Safety Dance

Lock nuts, safety wire, and other ways to keep bolts tight

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All hardware on aircraft must be installed in such a way that it can't fall off the plane in flight. Several different methods are used to secure aircraft hardware: safety wire, cotter pins, self-locking nuts, and lock washers.

Regardless of which safetying method you use, there are some common points to consider. First on the list is torque, which is the first step in making sure bolts and nuts stay where they're supposed to.

The principle behind torque is that the bolt is stretched during the torque application, which creates a clamp-up pressure and keeps the nut secured. Undertorque can result in fatigue failures of the bolt and nut combination, and overtorque can result in premature failure of the bolt from overstressing the threaded parts.

A common mistake is using the head size of the bolt (wrench size) for the calculation of torque. This will result in severe overtorquing and possible failure of the bolt. You need to measure the bolt shank for the determination of the correct torque value. For most hex bolts you can use a wrench to determine the head size and subtract 3/16 to find the shank size. If you use a 7/16 wrench for a bolt, the shank size is 7/16 - 3/16 = ¼. Be careful because this is not always true. Always measure the bolt shank with a caliper if in doubt.

If there are no torque values specified in the maintenance manual for your airplane, use Advisory Circular 43-13-1B Table 7-1. Just because the maintenance manual doesn't specify a torque value doesn't mean that

Torque wrenches

torque is not important.

Make sure the nut and bolt threads are dry and clean and use the torque wrench to determine the friction drag required to turn the nut. In the case of self-locking nuts this could range from a few pounds for small bolt sizes up to 90 pounds for larger bolts. Use a wrench or socket to run the nut down to near contact with the washer. Add the friction drag torque to the desired torque value that is specified in the aircraft manual or general torque chart in AC-43-13-1B. This will be the final torque.

Apply a smooth even pull and torque the nut. Torque the nut instead of the bolt so as to prevent turning the bolt in the hole, which could result in wear of the bolt hole.

There are several types of torque wrenches: indicating or dial type, ratchet type, clip type, and flexible beam type. Torque wrenches indicate in foot-pounds or inch-pounds.

Choose the correct torque wrench for your application. Generally speaking, torque wrenches are accurate between 30 percent and 80 percent of their scale. Torque wrenches need to be calibrated at least once a year or after they have been abused or dropped.

Store the torque wrench in a dry place away from other tools. The bottom of your toolbox is not a good place to keep your torque wrench.

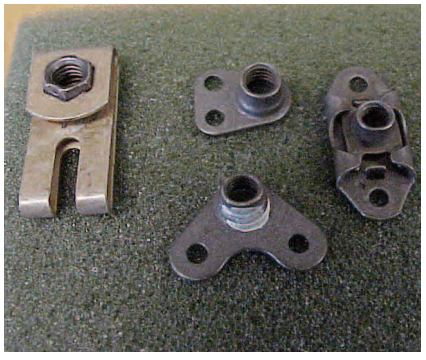
Metal lock nuts

In some cases an extension needs to be used in combination with a torque wrench. This will affect the actual torque value, but the correct value can be calculated. Multiply the desired torque on the fastener by the length of the lever. Divide that value by the sum of the length of the lever and the length of the extension. The result is the value to be indicated on the torque wrench.

Self-Locking Nuts

There are two types of self-locking nuts, the all-metal type and the fiber or nylon type. Do not use self-locking nuts on parts subject to rotation, in areas where the loose nut or bolt could fall or be drawn into an engine intake, or for access panels that

Nylon unthreaded ring lock nut top



Nut plates

Hi-Lok bolts

have to be removed frequently.

Metal lock nuts are constructed with the threads in the locking insert out-of-round with the load-carrying section or with a saw-cut insert with a pinched-in thread in the locking section. This creates friction between the bolt and the nut and prevents loosening of the nut.

In a fiber or nylon type, an unthreaded ring provides the locking action because it has a smaller diameter than the nut. These lock nuts can't be used in areas where the temperature exceeds 250°F. Do not reuse a fiber or nylon lock nut if the nut cannot meet the minimum prevailing torque values.

Nuts That Need Help

Castle nuts and castellated shear nuts are used with drilled shank bolts, hex-head bolts, clevis bolts, eye bolts, and drilled-head studs. These nuts are designed to be secured with cotter pins or safety wire.

Cotter pins are used to secure bolts, screws, nuts, and pins. The most common cotter pins are made of cadmium-plated carbon steel. Sometimes stainless steel cotter pins are used.

Torque the castle nut to the lower range of the required torque value and check if you can install a cotter pin. If not tighten the nut till a hole lines up, but do not exceed the maximum permissible torque value. If the cotter pin can't be installed within the torque range, you can use a maximum of two washers to line up the nut. Install the head of the cotter pin parallel to the slot in the castellated nut.

If you have to cut the prongs of the cotter pin because you don't have the correct size, make sure to cup the cotter pin and bolt with your hand while you cut it, so that you can recover the end piece and prevent eye injury.

Bend the top prong over the bolt head. Preferably the prong shall extend to the center of the bolt end. You can cut the prongs to the right dimension using a diagonal cutter. Bend down the bottom prong, but don't let it touch the washer. Cut to size if necessary. A pair of duckbill pliers or safety wire pliers are handy to bend the prongs.

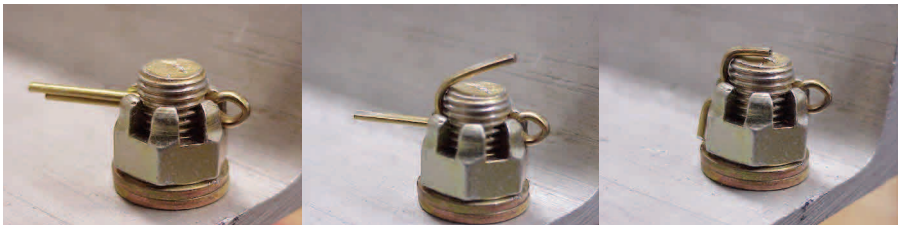
You can use a light hammer and tap the prongs close to the bolt for the final installation.

Nut plates are available in many different styles and sizes. In some types the nut can move around a little to account for a slight misalignment, and these are called floating anchor nuts. Most nut plates are riveted to the structure with small countersunk rivets, but some are installed in channels and are called channel nuts. Another type slides over a piece of structure like a floor beam and stays in place by a light pressure (often used for floorboards). The locking device is the same as the all-metal nuts.

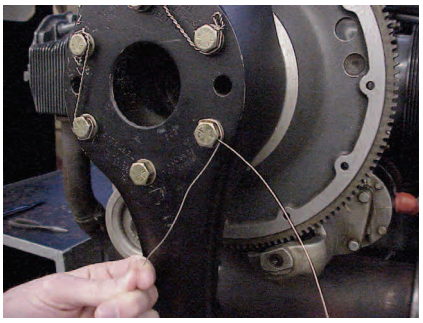
Lock washers come in several varieties, including spring, internal, and external star washers. Lock washers are not to be used on primary structures, secondary structures, or accessories where failure might result in damage to the airplane or danger to people.

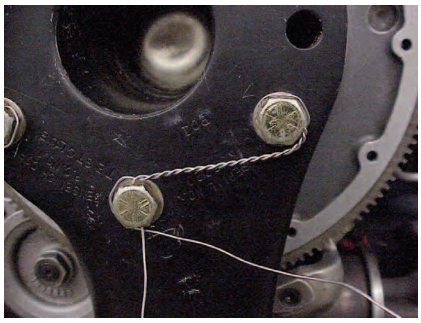
You can use lock washers if self-locking or castellated nuts are not available. Do not use in parts that require frequent removal or in areas exposed to the airflow. Always use a plain washer under the lock washer.

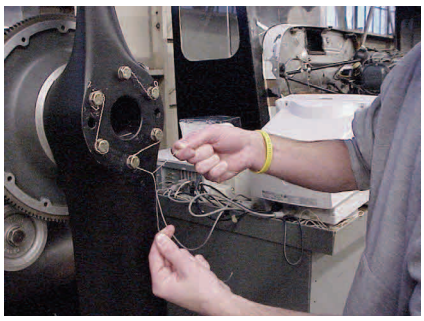
Hi-Lok bolts are secured with a unique collar. The collar can also be used with regular bolts. The hex part of the collar breaks off at a predetermined torque value, and the collar locking mechanism is similar to the all-steel nuts. A special set of pliers is used to remove the collar. Sometimes collar cutters inserted in a rivet gun are used to split the collars open, but try the pliers first.



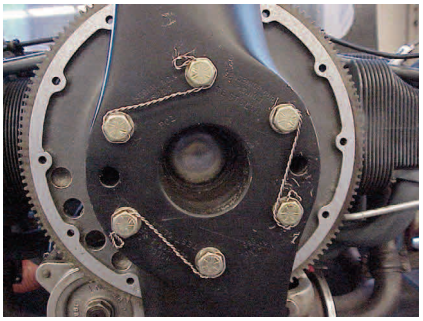
Cotter pin installation starts by inserting cotter pin, then bending the long prong to the center of the bolt. Finish it by tapping the prong to the bolt and bending the short prong down against the nut.







The double-twist method can secure multiple bolts with one wire, as long as the wire is routed so that pull on the wire will tend to tighten the bolt.



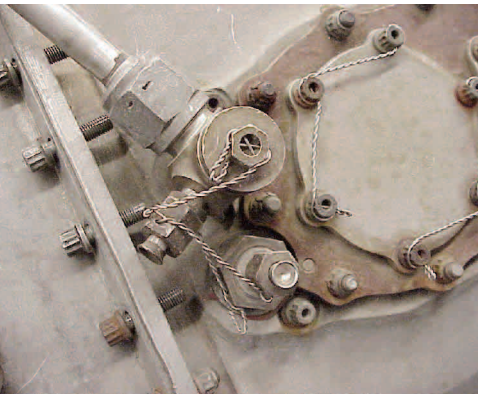
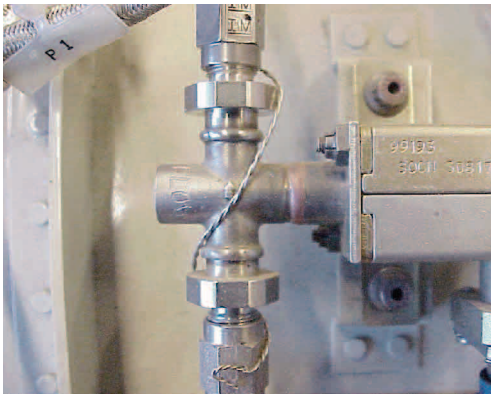
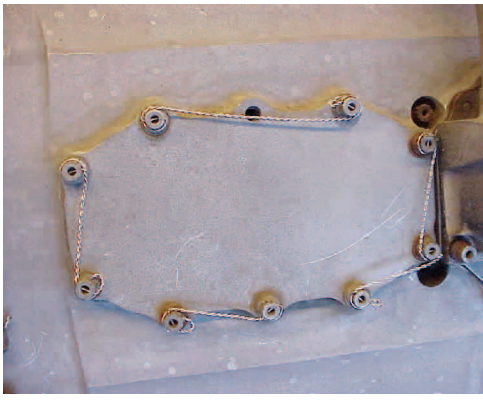
Safety Wire

Safety wire, sometimes called lock wire, comes in many types and sizes. You must first select the type and size of wire for the job. The most commonly used safety wire material is stainless steel. Be sure to always check the part number on the roll of safety wire to verify that you are using the correct size and material for the job in question.

There is also another kind of safety wire called shear wire that is used to safeguard emergency switches and seal first aid kits. This wire must break by hand pressure. Be careful not to install safety wire for shear wire applications. The color of shear wire is in general copper.

Safety wire should be between one-third and three-quarters of the hole diameter, except when using the single wire method. For single wire method, use the largest standard wire size that will fit the hole. Common wire sizes are 0.020, 0.032, 0.041, and 0.047.

Even the most experienced mechanics cut themselves occasionally

Examples of double-twist method.

with safety wire. If you cut yourself, clean your hands and treat the cut with a disinfectant. Safety glasses are a good idea, particularly if you are using long pieces of wire. Be careful of your eyes.

When working with safety wire, there are a number of general safety rules that will help ensure the wire draws as little blood as possible and still works as intended.

- All safety wires must be tight after installation, but not under so much tension that normal handling or vibration will break the wire.
- The wire must be applied so that all pull exerted by the wire tends to tighten the nut or bolt.
- The loop of double wire should pass around, not over, the head of the bolt or screw.
- When safetying nuts and bolts, tighten to the low side of the selected torque range, and if necessary, continue tightening until a slot aligns with the safety hole.
- Twists should be tight and even, and the wire between nuts as taut as possible without overtwisting.

Sometimes a single wire is used

to secure small screws that are placed closely together. Make sure that the pull exerted by the wire tends to tighten the screws.

If using the double twist method, cut a piece of wire that is long enough to secure the bolts. Too long a wire is difficult to work with.

Loop one part of the wire around the bolt head and run it below the other piece of wire and make a clockwise twist. Place the wire pieces between your fingertips and start twisting the wire. Pay attention to the maximum number of twists per inch while twisting. If the loop around the bolt is loose, you can use smooth duckbill pliers to twist the safety wire to tighten the loop.

Twist the wire a little short of the hole of the opposing bolt and insert the top wire through the hole and loop the bottom wire around the bolt head. You can use the duckbill pliers to pull on both wires to tighten the safety wire. Run the wire that loops around the head under the wire that sticks out of the hole and start twisting counterclockwise.

Make the pigtail about 1 inch long. Put more pressure on the last few twists where you are going to cut the pigtail and bend it back toward the bolt head with needle nose pliers so that you or someone else won't get cut while performing maintenance on the aircraft.

Double-check your work after you are done and verify that the safety wire is taut, with the correct number of twists per inch, and that the pull exerted by the wire tends to tighten the bolts.

Safety wire pliers are handy tools to use, and many mechanics use them. It might be a good idea to buy a pair of safety wire pliers that rotate clockwise and counterclockwise. The cheaper ones only rotate clockwise. If you safety more than two bolts together, you will have to alternate the twisting direction.

When you start twisting the safety wire, try to make the first twist by hand. Then pull the wires until they are just past the hole of the second bolt; grasp the two wires with the pliers and pull the bottom knob of the pliers. The rotating action of the pliers will twist the wires.

If the wires are long, sometimes it works to wrap the wires around the pliers. It is easy to overtwist the wires.

Release the pliers and check that the safety wire twist ends just short of the second bolt hole. If the twist is too short, hand twist the wires till they are just short of the bolt hole. Insert one wire through the bolt and the other around it. You will have to hand-twist the pigtail end if your pliers don't rotate counterclockwise.