

**MODULE 17A**

**FOR A CERTIFICATION**

# **PROPELLER**

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## **Aviation Maintenance Technician Certification Series**



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## REVISION LOG

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## PROPELLER CONSTRUCTION

### PROPELLERS USED ON GENERAL AVIATION AIRCRAFT

An increasing number of light aircraft are designed for operation with governor regulated, constant-speed propellers. Significant segments of general aviation aircraft are still operated with fixed-pitch propellers. A majority of small, single engine aircraft use fixed-pitch metal propellers. Some light sport aircraft (LSA) use multi blade fixed-pitch composite propellers. Medium size turbo prop aircraft will often be equipped controllable propellers with pitch reversing systems. Larger transport and cargo turbo prop aircraft use propeller systems with dual or double acting governors and differential oil pressure to change pitch.

#### FIXED-PITCH WOODEN PROPELLERS

Although many of the wood propellers were used on older airplanes, some are still in use. Early aviation pioneers carved propellers from laminated wooden blanks using hand tools. The construction of a fixed-pitch, wooden propeller is such that its blade pitch cannot be changed after manufacture. *(Figure 2-1)* The choice of the blade angle is decided by the normal use of the propeller on an aircraft during level flight when the engine performs in an efficient manner. The impossibility of changing the blade pitch on the fixed-pitch propeller restricts its use to small aircraft with low horsepower engines in which maximum engine efficiency during all flight conditions is of lesser significance than in larger aircraft. The wooden, fixed-pitch propeller is well suited for small aircraft because of its lightweight, rigidity, economy of production, simplicity of construction, and ease of replacement. Because many small aircraft have a variety of approved propellers for installation, aircraft owners or operators have the option of selecting the appropriate

propeller for their operation. The two common options are a “climb prop” or “cruise prop.” Climb propellers generally have a lower pitch or shorter diameter that allows the engine to attain higher rpms while cruise propellers are built with higher pitch angles and longer diameters and are well suited for cruise operations. *(Figure 2-2)*

A wooden propeller is not constructed from a solid block of wood, but is built up of a number of separate layers or laminates of carefully selected and well seasoned hardwoods. Many woods, such as mahogany, cherry, black walnut and oak, are used to some extent, but birch is the most widely used. Five to nine separate layers are typically used, each about 3/4 inch (2 cm) thick. Generally, the growth rings of the laminates are alternated in terms of direction to minimize warping. The wood laminates are glued together using a waterproof, resinous glue and allowed to set. The blank is then roughed out to the approximate shape and size of the finished product. The roughed out propeller is then allowed to dry for approximately one week to permit the moisture content of the layers to become equalized. This additional period of seasoning prevents warping and cracking that might occur if it was immediately carved from a blank. Following this period, the propeller is carefully constructed. Templates and bench protractors are used to assure the proper contour and blade angle at all stations.

After the propeller blades are finished, a fabric covering is cemented to the outer 12 to 15 inches (30 to 38 cm) of each finished blade. A metal or composite tipping is fastened to the leading edge and tip of each blade to protect the propeller from damage caused by flying particles in the

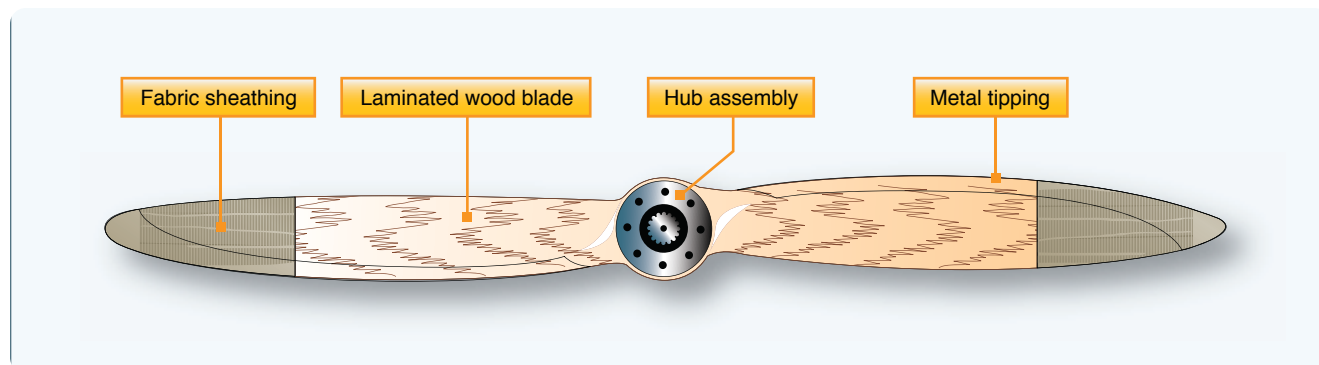


Figure 2-1. Wooden propeller.



Figure 2-2. Propeller data. This propeller has a 72-inch diameter with a 44-inch pitch. It could serve as a climb propeller on some airplanes and a cruise propeller on others. Note the laminates.



Figure 2-3. Wooden propeller showing spinner, hub, laminates, metal tipping, fabric covering, and drain holes.

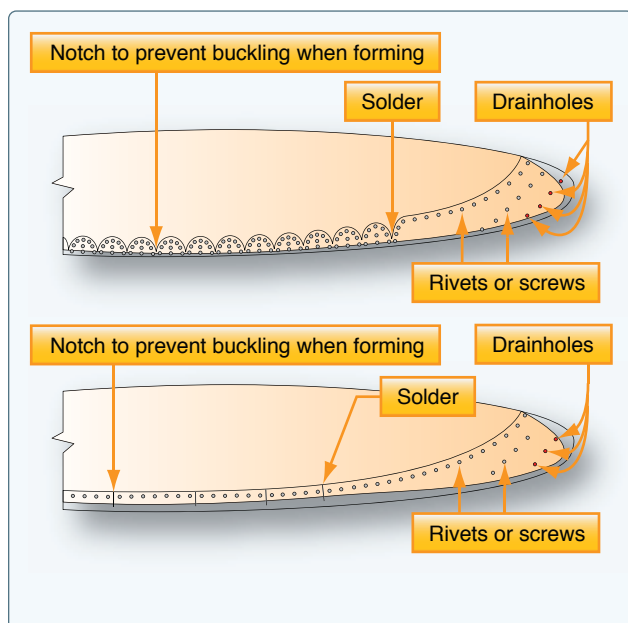


Figure 2-4. Wooden propeller tipping.

air during landing, taxiing, or takeoff. The tipping also serves as an erosion strip to protect the leading edge of the propeller. (Figures 2-3 and 2-4) Metal tipping may be of terneplate, monel metal, or brass. Stainless steel has been used to some extent. The metal tipping is secured

to the leading edge of the blade by countersunk wood screws and rivets. The heads of the screws are soldered to the tipping to prevent loosening, and the solder is filed to make a smooth surface. Since moisture condenses on the tipping between the metal and the wood, the tipping is provided with small holes near the blade tip to allow this moisture to drain away or be thrown out by centrifugal force. (Figure 2-5) It is important that these drain holes be kept open at all times. When the aircraft is inactive for an extended period, the engine is positioned so that the wooden propeller remains in a horizontal position to maintain even water content between the blades. If the blades are left in a vertical position for a protracted period, water in the wood will tend to migrate to the lower blade.



Figure 2-5. Tip on wooden propeller revealing soldered attachment hardware and drain holes.

Since wood is subject to swelling, shrinking, and warping because of changes of moisture content, a protective coating is applied to the finished propeller to prevent a rapid change of moisture content. The finish most commonly used is a number of coats of water repellent, clear varnish. After these processes are completed, the propeller is mounted on a spindle and very carefully balanced.

Several types of hubs are used to mount wooden propellers on the engine crankshaft. The propeller may have a forged steel hub that fits a splined crankshaft. It may be connected to a tapered crankshaft by a tapered, forged steel hub. Or it may be bolted to a steel flange forged on the crankshaft. In any case, several attaching parts are required to mount the propeller on the shaft properly.



Hubs fitting a tapered shaft are usually held in place by a retaining nut that screws onto the end of the crankshaft. A lengthy metal key is used to align the propeller hub with the crankshaft. Proper positioning of the propeller on the crankshaft in terms of clock angle is needed when the engine is started by hand cranking or propping. A snap ring is used in many hubs. The snap ring retains the crankshaft nut when the propeller is removed from the engine. The snap ring also serves as a pulling surface when breaking the hub free from the tapered crankshaft using the crankshaft nut. A loud cracking sound is emitted when the hub is broken free from the tapered crankshaft.

On splined shaft installations, front and rear cones may be used to accurately center the propeller on the crankshaft or propeller shaft and seat the propeller. The rear cone is a one piece bronze design that fits around the shaft and against the thrust nut (or spacer) and seats in the rear cone recess of the hub. The front cone is a two piece, split type steel cone that has a groove around its inner circumference so that it can be fitted over a flange of the propeller retaining nut. Then, the retaining nut is threaded into place and the front cone seats in the front cone hub. A snap ring is fitted into a groove in the hub in front of the front cone so that when the retaining nut is unscrewed from the propeller shaft, the front cone acts against the snap ring and pulls the propeller from the shaft.

One type of hub incorporates a bronze bushing instead of a front cone. When this type of hub is used, it may be necessary to use a puller to start the propeller from the shaft. A rear cone spacer is sometimes provided with the splined shaft propeller assembly to prevent the propeller from interfering with the engine cowling. The wide flange on the rear face of some types of hubs eliminates the use of a rear cone spacer.

One type of hub assembly for the fixed-pitch, wooden propeller is a steel fitting inserted in the propeller to mount it on the propeller shaft. It has two main parts: the faceplate and the flange plate. (*Figure 2-6*) The faceplate is a steel disk that forms the forward face of the hub. The flange plate is a steel flange with an internal bore splined to receive the propeller shaft. The end of the flange plate opposite the flange disk is externally splined to receive the faceplate. The faceplate bore has splines to match these external splines. The units used on lower horsepower engines with tapered shafts generally do not have these splines. Both faceplate and flange plates have

a corresponding series of holes drilled on the disk surface concentric with the hub center. The bore of the flange plate has a 15° cone seat on the rear end and a 30° cone seat on the forward end to center the hub accurately on the propeller shaft.

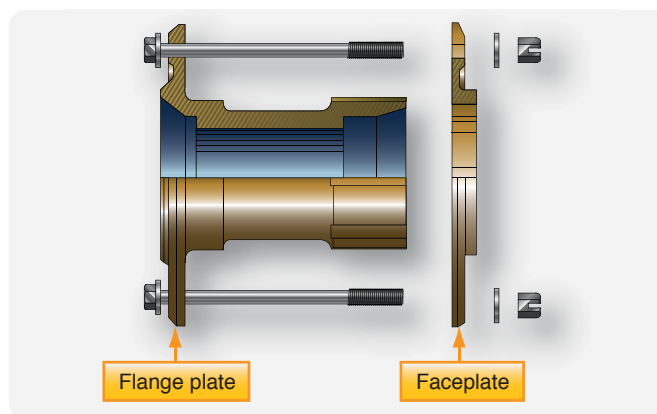


Figure 2-6. Wooden propeller hub adapter.

## TORQUING WOODEN PROPELLERS

As with other examples of maintenance procedures provided in this unit, the information contained herein is only for instructional purposes. Always refer to the current manufacturer's technical data for explicit maintenance instructions.

The installation of a wooden propeller must adhere to strict torquing procedures. The torque placed on a wooden propeller must be enough to apply a compressive force to the hub without crushing the wood. Before installing the propeller, or checking the torque, ensure that the magneto switch(es) are in the OFF position and that the aircraft is chocked or tied-down. Removing a spark plug from each cylinder will further enhance safety and will make it easier to rotate the engine for torquing purposes and for checking propeller track. Always use an accurate torque wrench that fulfills calibration requirements.

## METAL FIXED-PITCH PROPELLERS

Metal fixed-pitch propellers are similar in general appearance to a wooden propeller, except that the sections are usually thinner. The metal fixed-pitch propeller is widely used on many models of light aircraft. Many of the earliest metal propellers were manufactured in one piece of forged Duralumin. Compared to wooden propellers, some were lighter in weight because of elimination of blade clamping devices, offered a lower

maintenance cost because they were made in one piece, provided more efficient cooling because of the effective pitch nearer the hub and, because there was no joint between the blades and the hub, the propeller pitch could be changed, within limits, by twisting the blade slightly by a propeller repair station. Generally, metal propellers are heavier than their wooden counterparts. Propellers of this type are now manufactured as one piece anodized aluminum alloy. They are identified by stamping the propeller hub with the serial number, model number, type certificate number, production certificate number, and the number of times the propeller has been reconditioned. The complete model number of the propeller is a combination of the basic model number and suffix numbers to indicate the propeller diameter and pitch. An explanation of a complete model number, using the McCauley 1B90/CM propeller, is provided in *Figure 2-7*.

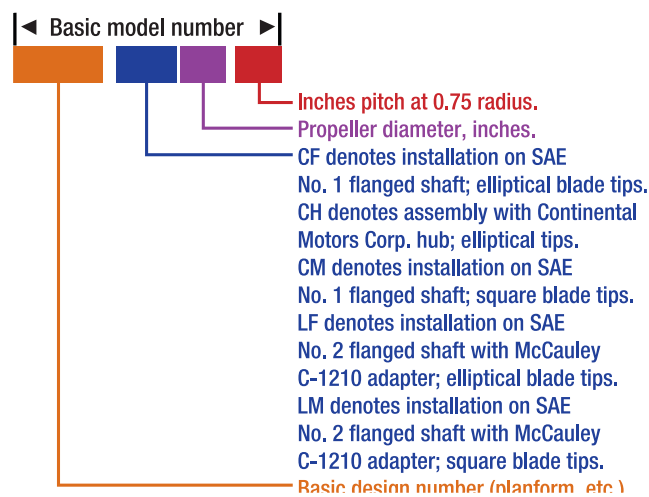


Figure 2-7. Propeller data information.

## STEEL PROPELLER BLADES

A number of propeller blades are manufactured from steel. These blades are sometimes found on propellers used on larger aircraft. A number of World War II aircraft and large transport piston powered aircraft of that era use propellers with steel blades.



Figure 2-8. Cross section of steel propeller blade.

Steel propeller blades are typically hollow to keep weight to a minimum. By comparison to blades made from other materials, steel propeller blades possess more heft. (*Figure 2-8*)

## COMPOSITE PROPELLERS

As with other parts of the airplane, composite materials and construction techniques have been adopted by the propeller manufacturers. They offer numerous advantages, especially for higher speed turboprop aircraft. The strength offered by composite blades in conjunction with lightweight and reduced sound levels have proven useful attributes.

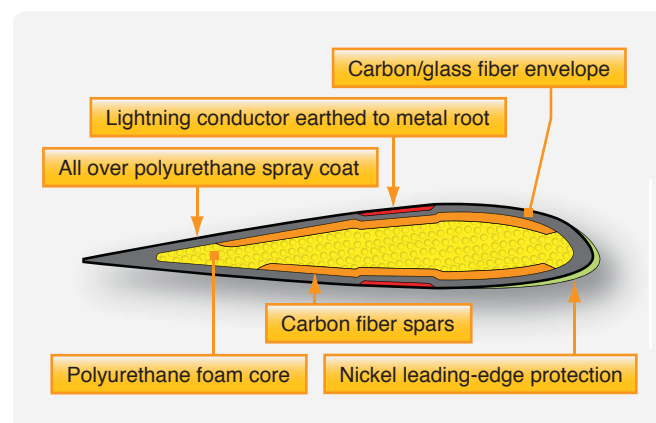


Figure 2-9. Makeup of composite propeller blade.

Similar to other composites used throughout the aviation industry, two essential components are utilized to produce the blades, the matrix and the fiber material. The former is similar to an epoxy and is used to keep the strands of the fiber in position. The fibers possess considerable tensile strength and provide vigor in terms of blade resiliency. A number of propellers flown in aerobatics are composite because of their lightweight, low inertia, durability, and affordability. (*Figure 2-9*)

Composite blades typically begin at the blade root where they are formed around the metal blade shank. Numerous layers of carbon fiber laminates are wound around a core. An attached erosion strip, when included, provides protection against blade erosion. (*Figure 2-10*)

## BLADE STATIONS

Propeller blades are rotating airfoils that have a relatively complex shape when compared to wings. The main reason for the intricate shape is related to airspeed. Near the propeller hub the relative velocity between the blade section and air is comparatively slow. By contrast, the



Figure 2-10. Cross section of composite propeller blade.

propeller tip experiences a high velocity with the air. (*Figure 1-8*) To accommodate the difference in airspeed, a typical propeller blade will have a high blade angle near the hub and a shallow blade angle at the tip. An examination of a propeller blade reveals that the blade angle gradually decreases from the hub or shank area of the blade to the tip. The length of the chord of the propeller blade may also change moving from the hub to the tip. The structural need of the propeller blade near the hub may require a shape that lacks aerodynamic qualities but provides ample strength to combat the various forces placed on the propeller assembly.

Propeller stations are often provided in six inch increments (15 cm). Refer to *Figure 1-7*. Note the gradual change in pitch angle and chord width.

### PROPELLER HUB, SHANK, BACK, AND FACE

The propeller hub is designed to withstand all the forces experienced by the propeller during operation. On fixed-pitched units, the opposing blades connect at the hub, which is a thick, heavily built member. On controllable-pitch propellers, the hub accommodates the pitch change mechanisms, bearings, passageways, and necessary lubricant(s). In addition to retaining the blades and internal members of the pitch control mechanism, the propeller hub is attached to the crankshaft or propeller shaft. The thrust generated by the propeller is transmitted to the engine and ultimately to the airframe through the propeller hub. Some propeller models attach the spinner bulkhead, or spinner backplate, to the hub.

The portion of the blade inserted into the hub of a controllable pitch propeller is known as the blade butt

or blade root. The propeller blade shank connects the blade root or butt to the airfoil section of the propeller blade. The shape of the shank ranges from circular or oval to a highly cambered form. The shank must be capable of absorbing the loads placed upon the propeller and transmitting the thrust to the hub. Overshoes or boots associated with de-icing and anti-icing systems are attached to the shank of the propeller blades and extend down a measure of the blade. (*See Figure 1-2*)

The surface of the propeller blade known as the back is the side of the blade containing the camber or curvature. The propeller back is similar to the upper surface of a wing in that it generates a lower pneumatic pressure as the blade rotates. Where a wing produces lift, the propeller generates thrust.

The face of the propeller blade is the surface that is relatively flat. As the propeller rotates, the face strikes the air. Pilots who fly single engine airplanes equipped with tractor propellers look at, or face, the face of the propeller as they operate the aircraft. (*Figure 2-11*)

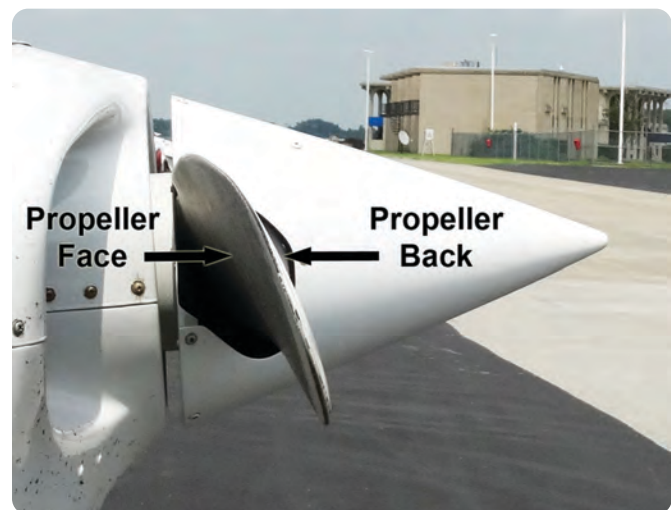


Figure 2-11. Propeller face and back.

### TYPES OF PROPELLERS

There are various types or classes of propellers, the simplest of which are the fixed-pitch and ground adjustable propellers. The complexity of propeller systems increases from these simpler forms to controllable-pitch and complex constant speed systems (automatic systems). Various characteristics of several propeller types are discussed in the following paragraphs, but no attempt is made to cover all types of propellers.