**Course M-1/R-1**
***Advanced Composite Structures: Fabrication & Damage Repair-Phase 1***

## Course Summary

Our most popular class, Advanced Composite Structures: Fabrication & Damage Repair-Phase 1 is designed to meet the needs of a wide range of personnel; from the novice to the seasoned professional.

This course is a prerequisite for both our repair and manufacturing programs and is highly recommended to anyone seeking a better understanding of advanced composite materials, processes, layup/lamination, vacuum bagging, adhesive bonding, tooling, repair, and inspection methods and techniques.

**Note: Engineers involved in composite repair design and anaylsis are advised to take the ER-1 course, and engineers involved in structures design are advised to take the ES-1 course.**

## Introduction

Balanced with theoretical and practical presentations, the hands-on exercises in this course are extensive; they will work with prepreg carbon fiber unidirectional tape to explore the effects of orientation; “balance” and “symmetry” in a laminate. The students will also work with dry glass fabric and liquid epoxy resin in an exercise designed to teach fundamental vacuum bagging, bleeder & breather concepts. Mid-week, teams work with prepreg glass and carbon fiber fabrics, along with Nomex® honeycomb and polyurethane foam core materials, making sandwich panel structures, utilizing laminate “nesting” techniques. And finally, basic repair methods and techniques will be presented along with performing a “wet layup” repair in the lab. On the last day, the final repaired part will be cut in half for evaluation of the manufactured and repaired panel.

# Topics

**Key Lecture Elements:**

- History of composites, recent developments and terminology.
- Introduction to advanced composite materials/structures.
- Resin/adhesive systems: thermosets vs. thermoplastics, mix ratios, viscosity, service temperature limits, cold storage requirements/shelf life limits, pot life, etc.
- Material Forms: dry cloth and wet resins vs. prepregs, weave/styles, etc.
- Fundamentals of Fabrication: prepreg cloth handling, ply orientation, layup procedures, vacuum bagging.
- Fabrication Methods: wet layup, prepreg layup, filament winding, RTM, infusion, press molding, pultrusion as well as automated tape layup (ATL) and fiber placement (AFP).
- Curing methods: oven/autoclave/hot bonder cures. Viscoelastic properties.
- Health and Safety Issues: proper handling, personal protection, allergic reactions, waste disposal.
- Introduction to adhesive bonding technology: co-curing vs. secondary bonding, surface preparation, cleanliness, bond line thickness and clamping pressure requirements.
- Principles of Tooling: types of tools, thermal characteristics of various tooling materials.
- Drilling and fastening; proper speed and feed requirements, use of mechanical and adhesive bonded fasteners.
- Primer on repair design; permanent vs. temporary repairs, scarf vs. stepped vs. mechanical patch repair scenarios.
- Inspection methods and techniques: non-destructive inspection methods, defect detection, documentation, acceptable vs. unacceptable defects, defect prevention.

**Workshop Exercises:**

- Panel layup using prepreg carbon uni-tape materials; symmetric and asymmetric laminates.
- Panel layup using dry glass cloth and liquid epoxy resin materials. Vacuum bagging with varied bleeder/breather sequences to evaluate resin bleed and flow characteristics.
- Sandwich panel layup, bagging and processing of nested glass fabric/foam and carbon fiber/honeycomb sandwich core panels.
- Vacuum bagging using non-autoclave bleeder/breather schedules. Installation of pleats to minimize bridging in high-angle core transitions. Vacuum debulking, leak checking, and identification of other potential bagging problems.
- Oven curing; vacuum, ramp rate, soak, and cooling requirements.
- Composite repair; damage removal, scarf preparation, core and skin repair using wet layup materials and processes.
- Introduction to hot-bond repair equipment; demonstration of bonders, heat blankets and thermocouple placement.

## Course Benefits

Students come away with a fundamental understanding of advanced composite materials & processes at a level sufficient to put learned skills into practice immediately upon entry or return to the workplace.

## Prerequisites

None - This course is a prerequisite for subsequent manufacturing and technical repair courses.

## Teaching Method

Active classroom lecture and workshop exercises: 50% Theory and 50% Practical

## CEU

3.6