Abdulla Aljunibi

WOODEN STRUCTURES

Part of the reason was the slow development of strong, lightweight, metal aircraft structures and the lack of suitable corrosion resistant materials for all metal aircraft

WOOD AIRCRAFT CONSTRUCTION AND REPAIRS

Be sure to follow all manufacturer's instructions

inspect wood structures and recognize defects: the defects;

- dry rot
- compression failures

CHARACTERISTICS, PROPERTIES AND TYPES OF WOOD AND GLUE IN AIRPLANES

SUITABLE WOOD

Several forms of wood are commonly used in aircraft:

1, Solid wood: with such nouns as "beam" or "spar" refers to a member consisting of one piece of wood.

2, Laminated wood:

- is an assembly of two or more layers of wood that have been glued together
- the grain of all layers or laminations approximately parallel

3, Plywood:

- an assembled product of wood and glue
- that is usually made of an odd number of thin plies with ;
- the grain of each layer placed 90° with the adjacent ply or plies

4, High-density material: includes

- compreg, impreg, or similar commercially made products, heat stabilized wood, or any of the hardwood plywoods
- commonly used as bearing or reinforcement plates.

Species of Wood	Strength Properties (as compared to spruce)	Maximum Permissible Grain Deviation (slope of grain)	Remarks
1	2	3	4
Spruce (Picea) Sitka (P. sitchensis) Red (P. rubra) White (P. glauca)	100%	1.15	Excellent for all uses. Considered standard for this table.
Douglas fir (Pseudotsuga taxifolia)	Exceeds spruce	1.15	May be used as substitute for spruce in same sizes or in slightly reduced sizes if reductions are substantiated. Difficult to work with hand tools. Some tendency to split and splinter during fabrication and much greater care in manufacture is necessary. Large solid pieces should be avoided due to inspection difficulties. Satisfactory for gluing.
Noble fir (Abies procera, also known as Abies nobilis)	Slightly exceeds spruce except 8% deficient in shear	1.15	Satisfactory characteristics of workability, warping, and splitting. May be used as direct substitute for spruce in same sizes if shear does not become critical. Hardness somewhat less than spruce. Satisfactory for gluing.
Western hemlock (Tsuga heterophylla)	Slightly exceeds spruce	1.15	Less uniform in texture than spruce. May be used as direct substitute for spruce. Upland growth superior to lowland growth. Satisfactory for gluing.
Northern white pine, also known as Eastern white pine (Pinus strobus)	Properties between 85% and 96% those of spruce	1.15	Excellent working qualities and uniform in properties, but somewhat low in hardness and shock-resistance. Cannot be used as substitute for spruce without increase in sizes to compensate for lesser strength. Satisfactory for gluing.
Port Orford white cedar (Chamaecyparis lawsoniana)	Exceeds spruce	1.15	May be used as substitute for spruce in same sizes or in slightly reduced sizes if reductions are substantiated. Easy to work with hand tools. Gluing is difficult, but satisfactory joints can be obtained if suitable precautions are taken.
Yellow poplar (Liriodendron tulipifera)	Slightly less than spruce except in compression (crushing) and shear	1.15	Excellent working qualities. Should not be used as a direct substitute for spruce without carefully accounting for slightly reduced strength properties. Somewhat low in shock-resistance. Satisfactory for gluing.

The various species of wood listed in Figure 3-97 are acceptable for structural purposes when used for the repair of aircraft.

- Spruce is the preferred choice
- lists the strength and characteristics of the wood in comparison to spruce.
- The one item common to all the species is that the slope of the grain cannot be steeper than 1:15.
- All solid wood and plywood used for the construction and repair of aircraft should be of : the highest quality and grade.

For certificated aircraft:

- the wood should have traceability to a source that can provide certification to a Military Specification (MIL-SPEC)

wood cannot be purchased from a local lumber company.

- To purchase the material, contact one of the specialty aircraft supply companies and request a certification document with the order.

The MIL-SPEC for some type of wood:

- solid spruce is : MIL-S-6073
- plywood is MIL-P-6070B

Parts Manufacturer Approval (PMA):

- fabricated wood components should be purchased from the aircraft manufacturer, or someone who may have a PMA

To help determine the suitability of the wood:

- inspect it for defects that would make it unsuitable material to repair or construct an aircraft. :
- type,
- location,
- amount or size of the defects grade the wood for possible use

All woods used for structural repair of aircraft are classified as : softwood.

Softwood:

- typically used for construction
- graded based on strength, load carrying ability, and safety

Hardwoods:

- typically appearance woods
- graded based on the number and size of clear cuttings from the tree.

Defects Permitted:

1, Cross grain
2, Wavy, curly, and interlocked grain
3, Hard knots
4, Pin knot clusters
5, Pitch pockets
6, Mineral streaks

Defects Not Permitted:

1. Cross grain
2. Wavy, curly, and interlocked grain
3. Hard knots
4. Pin knot clusters
5. Spike knots
6. Pitch pockets
7. Mineral streaks
1. Checks, shakes, and splits
2. Compression
3. Compression failures
4. Tension
5. Decay

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Must read

GLUES ADHESIVES

adhesives play a critical role in the bonding of aircraft structure

mechanic must employ only those types of adhesives that meet all of the performance requirements

The product must be used strictly in accordance with: the manufacturer manual (follow the rules very strictly)

All instructions must be followed exactly, including the

- mixing ratios
- the ambient and surface temperatures
- the open and closed assembly times
- the gap filling ability or glue line thickness,
- the spread of the adhesive
- whether one or two surfaces
- and the amount of clamping pressure and time required for full cure of the adhesive.

Refer to the aircraft maintenance or repair manual for specific instructions on acceptable adhesive selection for use on that type aircraft.

Adhesives meeting the requirements of a

- MILSPEC
- Aerospace Material Specification (AMS),
- Technical Standard Order (TSO) for wooden aircraft structures are satisfactory

The product must be used strictly in accordance with: the manufacturer manual (follow the rules very strictly)

Some of the more common adhesives that have been used in aircraft construction and repair include :

- casein glue
- plastic resin glue
- resorcinol glue
- epoxy adhesives

1, Casein glue Not good

- should be considered obsolete for all aircraft repairs.
- adhesive deteriorates when exposed to: moisture and temperature variations in a normal operating environment

2, Plastic resin glue: also known as a urea-formaldehyde adhesive, Not good

- plastic resin glue should be considered obsolete for all aircraft repairs
- it will fail because of normal environment

3, Resorcinol glue: or resorcinol-formaldehyde glue Good

- immediately found wide application in the wood
- has better wet weather and Ultraviolet (UV) resistance than other adhesives
- This glue meets all strength and durability requirements if the fit of the joint and proper clamping pressure results in a very thin and uniform bond line.

4, Epoxy adhesive Not recommended only in some cases accessible

- is a two-part synthetic resin product that depends less on joint quality and clamping pressure.
- not recommended for structural aircraft bonding unless they meet the acceptable standards.

Definition of Terms Used in the Glue Process

1, Close contact adhesive:

- a non-gap-filling adhesive
- This adhesive is suitable for joints where surfaces can be pressed together tightly, leaving a glue line with a maximum 0.005-inch gap.

2, Gap-filling adhesive:

- suitable for use in those joints in which the surfaces to be joined may not be close or in continuous contact

3, Glue line

- resultant layer of adhesive joining any two adjacent wood layers in the assembly

4, Single spread:

- spread of adhesive to one surface only.

5, Double spread:

- adhesive to both surfaces and equally divided between the two surfaces to be joined.

6, Open assembly time:

- period of time between the application of the adhesive and the assembly of the joint components.

7, Closed assembly time:

- time elapsing between the assembly of the joints and the application of pressure.

8, Pressing or clamping time:

- time—time during which the components are pressed tightly together under recommended pressure
- until the adhesive cures (may vary from 10 to 150 pounds per square inch (psi)

9, Caul:

- clamping device

10, Adhesive pot life:

- time elapsed from the mixing of the adhesive components until the mixture must be discarded,
- once expired, the adhesive must not be used

Preparation of Wood for Gluing

These conditions required:

1, Proper and equal moisture content of wood to be joined (8 to 12 percent).

2, Properly prepared wood surfaces that are machined or planed, and not sanded or sawed.

3, Selection of the proper adhesive for the intended task,

4, The application of good gluing techniques

5, Performing the gluing operation under the recommended temperature conditions

Preparing Glues for Use

- The manufacturer's directions should be followed for the preparation of any glue or adhesive

Unless otherwise specified by the glue manufacturer:

- clear, cool water should be used with glues that require mixing with water

The recommended proportions of glue, catalyst, and water or other solvent should be determined by the : weight of each component

Mixing can be either by :

- hand
- machine

Whatever method is used:

the glue should be thoroughly mixed and free of air bubbles, foam, and lumps of insoluble material

Applying the Glue/Adhesive

The adhesive can be applied with a

- brush
- glue spreader
- grooved rubber roller

Follow manufacturer instructions for satisfactory results.

Be careful to ensure the

- surfaces make good contact
- the joint is positioned correctly before applying the adhesive.

Keep open assembly time as short as possible

do not :

- exceed the recommended times indicated in the product data sheet.

Pressure on the Joint

To ensure the maximum strength of the bonded surfaces:

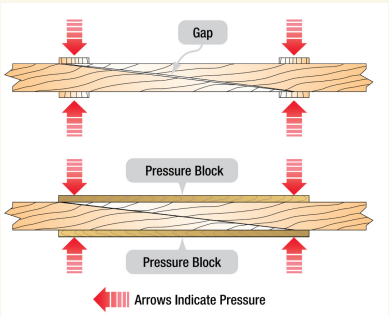
- apply even force to the joint

Non-uniform gluing pressure commonly results in :

- weak areas and strong areas in the same joint.

Use pressure to:

- squeeze the glue out into a thin continuous film between the wood layers
- force air out from the joint
- bring the wood surfaces into intimate contact with the glue
- hold them in this position during the setting of the glue



Other methods used to apply pressure to joints in aircraft gluing operations range from the use of:

- brads
- nails
- screws
- use of electric and hydraulic power presses

The amount of pressure required to produce strong joints in aircraft assembly operations may vary from:

- 10 to 150 psi for softwoods
- high as 200 psi for hardwoods.

All gluing operations should be performed above :

- 21°C for proper performance of the adhesive

Higher temperatures :

- shorten the assembly times
- as does coating the pieces of wood with glue and exposing openly to the air

Testing Glued Joints

Satisfactory glue joints in aircraft should :

- develop the full strength of the wood under all conditions of stress.

Tests should be made by the :

- mechanic prior to gluing a joint of a major repair

Whenever possible, perform tests using:

- pieces cut from the actual wood
- used for the repair under the same mechanical and environmental conditions that the repair will undergo

After full cure: place the test sample in a bench vise and break the joint by exerting pressure on the overlapping member

The fractured glue faces should show a high percentage of at least 75 percent of the wood fibers evenly distributed over the fractured glue surface.

PRESERVATION AND MAINTENANCE OF WOOD FRAME STRUCTURES

WOOD PRESERVATION:

Wood preservatives must possess the following qualities:

- They must be toxic to fungi, pests, and marine organisms.
- They must be free from objectionable properties in use and handling.
- They must possess satisfactory properties permanence under the conditions for which they are recommended.
- They should not have corrosive properties.

CARE AND MAINTENANCE OF WOOD FRAME STRUCTURES:

Wood structures must be kept clean by

- wiping occasionally with a soft and slightly dampened cloth
- and then wiped dry with a clean soft cloth

good quality furniture spray (such as Endust) is then rubbed into the structure with a soft cloth.

DEFECTS AND INSPECTION IN WOOD STRUCTURES

To properly inspect an aircraft :

- aircraft must be dry
- should be placed in a dry, well ventilated hanger
- Wet, or even damp, wood causes swelling and makes it difficult to make a proper determination of the condition of the glue joints

If there is any doubt that the wood is dry :

- a moisture meter is used to verify the percentage of moisture in the structure

Non-destructive meters are: available that check moisture without making holes in the surface.

The ideal range is 8–12 percent, with any reading over 20 percent providing an environment for the growth of fungus in the wood.

EXTERNAL AND INTERNAL INSPECTION

inspection should begin with: external surface of the aircraft
This provides a general overall condition of the wood and structure.

The wings, fuselage, and empennage should be inspected for:

- undulation
- warping
- or any other disparity from the original shape

Where light structures using single plywood covering are concerned, some slight sectional undulation or bulging between panels may be permissible if the wood and glue are sound.

GLUED JOINT INSPECTION

The inspection of glued joints in wooden aircraft structures presents:

- considerable difficulties

Even where access to the joint exists:

- it is still difficult to positively assess the integrity of the joint

Some common factors in premature glue deterioration include:

- Chemical reactions of the glue caused by aging or moisture, extreme temperatures, or a combination of these factors

- Mechanical forces caused mainly by wood shrinkage,and Development of fungal growths

exposed to large cyclic changes of temperature and humidity are especially prone to wood:

- shrinkage that may lead to glue joint deterioration

When checking a glue line:

- all protective coatings of paint should be removed by : careful scraping
- It is important to ensure that : the wood is not damaged during the scraping operation
- Scraping should stop immediately when : the wood is revealed in its natural state and the glue line is clearly discernible
- At this point, it is important that the surrounding wood: is dry
- otherwise, you will get a false indication of the integrity of the glue line due to swelling of the wood and subsequent closing of the joint.
- Inspect the glue line using a : magnifying glass
- if the presence of glue cannot be detected or is suspect: check the glue line with a thin feeler gauge.
- If any penetration is observed, the joint is : defective.
- The structure usually dictates the feeler gauge thickness, but use the thinnest feeler gauge whenever possible.
-

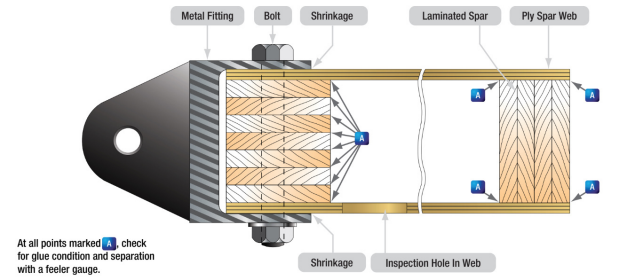


Figure 3-106. Inspection points for laminated glue joints.

- glued joint may fail in service as a result of an :

- accident

or

- because of excessive mechanical loads having been imposed upon it.

Glued joints are generally designed to take : shear loads.

If a joint is expected to take tension loads:

- it is secured by a number of

1, bolts

2, screws

- in the area of tension loading

In all cases of glued joint failure:
whatever the direction of loading, there should ;

- be a fine layer of wood fibers adhering to the glue.
- The presence of fibers usually indicates that the : joint itself is not at fault

- Examination of the glue under magnification that does not reveal any wood fibers

but

- shows an imprint of the wood grain, indicates that the cause of the failure was:

the predrying of the glue before applying pressure during the manufacture of the joint.

If the glue exhibits an irregular appearance with star-shaped patterns, this is an indication:

- precuring of the glue occurred before pressure was applied

or

- that pressure had been incorrectly applied or maintained on the joint.

If there is no evidence of wood fiber adhesion, there may also be :

- a glue deterioration

WOOD CONDITION

Wood decay and dry rot are usually : easy to detect

Decay may be evident as either a :
1, discoloration
2, softening of the wood

Dry rot is a term loosely applied to many types of decay, but
especially to a condition that, in an advanced stage, that :

- permits the wood to be crushed to a dry powder.

The term is actually a misnomer for any decay,

all fungi require considerable: moisture for growth

water penetration:

- Dark discolorations of the wood
- or
- gray stains running along the grain
- discoloration cannot be removed by light scraping, replace the part

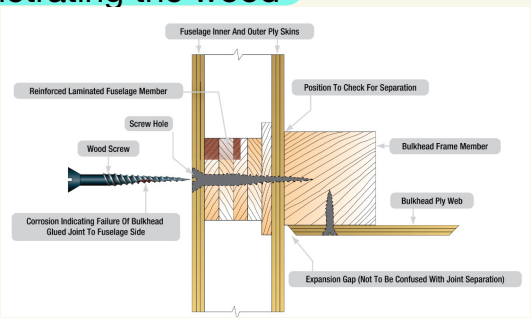
Avoid local staining of the wood by :

- dye from a synthetic adhesive hardener

In some instances where water penetration is suspected, a few:

- Removals of screws is needed;if the screws have corrosion the wood have water inside of it.

This is a way to know if the water is penetrating the wood



Another method of detecting water penetration is to remove the:

- bolts holding the fittings at spar root end joints, aileron hinge brackets,
- Corrosion on the surface of such bolts and wood discoloration provide a useful indication of water penetration

Plain brass screws :

- are normally used for reinforcing glued wooden members

For hardwoods, such as :

- mahogany or ash,
- steel screws

may be used

Unless specified by the aircraft manufacturer, replace removed screws with new screws of identical length, but one gauge larger in diameter.

The condition of the fabric covering on plywood surfaces provides an : indication of the condition of the wood underneath.

If there is any evidence of poor adhesion:

- cracks in the fabric,

or

- swelling of the wood,

remove the fabric to allow further inspection

Cracks in wood spars are :

hidden under ; metal fittings or metal rib flanges and leading edge skins

It is important to ensure the: bolts are a good fit in the holes.

Check for evidence of bruises or crushing of the structural member, which can be caused by over torquing of the bolts.

Check all metal fittings that are attached to a :

wood structure for looseness, corrosion, cracks, or bending

Areas of particular concern are :

- strut attach fittings
- spar butt fittings
- aileron and flap hinges
- jury strut fittings
- compression struts
- control cable pulley brackets
- landing gear fittings

All exposed end grain wood, particularly the spar butts, should be :
inspected for cracking or checking.

Inspect structural members for compression failures, which is indicated by:

- rupture across the wood fibers (كسر)
- This is a serious defect that can be difficult to detect.

If a compression failure is suspected:
a flashlight beam shown along the member, and running parallel to the grain, will assist in revealing it.

The surface will appear to have :

- minute ridges or lines running across the grain.

Particular attention is necessary when inspecting any wooden member that has been subjected to:

- abnormal bending
- compression loads during a hard landing

When a member has been subjected to an excessive bending load, the failure appears on the:

- surface that has been compressed

surface subject to tension normally shows

- no defects

surface subject to excessive direct compression load:

- the failure is apparent on all surfaces.

Front and rear spars should be checked for :

- longitudinal cracks at the ends of the plywood reinforcement plates where the lift struts attach.

Check the ribs on either side of the strut attach points for :

- cracks
- where the cap strips pass over and under the spars,
- Check for missing or loose rib-to-spar attach nails

All spars, those in the wing(s) and empennage, should be:

- inspected on the face and top surface for compression cracks.

borescope can be utilized by accessing existing inspection holes.

Various mechanical methods can be employed to enhance the visual inspection of wood structures:

1, Tapping the subject area with a

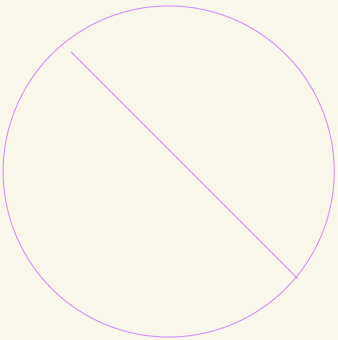
- light plastic hammer
- screwdriver handle
- should produce a sharp solid sound.

If the suspected area sounds hollow and dull:

- further inspection is warranted.

Use a sharp metal awl or thin bladed screwdriver to probe the area

- The wood structure should be solid and firm.
- If the area is soft and mushy, the wood is rotted and disassembly and repair of the structure is necessary



REPAIR OF WOOD AIRCRAFT STRUCTURES

The standard for any repair is that it should return the aircraft or component to its original condition in :

- strength
- function
- aerodynamic shape

should be accomplished in accordance with the :

- manufacturer's specifications and/or instructions
- Or
- other approved data

The purpose of repairing all wood structural components is to :

- obtain a structure as strong as the original

Major damage :

- probably requires replacement of the entire damaged assembly

minor damage :

- can be repaired by :
- removing or cutting away the damaged members
- and replacing them with new sections.

This replacement may be accomplished by:

- gluing
- glue and nails
- glue and screw reinforced splicing

WING RIB REPAIRS

Ribs that have
-sustained damage :

- may be repaired or replaced,
- depending upon the type of damage and location in the aircraft

But
If new parts are available from the aircraft manufacturer:

- it is advisable to replace the part

If you make a repair to a rib, do the work in such a manner and using:

- materials of such quality that the completed repair is at least equal to the original part in aerodynamic function,
- structural strength,
- deterioration,
- other qualities affecting airworthiness, such as fit and finish.

Follow manufacturer's repair manual instructions when performing the repair

When necessary,
A rib can be :

- fabricated
- installed

using the same :

- materials
- dimensions

from a manufacturer approved drawing or by reference to an original rib.

However, if you fabricated it from an existing rib:

- must provide evidence to verify that the :
- dimensions are accurate
- the materials are correct for the replacement part

You can repair a cap strip of a wood rib using a:

- scarf splice.

The repair is :

- reinforced on the side opposite the wing covering by a spruce block

(that extends beyond the scarf joint not less than three times the thickness)

Reinforce the entire splice, including the:

- spruce reinforcing block, on each side with a plywood side plate.

The scarf length bevel is:

- 10 times dimension A (thickness of the rib cap strip)

with

- the spruce reinforcement block being 16 times dimension A (the scarf length plus extension on either end of the scarf).

The plywood splice plates should be of the:

- same material and thickness as the original plates used to fabricate the rib.

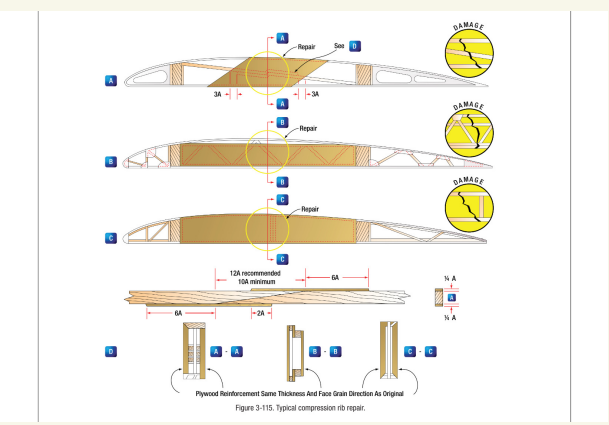


Figure 3-115. Typical compression rib repair.

WING SPAR REPAIRS:

Wood wing spars are fabricated in various designs using :

- solid wood
- plywood
- combination of the two.

When a spar is damaged, the method of repair :

- must conform to the manufacturer's instructions

If instructions are not available for a specific type of repair, it is highly recommended that you request :

- appropriate engineering assistance to evaluate and provide guidance

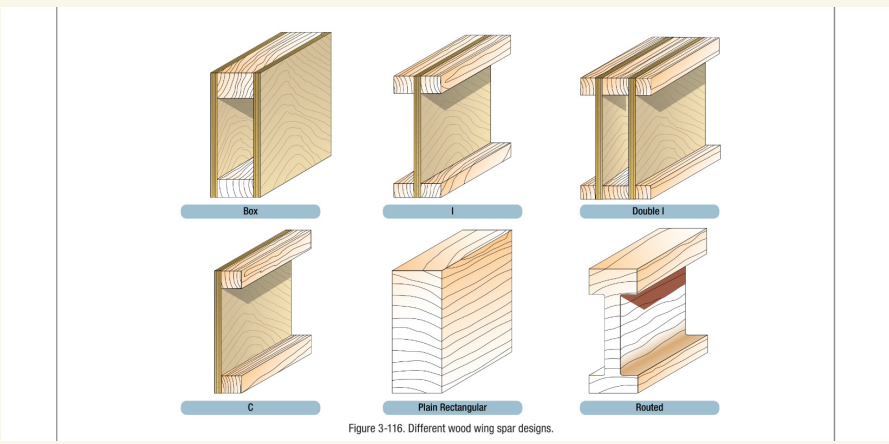


Figure 3-116. Different wood wing spar designs.

The slope of the scarf in any stressed part, such as a spar, should not be steeper than :

- 15 to 1.

Unless

- specified by the aircraft manufacturer
- a damaged spar may be spliced at almost any point except at wing attachment fittings
- landing gear fittings
- engine mount fittings
- lift and interplane strut fittings.

These fittings may not overlap any part of the splice.

The reinforcement plates of the splice should not

- interfere with the proper attachment or alignment of the fittings. Taper reinforcement plates on the ends at a 5:1 slope

PLYWOOD SKIN REPAIRS

Plywood skin can be repaired using a number of diff rent methods depending on the

- size of the hole
- its location on the aircraft.

Manufacturer's instructions, : when available, should be the first source of a repair scheme

Fabric Patch

fabric patch is the :

- simplest method to repair a small hole in plywood

This repair is used on:

- holes not exceeding 1 inch in diameter after being trimmed to a smooth outline.

First step : The edges of the trimmed hole should first be :

- sealed preferably with a two part epoxy varnish

-varnish requires a long cure time, but it provides the best seal on bare wood.

The fabric used for the patch should be of an

- approved material
- using the cement recommended by the manufacturer of the fabric system.

Second step: The fabric patch should be :

- cut with pinking shears and overlap the plywood skin by at least 1 inch

fabric patch should not be used to repair holes in the : not allowed

- leading edge of a wing in the frontal area of the fuselage
- nearer than 1 inch to any frame member.

Splayed Patch

- A splayed patch is a flush patch

The term splayed denotes that
- the edges of the patch are tapered, with the slope cut at a 5:1 ratio to the thickness of the skin

This may be used for
- small holes
- where the largest dimension of the hole to be repaired is not more than 15 times the skin thickness
- and the skin is not more than 1/10 inch thick.
- This calculates to nothing larger than a 11/2 inch

trimmed hole in very thin plywood

Using the sample :
- 1/10 inch thick plywood
- a maximum trimmed hole size of 11/2 inches
- cutting a 5:1 scarf,
- results in a 21/2 inches round section to be patched

The patch should be fabricated with a
- 5:1 scarf,
- from the same type and thickness plywood as the surface being repaired

- Glue is applied to the beveled edges

and the patch is set with
- the grain parallel to the surface being repaired

- pressure plate of thicker plywood cut to the exact size of the patch is centered over the patch covered with waxed paper.
- suitable weight is used for pressure until the glue has set.
- repair is then sanded and finished to match the original surface

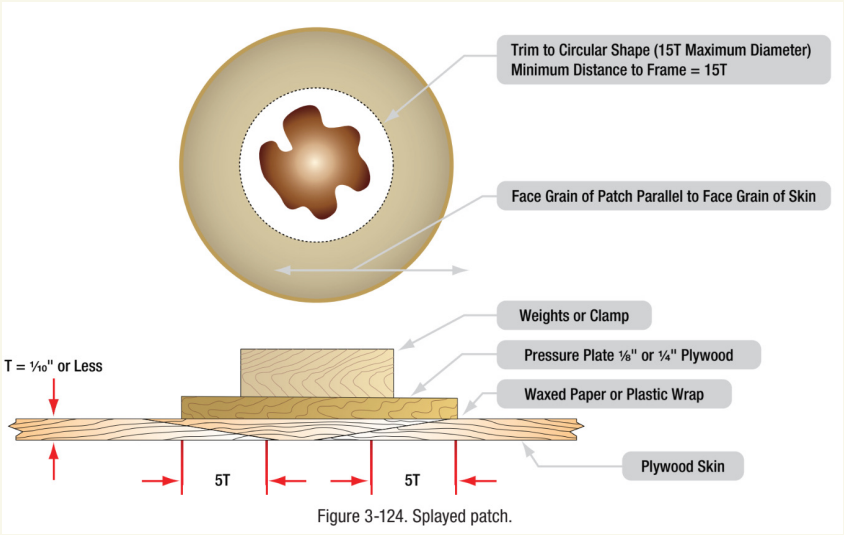


Figure 3-124. Splayed patch.

Surface Patch

may be repaired with a surface or overlay patch:if

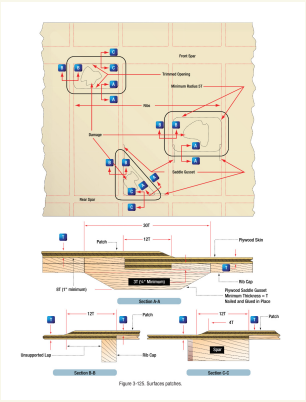
- Plywood skins not over 1/8 inch thick
- that are damaged between or along framing members

Surface patches located aft of the

- 10 percent chord line
- or which wrap around the leading edge and terminate aft of the 10 percent chord line, are permissible.

You can use surface patches to patch

- trimmed holes up to a 50 inch perimeter.
- may cover an area as large as one frame or rib space



Process of surface patching

1, Trim the damaged area to a rectangle or triangular shape with rounded corners.

1.2rule: The radius of the corners must be at least 5 times the skin thickness

1.3, Doublers made of plywood at least 1⁄4 inch thick are reinforcements placed under the edge of the hole inside the skin.

1.4, Nail and glue the doublers in place.

2, Extend the doublers from one framing member to another and strengthen at the ends by saddle gussets attached to the framing members.

Information about the outcome orientation and curing

- The surface patch is sized to extend beyond the cutout as indicated
- All edges of the patch are beveled, but the leading edge of the patch should be beveled at an angle at least 4:1 of the skin thickness
- The face-grain direction of the patch must be in the same direction of the original skin.
- Where possible, weights are used to apply pressure to a surface patch until the glue has dried

If the location of the patch precludes the use of weight:

- small round head wood screws can be used to apply glue pressure to secure the patch.
- After a surface patch has dried, the screws can be removed and the holes filled

- The patch should be covered with fabric that overlaps the original surface by at least 2 inches.
- The fabric should be from one of the approved fabric covering systems using the procedures recommended by the manufacturer to cement and finish the fabric

Plug Patch

Two types of plug patch:
1, oval
2, round

Both may be used on :
- plywood skins.

Because
- the plug patch is only a skin repair, use it only for damage that does not involve the supporting structure under the skin.

You can use a round plug patch where the cutout repair is no larger than 6 inches in diameter.

The following steps provide a method for making a round plug patch:
1:
- Cut a round patch large enough to cover the intended repair.
- If applicable for size, use the sample dimensions
- The patch must be of the same material and thickness as the original skin.

2, Place the patch over the damaged spot and mark a circle of the same size as the patch.

3, Cut the skin inside the marked circle so that the
plug patch fits snugly into the hole around the entire perimeter.

4, Cut a doubler of soft quarter inch plywood, such as poplar. A small patch is cut so that its outside radius is 5/8nch greater than the hole to be patched and the inside radius is 5/8nch less. For a large patch the dimensions would be increased to 7/8nch each. If the curvature of the skin surface is greater than a rise of 1/8nch in 6 inches, the doubler should be preformed to the curvature using hot water or steam. As an alternative, the doubler may be laminated from two pieces of 1/8nch plywood.

5, Cut the doubler through one side so that it can be inserted through the hole to the back of the skin. Place the patch plug centered on the doubler and mark around its perimeter. Apply a coat of glue outside the line to the outer half of the doubler surface that will bear against the inner surface of the skin.

6, Install the doubler by slipping it through the cutout hole and place it so that the mark is concentric with the hole. Nail it in place with nailing strips, while holding a bucking bar or similar object under the doubler for backup. Place waxed paper between the nailing strips and the skin. Cloth webbing under the nailing strips facilitates removal of the strips and nails after the glue dries

7, After the glue has set for the installed doubler, and you have removed the nail strips, apply glue to the inner half of the doubler and to the patch plug. Drill holes around the plug's circumference to accept No. 4 round head wood screws. Insert the plug with the grain aligned to the surface wood.

8, Apply the pressure to the patch by means of the wood screws. No other pressure is necessary

9, After the glue has set, remove the screws and fill the nail and screw holes. Sand and finish to match the original surface.

The steps for making an oval plug patch are identical to those for making the round patch. The maximum dimensions for large oval patches are 7 inches long and 5 inches wide.

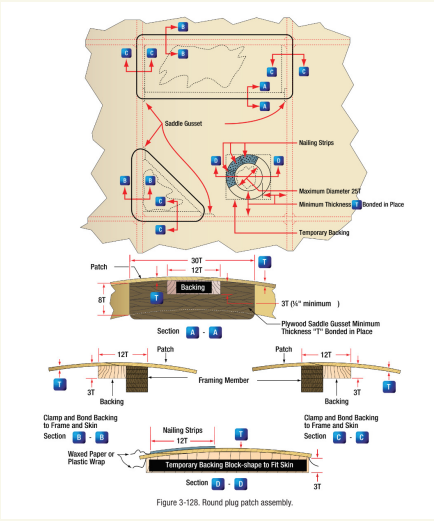


Figure 3-128. Round plug patch assembly.

ScarfPatch

properly prepared and installed scarf patch :

- is the best repair for damaged plywood and is preferred for most skin repairs

The scarf patch has edges beveled at a

- 12:1 slope;

the splayed patch is beveled at a

- 5:1 slope

scarf patch also uses

- reinforcements under the patch at the glue joints.

If the damaged plywood skin has a radius of curvature not greater than 100 times the skin thickness

- you can install a scarf patch.
- it may be necessary to soak or steam the patch, to preform it prior to gluing it in place.
- Shape backing blocks or other reinforcements to fit the skin curvature

You can make scarf cuts in plywood with various tools, such as a

- hand plane,
- spoke shave
- sharp scraper
- sanding block.

Not recommended to use these tools:

- Sawn
- roughly filed surfaces

are not recommended because they are normally inaccurate and do not form the best glue joint.

The Back OfThe Skin Is Accessible For Repair

When the back of a damaged plywood skin is accessible, such as a
- fuselage skin

repair it with
- scarf patches cut
- installed with the grain parallel to the surface skin

The Back OfThe Skin Is Not Accessible For Repair

To repair a section of the skin with a scarf patch when access to the back side is not possible use the following steps to facilitate a repair:
1, Cut out and remove the damaged section

2, Carefully mark and cut the scarf around the perimeter of the hole.

3, install backing strips along all edges that are not fully backed by a rib or spar

- To prevent warping of the skin, fabricate backing strips from soft textured plywood, such as yellow poplar or spruce, rather than a piece of solid wood.

4, Use nailing strips to hold backing strips in place while the glue sets.
- Use a bucking bar, where necessary, to provide support for nailing

5, saddle gusset of plywood should support the end of the backing strip at all junctions between the backing strips and ribs or spars

- If needed, nail and bond the new gusset plate to the rib or spar.

6, It may be necessary to remove and replace an old gusset plate with a new saddle gusset, or nail a new gusset over the original.

- Unlike some of the other type patches that are glued and installed as one process, this repair must wait for the glue to set on the backing strips and gussets

7, At that point, the scarf patch can be cut and fit to match the grain, and glued, using weight for pressure on the patch as appropriate.

8, When dry, fill and finish the repair to match the original surface.

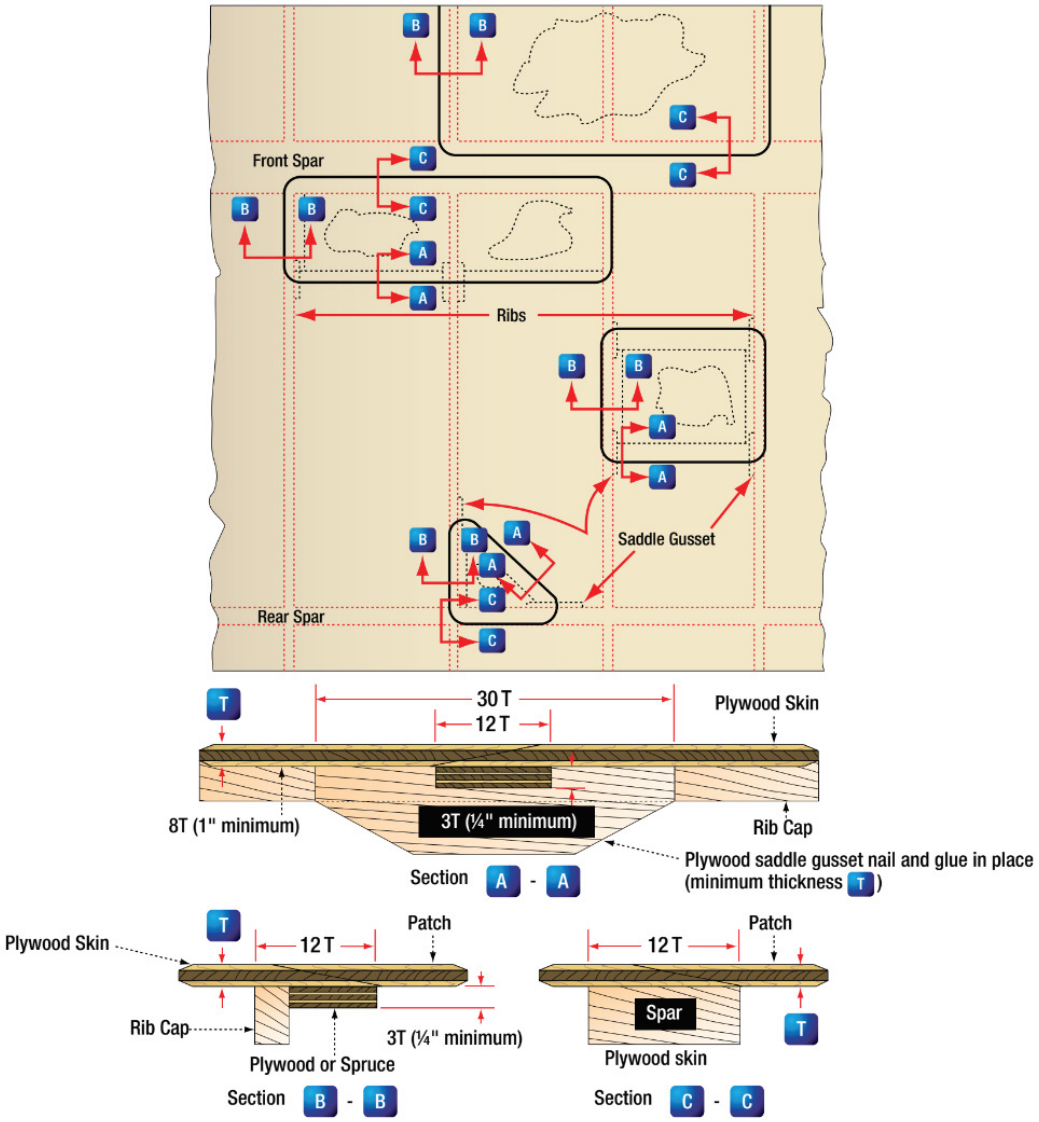


Figure 3-129. Round plug patch assembly.

FINISHING WOOD STRUCTURES

The surface finish is the final line of defense to prevent the destructive eff cts of moisture entry into the structure.

The time and effort will be reflected in the appearance

Adherence to the instructions issued by the finish manufacturer is necessary to

- obtain the appearance desired
- protective characteristics for the product used.

The primary objective of interior finishes is to

- afford protection of the wood against serious change in moisture content (coating)

Coatings, on contact areas between wood and metal protect the

- metal against corrosion from moisture in the wood.

The primary objectives of the exterior finish are to

- protect the wood against weathering
- provide a suitable appearance
- present a smooth surface in flight

AIRCRAFT FABRIC COVERINGS

29 Pages

CHARACTERISTICS, PROPERTIES, AND TYPES OF FABRIC USED IN AIRPLANES

FABRIC TERMS:

- 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.
- 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.

APPROVED MATERIALS

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.

Approved materials:

1, Fabric:

- Fabric that meets or exceeds the TSO can be used as a covering. Fabric approved to replace Grade-A cotton
- When a company is approved to manufacture or sell an approved aviation fabric, it applies for and receives a Parts Manufacturer Approval (PMA)

2, Anti-Chafe Tape

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

3, Reinforcing Tape

- used on rib caps after the fabric covering is installed to protect
- strengthen the area for attaching the fabric to the ribs

4, Rib Bracing

- used on wing ribs before the fabric is installed.
- It is applied spanwise and alternately wrapped around a top rib cap
- Lacing the ribs in this manner holds them in the proper place and alignment during the covering process.

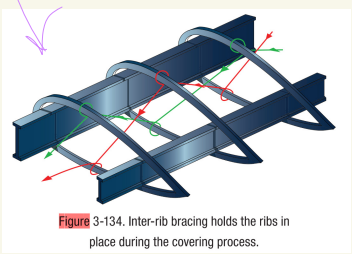


Figure 3-134. Inter-rib bracing holds the ribs in place during the covering process.

Rib Bracing

Anti-Chafe Tape

Reinforcing Tape

5, Surface Tape

- made of polyester material and often preshrunk,
- obtained from the STC holder(manufacturer)
- This tape, also known as finishing tape, is applied after the fabric is installed.
- 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

6, Rib Lacing Cord

- used to lace the fabric to the wing ribs.
- 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.

7, Sewing Thread

- rare and mostly limited to the creation of prefitted envelopes used in the envelope method covering process
- fabric seam must be made with no structure underneath it, a sewn seam could be used. Polyester
- Polyester threads of various specifications are used on polyester fabric.
- Diff rent thread is specified for hand versus machine sewing
- 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

Sewing Thread

Rib Lacing Cord

8, Special Fabric Fasteners

Read

- Each fabric has a method of attaching the fabric to wing and empennage ribs
- 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.
- The first step in using any of these fasteners is to :

1, 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.
- 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 airfl w

9, Grommets

- 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.
- to make a hole use; hot soldering pencil that also heat seals the fabric edge to prevent raveling.

10, Inspection Rings

- To facilitate this in fabric covered aircraft,
- inspection rings are glued or doped to the fabric.
- They provide: 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 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

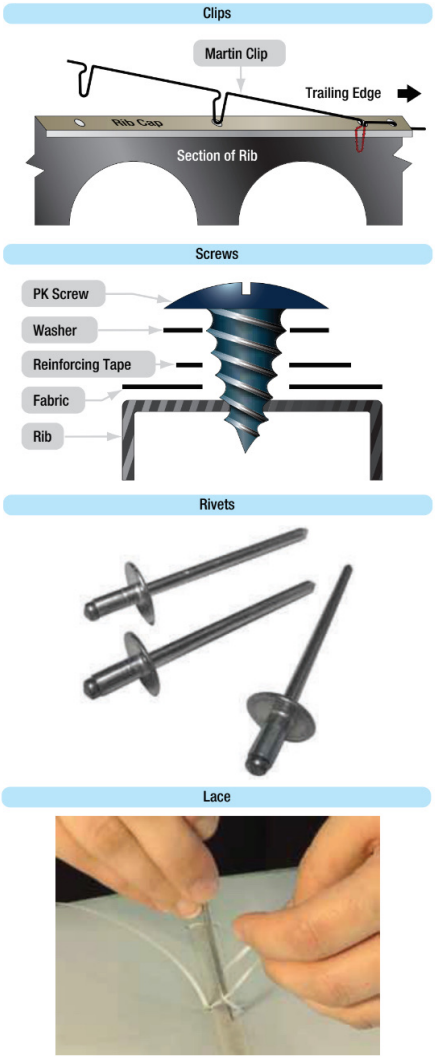


Figure 3-135. Clips, screws, rivets, or lace are used to attach the fabric to wing and empennage ribs.

Special Fabric Fasteners

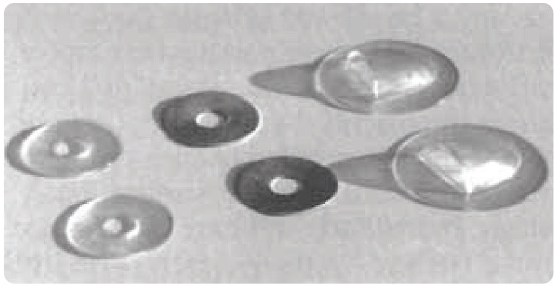


Figure 3-136. Plastic, aluminum, and seaplane grommets are used to reinforce drain holes in the fabric covering.

Grommets

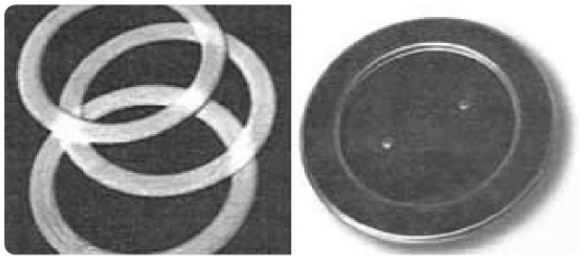


Figure 3-137. Inspection rings and an inspection cover.

Inspection Rings

- 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.

11, Primer

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
- Most often, two part epoxy primers are used on metal structure
- two part epoxy varnishes are used on wood structure.
- Utilize the primer specified by the manufacturer's or STC's instructions.

12, Fabric Cement

Modern fabric covering systems utilize special fabric cement to attach the fabric to the airframe. There are various types of cement

- 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.

13, 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.

Primer

Fabric Cement

14, Fillers

- After the fabric sealer is applied, a filler is used.
- 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: causes polyester fabric to deteriorate.
- 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

15, Topcoats

- 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
- use STC products : for airworthiness fabric recovering job.
- 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;

1, catalysts ; accelerates a chemical reaction

- commonly used with epoxies and polyurethanes.

2, 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

3, retarder; Make the dry process slower

4, accelerators; Speed the drying time If the dryer dry very slow use this

- used when the application working temperature is below that of the ideal working temperature.
- can also be used for faster drying when airborne contaminants threaten a coating finish.

5, Rejuvenator; used on dope finishes only

- contains solvents that soften coatings and allow them to fl w slightly.
- contains fresh plasticizers that mix into the original coatings. This increases the overall flexibility and life of the coatings

AVAILABLE COVERING PROCESSES

Page 3.97
Paragraph 1,2,3,4
Read them

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.

TYPES OF DEFECTS IN FABRICS

The fabric covering of an aircraft will deteriorate in time.

The rate of deterioration depends to a large extent on the type of operation:
1, climate
2, storage conditions
3, and the maintenance of a satisfactory surface finish

great deal depends on ;
- how well the fabric has been protected from UV (ultraviolet).

the covering will not deteriorate uniformly Due to :
- water soakage
- chafing against the structure and local wear

In the case of the fabric covered components on large aircraft:
- an arbitrary life may be placed on the fabric.

The fabric coverings of light aircraft should be :
- checked at the periods specified in the approved maintenance schedule
- and before renewal of the Airworthiness Certificate.

In general terms, all components of the covering should be regularly inspected for the following which are unacceptable:

- Loose finishing tape and reinforcing patches
- Chafing under fairings
- Brittleness, cracking, peeling, or deteriorated coatings
- Fabric tears and stone damage
- Broken or missing rib stringing
- Rodent and insect nests

20-29

The entire fabric covering should be

- uniformly taut with no loose or wrinkled areas.

The fabric tension must not be

- excessive otherwise the underlying structure can be warped or damaged.

EXCESS TENSION:
methods of measuring fabric tension

- by observation the only way

Excessive tension may lead to: a warp longerons, in;تشوه

- wing ribs
- trailing edges thus weakening the structure.

The entire fabric covering should be
- uniformly taut with no loose or wrinkled areas.

LOOSE FABRIC

Fabric finished with dope that flutters or ripples in the propeller slipstream, balloons, or is depressed excessively
in flight is unacceptable.

These issues may be caused by:
- Inadequate dope film
- Poor quality dope
- Fabric attached with excessive slack
- Bent or warped structure

Temporary wrinkles will develop in any fabric which is
- coated and finished with dope when ;
- moisture from rain,
- fog,
- dew is absorbed into a poor quality dope film,

causing the film to expand.

Temporary wrinkles may also develop with
- any type of thick coating, in any type of fabric

when an aircraft is moved from a cold storage area to a warm hangar or parked in the warming sunshine cause:
- rapid expansion of the coating

Loose or wrinkled polyester fabric covering finished with coatings other than dope may be caused by:
- Inadequate or excessive heat application during tautening
- Excess slack when the fabric was attached
- Bent broken or warped structure

Polyester fabric which does not meet aircraft quality specifications is likely to become ;

- loose after a short period of time.

Particular attention must be given to the area within the

- propeller slipstream.

If failure is indicated by lifting of the fabric covering;

- the rib stringing cord and reinforcing tape must be reinstalled with double the number of original stitches.

COATING CRACKS

Fabric exposed through cracks in the coating should be inspected for :

- deterioration by ;
- pressing firmly with a thumb to check the fabric's strength

Natural fibers deteriorate by exposure to :

- ultraviolet radiation
- mildew
- fungus from moisture
- high acid content
- rain
- dew
- fog
- pollution
- age

Polyester filaments will deteriorate by exposure to

- UV radiation.

Glass fabric will not deteriorate from exposure to UV,
but will if exposed to ;

- acid rain
- dew
- or chafing if loose in the propeller slipstream area

Polyester fabric that is coated with materials other than dope is dependent solely on:

- the heat tautening characteristics of the polyester filaments

to

- develop tension and transmit the airloads to the airframe without excessive deflection from the unloaded position

Cracks in dope and other coatings will allow :

- any type of exposed fabric to deteriorate.

Cracks should be closed by

- sealing

or

- by removing the coatings in the immediate area and then replacing them with new coatings

DETERIORATION

- When approved coat ings completely protect the fabric, its service life is infinite.

Therefore it is very important to;

- Thoroughly protect structure beneath before covering fabric
- Provide adequate access for inspection of:

1, Corrosion
2, Wood rot
3, Mice infestation

- Ensure multiple drain holes in lower ends of fabric-covered sections
- Drain holes provide ventilation to remove condensation

INSPECTION METHODS

DETERMINING FABRIC CONDITION; REPAIR OR RECOVER?

Recovering an aircraft with fabric is a :
- major repair and should only be undertaken when necessary

repair to the present fabric is ;
- sufficient to keep the aircraft airworthy

The original manufacturer's recommendations or the covering process STC should be:
- consulted for the type of repair required for the damage incurred by the fabric covering.

large area that needs repair is judged in:
- reference to the overall remaining lifespan of the fabric on the aircraft.

example, if the fabric has reached the limit of its durability, it is better to recover the entire aircraft than to replace a large damaged area when the remainder of the aircraft would soon need to be recovered.

aircraft with dope based covering systems, continued shrinkage of the dope can cause:
- the fabric to become too tight.

Overly tight fabric may require the aircraft to be :
- recovered rather than repaired

because ;
- excess tension on fabric can cause airframe structural damage

Loose fabric flaps in the wind during flight, affecting
- weight distribution and unduly stressing the airframe.
- It may also need to be replaced because of damage to the airframe

Another reason to recover rather than repair occurs when ;
- dope coatings on fabric develop cracks

These cracks could expose the :
- fabric beneath to the elements that can weaken it.

Close observation and field testing must be used to determine if the fabrics are airworthy

If not:

the aircraft must be recovered

If the fabric is airworthy and no other problems exist:
- rejuvenator can be used per manufacturer's instructions

rejuvenator is a product usually ;
- sprayed on and softens the coatings with very powerful solvents.

Plasticizers in the rejuvenator become:
- part of the film that fills in the cracks

After the rejuvenator dries:
- additional coats of aluminum pigmented dope must be added and then final topcoats applied

Polyurethane-based finishes cannot be :
- rejuvenated

FABRIC STRENGTH

Deterioration of the strength of the present fabric covering is the ;
- most common reason to recover an aircraft.

strength of fabric coverings must be determined at
- every 100 hour and annual inspection

Minimum fabric breaking strength is used to determine
- if an aircraft requires recovering.

Fabric is considered to be airworthy until
- it deteriorates to a breaking strength less than 70 percent of the strength of the new fabric required for the aircraft.

In general, an aircraft is certified with a certain fabric based on its wing loading and its Never Exceed Speed (VNE):
- The higher the wing loading and VNE, the stronger the fabric must be.

Fabric Performance Criteria				
IF YOUR PERFORMANCE IS. . .		FABRIC STRENGTH MUST BE. . .		
Loading	V_{NE} Speed	Type	New Breaking Strength	Minimum Breaking Strength
> 9 lb/sq ft	> 160 mph	Grade A	> 80 lb	> 56
< 9 lb/sq ft	< 160 mph	Intermediate	> 65 lb	> 46
< 8 lb/sq ft	< 135 mph	Lightweight	> 50 lb	> 35

Figure 3-139. Aircraft performance affects fabric selection.

How Fabric Breaking Strength is Determined

Manufacturer's instructions should always be consulted first for fabric strength inspection methodology

The test strip method for the breaking strength of aircraft covering fabrics process:

Selecting the Sample:
- Choose a 1¼ inch by 4–6 inch strip of fabric from the aircraft covering.
- Select from an area exposed to the elements, preferably an upper surface.
- Opt for a spot with a dark-colored finish if possible, as it may have degraded faster due to UV exposure.

Preparing the Sample:
- Remove all coatings from the selected strip.
- Ravel the edges to leave a 1-inch width.
- Clamping the Sample:
- Secure one end of the strip into a clamp tightly.
- Clamp the other end in a way that a suitable container can be suspended from it.

Adding Weight:
- Suspend a container from the free end of the fabric strip.
- Gradually add weight to the container until the fabric breaks.
- Recording the Breaking Strength:
- Measure and record the combined weight of the lower clamp, container, and added weight at the point of fabric failure.

Verification and Further Testing:
If there are doubts about the breaking strength, consider sending a sample to a qualified testing laboratory:
- Conduct breaking strength tests in accordance with ASTM publication D5035 for accurate results.

FABRIC TESTING DEVICES

Mechanical devices used to test fabric by pressing against or piercing the finished fabric are

- not approved
- and are used at the discretion of the certificated mechanic to form an opinion on the general fabric condition

Types and their process

Punch test

Punch test accuracy depends on
- the individual device calibration
- total coating thickness
- brittleness,
- types of coatings and fabric

If the fabric tests in the lower breaking strength range with the mechanical punch tester or if the overall fabric cover conditions are poor:
- then more accurate field tests may be made.

The test should be performed on :
1, exposed fabric
2, there is a crack or chip in the coatings

If there is no crack or chip:
- coatings should be removed to expose the fabric wherever the test is to be done

1, The Maule punch tester

The Maule punch tester is:

- spring loaded device with its scale calibrated in breaking strength

The Maule punch tester is used for:

- tests fabric strength

Test strength by:

- tests fabric strength by pressing against it while the fabric is still on the aircraft.

Unit:

- It roughly equates strength in pounds per square inch (psi) of resistance to breaking strength

How it reads:

- The tester is pushed squarely against the fabric until the scale reads the amount of maximum allowable degradation

If the tester does not puncture the fabric:

- it may be considered airworthy.

a puncture indicates that:

- the fabric is in need of replacement.

2, the Seyboth

not as popular as the Maule because
- it punctures a small hole in the fabric

when the mechanic pushes the
- shoulder of the testing unit against the fabric

Construction and how it work ;
- A pin with a color coded
- calibrated scale protrudes from the top of the tester
- the mechanic reads this scale to determine fabric strength.

Since this device requires a repair regardless of the strength of the fabric indicated
- it is not widely used.

Seyboth and Maule fabric strength testers designed for
- cotton and linen covered aircraft
- not to be used on modern Dacron fabrics

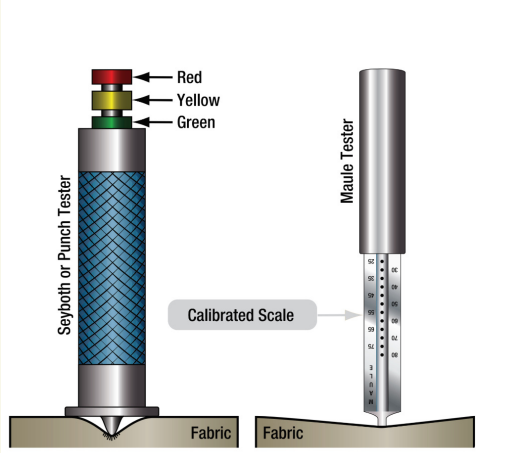


Figure 3-140. Seyboth and Maule fabric strength testers.

REPAIR OF FABRIC COVERING

Th method of fabric attachment should be identical, as far as :

- strength
- reliability are concerned,
- the method used by the manufacturer of the aircraft being recovered or repaired.

1, Blanket Method

key points regarding the blanket method of recovering aircraft:

1, Fabric Selection:
- Certified greige polyester fabric, up to 70 inches in width, is commonly used for covering aircraft.

2, Individual Assessment:
- Each aircraft is evaluated individually to determine the size and layout of blankets needed for covering.

3, Blanket Cutting:
- Small surfaces (e.g., stabilizers, control surfaces) typically require a single blanket cut.
- Wings may need two overlapping blankets.
- Fuselages are covered with multiple blankets spanning between major structural members.

4, Fuselage Coverage:
- Multiple blankets cover fuselages, often with a single blanket for the bottom.
- Additional blankets cover the sides and top.

5, Adhesion Process:
- Approved adhesives are used to adhere the fabric to the airframe.
- Specific rules and procedures must be followed for proper adhesion.

6, Large Wing Considerations:
- Very large wings may need more than two blankets for full coverage.
- The number of blankets depends on the wing's size and configuration.

2, Envelope method

envelope method of aircraft covering in solid points:

1, Precut Envelopes:
- Envelopes of fabric, precut and presewn, are used to cover the aircraft, saving time and effort in the covering process.

2, Sewing Standards:
- Envelopes must be sewn with approved machine sewing thread, maintaining proper edge distance, fabric fold, etc., or adhere to an STC (Supplemental Type Certificate) for quality and safety.

3, Pattern Design:
- Patterns are created, and fabric is cut and stitched to ensure each major surface of the aircraft, including the fuselage and wings, can be covered with a single, closely fitting envelope.

4, Installation Process:
- Envelopes are slid into position on the airframe, with attention to orientation to ensure seams are properly aligned.
- They are then attached with adhesive to secure them in place.

5, Seam Placement:
- Envelope seams are strategically located over airframe structures in inconspicuous areas, such as trailing edge structures, and the top and bottom of the fuselage, based on the aircraft's construction.

6, Adherence to Instructions:
- Manufacturers' or STC instructions must be followed precisely to ensure proper placement of the sewn seams of the envelope and adherence to safety and quality standards.

Preparation for Fabric Covering Work;

- First, assemble the materials and tools required to complete the job.
- The holder of the STC usually supplies a materials and tools
- Control of temperature, humidity, and ventilation is needed in the work environment

-If ideal environmental conditions cannot be met:

- additives are available that compensate for this for most re-covering products. (A way of controlling the Chemical)
- to support the aircraft structure while working. A workbench or table, as well as a rolling cart and storage cabinet, are also recommended
- Many of the substances used in most recovering processes are highly toxic. Proper protection must be used
- Eye protection, a proper respirator, and skin protection are vital
- Proper ventilation and a rated fire extinguisher should be on hand when working with this and other covering process
- Grounding of work to prevent static electricity buildup may be required (connect a wire from the aircraft to the floor)
- All fabric recovering processes also involve multiple coats of various products that are sprayed onto the fabric surface. Use of a High-Volume, Low-Pressure (HVLP) sprayer is recommended
- Good ventilation is needed for all of the processes.

1, Removal of Old Fabric Coverings

the steps for removing the old fabric covering from an aircraft:

1. Initial Step:
- The first step in replacing the aircraft fabric covering is removing the old covering from the airframe.

2, Tool Usage:
- Use razor blades or a utility knife to cut away the old fabric. Care should be taken to avoid damaging the airframe during this process.

3, Consideration for Templates:
- If the old covering will be used as templates for transferring the location of inspection panels, cable guides, and other features to the new covering, it should be removed in large sections.

4, Precautionary Note:
- Any rib stitching fasteners used to attach the fabric to the structure should be removed before pulling the fabric free of the airframe.

5, Risk of Damage:
- Leaving fasteners in place during fabric removal can potentially cause damage to the structure. Therefore, it's crucial to ensure that they are removed before pulling the fabric off the airframe.

2, Preparation ofthe Airframe Before Covering Once

- Once the old fabric has been removed, the exposed airframe structure must be thoroughly cleaned and inspected.

- inspection should follow the manufacturer's guidelines, or the STC.

- old adhesive must be completely removed from the airframe with solvent, such as MEK.

- Any repairs that are required, including the removal and treatment of all corrosion, must be done at this time

- Plywood leading edges must be sanded until smooth, bare wood is exposed

- oil or grease spots exist, they must be cleaned with naphtha or other specified cleaners.

- If there are any chips, indentations, or irregularities, approved filler may be spread into these areas and sanded smooth.

- The entire leading edge should be cleaned before beginning the fabric covering process.

- sheet of felt or polyester padding may be applied before the fabric is installed (for a smooth finish)

3, the process of preparing the airframe for fabric covering:

1. Cleaning and Inspection:
- After the old fabric is removed, the airframe should be thoroughly cleaned, inspected, and any necessary repairs made.

2, Primer Application:
- An approved primer or varnish (for wood structures) should be applied to the airframe. This step, often referred to as dope proofing, ensures protection and enhances adhesion for the fabric covering.

3, Surface Preparation for Aluminum:
- Exposed aluminum surfaces must be acid etched before priming. Specific products specified by the manufacturer or in the STC should be used to prepare the metal for priming.

4, Primer Selection:
- Two-part epoxy primers and varnishes are usually specified, as they are not affected by the fabric adhesive and subsequent coatings. One-part primers, such as zinc chromate and spar varnish, are typically not acceptable due to their susceptibility to being dissolved by the fabric adhesive, leading to adhesion issues.

5, Anti-Chafe Tape Application:
- Sharp edges, metal seams, rivet heads, and other features that might cut or wear through the fabric should be covered with anti-chafe tape. Cloth sticky back tape specifically approved for this purpose should be used, and substitutions with masking or other types of tape are not recommended.

6, Rib Cap Strips and Anti-Chafe Tape:
- Rib cap strips may require anti-chafe tape application, especially when the edges are not rounded over, to prevent damage to the fabric.

7, Inter-Rib Bracing:
- Inter-rib bracing should be completed before installing the fabric. This bracing, typically without adhesive, is wrapped around each rib once to hold them in place during the covering process while allowing for small movements during fabric shrinking.

ATTACHING POLYESTER FABRIC TO THE AIRFRAME

suggested to cover smaller surfaces first, such as the empennage and control surfaces because:

- Mistakes on these can be corrected and are less costly if they occur
- Once dexterity has been established, the order in which one proceeds is often a personal choice
- When approved, attachment of the fabric may begin. The manufacturer's or STC's instructions must be followed without deviation for the job to be airworthy

The following are the general steps taken. Each approved process has its own nuances

1, Seams

solid points summarizing fabric seam considerations and installation procedures for aircraft covering:

1, Primary Concerns:
- Fabric seams should prioritize strength, elasticity, durability, and good appearance during installation.

2, Seam Positioning:
- Position fabric seams over the airframe structure whenever possible during the covering process to ensure proper adhesion. In the envelope method, seam overlap is predetermined, while in the blanket method, overlap is specified in the covering instructions or manufacturer's guidelines.

3, Seam Specifications:
- Seams should be sewn according to the specifications outlined in the STC or manufacturer's instructions to ensure adequate performance.

4, Seam Types:
- Most polyester fabric covering procedures rely on doped or glued seams instead of sewn seams for simplicity, ease of making, and excellent strength, elasticity, durability, and appearance.

5, Overlap Requirements:
- In the blanket method, fabric overlap seam specifications are typically provided in covering instructions. Generally, a minimum of two to four inches of fabric overlap is required in critical airflow areas like the wing's leading edge, while one to two inches of overlap may suffice in other areas.

6, Consideration of Function and Appearance:
- When deciding where to overlap the fabric for coverage, consider both function and final appearance. For instance, seams on the top surface of a high wing aircraft may not be visible from certain angles, whereas seams on low wing aircraft and many horizontal stabilizers are usually made on the bottom for aesthetic reasons.

2, Fabric Cement

solid points outlining the process of attaching polyester fabric covering to an aircraft airframe:

1, Adhesive Application:
- Polyester fabric is cemented or glued to the airframe structure at all points where it makes contact. Special formula adhesives, which have replaced nitrate dope in most covering processes, are used for adhesion.

2, Temperature Consideration:
- Adhesive and subsequent coating materials should be mixed for optimum characteristics at the temperature at which the work is being performed. Follow the manufacturer's or STC's guidance for mixing.

3, Pre-Application of Adhesive:
- Pre-apply two coats of adhesive to the structure at all points where the fabric is to contact it. The number of coats and specific instructions may vary depending on the manufacturer's or STC's guidance.

4, Fabric Positioning:
- Spread the fabric over the surface of the airframe and clamp it into position. Avoid pulling the fabric tighter than its relaxed but not wrinkled condition. Clamps or clothespins are used to attach the fabric completely around the perimeter.

5, Final Adhesion:
- Once the fabric is positioned, undertake final adhesion. This often involves lifting the fabric, applying a wet bed of cement, and pressing the fabric into the bed. An additional coat of cement over the top of the fabric may be applied.

6, Wrinkle and Excess Cement Removal:
- Depending on the process, wrinkles and excess cement are smoothed out with a squeegee or ironed out. The Stewart System, for example, calls for heat activation of the cement precoats through the fabric with an iron while the fabric is in place.

7, Follow Approved Instructions:
- Follow the approved instructions for the covering method being used, whether it's the blanket method, envelope method, or another approved process.

FABRIC HEAT SHRINKING

Once the fabric has been glued to the structure, it can be made taut by heat shrinking

process is done with an ordinary
- household iron
- A smaller iron is also used to iron in small or tight places.

The iron is run over the entire surface of the fabric
- Follow the instruction

avoid ironing seams while other processes
- begin ironing over structure and move to spanned fabric or visa versa

It is important to shrink the fabric evenly.

Starting on one end of a structure and progressing sequentially to the other end is
- not recommended.

Skipping from one end to the other, and then to the middle, is
- more likely to evenly draw the fabric tight.

The amount polyester fabric shrinks is
- directly related to the temperature applied

Polyester fabric can shrink nearly 5 percent at
- 120°C and 10 percent at 175°C

It is customary to shrink the fabric in stages,
- using a lower temperature first, before finishing with the final temperature setting.

The first shrinking is used to

- remove wrinkles and excess fabric

The final shrinking:

- gives the finished tautness desired

Each process has its own temperature regime for the stages of tautening

Typically ranging from 107°C to 120°C, it is imperative to follow the process instructions

Ensure irons are calibrated to prevent damage at high temperature settings

ATTACHING FABRIC TO THE WING RIBS

Once the fabric has been tautened, covering processes vary.

Wing:
Some require a sealing coat be applied to the fabric at this point:
- It is usually put on by brush to ensure the fibers are saturated.

Other processes seal the fabric later.

Whatever the process, the fabric on wings must be:
- secured to the wing ribs with more than just cement

The forces caused by the airfl w over the wings are too great for cement alone to hold the fabric in place

described in the materials section, screws, rivets, clips and lacing
- hold the fabric in place on manufactured aircraft
- Use the same attach method as used by the original aircraft manufacturer.

Care must always be taken to identify and eliminate
- any sharp edges that might wear through the fabric

Reinforcing tape of the exact same width as the rib cap
- is installed before any of the fasteners
- approved sticky-back tape helps prevent the fabric from tearing
- Then, screws, rivets, and clips simply attach into the predrilled holes in the rib caps to hold the fabric to the caps.

Rib Lacing

There are two kinds of rib lacing cord:

- One has a round cross section
- the other flat

use is a matter of preference based on ease of use and final appearance. Only approved rib lacing cord can be used

solid points summarizing the process of attaching the fabric to the wing structure using lacing:

1, Simultaneous Attachment:

- Lacing cord is used to attach the top and bottom skin of the wing to the ribs simultaneously, spanning from the upper surface to the lower surface.

2, Preparation of Holes:

- Holes are laid out and prepunched through the skin as close to the rib caps as possible to accommodate the lacing cord. This minimizes the leverage that the fabric could develop while trying to pull away from the structure, thereby preventing tearing.

3, Hole Location Importance:

- The location of the holes is not arbitrary. The spacing between lacing holes and knots must adhere to the manufacturer's instructions, if available. If specific instructions are not provided, STC lacing guidance refers to the manufacturer's instructions

solid points summarizing the specific considerations for rib lacing on an aircraft wing:

1, Turbulence Consideration:
- Closer spacing between the lacing is required in the area of the propeller wash due to greater turbulence. The slipstream area is considered to be the width of the propeller plus one additional rib.

2, Lacing Direction:
- Ribs are typically laced from the leading edge to the trailing edge of the wing.

3, Lacing Technique:
- Rib lacing is performed using a long curved needle to guide the cord in and out of holes and through the depth of the rib.

4, Knot Design:
- Knots are designed not to slip under the forces applied and can be made in a series out of a single strand of lacing.

5, Starting Point:
- Stitching can begin at either the leading edge or trailing edge of the wing.

6, Knot Type:
- A square knot with a half hitch on each side is typically used for the first knot when lacing a rib.