Sub-Module 03
AIRCRAFT MATERIALS — COMPOSITE AND NON-METALLIC

NON-METALLIC AIRCRAFT MATERIALS

TRANSPARENT PLASTICS

Transparent plastic materials used in aircraft canopies, windshields, windows and other similar transparent enclosures may be divided into two major classes or groups. These plastics are classified according to their reaction to heat. The two classes are: thermoplastic and thermosetting.

THERMOPLASTIC

Thermoplastic materials will soften when heated and harden when cooled. These materials can be heated until soft, and then formed into the desired shape. When cooled, they will retain this shape. The same piece of plastic can

THERMOSETTING

- Thermosetting plastics harden upon heating, and reheating has no softening effect.
- These plastics cannot be reshaped once being fully cured by the application of heat.

Laminated transparent plastics are made from transparent plastic face sheets bonded by an inner layer material, usually polyvinyl butyl. Because of its shatter resistant qualities, laminated plastic is superior to solid plastics and is used in many pressurized aircraft.

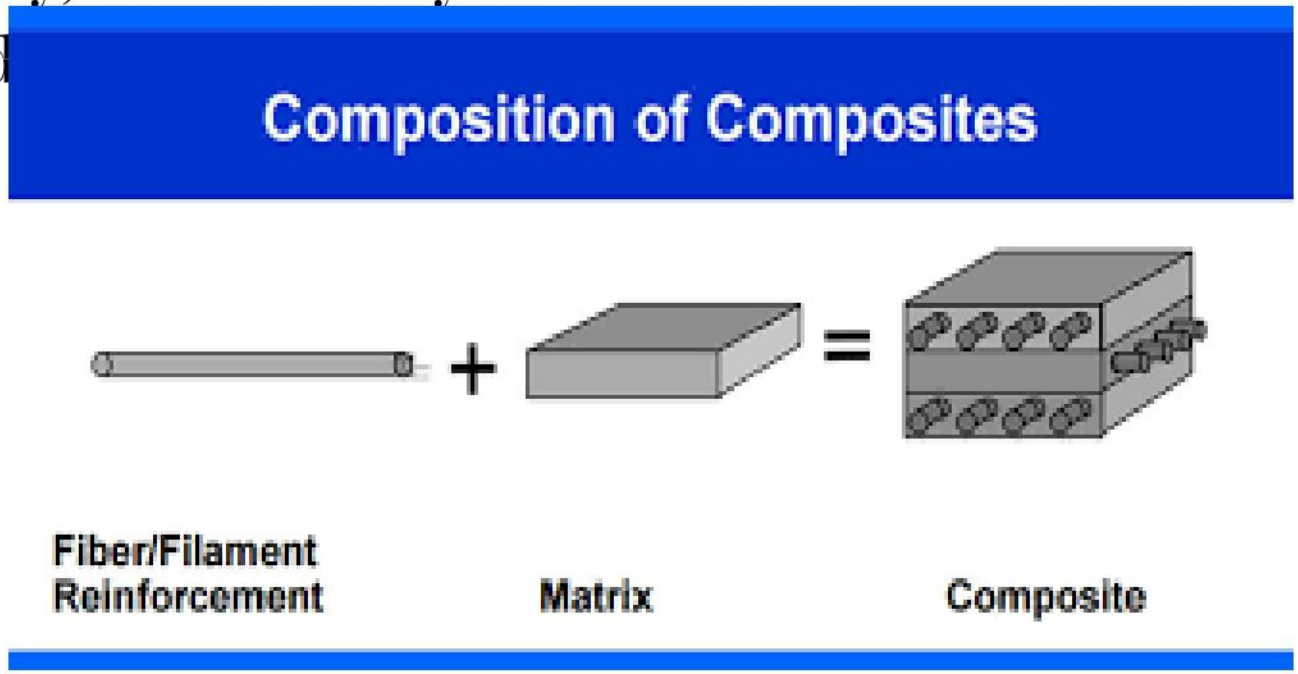
Individual sheets of plastic are covered with a heavy masking paper to which a pressure sensitive adhesive has been added. This paper helps to prevent accidental scratching during storage and handling. Be careful to avoid scratches and gouges which may be caused by

If possible, store sheets in bins which are tilted at approximately 10° from vertical. If they must be stored horizontally, piles should not be over 18 inches high, and small sheets should be stacked on the larger ones to avoid unsupported overhang. Store in a cool, dry place away from solvent fumes, heating coils, radiators, and steam pipes. The temperature in the storage room should not exceed 120 °F.

While direct sunlight does not harm acrylic plastic, it will cause drying and hardening of the masking adhesive, making removal of the paper difficult. If the paper will not roll off easily, place the sheet in an oven at 250 °F for 1 minute, maximum. The heat will soften the masking adhesive for easy removal of the paper.

COMPOSITE MATERIALS

A "composite" material is defined as a mixture of different materials or things. This definition is so general that it could refer to metal alloys made from several different metals to enhance the strength, ductility, conductivity or whatever characteristics are desired



ADVANTAGES OF COMPOSITES

- High strength to weight ratio
- Fiber-to-fiber transfer of stress allowed by chemical bonding
- Modulus (stiffness to density ratio) 3.5 to 5 times that of steel or aluminum
- Longer life than metals
- Higher corrosion resistance
- Tensile strength 4 to 6 times that of steel/aluminum
- Greater design flexibility
- Bonded construction eliminates joints and fasteners
- Easily repairable

DISADVANTAGES OF COMPOSITES

- Inspection methods difficult to conduct, especially delamination detection.
- Lack of long term design database, relatively new technology methods
- Cost
- Very expensive processing equipment
- Lack of standardized system of methodology
- Great variety of materials, processes, and techniques
- General lack of repair knowledge and expertise
- Products often toxic and hazardous
- Lack of standardized methodology for construction and repairs

FIBER REINFORCED MATERIALS

The purpose of reinforcement in reinforced materials is to provide most of the strength. The three main forms of fiber reinforcements are particles, whiskers, and fibers.

- **PARTICLES**

A particle is a square piece of material. Glass bubbles (Q-cell) are hollow glass spheres, and since their dimensions are equal on all axes, they are called a particle.

- **WHISKER**

A whisker is a piece of material that is longer than it is wide. Whiskers are usually single crystals. They are very strong and used to reinforce ceramics and metals.

- **FIBERS**

Fibers are single filaments that are much longer than they are wide. Fibers can be made of almost any material, and are not crystalline like whiskers. Fibers are the base for most composites. Fibers are smaller than the finest human hair and are normally woven into cloth-like materials.

LAMINATED STRUCTURES

- Composites can be made with or without an inner core of material.
- Laminated structure with a core center is called a sandwich structure.
- Laminate construction is strong and stiff, but heavy.
- The sandwich laminate is equal in strength, and its weight is much less.

Various types of cores for laminated structures include rigid foam, wood, metal, or the aerospace preference of honeycomb made from paper, Nomex, carbon, fiberglass or metal.

REINFORCED PLASTIC

- Reinforced plastic is a thermosetting material used in the manufacture of radomes, antenna covers, and wingtips, and as insulation for various pieces of electrical equipment and fuel cells.
- It has excellent dielectric characteristics which make it ideal for radomes.
- Reinforced plastic components of aircraft are formed of either solid laminates or sandwich-type laminates.

SOLID LAMINATES

Solid laminates are constructed of three or more layers of resin impregnated cloths "wet laminated" together to form a solid sheet facing or molded shape.

SANDWICH TYPES LAMINATES

- Sandwich-type laminates are constructed of two or more solid sheet facings or a molded shape enclosing a fiberglass honeycomb or foam-type core.
- Honeycomb cores are made of glass cloths impregnated with a polyester or a combination of nylon and phenolic resins.

RUBBER

Rubber is used to prevent the entrance of dirt, water, or air, and to prevent the loss of fluids, gases, or air. It is also used to absorb vibration, reduce noise, and cushion impact loads.

NATURAL RUBBER

- Natural rubber has flexibility, elasticity, tensile strength, tear strength, and low heat buildup due to flexing .
- Natural rubber is a general purpose product. it swells and often softens in all aircraft fuels and in many solvents (naphthas).
- Natural rubber deteriorates more rapidly than synthetic rubber.

SYNTHETIC RUBBER

Synthetic rubber, the most widely used are the butyls, Buna-S, and neoprene. Butyl is a hydrocarbon rubber with superior resistance to gas permeation. Butyl will resist oxygen, vegetable oils, animal fats, alkalies, ozone, and weathering.

➢ BUTYL

- Butyl will swell in petroleum or coal tar solvents.
- It has a low water absorption rate and good resistance to heat and low temperature.
- Depending on the grade, it is suitable for use in temperatures ranging from −65 °F to 300 °F.
- Butyl is used with phosphate ester hydraulic fluids (Skydrol), silicone fluids, gases, ketones, and acetones.

➢ BUNA-S

- Generally, Buna-S has poor resistance to gasoline, oil, concentrated acids, and solvents.
- Buna-S is normally used for tires and tubes as a substitute for natural rubber.

➢ BUNA- N

- Buna-N is outstanding in its resistance to hydrocarbons and other solvents; however, it has poor resilience in solvents at low temperature.
- Buna-N has fair tear, sunlight, and ozone resistance.
- It has good abrasion resistance and good breakaway properties when used in contact with metal.
- When used as a seal on a hydraulic piston, it will not stick to the cylinder wall.
- Buna-N is used for oil and gasoline hose, tank linings,

➢ NEOPRENE

- Neoprene has superior resistance to oil. Although it is good material for use in nonaromatic gasoline systems, it has poor resistance to aromatic gasolines.
- Neoprene is used primarily for weather seals, window channels, bumper pads, oil resistant hose, and carburetor diaphragms.
- It is also recommended for use with Freons™ and silicate ester lubricants.

➢ THIOKOL

- Thiokol, known also as polysulfide rubber, has the highest resistance to deterioration but ranks the lowest in physical properties.
- Thiokol is used for oil hose, tank linings for aromatic

➢ SILICONE RUBBERS

- Silicone rubbers are a group of plastic rubber materials made from silicon, oxygen, hydrogen, and carbon.
- The silicons have excellent heat stability and very low temperature flexibility.
- They are suitable for gaskets, seals, or other applications where elevated temperatures up to 600 °F are prevalent .
- Silastic, one of the best known silicones, is used to insulate electrical and electronic equipment.

SEALING COMPOUNDS

Certain areas of all aircraft are sealed to withstand pressurization by air, to prevent leakage of fuel, to prevent passage of fumes, or to prevent corrosion by sealing against the weather. Most sealants consist of two or more ingredients properly proportioned and compounded to obtain the best results.

➢ ONE-PART SEALANTS

One part sealants are prepared by the manufacturer and are ready for application as packaged.

➢ TWO PART SEALANTS

Two part sealants are compounds requiring separate packaging to prevent cure prior to application and are

LAMINATED STRUCTURES

Composite materials consist of a combination of materials that are mixed together to achieve specific structural properties.

Applications of composites on aircraft include:

- Fairings
- Flight control surfaces
- Landing gear doors
- Leading and trailing edge panels on the wing and stabilizer
- Interior components
- Floor beams and floor boards
- Vertical and horizontal stabilizer primary structure on large aircraft
- Primary wing and fuselage structure on new generation

FIBER ORIENTATION AND FABRIC STYLES

- **WARP**

The threads that run the length of the fabric are referred as warp. The warp direction is designated at 0°, in a woven application.

- **FILL**

A material is stronger in the direction than in the fill direction.

- **WEFT**

Weft threads are those that run perpendicular to the warp fibers. They are designated as 90° the weft or fill

➢ BIAS

The bias is at 45° angle to the warp threads. Fabric can be formed into contoured shapes by using the bias. Fabric can often be stretched along the bias.

➢ SELVAGE EDGE

A tightly woven edge produced by the weaver to prevent the edges from raveling is referred to as the selvage edge. It is parallel to the warp threads.