Fatigue Performance of Composite Patch Repaired Cracked Aluminum Plates

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The Navy is currently experimenting with alternative repair methods to address sensitized aluminum superstructure cracking on the CG-47 Ticonderoga class cruisers. The process of sensitization occurs slowly over years and can begin when plating temperature exceeds 100°F, which occurs during typical diurnal solar cycles. Sensitization is determined by the measured mass loss according to test standard ASTM G67; Levels greater than 60mg/cm² are considered un-weldable. One alternative to traditional welded repair is the composite patch, which is designed to return water tight integrity to the compromised compartment, mitigate or stop crack growth, and inherently eliminate the need for “hot work”. Testing of composite patch repaired aluminum Center Crack Tension (CCT) specimens documents the baseline performance and provides proof of concept for the repair methodology on aluminum marine structures. Basic performance and the ability to delay initiation and retard crack growth was demonstrated through a series of static and tension-tension fatigue testing composite patch repaired cracked aluminum CCT specimens. CCT specimens modeled after an ASTM E647 middle (tension) specimen with 5 and 7 inch initial crack lengths were analyzed and tested. The base panel was 0.25 inch thick 5456-H116 plate in as-delivered, oven sensitized, and ship sensitized conditions with E-Glass and Carbon reinforced toughened epoxy composite patches. Base line composite patch repairs increased the cycles to failure of the cracked aluminum plate by more than 4, 6, and 10 times at three far-field tensile stress levels. Under quasi-static tensile loading the composite patch repair increased the tensile load capacity of the specimen by more than 80% and increased the crack growth initiation load by 33%. Composite patch disbonding was limited to localized areas around the crack and typical patch failure was within the laminate stack, not the aluminum to epoxy bondline. Further fatigue testing of the composite patch repair method was performed with a single far field stress level with cracked aluminum plates using uni-directional E-Glass and Carbon fabrics. The stiffer composite patch carries a significant amount of the load and increases the load cycles to failure more than the low modulus baseline laminate.