AIRCRAFT
INSPECTION, REPAIR & ALTERATIONS

Acceptable Methods, Techniques & Practices

U.S. Department
of Transportation
FEDERAL AVIATION ADMINISTRATION

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**Federal Aviation
Administration**

Advisory Circular

TITLE 14 OF THE CODE OF FEDERAL REGULATIONS (14 CFR) GUIDANCE MATERIAL

Subject: ACCEPTABLE METHODS, TECHNIQUES, AND PRACTICES—AIRCRAFT INSPECTION AND REPAIR

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1. PURPOSE. This advisory circular (AC) contains methods, techniques, and practices acceptable to the Administrator for the inspection and repair of nonpressurized areas of civil aircraft, only when there are no manufacturer repair or maintenance instructions. This data generally pertains to minor repairs. The repairs identified in this AC may only be used as a basis for FAA approval for major repairs. The repair data may also be used as approved data, and the AC chapter, page, and paragraph listed in block 8 of FAA form 337 when:

a. the user has determined that it is appropriate to the product being repaired;

b. it is directly applicable to the repair being made; and

c. it is not contrary to manufacturer's data.

2. CANCELLATION. The AC 43.13-1A dated 1988 is canceled.

3. REFERENCE: Title 14 of the Code of Federal Regulations part 43, section 43.13(a) states that each person performing maintenance, alteration, or preventive maintenance on an aircraft, engine, propeller, or appliance shall use the methods, techniques, and practices prescribed in the current manufacturer's maintenance manual or Instructions for Continued Airworthiness prepared by its manufacturer, or other methods, techniques, or practices acceptable to the Administrator, except as noted in section 43.16. FAA inspectors are prepared to answer questions that may arise in this regard. Persons engaged in the inspection and repair of civil aircraft should be familiar with 14 CFR part 43, Maintenance, Preventive Maintenance, Rebuilding, and Alteration, and part 65, Subparts A, D, and E of Certification: Airmen Other Than Flight Crewmembers, and the applicable airworthiness requirements under which the aircraft was type certificated.

4. ACKNOWLEDGMENTS. The FAA would like to thank the following persons and organization for their assistance in producing AC 43.13-1B: Richard Finch, Richard Fischer, Michael Grimes, Ray Stits, William A. Watkins, and the SAE, Aerospace Electronics and Electrical Systems Division. Acknowledgment is also extended to all in the aviation community who commented on the document.

5. COMMENTS INVITED. Comments regarding this AC should be directed to DOT/FAA; ATTN: Airworthiness Programs Branch, AFS-610; PO Box 25082; Oklahoma City, OK 73125

Acting Deputy Director, Flight Standards Service

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CHAPTER 1. WOOD STRUCTURE

SECTION 1. MATERIALS AND PRACTICES

1-1. GENERAL. Wood aircraft construction dates back to the early days of certificated aircraft. Today only a limited number of wood aircraft structures are produced. However, many of the older airframes remain in service. With proper care, airframes from the 1930's through the 1950's have held up remarkably well considering the state of technology and long term experience available at that time. It is the responsibility of the mechanic to carefully inspect such structures for deterioration and continuing airworthiness.

1-2. WOODS.

a. Quality of Wood. All wood and plywood used in the repair of aircraft structures should be of aircraft quality (reference Army Navy Commerce Department Bulletin ANC-19, Wood Aircraft Inspection and Fabrication). Table 1-1 lists some permissible variations in characteristics and properties of aircraft wood. However, selection and approval of woodstock for aircraft structural use are specialized skills and should be done by personnel who are thoroughly familiar with inspection criteria and methods.

b. Substitution of Original Wood. The wood species used to repair a part should be the same as that of the original whenever possible; however, some permissible substitutes are given in table 1-1. Obtain approval from the airframe manufacturer or the Federal Aviation Administration (FAA) for the replacement of modified woods or other non-wood products with a substitute material.

c. Effects of Shrinkage. When the moisture content of a wooden part is lowered, the part shrinks. Since the shrinkage is not equal in all directions, the mechanic should consider the effect that the repair may have on the completed structure. The shrinkage is greatest in a tangential direction (across the fibers and parallel to the growth rings), somewhat less in a radial direction (across the fibers and perpendicular to the growth rings), and is negligible in a longitudinal direction (parallel to the fibers). Figure 1-1 illustrates the different grain directions and the effects of shrinkage on the shape of a part. These dimensional changes can have several detrimental effects upon a wood structure, such as loosening of

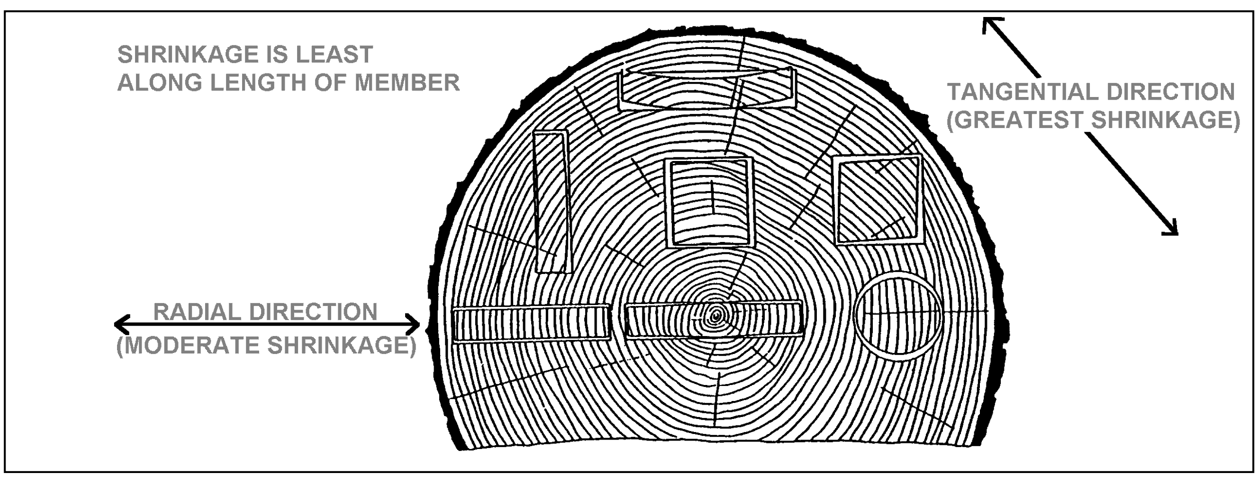


FIGURE 1-1. Relative shrinkage of wood members due to drying.

TABLE 1-1. Selection and Properties of Aircraft Wood. (See notes following table.)

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 as 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 providing reductions are substantiated. Difficult to work with handtools. Some tendency to split and splinter during fabrication and considerable more care in manufacture is necessary. Large solid pieces should be avoided due to inspection difficulties. Gluing satisfactory.
Noble Fir (Abies Nobiles).	Slightly exceeds spruce except 8% deficient in shear.	1:15	Satisfactory characteristics with respect to workability, warping, and splitting. May be used as direct substitute for spruce in same sizes providing shear does not become critical. Hardness somewhat less than spruce. Gluing satisfactory.
Western Hemlock (Tsuga Heterpphylla).	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. Gluing satisfactory.
Pine, Northern White (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-resisting capacity. Cannot be used as substitute for spruce without increase in sizes to compensate for lesser strength. Gluing satisfactory.
White Cedar, Port Orford (Charaecyparis Lawsoniana).	Exceeds spruce.	1:15	May be used as substitute for spruce in same sizes or in slightly reduced sizes providing reductions are substantiated. Easy to work with handtools. Gluing difficult, but satisfactory joints can be obtained if suitable precautions are taken.
Poplar, Yellow (Liriodendrow 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-resisting capacity. Gluing satisfactory.

Notes for Table 1-1

1. Defects Permitted.

a. Cross grain. Spiral grain, diagonal grain, or a combination of the two is acceptable providing the grain does not diverge from the longitudinal axis of the material more than specified in column 3. A check of all four faces of the board is necessary to determine the amount of divergence. The direction of free-flowing ink will frequently assist in determining grain direction.

b. Wavy, curly, and interlocked grain. Acceptable, if local irregularities do not exceed limitations specified for spiral and diagonal grain.

c. Hard knots. Sound, hard knots up to 3/8 inch in maximum diameter are acceptable providing: (1) they are not projecting portions of I-beams, along the edges of rectangular or beveled unrouted beams, or along the edges of flanges of box beams (except in lowly stressed portions); (2) they do not cause grain divergence **at the edges of** the board or in the flanges of a beam more than specified in column 3; and (3) they are in the center third of the beam and are not closer than 20 inches to another knot or other defect (pertains to 3/8 inch knots—smaller knots may be proportionately closer). Knots greater than 1/4 inch must be used with caution.

d. Pin knot clusters. Small clusters are acceptable providing they produce only a small effect on grain direction.

e. Pitch pockets. Acceptable in center portion of a beam providing they are at least 14 inches apart when they lie in the same growth ring and do not exceed 1-1/2 inches length by 1/8 inch width by 1/8 inch depth, and providing they are not along the projecting portions of I-beams, along the edges of rectangular or beveled unrouted beams, or along the edges of the flanges of box beams.

f. Mineral streaks. Acceptable, providing careful inspection fails to reveal any decay.

TABLE 1-1. Selection and Properties of Aircraft Wood. (See notes following table.) (continued)

2. Defects Not Permitted.

a. Cross grain. Not acceptable, unless within limitations noted in 1a.

b. Wavy, curly, and interlocked grain. Not acceptable, unless within limitations noted in 1b.

c. Hard knots. Not acceptable, unless within limitations noted in 1c.

d. Pin knot clusters. Not acceptable, if they produce large effect on grain direction.

e. Spike knots. These are knots running completely through the depth of a beam perpendicular to the annual rings and appear most frequently in quarter-sawed lumber. Reject wood containing this defect.

f. Pitch pockets. Not acceptable, unless within limitations noted in 1e.

g. Mineral streaks. Not acceptable, if accompanied by decay (see 1f).

h. Checks, shakes, and splits. Checks are longitudinal cracks extending, in general, across the annual rings. Shakes are longitudinal cracks usually between two annual rings. Splits are longitudinal cracks induced by artificially induced stress. Reject wood containing these defects.

i. Compression wood. This defect is very detrimental to strength and is difficult to recognize readily. It is characterized by high specific gravity, has the appearance of an excessive growth of summer wood, and in most species shows little contrast in color between spring wood and summer wood. In doubtful cases reject the material, or subject samples to toughness machine test to establish the quality of the wood. Reject all material containing compression wood.

j. Compression failures. This defect is caused from the wood being overstressed in compression due to natural forces during the growth of the tree, felling trees on rough or irregular ground, or rough handling of logs or lumber. Compression failures are characterized by a buckling of the fibers that appear as streaks on the surface of the piece substantially at right angles to the grain, and vary from pronounced failures to very fine hairlines that require close inspection to detect. Reject wood containing obvious failures. In doubtful cases reject the wood, or make a further inspection in the form of microscopic examination or toughness test, the latter means being the more reliable.

k. Decay. Examine all stains and discoloration carefully to determine whether or not they are harmless, or in a stage of preliminary or advanced decay. All pieces must be free from rot, dote, red heart, purple heart, and all other forms of decay.

fittings and wire bracing and checking or splitting of wood members. A few suggestions for minimizing these shrinkage effects are:

(1) Use bushings that are slightly short so that when the wood member shrinks the bushings do not protrude and the fittings may be tightened firmly against the member.

(2) Gradually drop off plywood faceplates by feathering as shown in figure 1-2.

(3) Thoroughly seal all wood surfaces, particularly end grain and bolt holes, with varnish, epoxy, or other acceptable sealer to slow or prevent moisture changes in the member. (See Section 5. Finishing Wood Structures.)

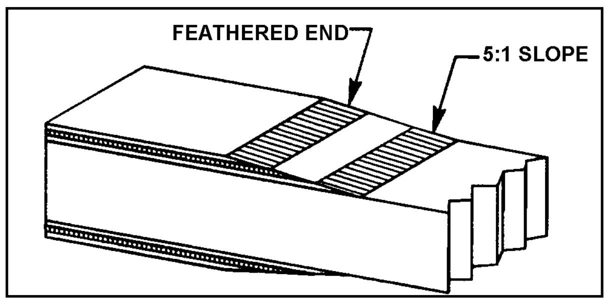


FIGURE 1-2. Tapering of faceplate.

1-3. MODIFIED WOOD PRODUCTS. The most common forms of modified woods found in aircraft construction are plywood. Although not a wood product, Phenolic parts are sometimes incorporated into structures. These products are used whenever the manufacturer requires specialized strength or durability characteristics.

1-4. ADHESIVES. Because of the critical role played by adhesives in aircraft structure, the mechanic must employ only those types of adhesives that meet all of the performance requirements necessary for use in certificated civil aircraft. Use each product strictly in accordance with the aircraft and adhesive manufacturer's instructions.

a. Adhesives acceptable to the FAA can be identified in the following ways:

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

(2) Adhesives meeting the requirements of a Military Specification (Mil Spec), Aerospace Material Specification (AMS), or Technical Standard Order (TSO) for wooden aircraft structures are satisfactory providing they are found to be compatible with existing structural materials in the aircraft and the fabrication methods to be used in the repair.

b. Common types of adhesives that are or have been used in aircraft structure fall into two general groups: casein and synthetic-resins. Adhesive technology continues to evolve, and new types (meeting the requirements of paragraph 1-4a) may become available in the future.

(1) Casein adhesive performance is generally considered inferior to other products available today, modern adhesives should be considered first.

CAUTION: Casein adhesive deteriorates over the years after exposure to moisture in the air and temperature variations. Some modern adhesives are incompatible with casein adhesive. If a joint that has previously been bonded with casein is to be rebonded with another type adhesive, all traces of the casein must be scraped off before the new adhesive is applied. If any casein adhesive is left, residual alkalinity may cause the new adhesive to fail to cure properly.

(2) Synthetic-resin adhesives comprise a broad family which includes plastic resin glue, resorcinol, hot-pressed Phenol, and epoxy.

(3) Plastic resin glue (urea-formaldehyde resin glue) has been used in wood aircraft for many years. Caution should be used due to possible rapid deterioration (more rapidly than wood) of plastic resin glue in hot, moist environments and under cyclic swell-shrink stress. For these reasons, urea-formaldehyde should be considered obsolete for all repairs. Any proposed use of this type adhesive should be discussed with the appropriate FAA office prior to using on certificated aircraft.

(4) Federal Specification MMM-A-181D and Military Specification MIL-A-22397 both describe a required series of tests that verify the chemical and mechanical properties of resorcinol. Resorcinol is the only known adhesive recommended and approved for use in wooden aircraft structure and fully meets necessary strength and durability requirements. Resorcinol adhesive (resorcinol-formaldehyde resin) is a two-part synthetic resin adhesive consisting of resin and a hardener. The appropriate amount of hardener (per manufacturer's instruction) is added to the resin, and it is stirred until it is uniformly mixed; the adhesive is now ready for immediate use. Quality of fit and proper clamping pressure are both critical to the achievement of full joint strength. The adhesive bond lines must be very thin and uniform in order to achieve full joint strength.

CAUTION: Read and observe material safety data. Be sure to follow the manufacturer's instructions regarding mixing, open assembly and close assembly times, and usable temperature ranges.

(5) Phenol-formaldehyde adhesive is commonly used in the manufacturing of aircraft grade plywood. This product is cured at elevated temperature and pressure; therefore, it is not practical for use in structural repair.

(6) Epoxy adhesives are a two-part synthetic resin product, and are acceptable providing they meet the requirements of paragraph 1-4a. Many new epoxy resin systems appear to have excellent working properties. They have been found to be much less critical of joint quality and clamping pressure. They penetrate well into wood and plywood. However, joint durability in the presence of elevated temperature or moisture is inadequate in many epoxies. The epoxy adhesives generally consist of a resin and a hardener that are mixed together in the proportions specified by the manufacturer. Depending on the type of epoxy, pot life may vary from a few minutes to an hour. Cure times vary between products.

CAUTION: Some epoxies may have unacceptable thermal or other hidden characteristics not obvious in a shop test. It is essential that only those products meeting the requirements of paragraph 1-4a be used in aircraft repair. Do not vary the resin-to-hardener ratio in an attempt to alter the cure time. Strength, thermal, and chemical resistance will be adversely affected. Read and observe material safety data. Be sure to follow the adhesive manufacturer's instructions regarding mixing, open and closed curing time, and usable temperature ranges.

1-5. BONDING PRECAUTIONS. Satisfactory bond joints in aircraft will develop the full strength of wood under all conditions of stress. To produce this result, the bonding operation must be carefully controlled to obtain a continuous thin and uniform film of solid adhesive in the joint with adequate adhesion and penetration to both surfaces of the wood. Some of the more important conditions involve:

a. Properly prepared wood surfaces.

b. Adhesive of good quality, properly prepared, and properly selected for the task at hand.

c. Good bonding technique, consistent with the adhesive manufacturer's instructions for the specific application.

1-6. PREPARATION OF WOOD SURFACES FOR BONDING. It is recommended that no more time than necessary be permitted to elapse between final surfacing and bonding. Keep prepared surfaces covered with a clean plastic sheet or other material to maintain cleanliness prior to the bonding operation. The mating surfaces should be machined smooth and true with planers, joiners, or special miter saws. Planer marks, chipped or loosened grain, and other surface irregularities are not permitted. Sandpaper must never be used to smooth softwood surfaces that are to be bonded. Sawn surfaces must approach well-planed surfaces in uniformity, smoothness, and freedom from crushed fibers. It is advisable to clean both joint surfaces with a vacuum cleaner just prior to adhesive application. Wood surfaces ready for bonding must be free from oil, wax, varnish, shellac, lacquer, enamel, dope, sealers, paint, dust, dirt, adhesive, crayon marks, and other extraneous materials.

a. Roughening smooth, well-planed surfaces of normal wood before bonding is not recommended. Such treatment of well-planed wood surfaces may result in local irregularities and objectionable rounding of edges. When surfaces cannot be freshly machined before bonding, such as plywood or inaccessible members, very slight sanding of the surface with a fine grit such as 220, greatly improves penetration by the adhesive of aged or polished surfaces. Sanding should never be continued to the extent that it alters the flatness of the surface. Very light sanding may also improve the wetting of the adhesive to very hard or resinous materials.

b. Wetting tests are useful as a means of detecting the presence of wax, old adhesive, and finish. A drop of water placed on a surface that is difficult to wet and thus difficult to bond will not spread or wet the wood rapidly (in seconds or minutes). The surface may be difficult to wet due to the presence of wax, exposure of the surface to heat and pressure as in the manufacture of hot press bonded plywood, the presence of synthetic resins or wood extractives, or simply chemical or physical changes in the wood surface with time. Good wettability is only an indication that a surface can be bonded satisfactorily. After performing wetting tests, allow adequate time for wood to dry before bonding. Preliminary bonding tests and tests for bond strength are the only positive means of actually determining the bonding characteristics of the adhesive and material combinations. (See paragraph 1-29h.)

1-7. APPLYING THE ADHESIVE. To make a satisfactory bonded joint, spread the adhesive in a thin, even layer on both surfaces to be joined. It is recommended that a clean brush be used and care taken to see that all surfaces are covered. Spreading of adhesive on only one of the two surfaces is not recommended. Be sure to read and follow the adhesive manufacturer's application instructions.

1-8. ASSEMBLY TIME IN BONDING. Resorcinol, epoxy, and other adhesives cure as a result of a chemical reaction. Time is an important consideration in the bonding process. Specific time constraints are as follows:

a. Pot life is the usable life of the adhesive from the time that it is mixed until it must be spread onto the wood surface. Once pot life has expired, the remaining adhesive must be discarded. Do not add thinning agents to the adhesive to extend the life of the batch.

b. Open assembly time is the period from the moment the adhesive is spread until the parts are clamped together. Where surfaces are coated and exposed freely to the air, some adhesives experience a much more rapid change in consistency than when the parts are laid together as soon as the spreading has been completed.

c. Closed assembly time is the period from the moment that the structure parts are placed together until clamping pressure is applied. The consistency of the adhesive does not change as rapidly when the parts are laid together.

d. Pressing (or clamping) time is the period during which the parts are pressed tightly together and the adhesive cures. The pressing time must be sufficient to ensure that joint strength is adequate before handling or machining the bonded structure.

NOTE: Follow the adhesive manufacturer's instructions for all time limits in the bonding process. If the recommended open or closed assembly periods are exceeded, the bond process should not be continued. Discard the parts if feasible. If the parts cannot be discarded, remove the partially cured adhesive and clean the bond line per adhesive manufacturer's instructions before application of new adhesive.

1-9. BONDING TEMPERATURE. Temperature of the bond line affects the cure rate of the adhesive. Some adhesive types, such as resorcinol, require a minimum temperature which must be maintained throughout the curing process. Each type of adhesive requires a specific temperature during the cure cycle, and the manufacturer's recommendations should be followed.

1-10. CLAMPING PRESSURE.

a. Use the recommended pressure to squeeze adhesive out into a thin, continuous film between the wood layers. This forces air from the joint and brings the wood surfaces into intimate contact. Pressure should be applied to the joint before the adhesive becomes too thick to flow and is accomplished by means of clamps, presses, or other mechanical devices.

b. Nonuniform clamping pressure commonly results in weak and strong areas in the same joint. The amount of pressure required to produce strong joints in aircraft assembly operations varies with the type of adhesive used and the type of wood to be bonded. Typical pressures when using resorcinol may vary from 125 to 150 pounds per square inch for softwoods and 150 to 200 pounds per square inch for hardwoods. Insufficient pressure or poorly machined wood surfaces usually result in thick bond lines, which indicate a weak joint, and should be carefully guarded against. Some epoxy adhesives require much less clamping pressure to produce acceptable joint strength. Be sure to read and follow the manufacturer's instructions in all cases.

1-11. METHOD OF APPLYING PRESSURE. The methods of applying pressure to joints in aircraft bonding operations range from the use of brads, nails, small screws, and clamps; to the use of hydraulic and electrical power presses. The selection of appropriate clamping means is important to achieving sound bond joints.

a. Hand nailing is used rather extensively in the bonding of ribs and in the application of plywood skins to the wing, control surfaces, and fuselage frames. Small brass screws may also be used advantageously when the particular parts to be bonded are relatively small and do not allow application of pressure by means of clamps. Both nails and screws produce adverse after effects. There is considerable risk of splitting small parts when installing nails or screws. Metal fasteners also provide vulnerable points for moisture to enter during service.

b. On small joints using thin plywood for gussets or where plywood is used as an outer skin, the pressure is usually applied by nailing or stapling. Thin plywood nailing strips are often used to spread the nailing pressure over a larger area and to facilitate removal of the nails after the adhesive has cured.

c. The size of the nails must vary with the size of the members. If multiple rows of nails are required, the nails should be 1 inch apart in rows spaced 1/2 inch apart. The nails in adjacent rows should be staggered. In no case should the nails in adjacent rows be more than 3/4 inch from the nearest nail. The length of the nails should be such that they penetrate the wood below the joint at least 3/8 inch. In the case of small members, the end of the nail should not protrude through the member below the joint. Hit the nails with several light strokes, just seating the head into the surface of the gusset. Be careful not to crush the wood with a heavy hammer blow.

d. In some cases the nails are removed after adhesive cure, while in others the nails are left in place. The nails are employed for clamping pressure during adhesive cure and must not be expected to hold members together in service. In deciding whether to re move nails after assembly, the mechanic should examine adjacent structure to see whether nails remain from original manufacture.

e. On larger members (spar repairs for example), apply pressure by means of screw clamps, such as a cabinet-maker's bar or "C-clamps." Strips or blocks should be used to distribute clamping pressure and protect members from local crushing due to the limited pressure area of the clamps, especially when one member is thin (such as plywood). The strip or block should be at least twice as thick as the thinner member being bonded.

f. Immediately after clamping or nailing a member, the mechanic must examine the entire joint to assure uniform part contact and adhesive squeeze-out. Wipe away excess adhesive.

1-12.—1-17. [RESERVED.]

SECTION 2. HEALTH AND SAFETY

1-18. GENERAL. The possibility of an injury is an important consideration when working with wooden aircraft structures. The tools and machines used to shape wooden members can be very dangerous. In addition, there are potential health hazards in working with adhesives and finishes. The mechanic should follow manufacturer's instructions wherever applicable to prevent injury. Federal law mandates that individual chemical manufacturers are to provide Material Safety Data Sheets (MSDS) with health hazard data to all consumers. First aid information and handling precautions must also be identified. Most of the products used in wooden aircraft construction are flammable. Some, such as dope and paint, may be highly flammable.

1-19. SANDING IN AREAS OF EXISTING BOND JOINTS AND FINISHES. Some adhesives used in wooden aircraft construction contain biocides. A commonsense precaution when machining or sanding existing structure is to wear a respirator to avoid inhaling dust products. To lower potential fire hazards avoid using electric sanders around dope, paints, and adhesives.

1-20. HANDLING OF ADHESIVES AND FINISHES. Most adhesives and finish products present at least some toxic potential to users. Injury may occur from skin or eye contact, inhalation, or accidental ingestion. Users should be aware of the manufacturer's instructions and MSDS.

a. Appropriate skin, eye, ear, and respiratory protection should be worn whenever indicated.

b. Shop cleanliness is essential for health and fire safety.

c. Shop personnel should maintain awareness of others in the work area to assure that bystanders are not injured.

d. Proper shop ventilation is essential to disperse fumes emitted from adhesives such as resorcinol and epoxy.

1-21.—1-26. [RESERVED.]

SECTION 3. INSPECTION

1-27. GENERAL. Inspection of wooden structure includes some methods, equipment, and awareness of failure modes which are unique to wooden aircraft.

1-28. TYPES OF DETERIORATION AND DAMAGE.

a. Wood Decay. Wood is an organic product which is subject to attack by fungi. Fungi are plants that grow on and in wood. The moisture content of the wood nominally will have to be 20 percent or greater to sustain fungus growth. The result of this growth is called decay. Decayed wood exhibits softness, swelling if still wet, excessive shrinkage when dry, cracking, and discoloration. Repair or replace wood if any amount or form of decay is found.

b. Splitting. Splits or cracks in wooden members occur along grain lines. When the moisture content of wood is lowered, its dimensions decrease. The dimensional change is greatest in a tangential direction (across the fibers and parallel to the growth rings), somewhat less in a radial direction (across the fibers and perpendicular to the growth rings), and is negligible in a longitudinal direction (parallel to the fibers). These dimensional changes can have detrimental effects upon a wood structure, particularly when two parts are bonded together with grains in different directions. This effect can often be seen where a plywood doubler is bonded to a spruce member. As the spruce member dries, it attempts to shrink, but is restrained by the plywood, which shrinks less. The resulting stress in the spruce member exceeds its cross-grain strength, and a split occurs.

c. Bond Failure. Bond joint failure is generally due to improper fabrication technique or prolonged exposure to moisture in service. Although none of the older adhesives have been specifically found to fail by simple aging, the mechanic is advised to inspect all accessible joints carefully.

d. Finish Failure. The finish coat on wood structure (usually varnish) is the last line of defense to prevent water entry into wood and the resulting decay. Finish failure can be the result of prolonged water exposure, wood splitting, ultraviolet light exposure, or surface abrasion.

e. Damage. Stress, impact, or mechanical damage to a wood structure is caused by excessive aerodynamic loads or impact loads occurring while the aircraft is on the ground. Overtightening of fittings can also cause crushing of the underlying wood member and possible bending of the metal fitting.

1-29. INSPECTION METHODS. Whenever possible, the aircraft should be kept in a dry, well-ventilated hangar, with all inspection covers, access panels, etc., removed for as long as possible before final inspection. The aircraft should be given a preliminary inspection when first removing the inspection covers and access panels and inspected with a moisture meter at this time. If the moisture content is high, the aircraft should be thoroughly dried. If the aircraft is dry, this will facilitate later inspection, especially when determining the condition of bonded joints.

a. Likely locations for wood structure deterioration should be given special attention. Most damage is caused by external influence such as moisture, temperature extremes, or sunlight. Care should be taken to note all possible entry points for moisture, (i.e., cracks or breaks in the finish, fastener holes, inspection/access openings, control system openings, drain holes, and the interfaces of metal fittings and the wood structure). The mechanic should also look for evidence of swelling or warpage of the aircraft's wood structure, which would indicate underlying damage or decay. Particular attention should be paid to the wood structure immediately beneath the upper surfaces, especially under areas that are finished in dark colors, for signs of deteriorating adhesives. Cracks in wood spars are often hidden under metal fittings or metal rib flanges and leading edge skins. Any time a reinforcement plate exists that is not feathered out on its ends, a stress riser exists at the ends of the plate. A failure of the primary structure can be expected to occur at this point.

b. Tapping the wood structure with a light plastic hammer or screwdriver handle should produce a sharp solid report. If the suspect area sounds hollow and soft, further inspection is warranted by the following methods.

c. Probe the area in question, if accessible, with a sharp metal tool. The wood structure should be solid and firm. If the suspect area feels soft and mushy the mechanic should assume that the area is rotted. Disassembly of the structure is warranted at this point.

d. Prying the area of a bond joint will reveal any mechanical separation of the joint. If the mechanic detects any relative movement between two adjacent wood members, a failure of the bond is evident. Any loose fittings should arouse the mechanic's suspicion, and the fittings should be removed to check for elongated bolt holes. Disassembly is warranted for further inspection.

e. Odor is an important indicator of possible deterioration. During the initial inspection, as the access panels are being removed from the structure, the mechanic should be aware of any areas that smell musty or moldy. These odors are indicative of the presence of moisture and associated fungal growth and decay.

f. Visual inspection requires looking at the wood structure both externally and internally for visual signs of decay or physical damage. Any accumulations of dirt, bird nests, or rodent nests are likely places to hold moisture and promote decay.

(1) The mechanic should remove any such accumulations that are found and inspect the area for signs of decay. Decay will appear as a dark discoloration or gray stains running along the grain and often a swelling of the wood member if still wet. Fittings will be imbedded in the wood instead of flush.

(2) Highly suspected structurally damaged areas are shown in figure 1-3. A list of most likely areas to incur structural damage include the following:

(a) Check front and rear spars for compression cracks adjacent to the plywood reinforcing plates, where the lift struts attach, and at the rib attach points on either side of the strut attach points. Triple-check these areas and the spar to fuselage attach points for cracks if the wingtip has contacted the ground, a hangar wall, etc.

(b) Check all metal fittings which attach to wooden structure for looseness, corrosion, cracks, or warps. Areas of particular interest are strut attach fittings, spar butt fittings, aileron and flap hinges, jury strut fittings, compression struts, pulley brackets, and any landing gear fittings.

(c) Check front and rear spars for longitudinal cracks at the ends of the plywood reinforcement plates where the lift struts attach. Triple-check this area if the wing has encountered any kind of ground strike.

(d) Check ribs on either side of strut attach points for missing or loose rib-to-spar attach nails.

(e) Check ribs on either side of strut attach points for cracks where the cap strips pass over and under the spars.

(f) Check for cracked leading edge skin and/or failed nose ribs in the area directly in front of the jury strut.

(g) Check the brackets which attach the struts to the spars for cracks.

(h) Check the aileron, flap hinge, and hinge brackets for cracks and loose or missing rivets.

(i) Check all exposed end grain wood, particularly the spar butts, for cracking or checking. Checking, or splitting, of wood spar butts is common on aircraft based in arid areas.

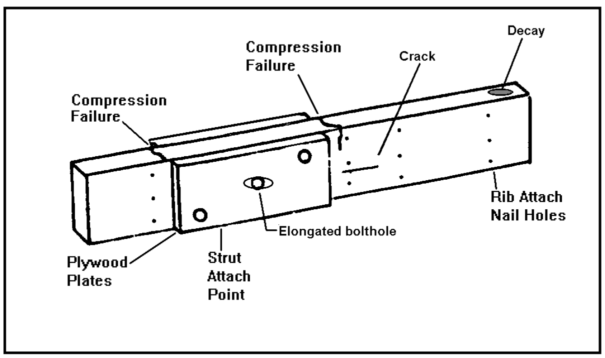


FIGURE 1-3. Likely areas to incur structural damage.

(j) Also check for any cracks that indicate a bond line failure or structural failure of the wood member. Any evidence of movement of fittings, bushings, or fasteners should be cause for concern, and further inspection is warranted. Splits in fabric covering the plywood, especially on upper surfaces exposed to ultraviolet light and water, dictate that the mechanic remove the fabric around the split so the underlying plywood may be inspected for physical damage or decay. When removing metal fasteners from wood, check for evidence of corrosion. Any corrosion present indicates the presence of moisture and the strong probability of decay in the adjoining wood structure.

(k) Any wooden member that has been overstressed is subject to compression failure (e.g., ground loop). Compression cracking and failure of the wood spars in certain aircraft are a continuing problem. Compression failures are defined as failure of wood fibers on a plane perpendicular to the wood fiber's longitudinal axis. If undetected, compression failures may result in structural failure of the wing during flight. Compression cracks have been found emanating from the upper surfaces of the wing spars and progressing downward.

(l) The usual locations for cracks have been the front spar at both ends of the reinforcement plate for the lift strut and the front spar rib attach points, both inboard and outboard of the spar reinforcement plate; and the rear spar lift strut and rib attach points. An inspection of both the front and rear spars for compression cracks is recommended.

(m) The two areas where it is possible to identify a compression crack are on the face and top surface of the spar. Using a borescope through existing inspection holes is one method of inspection. An alternate method is to cut inspection holes in the skin. If inspection holes are cut, they should be made on the aft side of the front spar and the forward side of the rear spar. This will allow the fabric to be peeled away from the spar. Longitudinal cracks may also be detected during this inspection. Loose or missing rib nails may indicate further damage and should be thoroughly investigated. The mechanic may shine a light, at a low angle and parallel with the grain, in the area of the member subjected to the compression load. An area of grain waviness would indicate a potential compression failure. In all cases the manufacturer's inspection data should be followed.

g. Moisture Meters are effective tools for detection of excessive moisture content in wood members. An instrument such as this allows the mechanic to insert a probe into the wood member and read its moisture content directly off the meter. A correction chart usually accompanies the instrument to correct for temperature and species of wood. Any reading over 20 percent indicates the probability of fungus growth in the member. Moisture content of the wood should be 8-16 percent, preferably in the 10-12 percent range (this range is during inspection). Where plywood skin covers the spar and the spar would be inaccessible without removing the skin, the moisture meter probe can be inserted through the plywood skin and into the spar to check the moisture content of the spar. The small holes made by the probe are easily sealed.

h. Destructive testing of sample bonded joints whenever a new bond joint is made, a sample joint should be made with the adhesive from the same batch used on the repair and scraps of wood left over from the repair. After curing, the sample joint should be destructively tested to ensure proper bonding of the two wood pieces. Any failure in the bond line indicates a cohesive failure of the adhesive. Any failure along the bond line indicates an adhesive failure, which is indicative of poor bonding. The ideal situation is when wood fibers are observed on both sides of the fracture surface. This indicates a failure in the wood, and indicates the bond joint is actually stronger than the wood.

1-30.—1-35. [RESERVED.]

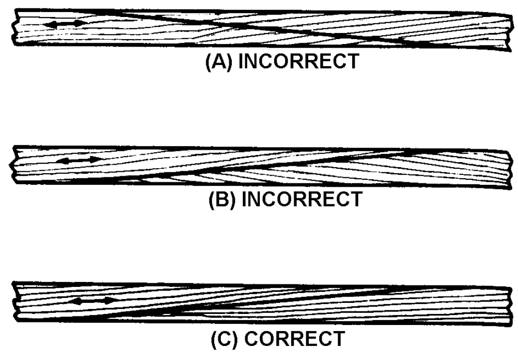
SECTION 4. REPAIRS

1-36. GENERAL. The basic standard for any aircraft repair is that the repaired structure must be as strong as the original structure and be equivalent to the original in rigidity and aerodynamic shape. Repairs should be made in accordance with manufacturer specifications whenever such data is available.

1-37. REPLACEMENT OF DRAIN HOLES AND SKIN STIFFENERS. Whenever repairs are made that require replacing a portion that includes drain holes, skin stiffeners, or any other items, the repaired portion must be provided with similar drain holes, skin stiffeners, or items of the same dimensions in the same location. Additional drain holes may be required if reinforcement under a skin repair interferes with waterflow to existing drain holes. Make any additional drain holes the same diameter as originals, usually 1/4 inch.

1-38. CONTROL SURFACE FLUTTER PRECAUTIONS. When repairing or refinishing control surfaces, especially on high-performance airplanes, care must be exercised that the repairs do not involve the addition of weight aft of the hinge line. Such a procedure may adversely affect the balance of the surface to a degree that could induce flutter. As a general rule, it will be necessary to repair control surfaces in such a manner that the structure is identical to the original, and that the stiffness, weight distribution, and mass balance are not affected in any way. Consult the aircraft maintenance manual or seek manufacturer's direction for specific requirements on checking control surface balance after repair and refinishing of any control surface.

1-39. SCARF JOINTS. The scarf joint is the most satisfactory method of making an end joint between two solid wood members. Cut both parts accurately. The strength of the joints depends upon good joint design and a thin, uniform bond line. Make the scarf cut in the general direction of the grain slope as shown in figure 1-4.



No grain deviation steeper than 1 in 15 should be present in an outer eighth of the depth of the spar. In adjacent eighths, deviations involving steeper slopes, such as a wave in a few growth layers, are unlikely to be harmful. Local grain slope deviations in excess of those specified may be permitted in spar flanges only in the inner one-fourth of the flange depth.

FIGURE 1-4. Consideration of grain direction when making scarf joints.

1-40. SPLICING OF SPARS. Unless otherwise specified by the manufacturer, a spar may be spliced at any point except under the wing attachment fittings, landing gear fittings, engine mount fittings, or lift and interplane strut fittings. These fittings may not overlap any part of the splice. A spar splice repair should not be made adjacent to a previous splice or adjacent to a reinforcing plate. Spacing between two splices or between a splice and a reinforcing plate should be no less than three times the length of the longer splice.

Splicing under minor fittings such as drag wire, antidrag wire, or compression strut fittings is acceptable under the following conditions:

a. The reinforcement plates of the splice should not interfere with the proper attachment or alignment of the fittings. Do not alter the locations of pulley support brackets, bellcrank support brackets, or control surface support brackets. Plates are to be tapered off, as depicted in figure 1-2.

b. The reinforcement plate may overlap drag wire, antidrag wire, or compression strut fittings, if the reinforcement plates are on the rear face of the rear spar or the front face of the front spar. In such cases, it will be necessary to install slightly longer bolts. The front face reinforcement plate should not overlap drag strut fittings, except when it does not require sufficient shortening of compression struts or changes in drag-truss geometry, to prevent adjustment for proper rigging. Even though take up is sufficient, it may be necessary to change the angles on the fittings. (Acceptable methods for splicing the various types of spars are shown in figure 1-4 through figure 1-9.) Reinforcement plates must be used as indicated on all scarf repairs to spars and the slopes of scarves shown are minimum slopes.

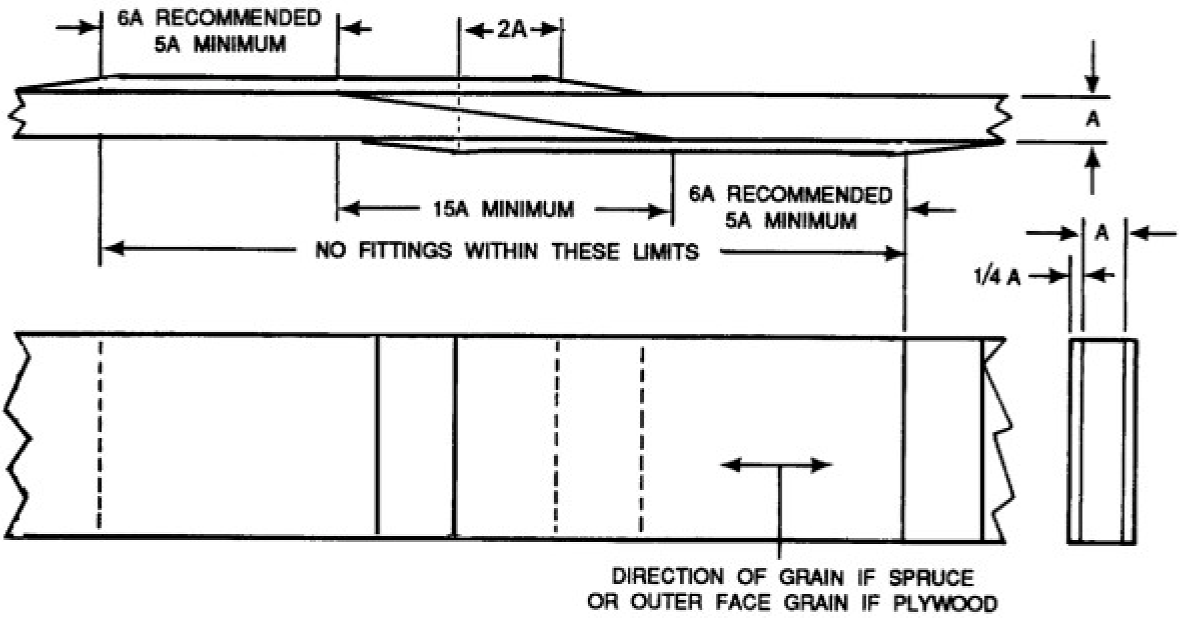
1-41. SPAR REPLACEMENT. Replacement of spars is a major repair. Spars may be replaced by new parts made by the manufacturer or the holder of a Parts Manufacturer Approval (PMA) for that part. Owner-produced spars may be installed providing they are made from a manufacturer-approved drawing. Also, a spar may be made by reference to an existing spar providing sufficient evidence is presented to verify that the existing spar is an original part, and that all materials and dimensions can be determined. The dimensions and type of wood used are critical to the structural strength of the aircraft. Care should be taken that any replacement spars accurately match the manufacturer's original design.

1-42. SPLICING OF BOX SPAR WEBS. Always splice and reinforce plywood webs with the same type of plywood as found on the original part. Do not use solid wood to replace plywood webs. Plywood is stronger in shear than solid wood of the same thickness due to the grain direction of the individual plies. The face-grain of plywood replacement webs and reinforcement plates must be in the same direction as the original member to ensure that the new web will have the required strength. (The method of splicing plywood webs is shown in figure 1-9.)

1-43. REPLACING SOLID-TYPE SPARS WITH LAMINATED-TYPE SPARS. Solid spars may be replaced with laminated spars or vice versa, provided the material is of the same high quality. External reinforcements (plywood or solid) must always be replaced as on the original member.

1-44. SPAR LONGITUDINAL CRACKS AND LOCAL DAMAGE. Cracked spars (except box spars) may be repaired by bonding plates of spruce or plywood of sufficient thickness to develop the longitudinal shear on both sides of the spar. Extend the plates well beyond the termination of the cracks, as shown in figure 1-10. A method of repairing small local damage to either the top or bottom side of a spar is also shown in figure 1-10.

a. Longitudinal Cracking of Wood Wing Spars of Aircraft Operating in Arid Regions. Aircraft having wood spars and operating in arid regions may develop longitudinal spar cracks in the vicinity of the plywood reinforcement plates. These cracks result from the tendency of the spar to shrink when drying takes place. Plywood resists this tendency to

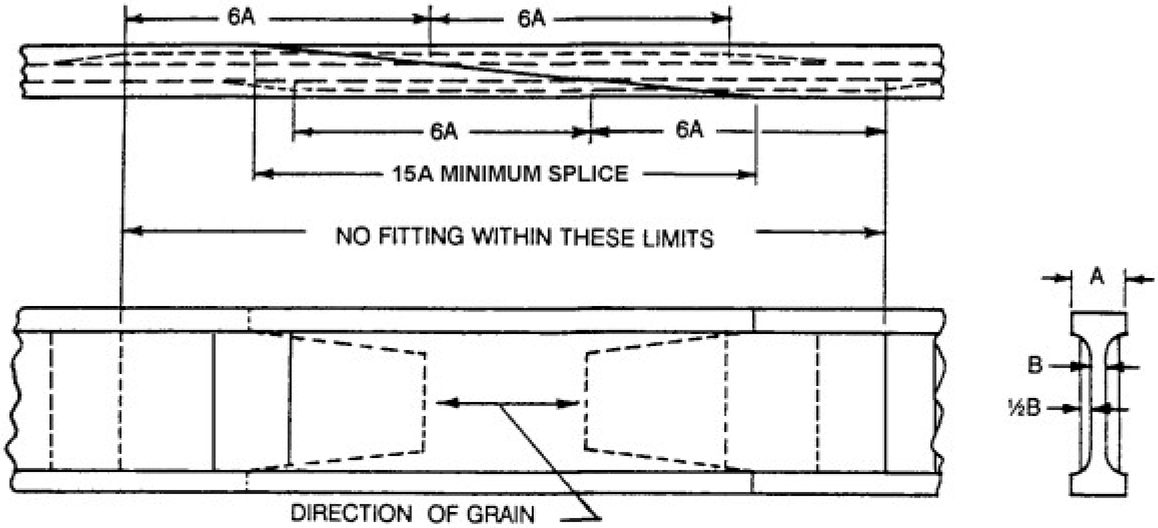


Reinforcement plates to be spruce or plywood and should be bonded only, with the ends feathered off at 5:1 slope as depicted in Figure 1-2. Solid spars may be replaced with laminated spars or vice versa, provided the material is of the same high quality.

FIGURE 1-5. Method of splicing solid or laminated rectangular spars.

shrink and causes the basic spar stock to split (see paragraph 1-2c). Cracks start under the plywood plates, usually (but not necessarily) at a bolt hole or cutout, and usually spread in each direction until they extend a short distance beyond the ends of the plates where the resistance to spar shrinkage disappears. Cracks have also been found in the butt end of spars. Other factors, which have been found conducive to the formation of cracks are poor protective finishes, large cutouts, and metal fittings that utilize two lines of large diameter bolts.

b. Repairing Cracks Versus Installing a New Spar. The presence of cracks does not necessarily mean that the spar must be discarded. If the crack is not too long or too close to either edge and can be reinforced properly, it will probably be more economical and satisfactory to perform repair rather than install a new spar or section. However, a generally acceptable procedure suitable for all airplane models is not available. Because of the possibility of strength deficiencies contact the manufacturer. In absence of the manufacturer, the FAA should be contacted for approval before making repairs not in accordance with the manufacturer-approved instructions or the recommendations of this advisory circular. Longitudinal cracking or the recurrence of cracking can be minimized by ensuring that the moisture content of the solid wood portion is within the proper range before bonding**.** In arid desert areas, during bonding the moisture content should be in the range of 6-8 percent before bonding, but in other areas 10-12 percent is satisfactory. If solid or plywood repair stock is procured from another climatic region, it should be allowed to season, If splice is made where routing is feathered to full width of spar, tapered plates (conforming to the contour of the routing) should be added first; otherwise, the splice is the same as shown.



Reinforcement plates may be of plywood, the same material as the spar, or material of equal or higher quality; and should be bonded only with ends feathered out with a 5:1 slope.

FIGURE 1-6. Method of splicing solid "I" spars.

in the same storage area as the part to be repaired, for no less than 2 weeks.

c. Preventing Cracks. An important step in the prevention of longitudinal cracking, particularly in spar butts, is to ensure that the wood is thoroughly sealed with a penetrating and highly moisture-resistant finish. Application of a thin, slow-curing epoxy adhesive or sealer can be very effective in slowing or preventing moisture changes in spar butts.

1-45. ELONGATED HOLES IN SPARS. In cases of elongated bolt holes in a spar, or cracks in the vicinity of bolt holes, splice in a new section of spar, or replace the spar entirely. If hole elongation or cracking is minimal and the bolt holes are for noncritical fittings, repair (rather than replacement) may be feasible. Obtain approval for any such repair from the manufacturer or a representative of the FAA. In many cases, it has been found advantageous to laminate the new section of the spar, particularly if the spar butts are being replaced.

1-46. RIB REPAIRS. Ribs may be replaced by new parts made by the manufacturer or the holder of a PMA for that part. Owner-produced ribs may be installed providing they are made from a manufacturer-approved drawing or by reference to an existing original rib. A rib may be made by reference to an existing rib providing sufficient evidence is presented to verify that the existing rib is an original part and that all materials and dimensions can be determined. The contour of the rib is important to the safe flying qualities of the aircraft, and care should be taken that any replacement ribs accurately match the manufacturer's original design.

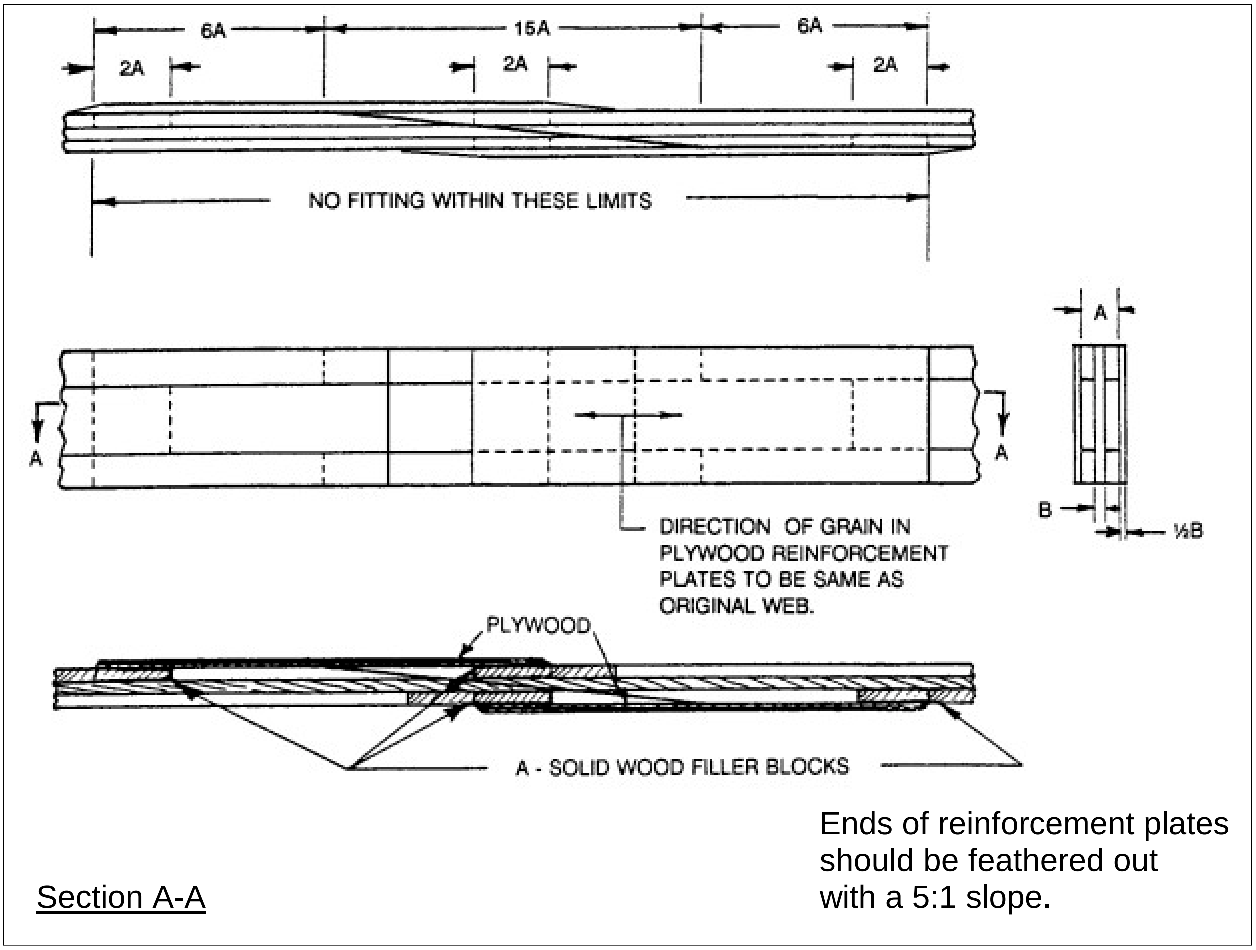


FIGURE 1-7. Repairs to built-up "I" spar.

a. Rib Repair Methods. Acceptable methods of repairing damaged ribs are shown in figure 1-11. Wood ribs should not be nailed to wood spars by driving nails through the rib cap strips, as this weakens the rib materially. The attachment should be by means of adhesive with cement coated, barbed, or spiraled nails driven through the vertical rib members on each face of the spar.

b. Compression Rib Repair. Acceptable methods of repairing damaged compression ribs are shown in figure 1-12.

(1) Figure 1-12(A) illustrates the repair of a compression rib of the "I" section type; i.e., wide, shallow cap strips, and a center plywood web with a rectangular compression member on each side of the web. The rib is assumed to be cracked through the cap strips, web member, and compression member in the illustration. Cut the compression member as shown in figure 1-12(D). Cut and replace the aft portion of the cap strips, and reinforce as shown in figure 1-11. The plywood side plates are bonded on, as indicated in figure 1-12(A). These plates are added to reinforce the damaged web.

(2) Figure 1-12(B) illustrates a compression rib of the type that is basically a standard rib with rectangular compression members added to one side and plywood web to the other side. The method used in this repair is essentially the same as in figure 1-12(A) except that the plywood reinforcement plate,

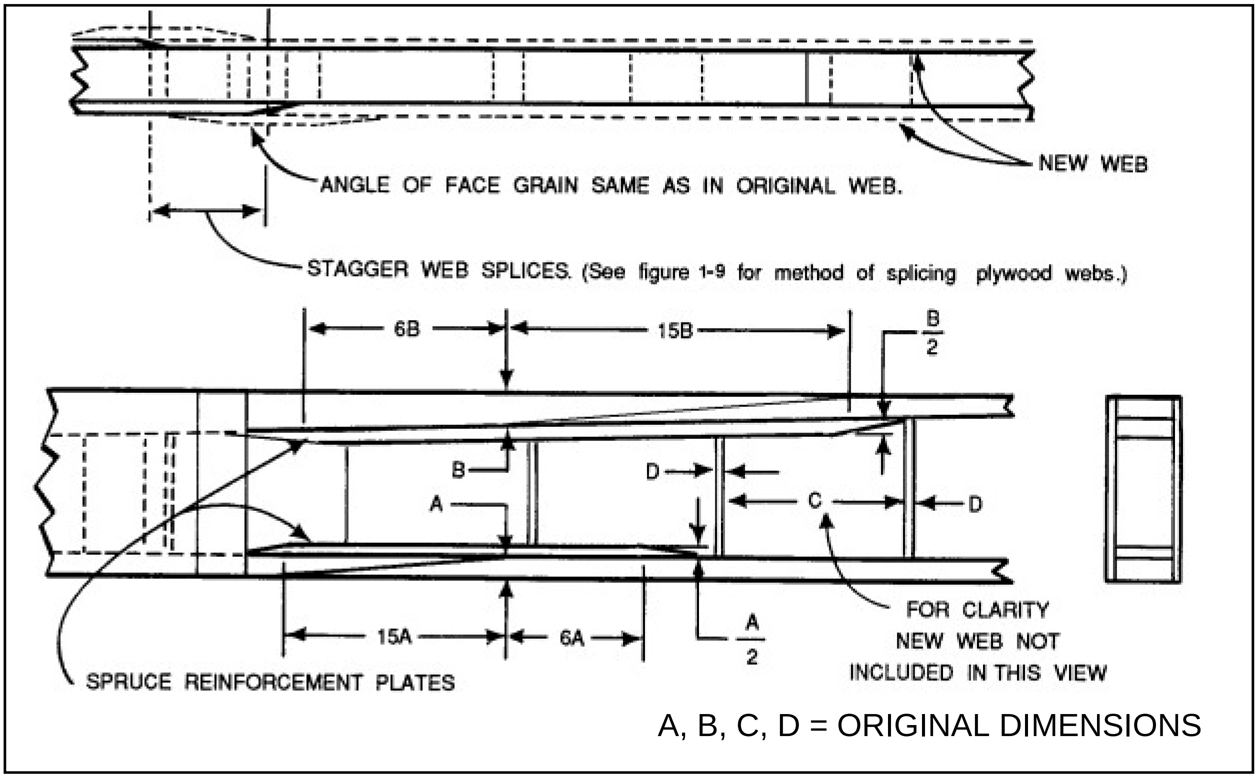


FIGURE 1-8. Method of splicing box spar flanges (plate method).

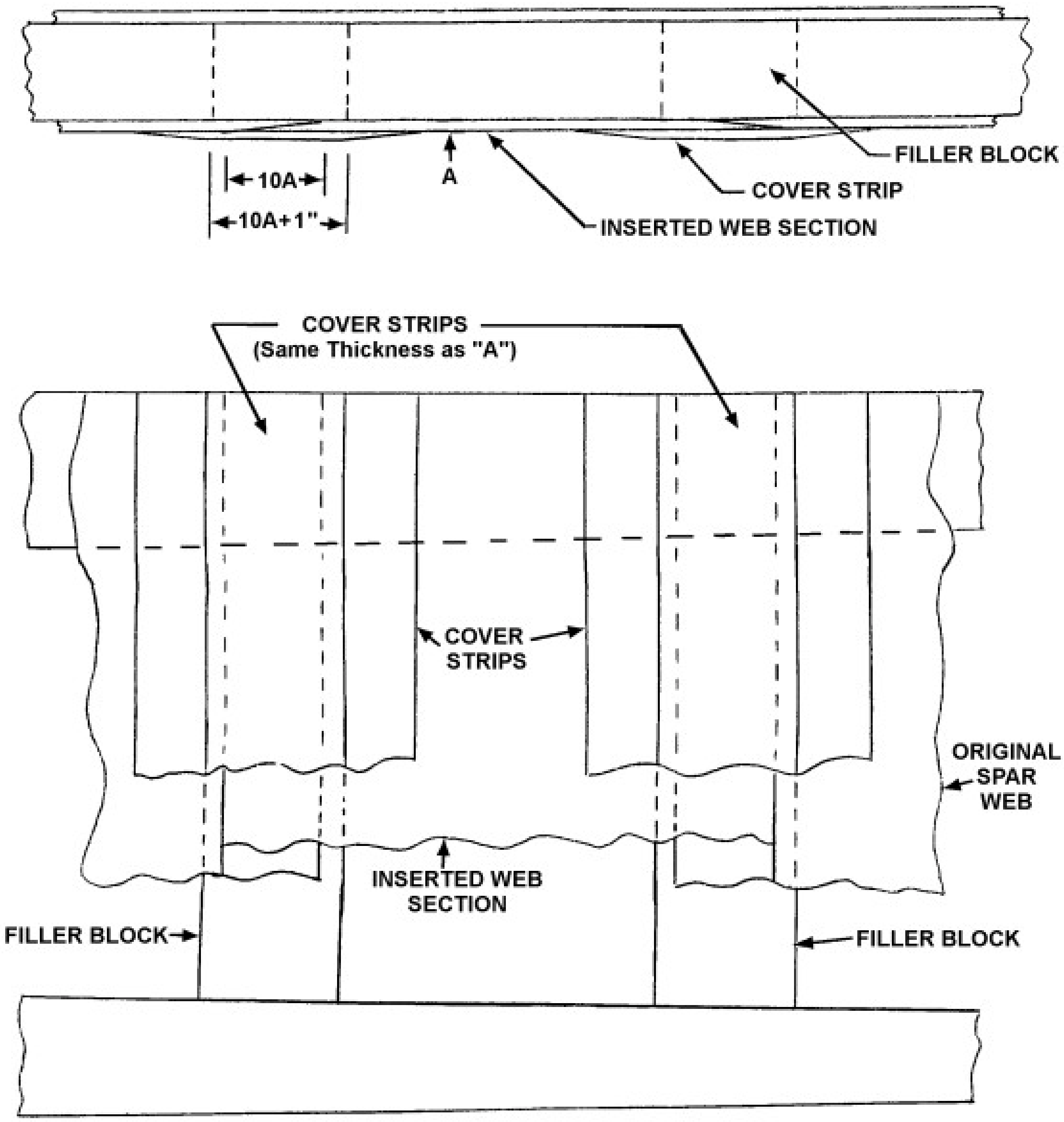
shown in section B-B, is continued the full distance between spars.

(3) Figure 1-12(C) illustrates a compression rib of the "I" type with a rectangular vertical member on each side of the web. The method of repair is essentially the same as in figure 1-12(A) except the plywood reinforcement plates on each side, shown as striped blocks in section C-C, are continued the full distance between spars.

1-47. PLYWOOD SKIN REPAIR. Make extensive repairs to damaged stressed skin plywood structures in accordance with specific recommendations from the aircraft manufacturer. It is recommended that repairs be made by replacing the entire panel, from one structural member to the next, if damage is very extensive. When damaged plywood skin is repaired, carefully inspect the adjacent internal structure for possible hidden damage. Repair any defective frame members prior to making skin repairs.

1-48. DETERMINATION OF SINGLE OR DOUBLE CURVATURE. Much of the outside surface of plywood aircraft is curved. On such areas, plywood used for repairs to the skin must be similarly curved. Curved skins are either of single curvature or of double (compound) curvature. A simple test to determine which type of curvature exists may be made by laying a sheet of heavy paper on the surface in question. If the sheet can be made to conform to the surface without wrinkling, the surface is either flat or single curvature. If the sheet cannot be made to conform to the surface without wrinkling, the surface is of double curvature.

1-49. REPAIRS TO SINGLE CURVATURE PLYWOOD SKIN. Repairs to single curvature plywood skin may usually be formed from flat plywood, either by bending it dry or after soaking it in hot water. The degree of curvature to which a piece of plywood can be bent will depend upon the direction of the grain and the thickness. Table 1-2 is a guide



1. AFTER INSERTED WEB HAS BEEN BONDED IN PLACE, BOND COVER STRIPS OVER ENTIRE LENGTH OF WEB SPLICE JOINTS.
2. SECTIONAL SHAPE OF FILLER BLOCKS MUST CONFORM EXACTLY TO TAPER OF SPAR. THEY MUST NOT BE TOO TIGHTLY FITTED, FOR WEDGING ACTION WILL LOOSEN EXISTING BONDS OF WEBS TO FLANGES. IF TOO LOOSELY FITTED, CRUSHING OF WEB WILL OCCUR WHEN CLAMPING.
3. DIRECTION OF FACE GRAIN OF INSERTED WEB SECTION AND COVER STRIPS TO BE SAME AS ORIGINAL WEB.

FIGURE 1-9. Method of splicing box spar webs.

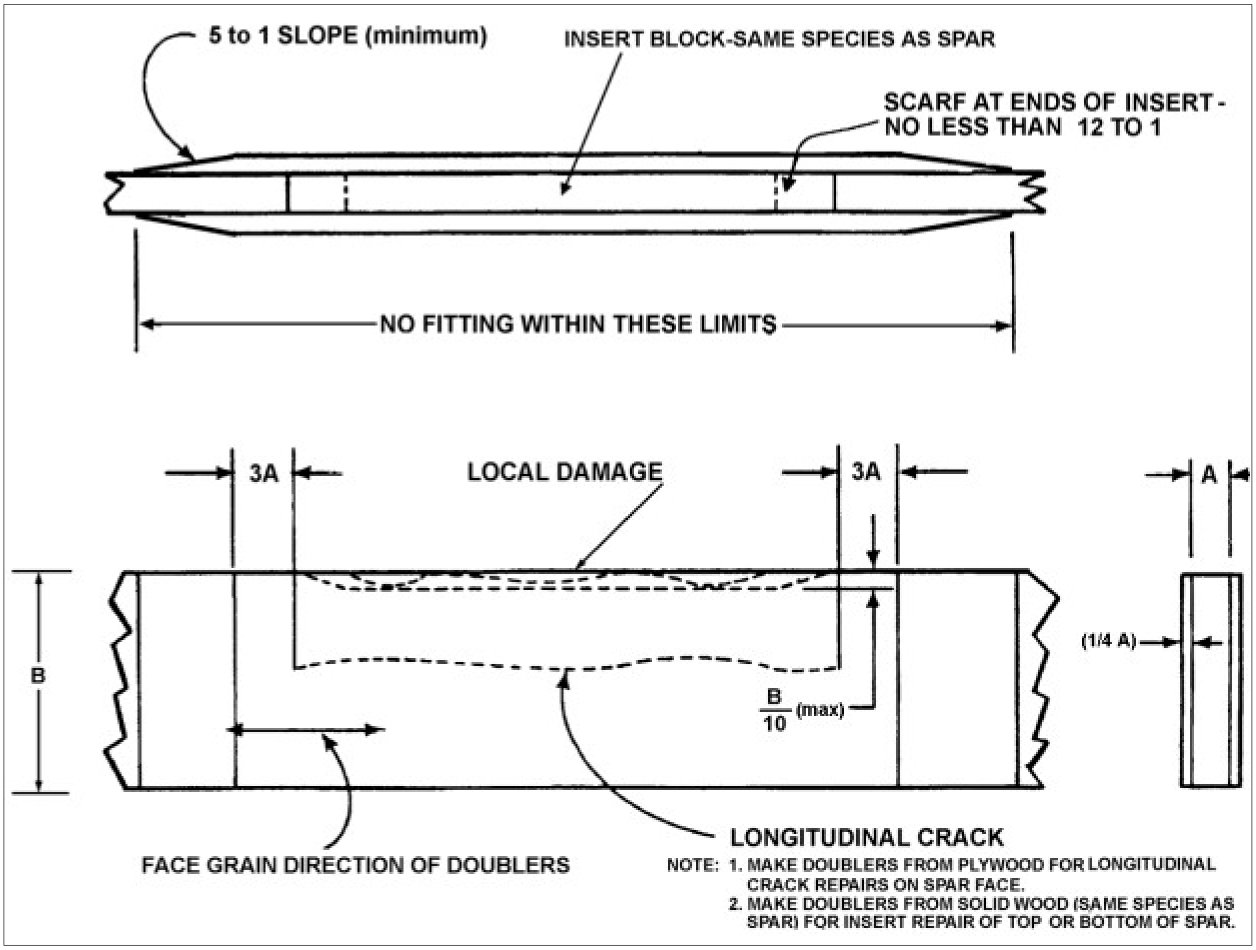


FIGURE 1-10. Method of reinforcing a longitudinal crack and/or local damage in a solid spar.

for determining which process of bending should be used for the curvature being considered.

a. Plywood, after softening, may be bent on a cold ventilated form, or it may be bent over the leading edge near the area being patched if space permits. In either method the repair part should be allowed to dry completely on the form. When bending plywood over a leading edge, drying may be hastened by laying a piece of coarse burlap over the leading edge before using it as a bending form. To speed drying, a fan may be used to circulate air around the repair part.

b. In bending pieces of small radii or to speed up the bending of a large number of parts of the same curvature, it may be necessary to use a heated bending form. The surface temperature of this form may be as high as 149 °C (300 ▪F), if necessary, without danger of damage to the plywood. The plywood should be left on the heated form only long enough to dry to room conditions.

1-50. REPAIRS TO DOUBLE CURVATURE PLYWOOD SKIN. The molded plywood necessary for a repair to a damaged plywood skin of double curvature cannot be made from flat plywood unless the area to be repaired is very small or is of exceedingly slight double curvature; therefore, molded plywood of the proper curvature must be on hand before the repair can be made. If molded plywood of the proper curvature is available, the repair may be made using the same procedure as on single curvature skins.

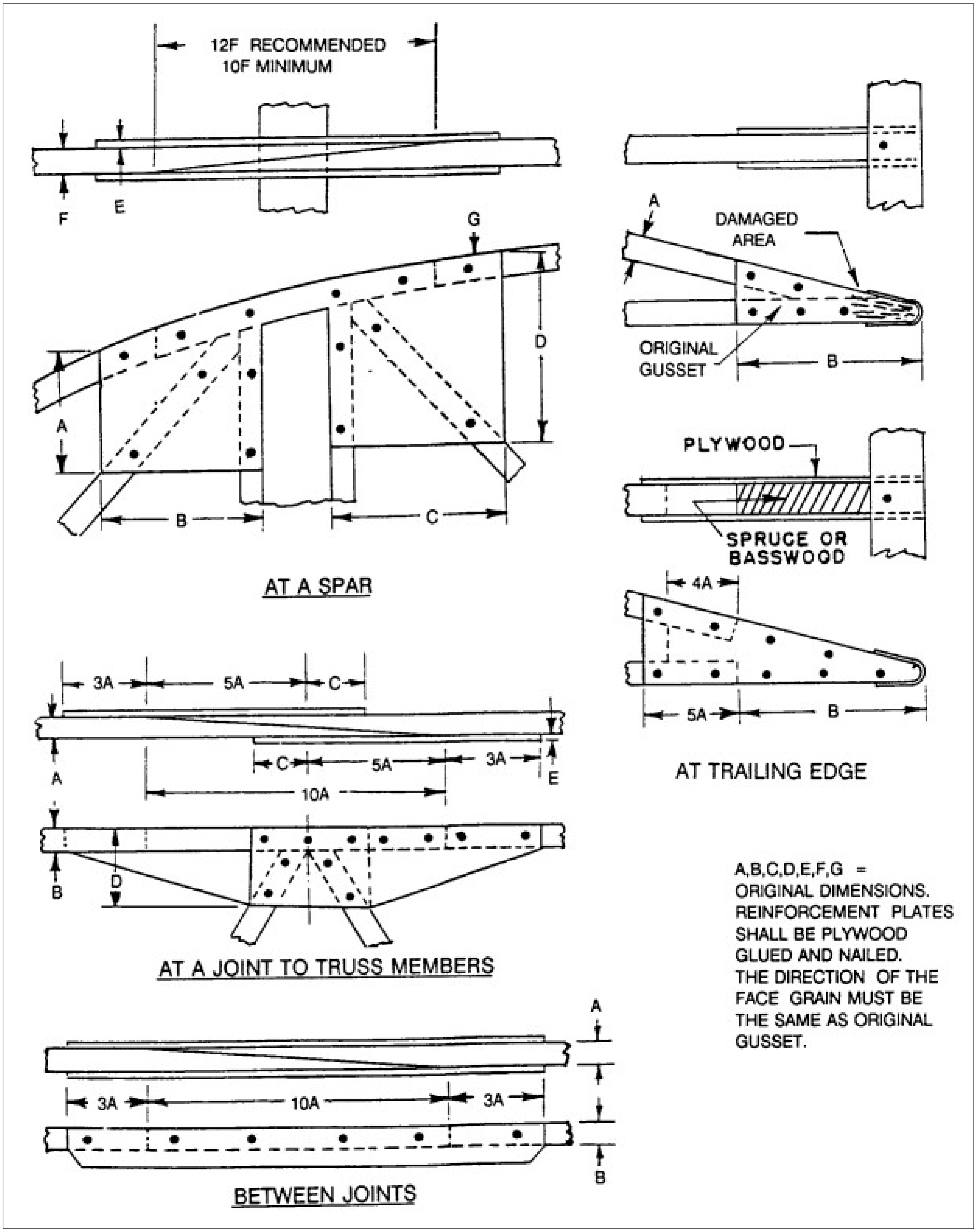


FIGURE 1-11. Repair of wood ribs.

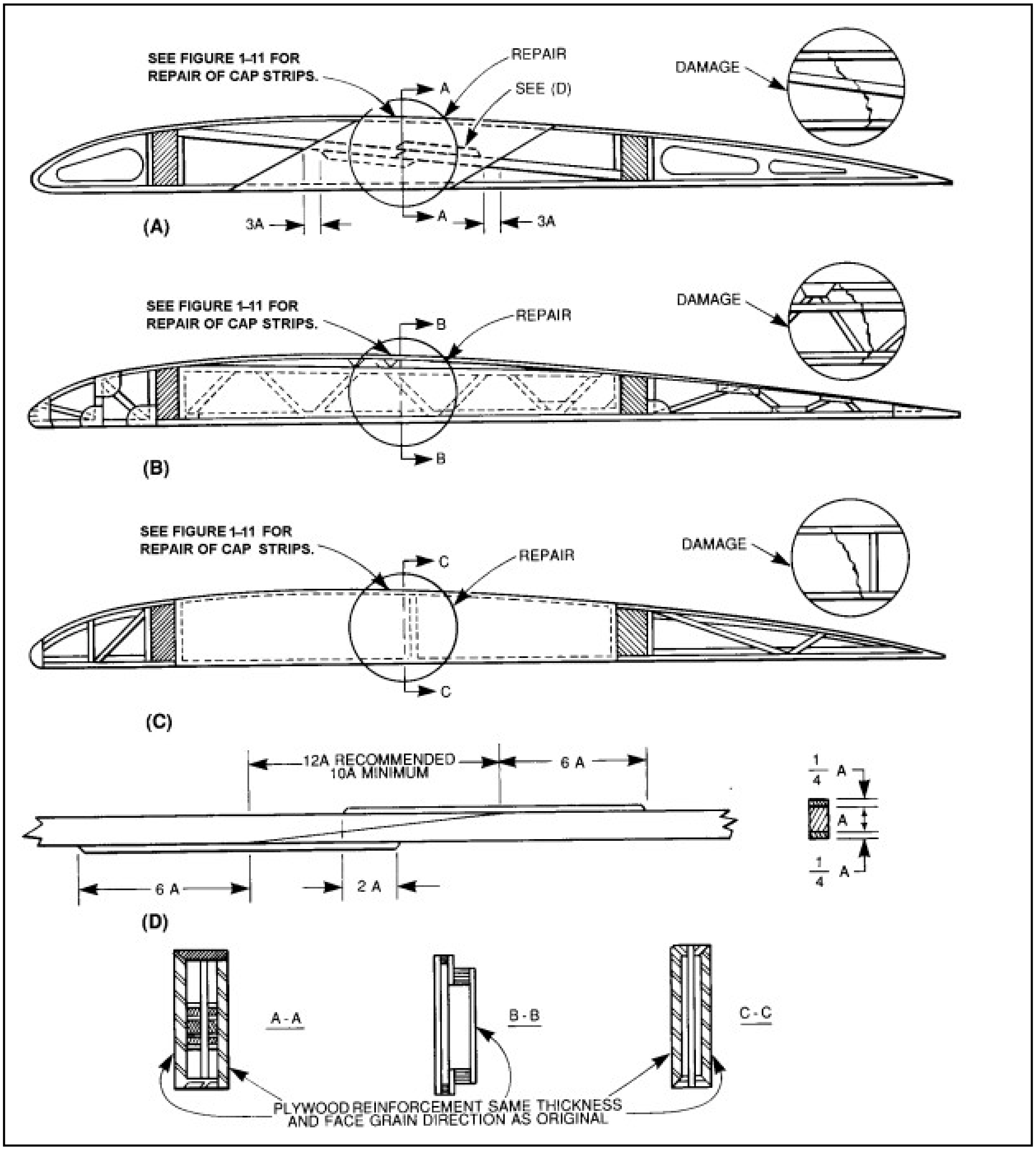
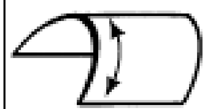
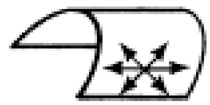
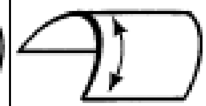
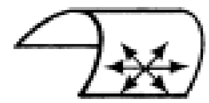


FIGURE 1-12. Typical wing compression rib repairs.

TABLE 1-2. Minimum recommended bend radii for aircraft plywood.

		10 PERCENT MOISTURE CONTENT, BENT ON COLD MANDRELS		THOROUGHLY SOAKED IN HOT WATER AND BENT ON COLD MANDRELS	
PLYWOOD CHARACTERISTICS		AT 90▪ TO FACE GRAIN 	AT 0▪ OR 45▪ TO FACE GRAIN 	AT 90▪ TO FACE GRAIN 	AT 0▪0R 45° TO FACE GRAIN 
THICKNESS (INCHES)	NUMBER OF PLIES	MINIMUM BEND RADIUS (INCHES)			
.035	3	2.0	1.1	0.5	0.1
.070	3	5.2	3.2	1.5	0.4
.100	3	8.6	5.2	2.6	0.8
.125	3	12	7.1	3.8	1.2
.155	3	16	10	5.3	1.8
.185	3	20	13	7.1	2.6
.160	5	17	11	6	2
.190	5	21	14	7	3
.225	5	27	17	10	4
.250	5	31	20	12	5
.315	5	43	28	16	7
.375	5	54	36	21	10

1-51. TYPES OF PATCHES. There are four types of patches: splayed patch, surface (or overlay) patch, scarf patch, and plug patch. They are all acceptable for repairing plywood skins.

a. Splayed Patch. Small holes with their largest dimensions not over 15 times the skin thickness, in skins not more than 1/10 inch in thickness, may be repaired by using a circular splayed patch as illustrated in figure 1-13. The term "splayed" is used to denote that the edges of the patch are tapered, but the slope is steeper than is allowed in scarfing operations.

(1) Lay out the patch according to figure 1-13. Tack a small piece of plywood over the hole for a center point and draw two circles with a divider, the inner circle to be the size of the hole and the outer circle marking the limits of the taper. The difference between the radii is 5T (5 times the thickness of the skin). If one leg of the dividers has been sharpened to a chisel edge, the dividers may be used to cut the inner circle.

(2) Taper the hole evenly to the outer mark with a chisel, knife, or rasp.

(3) Prepare a circular tapered patch to fit the prepared hole, and bond the patch into place with face-grain direction matching that of the original surface.

(4) Use waxed paper or plastic wrap, (cut larger than the size of the patch) between the patch and the plywood pressure plate. This prevents excess adhesive from bonding the pressure plate to the skin. Center the pressure plate carefully over the patch.

(5) As there is no reinforcement behind this patch, care must be used so that pressure is not great enough to crack the skin. On horizontal surfaces, weights or sandbags will be sufficient. On patches too far from any edge for the use of standard hand clamps, jaws of greater length may be improvised. Table 1-2, columns (1) and (3), may also be used for determining the maximum thickness of single laminations for curved members.

(6) Fill, sand, and refinish the patch.

b. Surface Patch. Plywood skins that are damaged between or along framing members may be repaired by surface or overlay patches as shown in figure 1-14. Surface patches located entirely 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. Surface patches may have as much as a 50 inch perimeter and may cover as much as 1 frame (or rib) space. Trim the damaged skin to a rectangular or triangular shape and round the corners. The radius of rounded corners must be at least 5 times the skin thickness. Bevel the forward edges of patches located entirely aft of the 10 percent chord line to 4 times the skin thickness. The face-grain direction must be the same as the original skin. Cover completed surface patches with fabric to match surrounding area. The fabric must overlap the original fabric at least 2 inches.

c. Scarf Patch. A properly prepared and inserted scarf patch is the best repair for damaged plywood skins and is preferred for most skin repairs. Figure 1-15 shows the details and dimensions to be used when installing typical scarf skin patches, when the back of the skin is accessible. Follow figure 1-16 when the back of the skin is not accessible. The scarf slope of 1 in 12, shown in both figures, is the steepest slope permitted for all kinds of plywood. If the radius of curvature of the skin at all points on the trimmed opening is greater than 100 times the skin thickness, a scarf patch may be installed.

(1) Scarf cuts in plywood may be made by hand plane, spoke shave, scraper, or accurate sandpaper block. Rasped surfaces, except at the corners of scarf patches and sawn surfaces, are not recommended as they are likely to be rough or inaccurate.

(2) Nail strip or small screw clamping is often the only method available for bonding scarf joints in plywood skin repairs. It is essential that all scarf joints in plywood be backed with plywood or solid wood to provide adequate nail holding capacity. The face-grain direction of the plywood patch must be the same as that of the original skin.

(3) If the back of a damaged plywood skin is accessible (such as a fuselage skin), it should be repaired with a scarf patch, following the details shown in figure 1-15. Whenever possible, the edges of the patch should be supported as shown in section C-C of figure 1-15. When the damage follows or extends to a framing member, the scarf may be supported as shown in section B-B of figure 1-15. Damages that do not exceed 25 times the skin thickness in diameter after being trimmed to a circular shape and are not less than 15 times the skin thickness to a framing member, may be repaired as shown in figure 1-15, section D-D.

(a) The backing block is carefully shaped from solid wood and fitted to the inside surface of the skin, and is temporarily held in place with nails.

(b) Use waxed paper or plastic wrap to prevent bonding of the backing block to the skin.

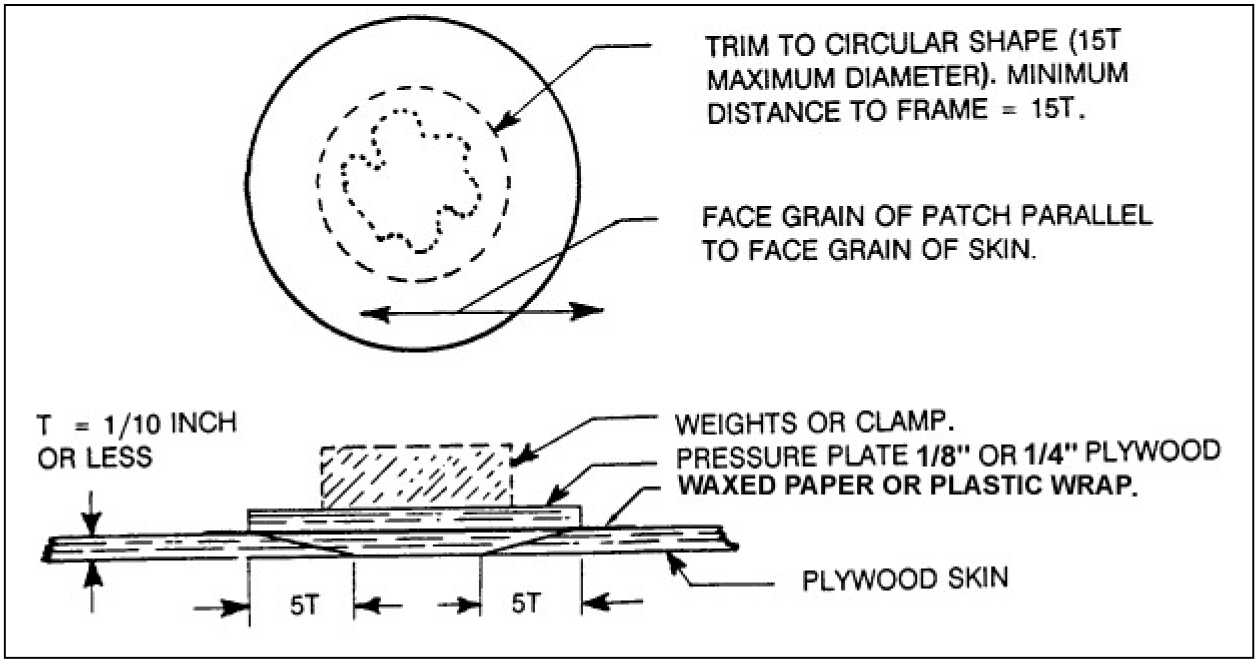


FIGURE 1-13. Splayed patch.

(c) A hole, the exact size of the inside circle of the scarf patch, is made in the block, and is centered over the trimmed area of damage.

(d) The block is removed, after the adhesive on the patch has set, leaving a flush surface to the repaired skin.

(4) Steps in making a scarf patch when the back of the skin is not accessible are as follows:

(a) After removing damaged sections, install backing strips, as shown in figure 1-16, along all edges that are not fully backed by a rib or a spar. To prevent warping of the skin, backing strips should be made of a soft-textured plywood, such as yellow poplar or spruce rather than solid wood. All junctions between backing strips and ribs or spars should have the end of the backing strip supported by a saddle gusset of plywood.

(b) If needed, nail and bond the new gusset plate to rib. It may be necessary to remove and replace the old gusset plate with a new saddle gusset, or it may be necessary to nail a saddle gusset over the original gusset.

(c) Attach nailing strips to hold backing strips in place while the adhesive sets. Use a bucking bar, where necessary, to provide support for nailing. After the backing strips are fully bonded, install the patch.

d. Plug Patch. Either oval or round plug patches may be used on plywood skins provided the damage can be covered by the patches whose dimensions are given in figure 1-17 and figure 1-18. The plug patch is strictly a skin repair, and should be used only for damage that does not involve the supporting structure under the skin. The face-grain direction of the finished patch must match the surrounding skin.

(1) Steps in making an oval plug patch are as follows:

(a) Explore the area about the hole to be sure it lies at least the width of the oval

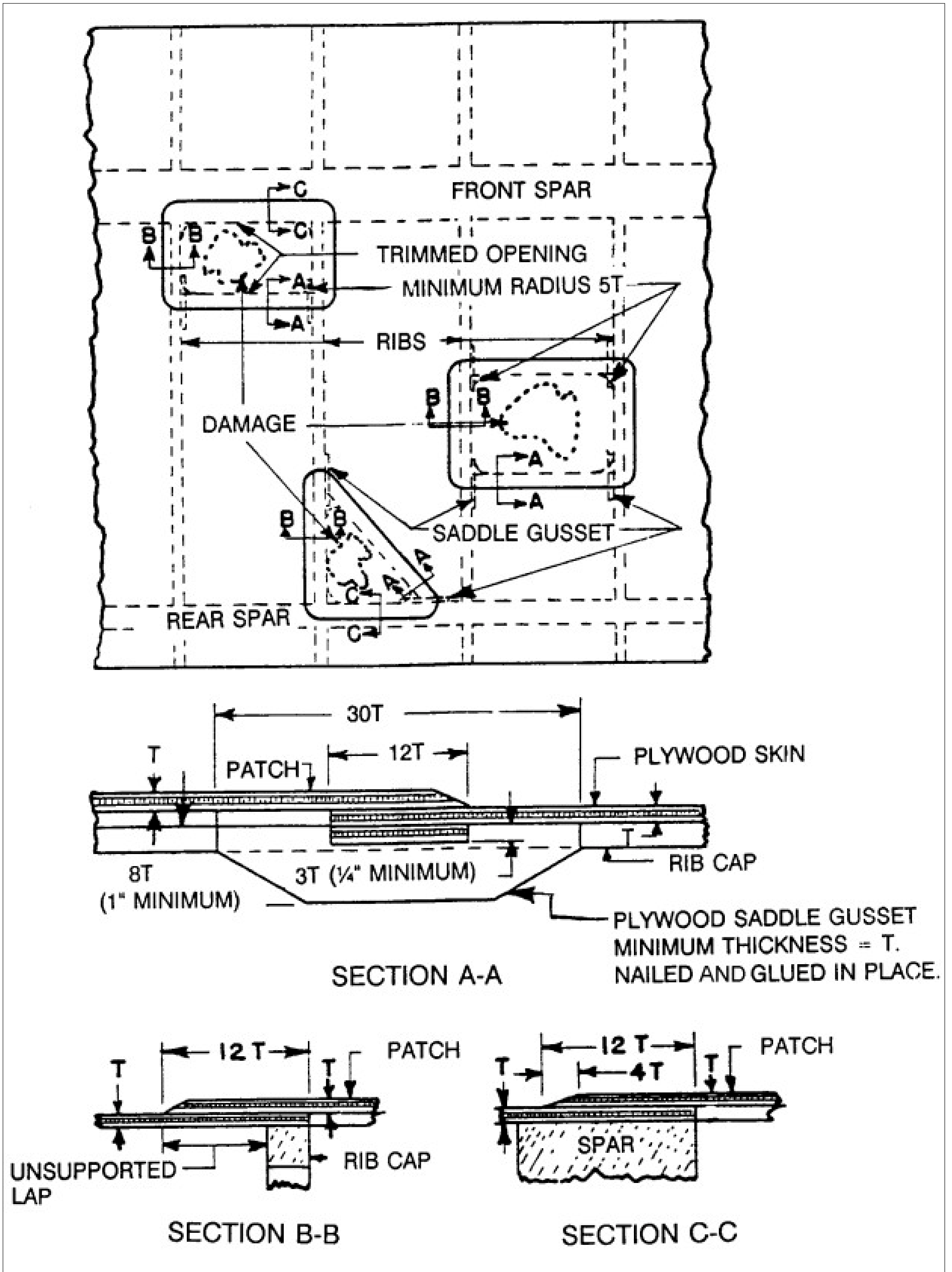


FIGURE 1-14. Surface patches.

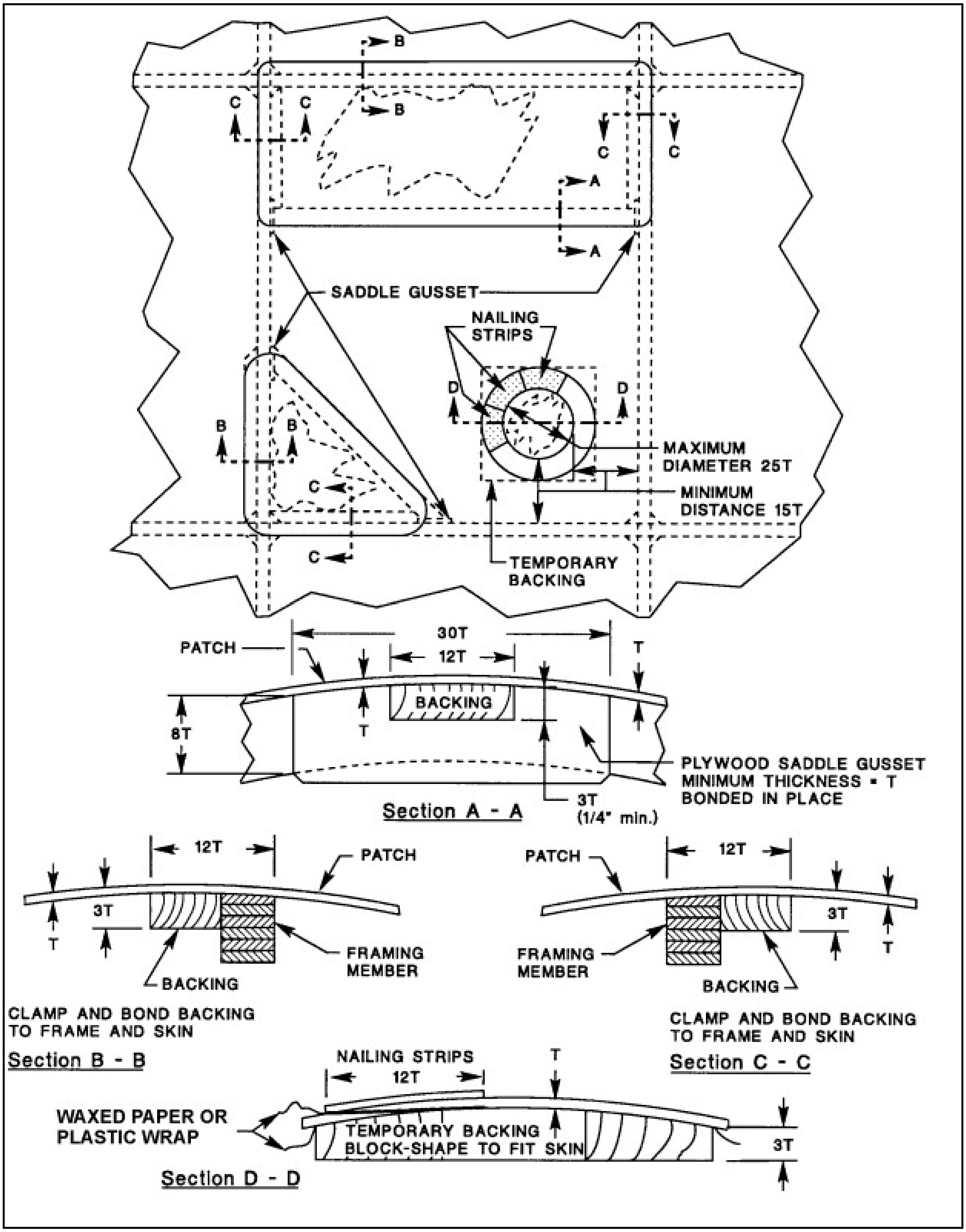


FIGURE 1-15. Scarf patches (back of skin accessible).

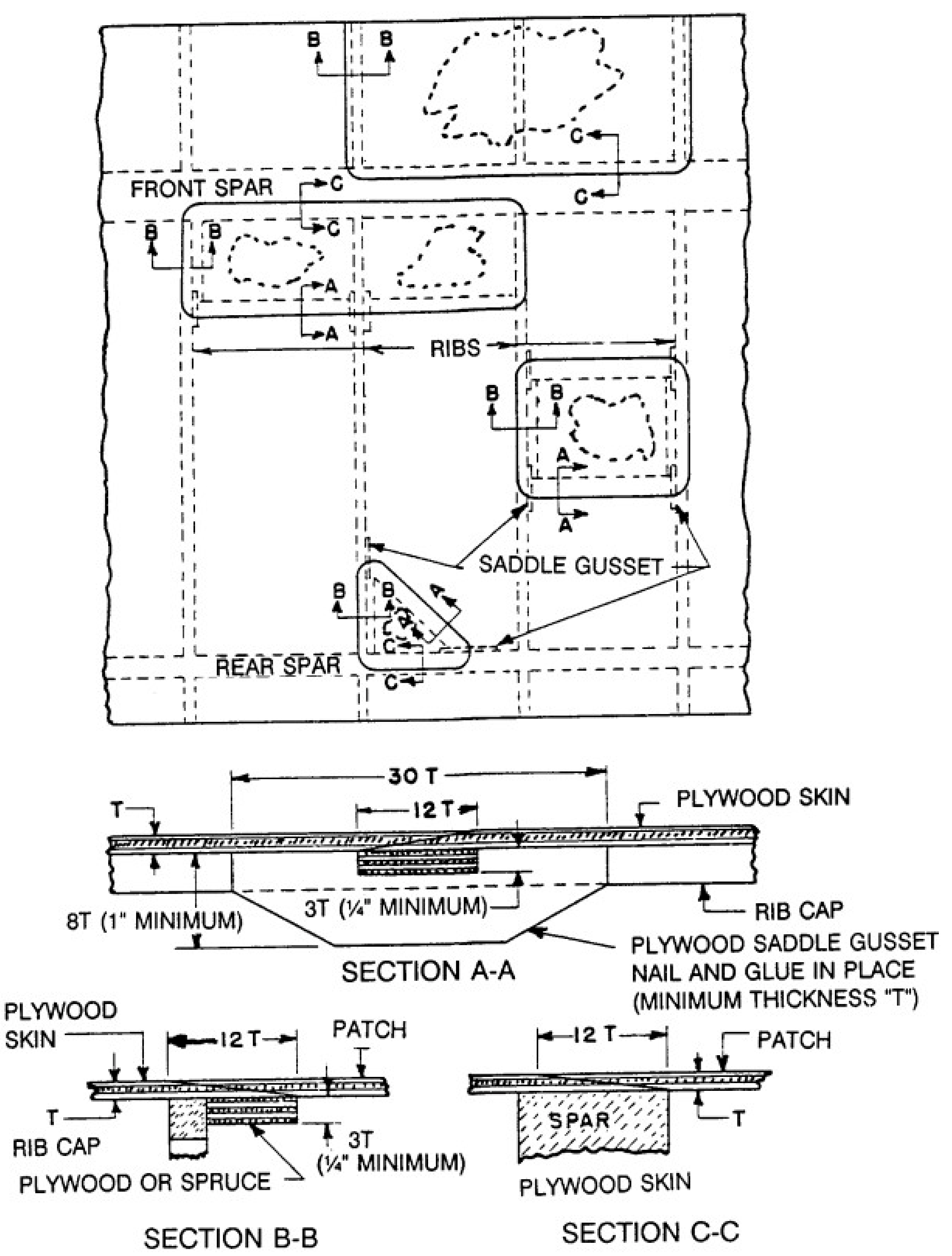


FIGURE 1-16. Scarf patches (back of skin not accessible).

doubler from a rib or a spar. Refer to figure 1-17 for repair details.

(b) Prepare a patch and a doubler of the same species plywood as the surrounding skin using the dimensions shown in figure 1-17.

(c) Lay the oval plug patch over the damage and trace the patch onto the skin. Saw to the line, and trim the hole edges with a knife and sandpaper.

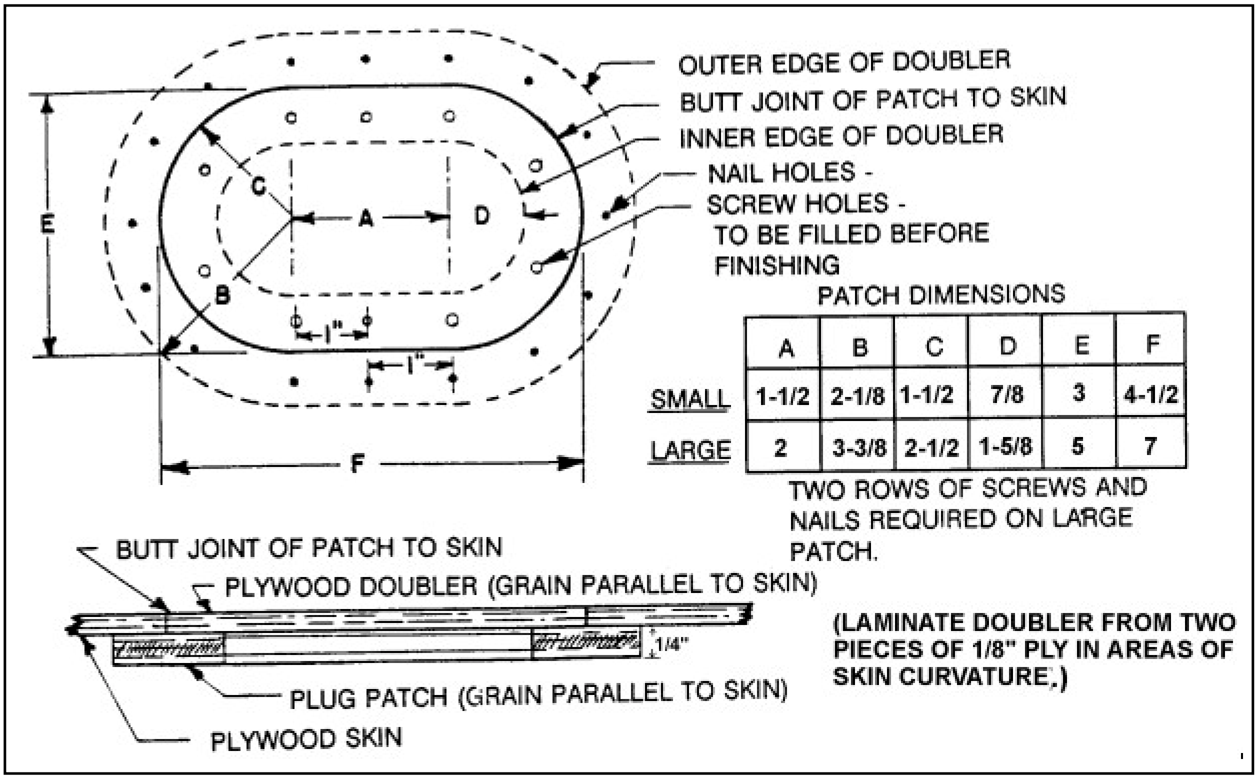
(d) Mark the exact size of the patch on one surface of the oval doubler and apply adhesive to the area outside the line. Insert doubler through the hole and bring it, adhesive side up, to the underside of the skin with the pencil outline of the patch matching the edges of the hole. If the curvature of the surface to be repaired is greater than a rise of 1/8 inch in 6 inches, the doubler should be preformed by hot water or steam bending to the approximate curvature. As an alternative to preforming of the 1/4 inch stock, the doubler may be laminated from two thicknesses of 1/8 inch ply.

(e) Apply nailing strips outlining the hole to apply bonding pressure between doubler and skin. Use a bucking bar to provide support for nailing. When two rows of nails are used, stagger nail spacing. Allow adhesive to cure.

(f) Apply adhesive to remaining surface of the doubler and to the mating surface on the patch. Lay the patch in position over the doubler, and screw the pressure plate to the patch assembly using a small nail to line up the holes that have been previously made with patch and plate matching. No. 4 round head screws are used. Lead holes in the plywood doubler are not necessary. Waxed paper or plastic wrap between the plate and patch prevents adhesive from bonding the plate to the patch. No clamps or further pressure need be applied, as the nailing strips and screws exert ample pressure.

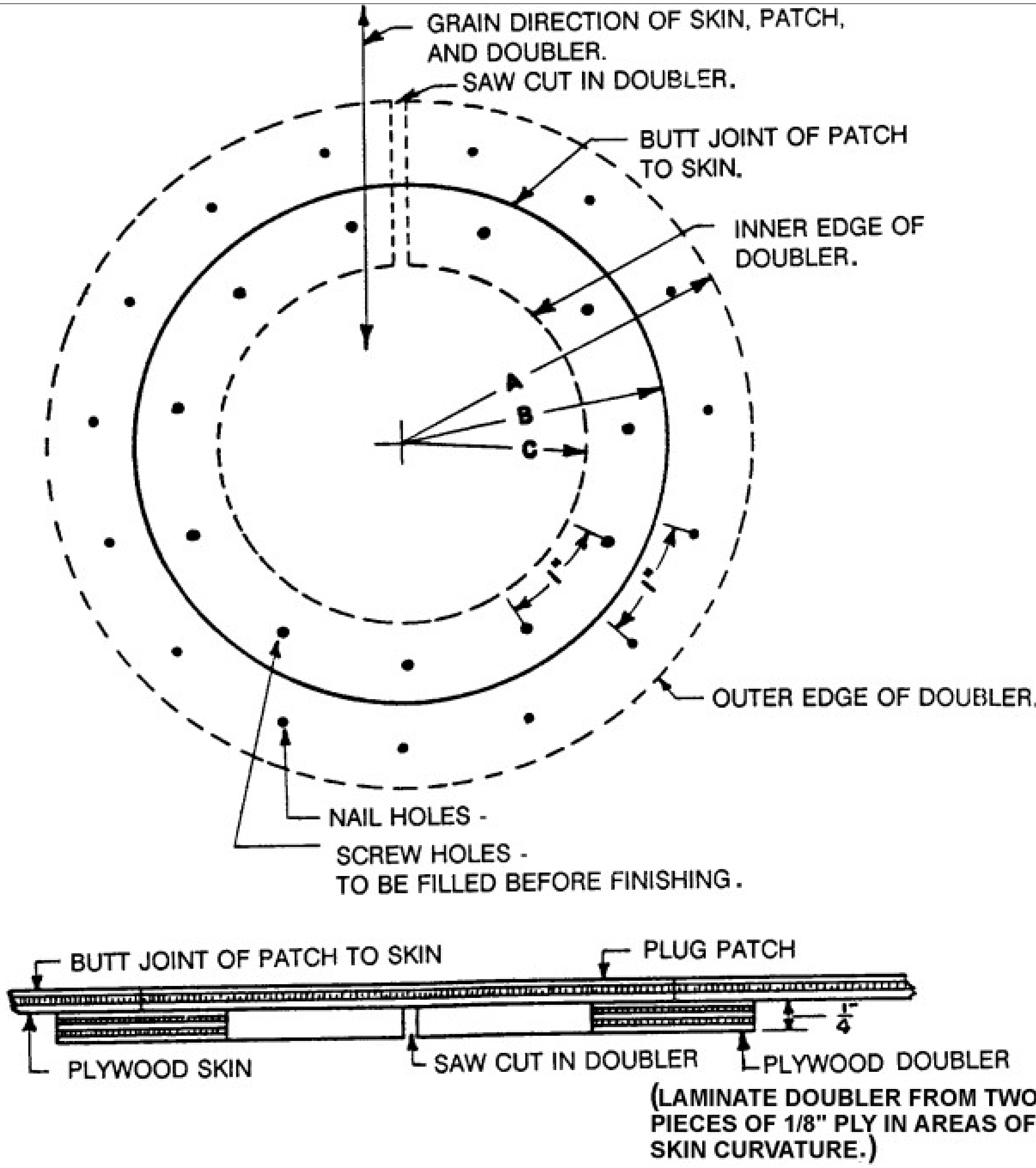
(2) Round plug patches may be made by following the steps in figure 1-18. The steps are identical to those for making the oval patch except for the insertion of the doubler. In using the round patch, where access is from only one side, the round doubler cannot be inserted unless it has been split.

1-52. FABRIC PATCH. Small holes not exceeding 1 inch in diameter, after being trimmed to a smooth outline, may be repaired by doping a fabric patch on the outside of the plywood skin. The edges of the trimmed hole should first be sealed, and the fabric patch should overlap the plywood skin by at least 1 inch. Holes nearer than 1 inch to any frame member, or in the leading edge or frontal area of the fuselage, should not be repaired with fabric patches.



	A	B	C	D	E	F
SMALL	1-1/2	2-1/8	1-1/2	7/8	3	4-1/2
LARGE	2	3-3/8	2-1/2	1-5/8	5	7

FIGURE 1-17. Oval plug patch assembly.



DIMENSIONS

	A	B	C
SMALL CIRCULAR PLUG PATCH	2 5/8	2	1 3/8
LARGE CIRCULAR PLUG PATCH	3 7/8	3	2 1/8

(TWO ROWS OF SCREWS AND NAILS REQUIRED FOR LARGE PATCH)

FIGURE 1-18. Round plug patch assembly.

1-53.—1-63. [RESERVED.]

SECTION 5. FINISHING WOOD STRUCTURES

1-64. GENERAL. Any repair to spars, ribs, skin surfaces, or other structural parts of the airframe involves finishing as the final step of the job. The surface finish is the final line of defense to prevent the destructive effects of moisture entry into the structure. The time and effort spent during the preparatory phase of the refinishing process will be reflected in the appearance and longevity of the finished surface. Adherence to the instructions issued by the finish manufacturer is necessary to obtain the appearance desired and 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 when exposed to damp air or to water that gains entrance to closed spaces by condensation or by penetration of rain, mist, or fog. 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, and present a smooth surface in flight.

1-65. ACCEPTABLE FINISHES. Any varnish conforming to Federal Specification TT-V-109, as amended, or other coating approved by the airframe manufacturer or the FAA is acceptable. Exterior surfaces must be further protected from the effects of abrasion, weather, and sunlight. A number of systems for exterior finishing have STC approval and are manufactured under a PMA. (See Chapter 2, Fabric Covering.) Low viscosity epoxy adhesive (meeting the requirements of paragraph 1-4 for that purpose) may be used as an internal surface finish when subsequent bonding is necessary.

1-66. PRECAUTIONS.

a. When making repairs, avoid excessive contamination of surfaces with adhesive squeeze-out at joints and on all surfaces. Excess adhesive should always be removed before applying finish. Because many paints and adhesives are incompatible, even a slight amount of adhesive underneath the finish may cause premature deterioration of the finish.

b. Soiling substances, such as oil and grease, should be removed as completely as possible. Naphtha may be used to remove surface deposits of oil and grease; however, thinned residue may penetrate into any unprotected wood. In areas where minor amounts of oil or grease have penetrated the wood surface, removal may be accomplished by use of an absorbent type of cleaner such as gunsmith's whiting or a clothing spot lifter such as K2r™. Marks that are made by grease pencils or lumber crayons containing wax are harmful and should be removed, but marks made by ordinary soft graphite pencils and nonoily stamp pad inks may be safely finished over. All dust, dirt, and other solid particles should be removed.

c. Sawdust, shavings, and chips must be removed from enclosed spaces before they are sealed off by replacement of skin. A vacuum cleaner is useful for such cleaning.

d. Since most adhesives will not bond satisfactorily to sealers, it is necessary to avoid applying sealer over the areas where adhesive will be applied. Mark off areas to receive adhesive, and allow an additional 1/4 inch on each side of the adhesive area to provide for misalignment when mating the parts. It is preferable to leave some unsealed areas rather than risk weakening the joint by accidental overlap of the sealer into the bonded areas. Wherever possible, apply sealer to the margins after the adhesive has cured. As an example, the lower skin of a wing bay would be installed first, leaving access from above to apply sealer. All low spots (where moisture would collect) are well sealed. The top skin would be installed last, so that the only unsealed margins would be on upper surfaces where moisture is least likely to collect.

e. An alternative to the previous paragraph is to use an approved epoxy coating and compatible epoxy adhesive. Apply the coating, allowing 1/4 inch margins as in the previous paragraph. After the coating has cured, apply epoxy adhesive to joint surfaces, and overlap the adhesive onto the sealer. Close joint and clamp. The epoxy adhesive will bond satisfactorily to the coating and ensure a complete coverage of the wood surfaces. Use only approved and compatible adhesives and coatings for this method.

1-67. FINISHING OF INTERIOR SURFACES. Finish repaired ribs, spars, interior of plywood skin, and other internal members, including areas of contact between metal and wood, by applying one thinned coat (for penetration into wood grain) of varnish or other acceptable finish, followed by two full coats. Protect built-up box spars and similar closed structures on the interior in the same way. Where better protection is required, as on the surfaces of wheel wells and the bottoms of hulls below the floor boards, an additional coat of aluminized sealer consisting of 12 to 16 ounces of aluminum paste per gallon of sealer, may be applied.

1-68. FINISHING OF EXTERIOR SURFACES. Exterior surfaces require more protection than interior areas due to the effects of abrasion, weather, and sunlight. (See chapter 2.) Tests have shown that the interior temperature of wooden aircraft structures can reach 185 °F when the aircraft is finished in a dark color and parked outdoors on a hot, still day. Exposure to prolonged high temperature is detrimental to wood, adhesives, and finishes. Wood loses approximately 25 percent of its strength at 125 °F. For this reason, the mechanic should consider temperature effects when selecting finish colors or looking for areas of likely deterioration. The lowest temperatures are found when the aircraft is finished in white or very light colors, while darker colors produce higher temperatures. A general trend toward higher temperatures may be seen when exterior colors are yellow, pink, light blue, aluminum, purple, blue, light green, orange, tan, red, green, brown, and black. A lighter shade of a particular color helps to reduce temperatures.

1-69. FINISHING OF END GRAIN SURFACES. End grain portions of wooden members are much more absorbent than side grain. Because of this extreme vulnerability to moisture entry, it is necessary to take extra precautions to seal end grain.

a. Apply at least one thinned coat of acceptable sealer to ensure maximum penetration, and then follow with as many full strength coats as necessary to achieve a smooth, glossy coating. Depending on the type wood to be finished, two to four full coats will be required. A final coat of aluminized varnish may be applied to end grain surfaces. If the surfaces are to be finished with dope or lacquer, a dope-proof sealer, similar to Federal Specification TT-V-109, or epoxy sealer should be used.

b. Exposed end grain includes such surfaces as spar butts, skin edges, areas around vent holes, inspection holes, fittings, and exposed scarfed or tapered surfaces.

1-70. FINISHING WITH FABRIC OR TAPE. A number of systems for exterior finishing have STC approval and are manufactured under a PMA. Follow the product manufacturer's instructions for the system used.

a. If the finish surrounding the repair is a traditional dope system, seal the wood grain with a suitable solvent resistant one-part varnish, commonly described as "dope proof," or a two-part epoxy varnish. Follow with two coats of clear dope, and allow sufficient drying time between coats.

b. Apply a third coat of clear dope and lay a piece of pinked-edge airplane cloth into the wet film. All air bubbles should be worked out by brushing to ensure maximum adhesion. When dry, apply one brush coat, to ensure proper penetration, and at least one spray coat of clear dope. The dried spray coat may be sanded with fine sandpaper to obtain a smoother finish. Complete the refinishing of the surface by application of a topcoat as required to match the adjacent area.

1-71. SEALING OF BOLT HOLES. Bolt holes in wooden structure provide a vulnerable entry point for moisture. Variations in moisture content around bolt holes can lead to decay or splitting. In addition, excessive moisture at bolt holes promotes corrosion of the bolts. Sealing of the wood surfaces in bolt holes can be accomplished by application of varnish or other acceptable sealer into the open hole. The sealer must be allowed to dry or cure thoroughly prior to bolt installation.

1-72.—1-79. [RESERVED.]

CHAPTER 2. FABRIC COVERING

SECTION 1. PRACTICES AND PRECAUTIONS

2-1. GENERAL. Cotton and Irish linen fabrics were the airframe coverings of choice from WWI through the 1950's. However, increases in cost and the short lifespan of natural fabrics became the driving factors which resulted in almost 100 percent replacement of original airframe fabrics by man-made, STC-approved, polyester, and glass filament fabric.

2-2. PROBLEM AREAS.

a. Deterioration. Polyester fabric deteriorates only by exposure to ultraviolet radiation as used in an aircraft covering environment. When coatings completely protect the fabric its service life is infinite. Therefore, it is very important to thoroughly protect the structure from deterioration before covering and provide adequate inspection access to all areas of fabric-covered components to allow inspection for corrosion, wood rot, and mice infestation. Multiple drain holes in the lower ends of all fabric-covered sections also provide needed ventilation to remove condensation.

b. Tension. Polyester fabric obtains maximum tension on an airframe at 350 °F, and will not be excessive on aircraft originally covered with natural fabric and 12 coats of Nitrate or Butyrate Dope. However, dope applied over full heat-tauted fabric can develop excess tension after aging and damage light aircraft structures. Coatings other than dope will not increase fabric tension after aging. The heat-tauting instructions given in the manual of each STC-approved covering process should be followed.

2-3. AIRCRAFT FABRIC-SYNTHETIC.

a. STC-Approved Covering Materials. There is a wide selection of STC-approved covering materials available which utilize synthetic fabric falling within the generic class "Polyester" and may vary in characteristics. Difference in the fabric may be denier, tenacity, thread count, weight, shrink, tension, and weave style.

b. Polyester Filaments. Polyester Filaments are manufactured by polymerization of various select acids and alcohols, then extruding the resulting molten polymers through spinnerets to form filaments. The filaments are heat stretched to reduce to the desired denier or size. It is the heat stretching that imparts a memory in the filaments causing them to try and return to their original shorter length when reheated at a controlled temperature. Overheating will cancel the memory and melt the filaments.

c. Covering Procedures. Coating types, covering accessories, and covering procedures also may vary; therefore, the covering procedures given in the pertinent manuals must be followed to comply with the STC. The FAA STC-approved installation takes precedence over instructions in this advisory circular.

d. Installation. Initial installation of polyester fabric is similar to natural fabric. The fabric is installed with as little slack as possible, considering fittings and other protrusions. It may be sewn into an envelope, installed as a blanket, or installed by cementing to the airframe with a fabric cement. Each STC may differ in the cement seam overlap, type of sewn seam, heat shrinking procedures, and temperature.

2-4. AIRCRAFT FABRIC-NATURAL. Physical specifications and minimum strength requirements for natural fiber fabric, cotton and linen, used to recover or repair components of an aircraft, are listed in table 2-1. Tear resistance is an important factor when considering aircraft fabric. A test method such as ASTM D 1424 is recommended. Technical Standard Order TSO-C15d, entitled Aircraft Fabric, Grade A (AMS 3806D); and TSO-C14b, Aircraft Fabric, Intermediate Grade (AMS 3804C) current edition, respectively, describe the minimum standards that all fabric must meet to qualify as aircraft covering material.

2-5. RECOVERING AIRCRAFT. Recover or repair aircraft with a fabric of equal quality and strength to that used by the original aircraft manufacturer. It is recommended that fabric conforming to TSO-C15d or TSO-C14b be used to recover aircraft originally covered with lower strength fabric conforming to AMS 3802, current edition.

NOTE: Recovering or repairing aircraft with any type fabric and/or coating other than the type used by the original aircraft manufacturer is considered a major alteration. Obtain approval from the FAA on fabric and installation data. Cotton and linen rib lacing cord, machine and hand-sewing thread, and finishing tapes should not be used with polyester and glass fabric covering.

a. Reinforcing tape minimum tensile strength is listed in table 2-2. Reinforcing tape meeting specification MIL-T-5661, Type I, current edition, is acceptable. Reinforcing tape should have a minimum 40 lb. resistance without failure when static tested in shear against a single rib lace, or a pull-through resistance when tested against a single-wire clip, rivet, screw, or any other type of fabric-to-rib attachment. Reinforcing tape is used over the rib cab on top of the fabric and for inter-rib bracing.

b. Finishing Tape, sometimes referred to as surface tape, should have the same properties as the fabric used to cover the aircraft.

c. Lacing Cord shall have a minimum breaking strength of 40 lb. Lacing cord meeting the specifications listed in table 2-2 is acceptable. Rib lace cord should have a microcrystalline fungicidal wax, paraffin-free wax, or beeswax coating, or other approved treatment to prevent wearing and fraying when pulling through the structure.

d. Machine Thread shall have a minimum breaking strength of 5 lb. Thread meeting the specifications listed in table 2-2 is acceptable.

e. Hand-Sewing Thread shall have a minimum breaking strength of 14 lb. Thread meeting the specifications listed in table 2-2, is acceptable. When covering with STC-approved fabric covering material, use the type of sewing thread approved by the STC and manufactured under the specific PMA.

f. Flutter Precautions. When re-covering or repairing control surfaces, especially on high performance airplanes, make sure that dynamic and static balances are not adversely affected. Weight distribution and mass balance must be considered to preclude to possibility of induced flutter.

2-6. PREPARATION OF THE STRUCTURE FOR COVERING. One of the most important items when covering aircraft is the proper preparation of the structure. Before covering, the airframe must be inspected and approved by a FAA-certified mechanic or repair station.

TABLE 2-1. Cotton and linen fabrics.

Materials	Specification	Minimum Tensile Strength New (undoped)	Minimum Tearing Strength New (undoped) (ASTM D 1424)	Minimum Tensile Strength Deteriorated (undoped)	Thread Count Per Inch	Use and Remarks
Airplane cloth mercerized cotton (Grade "A").	TSO-C15d, as amended, references Society Automotive Engineers AMS 3806d, as amended or MIL-C-5646	80 pounds per inch warp and fill.	5 pounds warp and fill.	56 pounds per inch.	80 min., 84 max. warp and fill.	For use on all aircraft. Required on aircraft with wing loading of 9 p.s.f. or greater or placard never exceed speed of 160 m.p.h. or greater.
Airplane cloth mercerized cotton.	TSO-C14b, as amended, references Society Automotive Engineers AMS-3804c, as amended.	65 pounds per inch warp and fill.	4 pounds warp and fill.	46 pounds per inch.	80 min., 94 max. warp and fill.	For use on aircraft with wing loading less than 9 p.s.f. and never exceed speed of less than 160 m.p.h.
Airplane cloth mercerized cotton.	Society Automotive Engineers AMS 3802, as amended.	50 pounds per inch warp and fill.	3 pounds warp and fill.	35 pounds per inch.	110 max. warp and fill.	For use on gliders with wing loading of 8 p.s.f. or less, provided the placarded never-exceed speed is 135 m.p.h. or less.
Aircraft linen.	British 7F1.					This material meets the minimum strength Requirements of TSO-C15.

a. Battery Box Treatment. An asphaltic, rubber-based acid-proof coating should be applied to the structure in the area of a battery box, by brush, for additional protection from battery acid. Control cables routed in the area of the battery box should be coated with paralketone.

b. Worn Holes. Oversized screw holes or worn size 4 self-tapping screw holes through ribs and other structures used to attach fabric may be redrilled a minimum 1-1/2 hole diameter distance from the original hole location with a # 44 (0.086) drill bit. Size 6 screws, drill bit size # 36 (0.1065), may be installed in stripped or worn holes drilled for size 4 screws, usually without redrilling. Worn holes for wire clips and wire barbs should be redrilled a minimum 1-1/2 hole distance from the original locations using a drill jig to ensure correct spacing, with the appropriate size drill bit. Drill bit size # 30 (0.128) may be used to redrill oversize holes for 1/8-inch diameter blind rivets a minimum 1-1/2 hole diameter distance from the original location.

TABLE 2-2. Cotton and Linen, Tapes and Threads.

Materials	Specification	Yarn Size	Minimum Tensile Strength	Yards Per Pound	Use and Remarks
Reinforcing tape, cotton.	MIL-T-566 1 E, Type 1 MIL-Y-1140H		150 pounds per 1/2 inch width.		Used as reinforcing tape on fabric and under rib lacing cord. Strength of other widths approx. in proportion.
Lacing cord, prewaxed braided cotton.	Federal T-C-57 1F		40 pounds.	310 minimum.	Lacing fabric to structures. Unless already waxed, must be lightly waxed before using.
Lacing cord, braided cotton.	MIL-C-5648A		80 pounds.	170 minimum.	Lacing fabric to structures. Unless already waxed, must be lightly waxed before using.
Lacing cord thread, high tenacity cotton.	MIL-T-5660B	Ticket No. 10.	62 pounds.	480 minimum.	Lacing fabric to structures. Unless already waxed, must be lightly waxed before using.
Machine thread cotton	Federal V-T-276H	20/4 ply	5 pounds.	5,000 nominal.	Use for all machine sewing.
Hand-Sewing thread cotton.	Federal V-T-276H Type III B	8/4 ply	14 pounds.	1,650 nominal.	Use for all hand-sewing. Use fully waxed thread.
Finishing (Surface) tape cotton.	Same as fabric used.		Same as fabric used.		Use over seams, leading edges, trailing edges, outer edges and ribs, pinked, raveled or straight edges.

c. Fairing Precautions. Aluminum leading edge replacement fairings installed in short sections may telescope during normal spar bending loads or from thermal expansion and contraction. This action may cause a wrinkle to form in the fabric, at the edge of the lap joint. Leading edge fairing sections may be fastened together with rivets or screws to prevent telescoping after installation. Trailing edges should be adequately secured to prevent movement and wrinkles.

d. Dope Protection. Solvents found in nitrate and butyrate dope will penetrate, wrinkle, lift, or dissolve most one-part wood varnishes and one-part metal primers. All wood surfaces that come in contact with doped fabric should be treated with a protective coating such as aluminum foil, cellulose tape, or dope-proof paint to protect them against the action of the solvents in the dope. This can also be accomplished by recoating with a suitable, solvent resistant two-part epoxy varnish, which will be impervious to solvent penetration and damage after curing. Clad aluminum and stainless steel parts need not be dope-proofed.

(1) A solvent-sensitive primer on ferrous metal and aluminum alloy components which will be in contact with fabric may be protected from solvent damage by overcoating with a two-part epoxy primer. Epoxy primer meeting MIL-P-53022B is acceptable.

(2) Small metal or wood surfaces, such as rib caps, to which fabric will not be dope bonded as a part of the particular fabric attachment procedure may be protected from dope damage by cellophane tape or aluminum foil.

e. Chafe Protection. Fabric and finishing tape is often cut through with sandpaper over sharp edges during the coating and finishing procedure and later polishing. All sharp metal edges or protruding screws, nails, rivets, and bolt heads should be covered with an anti-chafe tape to prevent cutting and wearing through the fabric after installation. Use appropriate non-bleeding cotton adhesive coated tape, finishing tape, or strips of fabric, cut from the fabric being used to cover the aircraft, doped in place.

(1) Small holes cut through the fabric to accommodate flying wires, control cables, and fittings, must be reinforced with finishing tape or fabric patches cut from the same fabric used for the covering.

(2) Areas needing additional chafe protection such as control cables routed firm against the fabric surface should be protected with patches cut from cotton duck, leather, or plastic. These patches may be sewn, doped, or cemented in place, as appropriate.

(3) Any drag and anti-drag wires in the wings should be protected from chafing at cross points.

f. Inter-Rib Bracing. Use a woven fabric tape of the same quality and width as that used for the rib lace reinforcing, where so incorporated in the wing design by the original aircraft manufacturer. When the original routing for the inter rib bracing is not known, the tape will be routed diagonally, alternating between the top and bottom of each rib cap on each successive rib, if a single pair, half way between the front and rear spars. The number of tape pairs will duplicate the original aircraft manufacturer's installation. Tapes will be routed continuously from the wing butt to the wingtip bow, with one turn of tape around each intermediate rib cap strip. Care should be given to position the tape so as not to interfere with control cables, bellcranks or push-pull rods.

g. Preparation of Plywood Surfaces for Covering. Prior to covering plywood surfaces, prepare the surface by sanding, cleaning, and applying sealer and dope. When plywood surfaces are to be covered with light weight glass fiber deck cloth instead of fabric, no sealer or dope should be applied to the plywood as it would inhibit penetration of epoxy resin.

(1) Sand plywood surfaces as needed to remove old loose dope or varnish residue to provide a clean bonding surface. Remove any oil, grease, or other contamination with a suitable solvent such as naphtha. Small, rough areas and irregularities in the plywood surface and around any plywood repairs may be filled and smoothed with an appropriate commercial grade wood filler. Filling large warp depressions on plywood surfaces with a wood filler for cosmetic purposes is not acceptable.

(2) After cleaning and sanding all plywood surfaces, seal the wood grain with a suitable solvent resistant two-part epoxy varnish. After the varnish has thoroughly dried, apply two brush or spray coats of clear dope, allowing sufficient drying time between coats.

2-7. FABRIC SEAMS. Seams parallel to the line of flight are preferable; however, spanwise seams are acceptable.

a. Sewn Seams.

(1) Machine-sewn seams should be double stitched using any of the styles illustrated in figure 2-1 A, B, C, or D. A machine-sewn seam used to close an envelope at a wingtip, wing trailing edge, empennage and control surface trailing edge, and a fuselage longeron may be made with a single stitch when the seam will be positioned over a structure. (See figure 2-1 E.) The envelope size should accommodate fittings or other small protrusions with minimum excess for installation. Thick or protruding leading edge sewn seams should be avoided on thin airfoils with a sharp leading edge radius because they may act as a stall strip.

(2) Hand sew, with plain overthrow or baseball stitches at a minimum of four stitches per inch, or permanent tacking, to the point where uncut fabric or a machine-sewn seam is reached. Lock hand sewing at a maximum of 10 stitch intervals with a double half hitch, and tie off the end stitch with a double half hitch. At the point where the hand-sewing or permanent tacking is necessary, cut the fabric so that it can be doubled under a minimum of 3/8 inch before sewing or permanent tacking is performed. (See figure 2-2.)

(3) After hand sewing is complete, any temporary tacks used to secure the fabric over wood structures may be removed.

(4) Cover a sewn spanwise seam on a wing's leading edge with a minimum 4-inch wide pinked-edged surface tape with the tape centered on the seam.

(5) Cover a spanwise-sewn seam at the wing trailing edge with pinked-edge surface tape that is at least 3 inches wide. For aircraft with never-exceed speeds in excess of 200 mph, cut V notches at least 1 inch in depth and 1/4 inch in width in both edges of the surface tape when used to cover spanwise seams on trailing edges of control surfaces. Space notches at intervals not exceeding 6 inches. On tape less than 3 inches wide, the notches should be 1/3 the tape width. In the event the surface tape begins to separate because of poor adhesion or other causes, the tape will tear at a notched section, thus preventing progressive loosening of the entire length of the tape which could seriously affect the controllability of the aircraft. A loose tape acts as a trim tab only on a movable surface. It becomes a spoiler on a fixed surface and has no effect at the trailing edge other than drag.

(6) Make spanwise-sewn seams on the wing's upper or lower surfaces in a manner that will minimize any protrusions. Cover the seams with finishing tape at least 3 inches wide, centering the tape on the seam.

(7) Sewn seams parallel to the line of flight (chordwise) may be located over ribs. However, careful attention must be given to avoid damage to the seam threads by rib lace needles, screws, rivets, or wire clips that are used to attach the fabric to the rib. Cover chordwise seams with a finishing tape at least 3 inches wide with the tape centered on the seam.

b. Doped Seams.

(1) For an overlapped and doped spanwise seam on a wing's leading edge, overlap the fabric at least 4 inches and cover with finishing tape at least 4 inches wide, with the tape centered at the outside edge of the overlap seam.

(2) For an overlapped and doped spanwise seam at the trailing edge, lap the fabric at least 3 inches and cover with pinked-edge surface tape at least 4 inches wide, with the tape centered on the outside edge of the overlap seam.

(3) For an overlapped and doped seam on wingtips, wing butts, perimeters of wing control surfaces, perimeters of empennage surfaces, and all fuselage areas, overlap the fabric 2 inches and cover with a finishing tape that is at least 3 inches wide, centered on the outside edge of the overlap seam.

(4) For an overlapped and doped seam on a wing's leading edge, on aircraft with a velocity never exceed (Vne) speed up to and including 150 mph, overlap the fabric 2 inches and cover with a finishing tape that is at least 3 inches wide, with the tape centered on the outside edge of the overlap seam.

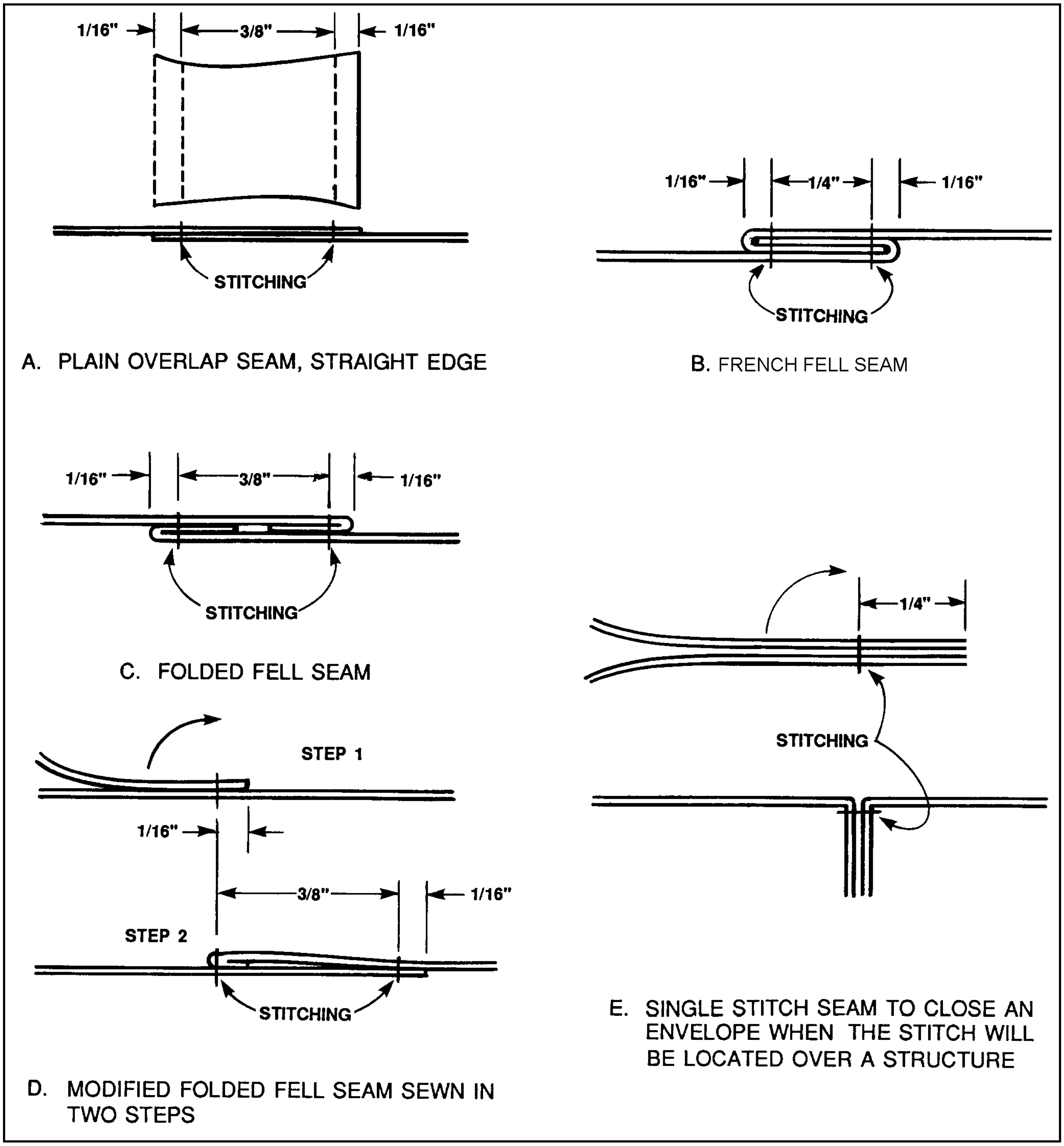
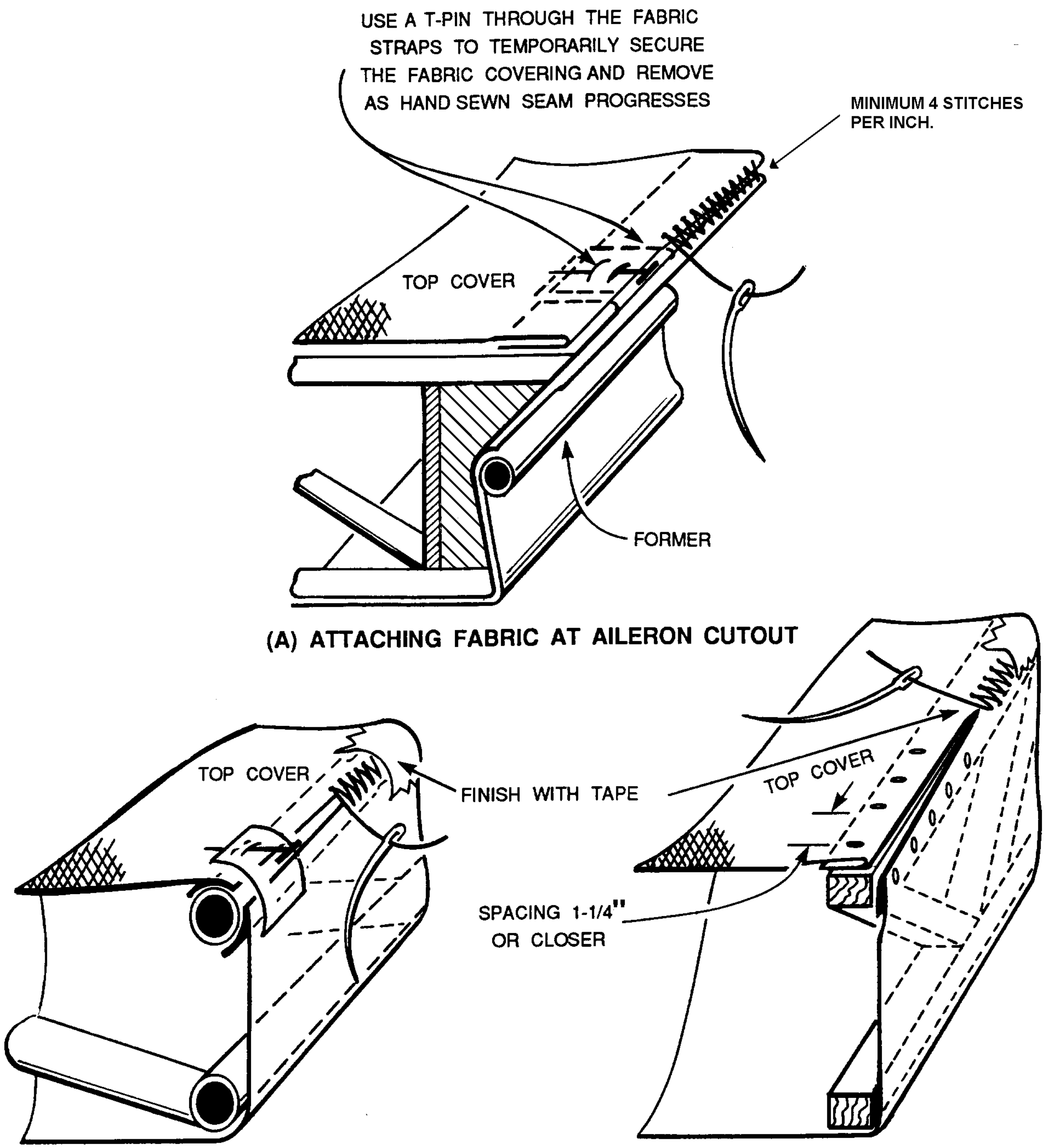


FIGURE 2-1. Fabric seams.



TEMPORARY TACKS MAY BE USED TO SECURE FABRIC IN POSITION FOR HAND-SEWN SEAMS OVER A WOOD STRUCTURE. PERMANENT TACKS MAY BE USED TO SECURE FABRIC AT WING BUTT STRUCTURES IN LIEU OF A HAND-SEWN SEAM AND SHOULD BE OF THE APPROPRIATE LENGTH AND GAUGE, AND MADE OF CORROSION RESISTANT STEEL OR BRASS.

FIGURE 2-2. Typical methods of attaching fabric.

(5) For an overlapped and doped seam on the perimeter of a wing (except a leading edge), perimeters of wing control surfaces, perimeters of empennage surfaces, and all areas of a fuselage, on aircraft with a Vne speed up to and including 150 mph, overlap the fabric 1 inch and cover with a finishing tape that is at least 3 inches wide, centered on the outside edge of the overlap seam.

2-8. COVERING METHODS. The method of fabric attachment should be identical, as far as strength and reliability are concerned, to the method used by the manufacturer of the airplane being recovered or repaired. Carefully remove the old fabric from the airframe, noting the location of inspection covers, drain grommets, and method of attachment. Cotton or linen fabric may be applied so that either the warp or fill-threads are parallel to the line of flight. Either the envelope method or blanket method of covering is acceptable.

a. The Envelope Method. A wing envelope may be developed by two methods. Machine sew together, side by side multiple fabric sections, cut to reach chordwise around the wing, starting and ending at the trailing edge with a minimum of 1 inch excess length. The sewn envelope is then positioned around the wing and secured with closely spaced T-Head pins at the wingtip and trailing edge. Excess material may then be trimmed. Carefully remove the envelope and complete by machine sewing at the wingtip and along the trailing edge, except where the geometry of the wing (aileron and flap cut out) would prevent the sewn envelope from being reinstalled. After reinstalling the envelope, the un-sewn sections and butt end are then closed by hand-sewn or overlapped and doped seams in accordance with the aircraft Vne speed. (Refer to paragraph 2-7 b.)

(1) An alternative method, when fabric of sufficient width is available, is to sew together, side-by-side, two sections of fabric, placing the seams spanwise on the leading edge, then fit and sew the wingtip and trailing edge in the same manner as the multiple piece chordwise envelope.

(2) An envelope may be developed for the fuselage in the same manner, with a final closing along a longeron by hand-sewn or overlapped and doped seams in accordance with the aircraft Vne speed.

b. The Blanket Method. A blanket is developed by sewing together, side-by-side, multiple sections of fabric with the seams chordwise or two wide sections of fabric, side-by-side, placing the seam spanwise on the leading edge, the same as an envelope. Close the three remaining sides with a hand-sewn seam or overlapped and doped seams in accordance with the aircraft Vne speed. Small components may be covered by wrapping one piece of fabric over a straight leading or trailing edge, then closing three sides with hand-stitched or overlapped and doped seams in accordance with the aircraft Vne speed.

NOTE: All overlapped and doped seams will be made only over underlying supporting structures extending the full width of the seam.

c. Machine-sewn alternate. An alternate to machine-sewn seams on a wing envelope or blanket is to use two sections of wide fabric spanwise. Attach the fabric with overlapped and doped seams at the leading and trailing edge, wingtip and wing butt, in accordance with the aircraft Vne speeds. (Reference paragraph 2-7 b.) Smaller components may be covered in the same manner. The fuselage may be covered with multiple fabric sections with