were employed. The 90-degree peel test was modified such that the effects of stress corrosion, water salinity and gas content could be examined. Most commercial systems were found to give adequate dry bond strength. Preliminary environmental aging studies also showed that thermal aging did not produce any measurable effect in accelerating the degradation of the elastomer/metal bond. However, chemical attacks from salt water under stress caused great reductions in the bond strength, especially when the oxygen supply was abundant. The weakened bonds were found to show increasingly large portions of fracture failure at the adhesive/metal interface rather than rupture failure of the bulk rubber.

INTRODUCTION

In addition to applications for joining the structural components in hydrofoil boats, surface effect vehicles and other advanced ships, adhesive-bonding technology is also applied in many underwater systems such as vibration damping mounts, acoustic windows for sonar transducers and other acoustic conditioning devices. Elastomer-to-metal bonding usually appears in one of two
forms. Either the cured rubber components are bonded to a metal substrate or the uncured rubber is molded in place onto metal surfaces which have been prepared in advance with primers and adhesives. The latter technique is extremely popular, especially when the area of coverage is reasonably small. Essentially all the rubber face plates of wet-end sonar transducers are fabricated in this fashion. For large rubber structures such as sonar dome windows which contain steel reinforcements, adhesives are often applied in-between plies during the lay-up process before autoclave cure. In this case, the adhesive is used to promote adhesion between the cured rubber surfaces. In the discussion here, however, the emphasis will be on the elastomer/metal bond prepared by direct vulcanization of uncured rubber to a metal substrate.

The life-time requirement of many sonar devices may be as long as ten to fifteen years. Since the device is constantly exposed to rigorous environmental stresses due to chemical attack of sea water, temperature extremes, pressure cycling plus mechanical stresses, it is at first glance very unlikely that an elastomer-to-metal bond will survive over such a long period of time. Many factors may contribute to this pessimistic observation. First of all, the bonds are normally prepared in manufacturers' production warehouse or in shipyard environments where a "clean room" condition is probably difficult to maintain, if not impossible. Subtle changes in bonding procedure or sheer negligence of the workers in matters such as surface treatment, adhesive mixing and application, and vulcanization temperature control could easily lead to an unsatisfactory bond. Furthermore, primers, adhesives and rubber compounds are all typically complex chemical mixtures. Their compositions are often kept by the manufacturer as secretive as possible under proprietary claims. At the same time, since these materials usually have narrow profit margins, the formulator will frequently change suppliers or replace ingredients in order to maintain a low cost basis. Without extensive studies of the long-term effect of such changes, these formulation variations, even minor at times, often lead to compromises in performance. Degraded adhesive bonds cause serious water-leakage, corrosion, loss of mechanical integrity and ultimately the failure of the complete sonar system. The result is ever-increasing cost of maintenance, repair and replacement for these systems, which also adversely affects fleet readiness. This makes the reliability consideration an utmost important matter.

In order to improve the reliability of elastomer-to-metal bonds in sonar devices, it is believed that steps toward stringent quality control must be taken. It would be necessary to specify the chemical composition of adhesives and elastomers, and to develop required bonding and molding procedures. The materials will eventually have to be developed to replace proprietary commercial products. Quality control methods need also be investigated, both for chemical analysis and for performance testing. In this paper, the first effort made