Tying the knot

Know the ropes so your aircraft won't be gone with the wind

By Jeff Pardo

Photography by Mike Fizer

If you've ever been a sailor, gone rock climbing, or earned a few merit badges, chances are you've come across at least a few dozen kinds of knots. Even if you haven't done any of those things, chances are pretty good that at some point, you've had to fasten something to something else. Keeping an airplane on the ground after you've walked away from it certainly comes to mind.

Improper tiedowns can be as potentially damaging to your airplane as inattentive taxiing. Unless you're into chains, or you use self-ratcheting tiedown straps, you ought to know a bit about knots: What kind of lines should you use, and how should they be tied?

Knots can be complicated and, for those of us who don't have great spatial memories, challenging. The ideal knot is one that is easy to remember, won't come loose, is easy to untie even after being under a heavy load, and—perhaps most overlooked—reduces a line's breaking strength as little as possible. Every year, pilots continue to sacrifice aircraft to merciless storms. Although it's good news if nobody gets hurt, the bad news is that this damage occurs after they've landed and gone home. And much of it can be prevented.

In many cases, the enemy is a thunderstorm. I hasten to add that if the origin of an ill wind was a tornado or hurricane, the

best thing you could do (if you had enough time) is get in the aircraft and fly it out of there. If your hangar is built from reinforced concrete, you're definitely in a very privileged minority, although if you have a hangar at all, you're still in the minority. Knowing how to properly tie down an airplane is the only other defense available to most of us.

If you own an aircraft, you're probably already fairly weather-conscious. But even for you and certainly the rest of us, here are some of the most important things to remember when high winds threaten:

• Aside from the tiedowns themselves, remember to batten down the hatches. Flight controls should be locked either by the use of a standard yoke-mounted gust lock inside the cockpit, or with external padded battens. Brakes should be on, and the wheels blocked fore and aft with the familiar prism-shaped *chocks* (not two-by-fours). Attaching each pair together fore-and-aft with rods bolted into the ends of each chock makes for an even tighter "boot" around each wheel. Going beyond locking all doors and windows, cover all engine intakes and exhausts as well as pitot tubes to keep out windborne intruders—insects and debris.

• Use an approved three-point tiedown, ideally installed pointing into the prevailing wind. Each tiedown anchor for a single-engine airplane should be able to withstand a 3,000-pound pull (4,000 for a light twin).

• Although vertical tiedown lines offer the most tenacious anchor against high winds as well as the lowest impact loads imposed by gusts, they fall short on forward and lateral stability. The recommended configuration calls for pavement tiedown points several feet outside and beyond their corresponding points on the airplane.

• Tiedown rings at your airport might not have been installed "ahead of and behind" the aircraft. Your configuration might only offer wing tiedowns toward the left and right, in about the same vertical/lateral plane as your wing tiedown eyelets. Whatever the case, the angle of all tiedown lines, main wing and tail, should never be in the same direction. In other words, lines from the wings should angle forward to tiedown rings, while the line from the tail should angle back. If all the lines angle in the same direction and the airplane moved toward the ground anchors, all the lines would then slacken, thus compromising their ability to hold down the airplane.

• Never use tent stakes or manila rope. One good rain, and you'll find out that mud doesn't hold very well. Manila can mildew and rot; it's much less strong than synthetic line, and it shrinks when wet. That could effectively impose significant inverted loads in which the aircraft would be pulling on the rope, approaching design limits.

• Unless your airplane is a bantam weight, tiedown lines should also be good for 3,000 pounds (more on what "good for" actually means, later).

• Never tie directly to a strut; they were built for longitudinal strength, and sideways pulls could bend them.

• Don't cut any slack—literally. Oscillations can permit even an anti-slip knot to loosen and come undone. But don't pull them tight with a draught horse or a block and tackle, either. (That could also entail large inverted loads, although you really would need several hundred pounds of lateral pull to do that.)

• The best types of knots to use include the bowline or a modified double half-hitch. There are many Web sites on knots; some even have animated instructions for the topologically challenged. The best time to learn them is before you desperately need them. My favorite involves two sets of half-hitches, where the first set is tied about six inches to one foot from the airplane's tiedown eyelet and the second about the same distance from the first. In tying the second half-hitch in each set, I bring the line around over the first and lock it under the first set with a sharp tug (see illustration at right). After the second set is done, I usually tie an additional half-hitch and snug it up against the second set, as a safety.

The ideal knot is easy to remember, won't come loose, is easy to untie, and maximizes the line's breaking strength.

• The attachment at the other end of the tiedown line, on the ground, tends to be taken for granted. Check it occasionally, and if something doesn't look right, report it to your airport manager, or fix it yourself if you're able.

• After cutting a length of synthetic line, the end strands should be "whipped" or melted together to prevent fraying.

• If your airplane is likely to be endangered by truly furious winds, consider padded 2-inch by 2-inch spoiler boards bungeed across the top of the wing, about one-quarter chord width from the leading edge. See FAA Advisory Circular 20-35C for details.

• Again, if you live within a couple of hundred miles of the East Coast or the Gulf Coast, you already know about hurricanes, and the best defense is to retreat.

• Though it isn't a standard practice, seaplane owners have partially or completely filled floats with water, when tied down ashore.

• For most small airplanes, the minimum acceptable diameter tiedown line is one-half inch. Five-eighths is much better, and three-quarters should be good for light twins. There are also other options besides a length of nylon braid-on-braid from Home Depot or BoatU.S. Some prefer to use chains, and many prefer the newer adjustable locking belts. (In my flying club, we use five-eighths-inch nylon double-braided line.)

How strong is strong enough? Several organizations, such as the American Boat and Yacht Council, offer guidelines and introductory information. To sum it up, there are two types of metrics. One is *tensile strength* or *static breaking strength,* which is determined by applying tension to the line between two large capstans until it breaks. For our five-eighths-inch nylon line, that's at least five tons! However, there is another measure: working load. A safe working load, according to the Cordage Institute, is anywhere from one-fifth to as little as one-fifteenth of a line's tensile strength. (That more critical value is applied to lifelines.) For our five-eighths-inch line, for example, one estimate for its working load is about 2,800 pounds. (Three-strand twisted polypropylene line of the same diameter, however, has only a third of that.) Such safety factors are really based more on engi-

Illustrations by Steve Karp

neering than superstitious caution: As lines age, they experience stretching, chafing, occasional shock loads, UV radiation, and heat (though for nylon and polyester it would have to be over 300 degrees Fahrenheit). Most importantly, every time you knot a rope, you can consider its tensile strength to have been cut in half.

And there's that problem of elongation. Almost any synthetic line approaching its working load can easily stretch by at least 10 percent. (This happens to be about the maximum allowed by the UIAA, an international mountain climbing federation.) What does that mean for your tiedown? It means that if the wings generate enough lift, your airplane could leave the ground anyway. With vertical tiedown lines, where it comes down again might be on top of the chocks; with angled tiedowns, it would be a little more consistent.

One technique I use is to tie the main tiedowns first, before I chock the wheels. (Our tiedowns are pretty much along the same "datum plane" as that of our Skyhawk's struts.) Then I loop the tail tiedown through and pull back on the loose end until the airplane has rolled back a few inches. Exerting just a 50-pound pull, moving it back 6 inches until the main tiedowns are angled back about 5 degrees further rearward would theoretically add about 550 pounds of tension (through the magic of component vectors), but only if the tiedown line were a steel cable.

You'd get even better results by pushing back from any structurally strong point in the front of the airplane and then quickly placing a chock in front of one wheel, to lock in the tension. But the nylon line's stretching (less than half of 1 percent) still confers some extra tautness to the tiedown lines (well under 100 pounds of pull but enough to get a nice bass fiddle "twang" out of the main tiedown lines).

The lowly tiedown is the last and in most cases the only line of defense we have to keep our airplanes from going AWOL. Knowing the ropes (or to use proper nautical terminology, knowing your lines) is the quickest and easiest way to ensure that your airplane will be waiting for you when you come back.

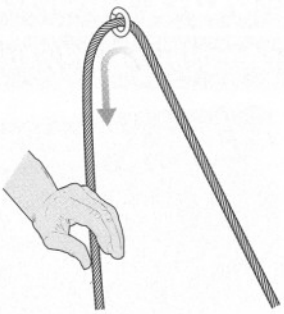
Want to know more?

Links to additional resources about the topics discussed in this article are available at AOPA Online (http://ft.aopa.org/links).

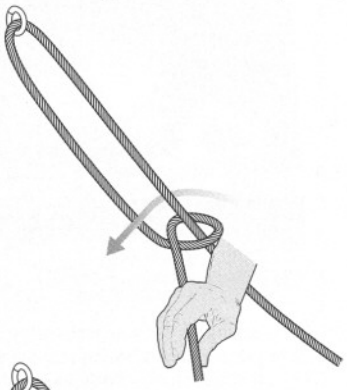
Jeff Pardo is an aviation writer in Maryland with a commercial private pilot certificate for airplanes, and instrument, helicopter, and glider ratings. He has logged about 1,200 hours in 12 years of flying. An Angel Flight mission pilot, Pardo has also flown for the Civil Air Patrol.

Tying two half-hitches

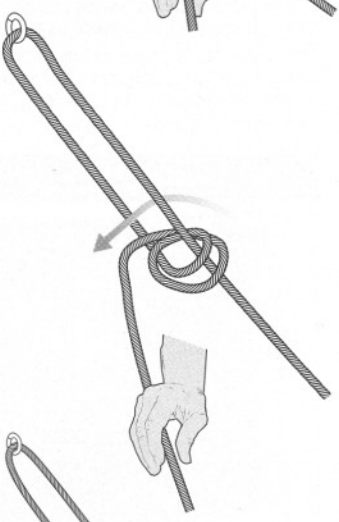
1 Run rope through the tiedown eyelet from the back of the airplane to the front.



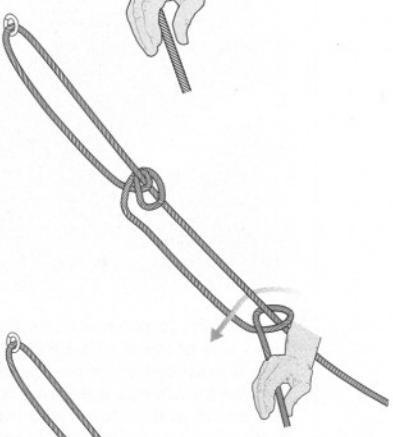
2 Circle the line around and through to form the first of two half-hitches, six to 12 inches from the airplane's tiedown eyelet.



3 Repeat to form a second half-hitch, pulling the line around and over the first, then locking it under the first with a sharp tug.



4 Now form a second set of half-hitches, six to 12 inches below the first set, by repeating steps 2 and 3.



5 The two sets of half-hitches are complete. For best results, use proper line and solid ground attachment points.