ALCOA FASTENING SYSTEMS

INDUSTRIAL FASTENER DIVISION

TEST REPORT

IDT # 175

July 5th, 2012

Performance of 5/8” Huck 360 Fasteners, and Comparison to Other Nuts and Bolts

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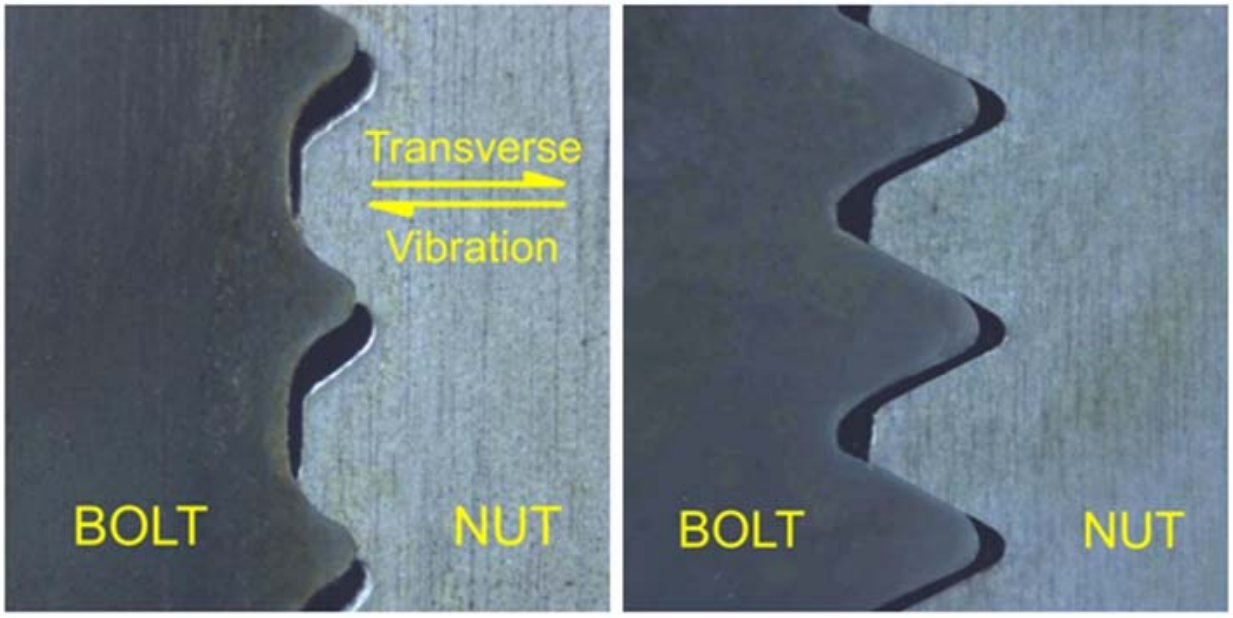
Introduction

Huck 360 is a high performance nut and bolt system designed by Alcoa Fastening Systems. Huck 360 meets the material, processing and mechanical requirements of SAE J429 Grade 8 UNC inch series and ISO 898-1 Class 10.9 metric series bolts. Huck 360 is installed and removed with conventional tools and methods, but it offers these advantages over conventional nuts and bolts:

1. **Vibration resistance: The Huck 360 nut thread is softer and thicker than the bolt thread. When tightened, the bolt thread is designed to embed into the nut thread to form a zero-gap condition between the nut and the pressure flank and crest of the bolt thread, for the entire length of thread engagement.**

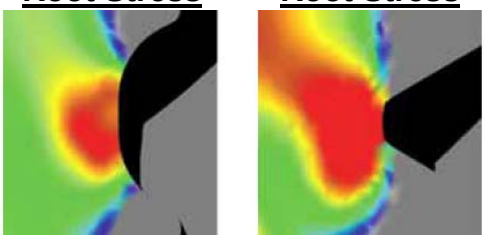
Huck 360 System **Conventional Nut & Bolt**



Bolt embedment prevents any transverse movement between the bolt and nut thread, so loosening is prevented if actual clamp is within ±20% of the target clamp. Conventional bolting allows transverse movement and loosening.

2. **Fatigue strength: Huck 360 thread section has 18% more cross-sectional area than a conventional UNC thread, to reduce bolt stress at any given load. Huck 360 bolt threads have three times more root radius to reduce stress concentration. Both of these factors increase Huck 360 fatigue strength by up to five times.**

Huck 360 Thread Root Stress **UNC Thread Root Stress**

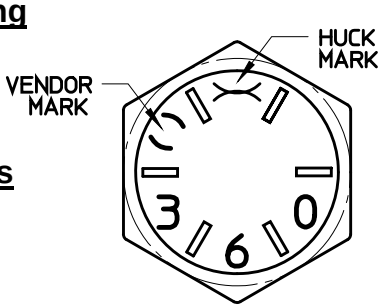


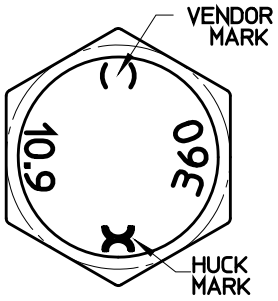
3. **Free-running nut: There is no initial interference between the Huck 360 nut and bolt threads, as with prevailing torque nuts. Because it is free-spinning, there is no coating damage to exposed Huck 360 bolt threads, and nut run-down time can be significantly reduced.**

Identification

Bolt Head Marking

Inch Series





Metric Series

Bolt Part Nomenclature

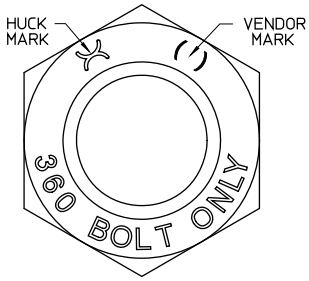
Inch Series: 360H-DT( )x( )

- Hex Head
- Dia. in 1/32”
- Grade 8
- Length in 0.001”

Metric Series: M360H-DT( )x( )

- Hex Head
- Dia. in mm
- Metric
- Class 10.9
- Length in mm

Nut Marking



Nut Nomenclature

Inch Series: 360NH-R( )

- Nut
- Grade 8
- Plain Hex
- Dia. in 1/32”

Metric Series: M360NH-R( )

- Nut
- Class 10.9
- Metric
- Plain Hex
- Dia. in mm

Standard Huck 360 nuts are distinguishable from conventional nuts in several ways:

1. **Huck 360 nuts say “360 BOLT ONLY” on the face of 5/8” and larger nuts.**
2. **Standard Huck 360 nuts are red in color.**
3. **Huck 360 nuts have a special thread and will not free spin onto regular bolt threads.**
4. **Huck 360 nuts are taller than regular nuts of the same nominal diameter.**
5. **Huck 360 nuts are thicker than regular nuts of the same nominal diameter.**

Use

Storage

Components should be protected from exposure to dirt and moisture, which can affect the torque-tension relationship. Prolonged storage above normal outdoor temperatures (>120°F, 50°C) may affect torque-tension on some finishes.

Tightening

The torque and turn-of-nut values in this report are recommended as a starting point. These methods, as well as others, can be used to validate each other. The best tightening values for a specific application and method are developed through testing and field evaluation.

Torque accuracy should be sufficient to meet the target clamp within ± 20%. Turn-of-nut accuracy is ±15° rotation after gap removal at low snug load. In cases of stiff gap pull-out, turn-of-nut method is not recommended.

Target clamp (bolt tension) is 70% of the minimum ultimate tensile strength.

Do not re-lube or add lube to either component.

Slope

The maximum recommended slope under the bolt head or the nut is 1:20 (3°). Beveled or curved washers are recommended to maintain this limit if it is exceeded by the application. The turned component (bolt head or nut) should be on the flattest surface when possible.

Washers

For best performance, hardened washers are recommended under the turning surface(s), or if the material is subject to embedment, or if oversized holes or slots are used. Load-indicating compressible washers may be used against hardened washers or the Huck 360 bolt head.

Re-Use

Like other high strength fasteners, other than re-tightening in joints that wear in, or re-tightening due to loosening from tightening adjacent bolts during assembly, re-use is not recommended for Huck 360.

Joint Condition

Huck 360 is designed to work in solid joints. Bolting and interior surfaces should be free of shavings, burrs, grease, dirt, loose scale or other contamination. Gaskets, insulation or other compressible materials should not be present.

Nominal Hole Sizes for Huck 360

Bolt Dia.	Hole Dia.	Bolt Dia.	Hole Dia.	Bolt Dia.	Hole Dia.	Bolt Dia.	Hole Dia.
3/8”	13/32”	7/8”	15/16”	10mm	11mm	24mm	26mm
7/16”	15/32”	1”	1-3/32”	12mm	13.5mm	36mm	39mm
1/2”	9/16”	1-1/8”	1-7/32”	14mm	15.5mm		
5/8”	11/16”	1-3/8”	1-1/2”	16mm	17.5mm		
3/4”	13/16”			20mm	22mm		

Minimum Socket Sizes for the Huck 360 Nut

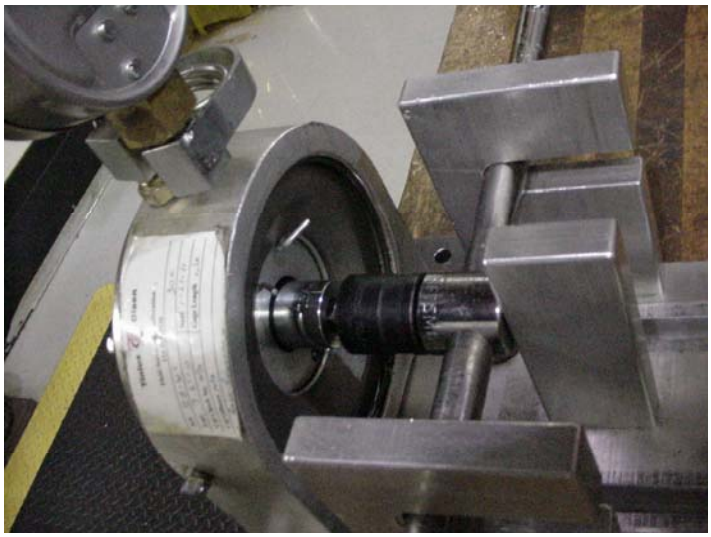
Nut Dia.	Socket Size	Nut Dia.	Socket Size	Nut Dia.	Socket Size	Nut Dia.	Socket Size
3/8”	11/16”	7/8”	1-7/16”	10mm	18mm	24mm	41mm
7/16”	3/4”	1”	1-5/8”	12mm	21mm	36mm	60mm
1/2”	7/8”	1-1/8”	1-7/8”	14mm	24mm		
5/8”	1-1/16”	1-3/8”	2-3/16”	16mm	27mm		
3/4”	1-1/4”			20mm	34mm		

Minimum Socket Sizes for the Huck 360 Bolt

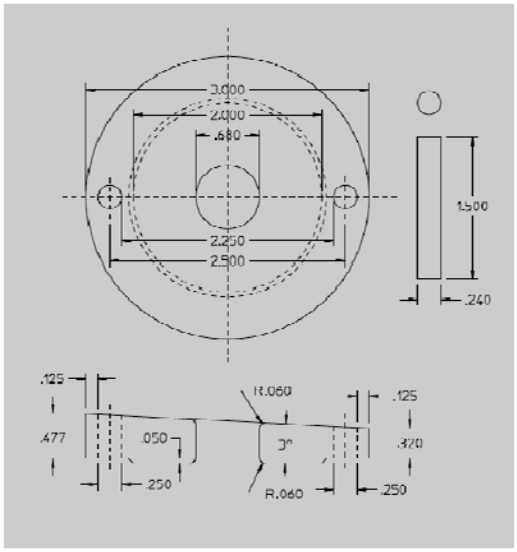
Bolt Dia.	Socket Size	Bolt Dia.	Socket Size	Bolt Dia.	Socket Size	Bolt Dia.	Socket Size
3/8”	9/16”	7/8”	1-5/16”	10mm	16mm	24mm	36mm
7/16”	5/8”	1”	1-1/2”	12mm	18mm	36mm	55mm
1/2”	3/4”	1-1/8”	1-11/16”	14mm	21mm		
5/8”	15/16”	1-3/8”	2-1/16”	16mm	24mm		
3/4”	1-1/8”			20mm	30mm		

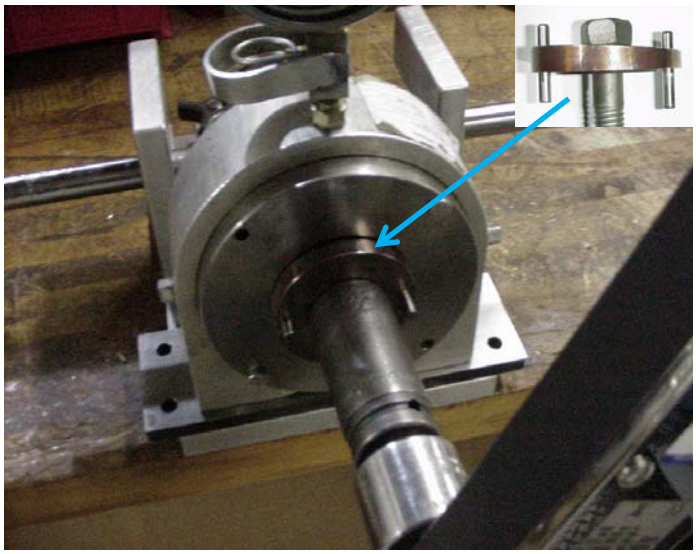
Tightening 5/8” Diameter Huck 360

5/8” diameter Huck 360 fasteners were tightened with a 36 inch long digital torque wrench on a 30,000 lbf Skidmore-Wilhelm test fixture, as shown in the photos below.



For testing bolt tension on a 3° slope, a special fixture was made as shown below, and was pinned in place to prevent it from rotating while the fastener was torqued.





SAE J429 UNC Grade 8 minimum tensile strength for 5/8” diameter is 33,900 lbf. Huck 360 target clamp (bolt tension) is 70% of this value, or 24,000 lbf. The torque required to reach 24,000 lbf target clamp is summarized in the following table.

Also listed are peak torque required to begin stripping the Huck 360 nut, and the corresponding clamp load at peak torque. The margins between target clamp and peak clamp load, and target torque and peak strip torque, are compared as percentages. For simplification, only the averages of five tests are shown.

Torque Method

360H-DT20x300 black oil finish, 360NH-R20 zinc electroplate with cetyl alcohol lube finish	Torque ft-lbf at 24,000 lbf Target Clamp	Peak Clamp at Beginning of Nut Strip	Peak Torque at Beginning of Nut Strip
1. Flat surface, tighten nut.	198 ft-lbf	35,500 lbf (148% of 24,000 lbf)	308 ft-lbf (156% of 198 ft-lbf)
2. 3° sloped surface, tighten nut.	212 ft-lbf	33,600 lbf (140% of 24,000 lbf)	297 ft-lbf (140% of 212 ft-lbf)
3. Flat surface, tighten bolt head.	227 ft-lbf	35,700 lbf (149% of 24,000 lbf)	348 ft-lbf (153% of 227 ft-lbf)
4. 3° sloped surface, tighten bolt head.	251 ft-lbf	34,300 lbf (143% of 24,000 lbf)	373 ft-lbf (149% of 251 ft-lbf)

Comments:

1. Tightening the bolt head instead of the nut increases the average torque to meet 24,000 lbf target clamp by 34 ft-lbf, or 17%, because the bolt is not lubed.

2. Tightening on a 3° slope instead of a flat surface increases the average torque to meet 24,000 lbf target clamp by 19 ft-lbf, or 9%.

3. The ratio between tightening to strip load and tightening to target clamp varies from 140% to 156%. Tightening on a flat surface gives the largest margin of safety, at over 150%.

4. The relationships described here can be used to adjust torque for other Huck 360 diameters and installation conditions.

Recommendation: The overall starting torque method recommendation for 5/8" Huck 360 with standard finishes and conditions is 220 ft-lbf.

Turn-of-Nut Method

The table below lists the average clamp of five tests per condition for 360H-DT20x( ) and 360NH-R20 in 1.94", 3.23" and 4.98" grip length (length between bolt head and nut) on both flat and 3° slope surfaces. Rotation was set at zero after the nut had been snugged at 10 ft-lbf torque, or about 1,000 – 2,000 lbf initial clamp.

Clamp lbf and Rotation	Flat Surface 1.94" Grip, 3.1 Diameters	3° Slope 1.94" Grip 3.1 Diameters	Flat Surface 3.23" Grip, 5.2 Diameters	Flat Surface 4.98" Grip, 8.0 Diameters
3/6 Rotation 180 Degrees	21,100 lbf 117 lbf / °	16,000 lbf 89 lbf / °	17,700 lbf 98 lbf / °	18,500 lbf 103 lbf / °
4/6 Rotation 240 Degrees	30,100 lbf 125 lbf / °	24,200 lbf 101 lbf / °	26,800 lbf 112 lbf / °	26,800 lbf 117 lbf / °
5/6 Rotation 300 Degrees	34,400 lbf 115 lbf / °	30,700 lbf 102 lbf / °	33,800 lbf 113 lbf / °	33,300 lbf 111 lbf / °
6/6 Rotation 360 Degrees	34,300 lbf 95 lbf / °	33,600 lbf 93 lbf / °	35,400 lbf 98 lbf / °	35,800 lbf 99 lbf / °
7/6 Rotation 420 Degrees	31,900 lbf 76 lbf / °	32,800 lbf 78 lbf / °	32,700 lbf 78 lbf / °	33,200 lbf 79 lbf / °
8/6 Rotation 480 Degrees	1 strip failure	31,000 lbf 65 lbf / °	31,800 lbf 66 lbf / °	31,300 lbf 65 lbf / °
9/6 Rotation 540 Degrees	3 strip failures	27,700 lbf 51 lbf / °	1 strip failure	3 strip failures
Rotation at 24,000 lbf target clamp	195°	240°	215°	215°

Comments:

1. **Grip length is not as critical with Huck 360 for Turn-of-Nut method, because the Huck 360 nut is designed to yield and form the lock during installation.**
2. **Tightening on a 3° slope requires an extra 45° (1/8 turn) rotation to obtain the target clamp of 24,000 lbf.**
3. **There is a half turn margin between rotation to target clamp and rotation to strip the nut thread. If excessive gap pull-out force is required, another method such as the torque method should be used.**

Recommendation: **The overall starting turn-of-nut method recommendation for 5/8" Huck 360 under normal conditions is 210° after snug.**

Vibration Test Set-Up

Fasteners were tested in Junker's transverse vibration on a 50,000 lbf capacity machine manufactured by SPS Unbrako. The fasteners were transversely loaded with a plate that incurred a deflection by a cam. There was clearance on the inside of the oscillating plate to allow for bending and to produce transverse loading.

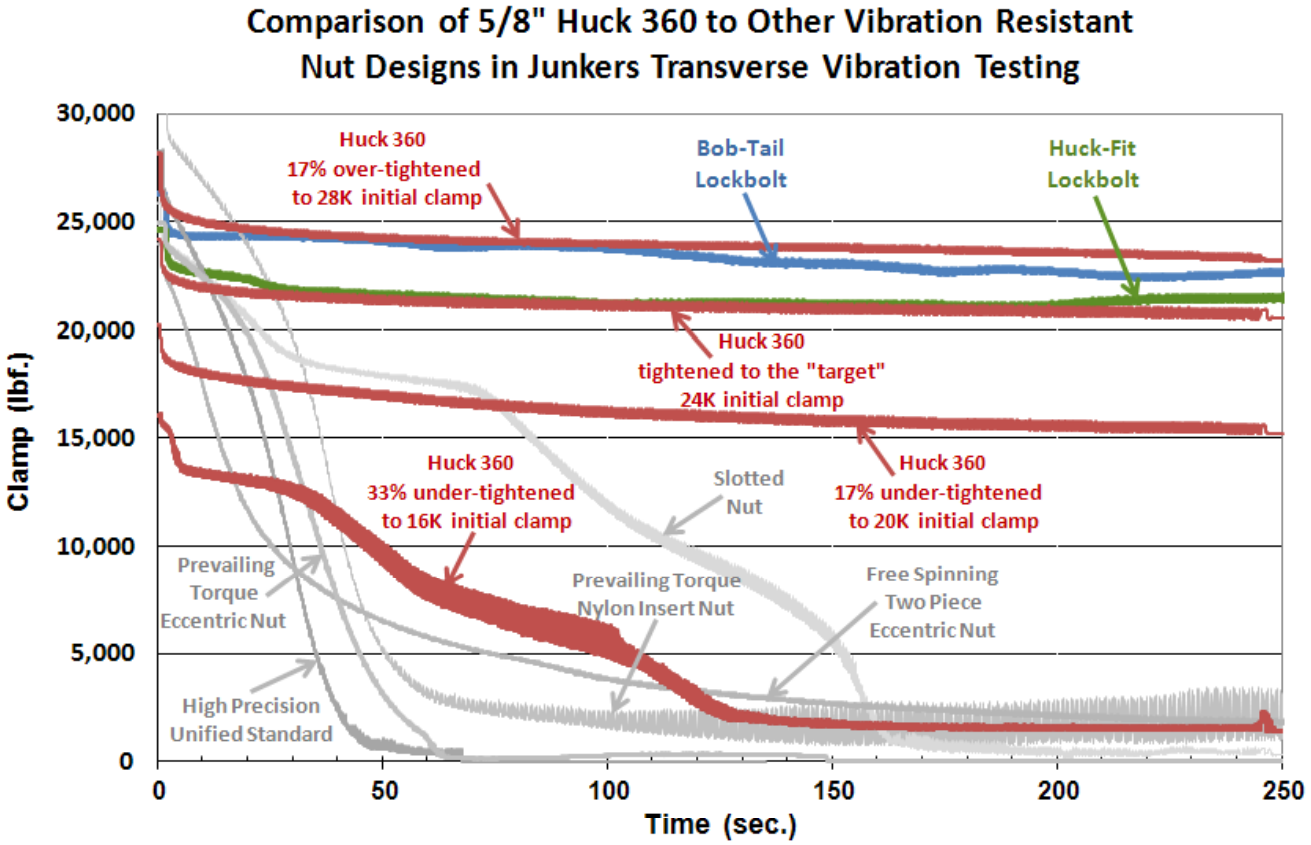
The fasteners were installed to a pre-determined clamp load with the nut against the oscillating plate, at the top of the machine. The Junkers machine was energized and the test clamp load was monitored with a Nicolet oscilloscope. The test was discontinued after four minutes or fastener failure, whichever came first.

Test speed: 750 cpm (12.5 Hz) Test Amplitude: ± 1/16" Test Duration: 4 minutes

5/8" diameter, 3" long Huck 360 bolts were tested at four different initial clamp loads:
Three tests at 28,000 lbf initial clamp.
Three tests at 24,000 lbf initial clamp (target clamp, 70% of minimum tensile strength).
Three tests at 20,000 lbf initial clamp.
Three tests at 16,000 lbf initial clamp.

Fastener Type	Bolt	Nut / Collar
5/8" Grade 8 Huck 360	360H-DT20x300	360NH-R20 at 4 initial clamp loads
16mm Class 10.9 Bob-Tail	MBT-DT16-50	MBTC-R16BL
16mm Class 10.9 Huck-Fit	MHFF-DT16-50	MHCH-R16U
Nut and Bolt # 1	M16x2 x 75 Class 10.9	M16-2 Class 10, 2-Piece Eccentric
Nut and Bolt # 2	5/8-11 x 3" Grade 8	5/8"-11 Grade DH, High Precision
Nut and Bolt # 3	M16x2 x 75 Class 10.9	M16-2 Class 10, Transverse Slot
Nut and Bolt # 4	5/8-11 x 3" Grade 8	5/8"-11 Nylon Ring Insert
Nut and Bolt # 5	5/8-18 x 3" Grade 8	5/8"-18 Grade 8, Prevailing Torque

Vibration Test Results



Comments:

1. **There is an initial reduction in clamp of about 10% for all fasteners, due to seating that is inherent in the nature of this test. After that, the reduction in clamp is inherent in the nature of the fastener. These results are not intended to correlate to the service life of any specific application, but the contrast in results can be used to compare the effectiveness of the different locking mechanisms.**

2. **Bob-Tail and Huck-Fit are types of mechanical lockbolts that use a hydraulic tool to swage a smooth-bore collar onto the lockbolt grooves to form internal grooves in the collar. Lockbolts do not loosen because collar material is press-fit around the lockbolt crest and both flanks for the entire swage length of the collar. Huck 360 creates a similar lock between the nut thread and the bolt thread crest and pressure-side flank, so relative movement between the nut and bolt is eliminated as long as there is sufficient embedment into the nut thread. If there is insufficient tightening of the Huck 360 fastener, such as 16,000 lbf initial clamp, the under-formed lock performs as well as conventional nuts with various vibration resistant features.**

3. **Conventional nuts with various locking features loosened from 24,000 to 31,000 lbf initial clamp to less than 3,000 lbf residual clamp within 40 to 160 seconds of this test. In all of these cases, clamp had reduced to under 20,000 lbf in less than 40 seconds of this test.**

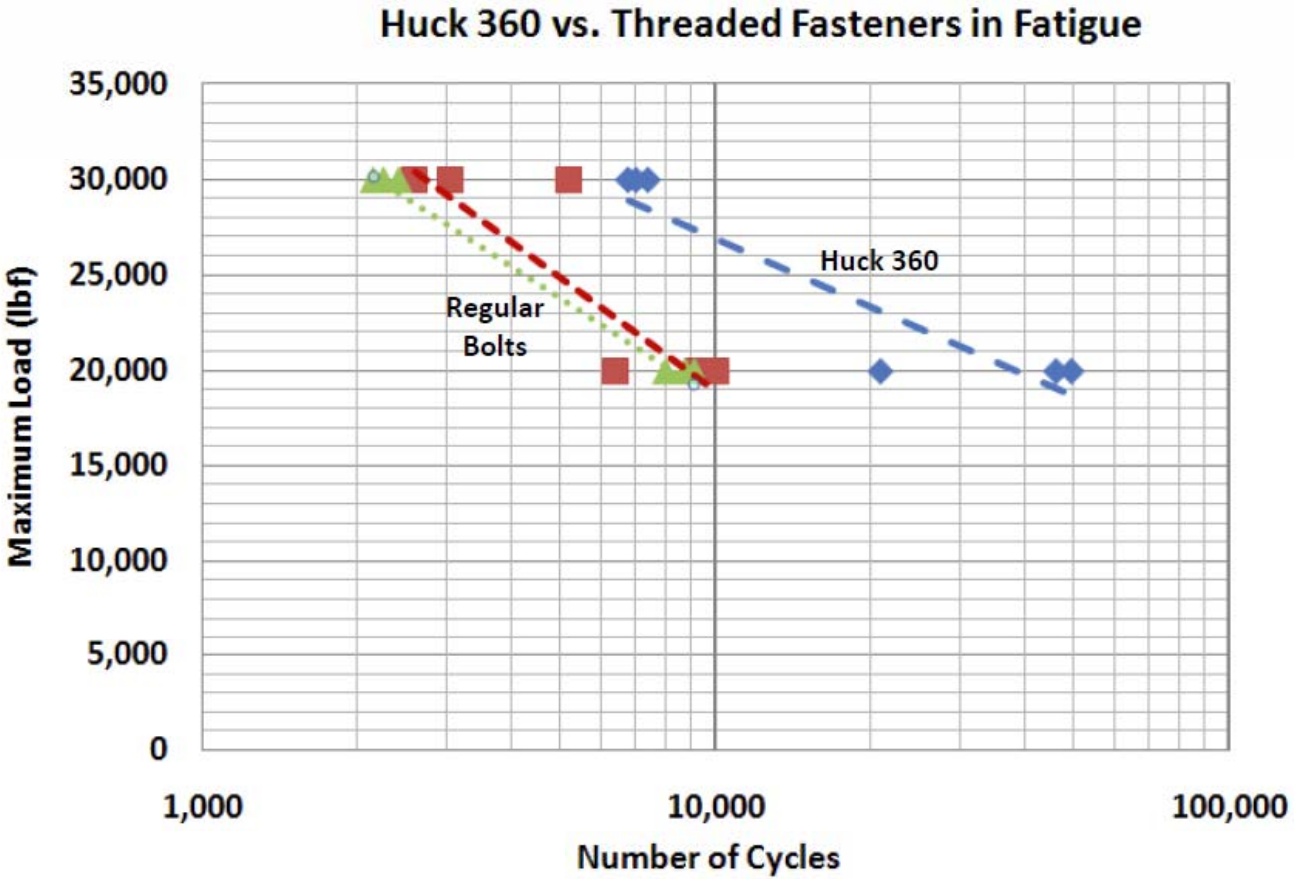
Fatigue Test Set-Up

Fasteners were installed to the normal torque in hardened steel test plates with aluminum crush washers between the test plates. The installed fastener was then placed in a 200,000 lbf Tinius Olsen mechanical test machine to relieve the fastener clamp by compressing the test plates together to permanently reduce the thickness of the aluminum washer. The purpose of relieving clamp is simply to reduce the number of cycles to failure, while still showing a contrast between the different types of bolts.

The test assembly was then placed in a spider cage fixture for fatigue testing in a 50,000 lbf Instron test machine. An alternating load was placed on the assembly at a rate of 5 Hertz. The minimum load was 10% of the maximum load. When failure occurred, the number of cycles and the failure location was recorded.

Tension-Tension Fatigue Test Set-Up

	Minimum Load lbf	Maximum Load lbf	Average Load lbf	Alternating Load lbf
Low Load Test	2,000	20,000	11,000	9,000
High Load Test	3,000	30,000	16,500	13,500



5/8"-UNC Grade 8 Bolt			M16x2 Class 10.9 Bolt		
3,000/ 30,000 Cycles	2,000/ 20,000 Cycles	Bolt Failure Location	3,000/ 30,000 Cycles	2,000/ 20,000 Cycles	Bolt Failure Location
2,265	8,712	Next to Nut	3,046	9,281	Next to Nut
2,162	7,988	Next to Nut	2,603	10,036	Next to Nut
2,425	9,083	Next to Nut	5,171	6,394	Next to Nut
2,284	8,594	Average	3,607	8,570	Average

5/8" Huck 360			
3,000/ 30,000 Cycles	Bolt Failure Location	2,000/ 20,000 Cycles	Bolt Failure Location
7,407	Head/Shank	49,493	Thread Run-Out
6,777	Head/Shank	21,019	Thread Run-Out
7,020	Head/Shank	46,195	Thread Run-Out
7,068	Average	38,902	Average

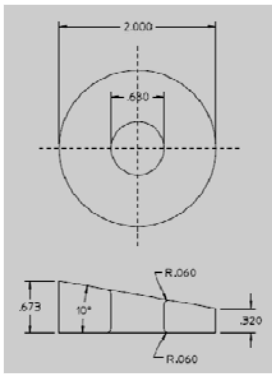
Under higher loading, Huck 360 has 2 to 3 times longer fatigue life than standard bolts. Under lower loading, Huck 360 has 4 to 5 times longer fatigue life.

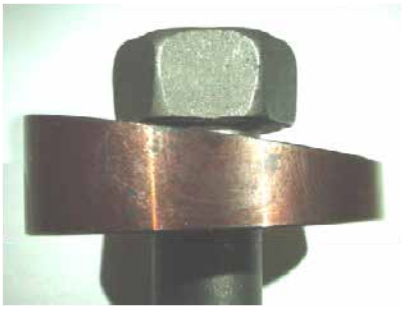
Because the Huck 360 thread is stronger than conventional, the failure location for Huck 360 varies, while failure location is always at the thread next to the nut for standard thread bolts.

Huck 360 Bolt Wedge Tensile Test

- **A hardened 10° wedge fixture was placed underneath the head of 360H-DT20x300**
- **Hardened 360H nuts were used to force failure to be from the bolt.**
- **Six exposed bolt threads were left in front of the nut to subject them to the load.**
- **Bolts were loaded at 1” per minute, and held at the specified load for 15 seconds.**

Test	Actual head angle at 33,900 lbf	Actual head angle at 36,700 lbf	Load at failure lbf	Failure location
1	7°	9°	46,000	Head
2	7°	9°	44,300	Thread
3	8°	9°	46,000	Thread
4	8°	9°	45,400	Thread
5	7°	9°	41,700	Head





Failure loads (lbf) in a flat fixture (no wedge): 46,400
(All failures were located at the bolt threads.) 46,200
45,900
44,800
46,000

33,900 lbf is the minimum tensile strength of a 5/8” SAE J429 UNC Grade 8 bolt. 36,700 lbf is the minimum tensile strength of a 16mm ISO 898-1 Class 10.9 bolt. 5/8” 360H bolts exceed these minimums by a significant amount because the shallow thread increases the cross-sectional area compared to common bolts. The larger threaded cross-section creates more balanced bolt strength, where wedge failure can be in either the head or thread.

Huck 360 Fastener Tensile Test

With common bolts, the normal failure mode in tension is to break the bolt in the threaded section. Huck 360 bolt threads are shallow, so the bolt cross-section is stronger.

Also, Huck 360 nuts are softer than common nuts so that they can form the lock, so the normal failure mode of Huck 360 in tension is to strip the nut thread, and not to break the bolt in the threaded section.

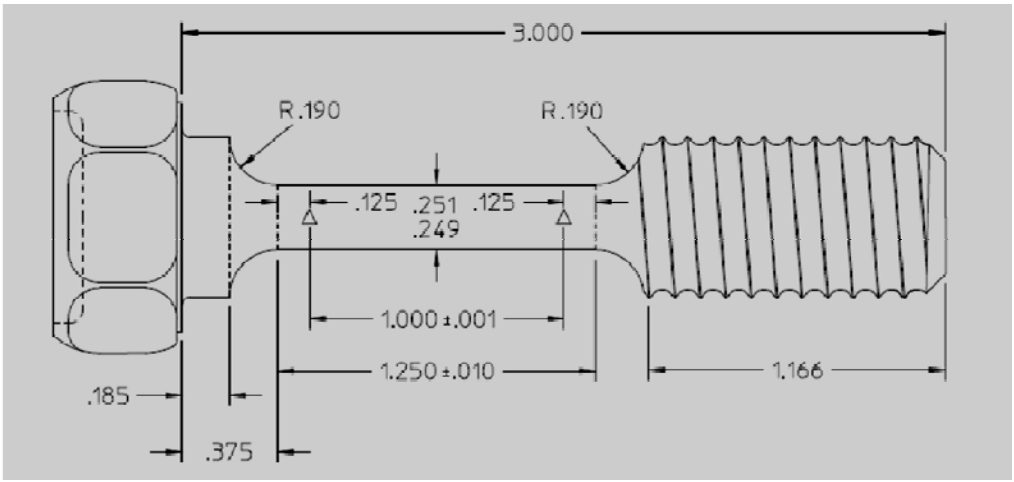
360H-DT20x300 bolts and 360NH-R20 nuts were installed in test plates and tensile tested in a spider fixture as shown. Tensile testing was done on fasteners that have been installed once, twice, and five times to compare degradation of tensile strength with repeated use, even though re-use is not recommended.

	Tensile lbf after one installation	Tensile lbf after one re-use	Tensile lbf after four re-uses
1.	37,145	36,890	37,725
2.	37,190	38,050	37,750
3.	37,105	37,885	37,265
Average	37,145	37,610	37,580

The minimum tensile specification for 5/8” diameter SAE J429 UNC Grade 8 is 33,900 lbf. Typical values exceed this requirement by 10%, and there is no degradation from repeated uses, when the nuts are properly tightened.

Huck 360 Bolt Elongation, Reduction in Area, and Tensile

- **Bolts were machined to 1” test length x 1/4” test diameter per the drawing below.**
- **Bolts were loaded at 1” per minute to failure.**
- **Elongation, reduction in area, and tensile strength were measured and calculated.**

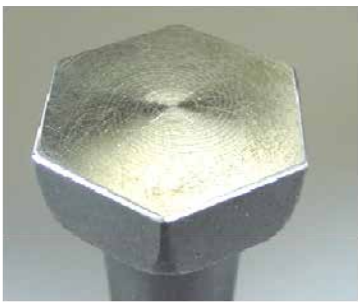


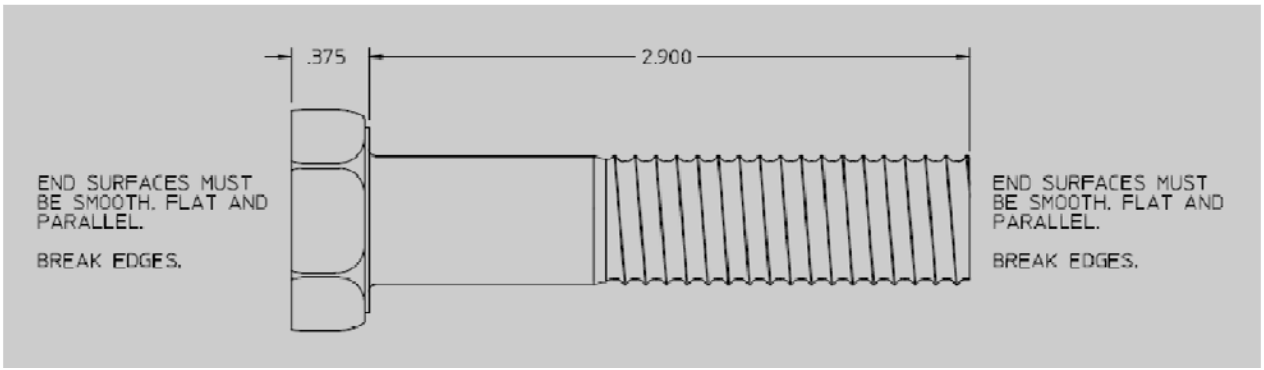
ELONGATION			REDUCTION IN AREA			TENSILE STRENGTH		
Original Length	Final Length	Elong.%	Original Diameter	Final Diameter	RA%	Original Diameter	Tensile Load lbf	KSI
.963”	1.130”	17%	.248”	.157”	60%	.248”	8466	174
1.001”	1.185”	18%	.249”	.158”	60%	.249”	8394	172
1.024”	1.183”	16%	.249”	.158”	60%	.249”	8336	171
1.078”	1.240”	15%	.249”	.161”	58%	.249”	8406	173
1.075”	1.249”	16%	.249”	.159”	59%	.249”	8433	173
1.083”	1.245”	15%	.249”	.161”	58%	.249”	8397	173
MINIMUM REQUIREMENT & ORGANIZATION		14% ASTM A490			44% ISO Class 10.9			150 SAE Grade 8

Note: Where the three organizations differ, the most restrictive requirement was used.

Huck 360 Bolt Proof Load

- **Parallel flats were ground at both ends of the bolt.**
- **Bolt lengths were measured to the nearest .0005".**
- **A hardened nut was placed on the bolt, which left six exposed threads (one diameter) under the nut.**
- **The bolt was loaded at 1/8" per minute to the specified load, and was then held for ten seconds and released.**
- **Bolt length was re-measured. Maximum length increase allowance is +.0005".**





Original Length	5/8" UNC Grade 8 27,100 lbf	16mm Class 10.9 29,300 lbf	80% of 150 KSI 32,700 lbf
3.2765"	3.2765"	3.2765"	3.2765"
3.2750"	3.2750"	3.2750"	3.2755"
3.2705"	3.2700"	3.2700"	3.2705"
3.2765"	3.2765"	3.2765"	3.2765"
3.2770"	3.2765"	3.2765"	3.2765"
Average increase over original length	-.0002"	-.0002"	+.0000"
Maximum increase over original length	+.0000"	+.0000"	+.0005"

No bolt yielding occurred at Grade 8 or Class 10.9 proof load, or using the Huck 360 thread area, at 80% of 150 KSI.

Huck 360 Bolt Bend Test

Bolts were blast cleaned and then bent approximately 30° on a press with the shank portion of another bolt, at a speed of 1” per minute.

Bolts were examined under a light at 4X magnification.

No cracks or voids were observed in the threaded section.

Huck 360 Hardness Tests

Bolt Core Hardness

- Cut a transverse section, one diameter from the end.
- Test Rc hardness at the half-radius (outlined by the blue ovals).
- Average three readings. Spec is Rc 33 to 39
  - 35.9, 37.5, 37.4, Average = Rc 36.9
  - 36.5, 34.9, 37.5, Average = Rc 36.3
  - 36.0, 36.2, 37.0, Average = Rc 36.4
  - 34.5, 33.1, 35.3, Average = Rc 34.3

Bolt Surface Hardness

- Expose flat steel surfaces on opposing bolt head flats.
- Test R30N hardness near the center of flat.
- Average three readings. Spec is R30N 59 maximum.
  - 56.0, 55.8, 55.4, Average = R30N 55.7 (Rc 35.8)
  - 55.9, 55.5, 56.2, Average = R30N 55.9 (Rc 36.0)
  - 56.4, 56.4, 58.0, Average = R30N 56.9 (Rc 37.0)
  - 57.0, 55.2, 55.3, Average = R30N 55.8 (Rc 35.9)

Nut Hardness

- Expose flat steel surfaces on nut bearing faces.
- Test Rb hardness at the center of bearing, near every other corner.
- Average three readings. Spec is proprietary, but Rb 90-95 is typical.
  - 93.8, 94.2, 98.0, Average = Rb 95.3
  - 93.6, 97.6, 95.4, Average = Rb 95.5
  - 97.5, 94.0, 93.7, Average = Rb 95.1
  - 94.4, 93.3, 97.0, Average = Rb 94.9

Huck 360 nuts are made to a lower hardness level than conventional nuts by design, to form the vibration resistant lock around the bolt thread.

Huck 360 nuts are taller than conventional nuts to have tensile strength equivalent to Grade 8 or Class 10.

Huck 360 nuts are thicker than conventional nuts to prevent dilation, which keeps the locking mechanism intact for loosening resistance.

Appendix

TIGHTENING TESTS

360H-DT20x300, EWO 9916, blackened oil finish
360H-DT20x425, EWO 9917, blackened oil finish
360H-DT20x600, EWO 9918, blackened oil finish
360NH-R20, EWO 9910, zinc electroplate, cetyl alcohol lube
CDI Digital Torque Wrench Model 10005CF-II, AFS Serial #28-59
Skidmore-Wilhelm Model J, AFS Serial #28-65

VIBRATION TESTS

360H-DT20x300, EWO 9916, blackened oil finish
360NH-R20, EWO 9910, zinc electroplate, cetyl alcohol lube
5/8-11x3” Grade 8 hex head bolt, zinc/yellow chromate
5/8-18x3” Grade 8 hex head bolt, black oxide finish
M16x2x75 Class 10.9 hex head bolt, blackened oil finish
SPS Unbrako 50 KIP Transverse Vibration Test Machine

FATIGUE TESTS

360H-DT20x300, EWO 9717, blackened oil finish
360NH-R20, EWO 9751, zinc electroplate, cetyl alcohol lube
5/8-11x3” Grade 8 hex head bolt, zinc/yellow chromate
M16x2x75 Class 10.9 hex head bolt, blackened oil finish
Instron 50 KIP Fatigue Test Machine

TENSILE, ELONGATION, PROOF, BEND TESTS

360H-DT20x300, EWO 9916, blackened oil finish
360NH-R20, EWO 9910, zinc electroplate, cetyl alcohol lube
United Testing Systems Model FM60, AFS Serial 28-106

HARDNESS TESTS

360H-DT20x300, EWO 9916
360NH-R20, EWO 9910
Rb, Wilson Hardness Tester Model C524-T, AFS Serial #28-12
Rc, Wilson Hardness Tester Model C524-T, AFS Serial #28-08
R30N, Wilson Hardness Tester Model R574, AFS Serial #28-14