

MODULE 06

FOR B1 CERTIFICATION

MATERIALS AND HARDWARE

Aviation Maintenance Technician Certification Series



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WELCOME

The publishers of this Aviation Maintenance Technician Certification Series welcome you to the world of aviation maintenance. As you move towards EASA certification, you are required to gain suitable knowledge and experience in your chosen area. Qualification on basic subjects for each aircraft maintenance license category or subcategory is accomplished in accordance with the following matrix. Where applicable, subjects are indicated by an "X" in the column below the license heading.

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We wish you good luck and success in your studies and in your aviation career!

REVISION LOG

VERSION	EFFECTIVE DATE	DESCRIPTION OF CHANGE
001	2013 01	Module Creation and Release
002	2014 07	Format Update/Minor Corrections
003	2018 07	Modified sub-module sequence in accordance to Appendix A. Added content in the following areas: 6.3 – Thixotropic agents; Wood preservation methods; Types of fabric defects. 6.4 – Stress corrosion; Exfoliated corrosion detection; Galvanic corrosion growth; Fretting corrosion. 6.5 – Screw threads; Dowels. 6.6 – Rigid fluid line sizes; Swaged fittings. 6.7 – Laws obeyed by springs. 6.8 – Bearing material and construction. 6.11 – Connector types, Identification codes, and ratings.

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6.3.3 - AIRCRAFT FABRIC COVERINGS

GENERAL HISTORY

Fabric covered aircraft play an important role in the history of aviation. The famous Wright Flyer utilized a fabric covered wood frame in its design, and fabric covering continued to be used by many aircraft designers and builders during the early decades of production aircraft. The use of fabric covering on an aircraft offers one primary advantage: light weight. In contrast, fabric coverings have two disadvantages: flammability and lack of durability.

Finely woven organic fabrics, such as Irish linen and cotton, were the original fabrics used for covering airframes, but their tendency to sag left the aircraft structure exposed to the elements. To counter this problem, builders began coating the fabrics with oils and varnishes. In 1916, a mixture of cellulose dissolved in nitric acid, called nitrate dope, came into use as an aircraft fabric coating. Nitrate dope protected the fabric, adhered to it well, and tautened it over the airframe. It also gave the fabric a smooth, durable finish when dried. The major drawback to nitrate dope was its extreme flammability.

To address the flammability issue, aircraft designers tried a preparation of cellulose dissolved in butyric acid called butyrate dope. This mixture protected the fabric from dirt and moisture, but it did not adhere as well to the fabric as nitrate dope. Eventually, a system combining the two dope coatings was developed. First, the fabric was coated with nitrate dope for its adhesion and protective qualities. Then, subsequent coats of butyrate dope were added. Since the butyrate dope coatings reduced the overall flammability of the fabric covering, this system became the standard fabric treatment system.

The second problem, lack of durability, stems from the eventual deterioration of fabric from exposure to the elements that results in a limited service life. Although the mixture of nitrate dope and butyrate dope kept out dirt and water, solving some of the degradation issue, it did not address deterioration caused by Ultraviolet (UV) radiation from the sun. Ultraviolet radiation passed through the dope and degraded not only the fabric, but also the aircraft structure underneath. Attempts to paint the coated fabric proved unsuccessful, because

paint does not adhere well to nitrate dope. Eventually, aluminum solids were added to the butyrate coatings. This mixture reflected the sun's rays, prevented harmful UV rays from penetrating the dope, and protected the fabric, as well as the aircraft structure.

Regardless of treatments, organic fabrics have a limited lifespan; cotton or linen covering on an actively flown aircraft lasts only about 5–10 years. Furthermore, aircraft cotton has not been available for over 25 years. As the aviation industry developed more powerful engines and more aerodynamic aircraft structures, aluminum became the material of choice. Its use in engines, aircraft frames, and coverings revolutionized aviation. As a covering, aluminum protected the aircraft structure from the elements, was durable, and was not flammable.

Although aluminum and composite aircraft dominate modern aviation, advances in fabric coverings continue to be made because gliders, home built, and light sport aircraft, as well as some standard and utility certificated aircraft, are still produced with fabric coverings. (*Figure 3-130*) The nitrate/butyrate dope process works well, but does not mitigate the short lifespan of organic fabrics. It was not until the introduction of polyester fabric as an aircraft covering in the 1950's that the problem of the limited lifespan of fabric covering was solved. The transition to polyester fabric had some problems because the nitrate and butyrate dope coating process is not as suitable for polyester as it is for organic fabrics. Upon initial application of the dopes to polyester, good adhesion and protection occurred; as the dopes dried, they would eventually separate from the fabric. In other words, the fabric outlasted the coating.

Eventually, dope additives were developed that minimized the separation problem. For example, plasticizers keep the dried dope flexible and non-tautening dope formulas eliminate separation of the coatings from the fabric. Properly protected and coated, polyester lasts indefinitely and is stronger than cotton or linen. Today, polyester fabric coverings are the standard and use of cotton and linen on United States certificated aircraft has ceased. In fact, the long staple cotton from which grade-A cotton aircraft fabric is made is no longer produced in this country.



Figure 3-130. Examples of aircraft produced using fabric skin.

Recovering existing fabric aircraft is an accepted maintenance procedure. Not all aircraft covering systems include the use of dope coating processes. Modern aircraft covering systems that include the use of non-dope fabric treatments show no signs of deterioration even after decades of service. In this chapter, various fabrics and treatment systems are discussed, as well as basic covering techniques.

CHARACTERISTICS, PROPERTIES, AND TYPES OF FABRIC USED IN AIRPLANES

FABRIC TERMS

To facilitate the discussion of fabric coverings for aircraft, the following definitions are presented.

Figure 3-131 illustrates some of these items.

- Warp—the direction along the length of fabric.
- Fill or weave—the direction across the width of the fabric.
- Count—the number of threads per inch in warp or filling.
- Ply—the number of yarns making up a thread.
- Bias—a cut, fold, or seam made diagonally to the warp or fill threads.
- Pinked edge—an edge which has been cut by machine or special pinking shears in a continuous series of Vs to prevent raveling.

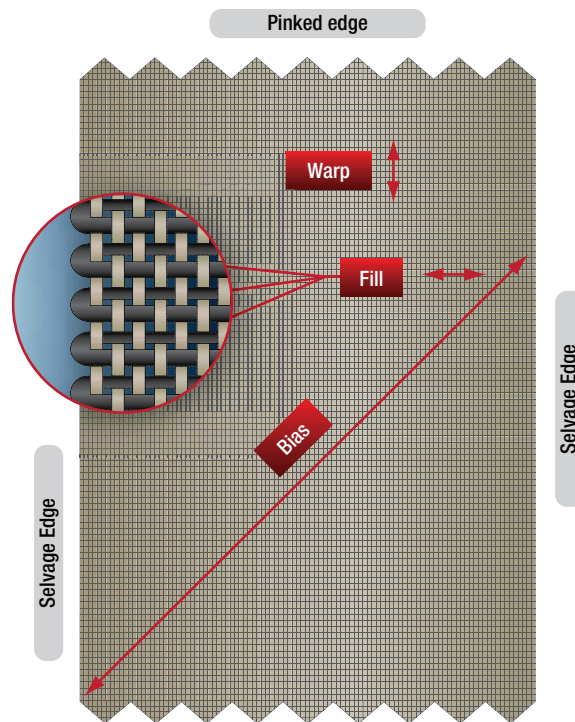


Figure 3-131. Aircraft fabric nomenclature.

- Selvage edge—the edge of cloth, tape, or webbing woven to prevent raveling.
- Greige—condition of polyester fabric upon completion of the production process before being heat shrunk.
- Cross coat—brushing or spraying where the second coat is applied 90° to the direction the first coat was applied. The two coats together make a single cross coat. (**Figure 3-132**)

APPROVED MATERIALS

There are a variety of approved materials used in aircraft fabric covering and repair processes. In order for the items to legally be used, the FAA must approve the fabric, tapes, threads, cords, glues, dopes, sealants, coatings, thinners, additives, fungicides, rejuvenators, and paints for the manufacturer, the holder of an STC, or a field approval.

Fabric

A Technical Standard Order (TSO) is a minimum performance standard issued by the FAA for specified materials, parts, processes, and appliances used on civil aircraft. For example, TSO-15d, Aircraft Fabric, Grade A, prescribes the minimum performance standards that approved aircraft fabric must meet. Fabric that meets or exceeds the TSO can be used as a covering. Fabric approved to replace Grade-A cotton, such as polyester,

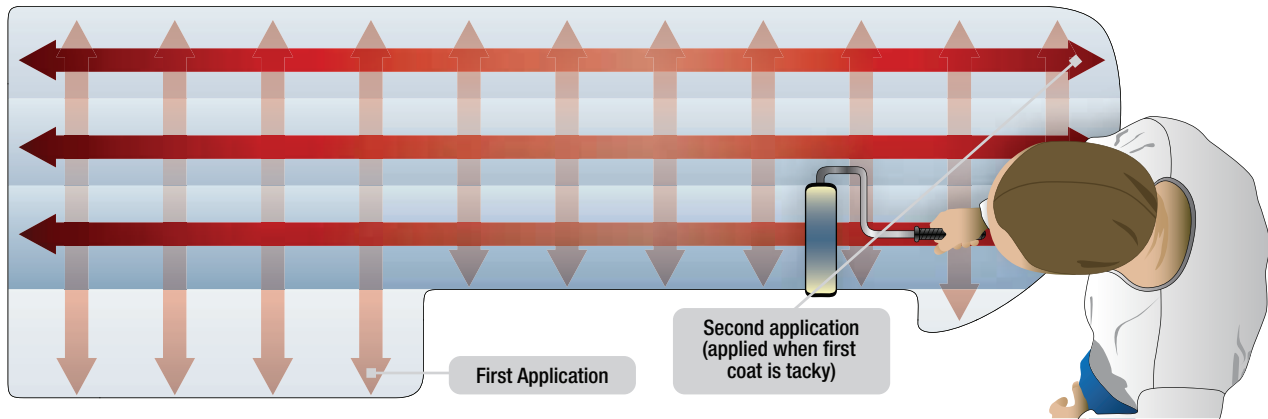


Figure 3-132. A single cross coat is made up of two coats of paint applied 90° to each other.

must meet the same criteria. TSO-15d also refers to another document, Society of Automotive Engineers (SAE) Aerospace Material Specification (AMS) 3806D, which details properties a fabric must contain to be an approved fabric for airplane cloth. Lighter weight fabrics typically adhere to the specifications in TSO-C14b, which refers to SAE AMS 3804C.

When a company is approved to manufacture or sell an approved aviation fabric, it applies for and receives a Parts Manufacturer Approval (PMA). Currently, only a few approved fabrics are used for aircraft coverings, such as the polyester fabrics Ceconite™, Stits/Polyfiber™, and Superflite™. These fabrics and some of their characteristics are shown in *Figure 3-133*.

The holders of the Parts Manufacturer Approval (PMA) for these fabrics have also developed and gained approval for the various tapes, chords, threads, and liquids that are used in the covering process. These approved materials, along with the procedures for using them, constitute the STCs for each particular fabric covering process. Only the approved materials can be used. Substitution of other materials is forbidden and results in the aircraft being unairworthy.

Anti-Chafe Tape

Anti-chafe tape is used on sharp protrusions, rib caps, metal seams, and other areas to provide a smoother surface to keep the fabric from being torn. It is usually self-adhesive cloth tape and is applied after the aircraft is cleaned, inspected, and primed, but before the fabric is installed.

Reinforcing Tape

Reinforcing tape is most commonly used on rib caps after the fabric covering is installed to protect and strengthen the area for attaching the fabric to the ribs.

Rib Bracing

Rib bracing tape is used on wing ribs before the fabric is installed. It is applied spanwise and alternately wrapped around a top rib cap and then a bottom rib cap progressing from rib to rib until all are braced. (*Figure 3-134*) Lacing the ribs in this manner holds them in the proper place and alignment during the covering process.

Surface Tape

Surface tape, made of polyester material and often preshrunk, is obtained from the STC holder. This tape, also known as finishing tape, is applied after the fabric is installed. It is used over seams, ribs, patches, and edges. Surface tape can have straight or pinked edges and comes in various widths. For curved surfaces, bias cut tape is available, which allows the tape to be shaped around a radius.

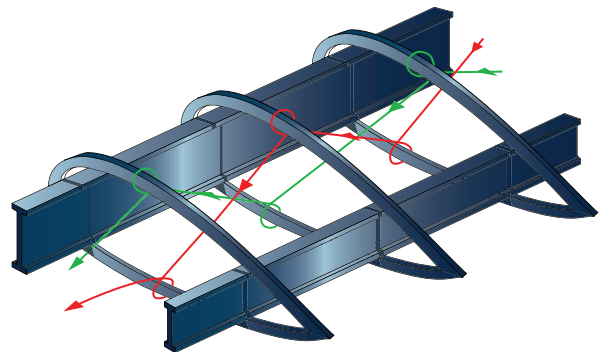


Figure 3-134. Inter-rib bracing holds the ribs in place during the covering process.

Aircraft Fabrics					
Fabric Name or Type	Weight (oz/sq yd)	Count (warp x fill)	New Breaking Strength (lb) (warp, fill)	Minimum Deteriorated Breaking Strength	TSO
Ceconite™ 101	3.5	69 x 63	125,116	70% of original specified fabric	C-15d
Ceconite™ 102	3.16	60 x 60	106,113	70% of original specified fabric	C-15d
Polyfiber™ Heavy Duty-3	3.5	69 x 63	125,116	70% of original specified fabric	C-15d
Polyfiber™ Medium-3	3.16	60 x 60	106,113	70% of original specified fabric	C-15d
Polyfiber™ Uncertified Light	1.87	90 x 76	66,72	uncertified	
Superflight™ SF 101	3.7	70 x 51	80,130	70% of original specified fabric	C-15d
Superflight™ SF 102	2.7	72 x 64	90,90	70% of original specified fabric	C-15d
Superflight™ SF 104	1.8	94 x 91	75,55	uncertified	
Grade A Cotton	4.5	80 x 84	80,80	56 lb/in (70% of New)	C-15d

Figure 3-133. Approved fabrics for covering aircraft.

Rib Lacing Cord

Rib lacing cord is used to lace the fabric to the wing ribs. It must be strong and applied as directed to safely transfer in-flight loads from the fabric to the ribs. Rib lacing cord is available in a round or flat cross section. The round cord is easier to use than the flat lacing, but if installed properly, the flat lacing results in a smoother finish over the ribs.

Sewing Thread

Sewing of polyester fabric is rare and mostly limited to the creation of prefitted envelopes used in the envelope method covering process. When a fabric seam must be made with no structure underneath it, a sewn seam could be used. Polyester threads of various specifications are used on polyester fabric. Different thread is specified for hand versus machine sewing. For hand sewing, the thread is typically a three ply, uncoated polyester with a 15 pound tensile strength. Machine thread is typically four-ply polyester with a 10 pound tensile strength.

Special Fabric Fasteners

Each fabric covering job involves a method of attaching the fabric to wing and empennage ribs. The original manufacturer's method of fastening should be used. In addition to lacing the fabric to the ribs with approved rib lacing cord, special clips, screws, and rivets are employed on some aircraft. (*Figure 3-135*) The first step in using any of these fasteners is to inspect the holes into which

they fit. Worn holes may have to be enlarged or re-drilled according to the manufacturer's instructions. Use of approved fasteners is mandatory. Use of unapproved fasteners can render the covering job unairworthy if substituted. Screws and rivets often incorporate the use of a plastic or aluminum washer. All fasteners and rib lacing are covered with finishing tape once installed to provide a smooth finish and airflow.

Grommets

Grommets are used to create reinforced drain holes in the aircraft fabric. Usually made of aluminum or plastic, they are glued or doped into place on the fabric surface. Once secured, a hole is created in the fabric through the center of the grommet. Often, this is done with a hot soldering pencil that also heat seals the fabric edge to prevent raveling. Seaplane grommets have a shield over the drain hole to prevent splashed water from entering the interior of the covered structure and to assist in siphoning out any water from within. (*Figure 3-136*) Drain holes using these grommets must be made before the grommets are put in place. Note that some drain holes do not require grommets if they are made through two layers of fabric.

Inspection Rings

The structure underneath an aircraft covering must be inspected periodically. To facilitate this in fabric covered aircraft, inspection rings are glued or doped

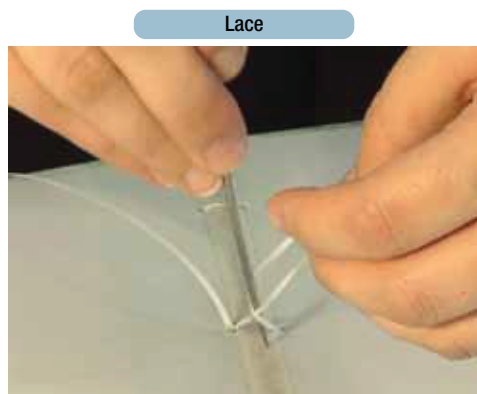
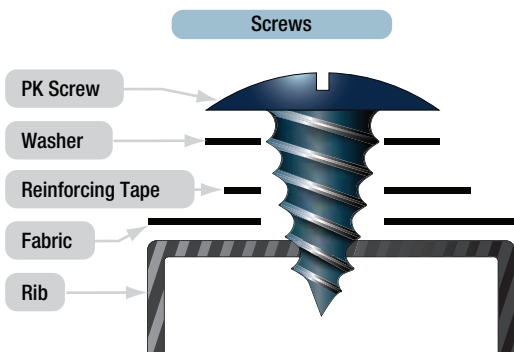
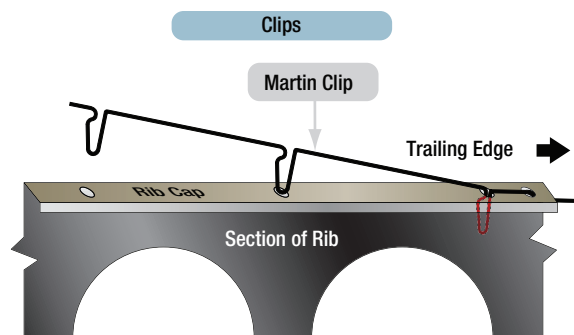


Figure 3-135. Clips, screws, rivets, or lace are used to attach the fabric to wing and empennage ribs.

to the fabric. They provide a stable rim around an area of fabric that can be cut to allow viewing of the structure underneath. The fabric remains uncut until an inspection is desired. The rings are typically plastic

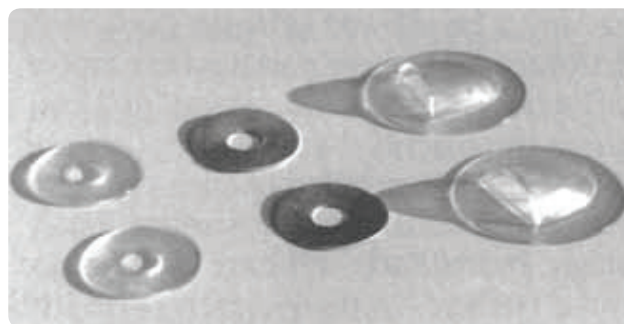


Figure 3-136. Plastic, aluminum, and seaplane grommets are used to reinforce drain holes in the fabric covering.

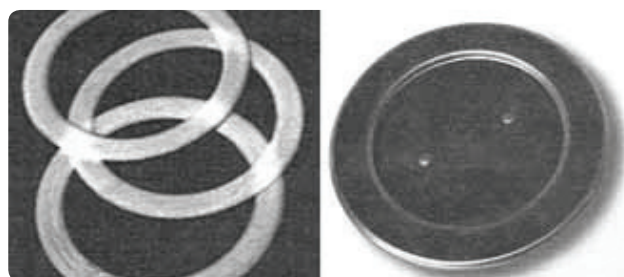


Figure 3-137. Inspection rings and an inspection cover.

or aluminum with an approximately three inch inside diameter. Spring clip metal panel covers can be fitted to close the area once the fabric inside the inspection ring has been cut for access. (*Figure 3-137*)

The location of the inspection rings are specified by the manufacturer. Additional rings are sometimes added to permit access to important areas that may not have been fitted originally with inspection access.

Primer

The airframe structure of a fabric covered aircraft must be cleaned, inspected, and prepared before the fabric covering process begins. The final preparation procedure involves priming the structure with a treatment that works with the adhesive and first coats of fabric sealant that are to be utilized. Each STC specifies which primers, or if a wood structure, which varnishes are suitable. Most often, two part epoxy primers are used on metal structure and two part epoxy varnishes are used on wood structure. Utilize the primer specified by the manufacturer's or STC's instructions.

Fabric Cement

Modern fabric covering systems utilize special fabric cement to attach the fabric to the airframe. There are various types of cement. (*Figure 3-138*)

Aircraft Covering Systems							
APPROVED PROPRIETARY PRODUCT NAME							
Covering System	STC #	Allowable Fabrics	Base	Cement	Filler	UV Block	Topcoats
Air-Tech	SA7965SW	Ceconite™	Urethane	UA-55	PFU 1020	PFU 1020	CHSM Color Coat
		Poly-Fiber™			PFU 1030	PFU 1030	
		Superflite™					
			Water		PFUW 1050	PFUW 1050	
Ceconite™/ Randolph System	SA4503NM	Ceconite™	Dope	New Super Seam	Nitrate Dope	Rand-O-Fill	Colored Butyrate Dope
							Ranthane
							Polyurethane
Stits/Poly-Fiber™	SA1008WE	Poly-Fiber™	Vinyl	Poly-tak	Poly-brush	Poly-spray	Vinyl Poly-tone, Aero-Thane, or Ranthane
							Polyurethane
Stewart System	SA01734SE	Ceconite™	Water-borne	EkoBond	EkoFill	EkoFill	EkoPoly
		Poly-Fiber™					
Superflite™ • System I • System VI	SA00478CH and others	Superflite™	Dope	U-500	Dacproofer	SrayFil	Tinted Butyrate Dope
		101,102					
		Superflite™	Urethane	U-500	SF6500	SF6500	Superflite™ CAB
		101,102					

Figure 3-138. Current FAA-approved fabric covering processes.

In addition to good adhesion qualities, flexibility, and long life, fabric cements must be compatible with the primer and the fabric sealer that are applied before and after the cement.

Fabric Sealer

Fabric sealer surrounds the fibers in the fabric with a protective coating to provide adhesion and keep out dirt and moisture. The sealer is the first coat applied to the polyester fabric after it is attached to the airframe and heat shrunk to fit snugly. Dope based fabric coating systems utilize non-tautening nitrate dope as the primary fabric sealant. The application of tautening dope may cause the fabric to become too taut resulting in excess stress on the airframe that could damage it. Non-dope coating systems use proprietary sealers that are also non-tautening. (*Figure 3-138*)

Fillers

After the fabric sealer is applied, a filler is used. It is sprayed on in a number of cross coats as required by the manufacturer or the fabric covering process STC. The filler contains solids or chemicals that are included

to block UV light from reaching the fabric. Proper fill coating is critical because UV light is the single most destructive element that causes polyester fabric to deteriorate. Dope based processes use butyrate dope fillers while other processes have their own proprietary formulas. When fillers and sealers are combined, they are known as fabric primers. Aluminum pastes and powders, formerly added to butyrate dope to provide the UV protection, have been replaced by premixed formulas.

Topcoats

Once the aircraft fabric has been installed, sealed, and fill coat protected, finishing or topcoats are applied to give the aircraft its final appearance. Colored butyrate dope is common in dope based processes, but various polyurethane topcoats are also available. It is important to use the topcoat products and procedures specified in the applicable STC to complete an airworthy fabric recovering job.

The use of various additives is common at different stages when utilizing the above products. The following is a short list of additional products that facilitate the

proper application of the fabric coatings. Note again that only products approved under a particular STC can be used. Substitution of similar products, even though they perform the same basic function, is not allowed.

- A catalysts accelerates a chemical reaction. Catalysts are specifically designed for each product with which they are mixed. They are commonly used with epoxies and polyurethanes.
- A thinner is a solvent or mixture of solvents added to a product to give it the proper consistency for application, such as when spraying or brushing.
- A retarder is added to a product to slow drying time. Used mostly in dope processes and topcoats, a retarder allow more time for a sprayed coating to flow and level, resulting in a deeper, glossier finish. It is used when the working temperature is elevated slightly above the ideal temperature for a product. It also can be used to prevent blushing of a dope finish when high humidity conditions exist.
- An accelerators contains solvents that speed up the drying time of the product with which it is mixed. It is typically used when the application working temperature is below that of the ideal working temperature. It can also be used for faster drying when airborne contaminants threaten a coating finish.
- Rejuvenator, used on dope finishes only, contains solvents that soften coatings and allow them to flow slightly. Rejuvenator also contains fresh plasticizers that mix into the original coatings. This increases the overall flexibility and life of the coatings.
- Fungicide and mildewicide additives are important for organic fabric covered aircraft because fabrics, such as cotton and linen, are hosts for fungus and mildew. Since fungus and mildew are not concerns when using polyester fabric, these additives are not required. Modern coating formulas contain premixed anti-fungal agents, providing sufficient insurance against the problem of fungus or mildew.

AVAILABLE COVERING PROCESSES

The covering processes that utilize polyester fabric are the primary focus of this chapter. The approved aircraft covering processes are listed in **Figure 3-138**. The processes can be distinguished by the chemical nature of the glue and coatings that are used. A dope-based covering process has been refined out of the cotton fabric era, with excellent results on polyester fabric. In particular, plasticizers added to the nitrate dope and

butyrate dopes minimize the shrinking and tautening effects of the dope, establish flexibility, and allow esthetically pleasing tinted butyrate dope finishes that last indefinitely.

Durable polyurethane based processes integrate well with durable polyurethane topcoat finishes. Vinyl is the key ingredient in the popular Poly Fiber covering system. Air Tech uses an acetone thinned polyurethane compatible system.

The most recent entry into the covering systems market is the Stewart Finishing System that uses waterborne technology to apply polyurethane coatings to the fabric. The glue used in the system is water based and nonvolatile. The Stewart Finishing System is Environmental Protection Agency (EPA) compliant and STC approved. Both the Stewart and Air Tech systems operate with any of the approved polyester fabrics as stated in their covering system STCs.

All the modern fabric covering systems listed in **Figure 3-138** result in a polyester fabric covered aircraft with an indefinite service life. Individual preferences exist for working with the different approved processes. A description of basic covering procedures and techniques common to most of these systems follows later in this chapter.

Ceconite™, Polyfiber™, and Superflight™ are STC approved fabrics with processes used to install polyester fabric coverings. Two companies that do not manufacturer their own fabric have gained STC approval for covering accessories and procedures to be used with these approved fabrics. The STCs specify the fabrics and the proprietary materials that are required to legally complete the re-covering job.

The aircraft fabric covering process is a three step process. First, select an approved fabric. Second, follow the applicable STC steps to attach the fabric to the airframe and to protect it from the elements. Third, apply the approved topcoat to give the aircraft its color scheme and final appearance. Although Grade-A cotton can be used on all aircraft originally certificated to be covered with this material, approved aircraft cotton fabric is no longer available. Additionally, due to the shortcomings of cotton fabric coverings, most of these aircraft have been re-covered with polyester fabric.