IMPLEMENTATION OF COMPOSITE SOLUTIONS IN SHIPBOARD TOPSIDE ELECTRICAL SYSTEMS

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BACKGROUND

Current metallic boxes/housings for electric equipment, indicator lights, and connectors used on Navy ships, Military Sealift Command (MSC) vessels, and Army watercraft corrode, require frequent repainting, and represent a significant source of corrosion-related topside maintenance tasks for ship's force. In a 1998 report, the Commander, Naval Air Force, Pacific Fleet (AIRPAC N-43) identified replacement of metallic electrical boxes as the "biggest maintenance problem on carriers."

In response the NAVSEA Corrosion Control Division initiated shipchecks starting in 2001 on the USS THEODORE ROOSEVELT (CVN-71), USS BARRY (DDG-52), USS COMSTOCK (LSD-45), and USS VELLA GULF (CG-72). These inspections showed that the metallic boxes corrode resulting in leakage and loss of electrical function, that the brass boxes are frequently repainted, and that the brass boxes corrode the ship structure. Figure 1 shows a picture of a corroding box with missing covers for the electrical connections that allows for moisture intrusion and loss of electrical function.

Figure 1 - Corroding Electrical Enclosure

Figure 2 shows typical galvanic corrosion of the ship-structure to which a brass box was attached.

Figure 2 - Ship-Structure Corrosion Resulting from Brass Enclosure

The analyses further showed that boxes corrode and require repainting and repair every three years. Half the boxes are replaced every six years. Ship's force must repair the corrosion damage to these boxes because they are integral to the ship's operating or force-protection systems. Box failures can require ship's force to "jury rig" temporary extension cords and relays to accomplish critical functions like communicating operating commands to force-protection stations (e.g., 50-cal. machine gun mount crews communicate with the bridge by connecting sound-powered telephones to electrical boxes mounted on the ship's structure) or ensuring anti-swimmer security lights are functional. Figure 3 shows such a temporary "jury-rig" installation. In some applications, a shock-hazard associated with deteriorated electrical boxes forced ships force to engage switches with a wooden broom handle.

Figure 3 - "Jury-Rig" Solution to Corroded Electrical Box

In response to these corrosion problems, NAVSEA initiated efforts in 2001 to begin to identify a solution to the problem. NAVSEA engineers utilized a composite electrical enclosure technology originally identified for U.S. Air Force applications. These enclosures were fabricated from a fiberglass-reinforced, composite material. Composite boxes were envisioned as drop-in replacements for metallic boxes that could be installed at a low marginal cost. While slightly more expensive than metallic boxes, these boxes were anticipated to last for the life of the ship.

The NAVSEA efforts included determining the box performance requirements as listed in military specification-performance requirements and standard drawings. These requirements were compared to industry supplier capabilities, including the specialized vendors of the aforementioned Air Force enclosures. Test boxes were obtained from three suppliers and subject to shock, fire, and other NAVSEA-required performance tests. Specific applications of interest were boxes for sound-powered telephones, 110v electrical power outlets, and switches and indicator lights. Shipboard testing was initiated for boxes satisfying the required performance tests. Trial installations were conducted on USS RUSHMORE (LSD 47) installed in September 2001, USS COMSTOCK (LSD 45) installed in April 2002, USS VELLA GULF (CG-72) installed in April 2002, USS BARRY (DDG-52) installed in August 2002, and on USS GEORGE WASHINGTON (CVN-73) installed by September 2003.

Table 1 shows the tests performed in the enclosures, with the boxes meeting (passing) all of the requirements. Key parameters included mechanical (e.g., shock, vibration), environmental (e.g., watertight characteristics, solar radiation), electrical (e.g., EMI/EMP), and fire performance.

Table 1 – Summary of Testing Requirements for Composite Enclosures

Test	Issue	Requirement
MIL-S-901	Shock	Grade A, Class 1. No Failure.
MIL-STD-167-1	Vibration	2-Hour test. No Failure.
MIL-STD-1344	Impact / Random Drop	Six times, 4 ft drop, No failure.
MIL-STD-461 / 1310	EMI / EMP	Min. 60dB
MIL-STD-810	Salt Fog	96 hr wet/dry, No corrosion.
MIL-STD-810	High and Low Temperature	-28F to 149F. 3 Days. Function. No cracking or sagging.
MIL-STD-810	Solar Radiation	56, 24 hr cycles, no color change.
MIL-STD-108	Splash proof, Watertight	Hose spray, 5 min. No liquid penetration.
ASTM E 162	Flame Spread / Dripping	25, self extinguish no drip.

Test	Issue	Requirement
ASTM E 1354	Smoke / Heat Release	Cone 25, 50, 75 kW/m2
ASTM E 662	Smoke Density	Smoke < 200
NAVSEA-Developed	Fire Containment	No "burn-thru" in 200 seconds

PRODUCT DEVELOPMENT AND FIELD TRIAL PROCEDURES

Alternative suppliers were sought for supplying the Navy with composite electrical enclosures. Four vendors were identified as primary candidates. Based on the demonstrated performance capability of commercial-off-the-shelf (COTS) technology, the supplier Glenair (Glendale, CA) was selected to provide the enclosures for the improved electrical boxes for the expanded field demonstrations. Glenair offered an enclosure fabricated from the resin Ultem 2300 which had demonstrated promise in similar applications for the U.S. Air Force. Such enclosures had also received approval of the British Royal Navy. Figure 4 shows the typical type of enclosures tested.

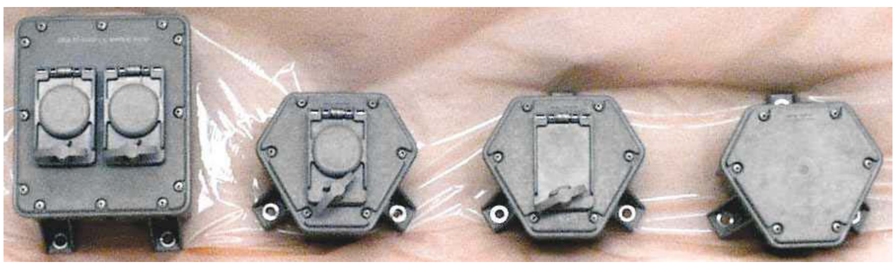

Figure 4 - Typical Composite Electrical Enclosures

These enclosures were chosen based on their attributes. They are inherently fire retardant, stable in sunlight, tough, and gray in color (eliminating the need for repainting). They have hinged latches to prevent loss of the "cap" and a "spring-closure" (absent of crew action) to ensure proper sealing against the corrosive marine environment. The method chosen to mount the enclosures was designed to prevent corrosion of the ship superstructure. Figure 5 shows the mounting method.

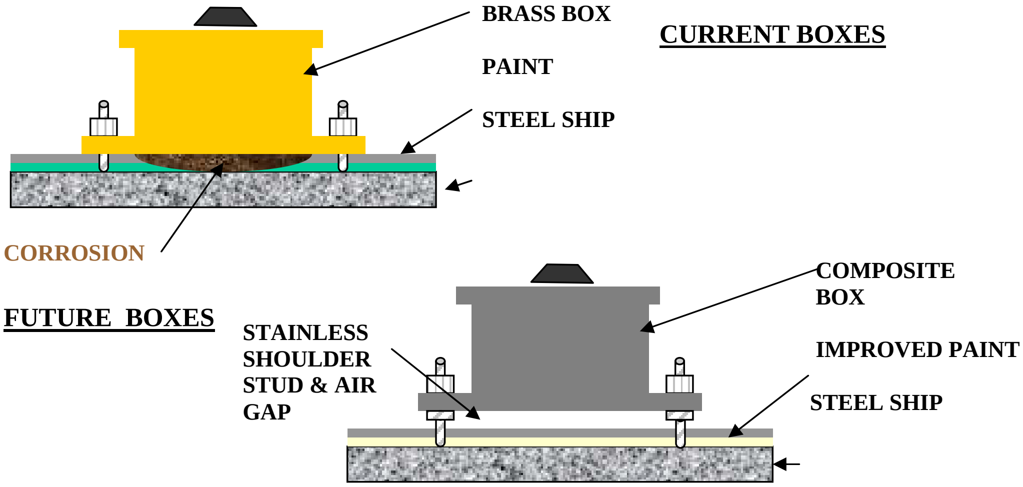

Figure 5 - Improved Composite Box Mounting Method

The use of a mounting stud with a stand-off boss provides an air-gap between the enclosure and the ship structure. This allows for draining of the area after being wet eliminating the aqueous environment conducive to corrosion. A high-solids coating system was installed following NAVSEA QA standards behind the box to provide an effective corrosion barrier.

The boxes were also modified to provide an electrical ground path that is necessary for crew safety. The interior of the Ultem 2300 was coated with an electroless nickel and the enclosure included a molded-in, stainless steel "grounding-foot" to allow electrical continuity to the ship structure.

Field demonstrations were conducted on ships with corrosion prone enclosure installations. Navy amphibious ships operate in the littoral environment incident to USMC operations and experience attendant high levels of corrosion. The Navy LSD-41 and LSD-49 class ships were accordingly selected. The stern-gate controller area on these ships is exposed to considerable sea-spray, a very harsh environment (Figure 6).

Figure 6 - Corrosion-Prone Stern Gate Controller Area

To institutionalize the use of composite boxes on Navy ships, the installation had to be introduced in accordance with the Navy's Ship Change Documentation (SCD) process. This process was instituted to ensure that new equipment installed on Navy ships was logistically supported. The process includes coordination with all affected parties and the generation of a cost-benefit analysis to demonstrate efficacy. The SCD was initiated on 9 March 2005 and approved on 16 March 2006 as SCD 609, to formalize installation of such enclosures on the LSD 41 and 49 class ships.

Under the FY05 OSD program, four (4) installations were made on LSD class ships. Table 2 lists these installations. Although some of these installations were made before approval of the final SCD 609, they were in concert with the process; the existence of the SCD allows the process to be institutionalized on the entire ship classes. Appendix A documents the installation process.

Table 2 - LSD Class Test Ships for Composite Electrical Enclosures

Ship	Installation Date
USS HARPERS FERRY (LSD 49)	APR 05
USS PEARL HARBOR (LSD 52)	JUL 05
USS GERMANTOWN (LSD 42)	JUL 05
USS GUNSTON HALL (LSD 44)	JUN 06

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Figure 7 depicts a new installation of the composite boxes in the stern gate controller area.

Figure 7 – New Composite Electrical Enclosure Installation for Stern Gate Controller

In addition to the expanded trial installation on the four additional LSD class ships listed in Table 2, the program continued to monitor the installations made in 2001 and 2002 on USS BARRY (DDG-52), USS GEORGE WASHINGTON (CVN-73), USS VELLA GULF (CG-72), USS RUSHMORE (LSD 47) and USS COMSTOCK (LSD 45) installed with NAVSEA Engineering for Reduced Maintenance (ERM) Program funds as a part of the concept demonstration process.

The program also included installations of similar electrical enclosures on an Army watercraft. Eleven (11) 125V/15A electrical receptacles were replaced on the USAV Bristoe Station, (LCU 2006) at various locations on the weather deck. This work was accomplished in August 2005.

RESULTS AND DISCUSSION

The following summarizes the performance of the composite boxes and conduit.

LSD CLASS SHIPS. Figure 8 shows the condition of the oldest installation on USS Rushmore after four years of service. Aside from some slight rust staining emanating from under a single enclosure, there is no corrosion damage. There has been no loss of function on any of the enclosures after more than four (4) years of service. There have been no reports of electrical failure or maintenance required on any of the installations. This represents a substantial change vs. the corrosion problems reported with the legacy systems.

Figure 8 - Composite Electrical Enclosures on USS RUSHMORE (4 Years Service)

Figure 9 shows excellent performance of the same style enclosures on the USS GUNSTON HALL after 6 months exposure.

Figure 9 - Composite Enclosures on USS GUNSTON HALL (6-Months)

All other LSD class ships reported no corrosion or functional problems with the composite electrical enclosures installed. Based on previous experience with trial installations—ships force will call if there is a problem.

<u>USS GEORGE WASHINGTON (CVN-73).</u> Figure 10 shows the condition of the composite electrical enclosures on USS GEORGE WASHINGTON (CVN-73) after three (3) years of service. The figure shows the ship during a maintenance availability so the electrical conduit has been removed from the boxes. Despite its location on the weather deck area, no corrosion or deterioration was observed on the box or the hull structure.

Figure 10 - Composite Enclosures on USS GEORGE WASHINGTON (Three Years Service)

USS BARRY (DDG-52). Boxes have been installed on USS BARRY for about 5 years. Figure 11 shows a composite picture of these boxes at the time of installation (photograph on the left) vs. the boxes after five years of service (right photograph). The box itself remains in virtually the same condition as upon installation. The only sign of corrosion is weeping and staining emanating from the mounting holes where the boxes is attached to the ship structure.

Figure 11 – USS BARRY Sound-Power Phone Box, Install (Left) and Five Years (Right)

US ARMY LCU-2006. An opportunity existed to make an inspection of the USAV Bristoe Station, LCU 2006 after nominally 1 ½ years of service. All of the composite electrical enclosures appeared intact and free of corrosion. The ship has not reported any problems or maintenance needs associated with any of the installed components. Figure 12 shows a typical electrical box after 1 ½ years service.

Figure 12 - Electrical Enclosure after 1 1/2 Years (LCU 2006)

INSTITUTIONALIZATION

In order to ensure that this technology was available to be installed on other Navy ships in the future, a NAVSEA Standard Drawing 803-6983506 "ELECTRICAL ENCLOSURES, COMPOSITE, INSTALLATION & DETAILS" (Appendix B) was drafted and forwarded to the LSD planning yard for institutionalization on 23 March 2006. The drawing provides configurations, materials, and installation guidance for composite boxes and can also be used as a basis for other installations.

Stock numbers 61A060105, 61A060106, 61A060107, and 61A060108 were established for composite boxes to ensure that they were available in the Navy supply system. The Ship Change Document (SCD) 609 "Composite Stern Gate Control Panel" for LSDs was formalized on 16 March 2006 to authorize the installation of composite electrical boxes in the stern-gate control station of all LSD class ships.

SUMMARY AND CONCLUSIONS

1. Composite topside electrical enclosures on Navy ships and Army watercraft have been demonstrated to perform without any need for interim maintenance for a period of up to four (4) years. Based on the observation that no visible degradation has occurred, it is anticipated that the enclosures will last the life of the ship.

2. Component drawings, stock numbers, and Ship Change Documentation paperwork have been completed, providing a basis for institutionalizing these materials on Navy ships. These products also provide a basis for their use on MSC ships and Army watercraft.

3. The cost of installing composite boxes in lieu of metallic boxes is estimated to be 13% higher. Though composite boxes are more expensive, most of the installation costs are for labor, which is the same for both materials.

4. With an investment in composite boxes for Navy ships which could be installed on failure of the corrosion-prone metallic boxes, the serious safety and operational problems of degraded electrical ship systems could be eliminated.