SANDIA REPORT
SAND97-3002 UC-1210
Unlimited Release
Printed December 1997

DOE/MSU Composite Material Fatigue Database: Test Methods, Materials, and Analysis

by

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ABSTRACT

This report presents a detailed analysis of the results from fatigue studies of wind turbine blade composite materials carried out at Montana State University (MSU) over the last seven years. It is intended to be used in conjunction with the DOE/MSU Composite Materials Fatigue Database. The fatigue testing of composite materials requires the adaptation of standard test methods to the particular composite structure of concern. The stranded fabric E-glass reinforcement used by many blade manufacturers has required the development of several test modifications to obtain valid test data for materials with particular reinforcement details, over the required range of tensile and compressive loadings. Additionally, a novel testing approach to high frequency (100HZ) testing for high cycle fatigue using minicoupons has been developed and validated. The database for standard coupon tests now includes over 4100 data points for over 110 materials systems. The report analyzes the database for trends and transitions in static and fatigue behavior with various materials parameters. Parameters explored are reinforcement fabric architecture, fiber content, content of fibers oriented in the load direction, matrix material, and loading parameters (tension, compression, and reversed loading). Significant transitions from "good" fatigue resistance to "poor" fatigue resistance are evident in the range of materials currently used in many blades. A preliminary evaluation of knockdowns for selected structural details is also presented. The high frequency database provides a significant set of data for various loading conditions in the longitudinal and transverse directions of unidirectional composites out to 10^8 cycles. The results are expressed in stress and strain based Goodman Diagrams suitable for design. A discussion is provided to guide the user of the database in its application to blade design.