Light Bases & Light Fixtures

Keeping Them Together

Introduction

Bolted joints common elements in construction and machine design, and consist of fasteners that join other parts using screw threads to keep the parts together. Bolted joints are common because they are easy to use and easy to design – just cut a hole in the pieces, then place a bolt through them and twist the mating threads together. However, there are some disadvantages. If the operating force is greater than the bolted joint's clamp load, it will fail. Another concern is corrosion which can cause the bolted joint to loosen.

There are two main types of bolted joints; tension joints and shear joints. In many cases the joint is in both tension and shear.

A **tension joint**, as illustrated, is affected by loads that try to pull the joint apart. The forces on the joint and those on the bolts are roughly parallel to the axes of the bolts. All tensile forces try to stretch and/or separate the joint.

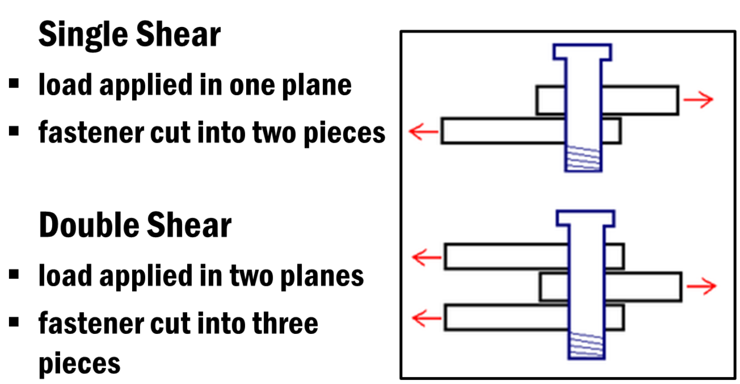
A **shear joint** is one in which the applied loading is at right angles to the fastener axis; that is, across the bolt shank. Shear joint failure occurs when the joint members slip sideways past each other, and eventually cut the fastener.

A shear joint can be a bearing joint or a slip friction joint.
In a bearing joint the pieces are allowed to slip until they run into the bolt. In this instance the bolt is acting as a pin. A slip friction joint requires a frictional force between the joint members. The shear forces have to overcome the friction developed by the clamp load.

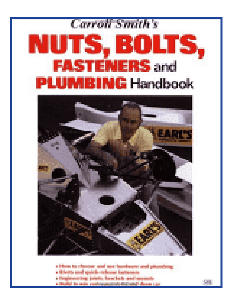
Shear joints will be single shear or double shear.

The double shear joint is stronger than the single shear bolted joint. If at all possible, design for double shear. Bolt threads should not be in the shear planes. Through holes should not be oversize.

The light base/fixture bolted joint is considered to be a slip friction shear joint in single shear. Not only single shear, but with multiple spacer rings, it has multiple single shear planes. Because each spacer ring creates an opportunity for movement, proper design must mitigate these weaknesses.



If you really want to get into bolted joint design and bolts, get a copy of Carroll Smith's *Nuts, Bolts, Fasteners & Plumbing Handbook*, a comprehensive guide to fasteners and racing hardware.



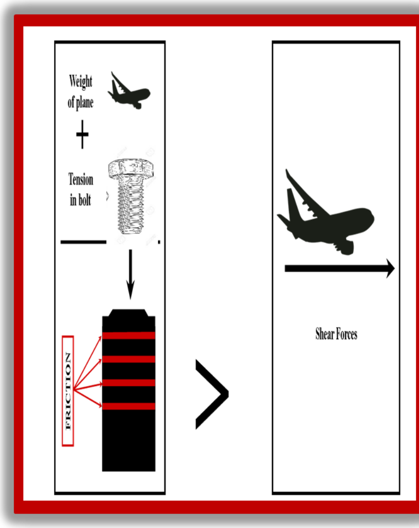
Airfield Lighting In-Pavement Lighting

On the airfield there are edge lights and in-pavement lights. The primary concern for keeping the fixtures and base cans together are the in-pavement lights. As previously noted, the bolted joint is considered a single shear slip friction bolted joint. That means that the forces holding the joint together have to be greater than the forces pulling it apart.

The forces pulling the joint apart are the plane landing, turning and running over the light fixture.

The forces holding it together is the friction between the faying surfaces. Faying surfaces are the surface of an object that comes into contact with the surface of another object such as plates. These surfaces are held together with fasteners.

With a slip friction joint the shear forces have to overcome the friction developed in the bolted joint. **The friction is developed by the weight of the plane and the additional clamp load provided by the bolts. This clamp load acts on the friction found on the faying surfaces. The coated surface of the faying surfaces have a certain friction or slip coefficient. The higher the slip coefficient the greater the forces holding the joint together.**



FORCES KEEPING IT TOGETHER   FORCES PULLING IT APART

Fixture **Pavement Ring** **Spacer rings** **Top Flange** w/threaded holes	**All faying surfaces major contribution to friction**
Bolts **Washers**	**Less contribution to friction**

With in-pavement lighting all of the faying surfaces -

the bottom of the fixture
the top and bottom of the pavement ring
the top and bottom of the spacer ring(s)
the top of the top flange

are a major contribution to the friction. The higher the slip coefficient the less reliance on the bolts to carry the load.

The table on the right gives coefficients of friction of selected materials. Notice the difference between the static and the kinetic frictions. The static coefficient is when the surfaces first start to move from a resting position and the kinetic one is the friction to continue the movement. The symbol for coefficient of friction is the Greek letter mu shown as "µ".

In this example the aluminum fixture and the mild steel pavement ring should give a kinetic coefficient of .47, and the mild steel spacer ring to the mild steel top flange gives a figure .57. However, in the "stack" (base can to fixture) the lowest or most slippery faying surface will be the first to move.

However, and this is a big <u>however</u>, the faying surfaces in the "stack" are not the base metals. The faying surfaces have a corrosion resistant coating or are stainless steel. Much more on that later.

Coefficient of Friction of Selected Materials

Surface A	Surface B	Coefficient of Static Friction μs	Coefficient of Kinetic Friction μk
Aluminium	Aluminuim	1.05-1.35	1.40
Aluminium	Mild Steel	0.61	0.47
Cast iron	Cast iron	1.10	0.15
Copper	Mild Steel	0.53	0.36
Glass	Glass	0.9-1.00	1.00
Graphite	Graphite	0.10	0.10
Mild steel	Brass	0.51	0.44
Mild Steel	Mild Steel	0.74	0.57
Rubber	Conrete	1.0	0.80
Teflon	Teflon	0.04	0.04

There are many organizations that have established minimum slip coefficients for design purposes. The American Association State Highway Transportation Operators (AASHTO) Load Resistance Factor (LRFD) Bridge Design Specifications are mandated by the Federal Highway Administration (FHWA) for use on all bridges using federal funding provides the following:

Revision 2019 in Green Italic

Class A Surface	Class B Surface	Class C Surface	*Class D Surface*
• Least amount of friction resistance. • Unpainted clean mill scale. • Blast cleaned surface with Class A coating. • Slip coefficient = ~~0.33~~ ***= 0.30*** • Usually not permitted for bridges.	• Unpainted, blast cleaned surfaces. • Blast cleaned surface with Class B coating • Slip coefficient = 0.50	• Hot dipped galvanized surface • Roughened by wire brushing (not power wire brush) after galvanizing • Slip coefficient = ~~0.33~~ ***= 0.30*** • Usually not permitted for bridges	• ***Blast cleaned surfaces*** • ***Organic, zinc-rich coating*** • ***Slip coefficient = 0.45***

For more detailed information:

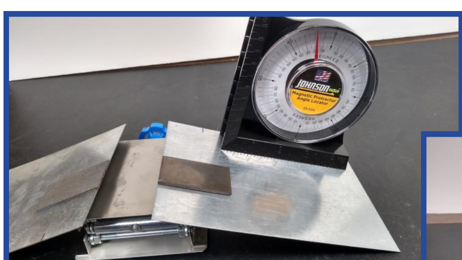
Slip Critical Connections & Updates to AASHTO LRFD Bridge Design Specification (8th Edition)
https://galvanizeit.org/knowledgebase/article/slip-critical-connections-updates-to-aashto-lrfd-bridge-design-specification-8th-edition

2016 AASHTO LRFD Specification Update
https://register.extension.iastate.edu/images/events/Structural/2016-AASHTO-LRFD-Specification-Update-2.pdf

Simple Demonstration of Slip Friction

Galvanized faying surfaces on the left;, Supergrip #21 on the right.

Both start the same at 20° angle. Slowly lift the platform. Galvanized slip about 23°. Supergrip #21 slips about 33°. Look these up in a tangent table for approximate slip coefficient. These slip coefficients are for comparison purposes only.



20°; μ=.36

All of this information will come together soon…...

23°; μ=.42

33°; μ=.64

What is a bolt ?

A screw thread is an inclined plane wrapped around a shaft – threads. Threaded fasteners come in various configurations; screws, bolts, tap bolts, studs….

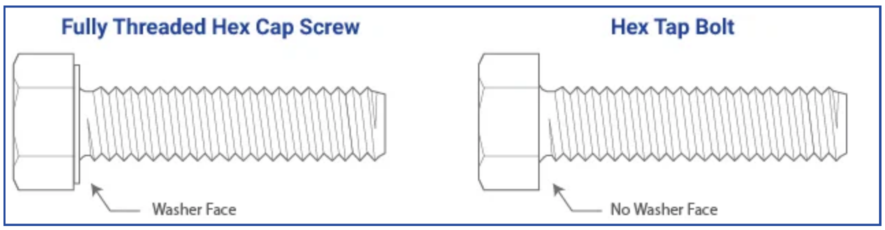
Screw – fastener designed to be installed in a pre-drilled hole, or they are engineered to tap their own hole with the threading while being installed. They do not use a nut and secure themselves by being tightened into their hole.

Bolt – fastener with threads and a head that is intended and designed to be used (installed) with a nut.

Hex Cap Screw – (typically) a hex head bolt that will be installed by turning the head of the bolt

Tap Bolt – (typically) a fully threaded hex bolt tighten with a nut

Stud – threaded rod used with 2 hex nuts



The main difference you will see between a hex tap bolt and a fully threaded hex cap screw is that the hex cap screw will have a washer face under the head and the tap bolt will not. The washer face on the hex cap screw ensures that you have a smooth surface that is perpendicular to the threads so that if you tighten the head, the assembly will develop the desired clamp load.

Airfield lighting uses fully threaded hex cap screws, however they are commonly called hex bolts or bolts.

Bolts are available in different sizes…. diameter, length and pitch.

Diameter refers to the threads and are major and minor.
Length is measured under the head
Pitch is the number of threads per inch (TPI) Pitch is either coarse or fine.

Airfield lighting typically ⅜"-16 x length.

Bolt Standards

There are multiple standards for bolts. The most common ones are SAE J429 for carbon steel bolts and ASTM F593 for stainless steel bolts.

Standards cover 4 major areas; chemistry, mechanical, dimensions and testing.

For example ASTM F593

TABLE 1 Chemical Requirements

Alloy Group	UNS Designation	Alloy	Composition, % maximum except as shown: Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Copper	Molybdenum	Others
							Austenitic Alloys					
1	S30300	303	0.15	2.00	0.20	0.15 min	1.00	17.0 to 19.0	8.0 to 10.0	. . .	0.60 max[A]	. . .
1	S30323	303 Se	0.15	2.00	0.20	0.060	1.00	17.0 to 19.0	8.0 to 10.0	. . .	. . .	Se 0.15 min
1	S30400	304	0.08	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 10.5	1.00	. . .	. . .
1	S30403	304 L	0.03	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 12.0	1.00	. . .	. . .
1	S30500	305	0.12	2.00	0.045	0.030	1.00	17.0 to 19.0	10.5 to 13.0	1.00	. . .	. . .
1	S38400	384	0.08	2.00	0.045	0.030	1.00	15.0 to 17.0	17.0 to 19.0	. . .	0.50 max[A]	. . .
1	S20300	XM1	0.08	5.0 to 6.5	0.040	0.18 to 0.35	1.00	16.0 to 18.0	5.0 to 6.5	1.75 to 2.25	. . .	. . .
1	S30430	18–9LW	0.10	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.0	3.0 to 4.0	. . .	. . .
1	S30433	302HQ	0.03	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.0	3.0 to 4.0	. . .	. . .
2	S31600	316	0.08	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0	. . .	2.00 to 3.00	. . .
2	S31603	316 L	0.03	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0	. . .	2.00 to 3.00	. . .
3	S32100	321	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 12.0	. . .	. . .	Ti 5× C min
3	S34700	347	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 13.0	. . .	. . .	Cb+Ta 10 × C min
							Ferritic Alloys					
4	S43000	430	0.12	1.00	0.040	0.030	1.00	16.0 to 18.0				
4	S43020	430F	0.12	1.25	0.060	0.15 min	1.00	16.0 to 18.0	. . .	. . .	0.60 max[A]	. . .
							Martensitic Alloys					
5	S41000	410	0.15	1.00	0.040	0.030	1.00	11.5 to 13.5				
5	S41600	416	0.15	1.25	0.060	0.15 min	1.00	12.0 to 14.0	. . .	. . .	0.60 max[A]	
5	S41623	416Se	0.15	1.25	0.060	0.060	1.00	12.0 to 14.0				Se 0.15 min
6	S43100	431	0.20	1.00	0.040	0.030	1.00	15.0 to 17.0	1.25 to 2.50	. . .	. . .	. . .
							Precipitation Hardening Alloy					
7	S17400	630	0.07	1.00	0.040	0.030	1.00	15.0 to 17.5	3.0 to 5.0	3.0 to 5.0	. . .	Cb+Ta 0.15–0.45

[A] At manufacturer's option, determined only when intentionally added.

3

F593 – 13a$^{\epsilon 1}$

TABLE 2 Mechanical Property Requirements[A]

Stainless Alloy Group	Condition[B]	Alloy Mechanical Property Marking	Nominal Diameter, in.	Full-Size Tests: Tensile Strength ksi[C]	Full-Size Tests: Yield Strength, ksi[D,C]	Full-Size Tests: Rockwell Hardness	Machined Specimen Tests: Tensile Strength ksi[C]	Machined Specimen Tests: Yield Strength, ksi[D,C]	Machined Specimen Tests: Elongation in 4 D, %
				Austenitic Alloys					
	AF	F593A	¼ to 1½, incl	65 to 85	20	B85 max	60	20	40
1	A	F593B	¼ to 1½, incl	75 to 100	30	B65 to 95	70	30	30
(303, 304,	CW1	F593C	¼ to ⅝, incl	100 to 150	65	B95 to C32	95	60	20
304 L, 305,	CW2	F593D	¾ to 1½, incl	85 to 140	45	B80 to C32	80	40	25
384,	SH1	F593A	¼ to ⅝, incl	120 to 160	95	C24 to C36	115	90	12
XM1, 18-9LW,	SH2	F593B	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
302HQ, 303Se)	SH3	F593C	1⅛ to 1¼, incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593D	1⅜ to 1½, incl	95 to 130	45	B90 to C28	90	40	28
	AF	F593E	¼ to 1½, incl	65 to 85	20	B85 max	60	20	40
	A	F593F	¼ to 1½, incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593G	¼ to ⅝, incl	100 to 150	65	B95 to C32	95	60	20
2	CW2	F593H	¾ to 1½, incl	85 to 140	45	B80 to C32	80	40	25
(316,	SH1	F593E	¼ to ⅝, incl	120 to 160	95	C24 to C36	115	90	12

For example SAE J429

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TABLE 1 - MECHANICAL REQUIREMENTS AND IDENTIFICATION MARKING FOR BOLTS, SCREWS, STUDS, SEMS, AND U-BOLTS(1, 8)

Grade Designation	Products	Nominal Size Dia, in	Full Size (7) Bolts, Screws, Studs Sems, Stress under Proof Load, psi	Full Size (7) Bolts, Screws Studs, Sems, Tensile Strength Min, psi	Machine Test Specimens of Bolts, Screws, and Studs Yield(2) Strength Min, psi	Machine Test Specimens of Bolts, Screws, and Studs Tensile Strength Min, psi	Machine Test Specimens of Bolts, Screws, and Studs Elongation Min, %	Machine Test Specimens of Bolts, Screws, and Studs Reduction of Area Min, %	Surface Hardness Rockwell 30N Max	Core Hardness Rockwell Min	Core Hardness Rockwell Max	Grade Identification Marking(3)
1	Bolts, Screws, Studs	1/4 thru 1-1/2	33 000(4)	60 000	36 000	60 000	18	35	—	B70	B100	None
2	Bolts, Screws, Studs	1/4 thru 3/4(5)	55 000(4)	74 000	57 000	74 000	18	35	—	B80	B100	None
		Over 3/4 thru 1-1/2	33 000	60 000	36 000	60 000	18	35	—	B70	B100	None
4	Studs	1/4 thru 1-1/2	65 000	115 000	100 000	115 000	10	35	—	C22	C32	None
5	Bolts, Screws, Studs (3)	1/4 thru 1	85 000	120 000	92 000	120 000	14	35	54	C25	C34	
		Over 1 thru 1-1/2	74 000	105 000	81 000	105 000	14	35	50	C19	C30	
5.1(6)	Sems	No. 4 thru 5/8	85 000	120 000	—	—	—	—	59.5	C25	C40	
5.2	Bolts, Screws	1/4 thru 1	85 000	120 000	92 000	120 000	14	35	56	C26	C36	
8	Bolts, Screws, Studs (3)	1/4 thru 1-1/2	120 000	150 000	130 000	150 000	12	35	58.6	C33	C39	
8.1	Studs	1/4 thru 1-1/2	120 000	150 000	130 000	150 000	10	35	58.6	C33	C39	None
8.2	Bolts, Screws	1/4 thru 1	120 000	150 000	130 000	150 000	10	35	58.6	C33	C39	

1. See footnote 2 of the scope.
2. Yield strength is stress at which a permanent set of 0.2% of gage length occurs.
3. Not applicable to studs or slotted and cross recess head products.
4. Proof load test. Requirements in these grades only apply to stress relieved products.
5. Grade 2 requirements for sizes 1/4 through 3/4 in. apply only to bolts and screws 6 in. and shorter in length, and to studs of all lengths. For bolts and screws longer than 6 in., Grade 1 requirements shall apply.
6. Grade 5 material heat treated before assembly with a hardened washer is an acceptable substitute.
7. "Full Size" means a tension test specimen consisting of a completed fastener for testing in the ready to use condition without alteration.
8. To convert pounds per square inch to Mega-Pascals (MPa) multiply the values above by .00689.

Bolt Standards are available from ASTM and SAE..

Head Markings

To meet the applicable standards bolts must have the appropriate head markings.

ASTM F539 | **SAE J429**

18-8
S30400

F593C
Alloy Group 1

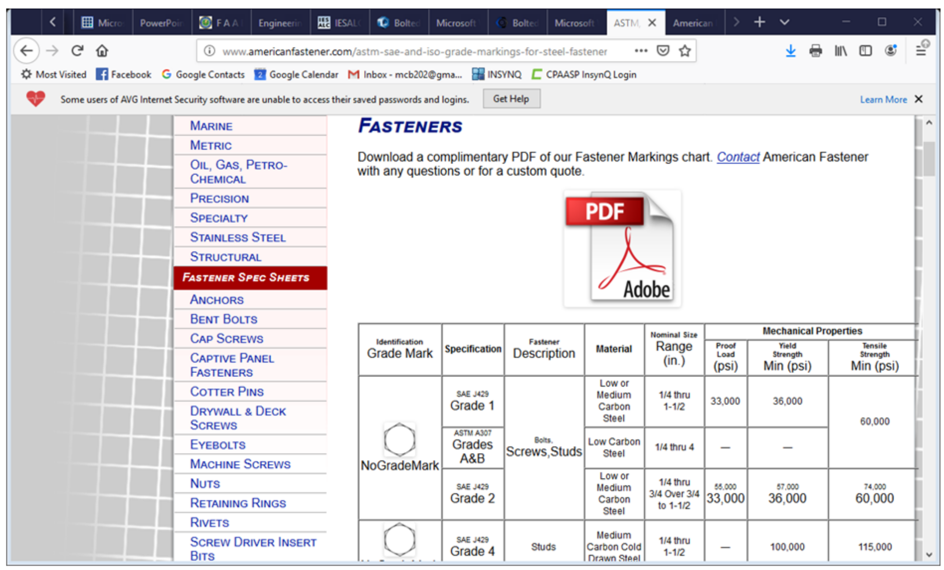
F593P
Alloy Group 5

Grade 2
No Marking

Grade 5
Mfg. Mark

Grade 8
Mfg. Mark

A bolt head marked with 3 radial lines and a manufacturer mark will designate it as an SAE J429 Grade 5 bolt. That means it was manufactured to meet all of the requirements found in SAE J429 for Grade 5 bolts. A bolt head marked with F593C is manufactured to meet all of the requirements found in ASTM F593 for "C" bolts.



Search:

bolt grade markings and strength chart

www.americanfastener.com astm-sae-and-iso-grade-markings-for-steel-fasteners

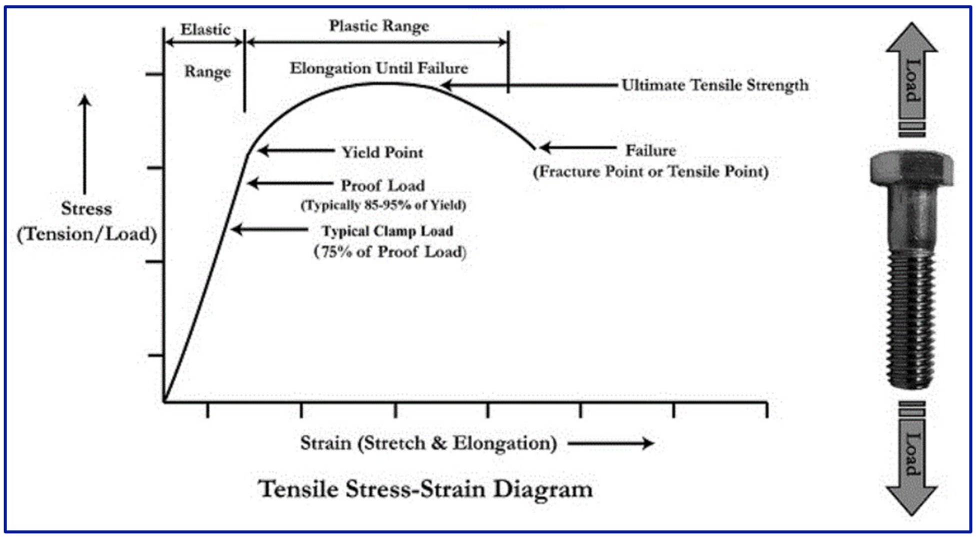
Proof – Yield – Tensile

Proof load is defined as the maximum tensile force that can be applied to a **bolt** that will not result in plastic deformation. In other words, the material must remain in its elastic region when **loaded** up to its **proof load**. **Proof load** is typically between 85-95% of the yield strength. ***Elastic Range***

Yield Strength is the **stress** a material can withstand without permanent deformation or a point at which it will no longer return to its original dimensions (by 0.2% in length). ***Plastic Range***

Tensile Strength is the maximum **stress** that a material can withstand while being stretched or pulled before failing or breaking. ***Failure***

A bolt can be considered a stiff spring. As it is tightened it stretches…. it wants to return to the original length (Proof) The elasticity is what creates clamp load. If it is tightened too much, it will not return to its original length (Yield) … continue to tighten and eventually it will break or fail. (Tensile)



When selecting which bolt to use engineers typically refer to the rated clamp load for a particular bolt. The rated clamp load calculation if proof (or yield) x tensile stress area x 75%.

Don't worry, tensile stress area charts are readily available. The tensile stress areas are different with each diameter of bolt and the pitch (threads per inch). The tensile stress area for a 3/8"-16 bolt is .0775.

The rated clamp loads for the common airfield lighting bolts:

F593C bolt
65,000 lbs x .0775 x.75%
Clamp Load = 3778 psi

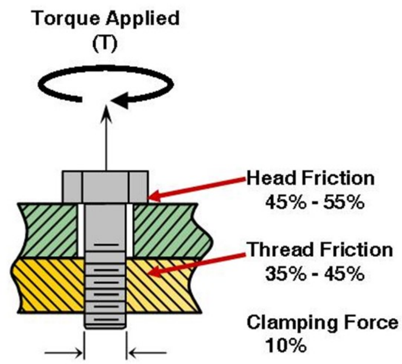
SAE J429 Grade 5 bolt
85,000 lbs x .0775 x.75%
Clamp Load = 4941 psi

Clamp Load = Bolt Tension

Torque

Torque is the means to an end, not the end itself. It is important to understand the role that torque plays in the torque/tension relationship. The end goal of torque is to develop the clamp load (tension) in the bolt. By using the torque/tension relationship we can infer tension in the bolt by its relationship to torque. When a bolt is turned in only small part of the torque actually creates tension in the bolt, the remaining torque force is used to overcome friction.

- **Only a small part of torque contributes to preload**
- **Anti-seize reduces friction**
- **Less torque to achieve preload**



Torque/Tension Relationship

This is the calculation for torque. Use this formula as a starting point only. Always test to confirm.

F_p does **NOT** change with different k value.

$T = F_p \times D \times k$

- **T = torque**
- **F_p = preload in lbs (tension)**
- **D = thread diameter in inches**
- **k = coefficient of friction on fastener**

T and k are variables /

F_p and D do not change

As k increases, T increases
As k decreases, T decreases

- **Rated clamp loads different for different bolts/sizes**
- **F_p should not exceed rated clamp load for bolt**
- **T not constant ; direct relationship with k**
- **Once T is determined it should be consistent so all bolts develop same tension**

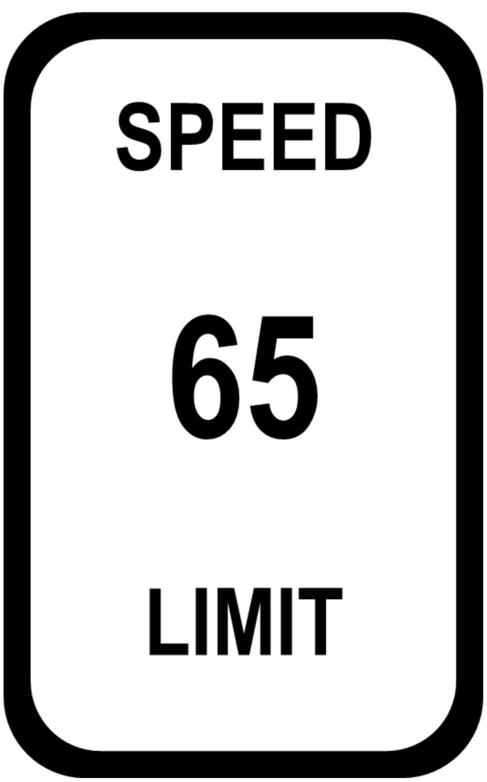
How Fast Are You Going ?

That depends….

What gear are you in ?

What is the tire diameter ?

You might be going 30 mph. Or 60 mph. Or 100 mph. That is why in driving we set a speed limit not at tach limit..



$$T = F_p \times D \times k$$

- T = RPM
- F_p = speed
- D = tire size
- k = gear ratio

Torque/Tension Relationship

Just like we want to limit speed and not torque, so do we want to limit clamp load (tension) and not torque. We already know that different bolts have different rated safe clamp loads. These are determined by the bolt/nut material, size of the fasteners, and so forth. Once a bolt is selected, then the clamp force is determined.

$T = F_p \times D \times k$

- **T = torque**
- **F_p = preload in lbs (tension)**
- **D = thread diameter in inches**
- **k = coefficient of friction on fastener**

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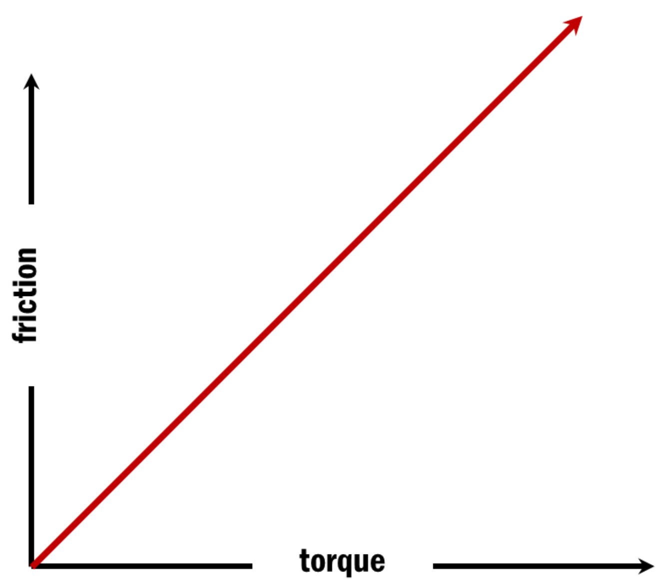
Remember...



Torque is not a constant, as friction increases – torque increases. Conversely, as friction decreases – torque decreases.

However, torque should be consistent.

Once a torque value is established for a given situation, the same torque should produce the same clamp load (tension).

Airfield lighting F593C bolt torque calculation. This is a dry, non-lubricated bolt.

T = 3800 x .375 x .2 = 285 in.lb.

= 24 ft.lb.

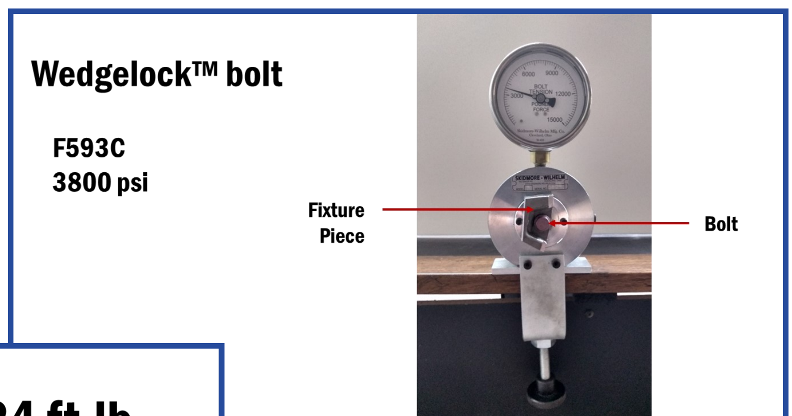
- T = torque
- Fp = 3,800 lbs
- D = .375"
- k = .2 ***(dry, non-lubricated bolts)***

If anti-seize or a coating is used the k value will change. 1
For example, with a k value of .18 the torque is 256 in.lb. or 21 ft.lb.

If there is corrosion in the threads then k will increase.
For example, with a k value of .22 the torque is 313 in.lb or 26 ft. lb.

Airfield lighting uses a 2-part wedgelock type washer for anti-vibration. This is not considered in the k value. To determine the proper torque with these washers, use a torque/tension test. A common one is a Skidmore-Wilhelm machine.

The test must use the exact setup of the installation; a piece of the fixture, pieces of spacer rings, and a “nut” of A36 material. Using a digital, dial or beam torque wrench, tighten the bolt head until the guage reads 3800 lbs. Then read the torque wrench value.



As you can see, with actual pieces the torque value changes considerably.

Torque/Tension Formula	**= 24 ft.lb.**
Skidmore Test	**= 42 ft.lb.**

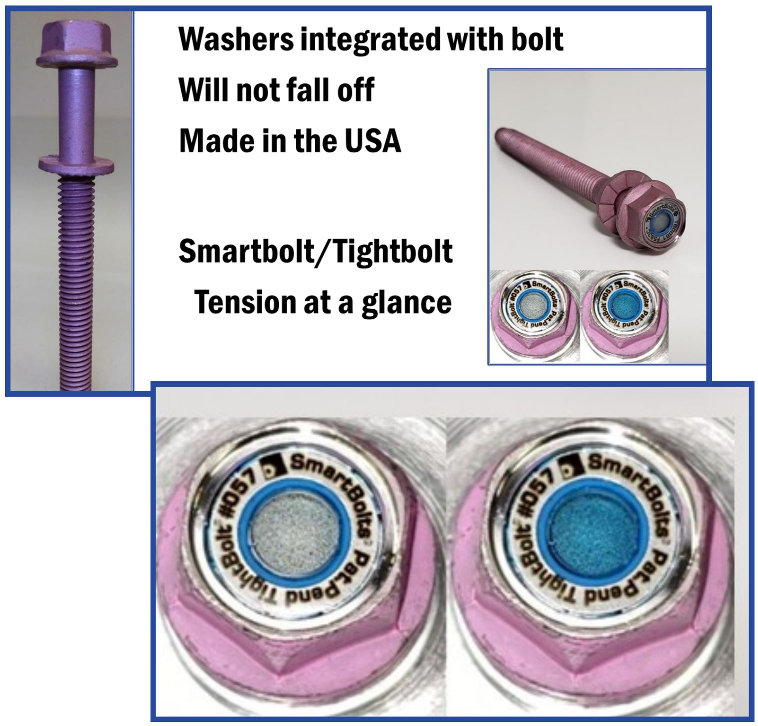
Always determine the torque value through testing. This can be done by the airport or a testing service. If you are using bolts that are manufactured specifically for the airport lighting bolted joint, verify that they have been tested as well. Do not rely on the "k" value supplied by the anti-seize product.

The effectiveness of using torque to achieve clamp load varies with method used. Even using a torque wrench the clamp load could be 25% lower or higher. Even so, torque wrenches are the most economical way to ensure proper torque.

Estimate of effectiveness (Industrial Fastener Institute)

• Strain Gauges	+/- 1%
• Fastener Elongation	+/- 5%
• Load Indicating Washer	+/- 10%
• Angle Torquing	+/- 15%
• Torque Wrench	+/-25%
• Operator "Feel"	+/- 35%

If more accurate clamp load is desired, you can use strain gauge in a bolt. These are highly accurate for clamp load. When the bolt is tightened to the proper clamp load the blue matches the blue ring. Because of increased expense, consider them for critical situations.



Engineering Brief 83A

EB 83/83A pertain to the in-pavement lights only. Edge lights are not part of EB 83A

Airfield lighting components are generally carbon steel that is galvanized. The airports began to use potassium acetate to deice the runways/taxiways. This purportedly caused a conflict with the galvanized infrastructure causing the HDG to prematurely corrode. To combat this, stainless steel base cans were introduced. This solved the problem with PA, but introduces a conflict with the 18-8 bolts, galling. EB 83 was published in 2010 and introduced the use of carbon steel bolts. While stainless steel bolts have inherent corrosion resistance, carbon steel bolts must be coated to protect against corrosion.

EB 83 was based on 3,000 lbs. of shear force. This was the figure given in AC 150/5345-46D for the light fixtures.

3.5.3.Shear Load. The light assembly must withstand a shear load of 3,000 pounds (1,360.78 kg) applied to the top of the light in any direction parallel to the mounting surface.

Also, there was great concern that the threads in the A36 steel top flange (Yield: 36,000) were too weak.

In response, the SAE J429 Grade 2 bolt was introduced.

In 2014 a light fixture separated from the light base. This started inquiry into bolts used on the runways. After much testing EB 83 was revised, and published December, 2018 as EB 83A.

The principle change was the shear force. EB 83A determined a shear force for the Airbus A380-800 as the highest shear force. This worked out to be more than 3 times the shear force given in AC 150/5345-46D. With an increased shear force, logically it would seem that a stronger bolt is needed to secure the fixture to the base. In actuality, even the strongest bolt failed to keep the bolted joint together. If the strongest bolt available fails, logically this is not a bolt problem and cannot be fixed by increased bolt strength.

EB 83A uses the SAE J429 Grade 5 bolt as an example. The slip coefficient is ***<u>assumed</u>*** at 0.37. This is only an example. For instance, if the slip coefficient is assumed to be 0.42, the F593C is an acceptable bolt. The slip coefficient is vital to determining which bolt to use. More on this later.

EB 83A discusses:

- 2.0 Best Practices
- 3.0 Bolt Torque
- 3.1 Clamp Force
- 3.2 Torque/Tension Relationship
- 4.0 K factor
- 5.0 Bolts, Light Bases and Light Fixtures
- 6.0 Anti-seize
- 7.0 Locking Washers
- 8.0 Coated Bolts
- 9.0 Galvanic Corrosion

2.0 Best Practices

The in-pavement lighting system consists of many components. It creates a bolted joint which must resist the loading forces imparted by today's commercial aircraft, and the Airbus A380-800 imparts the greatest loading forces.

To meet the clamping force requirements, the FAA uses the Grade 5 bolts as an example with an assumed slip coefficient of 0.37. In this example, the minimum required clamp force is determined to be 4,900 lbs. To determine the required torque to develop this clamp load it is recommended to test the bolt in a torque/tension calibrator. A more detailed discussion of the clamp load/slip coefficient topic will be at the end.

3.0 Torque; 3.1 Clamp Force; 3.2 Torque/Tension Relationship; 4.0 k factor

Discussed in previous sections.

5.0 Bolts, Light Bases and Light Fixtures

5.1 Stainless Steel Bolts Joining to L868 1B Light Bases made of Stainless Steel

Care must be taken when installing or removing stainless steel bolts with stainless steel bases. Galling or seizing is likely to occur. Galling occurs because the mating threads are of the same material. Stainless steel self-generates a thin chromium oxide surface. This is what makes stainless steel corrosion resistant. These surfaces can wipe off when installing or removing resulting in friction and heat and cause galling – they will "weld" together. . Always use anti-seize or use coated stainless steel bolts. Always reduce the speed when installing or removing.

5.2 *Stainless Steel Bolts Joining to Galvanized A36 Carbon Steel L868 1B Light Bases*

This combination has been used for years and has resulted in few problems.

6.0 Anti-seize

Anti-seize compounds must be applied to clean surfaces. It functions as a lubricant and will reduce the friction and therefore the torque required to develop clamp load. AC 150/5345-42 recommend the contractor use anti-seize. The airport determines which anti-seize to use. Anti-seize compound should always be used with uncoated stainless steel bolts.

Nickel anti-seize recommended. **(AC 150/5340-30)**

- **Reduces galling**
- **Helps resist galvanic corrosion**
- **Increase lubricity / decrease friction**
- **Type left up to individual airport**

Coated bolts – no additional anti-seize

8.0 Coated Bolts

Both carbon steel and stainless steel bolts may be coated. No additional anti-seize is needed with coated bolts. It provides a barrier between dissimilar metals. If used on stainless steel, it reduces the risk for seizing and galling. When used on carbon steel, it provides corrosion resistance.

Coated bolts are subject to mechanical damage. This occurs from the wrench or sweeping/ plowing the runways. Once the coating is damaged the steel beneath it is exposed to corrosion. This causes no corrosion problems for the stainless steel bolts, however the carbon steel bolts will rust.

FAA Test Results Average w/ 3 spacer rings galvanized
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Coated bolts reduce friction and therefore will reduce torque. Never torque a coated bolt to the same value as a dry bolt.

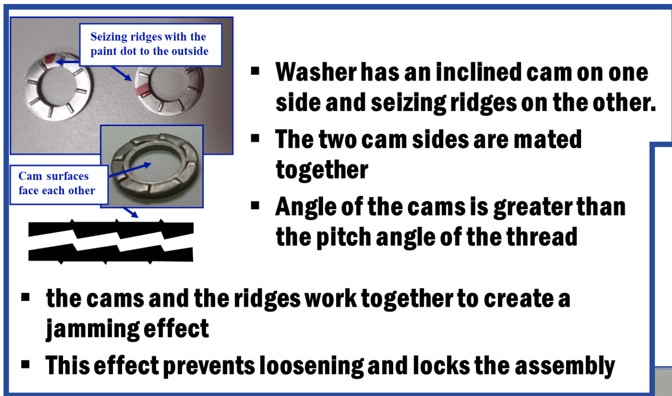
8.2 In-pavement Light Systems – recommended

No more than three spacer rings (includes flange ring/grooved spacer ring/pavement ring) to total no more than 2-3/16" in height for L868 light base. If required height is more than 2-3/16" the spacers must be replaced with an extension. Multiple spacer rings increase the chances of the bolt working loose.

Other bolt locking systems are allowed.

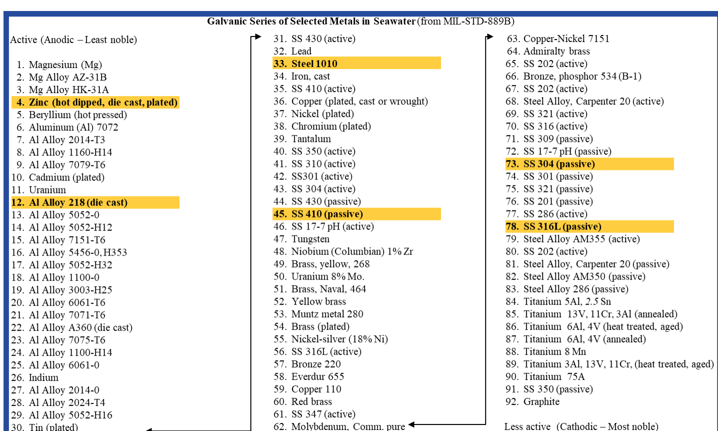
7.0 Lock Washers

Vibration is present on the runways/taxiways. There must be a method to counter this vibration. A common solution for this is the two-part wedge or cam washers.



9.0 Galvanic Corrosion

When dissimilar metals contact each other in the presence of a fluid, corrosion can occur. Metallic ions will flow from the less noble to the more noble metal resulting in corrosion of the less noble metal. Using coated bolts provides a barrier between dissimilar metals.

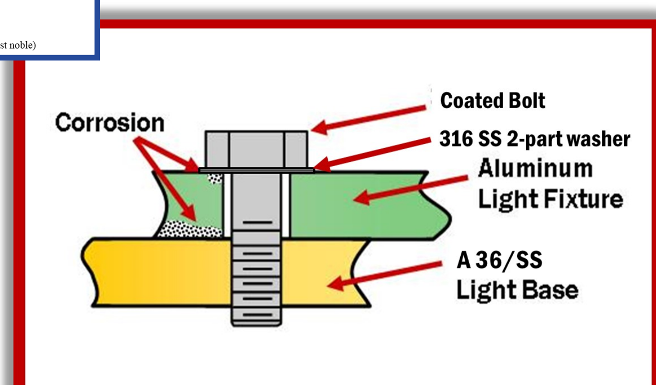


Galvanic Series of Selected Metals in Seawater (from MIL-STD-889B)

Active (Anodic – Least noble)

1. Magnesium (Mg)
2. Mg Alloy AZ-31B
3. Mg Alloy HK-31A
4. **Zinc (hot dipped, die cast, plated)**
5. Beryllium (hot pressed)
6. Aluminum (Al) 7072
7. Al Alloy 2014-T3
8. Al Alloy 1160-H14
9. Al Alloy 7079-T6
10. Cadmium (plated)
11. Uranium
12. **Al Alloy 218 (die cast)**
13. Al Alloy 5052-0
14. Al Alloy 5052-H12
15. Al Alloy 7151-T6
16. Al Alloy 5456-0, H353
17. Al Alloy 5052-H32
18. Al Alloy 1100-0
19. Al Alloy 3003-H25
20. Al Alloy 6061-T6
21. Al Alloy 7071-T6
22. Al Alloy A360 (die cast)
23. Al Alloy 7075-T6
24. Al Alloy 1100-H14
25. Al Alloy 6061-0
26. Indium
27. Al Alloy 2014-0
28. Al Alloy 2024-T4
29. Al Alloy 5052-H16
30. Tin (plated)
31. SS 430 (active)
32. Lead
33. **Steel 1010**
34. Iron, cast
35. SS 410 (active)
36. Copper (plated, cast or wrought)
37. Nickel (plated)
38. Chromium (plated)
39. Tantalum
40. SS 350 (active)
41. SS 310 (active)
42. SS301 (active)
43. SS 304 (active)
44. SS 430 (passive)
45. **SS 410 (passive)**
46. SS 17-7 pH (active)
47. Tungsten
48. Niobium (Columbian) 1% Zr
49. Brass, yellow, 268
50. Uranium 8% Mo.
51. Brass, Naval, 464
52. Yellow brass
53. Muntz metal 280
54. Brass (plated)
55. Nickel-silver (18% Ni)
56. SS 316L (active)
57. Bronze 220
58. Everdur 655
59. Copper 110
60. Red brass
61. SS 347 (active)
62. Molybdenum, Comm. pure
63. Copper-Nickel 7151
64. Admiralty brass
65. SS 202 (active)
66. Bronze, phosphor 534 (B-1)
67. SS 202 (active)
68. Steel Alloy, Carpenter 20 (active)
69. SS 321 (active)
70. SS 316 (active)
71. SS 309 (passive)
72. SS 17-7 pH (passive)
73. **SS 304 (passive)**
74. SS 301 (passive)
75. SS 321 (passive)
76. SS 201 (passive)
77. SS 286 (active)
78. **SS 316L (passive)**
79. Steel Alloy AM355 (active)
80. SS 202 (active)
81. Steel Alloy, Carpenter 20 (passive)
82. Steel Alloy AM350 (passive)
83. Steel Alloy 286 (passive)
84. Titanium 5Al, *2.5* Sn
85. Titanium 13V, 11Cr, 3Al (annealed)
86. Titanium 6Al, 4V (heat treated, aged)
87. Titanium 6Al, 4V (annealed)
88. Titanium 8 Mn
89. Titanium 3Al, 13V, 11Cr, (heat treated, aged)
90. Titanium 75A
91. SS 350 (passive)
92. Graphite

Less active (Cathodic – Most noble)



Procedures

AC 150/5340-26 C issued 06/24/20

5.3.2.1.3 Semi-annual Checks.

d. Check light bases and housings for evidence of moisture penetration. Check gaskets, seals, and clamps for deterioration and damage. Check the torque of light base cover bolts.

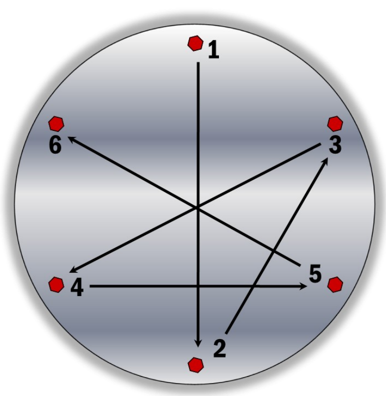
5.3.4 Runway and Taxiway In-pavement Lighting Systems.

i. When reinstalling the fixture, check the condition of O-ring gaskets installed on the light base upper flange ring (if supplied) and replace if necessary. Lubricate O-rings with a small amount of silicone grease. Make sure that new bolts and locking washers are used to reinstall the light fixture. Never reuse the bolts or locking washers for in-pavement light fixtures.
   (1) Torque all bolts to the torque specified by the light fixture manufacturer with a calibrated torque wrench. Do not use impact wrenches – they are not designed for the low bolt torques required for in-pavement light fixtures.
   (2) For more information about types of bolts and bolt torque, see FAA Engineering Brief #83, In-pavement Light Fixture Bolts
   (3) Always remove and replace any broken bolts. Leaving a broken bolt in place can result in all the bolts breaking from the impact of a landing aircraft. Develop a systematic plan for checking the torque of in-pavement light fixture bolts on a regular basis, particularly on the runway.

5.3.4.1.4 Bi-Monthly Checks.

a. Bolt Torque. The torque of the bolts attaching the light fixture to its base should be checked with a calibrated torque wrench – never use an impact wrench. Follow the light fixture manufacturer's recommendations for bolt torque. Always make sure that two part locking washers are properly installed. The impact of aircraft wheels can loosen mounting bolts and cause misalignment or fixture damage; this is particularly troublesome in the touchdown zone.

When fastening the fixture to the light base always follow the star pattern. First snug the bolts in the star pattern and then use a torque wrench to turn the bolts to the proper torque. Never use an impact wrench to turn the bolts in.

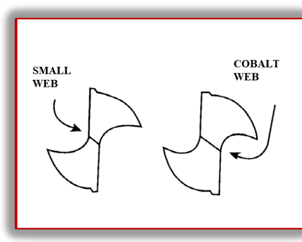


A small battery drill with a socket works perfect to snug the bolts. A good example is the M12™ 3/8" Drill/Driver Kit. This tool has enough power to snug the bolts, but not torque them.

Drilling stainless steel

Stainless steel bolts can be difficult to drill out. Use a tool designed for cutting stainless steel. These drill bits have a small web. Use a high feed rate to stay under the chip. **Use cutting fluid.** Try to drill it out in one cut. Never allow the drill bit to spin in the bottom of the hole, this will work harden the stainless steel and make it nearly impossible to drill out.

- **Use cutting fluid**
- **High feed – Slow speed**
- **Tools designed for cutting stainless steel**

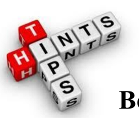


Compliant Hardware

Compliance is not limited to these examples.

- **Bolts**
  - **ASTM F593**
  - **SAE J429**
  - **Stainless Steel**
  - **Carbon Steel**

- **Lock Mechanism**
  - **Chemical Lock Systems**
  - **Mechanical Lock Systems**
  - **2 part wedge/ramp washers**
  - **Spiralock nuts**



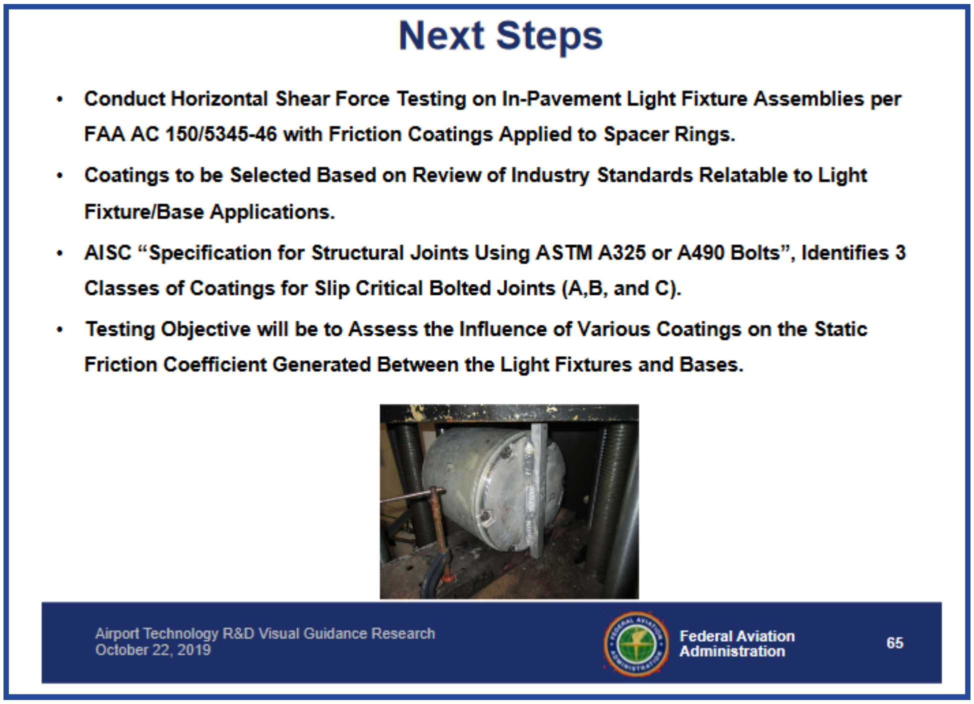
Bolt Tools

- **Torque**
  - **Digital Wrench**
  - **Beam Wrench**
  - **Click Wrench**
  - **Torque Limiters**

- **Drill**
  - **Battery**
  - **NO Impact Wrench**

Light Bases and Light Fixtures – Keeping Them Together

EB 83A Next Steps



The FAA will do additional testing on slip coefficient. Slip coefficient on the faying surfaces is vital to keeping the fixtures and bases together. This table shows the effect different slip coeffient has on bolt selection.

Slip coefficient	SAE J429 Grade 2	SAE J429 Grade 5	ASTM F593C	ASTM F593P	Superdooper bolt	Fantasy bolt
0.14[1]	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
0.19[2]	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
0.37[3]	FAIL	PASS	FAIL	PASS	PASS	PASS
0.42[4]	FAIL	PASS	PASS	PASS	PASS	PASS
0.45[5]	PASS	PASS	PASS	PASS	PASS	PASS
0.50[6]	PASS	PASS	PASS	PASS	PASS	PASS
0.64[7]	PASS	PASS	PASS	PASS	PASS	PASS

[1] FAA Test Results Average w/ 3 spacer rings galvanized
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[2] Mean slip coefficient for clean hot-dip galvanized surfaces is on the order of 0.19
Specification for Structural Joints Using ASTM A325 or A490 Bolts. 16.2-21

[3] FAA Engineering Brief 83A
Appendix A and Appendix B

[4] FAA Engineering Brief 83A
Alternate assumption

[5] AASHTO Class D

[6] AASHTO Class B

[7] Number 21 coating test results
Intertek Test 103473607CRT-001 Page 15

In the End

It's the hand that
turns the wrench that
keeps the light fixture
bolted to the light base !