Federal Aviation Administration

Memorandum

Date: December 26, 2018

To: All Regional Division Managers

From: Khalil E. Kodsi, P.E. PMP Manager, Airport Engineering Division, AAS-100

Subject: INFORMATION: In-Pavement Light Fixture Bolts

This Engineering Brief (EB) provides information and guidance for standard methods to be employed when using stainless steel or coated carbon steel bolts to secure light fixtures to L-868 light bases. Stainless steel and coated carbon steel bolts can be used for connecting extension rings or light bases to light fixtures. Bolt tension and clamping force are discussed to properly determine bolt torque values

Attachments

FAA
Airports

ENGINEERING BRIEF NO. 83A

In-Pavement Light Fixture Bolts

I. PURPOSE

This Engineering Brief (EB) provides information and guidance for standard methods to be employed when using stainless steel or coated carbon steel bolts to secure light fixtures to L-868 light bases. Stainless steel and coated carbon steel bolts can be used for connecting extension rings or light bases to light fixtures. Bolt tension and clamping force are discussed to properly determine bolt torque values.

II. BACKGROUND

Bolted connections are further addressed in AC 150/5345-42, *Specifications for Airport Light Bases, Transformer Housing, Junction Boxes, and Accessories*. In-pavement light fixture bolted connections typically consist of bolts installed into threaded holes in the light bases with a two-part lock washer system that functions to retain the light fixtures to the light base. The bolt is torqued to develop the needed clamping force at the light fixture/light base interface to resist the forces generated by a modern aircraft tire braking on an in-pavement light fixture.

The effects of snow plows during winter operations should be monitored. Over time, the in-pavement light fixture may shift causing significant horizontal load damage from snow plow blades. Winter season inspection of in-pavement light fixtures is recommended.

III. APPLICATION

The Federal Aviation Administration (FAA) recommends use of the information in this Engineering Brief for all bolted connections securing in-pavement light fixtures to their light bases. Torque calculations should be considered relative to the governing commercial aircraft maximum tire load at a given airport. This EB does not constitute a regulation and is not mandatory. This EB provides an alternative, but not the only, means of compliance with FAA standards.

However, use of these guidelines is mandatory for such activities funded under federal grant assistance programs, including the Airport Improvement Program (AIP). Mandatory terms such as “must” apply only to those who conduct these activities using federal grant funds or those who seek to demonstrate compliance by use of the specific method of compliance described by this EB.

IV. DESCRIPTION

Bolts, clamping force, and bolt torque are discussed in detail in this Engineering Brief. When installing an in-pavement light system, bolt selection should be based on strength requirements, compatibility of materials (corrosion resistance), and ease of installation. The strength requirement is based on torqueing the bolt to a preload (clamping force load) of 75% of the bolt material proof load. The rated proof load of a bolt is approximately 85% of the yield point (strength). Refer to Appendix C for relationships between yield point, proof load, and clamp force. Use of anti-seize compounds on stainless steel bolts and the coatings on carbon steel bolts will inhibit galvanic corrosion. Carbon steel bolts must be coated or treated in such a manner that the bolt will inhibit galvanic corrosion on the bolt and the light fixture and base it secures. Refer to Section 9.0. Stainless steel bolts should be coated with an anti-seize compound.

V. EFFECTIVE DATES

This Engineering Brief will be effective upon signature by the Manager of FAA Airport Engineering Division, AAS-100.

VI. APPLICABLE DOCUMENTS

FAA Advisory Circulars:

AC 150/5340-26, *Maintenance of Airport Visual Aid Facilities*

AC 150/5340-30, *The Design and Installation Details of Airport Visual Aids*

AC 150/5345-42, *Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories*

AC 150/5345-46, *Specification for Runway and Taxiway Light Fixtures*

Military Standards:

MIL-STD-889, Military Standard, *Dissimilar Metals* (7 July 1976)

Society of Automotive Engineers (SAE):

SAE J429, *Mechanical and Material Requirements for Externally Threaded Fasteners*

ASTM International (formerly known as American Society for Testing and Materials):

ASTM A36, *Standard Specification for Carbon Structural Steel*

ASTM F593, *Stainless Steel Bolts, Hex Cap Screws, and Studs*

Other:

Atlas Tech Note No. 7 (revised Aug 2010)

CONTENTS

FIGURES

1.0 General.

Through calculations found in Appendix A, a clamp force of 4,900 pounds per bolt is considered adequate to handle the wheel loadings generated by a governing modern commercial aircraft, the Airbus A380-800 aircraft. Please refer to Appendix B for sample calculations regarding a governing aircraft other than the A380-800.

2.0 Recommended Industry Best Practice.

The in-pavement lighting hardware system consists of many components that must be capable of resisting the loadings and forces imparted by the governing modern commercial aircraft being the Airbus A380-800 (refer to Appendix A). The FAA considers a clamping force of 4,900 pounds per bolt to be the minimum requirement for securing in-pavement light fixtures to in-pavement light bases or light base extension ring(s) based on the governing modern commercial aircraft.

To meet the clamping force requirement of 4,900 pounds, the required torque on the bolt must be determined. To determine the required torque, it is strongly recommended that a mock-up of the assembly, consisting of the light fixture and its light base, the bolt to be used with lock washers, and anti-seize material (if used) be tested in a bolt tension calibrator (Skidmore-Wilhelm or equivalent). During the testing of the mock-up, there should be no visible evidence of damage to any of the components once the desired torque is attained. An example of damage would be a deformed/broken washer.

The airport should phase in the requirements of this Engineering Brief as bolts are replaced. As bolts get replaced, the airport should strive to meet these new recommendations:

a. For better visibility, it is recommended that the coated bolts, if used, be of a color not currently used on the airport.

b. Bolts should be monitored after installation to verify corrosion resistance. Three-month intervals are recommended. The inspection intervals could also be used to establish a performance baseline for anticipating bolt corrosion.

c. An air-driven wrench is not recommended. If warranted, use a non-impact electric-driven wrench with its torque clutch at the lowest settings.

d. Always apply a thin layer of anti-seize material to a clean dry non-coated bolt. Do not dip the bolt into an anti-seize compound.

e. The friction coefficient for a coated bolt will be determined by the individual airport's bolt configuration using a bolt tension calibrator.

f. Always replace the two-part locking washers each time the bolt is removed from the light fixture/base. Never use a helical or split type of locking washer.

g. To preclude galvanic corrosion, use of coated stainless steel or coated carbon steel bolts should be considered. Coatings effectively insulate the bolt from both a zinc coating and an aluminum light fixture and preclude galvanic corrosion.

h. Maintain the surface flatness of light base flanges, base extensions, and spacer rings to ± 0.010 inches (0.254 mm), per AC 150/5345-42, to ensure optimum distribution of clamping forces. It is recommended the light fixture surface flatness be held to the same tolerance to avoid an uneven distribution of clamping forces. A best practice is to sequentially tighten bolts in a “star” pattern and not a “circular” pattern.

i. If 50% or more (3 or more in a fixture requiring 6 bolts) of the bolts securing a light fixture need to be replaced, replace all bolts securing the light fixture per the guidance in this document. If less than 50% (2 or less in a fixture requiring 6 bolts) of the bolts need to be replaced, the bolt(s) should be replaced in kind and to the original torque value. There should be an even distribution of clamping forces that secure the light fixture to the light base.

j. Airport management, or its agent, selects bolts based on governing commercial aircraft. The governing aircraft is determined by the heaviest wheel load of an aircraft that has at least 250 departures at the airport. The Airbus A380-800 and a Boeing 737-900 are used as examples in Appendix A and Appendix B respectively.

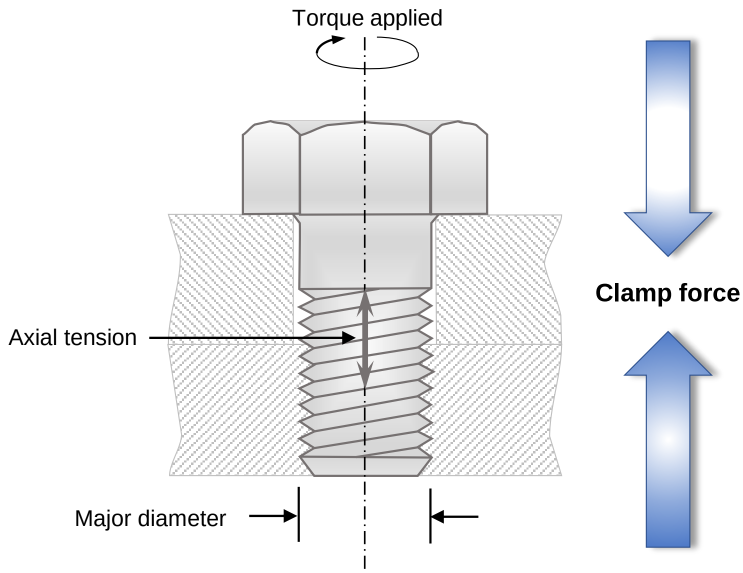
k. Airport management, or its agent, should consult with the light fixture manufacturer regarding any questions or issues regarding the bolt clamping force requirements in this document with respect to the airport’s governing commercial aircraft.

3.0 Understanding Bolt Torque.

Bolt tension is crucial to ensure that the two jointed surfaces are properly mated together to resist all forces generated by aircraft tires on the light fixture.

When a bolt is tightened to a specified torque, the bolt is subjected to a tension or preload force. The tension force slightly elongates the bolt. The more the bolt is tightened, the more the bolt elongates. In Figure 1, the axial tension (or preload) developed in the bolt functions to impose a clamping force between the light fixture and the light base. If the applied torque increases, then the clamping force increases.

Figure 1. Axial Tension and Clamping Force



If the torque continues to increase, either the bolt or the female threads in the light base will fail due to excessive tensile load. The bolt elongation or the thread deformation will cause thread stripping or a permanent plastic deformation of the supporting structure of metal. At this point, the bolt will no longer supply sufficient clamping force to secure the light fixture to the base. For a reliable connection between the light base and the light fixture, any thread stripping of either the light base flange internal threads or the bolt threads must be avoided. When bolts are over-tightened, they lose their ability to spring back to their original length. The bolt then has a permanent "set" and cannot be reused. Refer to Appendix C.

The friction coefficient of either a lubricated bolt or a coated bolt will be derived from a bolt tension calibrator (Skidmore-Wilhelm or equivalent). Manufacturer's value of these friction values should be used only as reference information. The proof load is the specific load the bolt will withstand without a permanent set or deformation. When a bolt is tensioned beyond the yield strength (yield point), the bolt tension exceeds the elastic limit of the material resulting in diminished ability to apply the correct clamping force.

3.1 Clamp Force.

As stated in the second paragraph of Section 2.0, torque values should be determined by testing the airport mock-up. The clamp force calculations in this section should only be used if testing is not possible or to determine approximate values. The calculations are approximate values and subject to many variables such as thread tolerance, compounds used, and materials involved.

The clamp force is the force that holds each side of the joint together. The rated amount of clamping force exerted by a properly tensioned fastener is normally stated to be 75% of the proof load, as derived from the applicable standard (for example, SAE J429). If the proof load is not provided by the applicable bolt standard, multiply the minimum yield strength (yield point) by the bolt stress area and by 0.85.

Proof Load (pounds) = minimum yield strength (psi) × stress area (si) × 0.85

Clamp Load (pounds) = Proof Load (pounds) × 0.75

Note: If the rated clamping force of a bolt is not provided/known, it can be calculated by the above two formulas.

Assume the rated clamping force of a coated SAE J429, Grade 5, 3/8″-16 bolt is 4,941 pounds. The amount of torque required to achieve this clamping force is approximated by:

$$T = K \times D \times Fp$$

where:

T = bolt torque in inch-pounds

K = friction coefficient (dimensionless and assumed to be approximately 0.18 for a carbon steel coated bolt)

D = nominal bolt diameter (inches)

Fp = axial clamp force (pounds)

Solving for the above numerical values:

T = 0.18 × 0.375 inches × 4941 pounds

= 333.5 inch-pounds of torque

= 27.8 foot-pounds of torque

The coated SAE J429, grade 5, 3/8″-16 bolt in this example should be torqued to 27.8 foot-pounds to obtain its rated clamping force of 4,941 pounds.

3.2 Determining Clamp Force from Bolt Torque.

As stated in the second paragraph of Section 2.0, the clamp force and torque values should be determined by testing the airport mock-up. The calculations in this section should only be used when testing is not possible or to determine approximate values. The calculations are approximate values and subject to many variables such as thread tolerance, compounds used, and materials involved.

The same coated SAE J429, Grade 5, 3/8″-16 bolt having a torque rating of 333.5 inch pounds or 27.8 foot pounds is used for this example calculation.

T = K×D×Fp (from paragraph 3.1)

Solve for Fp:

Fp = T/(K×D)

K = 0.18 (assumed value for a carbon steel coated bolt)

D = 0.375 inches

Fp = 333.5 inch-pounds / (0.18×0.375 inches)

= 4,941 pounds of clamping force per bolt

If there are 6 bolts securing the light fixture, then the total clamping force for the 6 bolts is: 6 × 4,941 pounds or 29,640 pounds.

Note: Many in-pavement light fixture manufacturers recommend torque values based on using 18-8 stainless steel bolts with anti-seize compound. Refer AC 150/5345-42 for further information on the 18-8 stainless steel bolts with anti-seize compound. The light fixture manufacturer must be consulted to confirm that the in-pavement light fixture can be safely installed using a 4,900 pounds bolt clamping force per calculations in Appendix A. The manufacturer should also be contacted regarding reference information concerning the torque value for bolt installation with anti-seize compound.

4.0 The K Factor.

The K factor is a dimensionless coefficient that exists between a bolt and its threaded receptacle. It is a function of the materials' frictional characteristics, which are based on surface finish, coatings and so on. This factor can be referenced from the anti-seize compound manufacturer's specified K values or from the coated bolts used with a bolt tension calibrator. It is always recommended to obtain K values using a bolt tension calibrator. The anti-seize compound functions as a lubricant to lower the bolt's frictional characteristics. As frictional characteristics change, so will the amount of torque required to achieve the same amount of clamping force be changed.

5.0 Bolts, Light Bases, and Light Fixtures.

This section describes field installations of light fixtures to light bases.

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

a. When using bolts made of stainless steel alloys to secure light fixtures to light bases, the bolt performance is highly dependent upon both the installation and removal techniques employed by maintenance personnel. Improper installation techniques will result in difficult bolt removal or breakage when a light fixture must be removed from the light base. This is especially true for light bases constructed of stainless steel alloys. If an anti-seize compound is not applied to the bolt before threading it into a stainless steel alloy light base upper flange, the bolt will likely gall or seize (cold weld) upon removal.

b. The stainless steel alloy used for the bolt self-generates an extremely thin oxide surface film (the film is the reason why a stainless steel bolt does not rust like a carbon steel bolt). When the bolt is tightened, pressure is exerted between the metal thread surfaces, and the protective oxides are subsequently wiped off. This allows the high points (also known as asperities) of the threads to make bare metal contact with each other resulting in both heat and pressure due to friction between surfaces. If the pressure and heat resulting from friction is sufficiently high, plastic deformation of the metal occurs. The deformation then causes more adhesion resulting in increased friction. This cumulative action eventually leads to seizing - the threads will cold weld (or seize). If tightening is continued, the fastener will eventually shear (break). The same sequence of events can occur for the removal of a bolt. When a bolt breaks within the light base flange threaded hole, removal can be both time consuming (expensive) and difficult.

c. The heat generated by the pressure of stainless steel bolt removal (especially when partial seizing occurs) will work harden the metal. This makes drilling out a broken bolt a time consuming and difficult process that requires special drill bits and drill fixtures. Never remove stainless steel bolts at high speeds with an electric or compressed air wrench. Removal by hand guarantees that the bolt will not be heated by excessive rotation. The same applies to bolt insertion – use the wrench at the lowest speed possible.

5.2 Stainless Steel Bolts and Galvanized A36 Carbon Steel L868 1A Light Bases.

The use of stainless steel bolts with standard ASTM A36 steel galvanized light bases (L868 1A) has resulted in few problems other than over-torque induced failures that result in stripped/damaged light base upper flange threaded holes. This is primarily due to the difference in hardness between the two materials. ASTM A36 steel, which is commonly used for is non-heat-treated applications, such as in pavement light basses, has a typical Brinell hardness around 119. The 18-8 stainless steel bolts typically have a hardness in the range of 201 on the Brinell scale. Because the bolt material is harder than the light base flange, the female threads in the flange will fail before the bolt.

Careful attention to the recommended torque values, especially when using an anti-seize compound will reduce the incidence of light base thread damage that arises from over-tightening.

5.3 Removing and Installing Bolts on Light Fixtures.

Because the time allotted for maintenance personnel on the airport surface movement area is frequently limited by airline and air cargo schedules, a torque adjustment non-impact type air or electric motor driven wrench is frequently used to remove and replace multiple light fixtures. This method increases the risk of:

a. Stripping the bolt or threads of the light base flange due to over-torque.

b. Galling, when a stainless steel bolt used with a stainless steel light base, is exacerbated when the anti-seize compound is not properly used.

It is important to select a tool that uses a minimum rotational speed that precludes stainless steel bolt galling or seizing with stainless steel light bases. The tool torque must be verified prior to its use on the airfield to prevent bolt over-torque. The determination of optimal parameters of speed and torque for air and electric motor driven wrenches can be time consuming and expensive.

The recommended method of light fixture bolt installation and removal is to use the lowest speed and minimum torque setting for electric or air driven wrenches, regardless of light base material. These wrench settings should be verified with a test in-pavement light fixture and base before attempting a field installation/removal. The goal is to accomplish the final light fixture bolt torque with a calibrated torque wrench.

A dial-type torque wrench is recommended because of its accuracy. Any torque wrench used should have a scale such that the desired value is about mid-range of the instrument.

Figure 2. Example of a Dial Type Torque Wrench

The accuracy of the torque wrench should be within 2% of the reading, from 20% of its scale to full scale.

6.0 Anti-Seize Compounds.

Anti-seize compounds are materials that most often consist of a blend of molybdenum disulfide or graphite-based lubricants suspended in a wax or grease used on slow moving surfaces to prevent seizing or galling. For the purposes of this Engineering Brief, only non-metallic anti-seize compounds are to be used. The compound functions as a lubricant between the sliding surfaces (threads) of the bolt and the light base flange threaded hole. This is applicable to installation and removal.

Anti-seize compound should only be applied to clean surfaces free of sand, water, and debris. The threaded hole in the light base flange must also be clean prior to the compound application. Threads for both the light base flange and bolt may be cleaned by any combination of compressed air, wiping, brushing, and an application of a safe degreasing solvent.

The use of anti-seize compound on a bolt will reduce the torque required to achieve the specified clamping force. Never torque a bolt with anti-seize compound applied to the same torque required as that of a dry bolt.

The light fixture manufacturer will normally furnish torque values in their installation manual(s) along with the recommended type of anti-seize compound. Each anti-seize compound has its unique effect upon the coefficient of friction, or K value (see Section 4.0). When calculating torque values, be sure to use the appropriate K value associated with the anti-seize compound used. The light fixture manufacturer determines the torque value based on the bolt specification and actual K value of the anti-seize compound from a system mockup for the bolts supplied with the light fixture bases.

AC 150/5345-42 recommends the installing contractor use an anti-seize compound. The anti-seize is not supplied by the light fixture nor light base manufacturer, therefore the installing contractor must calculate the bolt torque required based on the compound that is used and the bolt grade supplied with bases. Anti-seize compound should always be used with uncoated stainless steel bolts.

7.0 Locking Washers.

Two-part (or glued two-part) clamping lock washers (Figure 3) will be manufactured of surface hardened 316 or 316L stainless steel and are used to secure the light fixture bolts. This style of locking washer is effective in preventing bolt loosening caused by high dynamic loads. Manufacturers of the two-part lock washers must demonstrate sufficient locking performance in vibration tests per AC 150/5345-46, paragraph 3.5.1, Vibration.

If a bolt is over-tightened, the two-part locking washers will become concave (Figure 4). This occurs because the cap of the bolt begins to force the locking washers into the bolt hole. The result is the clamping action of the locking washer is compromised if the light fixture bolts are over-tightened. Thus, it will allow the bolt to work loose under load and greatly reduce the effective clamping force for resisting fixture shear forces.

The two-part locking washers should be replaced each time a light fixture is disassembled from its base. If a bolt is known to be over-tightened, replace both the bolt and the two-part locking washers when the light fixture is reinstalled on the light base.

The two-part lock washer manufacturer will be consulted by the airport owner, or its agent, to ensure the lock washer ratings are adequate based on the bolt clamping force. In addition, light fixture and flange through holes must comply with the manufacturer's criteria. Oversized through holes can cause the two-part lock washers to become concave in shape under a load.

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

Figure 4. Bolt with a Slightly Concave Upper Locking Washer

8.0 Coated Bolts.

With the known galling and seizing issues associated with uncoated stainless-steel bolts, coated carbon steel and coated stainless-steel bolts can be an effective alternative. The manufacturer of the coated bolt must make the bolt thread diameter compatible with the standard 3/8″ diameter internal threads in the in-pavement light base flange. Also, the manufacturer must provide a clear description of the coating on the bolt, its lubricity, and corrosion protection ability.

Figure 5. Cross-Section of a Fastener Coating

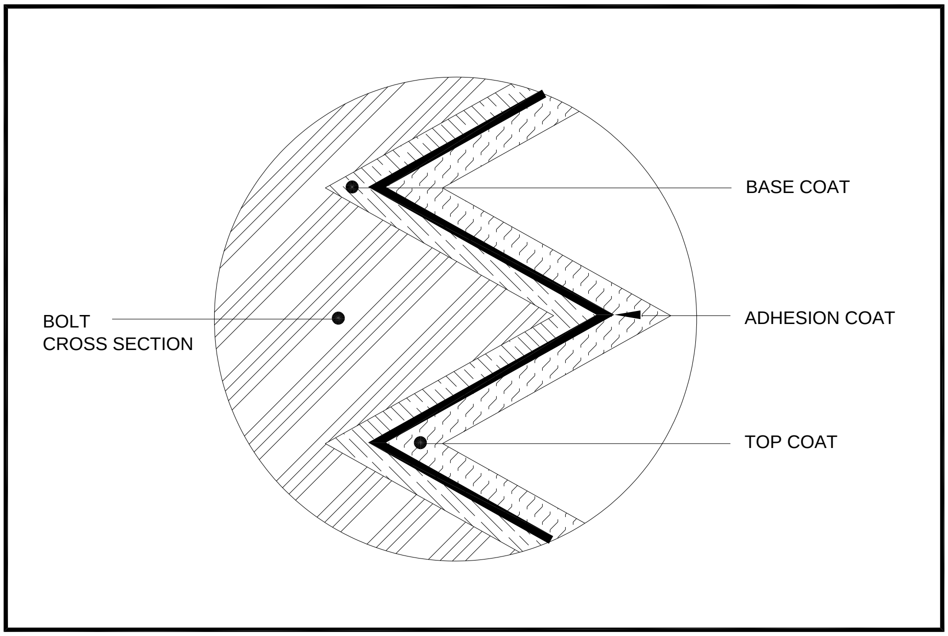


Figure 6. An Example of a Coated 3/8″-16 × 2″ Inch Bolt

Advantages of coated bolts are:

a. Anti-seize compound is not needed.
b. No exacerbation of corrosion between dissimilar metals since the coating does not conduct electrically. Refer to Section 9.0.
c. Can be used on stainless steel light bases with low potential for seizing and galling.

Coatings are durable and not easily removed, but there is a potential for coating damage caused by field installation. However, the damage is mitigated by any base coat that continues to provide corrosion protection should the outer coating be damaged. Coated fasteners are used throughout the petroleum industry and other specialized applications where corrosion is an issue.

Two-part locking washers are to be used with coated bolts. Helical and/or split lock washers are not to be used under any circumstance.

8.1 Initial Calculation of Coated Bolt Torque.

The use of coatings significantly affects the torque required to achieve the necessary light fixture clamping force to the light base upper flange. The coefficient of friction for these various coatings will be determined with a bolt tension calibrator.

8.2 In-Pavement Light Systems.

The following are also recommended best practices pertaining to the future modifications to the in-pavement lighting hardware:

a. It is recommended that no more than three spacer rings (including flange ring and/or grooved spacer ring) total no more than 2 3/16″ in height for a Type L-868 light base. If the required height adjustment is more than 2 3/16″, the spacers must be replaced with a light base extension. Horizontal shear force testing has demonstrated a clear correlation exists between increased quantity and thickness of spacer rings with reduced resistance to joint slippage due to the horizontal shear force. Thus, the quantity and thickness of spacer rings should be reduced as much as possible.

b. Bolts with nuts that require through holes through the light base flange will be allowed, provided the system can anchor the nut and generate sufficient resistance for the required torque. A two-part lock washer will be used with the nut in the same manner as the two-part lock washer is used with the bolt heads. An alternate to the two part lock washer can be a serrated flange bolt or a nut with locking threads may be used if it demonstrates sufficient locking performance in the vibration tests per AC 150/5345-46, paragraph 3.5.1, Vibration.

9.0 Galvanic Corrosion.

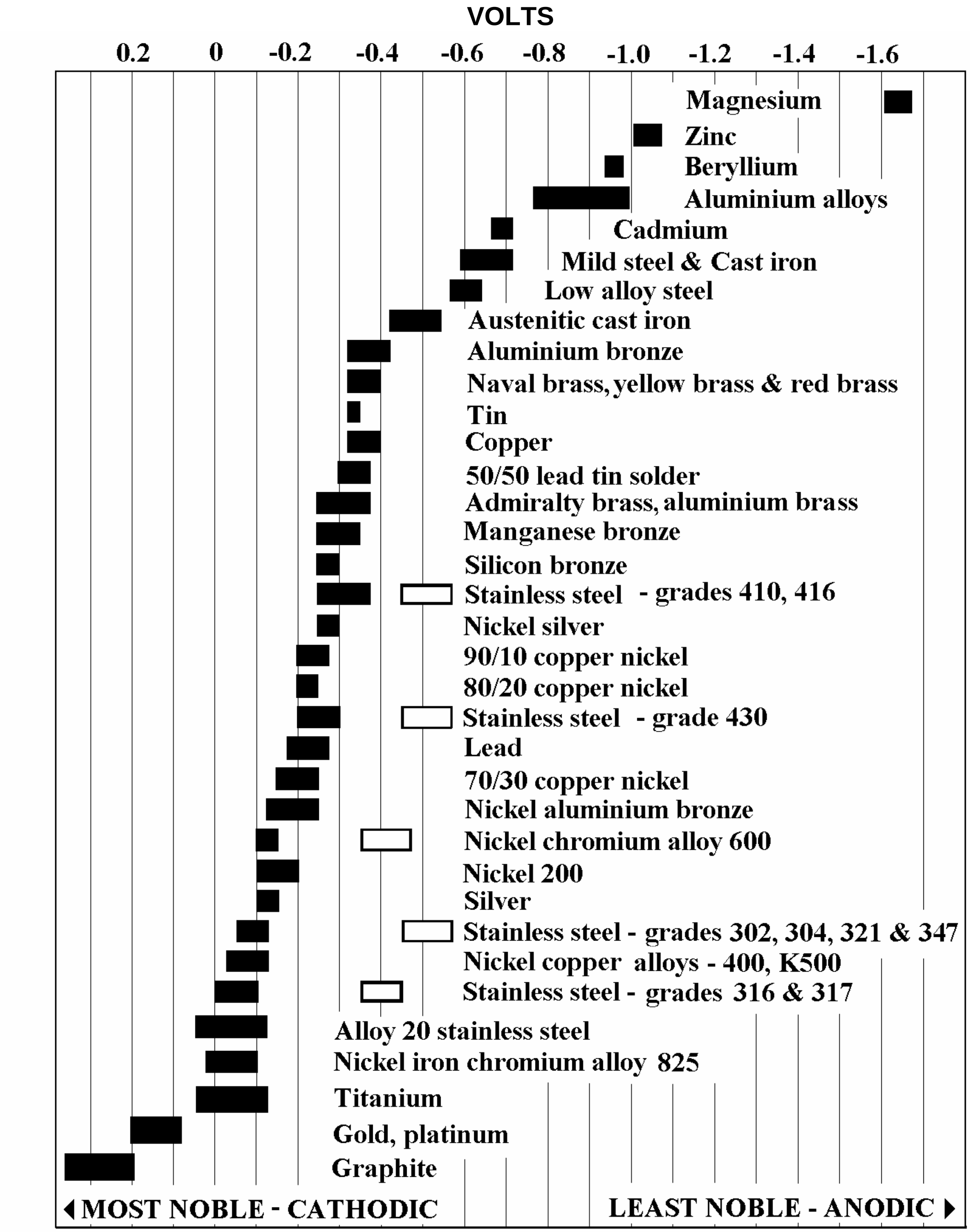
When dissimilar metals encounter each other, corrosion can result. Metallic ions from the less noble (anodic) metal will flow to the more noble (cathodic) metal resulting in corrosion of the less noble metal. In the situation of an aluminum light fixtures secured to a stainless steel light base in the presence of water or deicing agents, the aluminum fixture will corrode. The rain water and deicing agent acts as the electrolyte. The electrolyte provides a path for ion migration between the dissimilar metals (aluminum and steel) leading to the corrosion of the anodic metal (the aluminum light fixture). The corrosion of the cathodic metal (the steel light base) is retarded. Galvanic corrosion occurs where:

1. Metals are highly different and are ranked according to their galvanic or electrochemical potential. The result is generally viewed as a chart similar to Figure 7. A rule of thumb is that differences over 0.2 volts suggest galvanic corrosion is a concern.
2. Metals must be in contact with each other.
3. The metal junction must be bridged by an electrolyte (an electrical conducting fluid such as rain water or a deicing agent).

In Figure 7, note the almost extreme difference between zinc and stainless steel. In the presence of an electrolyte (such as water or a deicing fluid or both) zinc becomes an anode and is sacrificed in relation to stainless steel. Using stainless steel bolts with a zinc galvanized light base is not the best choice of materials. A coated bolt is a better option to secure the zinc galvanized light base.

Galvanic corrosion of light fixtures can have a serious negative consequence at airports constantly exposed to heavily salt laden air, such as Boston Logan International Airport and LaGuardia Airport.

Figure 7. Simplified Galvanic Table from Atlas Specialty Metals, Tech Note No. 7



Note: Corrosion potentials in flowing sea water at ambient temperature. The unshaded symbols show ranges exhibited by stainless steels in acidic water such as may exist in crevices or in stagnant or low velocity or poorly aerated water. The more Noble materials at the left side tend to be cathodic and hence protected; those at the right are less Noble and tend to be anodic and hence corroded in a galvanic couple.

APPENDIX A. CLAMP FORCE AND TORQUE CALCULATION FOR THE AIRBUS-A380-800 AIRCRAFT

A.1 Given Information and Assumptions.

Given: The governing modern commercial aircraft for these calculations is the A380-800 aircraft with a wheel load of 59,400 pounds at a tire pressure of 218 psi.

Given: The tire contact area with the pavement is 59,400 pounds/218 psi = 272.47 square inches (si) rounded to 272.5 si.

Given: A 12″ diameter in-pavement light fixture has an area of 113 si.

Assumption: The coefficient of traction (friction) between the tire and the pavement/light fixture is assumed to be 0.8.

Assumption: For these calculations, the pavement structure surrounding the in-pavement light fixture is assumed to have no affect resisting the traction force. This is a conservative assumption.

Assumption: The coefficient of friction between the light fixture flange and the light base or the light base extension ring is assumed to be 0.37. The same coefficient of friction is also assumed for the bolt clamping force and torque calculation. This assumed coefficient of friction value can be enhanced by the introduction of friction coatings on faying surfaces between light bases and lights.

A.2 Clamping Force Calculation.

Given: Coated SAE J492, Grade 5, 3/8″-16 bolt is used to secure the light fixture.

The load the tire imparts to the in-pavement light fixture is:

59,400 pounds × (113 si/272.5 si) = 24,662 pounds rounded to 24,700 pounds. (This is the maximum normal force that the fully loaded tire imparts to the in-pavement light fixture.)

The maximum traction force imparted to the light fixture is:

24,700 pounds × 0.8 = 19,760 pounds.

The maximum friction force between the light fixture and light base/extension ring interface is the maximum normal force multiplied by the coefficient of friction or:

24,700 pounds × 0.37 = 9,139 pounds rounded to 9,140 pounds

The force necessary to secure the light fixture is the maximum traction force minus the maximum friction resistant force between the interface or:

19,760 pounds - 9,140 pounds = 10,620 pounds

The clamping force necessary to secure the light fixture is equal to the opposing force divided by the coefficient of friction:

10,620 pounds/0.37 = 28,703 pounds rounded to 28,700 pounds

The clamping force for each of the 6 bolts securing the light fixture is:

28,700 pounds/6 = 4,783 pounds which is conservatively rounded to 4,900 pounds.

Note: The 3/8″ SAE J429, grade 5 bolt has a rated clamping force of 4,941pounds and is adequate for this installation.

A.3 Torque Calculation.

T = K × D × Fp

Where:

T = bolt torque (inch-pounds)

K = dimensionless friction coefficient (assumed value of 0.18)

D = nominal bolt diameter (inches)

Fp = Axial clamping Force (pounds)

T = 0.18 × 0.375 inches × 4,900 pounds

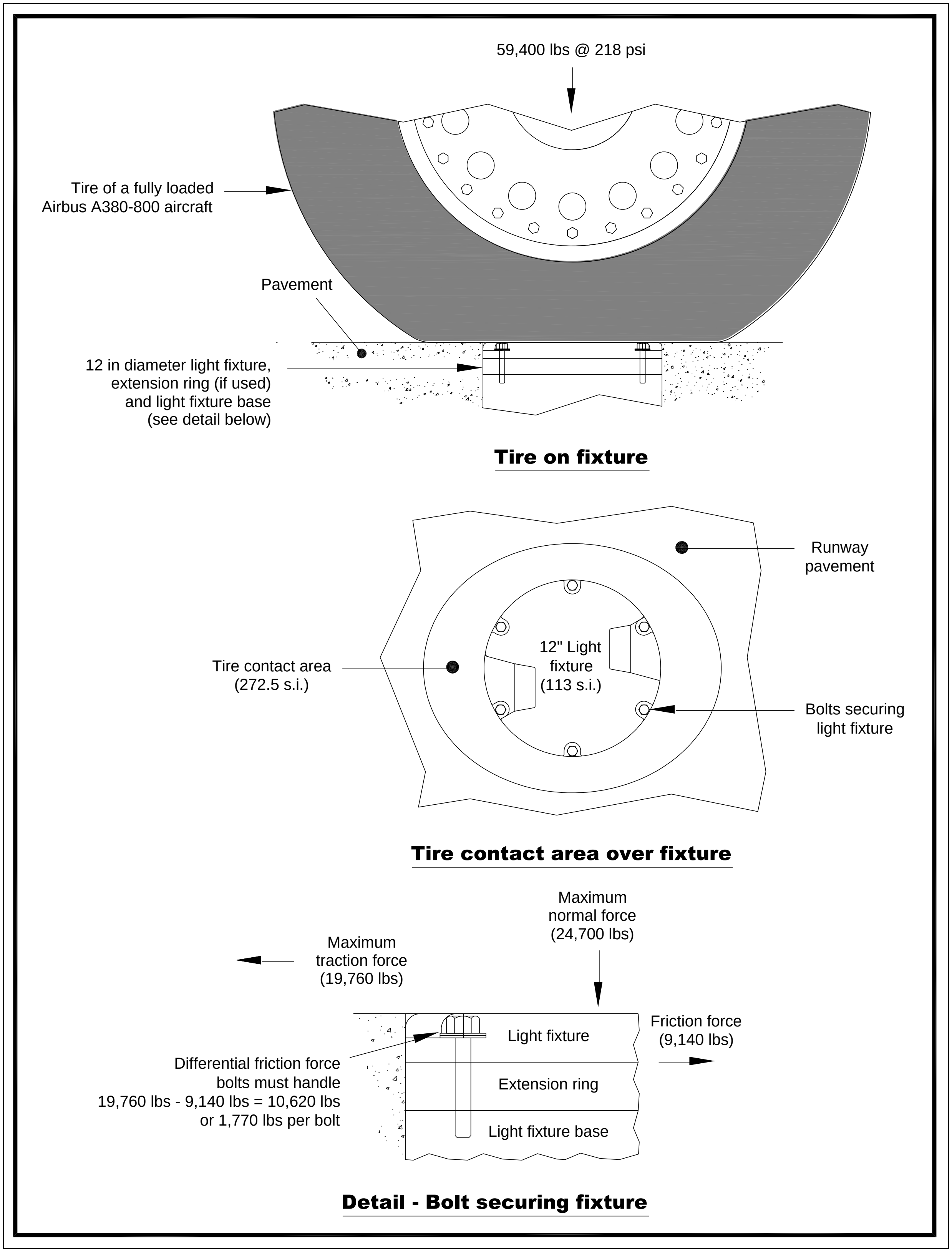
= 330.75 inch-pounds rounded to 330 inch-pounds

= 27.5 foot-pounds

Note: Per the calculations in paragraph 3.1, the SAE J429, grade 5, 3/8″-16 bolt, is capable of being torqued to 27.8 foot-pounds to obtain its maximum rated clamping force of 4,941 pounds. Therefore, this bolt is adequate for this installation.

Refer to the following figure for a pictorial representation of these calculations.

Figure A-1. Forces Acting on In-Pavement Light Fixture (Airbus A380-800)



APPENDIX B. SAMPLE CLAMP FORCE AND TORQUE FORCE CALCULATION FOR AN AIRCRAFT

Refer to **Figure B-1**.

B.1 Given Information:

- Airport management must determine the governing aircraft for their airport in determining the clamping force and bolt torque needed for securing the in-pavement light fixtures.
- For this sample calculation, an aircraft tire load of 44,496 pounds **[A1]** per tire at 204 psi **[A2]** tire pressure is assumed. This tire loading is similar to a Boeing 737-900 ER aircraft.
- The in-pavement light fixture has a 12″ diameter and a surface area of 113 si. **[C]**
- The coefficient of traction (friction) between the tire and the pavement light fixture is assumed to be 0.8. **[D]**
- The coefficient of friction between the light fixture flange and the light base (or the light base extension ring) is assumed to be 0.37. The coefficient of friction value can vary based on coatings of the faying surfaces light base and light fixture. **[E]**
- The same conservative coefficient of friction of 0.37 is assumed for the bolt clamping force and torque calculations. Six (6) bolts are used to secure the light fixture to the base. **[G]**

B.2 Sample Calculation:

A1: Tire Load = 44,496 pounds

A2: Tire Pressure = 204 psi

B: Tire Contact Area = A1 / A2 = 218 si

C: Maximum Normal Force on the in-pavement light fixture = A1 × (113/B) = 23,064 pounds

D: Traction Force imparted to the light fixture = C × 0.8 = 18,450 pounds

E: Resisting Frictional Force between the light fixture and light base = C × 0.37 = 8534 pounds

F: Differential Force the in-pavement light fixture bolts must handle = D – E = 9,916 pounds

G: Clamp Force = (F/6)/0.37 = 4,466 pounds

The grade of bolt to be used must be based on 75% of the proof strength.

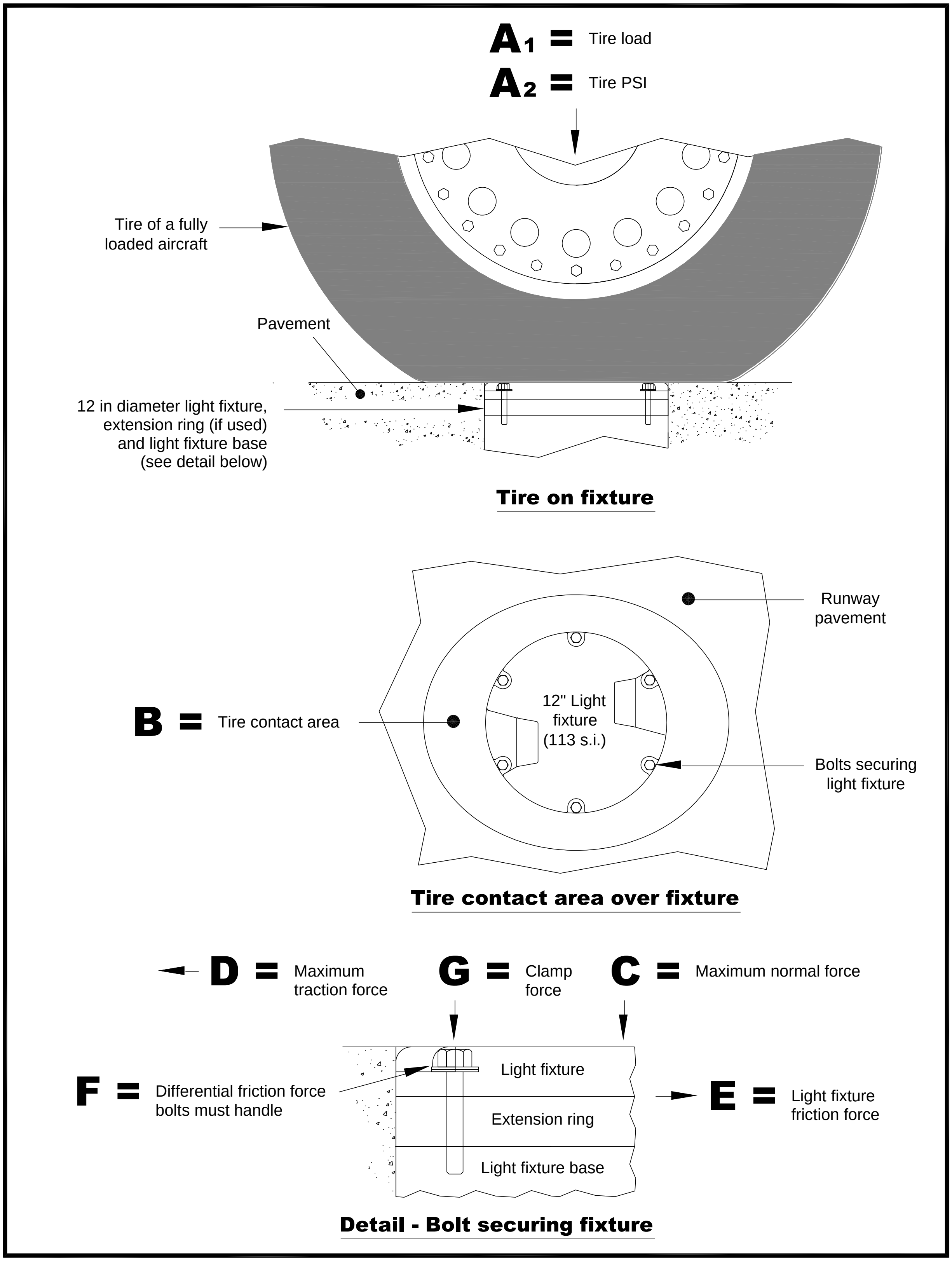
Torque required for a 3/8″ coated bolt having a K value of 0.18.

$$\mathbf{T} = K \times 0.375 \times G = 301.5 \text{ inch-pounds}$$

$$= 25.1 \text{ foot-pounds}$$

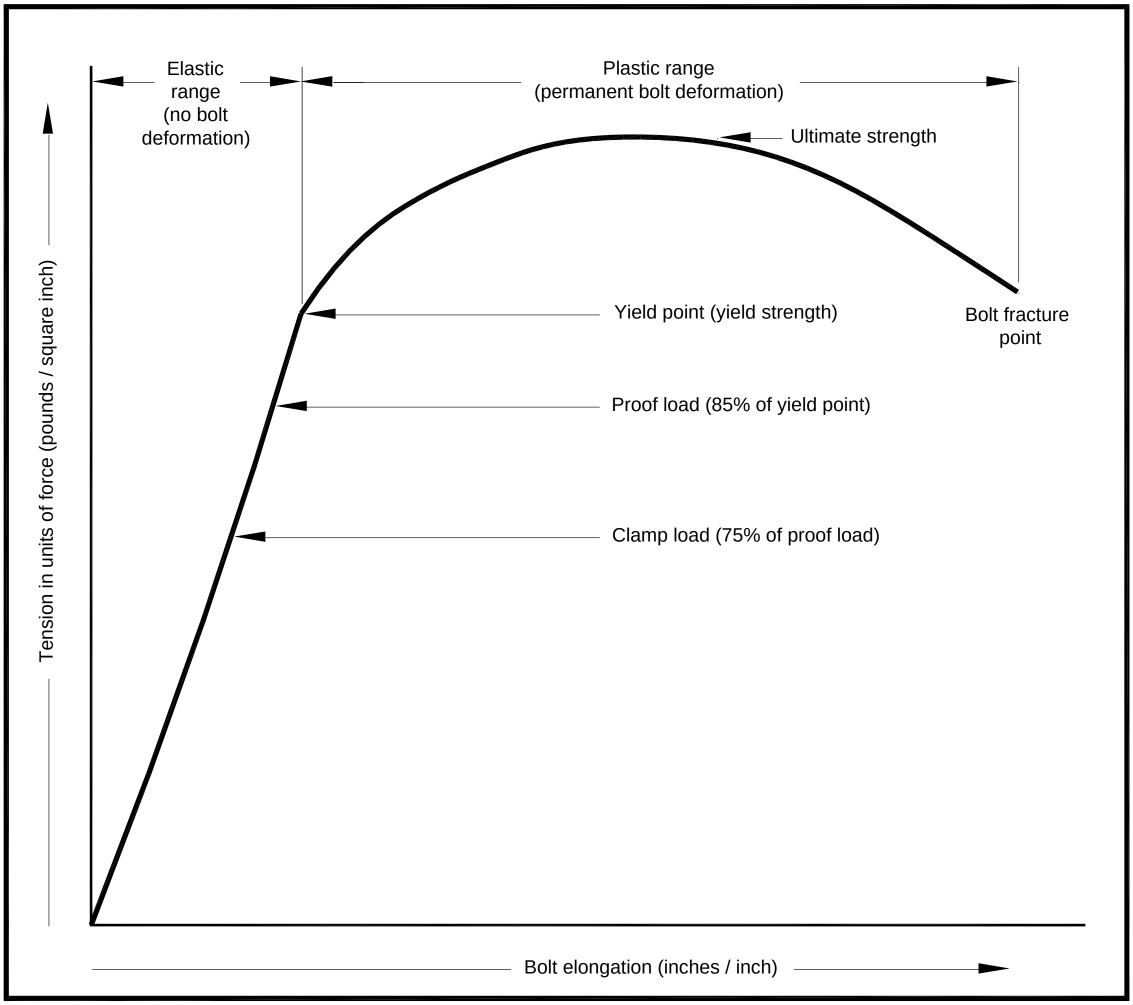
The grade of the 3/8″ bolt selected must be able to generate a clamping force of 4,466 pounds and a torque of 25.1 foot-pounds while not exceeding 75% of proof load.

Figure B-1. Forces Acting on In-Pavement Light Fixture (Generic)



APPENDIX C. BOLT TENSION VS BOLT ELONGATION DIAGRAM

Figure C-1. Bolt Tension vs Bolt Elongation



Notes:

Ultimate Strength: Maximum tensile force a bolt before fracturing.

Yield Point (Yield Strength): Tensile force that will start to induce a permanent deformation of the bolt.

Proof Load: Tensile force typically equal to 85% of the Yield Point.

Clamp Load: Typically, 75% of the Proof Load for joints that can be dissembled.