

# STRANDS AND STANDARDS

## COMPOSITES 1



### Course Description

This course is a stand-alone component of a coordinated 4-part group of courses focusing on advanced materials and general manufacturing. All four courses are appropriate for students desiring college preparation in engineering and also for students seeking direct entry into technician positions in industry. This course, Composites 1, is the first in a two-part sequence focusing on properties and manufacturing principles of both fiberglass reinforced plastics (FRP) and advanced composites (generally carbon-fiber parts for the aerospace industry).

<b>Intended Grade Level</b>	10-12
Units of Credit	0.5
Core Code	40.10.00.00.140
Concurrent Enrollment Core Code	N/A
Prerequisite	None
Skill Certification Test Number	N/A
Test Weight	N/A
<b>License Type</b>	CTE and/or Secondary Education 6-12
<b>Required Endorsement(s)</b>	
Endorsement 1	Machine Tool or Welding or
Endorsement 2	Cabinetmaking or
Endorsement 3	Technology and Engineering

## STRAND 1

**Students will understand the fundamental nature of composites and how they are used to improve our world.**

### Standard 1

Discuss what composites are.

- Definitions: composite, reinforcement, matrix, fiber, resin, plastic.
- Concept of composites: A reinforcement embedded in a matrix (compare to islands in an ocean).
- Role of the reinforcement: Carry the load, give strength, give stiffness.
- Role of the matrix: Hold reinforcements in place, protect from environment, contribute to impact toughness.

### Standard 2

Discuss the history of composites and how they have developed over the years.

- The use of straw combined with mud to make bricks – 3000 B.C. (Reinforced concrete is a more modern example.).
- Mongolian bows were made from a bamboo core with horn on the side under compression (facing the bowman) and sinews on the tensile side (away from the bowman) and held together with animal glue and, perhaps, wrapped with silk threads over a birch bark cover.
- Wright Brothers: wooden frame covered with cotton cloth and waxed string.
- Using rayon (reconstituted cellulose) as a means to lighten the fuselage for a WWII Spitfire aircraft.
- Plywood (multi-layers in which the grains are crossed, held together by adhesive).
- Manufacturing processes of fiber glass, non-fiber glass, and contemporary composites in the aerospace industry.
- Boeing 787 and other modern airplanes (layers of carbon fibers and epoxy resin laid with the fibers pointing in different directions in each layer and then cured to bind all together in a solid structure).

### Standard 3

Discuss the use of composites in today's society.

- Discuss fiberglass reinforced plastics (FRP) use for mid-strength/low cost and high-strength/low weight in such areas as:
  - Automobiles, boats, windmill blades, tubs and showers, medical devices, architectural structures, storage tanks
  - Spacecraft, airplanes, helicopters, body armor, artificial feet, energy applications, advanced automobiles and non-structural applications (heat transfer, electrical conductive)
- Discuss the FRP industry (fabrication shops, fabrication machine makers, production materials vendors, resin manufacturers, fiberglass manufacturers).

- Discuss the advanced materials industry (prime aerospace companies, major parts suppliers, minor parts suppliers, tooling suppliers, manufacturing machine makers, production materials vendors, fiber manufacturers, resin manufacturers, prepreg companies, core material makers, fiber weavers and preform makers).

#### Standard 4

Advantages and disadvantages of composites over other materials.

- Discuss advantages of strength and stiffness combined with light weight.
- Specific strength and specific stiffness (compare composite to steel and aluminum).
- Discuss fatigue and crash-worthiness (many energy absorbers when fibers are broken versus one unitary material with crack propagation).

## STRAND 2

**Students will understand the basic materials used in the composites industry.**

#### Standard 1

Compare advanced composites and fiberglass reinforced plastics (FRP).

- In FRP the properties of the plastic dominate and the reinforcement adds strength and stiffness, whereas advanced composites are dominated by reinforcement properties and the matrix is secondary.
- Discuss random fiber orientation (FRP) versus careful fiber placement (advanced composites).
- Discuss fiber properties.
- Fiberglass or natural fibers are used in FRP whereas carbon or other very strong and stiff fibers are used in advanced composites.

#### Standard 2

Discuss the differences between thermoset and thermoplastic resins.

- Thermoset resins.
  - Thermoset resins are often a liquid polymer at room temperature or a polymer dissolved in a reactive solvent (the solvent combines with the polymer during the curing process to create the solid).
  - The curing of thermoset resin is achieved by using an initiator to start the reaction, perhaps with some heat applied, while the resin and reinforcement are in a mold.
  - Molded parts can become softened but can never be re-melted or returned to their uncured (liquid) state.
  - Parts can be made in high production quantities but cure times must allow for the chemical reaction (crosslinking) to occur.
- Thermoplastic resins.
  - Thermoplastic resin (a solid at room temperature) can be formed to a desired shape by applying pressure (usually in a mold) when the resin is softened or melted.

- Molded parts can be reshaped by re-softening or re-melting and by applying additional pressure.
- These resins have a high melting temperature
- Excellent for mass producing small parts (short cycle times).
- Can be recycled easily.

## Standard 3

Identify the reinforcement materials used in FRP.

- Fiberglass
- Rovings
- Woven cloth
- Non-woven mat
- Chopped
- Natural fibers

## Standard 4

Identify the different types of fibers used in advanced composites.

- Carbon (including metal-coated)
- Aramid (Kevlar)
- Polyethylene (Spectra)
- Boron, basalt, and other specialty fibers
- Ceramic
- Metal

## Standard 5

Identify the different forms of fibers used in advanced composites.

- Filaments, tow, strands, yarns
- Prepreg (unidirectional) tape (include a discussion of why prepreg must be stored at low temperature)
- Woven and non-woven
- Preforms (braids, knits, stitched)

## Standard 6

Identify and briefly discuss the matrices used in advanced composites (comparisons, applications).

- Epoxies
- Bismaleimide (BMI)

## Standard 7

Identify core materials.

- The I-beam effect for stiffness.
- Types of sandwich materials (rigid foams, honeycomb, Balsa wood, others).
- Bonding sandwich materials to composite face sheets.

### Performance Skill

Understand the basic materials used in the composites industry.

- Compare advanced composites and fiberglass reinforced plastics (FRP).
- Discuss the differences between thermoset and thermoplastic resins.
- Identify the reinforcement materials used in FRP.
- Identify the different types of fibers used in advanced composites.
- Identify the different forms of fibers used in advanced composites.
- Identify and briefly discuss the matrices used in advanced composites (comparisons, applications).
- Identify core materials.

## STRAND 3

**Students will understand basic composite manufacturing methods and perform wet layup, hand layup, and vacuum bagging processes.**

### Standard 1

Discuss and illustrate the wet (thermoset) manufacturing methods used with FRP.

- Wet layup/hand layup
- Sprayup
- Compression molding (discuss BMC and SMC)
- Filament winding
- Pultrusion
- Resin transfer molding (RTM)

### Standard 2

Follow a drawing as it relates to the placement and orientation of the fibers to counteract the loads that will be applied.

- Be able to read and interpret layup drawings/manufacturing plans.
  - Plies
  - Orientation
  - Dimensions
  - Alignments
- Locate and proper interpret the layup tools for the orientation clock.
- Demonstrate the ability to apply laminates according to the documentation.

### Standard 3

Understand the documentation of the fundamental rules of advanced composite.

- Manufacturing
- Read the resin label.
- Gather the resin to meet the specifications.
- Select the reinforcement materials to meet the specifications.
- Control the resin/fiber content.

- Mix resins by weight not volume.
- Understand the cure profile.
- Consolidate the composite during cure to ensure that the layers are properly adhering, fiber-resin content is correct, and the voids are reduced.

#### Standard 4

Create wet layup and prepreg layups with and without bagging procedures.

- Discuss automated cutting (include nesting concept).
- Discuss clean-room rules.
- Discuss vacuum bagging (discuss all bagging materials, illustrate bag side and mold side, discuss use of caul plates or pressure pads).
- Discuss autoclave curing.
- Discuss out-of-autoclave curing.
- Discuss tooling (molds) for layup (including materials and support structures).
- Discuss roll wrapping.

#### Standard 5

Compare and contrast the material properties of composite samples.

- Wet layup without a vacuum bag and wet layup with a vacuum bag.
- Prepreg with a vacuum bag and prepreg without a vacuum bag.

#### Standard 6

Discuss and illustrate automated processes for advanced composites.

- Discuss and illustrate resin transfer molding (RTM) and other liquid infusion processes.
- Discuss the need for fiber placement and tape laying and the limitations (part size, complexity) for these methods.
- Discuss the economics of manufacturing processes for advanced composites.

#### Performance Skill

Understand basic composite manufacturing methods and perform wet layup, hand layup, and vacuum bagging processes.

- Discuss and illustrate the wet (thermoset) manufacturing methods used with FRP.
- Follow a drawing as it relates to the placement and orientation of the fibers to counteract the loads that will be applied.
- Understand the documentation of the fundamental rules of advanced composite.
- Create wet layup and prepreg layups with and without bagging procedures.
- Compare and contrast the material properties of composite samples.
- Discuss and illustrate automated processes for advanced composites.

## STRAND 4

**Students will enhance their understanding of the composites industry by learning and demonstrating appropriate and safe composites fabrication.**

### Standard 1

Understand and practice the use of personal protective equipment (PPE).

- Safety glasses
- Appropriate gloves for the procedure.
- Other personal protective equipment (PPE).
- Discuss safety rules for composites manufacturing and fabrication in general.
- Develop appropriate safety rules for the laboratory.

### Standard 2

Know how to find and interpret Safety Data Sheets (SDS).

- Be able to read and understand the product labeling.
- Know how to react to exposure of dangerous products.

### Standard 3

Understand the safety rules for storage of resins, solvents, and other volatile liquids.

- Peroxides and other dangerous liquids.
- Highly contaminating substances (including mold release).
- Discuss disposal.

### Standard 4

Demonstrate general shop safety for all tools (especially power tools) and equipment used in the course.

- Pass the safety test with 100%.
- No jewelry.
- Tie back long hair.
- Closed toe shoes.

### Standard 5

Use the precautions in protecting the product being manufactured.

- Maintain a high standard of work area cleanliness and order.
- Industrial – clean as you go, assign a place for all tools and supplies and then replace them to their assigned place.
- Personal – use PPE to protect yourself from chemicals and chemical reactions.
- Understand the requirements and purposes of protecting against foreign object damage/debris (FOD).
- Dust room procedures (isolation).

### Performance Skill

Understand the composites industry by learning and demonstrating appropriate and safe composites fabrication.

- Understand and practice the use of personal protective equipment (PPE).
- Know how to find and interpret Safety Data Sheets (SDS).
- Understand the safety rules for storage of resins, solvents, and other volatile liquids.
- Demonstrate general shop safety for all tools (especially power tools) and equipment used in the course.
- Use the precautions in protecting the product being manufactured.

## STRAND 5

**Students will enhance their understanding of the composites industry by learning and demonstrating appropriate and safe processes for parts fabrication.**

### Standard 1

Understand how the flow of parts through the plant is monitored and improved.

- Part travelers or computer.
- Understand the concepts of work in progress (WIP) and bottlenecks.

### Standard 2

Understand how unused or waste raw materials and waste molded parts are disposed of and/or recycled.

- Expired or scrap prepreg.
- Waste solvents.
- Expired peroxides.
- Dust and solid composite scraps.
- Rejected composite molded parts.

### Standard 3

Understand how cured composites can be cut (machined or milled).

- Setting a reference point for the cutting machine.
- Choosing a tool (depends on the type of reinforcement and the type of cut to be made).
- Tool wear considerations.
- Understand how composites are designed for machining.

### Standard 4

Understand how to accurately drill molded composites.

- The need for straight holes and how to achieve them (drilling fixtures).
- What to do if holes are not properly drilled.
- Countersinking holes.



**Standard 5**

Understand how fasteners are installed properly.

- The corrosion potential between carbon composites and aluminum.
- Purpose for fasteners in aircraft.
- Types of fasteners – steel, titanium, inconel.
- Installing the fasteners.

**Standard 6**

Understand how to make a proper adhesive bond on composites.

- Preparing the surface.
- Choice of adhesive.
- Curing the adhesive.

**Standard 7**

Understand what sandwich structures are, their purpose, and how to make them.

- Types of sandwich materials (rigid foams, honeycomb, others).
- Bonding sandwich materials to composite face sheets.
- Cutting and drilling sandwich structures.

**Standard 8**

Understand how to effectively use sealant.

- What is sealant and where is it used in composite assemblies.
- How to apply sealant.

**Performance Skill**

Understand the composites industry by learning and demonstrating appropriate and safe processes for parts fabrication.

- Understand how the flow of parts through the plant is monitored and improved.
- Understand how unused or waste raw materials and waste molded parts are disposed of and/or recycled.
- Understand how cured composites can be cut (machined or milled).
- Understand how to accurately drill molded composites.
- Understand how fasteners are installed properly.
- Understand how to make a proper adhesive bond on composites.
- Understand what sandwich structures are, their purpose, and how to make them.

**STRAND 6**

**Students will understand the purposes of good quality control, be able to follow quality procedures, demonstrate their understanding of precision measuring, and perform property testing and other quality control procedures as they relate to the composites industry.**

**Standard 1**

Be able to follow a quality control testing procedure.

- Comparing a quality procedure to a recipe.

**Standard 2**

Demonstrate how to measure linear and cylindrical measurements accurately and how to represent the result appropriately.

- Ruler
- Caliper

**Standard 3**

Evaluate the advantages and disadvantages of NDI versus destructive testing.

- Cost of using an actual part.

**Standard 4**

Understand environmental testing and its application to composites.

- UV degradation.

**Standard 5**

Understand International Standards Organization (ISO) certifications and their purposes.

**Performance Skill**

Understand the purposes of good quality control, be able to follow quality procedures, demonstrate their understanding of precision measuring, and perform property testing and other quality control procedures as they relate to the composites industry.

- Be able to follow a quality control testing procedure.
- Demonstrate how to measure linear and cylindrical measurements accurately and how to represent the result appropriately.
- Evaluate the advantages and disadvantages of NDI versus destructive testing.
- Understand environmental testing and its application to composites.
- Understand International Standards Organization (ISO) certifications and their purposes.

**STRAND 7**

**Students will understand the importance of career readiness skills as it relates to the workplace and outlined in the SkillsUSA Framework – Level 1.**

**Standard 1**

Understand and demonstrate the attitude of cooperation.

- Develop awareness of cultural diversity and equality issues.
- Demonstrate effective communication with others.
- Apply team skills to a group project.
- Identify and apply conflict resolution skills.

**Standard 2**

Understand and demonstrate the ability of being resourceful and innovative.

- Discover self-motivation techniques and establish short-term goals.

- Measure/modify short-term goals.
- Review a professional journal and develop a three- to five-minute presentation.

### Standard 3

Plan for your future career.

- Complete a self-assessment and identify individual learning styles.
- Define future occupations.
- Identify the components of an employment portfolio.
- List proficiency in program competencies.
- Complete a survey for employment opportunities.
- Create a job application.
- Assemble your employment portfolio.
- Employability skills: evaluate program comprehension.

### Standard 4

Understand and demonstrate the ability to manage a project.

- Apply team skills to a group project.
- Observe and critique a meeting.
- Demonstrate business meeting skills.
- Explore supervisory and management roles in an organization.
- Identify and apply conflict resolution skills.
- Demonstrate evaluation skills.
- Manage a project and evaluate others.