

## Propellers, Their Care and Handling.

Just as sled dogs love to run, airplanes love to fly. Give them anything remotely approaching what they need in the form of power and speed, and they will happily scramble for the sky and remain in the air until encouraged to return, or until gravity does its thing. They will fly even when there might be serious deficiencies existing “under the hood”.

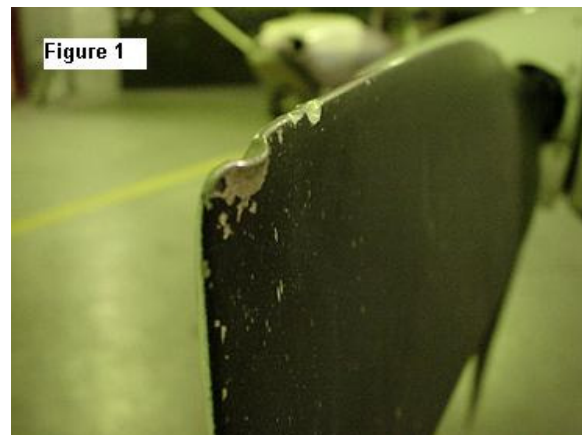
An oil seal might be weak and about to blow. A connecting rod might have a small crack or weakness and it might break. The wing strut could have a fatal flaw waiting for the pilot to impose a heavier –than-normal load. In many cases we are trained to handle the results of these failures. Losing the airplane is not an option, or should not be if we follow the manufacturer’s recommendations and emergency procedures correctly.

But some failures happen very fast, and give inconclusive indications, causing confusion or delaying the right response. In these cases, anticipation, preparation and a little luck separates us from the statistics. No matter how we handle our responsibilities as PIC we cannot protect ourselves and our passengers from disasters caused by mechanical failures that are hidden within the equipment and that do not give any warning of failure. Fortunately, that type of accident is extremely rare, and Maintenance practices are designed to reduce them to as low a risk as is humanly possible. But some defects can be more easily seen and we can be on guard against them if we know where to look.

### **Losing the airplane is not an option.**

Prop damage is one such incipient hazard. A recent mishap was caused by a propeller which had been damaged when it impacted some external object. It was thought that the damage was caused by a rock, or some other item picked up by the propeller during ground maneuvers. The pilots of this airplane examined the damage and decided that it did not reach the level that would prevent a return to base, and they duly started up, took off and flew home. See Figure 1 to see what the crew found on their pre-flight.

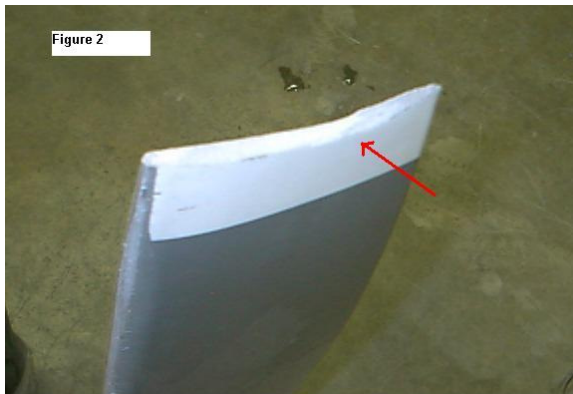
Once on the ground again, they called in their technical people and reported the damage in the log book. Two senior staff examined the damage and agreed that it was minor, requiring only that the propeller to be “dressed” before further flight. However when the mechanic responsible for the



follow-up saw the damage he realized that it was not minor. The propeller blades were severely damaged, to the degree that the propeller needed to be repaired and overhauled and the engine needed a tear-down. In the end, the engine was also overhauled. This was not a cheap or quick repair.

Why the big deal? What is the risk involved in flying an airplane with prop damage? This type of damage can sneak up on you. It might be a small mark on the blade, but internally there could be tension in the metal, or a crack, that is ready to let go. Perhaps on the next flight, several hours of flight later, or months might go by before the tip of the blade parts company with the airplane. When it does, the pilot will feel a severe vibration, the instruments will be hard to read, the engine will start vibrating as well due to the out-of-balance forces as the prop continues to turn, and in the worst case scenario, the engine too will leave for Terra Firma.

If the engine mounts fail, or the engine breaks away, there is little the pilot can do. The balance of the airplane will be so far outside the operating limits that there will not be enough elevator authority to control the pitch. The airplane will pitch up, stall and fall out of the sky. This type of accident is rarely survivable.



You can see the spread of the crack on this prop in Figure 2, two-thirds of the crack worked its way along the blade from a small chip on the leading edge, until the remaining part of the blade could not hold the forces and gave way. It was on a Cessna 206.

## **The centrifugal loads can be as much as 10 to 20 tons.**

We have all seen propeller damage of some degree, and few of us have had this type of failure, so am I making too big a deal of it? I hope so. But there have been too many cases to prove how important the integrity of the propeller is to ignore the danger. Figure 3 shows a prop that any of us would recognize as un-airworthy.

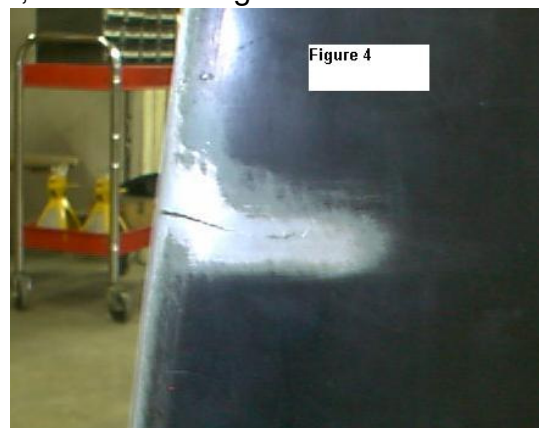
During takeoff, the centrifugal loads on a propeller blade can be as much as 10 to 20 tons. The tips of the blades are approaching the speed of sound, the blades are absorbing the vibrations of the engine power pulses and the airflow adds to the loads that must be carried by this critical part of



the equipment. Blades twist and flex and stresses are concentrated on the small areas of damage. The material used to build propellers is of necessity soft, with annealed surfaces to protect against scratches and the like. It resists fractures but the right type of "hit" can start the process of failure.

The type of damage that can cause this failure depends on the type of impact the blade has sustained. If the chip, or nick, is small, with sharp edges or a "V" shape, the stresses on the metal will be high. The sharp edges will concentrate the lines of force and are the starting point for a crack to form. As the crack propagates, and the engine continues to run, eventually there is not enough of the blade holding together to prevent the propeller blade outboard of the chip from detaching itself from the remaining blade and the out-of-balance forces will tear the entire mechanism free of the engine, or take the engine with it.

This crack (Figure 4) was hidden by paint and the airplane flew for a considerable time in this condition.



It is interesting to note that a chip in the blade only has to be as large as one sixteenth of an inch, or about the size of the head of a pin. Not too big, eh? One IA told me that if you run a finger nail

along the blade leading edge and it catches, it is a potential blade failure. Of course we all know to check that the mags are OFF before touching a prop. If not, see what a prop can do in Figure 5.



A dent in the blade, although it is larger, might not cause the lines of force in the metal to become so concentrated since the metal has been compressed, not torn out. If the damage shows clean, smooth curves, it should be able to handle the stresses of takeoff and cruise. SHOULD be able. Any case of blade bending is unsafe for flight, no matter how small the area affected.

Although the cause and effect is clear, it must be pointed out that not all propellers fail when damaged. Should a runway light be clipped, the blade might fail immediately on takeoff, or it might operate without symptoms for a long time. It depends on the internal damage caused by the prop strike as well as the loads the propeller carries. The more likely sequence of events would have a crack

start as a result of the damage and for the crack to propagate inside the blade until failure occurs, hours of flight time later. So even if you are not the one who picks up the stone or hits the obstacle on the taxiway, you might face the resulting failure and have to use your skills to maintain safe control of the situation. We share the flight time on the airplanes and it is a good habit for us all to do a good pre-flight on the prop.

Before flight, check the propeller for cleanliness as well as damage. A blade covered in grime will not work as well, and dirt can hide cracks or other small signs of damage. Check for scratches, pockmarks and gouges in the metal. Check the spinner at the same time.

### **Make sure you get advice.**

If you are not current with operations on gravel, or have not been trained to recognize how serious prop damage can be, make sure you get advice from a senior pilot or mechanic who does know.

No pilot in the Alaska Wing of the CAP has been trained to “Dress” a propeller blade. There is a certain skill needed to dress a blade, and it can change the balance of the propeller so it should not be done unless you are trained and approved. When properly dressed, a propeller is safe to continue in service, but if it is not done the right way, the prop will be even more likely to fail. Figure 6 shows how NOT to dress a propeller!



So what do you do if you find damage? Be careful. Look at the type of damage, where it has occurred, how deep the nick or chip is, if there has been any blade deformation and the like. Although a crack can result from the smallest of chips, it is unlikely that minor damage will cause an immediate failure and it would probably be safe to fly back to base for our own mechanics to inspect and fix. The size and shape of the damage will tell you when failure is imminent and this is very subjective. Contact a local A&P for advice. They are all, to a man (or woman) experienced in this field and can help you to make a safe decision.

### **We will send out an airplane to rescue you.**

Call the CAP hangar. If facilities exist, fax or email a picture of the damage. If you are not certain it is safe, ask for help and the squadron, or the hangar, will

send out an airplane to rescue you. Most likely they will be able to repair the damage sufficiently that your airplane will be safe to fly once more, and sometimes they will tell you it was safe anyway, but this is one case where it is better to be sure.

Of course we don't want our airplanes being grounded out in the boonies for no good reason, so before it happens to you, learn what to look for. Do a thorough pre-flight before leaving home and if you see any damage at all, contact the A&P before you go. When you go about your business on the ramp, look at other airplanes and check out their propellers. Would you fly that airplane? Is that damage beyond reasonable limits? Is that a good example of a dressed propeller? You will be able to make judgments on the severity of the damage that will help you when you are faced with the decision of whether to fly or to call for help.

It might be pertinent to remind you that as with a rental car, if you miss damage on your pre-flight, what you find on return, or what the next guy finds, is your responsibility.

### **Immediate action is needed.**

Should a blade fail in flight, you will feel a strong, sometimes extreme, rhythmic vibration dependent on rpm. Immediate action is needed. Close the throttle. Pull the prop control to full decrease to reduce the rpm if flying with a constant speed propeller. If the vibration reduces, slow to best glide speed and check to see what caused the vibration. If it is a prop, it will be rpm sensitive, but try to eliminate other causes. With the throttle at idle, the airplane should be flyable. You might have to shut the engine down. If you suspect blade failure, do not re-open the throttle. Carry out a forced landing, after declaring an emergency.

Propeller failures are serious events and a potential emergency that is best handled proactively.

For more information on prop strikes, see  
<https://ntc.cap.af.mil/se/Alerts/SafetyAlert00-01revised.htm>  
<https://ntc.cap.af.mil/se/Newsletters/2000/Aug00.htm>

Safe Flying, Glen Morthorpe. Wing Safety Director.