

# **Composite Certification Competencies**

# **Characteristics of Composites**

- 1. Demonstrate knowledge of the characteristics of composite materials (SK2, TK2)
  - General characteristics of composites
  - Prepreg
  - Bulk modulus
  - Young's modulus
  - Poisson's ratio
  - Specific strength
  - Buckling
  - Delamination
  - Symmetry
  - Honeycomb
  - Monolithic cast materials
  - Advantage of composites over metal
  - Out-of-plane buckling
  - FRP
  - GRP
  - SMC: description, advantages/disadvantages
  - BMC
  - Fiber content
  - Role/advantage of foam core
  - Styrofoam
  - Urethane foam
  - Fillers
  - Flexure (beam theory)
  - Cross-sectional area and the effect on Young's modulus
  - Lightning protection
  - Metal vs. Prepreg unidirectional composite
- 2. Demonstrate knowledge of fibers and uses (SK2, TK2)
  - High strength fiberglass (S-glass)
  - Hollow glass (H-glass)
  - Graphite
  - For stiffness carbon fiber over aramid
  - For weight, aramid over carbon fiber
  - Kevlar 129
  - Weave styles
    - plain weave
    - twill
    - basket



- Fiber definition
- Bundle
- Carbon tow
- Roving
- Directional properties
- Use of thin fibers
- Advantage of short fibers
- High density polyethylene
- Hybrid
- Sizing on a fiber
- Braid count
- Warp degrees

#### 3. Demonstrate knowledge of a matrix (SK2, TK2)

- Polymer
- Thermoset
- Thermoplastic
- Matrix properties
- Exothermic reaction
- Polymer chains and glass transition temperature (Tg)
- Heating above Tg
- Cross-linking
- Hardener effect on cross-linking
- Gelation
- Matrix materials
- Fracture toughness
- PMC
- Cure durations
- Voids
- Ероху
  - Resin
  - Hardener
  - Initiator
- Polyester
- Vinyl Ester
- Catalyst
- Liquid-crystal polymers
- Viscoelasticity
- Thixotropic
- 4. Identify the characteristics of fiber/matrix interfaces (SK2, TK2)
  - Working resin into fibers
  - Fiber/matrix bond
  - Bonding agent



- Effect of moisture (water) on fiber/matrix
- Effect of high temperature on fiber/matrix
- Carbon-carbon double bonds
- Polymeric composite primary bonds
- Polymer hardness index
- Interlaminar shear stress
- Interphase
- Delamination
- Shear strength determination
- Synthesis
  - A-stage
  - B-stage
  - C-stage
  - Post cure

# **Fabrication Methods**

- 1. Demonstrate knowledge and characteristics of fabrication methods (SK3, TK3, TP3)
  - Isotropy
    - metals vs. composites
    - quasi-isotropic
    - anisotropic
  - Hand lay-up
  - Spray-up process
  - Chopped laminate
  - Applying gel coat
  - Blow molding
  - Injection molding
  - Drawing polymers
  - Compression molding
  - Voids
  - Chopper gun
  - Advantage of Inconel tooling
  - Carbon/epoxy tooling
- 2. Demonstrate knowledge of the methods of vacuum bagging (SK3, TK3, TP3)
  - Characteristics
  - Benefit of vacuum bagging
  - Disadvantage of not vacuum-bagging
  - Maintaining vacuum
  - Bagging film
  - Bleeder cloth
  - Breather



- Leak check
- Purpose of peel ply
- Reason for removing peel ply
- Woven peel ply
- Materials order
- 3. Demonstrate knowledge of resin transfer molding (SK3, TK3, TP3)
  - VARTM description
  - VARTM advantage
  - Components
  - Preforms
- 4. Demonstrate knowledge of sheet molding compound (SK3, TK3, TP3)
  - Compression molding
- 5. Demonstrate knowledge of release films (SK3, TK3, TP3)
  - Woven peel ply
  - Perforated peel ply
- 6. Demonstrate principles of operation of a Platen Press (SK3, TK2)
  - Principles
  - Part geometries
  - Temperature and pressure effects
- 7. Identify the characteristics of filament winding (SK3, TK2)
  - Components
  - Fiber wetting
  - Part geometries
- 8. Demonstrate knowledge of pultrusion methods (SK3, TK2)
  - Pultrusion description
  - Components
  - Lubrication
  - Part geometries
  - Gelation
  - Important considerations:
    - fiber alignment
    - pulling rate
    - typical defects
    - reason for thermosets
  - Extrusion description
- 9. Demonstrate knowledge of the use and characteristics of the autoclave process (SK3, TK2)
  - Primary danger
  - Effective peel ply
  - Bleeder cloth
  - Temperature effect on trapped air
  - Controlling gelation
  - Pressure plate



- Baffles
- Thermocouple use
- Nitrogen use

10. Differentiate characteristics of joining and bonding (SK3, TK2, TP2)

- Surface preparation
- Covalent bond
- Co-bonding
- Bondline porosity
- Mechanical interlocking
- Metal surface preparation
- Coupling agent
- Use of abrasives
- van der Waal bonds
- Joining PMC primary structures
- Blind or solid riveting concerns
- 11. Demonstrate knowledge and characteristics of cohesive bonding (SK3, TK2)
- 12. Identify proper methods of surface treatment (SK3, TK2, TP2)
  - Metal surface preparation
  - Purpose of using abrasives
  - Preparing lap joints
  - Advantage of surface treatment
  - Carbon fiber surface treatment

## 13. Identify and demonstrate knowledge of the types of fasteners (SK3, TK2, TP2)

- Advantage of press-fit composite insert
- Materials for temp. extremes and moisture changes
- Carbon/epoxy composite inserts
- Blind fasteners
- Configuration for greatest bearing strength
- Length considerations
- Prevention of pull-through
- Press-fit advantages/disadvantageous
- Potted-in advantages/disadvantageous
- Aluminum washers in CFP Installation concerns
- 14. Demonstrate knowledge of proper hole sizing (SK3, TK2, TP2)
  - Hole size:
    - vs. tangential stress of large parts under tension
    - very small drilled hole effects
- 15. Identify the correct methods for drilling holes (SK2, TK2)
  - Speeds and feeds
  - Drilled holes and stress intensity
  - Hole pitch
  - Typical defects



- Delamination
- Break-out
- Major concerns
  - water ingress
- Damage detection
- Avoiding cutting coolants (oil)
- 16. Identify the proper equipment required for fastener installation (SK3, TK2)
  - Non-conductive putty
  - Torque tools (controlling compression)
  - Fastener removal
- 17. Demonstrate knowledge of repair methods and tools (SK2, TK2, TP2)
  - Classification of damage
  - Matrix technology for repairs
  - Honeycomb repairs:
    - low temp thermosets in autoclaves
    - severe damage repair
  - Repair adhesive concerns
  - Temporary repairs
  - Bolted repairs
  - Compatible materials
  - Adhesive patch repair theory, advantages/disadvantages
  - Cosmetic repair
  - Use of heat blanket
  - Negative rake
  - Water jet cutting
  - Structural repair
  - Scarf (taper-sand) repair
  - Diamond-tooth saw
  - Tool cleanup

## **Testing, Inspection, & Repair**

- 1. Demonstrate knowledge and characteristics of non-destructive testing techniques (SK3, TK2)
  - NDE
  - Detecting damage (best method)
  - Visual
  - Acoustic (tap test)
  - Ultrasound
  - Ultrasound testing process
  - Ultrasound on SMC parts
  - C-scan
  - Thermography



- Laser shearography
- 2. Demonstrate knowledge and characteristics of destructive testing techniques (SK3,

TK2)

- Lap shears
- Fatigue testing
- Tensile test description and ply failure mode
- Tabs
- Brittle failure
- Peel test
- Compression testing
- Axial stiffness test
- Strain gage meas. for localized deformation/elong
- Surface roughness test
- Surface abrasion testing
- Four-point bending test
- Impact testing for BVID
- Vf testing (resin burnout test)

# Health & Safety

- 1. Demonstrate knowledge and understanding of MSDS forms (SK3, TK3, TP3)
  - MSDS first aid information
  - Most important safety information for a user
  - Where found
  - local firefighting unit information
  - chemical information
  - manufacturer's name

## 2. Demonstrate knowledge and understanding of personal safety (SK3, TK3, TP3)

- OSHA
- When PPE is required
- Ventilation
- Primary mechanism for ingression of unhealthy material
- Sensitizing agents
  - aromatic carbon rings in epoxies
  - most dangerous sensitizing agent
- Hazards of polyester resins
- Particulate inhalation
- Industrial dermatitis
- Handling MEK
- Carbon fibers in the eye
- Handling acetone
- Eyewash duration
- Cleaning epoxy hardener off the skin
- Contact lenses



- Cured composites handling injuries (carbon splinters)
- Acute and chronic exposure
- Long term exposure to carcinogens, i.e. MEK
- Primary concern for prolonged exposure to epoxy
- Acetone concerns
- Carbon fiber conductivity and explosion risk
- Aid to incapacitated co-workers
- 3. Identify various personal safety equipment (SK3, TK3, TP3)
  - Respirators
    - full face, particulate
  - Organic (charcoal-filtered) respirator
  - Gloves
    - Nitrile, leather
  - Tyvek coveralls
  - Safety glasses

#### 4. Demonstrate knowledge of the proper disposal of materials (SK3, TK3, TP3)

- Polyester vacuum bag disposal
- Liquid chemical waste (uncured composites)
- Recycling challenges



#### COMPOSITE CERTIFICATION COMPETENCIES

All areas to be tested are defined by the SpaceTEC<sup>®</sup> National Aerospace Technology Program Composite Student Performance Standards outlined on the following pages. These skill standards are further defined by a combination of the three proficiency code keys below to indicate the desired minimum level of knowledge and performance for each task.

PROFICIENCY CODE KEY		
SUBJECT	1	Can identify basic facts and terms about the subject. (FACTS)
KNOWLEDGE	2	Can identify relationship of basic facts and state general principles about the subject.
LEVELS		(PRINCIPLES)
SK	3	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	4	Can evaluate conditions and make proper decisions about the subject (EVALUATION)
TASK	1	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
KNOWLEDGE	2	Can determine step by step procedures for doing the task. (PROCEDURES)
LEVELS	3	Can identify why and when the task must be done and why each step is needed.
ТК		(OPERATING PROCEDURES)
	4	Can predict, isolate, and resolve problems about the task. (ADVANCED THEORY)
TASK	1	Can do parts of the task. Needs to be supervised doing most of the task. (LIMITED)
PERFORMANCE	2	Can do most of the task. Needs help only on hardest parts. (PARTIALLY PROFICIENT)
LEVELS	3	Can do all parts of task. Needs only a spot check of completed work. (COMPETENT)
ТР	4	Can do the complete task quickly and accurately. Can tell or show others how to do
		the task. (HIGHLY PROFICIENT)

**Examples:** Disposal of Materials. SK4, TK3, TP3. The student should be able to evaluate and make proper decisions about the proper disposal of materials. They should be able to identify why and when the disposal of materials must be done and why each step is needed. The student should be able to do all parts of the tasks and need only a spot check on completed work.

**Complete a repair project per drawing and specifications**. SK1, TK1, TP1 The student should identify basic facts and terms and name parts, tools and simple facts about the repair project. The student should be able to do simple parts of the repair and work with supervision on the repairs.