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Issue Date: September, 21, 2016
Project No. G102710532
P.O. No.: 639

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Report No. 102710532CRT-001

MCB Industries, Inc.

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WI
54115

Standard

U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular, Specification for Runway and Taxiway Light Fixtures, AC No. 150/5345-46E dated 3/02/2016.

U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular, Specification for Runway and Taxiway Light Fixtures, AC No. 150/5345-42H dated 11/06/2015.

Purpose: Performance testing of Isabel fastening system
Model / Type: Isabel Fastening System
Test Dates: September 12, 2016 through September 13, 2016

Mike Guy
Associate Engineer
Lighting

Jeremy N. Downs PE
Staff Engineer
Lighting

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Project: G102710532
 Client: MCB
 Standard: AC No. 150/5345-46E dated 5/19/2009
 AC No. 150/5345-42H dated 11/06/2015

Product: Isabel system
 Model(s): TBD

| Test Plan and Datasheets | | | |
|--------------------------|---|----------|--------------|
| Client | MCB | Engineer | Mike Guy |
| Report | 102710532CRT-001 | Reviewer | Jeremy Downs |
| Product | Isabel system | Model(s) | TBD |
| Standard | AC No. 150/5345-46E dated 5/19/2009 AC No. 150/5345-42H dated 11/06/2015 | | |

| AC No. | Test name | Clause | Pass Fail NA |
|--------|----------------------------------|----------|--------------------|
| 42H | Load test | 4.3.1 | NA |
| 46E | Vibration, Leakage | 4.5.1.1 | NA |
| 46E | Horizontal Shear | 4.5.1.3 | NA |
| NA | Torque to failure | Torqfail | NA |
| NA | Torque versus Tension Evaluation | TorqTen | NA |
| | | | |

| Sample Information | | | | |
|--------------------|-------------------|---------------------------|-----------|-----------|
| Date Rec. | Intertek ID | | Condition | Model No. |
| 9/13/16 | CRT1609161442-001 | Coated, flange head bolts | New | TBD |
| 9/13/16 | CRT1609161442-002 | Nuts and clips | New | TBD |
| 9/13/16 | NA | Fixture cut-away | New | na |
| 8/23/16 | CRT1608231126-001 | Coated, hex bolts | New | TBD |
| 8/24/16 | CRT1608231126-002 | Stainless flange nut | New | TBD |
| 8/25/16 | CRT1608231126-003 | Flat washer | New | TBD |
| 8/26/16 | CRT1608231126-004 | Hex nut | New | TBD |

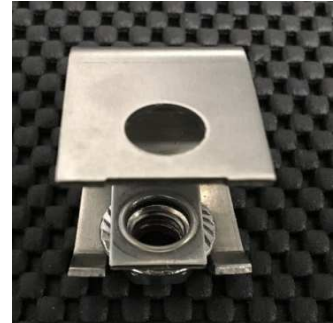
| Samples used for Vibration, Horizontal shear and Compressive load testing | |
|---|-----------------------------|
| Bolt description | |
| Length: | 4.36 inches (thread length) |
| Diameter: | 3/8 inch |
| Threads per inch: | 16 |
| Material: | ASTM F593C |
| Blue Coating: | Xylan 1424 |
| Head: | Hex with Flange |

| Isabel clip and serrated flange nut description | |
|---|--|
| Nut size: | 3/8 inch |
| Nut Material: | 302HQ |
| Red Adhesive: | Precote 80-3 High Strength and Heat Resistant Thread Coating |
| Threads per inch: | 16 |
| Clip material: | 301 SS |

| Samples used for torque vs. tension comparison, and torque to failure | |
|---|--|
| Bolt description | |
| Length: | 1.84 inches (thread length) |
| Diameter: | 3/8 inch |
| Threads per inch: | 16 |
| Material: | ASTM F593C |
| Blue Coating: | Xylan 1424 |
| Head: | Hex |
| Serrated Flange Nut description | |
| Nut size: | 3/8 inch |
| Material: | 302HQ |
| Red Adhesive: | Precote 80-3 High Strength and Heat Resistant Thread Coating |
| Threads per inch: | 16 |

Sample Information

Picture(s)



Above pictures of sample representations used for Vibration, Horizontal shear and Compressive load tests

Sample Information



Above pictures of sample representations used for Torque vs. Tension comparison

Sample Information



Above pictures of fixtures used for testing

Load Test AC 150/5345-42H 4.3.1 (excepting Rubber block thickness of 1" from AC 150/5345-46E)

Perform a static load test on the light fixture. Apply the compressive load in pounds of 450 times the area in inches of the light fixture to the top part of the light fixture through a rubber block at least 1 inch (25.40mm) less than the outside diameter of the light assembly, 1 inch thick, and of a Shore A hardness of 55-70. Apply the load uniformly at a rate of not greater than 10,000 pounds per minute and hold there for 1 minute.

Test to be completed 3 times. Check torque between each application of compressive load.

Results

| | | |
|----------------------|-------|---------|
| Light F Fixture Dia. | 12 | inches |
| Light Fixture Area | 113 | inch sq |
| Compressive Load | 50868 | lbs. |

| Rubber Block | | | Req. |
|--------------|----|--------|-------------------|
| Diameter | 11 | inches | ≤ Fixture Dia -1" |
| Thickness | 1 | inches | 1" (25.40mm) |
| Shore "A" | 66 | NA | 55-70 |

| Post Test Observations | Y/N |
|--------------------------------|-----|
| Permanent Deformation | N |
| Cracking of material or finish | N |
| Breaking or damage to Light | N |

| Bolt identification | Torque values (in.lbs.) | | | |
|---------------------|-------------------------|-------------------|-------------------|-------------------|
| | Initial torque | After 1st loading | After 2nd loading | After 3rd loading |
| 1 | 360 | 320 | 345 | 360 |
| 2 | 360 | 309 | 315 | 345 |
| 3 | 360 | 289 | 300 | 310 |
| 4 | 360 | 300 | 300 | 300 |
| 5 | 360 | 289 | 310 | 300 |
| 6 | 360 | 315 | 315 | 325 |



| | | | | | |
|--------------------------------|--|-----------------------|--|------------|--|
| Tested By | | Signature or initials | | Comp. Date | |
| Mike Guy | | MPG | | 9/13/16 | |
| Reviewed By | | Signature or initials | | | |
| JND | | JND | | | |
| Test Equipment Used 1,11,12,13 | | | | | |
| Sample ID# | | Ambient (°C) | | RH% | |
| CRT1609161442-001 (1-6) | | 26.3 | | 42 | |
| CRT1609161442-002 | | | | | |

Vibration

Subject the light fixture to a sinusoidal vibration along three mutually perpendicular axes. Operate the lamps to monitor the continuity continually. Vibrate the fixture over a frequency range of 20 to 500 Hz, with a maximum acceleration of 10 Gs for 10 minutes. Then vibrate the fixture from 500 to 2000 Hz, with a maximum acceleration of 15 Gs for 10 minutes. If the lamp filament or envelope is damaged, replace the lamp and repeat the test at 3 Gs. After the test, inspect the interior of the fixture for mechanical failure, loosening of any part, or displacement of any part.

Results

| Post Test Observations | Y/N |
|-------------------------------------|-----|
| Mechanical Failure of any Component | N |
| Loosening of any Part or Fastener | Y |

Torque values changed after each vibration segment

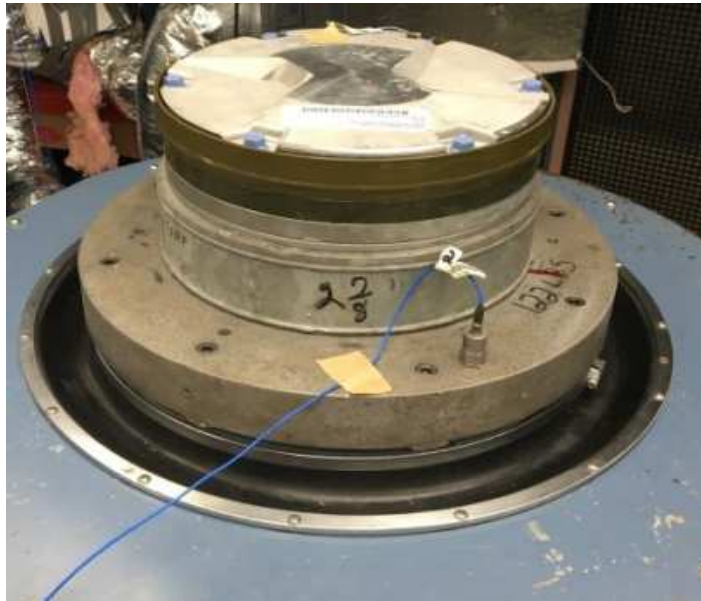
Note: Fresh bolts and nuts were used for each axis and the adhesive was allowed to set for 30 minutes before testing.

| Bolt identification | in.lbs. | in.lbs. |
|---------------------|----------------|-----------------|
| | Initial torque | Post Vertical |
| 1 | 360 | 320 |
| 2 | 360 | 320 |
| 3 | 360 | 330 |
| 4 | 360 | 330 |
| 5 | 360 | 300 |
| 6 | 360 | 335 |
| | | Post lateral |
| 7 | 360 | 320 |
| 8 | 360 | 300 |
| 9 | 360 | 320 |
| 10 | 360 | 305 |
| 11 | 360 | 315 |
| 12 | 360 | 295 |
| | | Post horizontal |
| 13 | 360 | 320 |
| 14 | 360 | 305 |
| 15 | 360 | 305 |
| 16 | 360 | 315 |
| 17 | 360 | 320 |
| 18 | 360 | 320 |

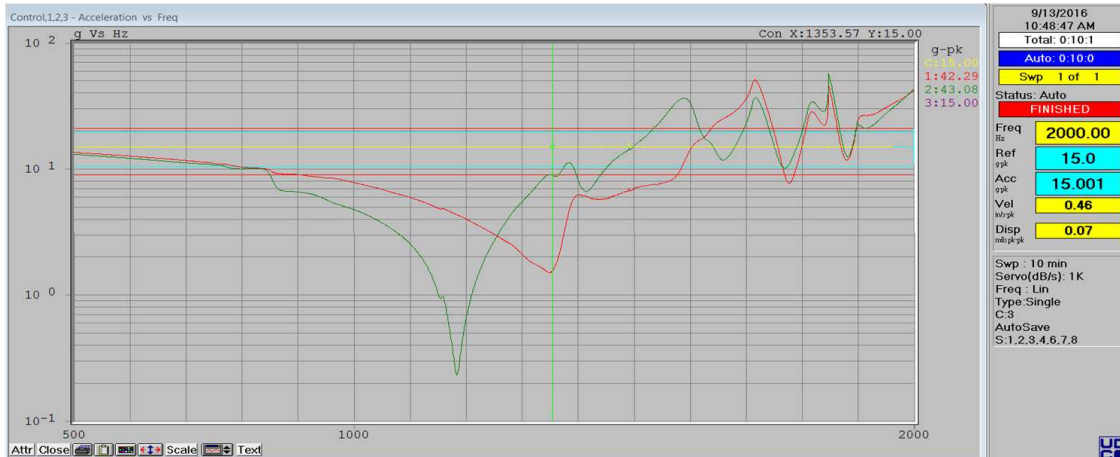
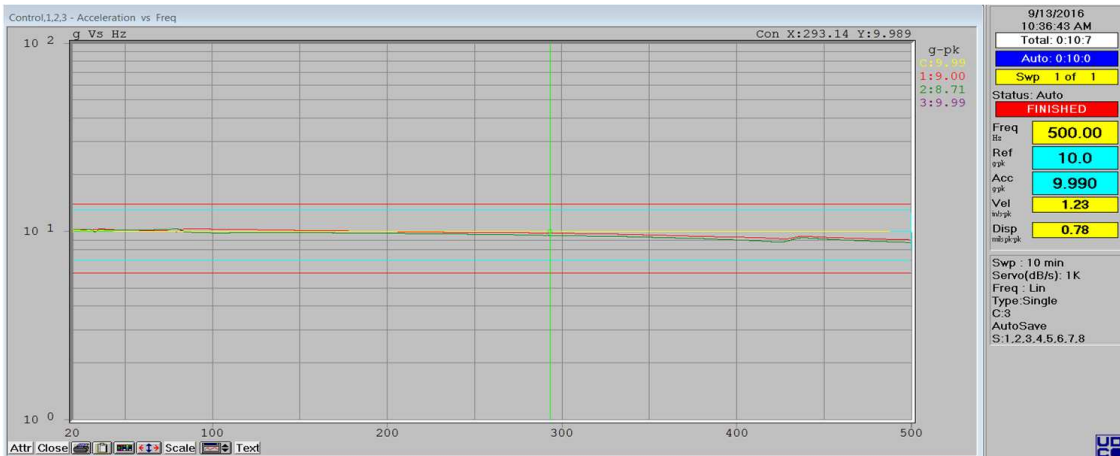
Test Results Summary

| | | | | | |
|---------------------|----------------------------|-----------------------|--------------------|------------|---------|
| Tested By | Gordon West | Signature or initials | <i>Gordon West</i> | Comp. Date | 9/13/16 |
| Reviewed By | JND | Signature or initials | <i>JND</i> | | |
| Test Equipment Used | 1,2,3,4,5,6,7,8,9,10,11,12 | | | | |
| Sample ID# | CRT1609161442-001 (1-18) | Ambient (°C) | 23.6 | RH% | 40 |
| | CRT1609161442-002 | | | | |

Vibration

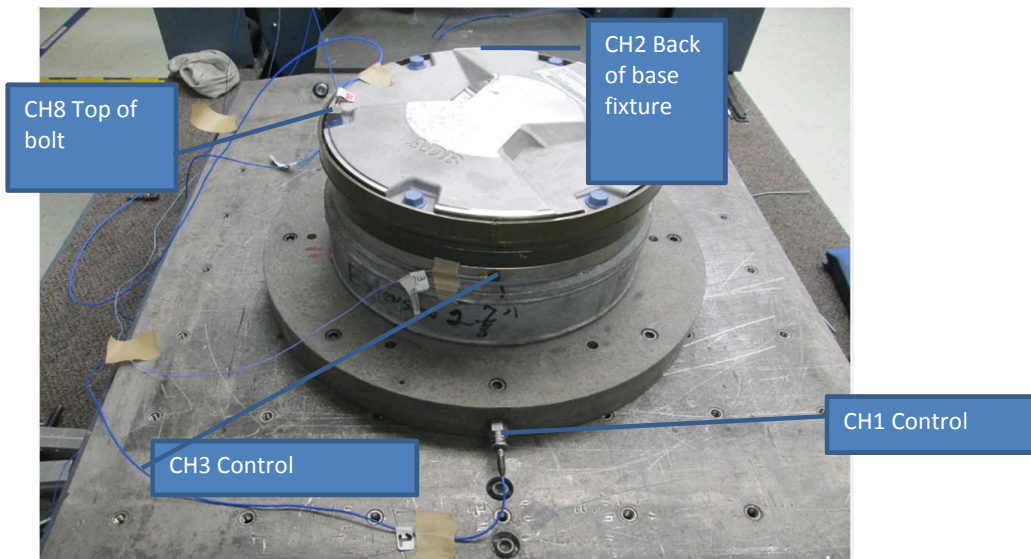


Vertical Axis set up control with ch3 on top of bolt head

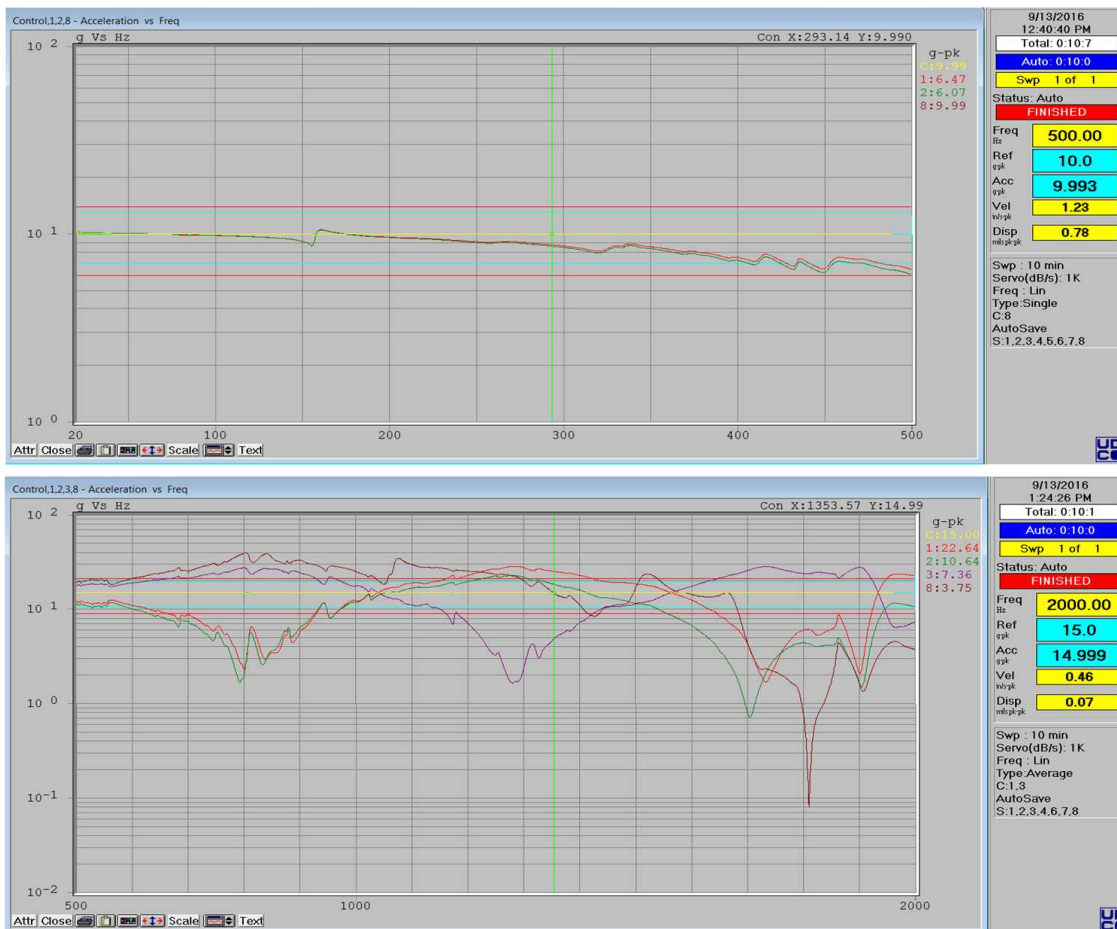


Vertical Axis Data

Vibration

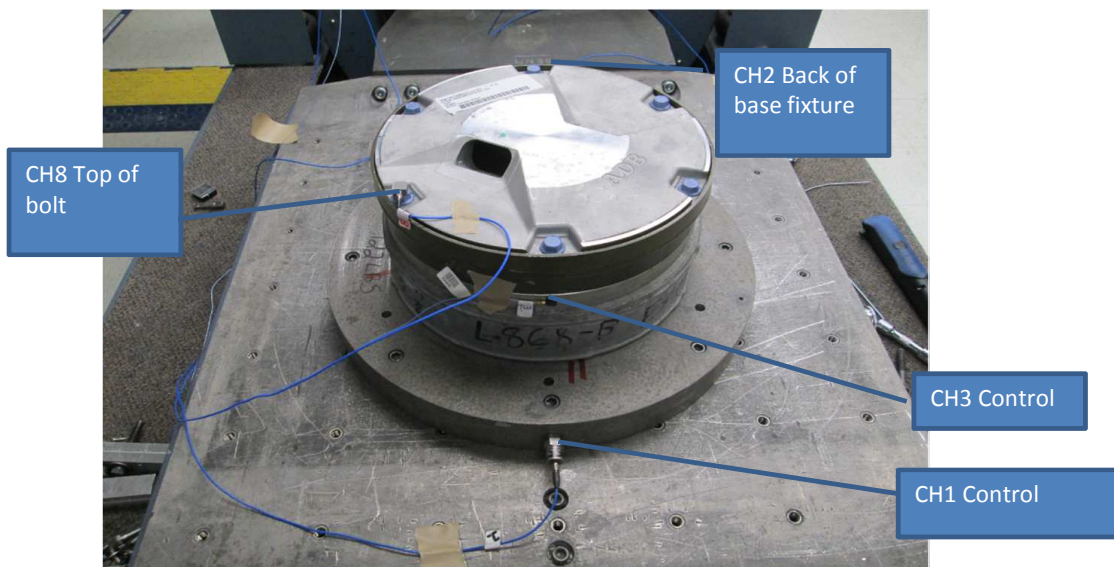


Lateral set up control averaging ch1 and ch3

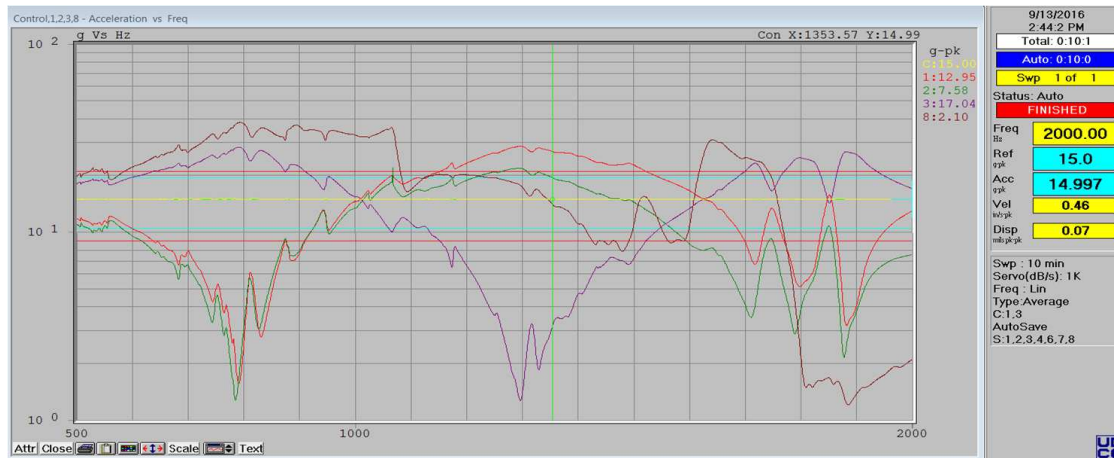
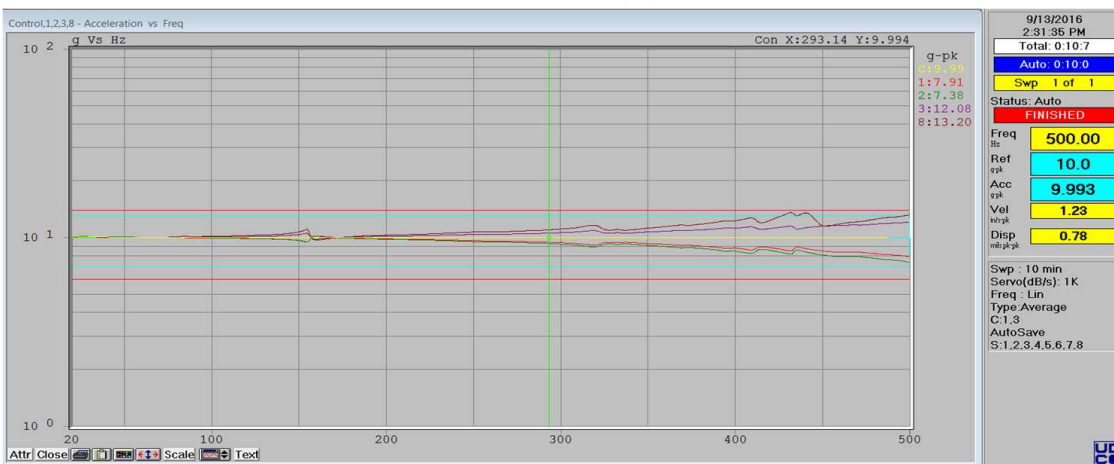


Lateral Axis Data

Vibration



Horizontal set up control averaging ch1 and ch3



Horizontal Axis Data

Vibration



Noted that hex nut was found turned in clip after vibration testing

Horizontal Shear FAA AC 150/5345-46E 4.5.13 (excepting load applied was 6000 lbs.)

Perform a test to simulate the shearing load applied to the top surface of an in pavement fixture by a braking aircraft tire. Weld a bar to the top of the fixture parallel to the runway centerline and parallel to the ground plane. Apply a shearing load of 6000 pounds and release 20 times to each end of the bar. Inspect the sample for any mechanical damage.

Results

| | | Bolt identification | | | | | |
|--------------------------|-----------|---------------------|------------|------------|------------|------------|------------|
| Direction | Fore | 19 | 20 | 21 | 22 | 23 | 24 |
| Initial (in.lbs.) | na | 360 | 360 | 360 | 360 | 360 | 360 |
| Load 1 | X | na | na | na | na | na | na |
| Load 2 | X | na | na | na | na | na | na |
| Load 3 | X | na | na | na | na | na | na |
| Load 4 | X | na | na | na | na | na | na |
| Load 5 | X | na | na | na | na | na | na |
| Load 6 | X | na | na | na | na | na | na |
| Load 7 | X | na | na | na | na | na | na |
| Load 8 | X | na | na | na | na | na | na |
| Load 9 | X | na | na | na | na | na | na |
| Load 10 | X | 305 | 315 | 290 | 308 | 295 | 318 |
| Load 11 | X | na | na | na | na | na | na |
| Load 12 | X | na | na | na | na | na | na |
| Load 13 | X | na | na | na | na | na | na |
| Load 14 | X | na | na | na | na | na | na |
| Load 15 | X | na | na | na | na | na | na |
| Load 16 | X | na | na | na | na | na | na |
| Load 17 | X | na | na | na | na | na | na |
| Load 18 | X | na | na | na | na | na | na |
| Load 19 | X | na | na | na | na | na | na |
| Load 20 | X | 323 | 325 | 300 | 320 | 305 | 320 |

| | | Bolt identification | | | | | |
|--------------------------|-----------|---------------------|------------|------------|------------|------------|------------|
| Direction | Aft | 19 | 20 | 21 | 22 | 23 | 24 |
| Initial (in.lbs.) | na | 360 | 360 | 360 | 360 | 360 | 360 |
| Load 1 | X | na | na | na | na | na | na |
| Load 2 | X | na | na | na | na | na | na |
| Load 3 | X | na | na | na | na | na | na |
| Load 4 | X | na | na | na | na | na | na |
| Load 5 | X | na | na | na | na | na | na |
| Load 6 | X | na | na | na | na | na | na |
| Load 7 | X | na | na | na | na | na | na |
| Load 8 | X | na | na | na | na | na | na |
| Load 9 | X | na | na | na | na | na | na |
| Load 10 | X | 288 | 306 | 279 | 320 | 300 | 280 |
| Load 11 | X | na | na | na | na | na | na |
| Load 12 | X | na | na | na | na | na | na |
| Load 13 | X | na | na | na | na | na | na |
| Load 14 | X | na | na | na | na | na | na |
| Load 15 | X | na | na | na | na | na | na |
| Load 16 | X | na | na | na | na | na | na |
| Load 17 | X | na | na | na | na | na | na |
| Load 18 | X | na | na | na | na | na | na |
| Load 19 | X | na | na | na | na | na | na |
| Load 20 | X | 320 | 323 | 320 | 340 | 325 | 320 |

Horizontal Shear FAA AC 150/5345-46E 4.5.13 (excepting load applied was 6000 lbs.)

Test set-up in the Fore position



Horizontal Shear FAA AC 150/5345-46E 4.5.13 (excepting load applied was 6000 lbs.)

Test set-up in the Aft position



| Post Test Observations | Y/N |
|----------------------------|-----|
| Any Structural Damage | N |
| Movement of any Part | Y |
| Loosening of any Fasteners | Y |

Movement of spacer rings noted in post test visual exam
 Torque value changed after load applied

Test Results Summary

| | | | | | |
|---------------------|---------------------------|-----------------------|-----|------------|---------|
| Tested By | Mike Guy | Signature or initials | MPG | Comp. Date | 9/13/16 |
| Reviewed By | JND | Signature or initials | JND | | |
| Test Equipment Used | 1,11,12,13 | | | | |
| Sample ID# | CRT1609161442-001 (19-24) | Ambient (°C) | 29 | RH% | 32 |
| | CRT1609161442-002 | | | | |

System torque to failure

The below light fixture/ spacer ring / light base cut-away test fixture was assembled and secured with one Isabel System bolt, and the torque was increased until failure occurred. The components of the assembly were then dissassembled and inspected.

Results

The bolt broke within the threaded region as pictured below. The system was able to be disassembled with basic hand tools, and removed.



Cut-away test fixture



Clip, nut, and bolt after test

| | | | | | |
|---------------------|-------------------|-----------------------|-----|------------|---------|
| Tested By | Mike Guy | Signature or initials | MPG | Comp. Date | 9/13/16 |
| Reviewed By | JND | Signature or initials | JND | | |
| Test Equipment Used | 10,12 | | | | |
| Sample ID# | CRT1609161442-003 | Ambient (°C) | 29 | RH% | 32 |

Bolt Torque vs. Bolt Tension Evaluation

A variety of fastening arrangements were assembled with a Skidmore-Wilhelm Bolt Tension Calibrator, and tightened to a range of torque values to evaluate the bolt torque / tension relationship, and to compare the friction coefficient (K) values of the bolted joints. The K values were calculated with the following equation: $T=K \cdot D \cdot F$. This data was also used to determine a torque value to be used with the Isabel System during the other mechanical tests. The below bolt tension values were obtained from the client's Skidmore - Wilhelm Bolt Tension Calibrator that did not possess a current calibration, so those values are provided for information only and are not presented as official Intertek data.

Results

| Test configuration | Torque (inlbs) | Bolt Tension (lbs) | K | average K |
|--|----------------|--------------------|------|-----------|
| Blue coated bolt 593C Flat washer Hex nut (stainless) | 50 | 800 | 0.17 | 0.17 |
| | 100 | 1400 | 0.19 | |
| | 150 | 2400 | 0.17 | |
| | 200 | 3200 | 0.17 | |
| | 230 | 4000 | 0.15 | |
| Blue coated bolt 593C Flat washer Hex nut (stainless) | 50 | 1000 | 0.13 | 0.16 |
| | 100 | 1600 | 0.17 | |
| | 150 | 2400 | 0.17 | |
| | 200 | 3200 | 0.17 | |
| | 230 | 4000 | 0.15 | |
| Blue coated bolt 593C Flat washer Hex nut (stainless) | 50 | 800 | 0.17 | 0.18 |
| | 100 | 1400 | 0.19 | |
| | 150 | 2100 | 0.19 | |
| | 200 | 2800 | 0.19 | |
| | 250 | 3600 | 0.19 | |
| | 270 | 4000 | 0.18 | |
| Blue coated bolt 593C Flat washer Hex nut (stainless) | 50 | 800 | 0.17 | 0.19 |
| | 100 | 1400 | 0.19 | |
| | 150 | 2000 | 0.20 | |
| | 200 | 2800 | 0.19 | |
| | 280 | 3800 | 0.20 | |
| | 290 | 4000 | 0.19 | |
| 18-8 Stainless bolt Flat washer Anti-seize on bolt threads and nut surface | 60 | 1100 | 0.15 | 0.15 |
| | 100 | 1700 | 0.16 | |
| | 150 | 2600 | 0.15 | |
| | 200 | 3600 | 0.15 | |
| | 220 | 4000 | 0.15 | |
| 18-8 Stainless bolt Flat washer Anti-seize on bolt threads and nut surface | 60 | 1200 | 0.13 | 0.15 |
| | 100 | 1900 | 0.14 | |
| | 150 | 2600 | 0.15 | |
| | 200 | 3600 | 0.15 | |
| | 250 | 4400 | 0.15 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 50 | 800 | 0.17 | 0.18 |
| | 100 | 1400 | 0.19 | |
| | 150 | 2200 | 0.18 | |
| | 200 | 2800 | 0.19 | |
| | 250 | 3800 | 0.18 | |
| | 285 | 4000 | 0.19 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 460 | 6500 | 0.19 | NA |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 570 | 7900 | 0.19 | NA |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 80 | 1200 | 0.18 | 0.20 |
| | 100 | 1400 | 0.19 | |
| | 150 | 1900 | 0.21 | |
| | 200 | 2600 | 0.21 | |
| | 250 | 3400 | 0.20 | |
| | 300 | 4000 | 0.20 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 60 | 750 | 0.21 | 0.22 |
| | 100 | 1100 | 0.24 | |
| | 150 | 1700 | 0.24 | |
| | 200 | 2800 | 0.19 | |
| | 250 | 3200 | 0.21 | |
| | 310 | 4000 | 0.21 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 70 | 800 | 0.23 | 0.26 |
| | 100 | 1200 | 0.22 | |
| | 150 | 1500 | 0.27 | |
| | 200 | 2000 | 0.27 | |
| | 250 | 2500 | 0.27 | |
| | 300 | 3000 | 0.27 | |
| | 400 | 4000 | 0.27 | |

| | | | | |
|---|-----|------|------|------|
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 70 | 700 | 0.27 | 0.30 |
| | 100 | 900 | 0.30 | |
| | 150 | 1300 | 0.31 | |
| | 200 | 1700 | 0.31 | |
| | 250 | 2100 | 0.32 | |
| | 300 | 2600 | 0.31 | |
| | 350 | 3200 | 0.29 | |
| | 400 | 3700 | 0.29 | |
| | 430 | 4000 | 0.29 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 75 | 850 | 0.24 | 0.29 |
| | 100 | 1000 | 0.27 | |
| | 150 | 1400 | 0.29 | |
| | 200 | 1700 | 0.31 | |
| | 250 | 2100 | 0.32 | |
| | 300 | 2600 | 0.31 | |
| | 350 | 3100 | 0.30 | |
| | 400 | 3600 | 0.30 | |
| | 435 | 4000 | 0.29 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 89 | 1000 | 0.24 | 0.23 |
| | 177 | 2000 | 0.24 | |
| | 266 | 3000 | 0.24 | |
| | 301 | 4000 | 0.20 | |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 350 | 4000 | 0.23 | NA |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 410 | 4400 | 0.25 | NA |
| Blue coated bolt 593C Flat washer SS serrated flange nut w/ red adhesive | 300 | 4000 | 0.20 | NA |
| Blue coated bolt 593C - 2.5" SS serrated flange nut w/ red adhesive Flat washer | 360 | 4800 | 0.20 | NA |
| Breakaway after 30 min.set time | 250 | NA | NA | NA |
| Blue coated bolt 593C - 1.5" SS serrated flange nut w/ red adhesive Flat washer | 360 | 4400 | 0.22 | NA |
| Breakaway after 30 min.set time | 300 | NA | NA | NA |

| | | | | | | |
|---------------------|-----------------------|-----------------------|-----|------------|---------|--|
| | | | | | | |
| Tested By | Mike Guy | Signature or initials | MPG | Comp. Date | 9/12/16 | |
| Reviewed By | JND | Signature or initials | JND | | | |
| Test Equipment Used | 10,12,14 | | | | | |
| Sample ID# | CRT1608231126-001-004 | Ambient (°C) | 29 | RH% | 32 | |

| Equipment list | | | | |
|----------------|-----------------|-------------------------|--------------------|-----------------|
| # | Intertek ID No. | Description | Manufacturer | Calibration Due |
| 1 | N580 | Torque Wrench | Dresser | 08-Jul-2017 |
| 2 | T1486 | Digit Hygro-Thermometer | Extech | 16-Mar-2017 |
| 3 | dated 5/19/2009 | Signal Conditioner | Unholtz-Dickie | 01-Feb-2017 |
| 4 | V393 | Vibration Controler | Unholtz-Dickie | 15-Jul-2017 |
| 5 | V255 | Accelerometer | Unholtz-Dickie | 24-Feb-2017 |
| 6 | V253 | Accelerometer | Unholtz-Dickie | 24-Mar-2017 |
| 7 | V358 | Accelerometer | PCB Piezotronics | 18-Nov-2016 |
| 8 | V328 | Accelerometer | PCB Piezotronics | 02-Dec-2016 |
| 9 | V272 | Signal Conditioner | Unholtz-Dickie | 27-Jun-2016 |
| 10 | N1456 | Torque Wrench | Westward | 12-Feb-2017 |
| 11 | 82718 | Load cell | Tinius-Olsen | 14-Apr-2017 |
| 12 | T1362 | Hygrothermometer | Extech | 28-Mar-2017 |
| 13 | N1449 | Digital Calipers | General | 21-Jan-2017 |
| 14 | 3804 (S/N) | Bolt Tension Calibrator | Skidmore - Wilhelm | 05-Dec-2015 |
| 15 | N797 | Shore A durometer | Fowler | 29-Apr-2017 |
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Note: For measurement uncertainty, refer to the calibration certificates for all the test equipment located in the equipment files