STRANDS AND STANDARDS
COMPOSITES 1

Course Description

This course is the first in a series of two courses on the manufacture of goods and items made of composites. This course will focus mainly on the material properties and manufacturing principles of fiberglass reinforced plastics (FRP).

Intended Grade Level	10-12
Units of Credit	0.5
Core Code	38.02.00.00.251
Concurrent Enrollment Core Code	None
Prerequisite	None
Skill Certification Test Number	None
Test Weight	N/A
License Area of Concentration	CTE or Secondary
Required Endorsement(s)	Composites

STRAND 1

Students will follow safety practices.

Standard 1

Identify potential safety hazards and follow general laboratory safety practices.

- Assess workplace conditions regarding safety and health.
- Identify potential safety issues and align with relevant safety standards to ensure a safe workplace/jobsite.
- Locate and understand the use of shop safety equipment.
- Select appropriate personal protective equipment.

Standard 2

Use safe work practices.

- Use personal protective equipment according to manufacturer rules and regulations.
- Practice a culture of safety, maintain an attitude of safety in daily operations.
- Follow correct procedures when using any hand or power tools.
- Ref: https://schools.utah.gov/file/4de1dd59-0425-4f76-9e33-fdcf5de45dbf

Standard 3

Complete a basic safety test without errors (100%) before using any tools or shop equipment.

STRAND 2

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

Standard 1

Discuss what composites are.
For example:

- Define: 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.
For example:

- 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.

- Early aircraft were designed with wooden frames covered with cotton cloth and waxed string.
- Later aircraft used rayon (reconstituted cellulose) to reduce weight.
- Plywood (multi-layers in which the grains are crossed, held together by adhesive) was sometimes used as a substitute for aluminum.
- Modern aircraft make regular use of fiber glass, non-fiber glass, and contemporary composites.
- High performance aircraft use layers of carbon fibers and epoxy resin laid with fibers pointing in different directions in each layer which are then cured to bind all together in a solid structure.

Standard 3

Discuss the use of composites in today's society.
For example:

- 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 conductivity)
- The FRP industry (resin manufacturers, fiberglass manufacturers, fabrication machine makers, and fabrication shops).
- 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

Discuss the advantages and disadvantages of composites over other materials.
For example:

- Strength, stiffness, and weight (compare composite to steel and aluminum).
- Fatigue and crashworthiness (sudden versus progressive failure modes).

STRAND 3

Students will demonstrate familiarity with the basic materials used in the composites industry.

Standard 1

Compare fiberglass reinforced plastics (FRP) and advanced composites.
For example:

- 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.

- FRP sometimes uses random fiber orientation, whereas advanced composites fibers are carefully placed.
- The material properties of the individual components in advanced composites are typically higher.
- Fiberglass or natural fibers are used in FRP whereas carbon or other very strong and stiff fibers are typically used in advanced composites.

Standard 2

Define the differences between thermoset and thermoplastic resins.
For example:

- Thermoset resins
  - 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)
  - Polymerization (curing) is achieved by using an initiator to start the reaction, perhaps with some heat applied, while the resin and reinforcement are in a mold
  - May be 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 (polymerization or crosslinking) to occur
- Thermoplastic resins
  - May be formed to a desired shape by applying pressure (usually in a mold) when the resin is softened or melted
  - May be reshaped by re-softening or re-melting and by applying additional pressure.
  - Have a high melting temperature
  - Excellent for mass producing small parts (short cycle times)
  - May easily be recycled

Standard 3

Identify the reinforcement material forms that are available for use in composites.
For example:

- Roving
- Chopped strand
- Non-oriented strand mat
- Fabric (woven)
- Preforms (braids, knits, stitched)

Standard 3

Distinguish common bagging materials from composites.
For example:

- Release film or peel ply
- Compression mat (commonly referred to as “Monkey Fur”)

STRAND 4

Students will gain experience performing wet layup and vacuum bagging processes with advanced composites materials.

Standard 1

Discuss the manufacturing methods used with advanced composites.
For example:

- Wet layup/hand layup
- Compression molding
- Filament-winding
- Pultrusion

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

Use common manufacturing practices employed for composites and documentation.
For example:

- Read the resin label.
- Select the resin that meet the specifications.
- Select the reinforcement materials that meet the specifications.
- Control the reinforcement to resin ratio (fiber volume).
- Resin system components are mixed by weight, not volume.
- Understand the cure profile (heat cycle).
- 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 layups with and without bagging procedures.

- Discuss automated cutting (include nesting concept).
- Use accepted industry clean-room procedures.
- Discuss vacuum bagging (discuss all bagging materials, illustrate bag side and mold side, discuss use of caul plates or pressure pads).
- 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
- Wet layup with a vacuum bag.

STRAND 5

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.

- Investigate organizations who produce accepted testing standards.
- 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.
For example:

- Pin Gages
- Rulers
- Calipers

Standard 3

Evaluate the advantages and disadvantages of non-destructive testing versus destructive testing.

- Test coupons
- Costs of using actual parts

Standard 4

Conduct environmental testing and evaluate its application to composites.

- UV degradation

Standard 5

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

Performance Skills

1. Identify the basic materials used in the composites industry.
2. Demonstrate appropriate and safe composites fabrication while performing wet layup and vacuum bagging processes to industry standard.
3. Demonstrate practice of the *Technology & Engineering Professional Workplace Skills*. https://schools.utah.gov/cte/engineering/resources

4. Participate in a significant activity that provides each student with an opportunity to render service to others, employ leadership skills, or demonstrate skills they have learned through this course, preferably through participation in a Career & Technical Student Organization (CTSO) such as SkillsUSA.