U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRCRAFT METAL PROPELLER MAINTENANCE

Date: 8/15/89
Initiated by: AFS-340

AC No: 20-37D
Change:

1. PURPOSE. This advisory circular (AC) provides information and describes maintenance procedures for service personnel to minimize failures and extend the service life of aluminum alloy aircraft propellers.

2. CANCELLATION. AC 20-37C, Aircraft Metal Propeller Blade Failure, dated July 15, 1980, is cancelled.

3. DISCUSSION. There is a margin of safety incorporated into the design of aircraft propellers. However, despite the safety factors engineered into propellers, partial or complete blade failures continue to occur. Federal Aviation Administration (FAA) data on propeller failures indicates that failures occur across the entire spectrum of aircraft/engine/propeller combinations. The propeller maintenance information contained in this AC can provide maintenance personnel with information and techniques to reduce these failures and increase the service life of a propeller.

4. PROPELLER DESIGN AND CAUSES OF FAILURE. An aircraft propeller produces thrust by converting engine horsepower into a mass movement of air. During normal operation, the propeller is subject to at least four separate stress loadings: thrust, torque, centrifugal force, and various aerodynamic forces. A properly maintained propeller is designed to perform normally under these loadings, but when additional stresses are imposed on it during operation, the design margin of safety can become greatly reduced. Propellers can become overstressed and fail because of direct mechanical damage from rocks, gravel, or debris. Most of these injuries tend to be sharp-edged nicks and scratches created by the displacement of material from the blade surface. This small-scale damage tends to concentrate stress in the affected area, and eventually, these high-stress areas may develop cracks. As a crack propagates, the stress becomes more and more concentrated, increasing crack growth, and in all probability, the growing crack will result in blade failure. Many other types of damage, such as corrosion of blades, propeller/ground strikes, and mechanical failures in the blade clamp or hub area, can also cause propellers to fail or become unairworthy.

5. BLADE DAMAGE CLASSIFICATION. The following lists the typical types of inservice damage to aluminum alloy propeller blades.

a. Corrosion. Corrosion on metal propeller components can be classified into three distinct types:

(1) Surface. Surface loss of metal due to chemical or electrochemical action, with visible oxidation products usually having a contrasting color and texture to the base metal.

(2) Pitting. Pits may be present under decals or blade overlays. These consist of visible cavities extending inward from the metal surface. In severe cases, pits can extend under the blade surface and reappear at another location.

(3) Intergranular. This is sometimes called metal delamination or exfoliation. The presence of intergranular corrosion may be the result of alloy impurities.

b. Face Nonalignment. Blades are bent around the propeller's chord-wise axis and blades will not track.

c. Nick. A sharp notch-like displacement of metal usually found on leading and trailing edges.

d. Erosion. Loss of metal from blade surface by the action of small particles such as sand or water, usually present on the leading edge close to the tip.

e. Scratch. A superficial small cut on the blade surface, usually located on the flat side of propeller.

f. Score. A surface tear or break on a blade that has a depth and length ranging between a scratch and a gouge.

g. Gouge. A deep groove on a blade formed by a heavy pressure contact with a solid object.

h. Cut. A deep, long, and narrow metal loss formed by a glancing blow from a sharp-edged object.

i. Crack. An opening between two adjoining sections of a blade. Cracks can be started by cuts, nicks, or severe corrosion in the area.

j. Dent. A depression in the blade as the result of a direct impact from a solid object, usually found on the blade's leading edge.

6. INSPECTION, SERVICE, AND MINOR REPAIRS.

a. Propeller Blades.

(1) Inspections. Aircraft maintenance personnel should adhere to the following procedures during propeller inspections.

(i) Airworthiness directives (AD's), propeller manufacturers' manuals, service letters, and bulletins specify methods and limits for blade maintenance, inspection, repair, and removal from service. When a manufacturer's data specifies that major repairs to a specific model blade or other propeller components are permitted, those repairs may be accomplished only by an appropriately certificated and rated propeller repair facility. All other propeller blade maintenance and minor repairs, such as removal of minor nicks, scratches, small areas of surface corrosion, and minor ice control boot repairs, can be accomplished only by an FAA-certificated mechanic using the practices and techniques specified by this AC and the propeller manufacturer's service data.

(ii) FAA data on propeller failures indicates that the majority of blade failures occur in the blade tip region, usually within several inches from the tip. However, a blade failure can occur along any portion of a blade including the midblade, shank, and hub, particularly when nicks, scratches, corrosion, and cracks are present. Therefore, during propeller inspection and routine maintenance, it is important that the entire blade be inspected.

(iii) Corrosion may be present on propeller blades in varying amounts. Prior to performing any inspection process, maintenance personnel should examine the specific type and extent of the corrosion and become familiar with the propeller manufacturer's recommended corrosion removal limitations and practices.

(2) Limitations. Service personnel should be familiar with the following limitations during any inspection.

(i) Corrosion, other than small areas (6 square inches or less) of light surface type corrosion, may require propeller removal and reconditioning by a qualified propeller repair facility. When intergranular corrosion is present, the repair can be properly accomplished only by an appropriately certificated propeller repair facility. Corrosion pitting under propeller blade decals should be removed as described in the propeller manufacturer's service bulletins and applicable AD's.

(ii) Unauthorized straightening of blades following ground strikes or other damage can create conditions that lead to immediate blade failure. These unapproved repairs may sometimes be detected by careful inspection of the leading edges and the flat face portion of the blade. Any deviation of the flat portion such as bows or kinks may indicate unauthorized straightening of the blade. Sighting along the leading edge of a propeller blade for any signs of bending can provide evidence of unapproved blade straightening. Blades should be examined for any discoloration that would indicate unauthorized heating. Blades that have been heated for any repair must be rejected, since only cold straightening is authorized. All blades showing evidence of unapproved repairs should be rejected. When bent propellers are shipped to an approved repair facility for inspection and repair, the propeller should never be straightened by field service personnel to facilitate shipping, as this procedure can conceal damage. Propeller tip damage will sometimes lead maintenance personnel to consider removing damaged material from the blade tips. However, propellers are often "tuned" to the aircraft engine and airframe resonant frequency by being manufactured with a particular diameter to minimize vibration. Unless the manufacturer specifically permits shortening of the blades on a particular propeller, any shortening of the blades will probably create an unairworthy condition. When conditions indicate, inspect blade tips for evidence of shortening and, if necessary, the propeller diameter should be measured to determine if it has been changed by an unauthorized repair.

(3) Minor Blade Repairs. Aircraft maintenance personnel should limit all blade repairs (except those performed at a certificated and rated propeller repair facility) to those described in the following paragraphs. Tools required to complete minor blade repairs are:

- Fine cut, round, and flat files.
- 10 Power loupe or magnifying glass.
- Emery cloth Nos. 240 and 320.
- Crocus cloth.

(i) Nicks or cuts in the leading or trailing edges of blades may be repaired by ensuring that the bottom of the injury is removed first by rounding out and fairing in the repair only slightly deeper than the nick or cut. The initial repair should be done by a fine cut file. All traces of file marks in the repaired area should be removed with No. 240 emery cloth followed by polishing with No. 320 emery cloth, then finished with crocus cloth, and visually inspected. An individual chordwise repair should not exceed a depth of 3/16-inch. The faired total length of the repair should not exceed 1 inch. When repair areas do not overlap, more than one repair may be accomplished. Appendix 1 illustrates these repair techniques and limitations. Table 1 shows leading edge nick repair limitations.

(ii) Gouges and small dents on blade faces may be repaired by ensuring that the bottom of the injury is removed first by rounding out and fairing in the repair to form a saucer-shaped depression only slightly deeper than the damage. The initial repair should be accomplished by filing with a fine cut file parallel to the damage and finishing with No. 240 and No. 320 emery abrasive cloth as in the manner of nick removal from blade-leading edges. Final polishing of the repair should be done with crocus cloth. An individual repair should not exceed 1/16-inch in depth and the surface radius of curvature of the repair must not be less than 3/8-inch. Chordwise repair width should not exceed 3/8-inch with the repair length not greater than 1 inch. More than one repair is permitted when repair areas do not overlap an identical blade radius. Appendix 1 illustrates these repair techniques and limitations.

(iii) Repairs of longitudinal cuts on blade faces can be accomplished using the same techniques for repairing gouges and small dents, and the same length, depth, and overlap restrictions will apply. Appendix 1 illustrates these repair techniques and limitations.

(iv) Leading edge nick repair limits are shown in Table 1. Any repair that exceeds Table 1 limits should be accomplished <u>using only the propeller manufacturer's repair manual limits as a guide</u>.

TABLE 1. BLADE LEADING EDGE REPAIR

When Leading Edge Nick Is: (From Appendix 1)	Finished Repair Depth Is: (From Appendix 1)
1/32-inch	1/16-inch
1/16-inch	3/32-inch
3/32-inch	5/32-inch
1/8-inch	3/16-inch
For nicks exceeding depths shown in this table, use the propeller manufacturer's service information limitations.	

(v) A crack in a blade may be discovered during the process of repair. Any chordwise crack or those present on a leading or trailing edge cannot be repaired. The presence of this type of crack indicates that blade failure is virtually certain at any time. Propellers with this type of damage are unairworthy and must be removed from service and clearly identified as unairworthy. Prior to returning any blade to service after minor repairs, the reworked area should be inspected with at least a 10 power lens to ensure that any sharp notches at the bottom of the damage have been removed. In any case, where a developing crack is suspected in the bottom of the repair, inspect the repair using the propeller manufacturer's approved dye penetrant or fluorescent penetrant method. The use of acid etching and anodizing for detection of cracks should be limited to approved propeller repair facilities due to the special facilities required for these processes. The repair of propeller blades by peening over the edges of damaged areas is not authorized since this method will prestress the damage and, in all probability, lead to a fatigue crack. The repair of blades by welding or heating is not authorized, as the high strength of the original aluminum forging will be significantly reduced by those procedures.

(vi) Accurate propeller tracking requires chocking the aircraft in a stationary position and ensuring that the engine crankshaft is tight against the thrust bearing. A blade tracking datum can be made simply by placing a block on the ground in front of the aircraft in the propeller arc. Raise the block as required to obtain a clearance between the blade tip (prop blade vertical) and datum block not exceeding 1/4-inch. Scribe a line on the block next to the blade tip position. Pull all the blades past the scribed datum. No blade should deviate more than 1/16-inch from the plane of rotation as defined by the scribe mark. When inspecting the propeller track, blades should be gently rocked to detect any possible looseness. Propeller blades exhibiting any looseness or out-of-track conditions exceeding 1/16-inch should not be returned to service without inspection/repair by an appropriately rated propeller repair facility.

b. Propeller Hub.

(1) Fixed Pitch.

(i) Inspection procedures require removal of the propeller spinner for examination of the prop hub area. Cracks may be present in the hub area between or adjacent to bolt holes and along the hub pilot bore. Cracks in these areas cannot be repaired and require immediate scrapping of the propeller.

(ii) Propeller attach bolts should be examined for looseness or an unsafetied or cracked condition. Cracked or broken bolts are usually the result of overtorquing. Correct torquing procedures require all bolt threads to be dry, clean, and free of any lubrication prior to torquing.

(2) Controllable Pitch.

(i) Complete inspection/servicing requires the removal of the spinner for examination and servicing of the propeller hub and blade clamp area. All inspection and servicing of the pitch control mechanism should follow the recommendations of the propeller, engine, and airframe manufacturer. All propeller AD's and manufacturers' service bulletins must be checked for compliance.

(ii) The hub, blade clamps, and pitch change mechanisms should be inspected for corrosion from all sources, including rain, snow, and bird droppings that may have entered through spinner openings. Examine the hub area for oil and grease leaks, missing lubricaps, and leaking or missing zerk fittings. When servicing the propeller thrust bearings through zerk fittings in the blade clamps, the rear zerk fitting on each clamp must be removed to avoid extruding grease past the bearing grease seal and damaging the seal. Lubricaps should then be pressed over the ends of all zerk fittings.

(iii) Propeller domes should be checked for leaks both at the seals and on the fill valve (if so equipped). The dome valve may be leak-tested by applying soapy water over the fill valve end. Domes should be serviced only with nitrogen or dry air in accordance with the manufacturer's recommendations. When propeller domes are inspected and found filled with oil, the propeller should be removed and inspected/repaired by an appropriately rated repair facility.

(iv) Fiber block pitch-change mechanisms should be inspected for deterioration, fit, and the security of the pitch-clamp forks.

(v) Certain models of full-feathering propellers utilize spring-loaded pins to retain the feathered blade position. Spring and pin units should be cleaned, inspected, and relubricated as per the manufacturer's recommendations and applicable AD's.

(vi) Pitch change counterweights on blade clamps should be inspected for security, safety, and to ensure that adequate counterweight clearance exists within the spinner.

7. PROPELLER MAJOR REPAIR AND OVERHAUL.

a. Periodic Reconditioning. A number of factors will require returning a propeller to an appropriately rated and certificated propeller repair facility for service, repair, or overhaul. Some propeller manufacturers recommend a periodic reconditioning of some fixed-pitch models at specified service time intervals to prevent blade failure from surface stress fatigue. This requires the propeller to be returned to the manufacturer for removal of a thin layer of surface metal to restore the propeller to the original unstressed condition. Fatigue cycles generated by some engine/propeller combinations can require manufacturer reconditioning intervals as often as every 500 hours of operation. Other propeller makes and models are required by AD's to be overhauled or partially disassembled for service or lubrication. In most cases, this requires that the propeller be returned to an appropriately certificated repair facility.

b. Service Personnel Limitations and Responsibilities. Federal Aviation Regulations (FAR) Section 65.81 specifically excludes certificated and rated mechanics from performing major repairs and/or major alterations on aircraft propellers. In this regard, FAR Part 43, Appendix A, Paragraphs (a)(3) and (b)(3) define what major alterations and repairs are to propellers. However, FAR Part 145 provides that properly certificated and rated repair stations may perform such major repairs or alterations provided the work is done in accordance with technical data approved by the Administrator. Part 145 also specifies the personnel and other requirements applicable to such repair stations. In addition to complying with AD's, service personnel should review all applicable manufacturers' service bulletins, manuals, and other information on the propeller being inspected. While compliance with propeller manufacturers' service bulletins is not mandatory, in many cases, they specify more rigorous limits on repair or inspection than are described by FAA-recommended practices. It is recommended that manufacturers' service bulletins receive the most careful consideration during the inspection process.

8. TACHOMETER INSPECTION. Due to the exceptionally high stresses that may be generated by particular propeller/engine combinations at certain engine revolutions per minute (RPM), many propeller and aircraft manufacturers have established areas of RPM restrictions and other restrictions on maximum RPM for some models. Some RPM limits have never exceed values as close as 3 percent of the maximum RPM permitted, and a slow-running tachometer can cause an engine to run past the maximum RPM limits. Since there are no post-manufacture accuracy requirements for engine tachometers, tachometer inaccuracy could be a direct cause of propeller failure, excessive vibration, or unscheduled maintenance. Tachometer accuracy should always be checked during normal maintenance intervals or sooner if indicators such as excessive vibration or aircraft performance changes might indicate inaccurate RPM readings.

9. PROPELLER BALANCING. Propellers can become imbalanced for a variety of reasons. There have been a number of instances where the process of moving an aircraft by pushing or pulling on the propeller blades has moved the blades to an out-of-track condition, creating an imbalance. Propeller damage, however, remains the major contributor to propeller imbalance. Unauthorized or improper repair of propeller spinners has also been identified as a cause of propeller imbalance. Propellers can be balanced by two methods: static balancing and dynamic balancing.

a. Static Balancing. Propellers can be properly statically balanced only by removing the propellers and evaluating the vertical and horizontal balance on a special fixture. Propeller static balancing should be accomplished only by a properly certificated and rated propeller repair facility.

b. Dynamic Balancing. Certain models of propellers may be dynamically balanced in place on the aircraft. When applicable, the aircraft maintenance manual will describe the specific procedures for adding dynamic balance weights. These are usually installed on the propeller spinner backing plate using specialized dynamic-balancing equipment to determine exact weight balance values. Unless the aircraft maintenance manual authorizes dynamic balancing for a specific model, propeller balancing should be limited to static balancing.

10. PROPELLER RECORDS. Maintenance records are a required part of a system of aircraft maintenance. Propeller maintenance recordkeeping responsibility is ultimately assigned to the owner/operator in accordance with FAR Part 91.165. Part 91.173(a)(2)(i) requires that a record of total time in service be maintained for each propeller. In some cases, lack of records may require recompliance with a particular propeller AD. Propeller logbooks are available from various sources, including the propeller manufacturer.

11. PROPELLER INSTALLATION. Propellers must be installed by an appropriately rated and certificated mechanic. Only the propeller manufacturer's bolt or nut torque requirements should be used for the installation. On some propellers, the correct installation torques may be shown on a propeller hub decal. When the propeller is correctly torqued, the blade track should be checked to the tolerances specified by this AC or the manufacturer's specifications, whichever is less. New or reconditioned propellers are required to have been statically balanced by the repair facility. However, if after installation the

propeller/engine combination runs rough (vibration) on the ground or in flight, the propeller should be removed and rotated 180 degrees on the engine crankshaft, reinstalled, and the blade track should be checked again. Certain propeller installations may require additional dynamic propeller balancing on the engine. Paragraph 9b discusses the general guidelines of dynamic balancing. Propeller action and RPM parameters must be checked during runup and the installation inspected for leaks. Spinner assemblies should be inspected during installation in accordance with the propeller or aircraft manufacturer's guidelines. Inspect spinners and backplates for warping, cracks, looseness, missing parts, fasteners, improper repairs, or unauthorized modifications (including addition of balance weights). Any repair of a spinner must be carefully evaluated prior to return to service, since a repair that adds weight to a spinner can create imbalance.

12. PROP TIPS. Following these simple procedures for the care and use of a propeller can greatly increase its service life.

a. Do the Following:

(1) Perform a visual preflight inspection of the blades for nicks, scratches, stone cuts, erosion, and cracks.

(2) All damage found should be inspected by an FAA-certificated mechanic.

(3) Clean propeller blades with a nonalkaline cleaner and wax periodically using a quality-type automotive paste wax to prevent moisture penetration and the resultant corrosion.

(4) Wipe blades frequently using an oily cloth.

(5) Ensure that the tachometer is appropriately marked for operational limitations of the propeller and that the tachometer accuracy is checked at periodic inspection intervals.

(6) Make sure that the applicable installation, information, and warning decals are on the propeller. These decals may include warnings against pushing or pulling on the propeller, the model number, the correct bolt torque, and any other manufacturer's identification.

(7) Although a propeller overhaul may not be required by an AD, the operator should consider reconditioning or overhauling the propeller when it reaches the manufacturer's recommended service time.

(8) For safety and glare reduction, keep the blade backs painted flat black and the propeller tips painted with the appropriate warning colors.

(9) Leave two-bladed propellers in the 1 o'clock position to minimize bird droppings and water being retained in the spinner.

b. Do Not Do the Following:

(1) Do not operate any aircraft after a propeller has been subjected to an impact without a thorough inspection, including propeller tracking, if indicated.

(2) Never straighten a damaged propeller. Even partial straightening of blades to permit shipment to a certificated propeller repair facility may result in hidden damage not being detected and an unairworthy propeller being returned to service.

(3) Never repair any blade defect by welding, heating, or peening. No propeller manufacturer permits this as it can induce premature blade failure.

(4) Do not fill any damaged areas of the blades, even when properly repaired, with bulk-filler materials such as epoxy or auto body fillers. This prevents areas of potential cracking from being inspected and affects balance.

(5) Do not paint over areas of corrosion on blades. Corroded areas should be removed in accordance with approved procedures prior to applying any protective finish.

(6) Do not run up engines in areas containing loose rocks, gravel, or debris. Avoid quartering rear winds during ground runup.

(7) Do not push or pull on propeller blades when moving the aircraft by hand. Tow bars are specifically designed for this operation.

(8) <u>Never</u> install a propeller on an aircraft unless it is a model approved by the aircraft type certificate data sheet or an appropriate Supplemental Type Certificate, and the service history of the propeller can be documented.

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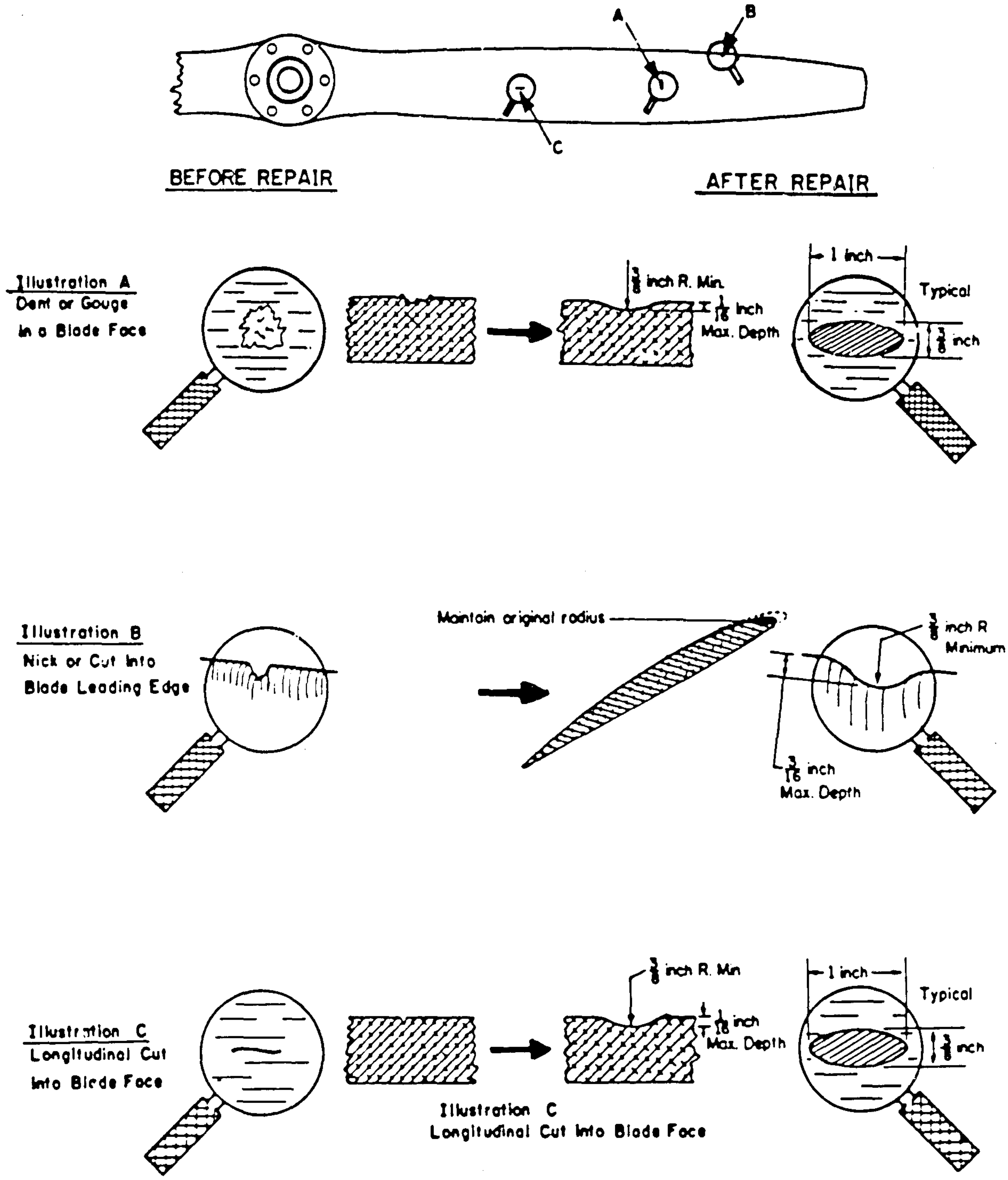

Figure 1. Techniques for Repair of Blade Damage