IES – 2010
Galloway, NJ

Light Bases & Light Fixtures

Keeping Them Together

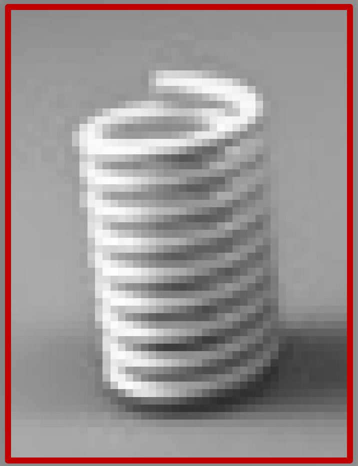
TOC

Clamping Force = Preload Force

Fastener acts like a spring

too much

just right



too little

TOC

- When fastener is tightened it is stretched
- Causes tension in fastener (Fp)
- Mating parts are compressed
- Creates clamp force (Fc)

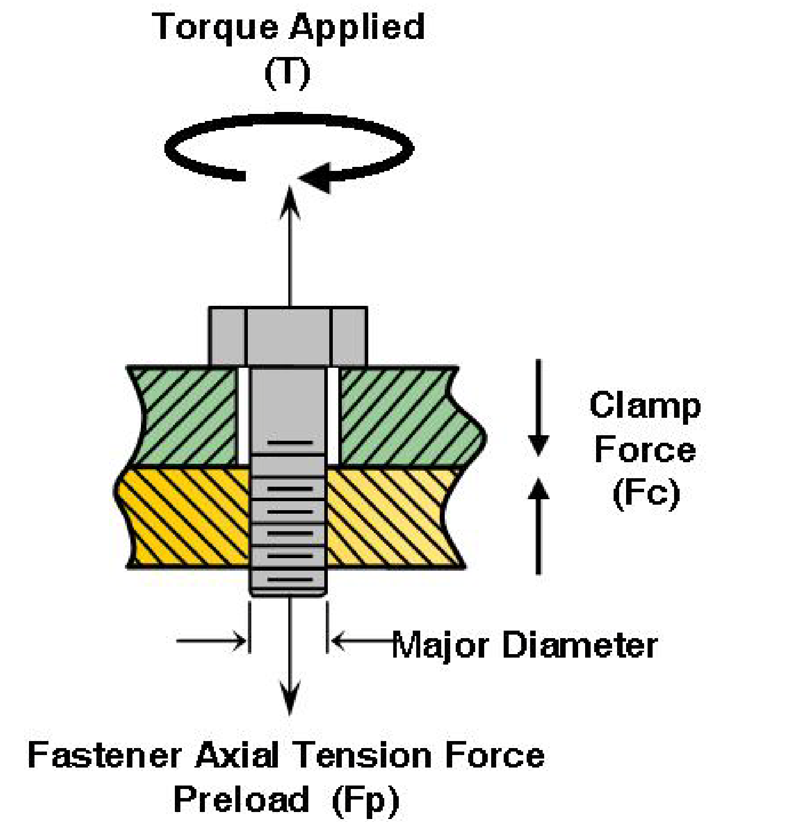


Figure 1

Clamp Force

- Exerts pressure on mating parts
- Increases friction between parts
- This friction offsets shear force
- External forces act on compressed parts, not on fastener

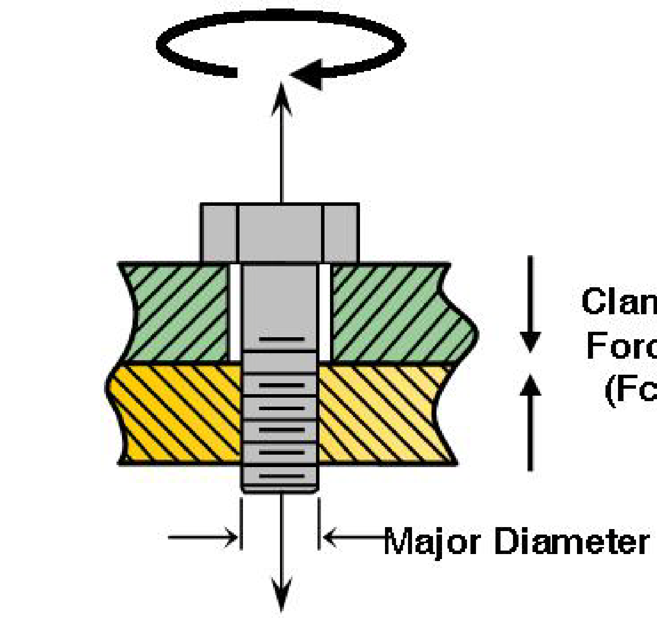
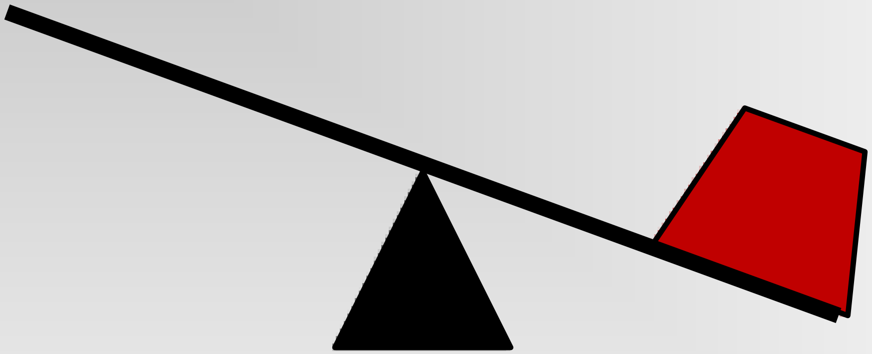


Figure 1

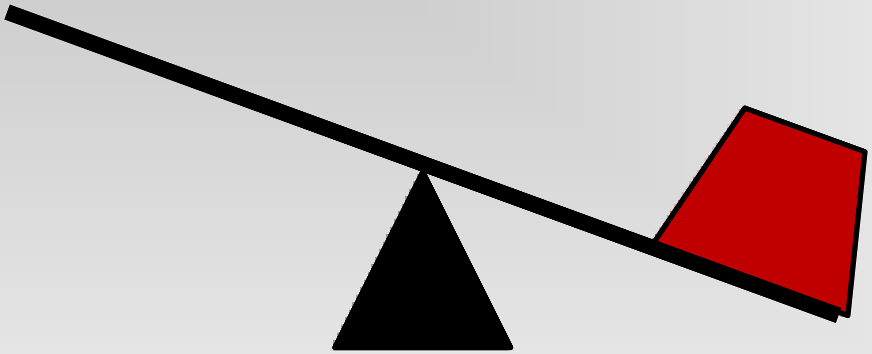
When . . . .

Clamp Force (Preload)
Greater than External Forces



However . . . .

If External Forces
Greater than Clamp Force (Preload)



Bolted joints fail because of improper preload

So, if preload is so important, how is it determined ?

Calculate Proper Preload

$$TFc = (Fs/\mu)*2$$

- TFc = total clamp force
- Fs = shear force in pounds
- μ = static coefficient of mating surfaces
- *2 = safety margin

Calculate Proper Preload

TFc = (3000/.45)*2

- TFc = total clamp force
- Fs = 3,000 lbs
  (AC 150/5345-46D 4.5.1.3. Horizontal Shear Test)
- μ = .45
  (mild steel light base and aluminum light fixture)
- *2 = safety margin

Calculate Proper Preload

$$TFc = (3000/.45)*2 = 13,333 \text{ lbs}$$

- TFc = total clamp force
- Fs = 3,000 lbs
  (AC 150/5345-46D 4.5.1.3. Horizontal Shear Test)
- $\mu = .45$
  (mild steel light base and aluminum light fixture)
- *2 = safety margin

Calculate Proper Preload

Total Clamp Force = 13,333 lbs.

- Divide by number of bolts (6)
- = 2,222 lbs/bolt
- Round up to 2,400 lbs/bolt
- Clamp Force = Preload on bolt

Torque – the means to an end

Achieve Preload by using Torque

T = Fp * D * k

- T = torque
- Fp = preload in lbs
- D = thread diameter in inches
- k = coefficient of friction on fastener

Achieve Preload by using Torque

$T = 2400 * .375 * .2$

- T = torque
- Fp = 2,400 lbs
- D = .375"
- k = .2 *(dry, non-lubricated bolts)*

Achieve Preload by using Torque

T = 2400 * .375 * .2 = 180 in.lb.

= 15 ft.lb.

- T = torque
- Fp = 2,400 lbs
- D = .375"
- k = .2 *(dry, non-lubricated bolts)*

How do we measure torque ?

Measure Torque

- **Estimate of effectiveness** (Industrial Fastener Institute)

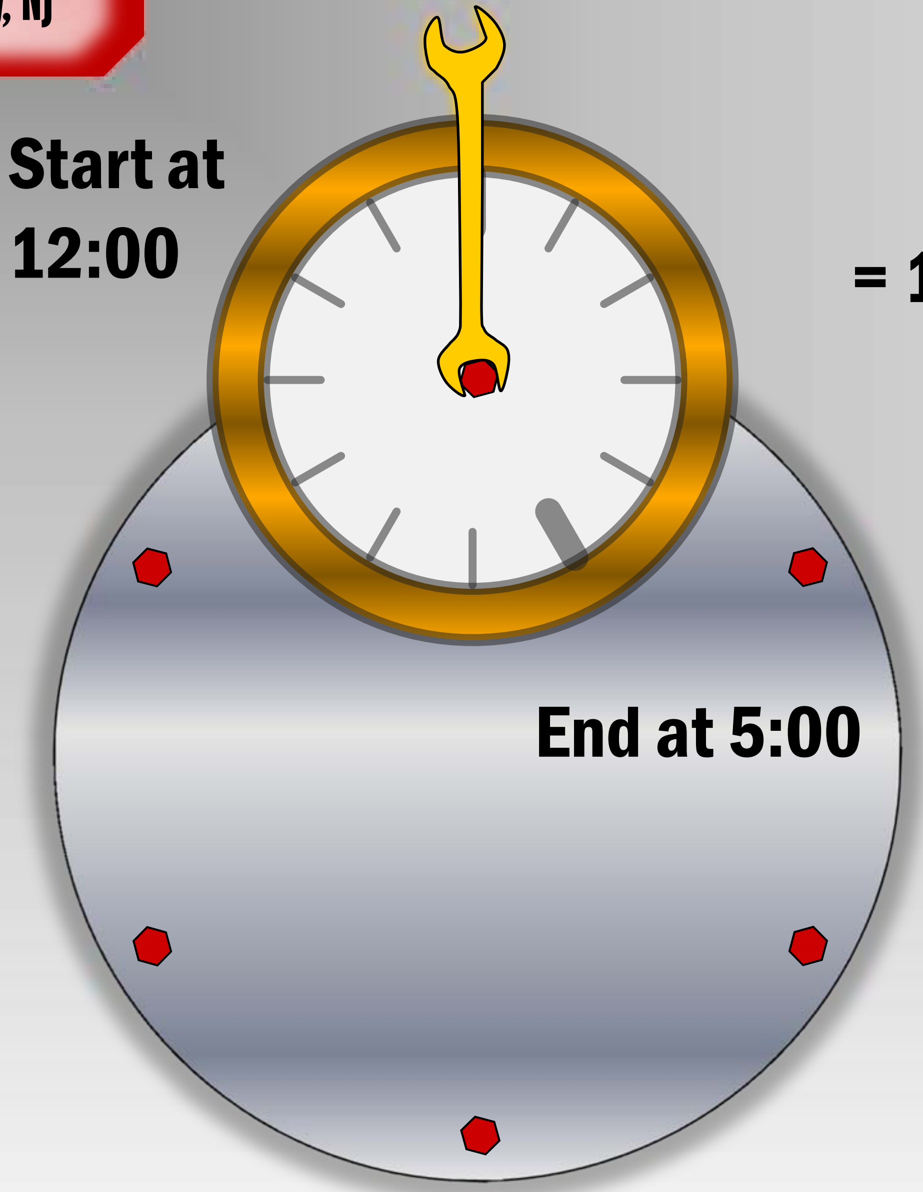
• Strain Gauges	+/- 1%
• Fastener Elongation	+/- 5%
• Load Indicating Washer	+/- 10%
• Angle Torquing	+/- 15%
• Torque Wrench	+/-25%
• Operator "Feel"	+/- 35%

Angle Torquing

Angle Torquing

TOC

Angle Torquing



= 180 in.lbs.

18-8 stainless steel
3/8"-16 bolt
Dry, non-lubricated

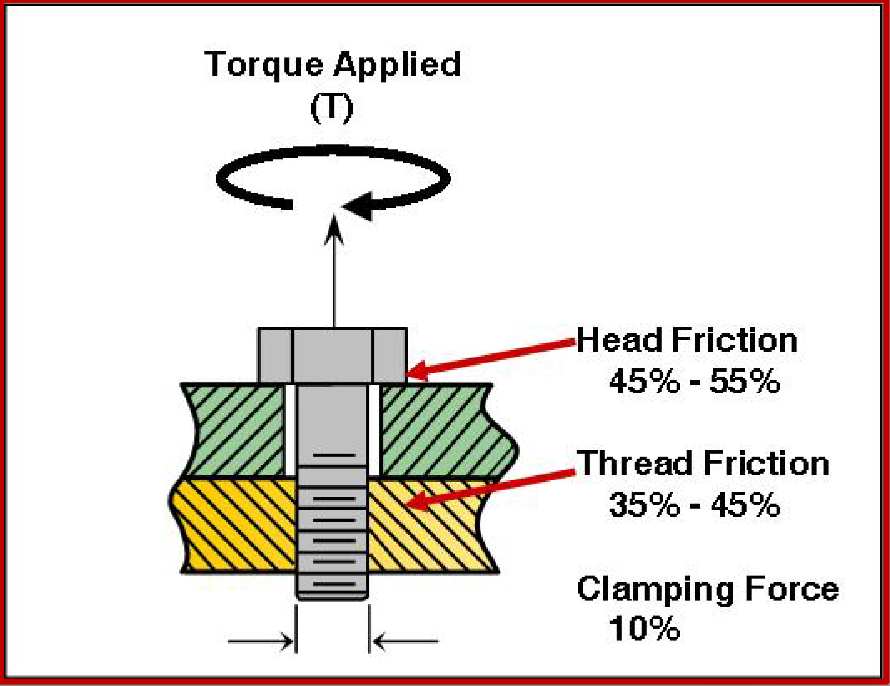
Using Anti-seize

Anti-seize products

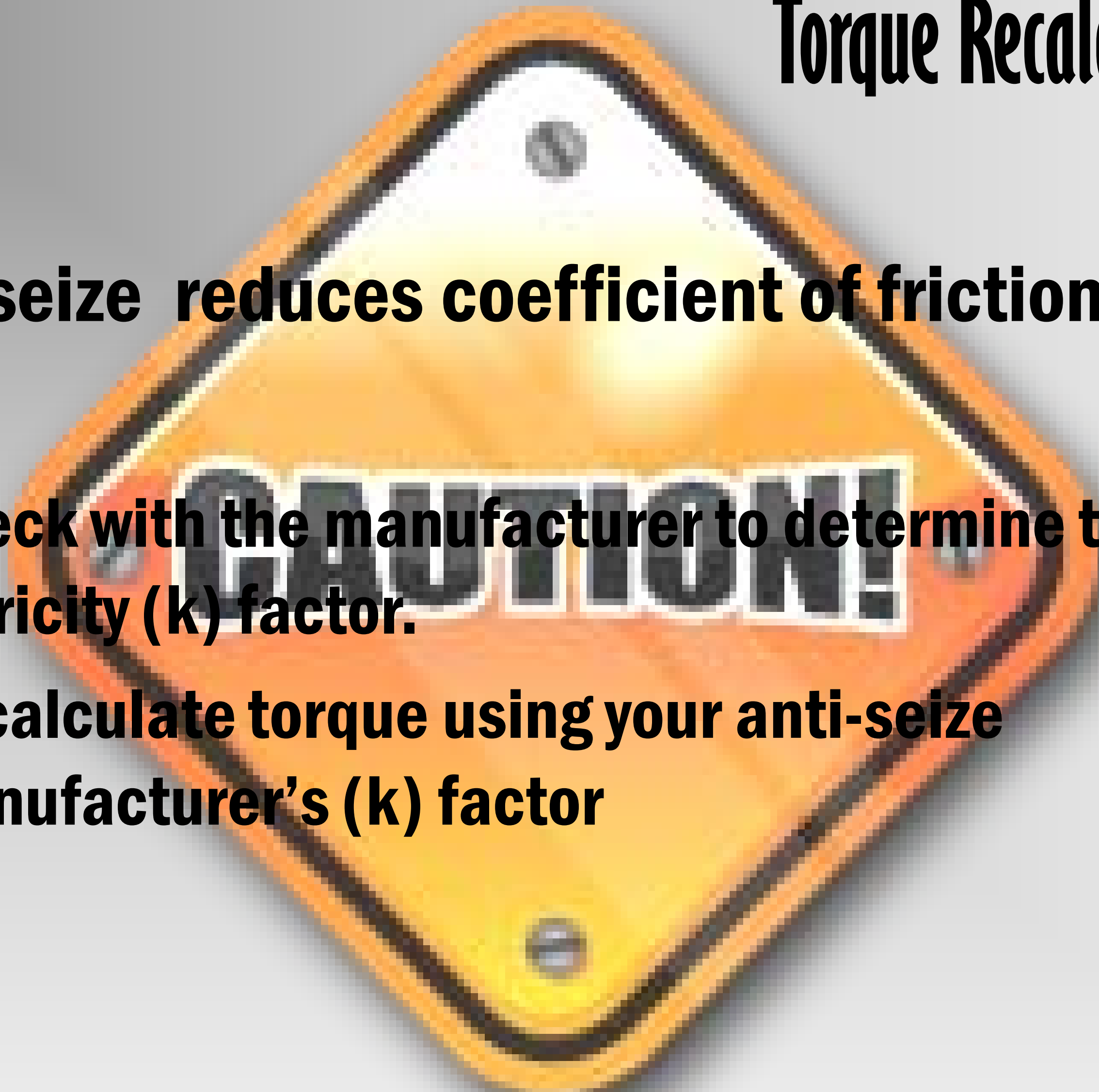
- **Nickel anti-seize recommended.** (AC 150/5340-30)
  - Reduces galling
  - Helps resist galvanic corrosion
  - Increases lubricity
  - Type left up to individual airport

Torque versus Clamp Force

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



Torque Recalculation



- **Anti-seize reduces coefficient of friction (k)**
  - **Check with the manufacturer to determine the lubricity (k) factor.**
  - **Recalculate torque using your anti-seize manufacturer's (k) factor**

Achieve Preload by using Torque

T = 2400 * .375 * .12

- T = torque
- Fp = 2,400 lbs
- D = .375"
- k = .12 ***(lubricated bolts)***

example only – check with anti-seize manufacturer

Achieve Preload by using Torque

$$T = 2400 * .375 * .12 = 108 \text{ in.lb.}$$

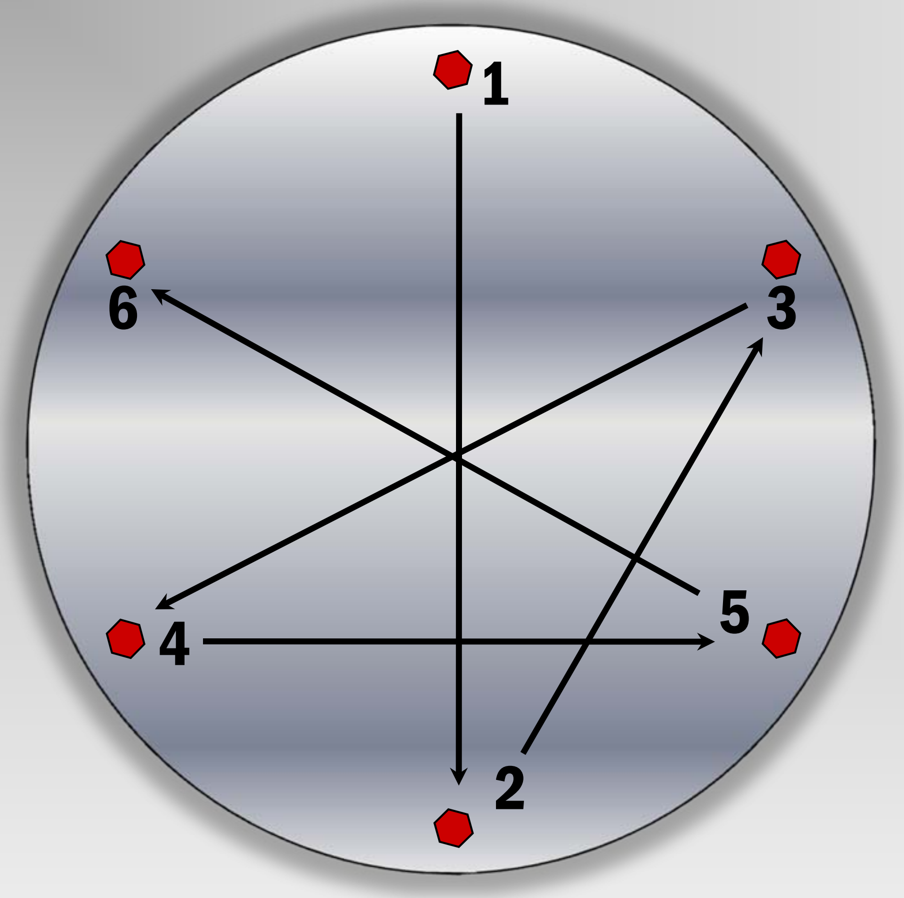
$$= 9 \text{ ft.lb.}$$

- T = torque
- Fp = 2,400 lbs
- D = .375"
- k = .12 ***(lubricated bolts)***

example only – check with anti-seize manufacturer

DRY Non-Lubricated	Lubricated Bolts (Anti-seize compound)
Fp= 2,400 (safety margin)	Fp= 2,400 (safety margin)
D= .375 (3/8-16 fastener) K= .2 (dry bolts – non lubricated)	D= .375 (3/8-16 fastener) K= .12 *(example only - check w/ anti-seize mfg.)*
= 180 in. lbs. = 15 ft. lbs.	= 108 in. lbs. = 9 ft. lbs.

Torquing Sequence



TOC

Bolt Strengths

- Tensile Strength – maximum load in tension (pulling apart) before breaking
- Yield Strength – maximum load at which material shows permanent deformation
- Proof Load – axial tensile load without evidence of permanent set
- Clamp Load – 75% of proof load * tensile stress area of threaded section

Bolt Specification Considerations

Material	Minimum Yield Strength (psi)	Minimum Tensile Strength (psi)
A36 Steel – Light Base	36,000	58,000
304 Stainless Steel Plate	31,200	73,200
Bolt Specification		
18-8 Stainless Steel	65,000	100,000
A307-A		60,000
Grade 2	57,000	74,000
Grade 5	92,000	120,000
Grade 8	130,000	150,000

Bolt Specification Considerations

Material	Recommended Torque Dry, Non-lubricated	Clamp Force
Stripped female threads in A36 (35 ft. lb)	Stripped female threads at 420 in. lb	
Clamp Force needed/bolt	180 in. lb	2,400 psi
3/8"-16 Bolt Specification		
18-8 Stainless Steel	236 in.lb	3,146 psi
A307-A	156 in. lb	2093 psi
Grade 2	240 in.lb	3,200 psi
Grade 5	372 in. lb	4,960 psi
Grade 8	528 in. lb	7,040 psi

Corrosion

Corrosion

- Deterioration of metals due to interaction with environment
- Metals want to corrode and return to oxides
- Metallic atoms leave metal until it fails

General Corrosion

- **Water and steel – iron oxide (rust)**
- **General protection**
  - **Corrosion resistant materials**

    Stainless steel forms surface oxide that interferes with electrochemical process
  - **Protective coatings such as plating, galvanizing, paints or epoxies**

Galvanic Corrosion

- Two dissimilar metals with different potentials placed in electrical contact in an electrolyte
- Larger potential difference, greater galvanic corrosion
- Most active becomes anode and corrodes - Least active becomes cathode and is protected

Galvanic Series

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

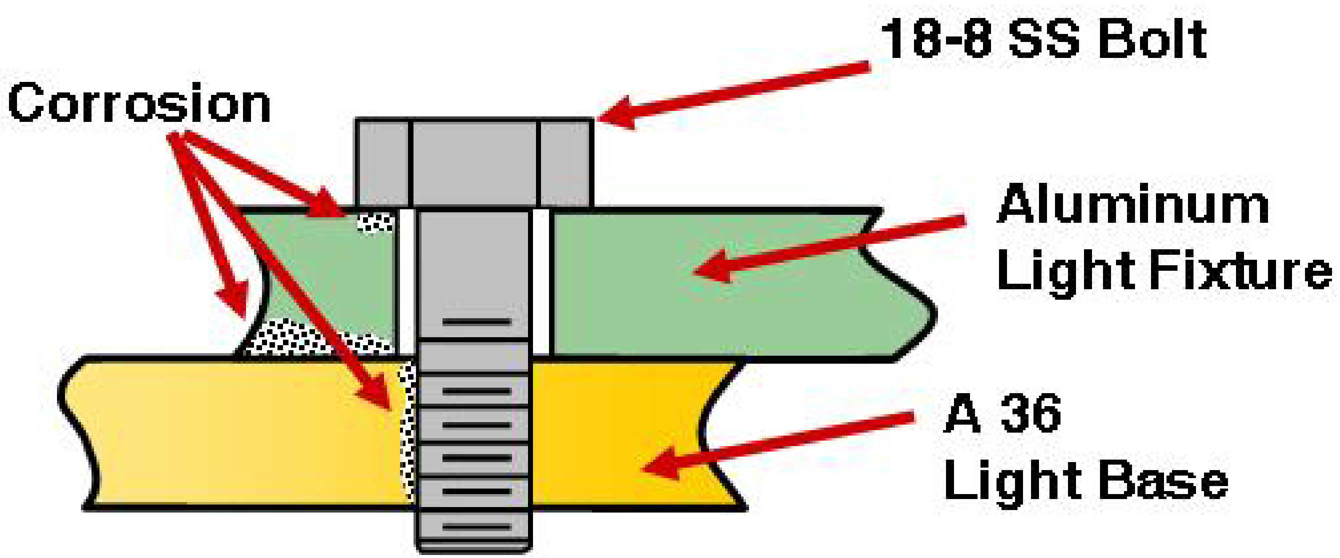
Active (Anodic – Least noble)

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

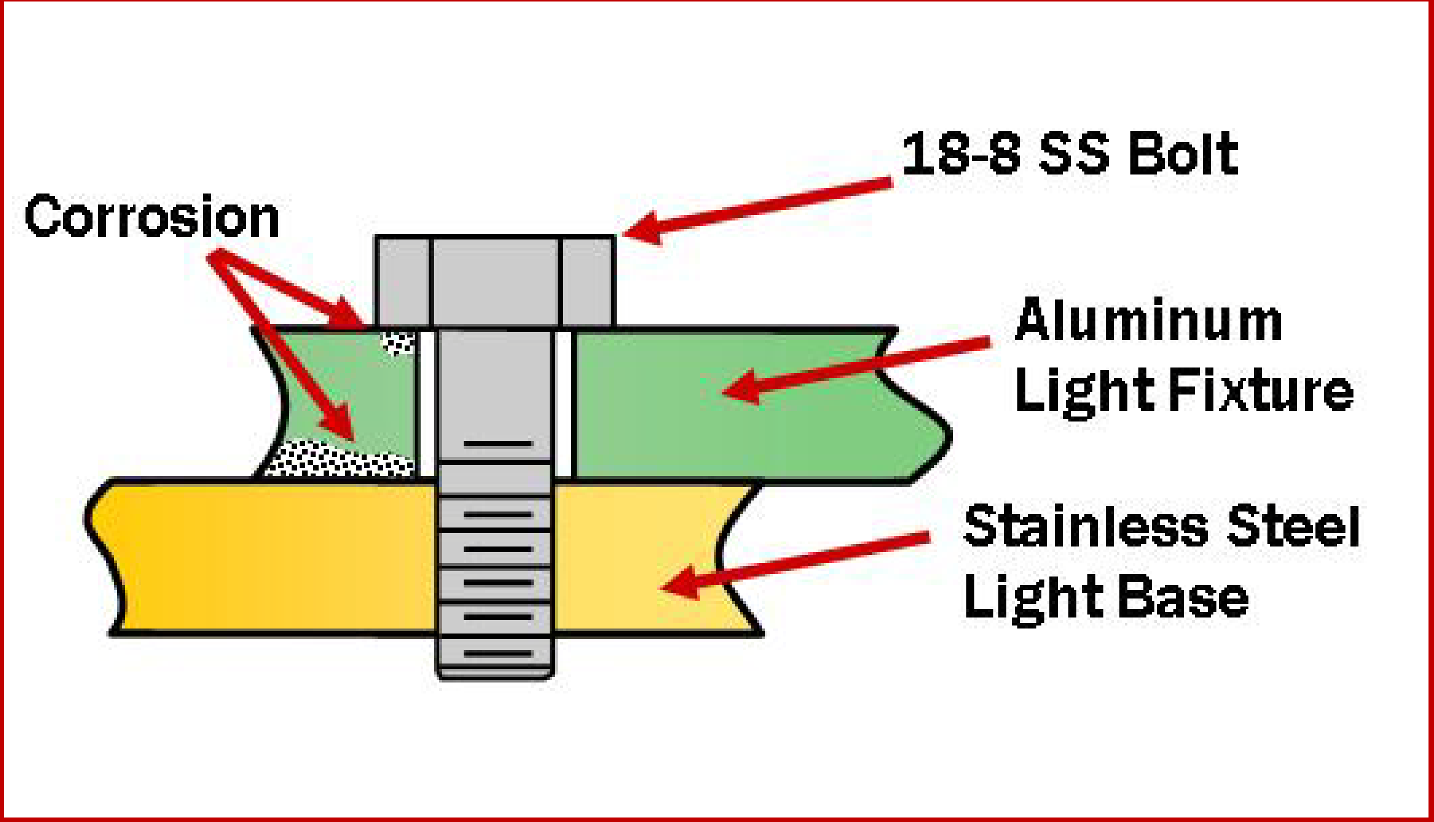
Less active (Cathodic – Most noble)

TOC

Galvanic Corrosion A36 Light Base



Galvanic Corrosion SS Light Base



Galvanic Corrosion

- **Minimize Galvanic Corrosion–**
  - **Minimize galvanic potential difference**
  - **Use large anode area;
    small cathodic for fastener**
  - **Interrupt the electrical path with a coating**

Comparison

Base Metal \ Fastener Metal	Austenitic Stainless Types 302,304,303,305 (18-8)	Zinc & Galvanized Steel	Martensitic Stainless Type 410	
Zinc & Galvanized Steel (Light Bases)	C	A	C	
Austenitic Stainless Types 302,304,303,305 (Light Bases)	AF	ADE	A	
Aluminum & Aluminum Alloys (Light Fixtures)	B	A	Not Recommended	
Steel & Cast Iron	B	AD	C	

A - The corrosion of the base metal is not increased by the fastener.

B - The corrosion of the base metal is marginally increased by the fastener.

C - The corrosion of the base metal may be markedly increased by the fastener.

D - The plating on the fastener is rapidly consumed, leaving the bare fastener metal.

E - The corrosion of the fastener is increased by the base metal.

F- Galling or cold welding of fastener.

Galling

Galling

Galling can occur when stainless steel parts, such as nuts and bolts, are forced together. The protective layer of chromium oxide can be scraped off, causing the parts to cold weld together by contact.

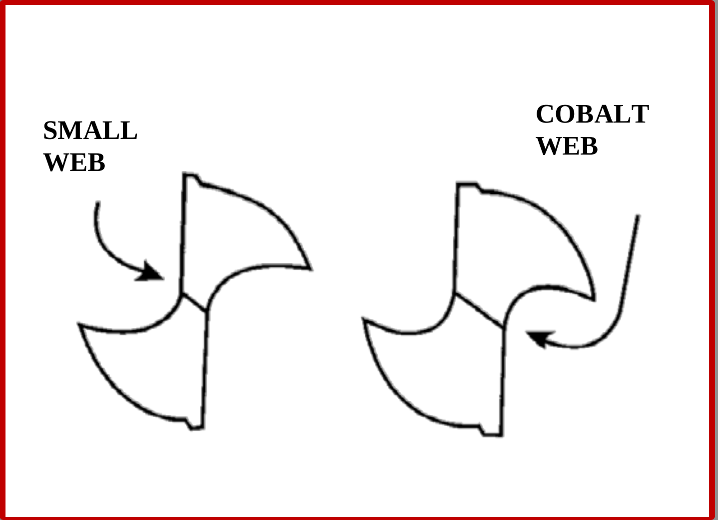
Reduce Galling

- Slow tool speed
- Different alloys
- Increase hardness of one material
- Coatings/Lubrication

18-8 Shortcomings

- Work hardens, hard to drill
- General corrosion
- Galvanic corrosion
- Galling with stainless steel bases

Drilling 18-8



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

Can we build a better bolt ?

- Select material
  - 18-8
  - A307-A
  - Grade 2
  - Grade 5
  - Grade 8
  - Other

- **Corrosion Protection**
  - Zinc and cadmium plating
  - Black oxide
  - Ceramic Metallic
- **Lubricity**
  - Use anti-seize product
  - Fluoropolymer (PTFE)

EB- 83 Bolts

EB-83 Bolt

- Low Carbon Steel
  - *1022 (ASE Grade 2)*
  - *A36 (NSTM A307-A)*
- Ceramic metallic base coat
- Fluoropolymer top coat
  - *FOD detection*

Low Carbon Steel, Ceramic metallic base coat, fluoropolymer top coat

Coating Comparison

- 720 Hours
- ASTM B-117 Salt Fog Test

Uncoated

Galvanized

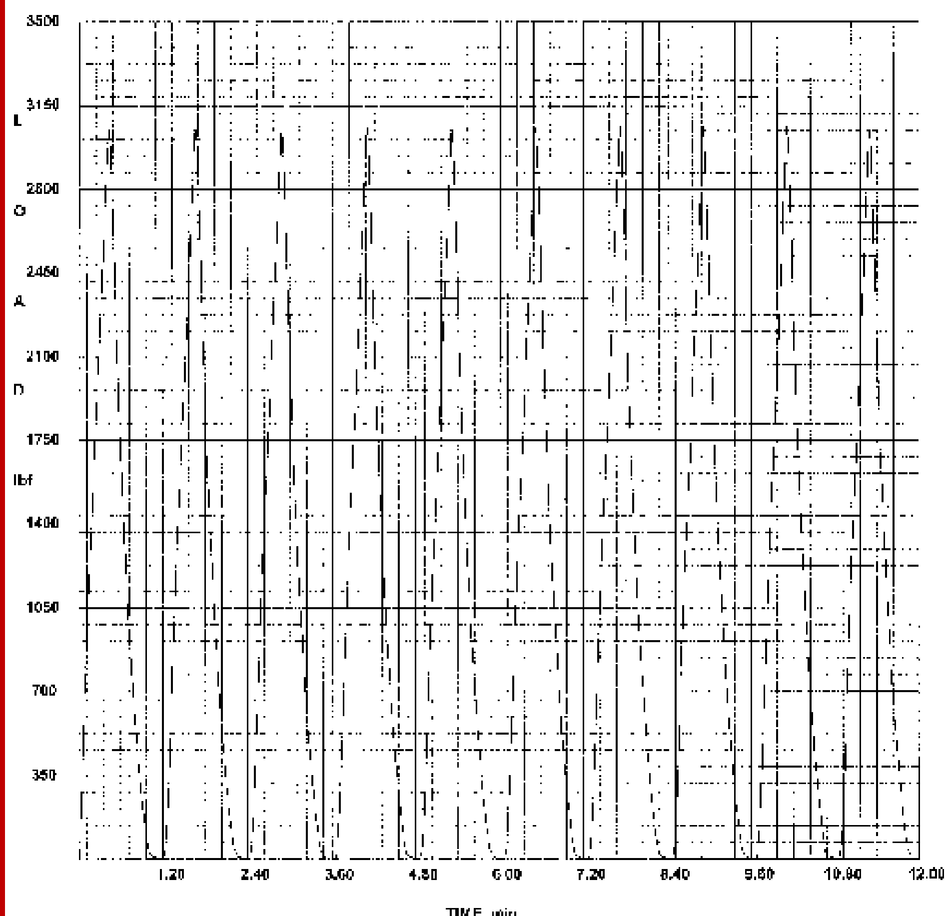
Cadmium

Zinc

C/M-PTFE

Test Fixture

1022 (Grade 2) Test Results

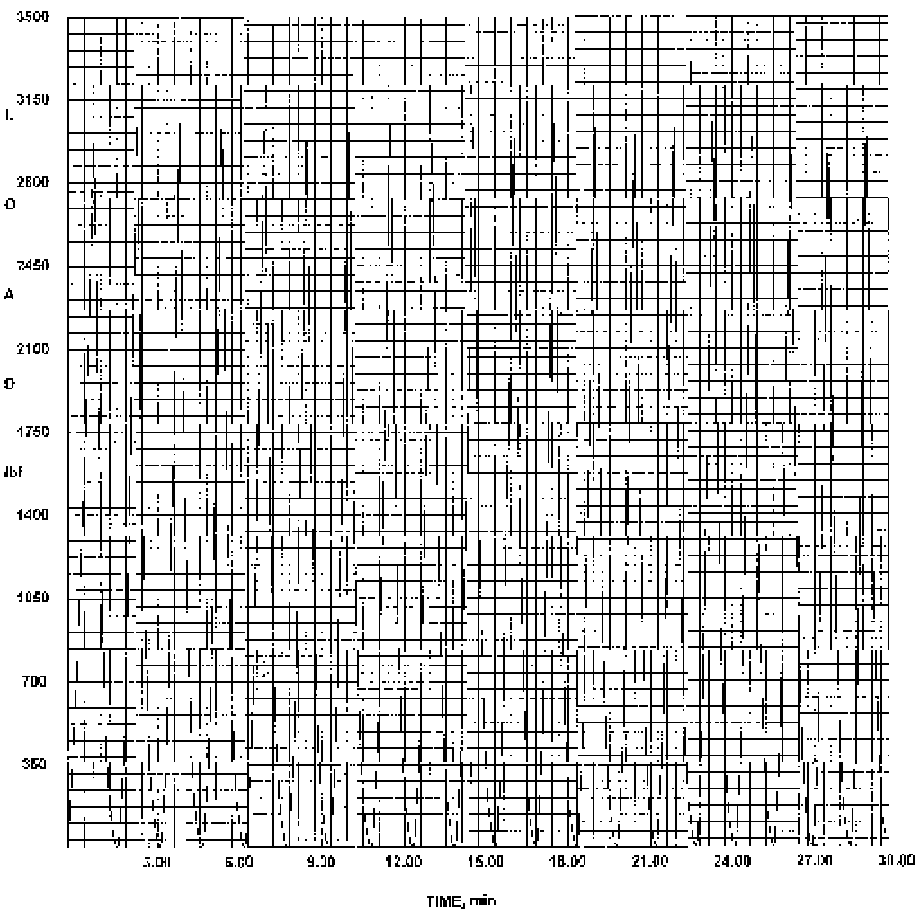


Northeast Wisconsin Technical College
2740 West Mason Street
Green Bay, WI 54307

Shear Test

Lot Number	1
Operator	RJ
Test Setting	Runway Hardware
Test Date	02/16/2010
Sample:	A
Sample No.:	1
Ultimate, lbf:	3070
Max Deflection, in:	0.0214

A-36 (A307-A) Test Results



Northeast Wisconsin Technical College
2740 West Mason Street
Green Bay, WI 54307

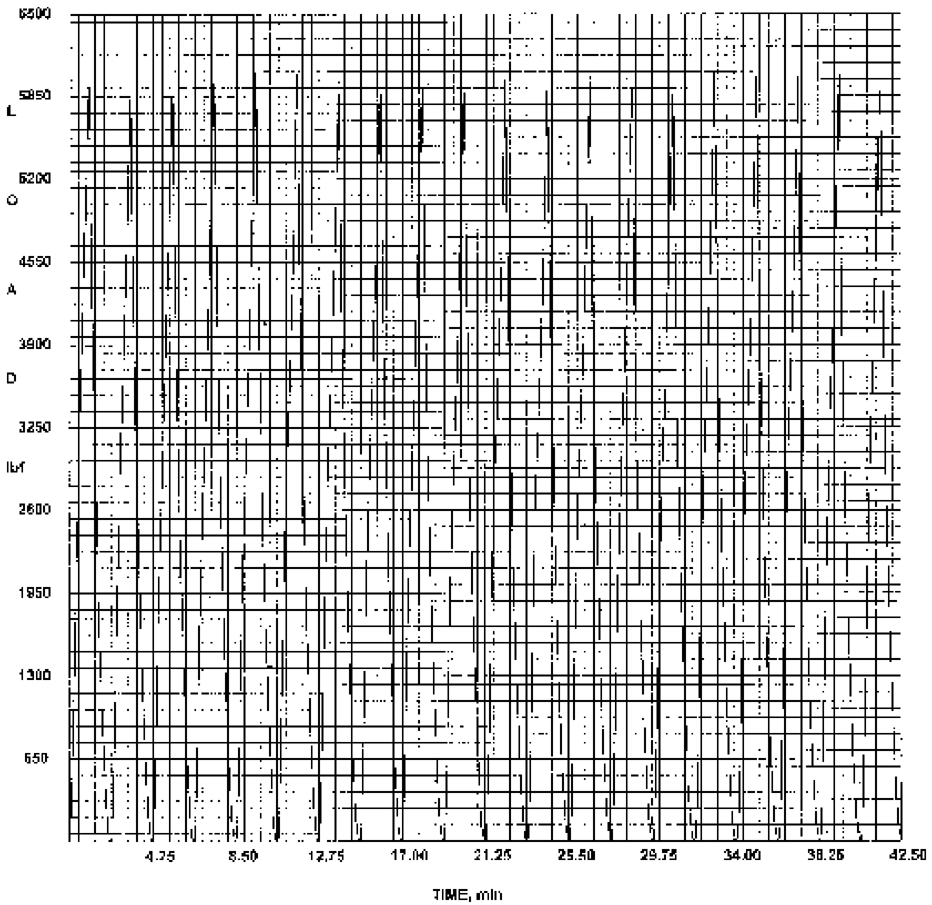
Shear Test

Lot Number	A307A
Operator	R.
Test Setting	Runway Hardware
Test Date	09/01/2010
Sample:	C
Sample No.:	1
Ultimate, lbf	3050
Max Deflection, in:	0.0502

10 lb 16

Sep 1 2010 3:06:00 PM

A-36 (A307-A) Test Results



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2740 West Mason Street
Green Bay, WI 54307

Shear Test

Lot Number	A307A
Operator	RJ
Test Setting	Runway Hardware
Test Date	09/02/2010
Sample:	C
Sample No.	5
Ultimate, lbf:	8030
Max Deflection, in:	0.0536

10 ft lb

EB-83 bolts installed

In the end …

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