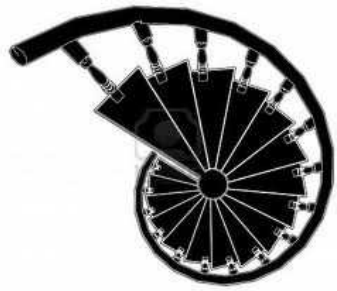
## Bolt Basics for Airport Lighting Maintenance Personnel

FAA Engineering Brief No 83: In Pavement Light Fixture Bolts is an important document that all of us who are involved in the design and maintenance of airport lighting fixtures should be familiar with. This Brief contains basic information regarding bolts used to adequately fasten in-pavement lighting fixtures to their respective bases. Increased emphasis is being placed on this subject due to the great number of in-pavement fixtures being used today and several instances where fixtures have become dislodged from their mounting base and endangered the safety of workers and passengers using our facilities. Lack of proper preventative maintenance is a primary cause for these fixture failures and has prompted the drafting of this ACE Module Supplement.

Bolts and screws are used to attach and compress one object to another by using the well-established "Incline Plane Principal". By applying a torque to the bolt the design is such that considerable clamping force is applied to the two mated objects forming a strong bond between them.

The **screw (bolt)** consists of a narrow **inclined plane** wrapped around a cylinder. You apply a smaller force to lift an object but have to travel a longer horizontal distance to get the desired advantage. Think of a circling staircase where you take a lot of short steps to get to the floor above. Or think of a boat being lifted up out of the water a rather short distance while travelling a longer horizontal ramp distance on a boat trailer,




The common bolt which we use every day to secure an in-pavement fixture to its mounting base has been designed with a thread design that allows the required clamping force to be applied with a reasonable amount of torque applied to the bolt head.

Figure 3. Two Part Locking Washers Installed on a 3/8 inch Tap Bolt

**1. Bolt Basics**

Bolts come in various lengths and diameters and are made of different materials depending on the strength required and the environment they are used in.

- In-pavement fixtures are usually bolted to the mounting surface using 3/8”D bolts of the required length.
- In-pavement bolts are often made of stainless steel to provide the required strength and corrosion protection for this application.
- When the bolt material is different from the materials that the bolt is clamping together (dissimilar metals: i.e. fixture/bolt metal and base flange metal) an electrical current flows between the dissimilar metals and causes a reaction that we call galvanic corrosion and is further explained in the following excerpt from FAA EB #83.

2. **Galvanic corrosion**

Both light fixtures and light bases are exposed to the runway environment where there is a great deal of dirt and water present. In addition, the use of de-icing agents can accelerate the corrosion of aluminum fixtures, bolts, and light bases.

a. The acceleration of corrosion with aluminum light fixtures is particularly true when using stainless steel light bases. While the light base may not corrode, the aluminum light fixture will. This is because of an electric current that flows between dissimilar metals. This is made possible by the presence of deicing agents and water. The water and deicing agents form an electrolyte. The electrolyte subsequently provides a path for ion migration where metallic ions (aluminum and steel) can move from an anode to the cathode. The preceding always leads to the anodic metal (the aluminum light fixture) corroding more quickly than it otherwise would in dry conditions. The corrosion of the cathodic metal (the light base) is retarded. The presence of an electrolyte and a conducting path between the metals may cause corrosion where otherwise neither metal by itself would be subject to corrosion.

**3. Physical characteristics of bolts**

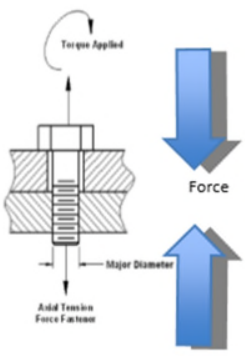
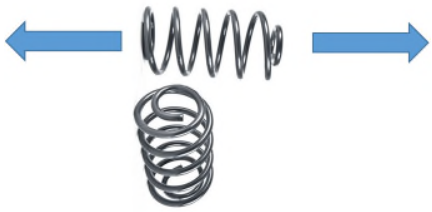



Figure 1. Axial Tension and Clamping Force

## Bolt Preload and Proof Load

- Preload – The tension created in a fastener as it is tightened
- Proof Load – The maximum load a bolt can take before it yields
- Rule of Thumb – Preload should be 75% of proof load

**Bolts can be compared to a spring.**



Once you stretch them beyond their **Proof Load** they will not return to normal after removing torque and therefore can no longer apply the proper clamping force when torqued to the same level as previous.

Even if a bolt has never been torqued above its proof load it should, when doing planned maintenance, never be retightened (torqued) to its previous specified torque level more than 3 times since the bolt will have fatigued and be unable to apply proper fixture clamping force. (Reference: EB#83 1.f)

## 4. How much Torque is enough?

This is the question we all should ask when it comes time to do maintenance work on in-pavement lights. Whether we are installing new or refurbished fixtures or just checking existing fixture torque we have to know the answer to this question.

Assuming we are using the fixture manufacturer's supplied or recommended bolts then the manufacturer should provide us the needed torque value. Someone has to determine what this value should be. There is a formula which is used to determine the proper value.

$$T = K*D*Fp$$

T = bolt torque in inch pounds K = friction coefficient (dimensionless)

D = nominal bolt diameter (inches) Fp = Axial clamp force (pounds)

Typical K factors include; .2 dry non-plated bolt, .11 high pressure wax, .12-.16 anti-seize compounds, .25 hot dipped galvanized bolt, .3 and higher for rusty or corroded bolts.

In order to use this formula we must know the required bolt axial clamp force for bolt application, the friction coefficient for the bolt, some examples of which are given above, and the bolt diameter. The K factor can vary depending on the thread friction at the time of bolt insertion.

A properly calibrated torque wrench is essential for determining proper torque applied which is analogous to our measurement of series circuit current. We must use a properly calibrated clamp-on ammeter. If either tool is not calibrated properly, safety is compromised.

Below is an example of the change in torque required due to change in bolt friction coefficient.

- Assume the required clamping force = 2,466 lbs. (preload).
- Using the formula with .2 k factor, torque required = **20 ft. lbs**.
- Using the formula with .12 k factor (anti-seize) torque required = **9.2 ft. lbs.**

The reduction in applied torque to create approximately 2,466 lbs. of clamping force is due to the reduction of friction on the bolt threads.

**Never apply a lubricant such as anti-seize compound to a bolt and then torque it to the same value as a dry bolt**. This will almost assure that damage to the bolts, base flange threads, and possibly the light fixture will occur.

## 5. Things to Remember!

1. **Don't reuse bolts once removed from fixture**
    a. **Don't re-torque multiple times (> 3) even if bolt is not removed**
2. **Don't use power impact wrenches**
    a. **Chance of over torqueing and damaging base threads**
    b. **Greater chance of exceeding bolt proof load**
    c. **Creates heat which ruins SS oxide surface film (corrosion)**
3. **Use a high quality calibrated torque wrench to achieve required torque after installing the bolt finger tight.**