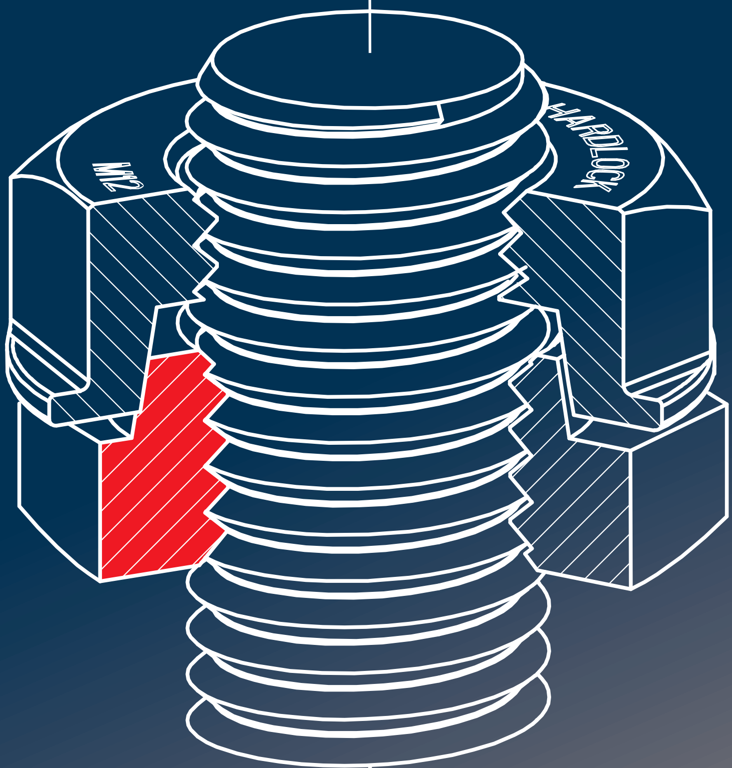
SAFETY IS POWER

HARDLOCK®

Register of International Marks

TECHNICAL DATA

Self-Locking Nut



HARDLOCK Industry Co., Ltd.

HARDLOCK NUT

HARDLOCK Nut (HLN)

- Safety is Power! The Worlds Strongest Self-locking Nut!
- From Industrial Machinery, Mining Equipment to Bridges and Railways, 100% corresponding to the needs of a variety of fields.

The Globally Recognized HARDLOCK Nut

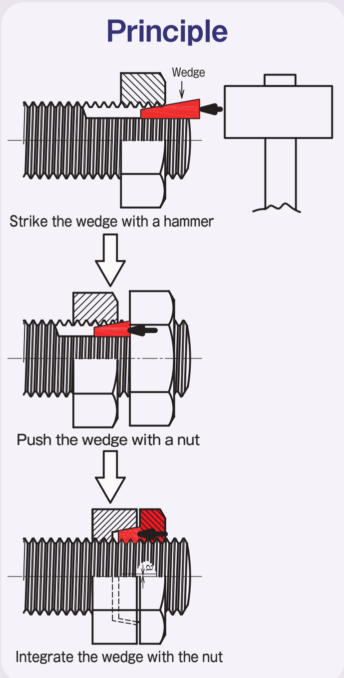
Utilizing the wedge principle used in ancient Japanese architecture, the HLN is the ultimate self-locking nut which perfectly succeeds to integrate the nuts with the bolt.

[MAIN FEATURES]

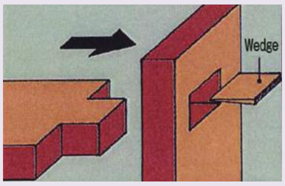
- **Self-locking Effect Recognized by the World!**
  HARDLOCK Nut also passed the United States NAS (National Aerospace Standard) Aviation Standards.
- **Enables Torque and Clamp Load Control!**
  Controlling Clamp Load with proper torque wherever it is used.
- **Reusable!**
  All metal with little abrasion, sustains a high self-locking effect.
- **Excellent and Simple Workability!**
  Easy installation with commercially available tools.
- **Provides Substantial Cost Savings!**
  Allows significant reduction in total cost by reducing maintenance costs, labor costs etc.

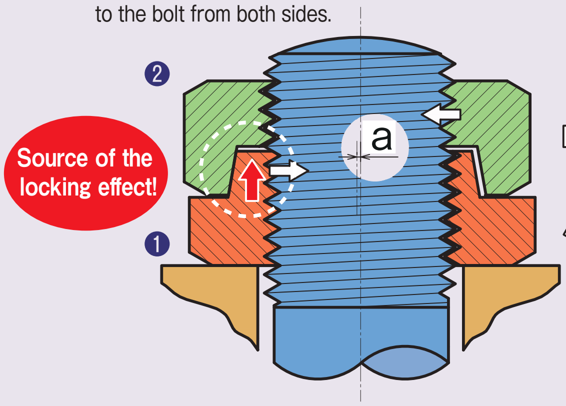
Self-locking Design

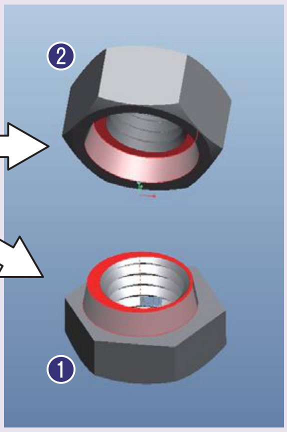
The design is based on the traditional Japanese "Wedge" principle!



1 HARDLOCK NUT consists of two nuts, the (1) nut "Convex Nut" (fixing nut) has a truncated protrusion arranged off-center on the upper part, the (2) nut "Concave Nut" (locking nut) is designed with a concentric conical depression for locking the two nuts together. By tightening the concave nut onto the convex nut, a strong perpendicular load will be applied to the bolt from both sides.







2 Due to the strong locking force created by the Wedge of the HARDLOCK NUT, no matter if it is exposed to severe vibrations and/or impacts the HARDLOCK NUT will stay intact.

TECHNICAL DATA

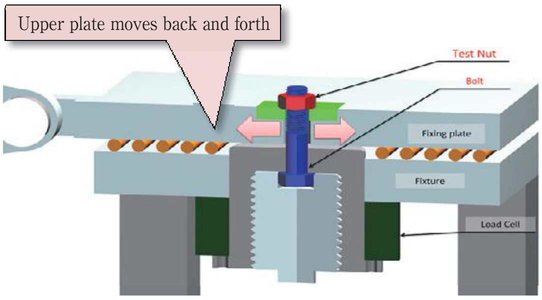
HARDLOCK Nut Features

HARDLOCK Nut Features

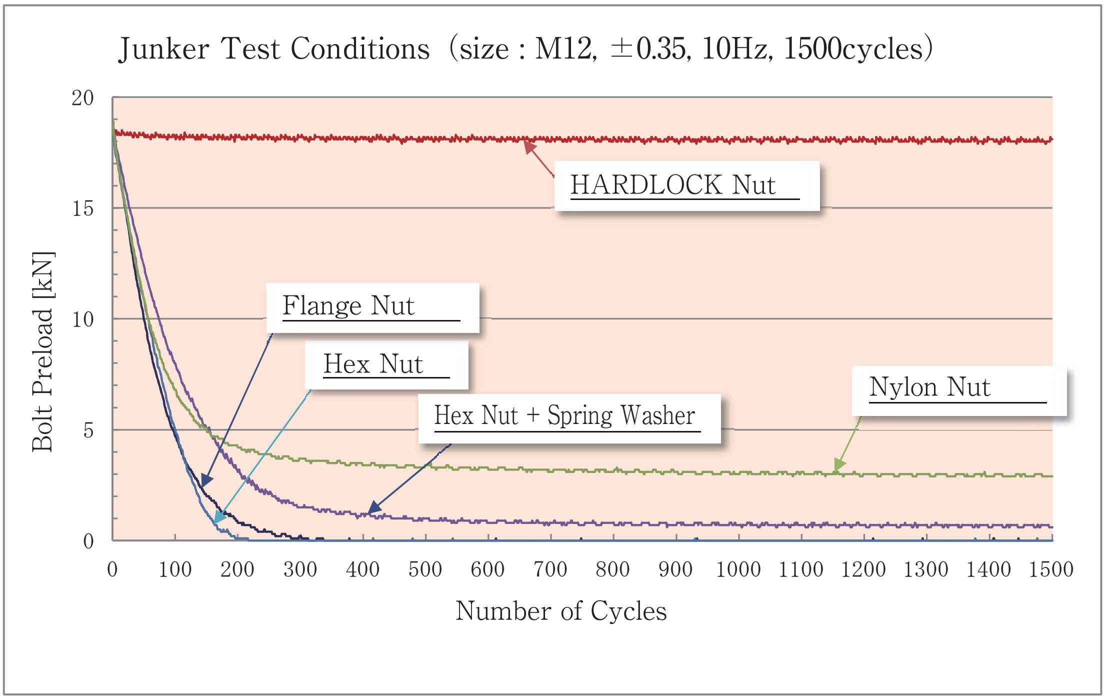
1.1 SELF-LOCKING EFFECT RECOGNIZED BY THE WORLD

1.1.1 JUNKER VIBRATION TEST (LOOSENING UNDER TRANSVERSE CYCLIC LOADS TEST)

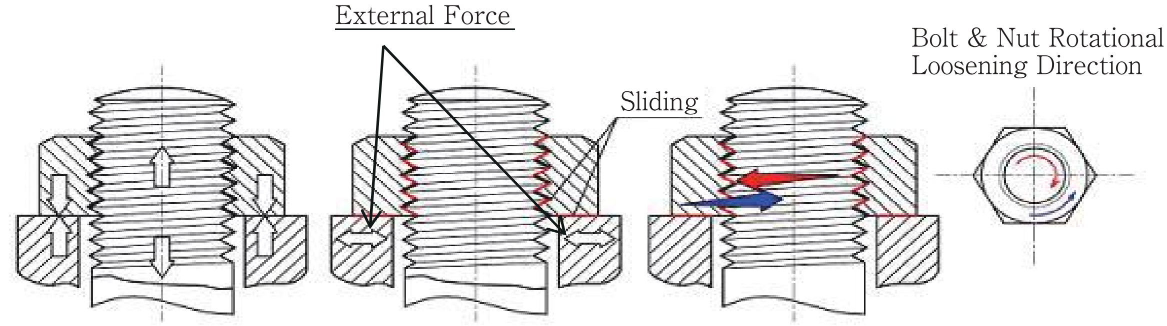
The representative tests which are used to loosen jointed bolts/threaded fasteners by subjecting transverse repeated loadings and impact to the bolt's axis in perpendicular direction are: the German Industrial Standards: DIN65151 Junker-type screw loosening test (Junker Vibration Test), and the National Aerospace Standards: NAS3350 / 3354 test.



Various Nuts Comparison Test Results



1.1.2 PRINCIPLES OF LOOSENING AND THE LOCKING FUNCTION OF HARDLOCK NUT



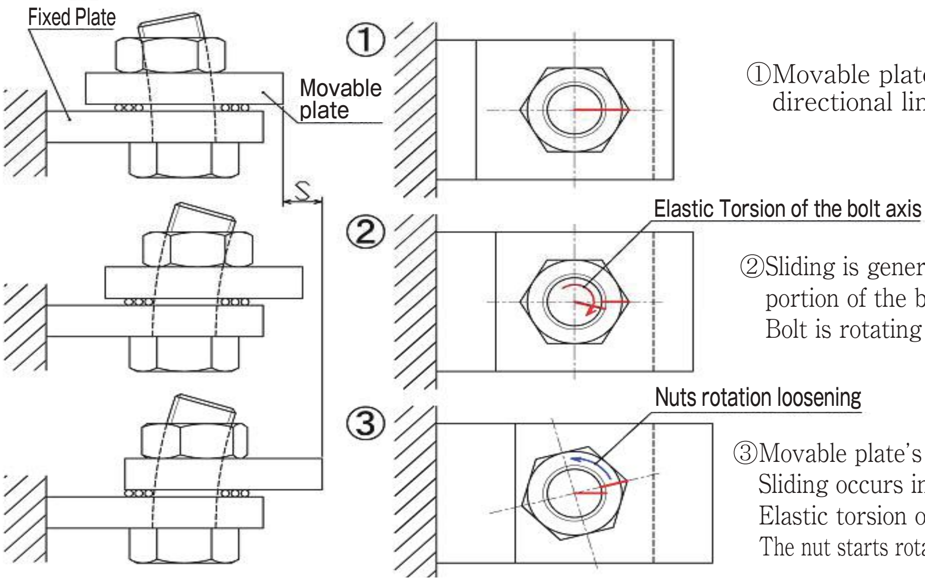
(1) Bolt & Nut fastened state

(2) When an external force is applied, sliding occurs in the threaded portion and the nuts bearing surface.

(3) The Bolt & Nut slides in the direction of the lead.

↓

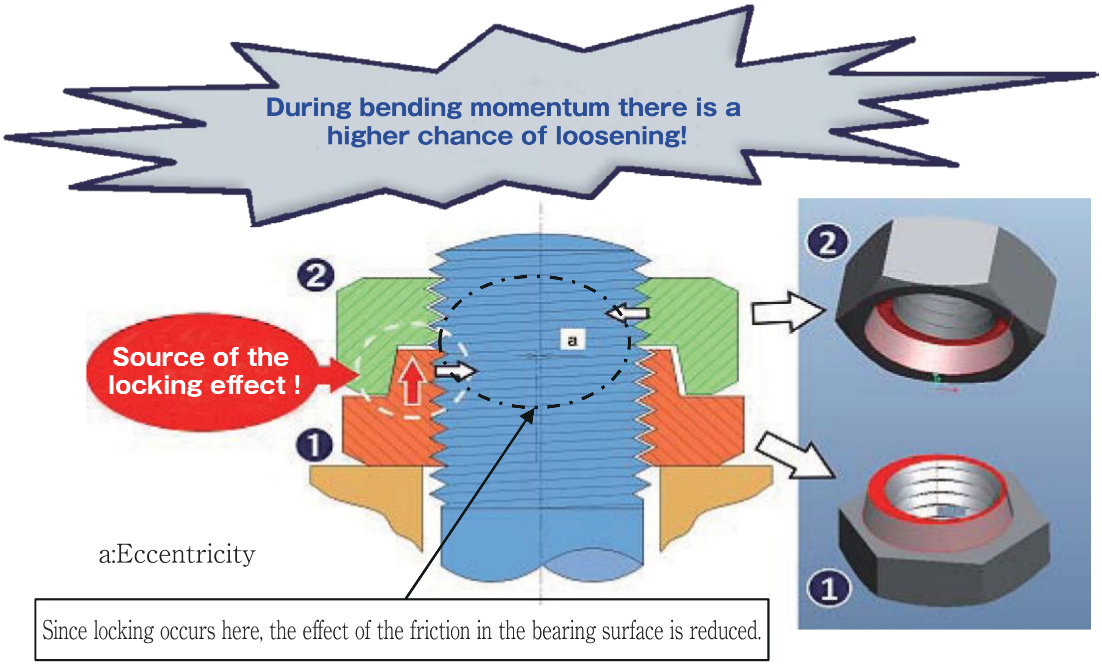
Rotation loosening occurs



①Movable plate`s left directional limit

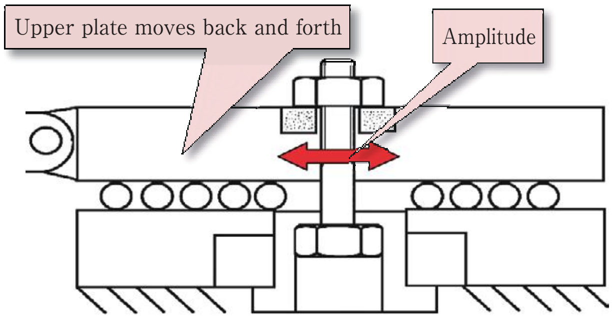
②Sliding is generated in the threaded portion of the bolts right directional limit. Bolt is rotating in the loosening direction.

③Movable plate's right directional limit. Sliding occurs in the nuts bearing surface. Elastic torsion of the bolt is released. The nut starts rotating in the loosening direction.



1.1.3 OTHER TEST CONDITIONS FOR LOOSENING UNDER TRANSVERSE CYCLIC LOADS TEST

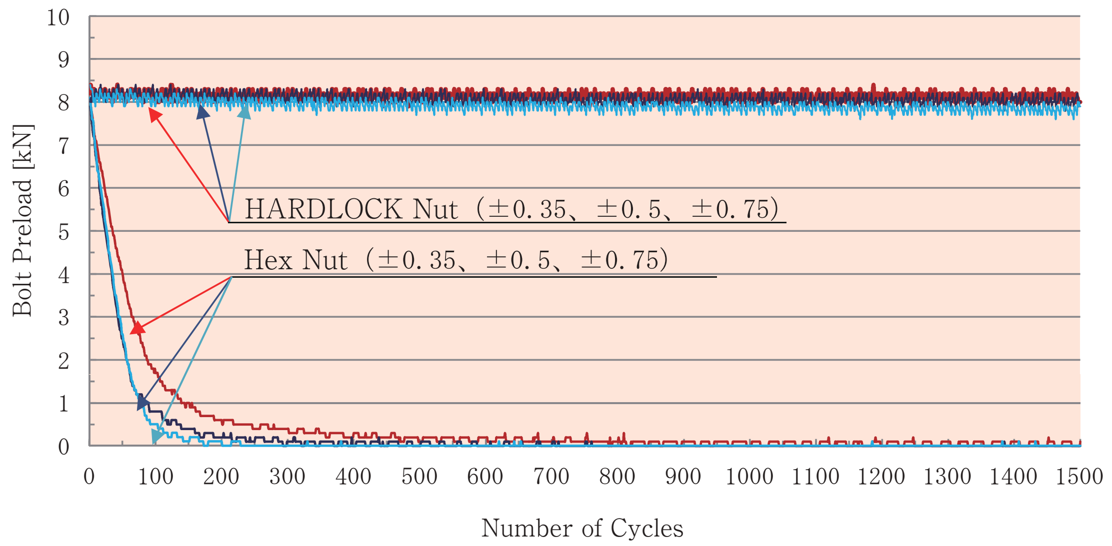
(1)Junker Test Results at Different Amplitudes



EUT
・Bolts: Hexagon M12 Bolt, Strength Class 4.8
・Nuts: Hex M12 Nut, HLN M12
Strength Class 4 (JIS SS400 Equiv.)

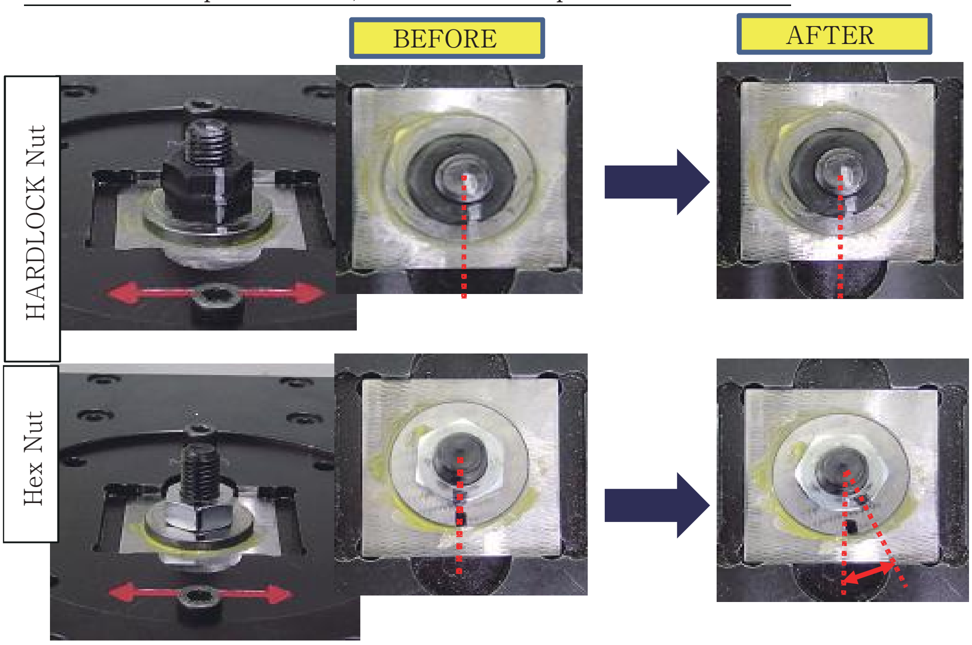
Test Conditions
・Initial Preload: 8.1kN, 30% of Bolts Yield Point
・Test Level: Amplitude±0.35、±0.5、±0.75mm

Comparison Loosening Test with set preload of 8.1kN and 3 different Amplitude Displacements (±0.35、±0.5、±0.75)



◇The EUTs was marked before initializing the test to verify loosening ratio

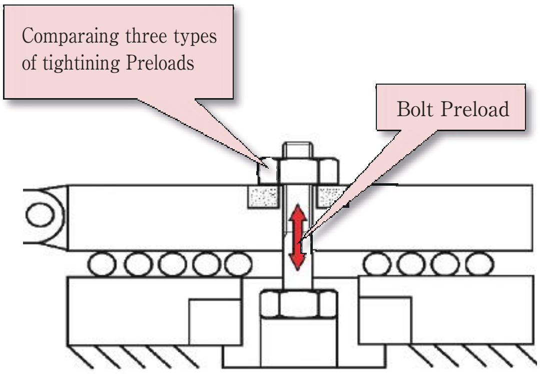
Test Level : Amplitude ±0.35, Before & After pictures of the EUTs



By inspecting the markings, we can conclude that the HLN did not work loose.

By inspecting the markings on the hex nut, we can conclude that loosening did occur.

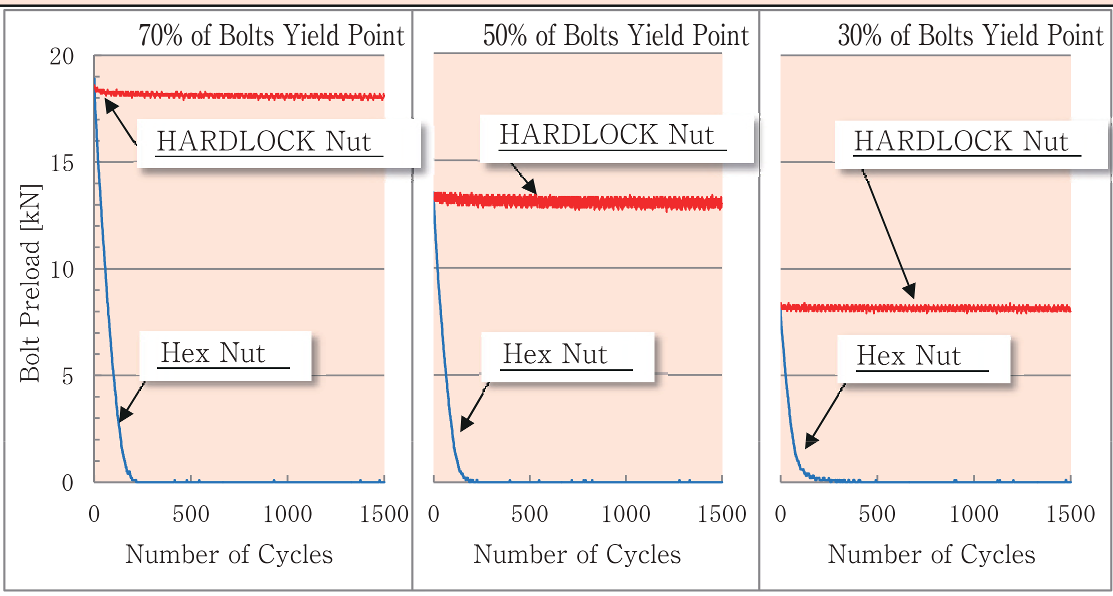
(2)Junker Test Results at different Initial Preload



EUT
・Bolts: Hexagon M12 Bolt, Strength Class 4.8
・Nuts: Hex M12 Nut, HLN M12
Strength Class 4 (JIS SS400 Equiv.)

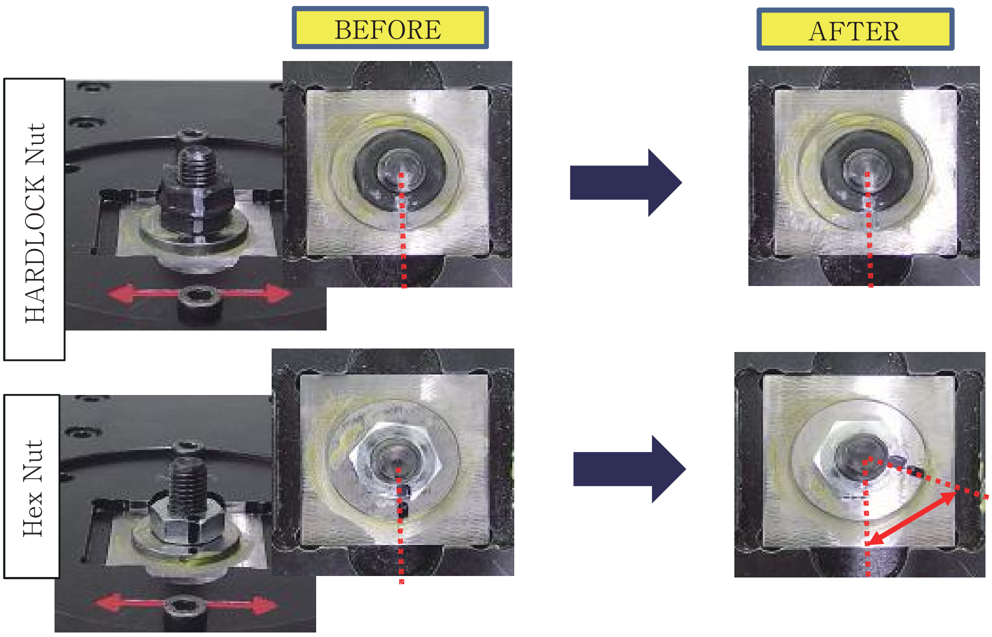
Test Condition
・Amplitude: ±0.35mm
・Test Level : 70%, 50%, 30% of Preload Yield Point

Comparison Loosening Test with set Amplitude Displacement at ±0.35mm and 3 different Preloads



◇The EUTs was marked before initializing the test to verify loosening ratio

Test Level : Preload 50% of Yield Point, Before & After Pictures of EUTs



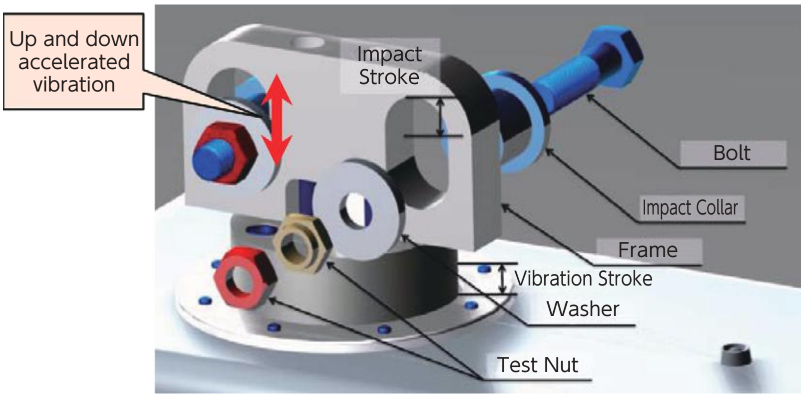
By inspecting the markings, we can conclude that the HLN did not work loose.

By inspecting the markings on the hex nut, we can conclude that loosening did occur.

1.2 NAS3350/3354 TEST

NAS: (NATIONAL AEROSPACE STANDARD)3350/3354 is an accelerated vibration test which is referred to as the NAS test.

The picture below is the schematics of the NAS3354



At HARDLOCK Industry Co., Ltd. we call our NAS Test for 「Accelerated Vibration Test Conforming to NAS 3350/3354」. The reason why we call it "Conforming to" is because the NAS Test we perform and the original NAS3350 differs as seen below.

1. All test nuts are specified in inch size.
2. Sintered for 6 hours in assembled condition.
3. Tightened by a specified torque.

Below is the specified preload table for the NAS3350 shown in Inches, we converted/recalculated it to N･m and added it to the table

One thing not mentioned above is that the material of the nuts and bolts used in the National Aerospace Standard (US) are made of heat-resistant alloys, the lubricant used is also heat-resistant, various criteria needs to be followed. To correctly perform the NAS Test you need to follow the above criteria.

Size		Maximum Tightening Torque			
Meter	Inch	Pre-Sintering (Room Temp.)		Post-Sintering (Room Temp.)	
		N･m	INCH･LBS	N･m	INCH･LBS
	No.10	2.0	18	4.1	36
M5		2.2		4.3	
M6		3.1		6.2	
	1/4	3.4	30	6.8	60
	5/16	6.8	60	13.6	120
M8		6.9		13.8	
	3/8	9.0	80	18.1	160
M10		9.7		19.4	
	7/16	11.3	100	22.6	200
M12		14.5		28.9	
	1/2	17.0	150	33.9	300
M14		21.6		43.2	
	9/16	22.6	200	45.2	400
	5/8	33.9	300	67.8	600
M16		34.3		68.7	

1.2.1 TEST METHOD

(1)Attach and detach the nut 4 times before sintering. By the fifth time, attach the nut and start sintering.
(2)Sinter in the assembled condition for 6 hours in tempratures at 800°F+25°F(425±2℃) or 450°F+25°F(230±2℃)
(3)After Baking, substantially apply SAE20 oil to the bolt, then tighten to the recommended preload.
(4)Mark the bolt, nut and washer with a line before initializing the test.
(5)Test conditions are set to a 1750～1800c.p.m vibration frequency. However, if the specimen rotates 360°before 30000 cycles the test will be terminated. (30000 cycles are approximately 17 minutes)
(6)After testing, the speciemen shall be examined under 10X magnification for cracks or broken segments.

※During this test No.(6) was not performed.

Test Description

4 different types of materials and 4 different types of nuts were tested.
Material(4 kinds)×Test nuts(4 kinds) = 16 Total.

Test Conditions

EUT

Bolt : Hexagon Bolt M16 x 70, Unplated
Nuts : Hex Nut (Type 1), Hex Jam Nut (Type 3), Unplated
HARDLOCK Nut M16x2.0, Unplated
Material : S45C(H), SCM435, C267 Alloy, Ti-6Al-4V (Titanium Alloy)
Tolerance Grade : S45C(H), SCM435 = 6H/6g. C276 Allot, Ti-6Al-4V = 4H/4h.
Sinter Temp : S45C(H), SCM435 = 230±2°C
C274 Alloy, Ti-8Al-4V = 425±2°C

Test Nut

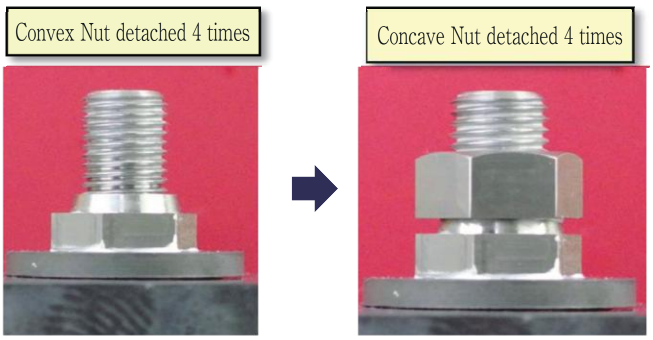
HLN : HARDLOCK Nut, SN+SW : Hex Nut (Type 1) + Spring Washer,
DN : Hex Nut (Type 1) + Hex Nut (Type 3), SN : Hex Nut (Type 1)

Tightening Method

HLN : Before sintering, attach and detach the Convex Nut 4 times, then do the same with the Concave Nut.
DN : Before sintering, attach and detach the Lower Nut 4 times, then do the same with the Upper Nut.
SN + SW, SN : Attach and detach according to test method

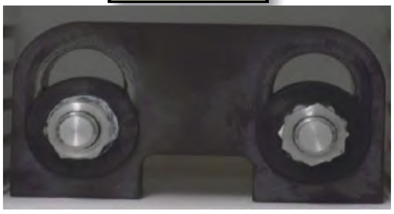
Test Method Description *The EUT's in the picture are of Ti-6Al-4V material

(1) Before sintering, the EUT is tightened with a torque of 34.3 Nm



(2)Sinter for 6 hours at 425 ± 2°C then let it cool of naturally

Pre-sintering



Post-sintering

*After sintering, the effect of the SW is reduced immensely

(3)After substantially applying SAE20 oil to the bolt, the sintered nut is tightened with a torque of 68.7 Nm

(4)Mark the EUT and initialize the test

Tighten the Convec Nut

Tighten the Concave Nut

1.2.2 TEST RESULTS

Material		S45C(H)		SCM435		C276 Alloy		Ti-6Al-4V	
	No.	Vibration time Cycles	EVAL.	Vibration time Cycles	EVAL.	Vibration time Cycles	EVAL.	Vibration time Cycles	EVAL.
SN	1	20 sec. 593	×	15 sec. 445	×	10 sec. 297	×	45 sec. 1335	×
	2	10 sec. 297	×	15 sec. 445	×	10 sec. 297	×	15 sec. 445	×
SN+SW	1	30 sec. 890	×	30 sec. 890	×	10 sec. 297	×	30 sec. 890	×
	2	10 sec. 297	×	45 sec. 1335	×	10 sec. 297	×	40 sec. 1187	×
WN	1	1 sec. 1780	×	1 sec. 1780	×	15 sec. 445	×	3 sec. 5340	×
	2	20 sec. 593	×	45 sec. 1335	×	20 sec. 593	×	5 sec. 8900	×
HLN	1	Approx. 17 Min. 30000	○	Approx. 17 Min. 30000	○	Approx. 17 Min. 30000	○	Approx. 17 Min. 30000	○
	2	Approx. 17 Min. 30000	○	Approx. 17 Min. 30000	○	Approx. 17 Min. 30000	○	Approx. 17 Min. 30000	○

By looking at the test results we can conclude that no matter what kind of material, the HARDLOCK Nut will not come loose.

1.3 LOOSENING UNDER TRANSVERSE CYCLIC LOADS TEST

1.3.1 OVERVIEW OF THE LOOSENING UNDER TRANSVERSE CYCLIC LOADS TEST

In addition to the perpendicular direction of the bolts axis, consider the cyclic loads in the transverse direction. During the transverse cyclic load test, rotational loosening will occur when the cyclic loads are more than twice of the preload.

$$\therefore\ W / F_0 = C,\ \text{when}\ C \geqq 2\ \text{Loosening rotation occurs.}$$

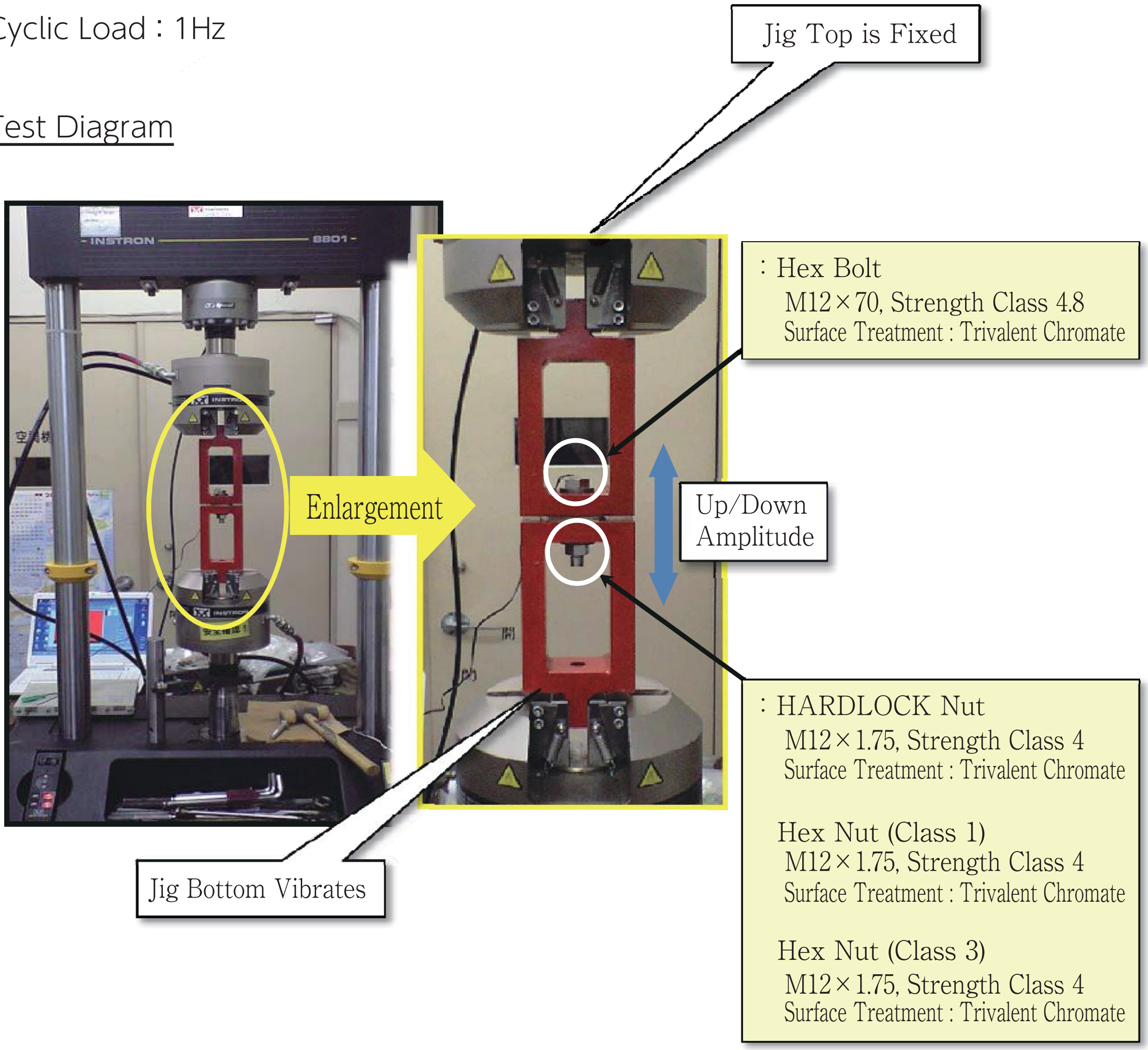
(W : Applied Load, F_0 : Initial Preload)

As seen in the diagram below, the bolt and nut is tightened to the jigs lower part and applied to cyclic loads.
By applying cyclic loads, you can observe whether rotational loosening occurs by measuring the axial force of the bolt and nut.

Test Frequency

Cyclic Load : 1Hz

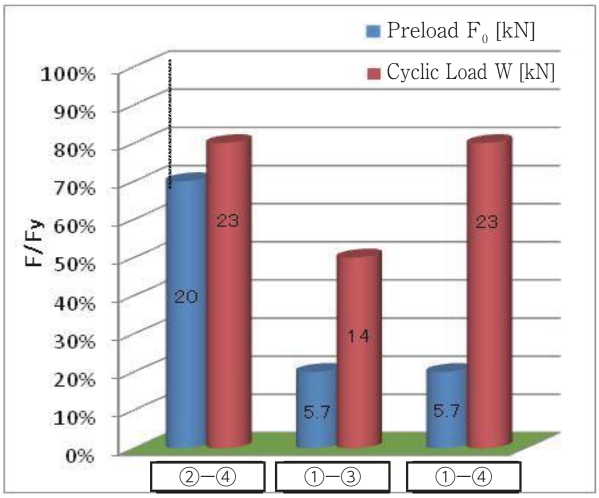
Test Diagram



Test Conditions

(1)Preload F_0

Bolt yield preload Fy20%、70% 2 sets
Fy= 340 × 84.3
= 28662 (N)
①Fy 20% = 5732 (N)
②Fy 70% =20063 (N)



(2)Cyclic Load W

Bolt yield preload Fy50%、80% 2 sets
③Fy 50% = 14331 (N)
④Fy 80% =22930 (N)

(3)Applied load·Preload combination

Condition / Combination	Preload F_0	Cyclic Loads W	Remarks
②-④	20063 N	22930 N	No Loosening
①-③	5732 N	14331 N	Chance of Loosening
①-④	5732 N	22930 N	Loosening

Test Nuts

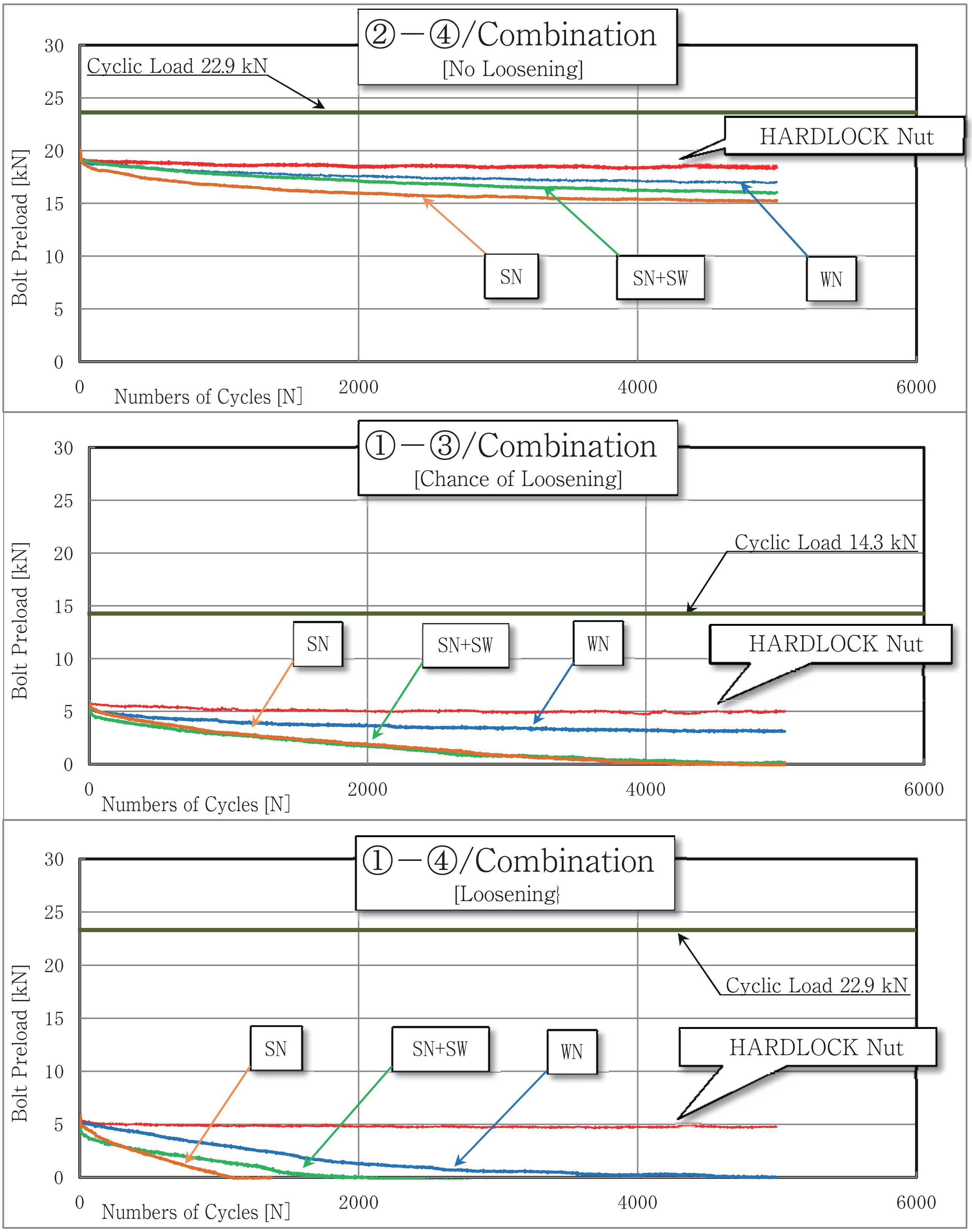
HLN :HARDLOCK Nut Standard Rim Type
WN :Hex Nut (Type 1) + Hex Jam Nut (Type 3)
SN+SW :Hex Nut (Type 1) + Spring Washer
SN :Hex Nut (Type 1)

The nuts were all tested in the different conditions.
The following is a summary of the results.

Test Results

Condition No.	Specimen	Number of Cycles	Preload F_0 (kN)	Remaining Clamp Load F_z (kN)	Preload Reduction F_0-F_z (kN)	Remaining Clamp Load
②−④	**HLN**	**5000**	**19. 25**	**18. 42**	**0. 83**	**96%**
	WN	5000	19. 95	17. 01	2. 94	85%
	SW	5000	19. 85	15. 79	4. 06	80%
	SN	5000	20. 07	15. 15	4. 92	75%
①−③	**HLN**	**5000**	**5. 73**	**4. 99**	**0. 74**	**87%**
	WN	5000	5. 77	3. 11	2. 67	54%
	SW	5000	5. 73	0. 00	5. 73	0%
	SN	5000	5. 75	0. 00	5. 75	0%
①−④	**HLN**	**5000**	**5. 67**	**4. 75**	**0. 92**	**84%**
	WN	5000	5. 96	0. 00	5. 96	0%
	SW	2500	5. 70	0. 00	5. 70	0%
	SN	1100	5. 78	0. 00	5. 78	0%

1.3.2 TEST RESULTS



As seen in the test results above, if the bolts and nuts are tightened with sufficient preload, it is difficult for rotational loosenign to occur.

However, if for some reason, the preload gets reduced, as long as the Hardlock Concave Nut is tightened, it is difficult for a loosening rotatio to occur.

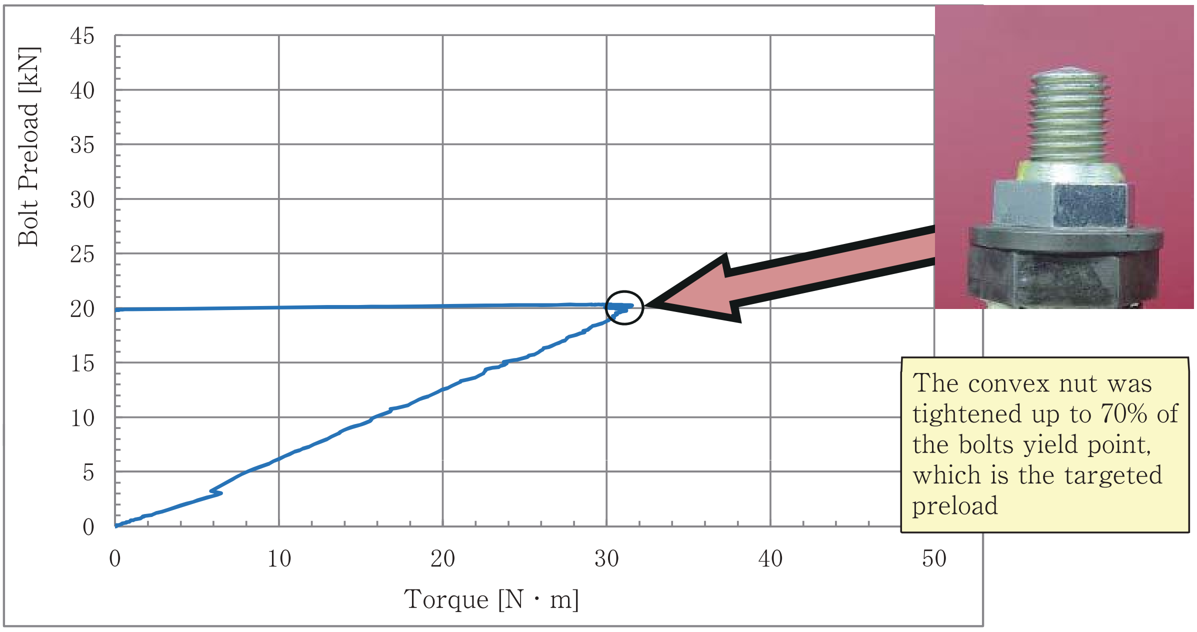
2 ENABLES TORQUE AND CLAMP LOAD CONTROL

TIGHTENING TEST RESULTS

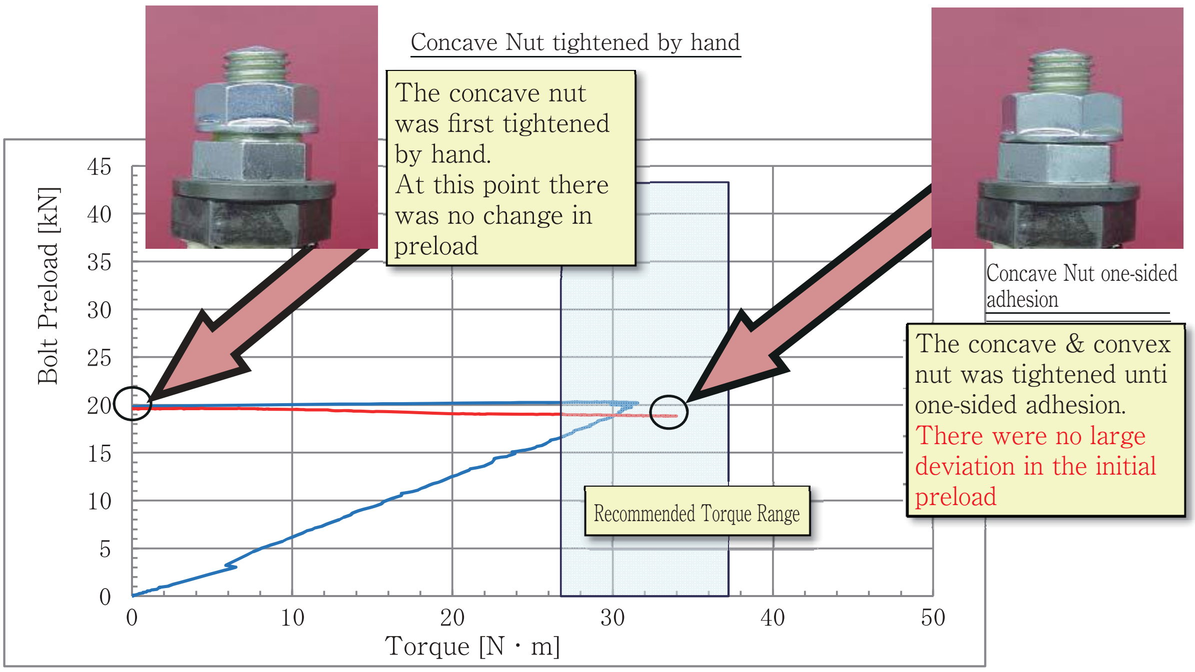
The basics of how to use the HARDLOCK Nut, after applying a clamp load/preload to the Convex Nut, use the Concave Nut to lock them together. The Convex Nut should be tightened with the appropriate torque required for the application, the Concave Nut however, shall be installed with the recommended torque set by HARDLOCK Industry Co., Ltd.

Below you can see the tightening test results of the HARDLOCK Nut and standard double nuts.

Graph (1) Tightening HLN Convex Nut



Graph (2) Tightening HLN Concave Nut



Test Conditions

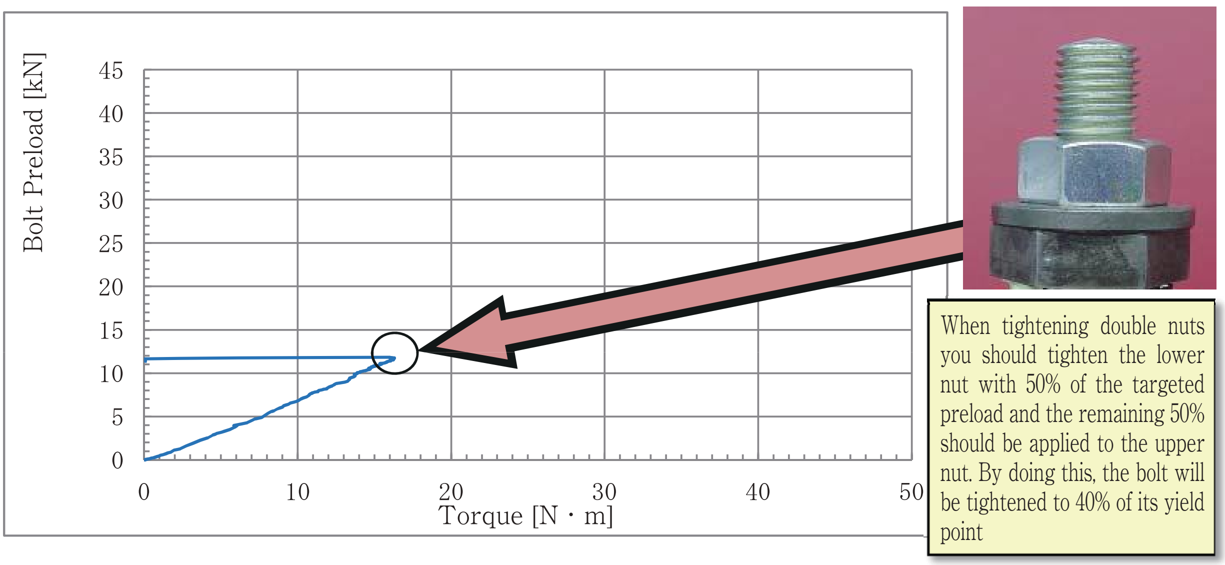
EUT

Bolt : M12×70, Strenght Class 4.8, Surface treatment: Trivalent chromate
Nut : Hexagon Nut (Type 1), Hexagon Nut (Type 3), HLN
Strenght Class 4, Surface Treatment : Trivalent Chromate
Lubricant : Paste

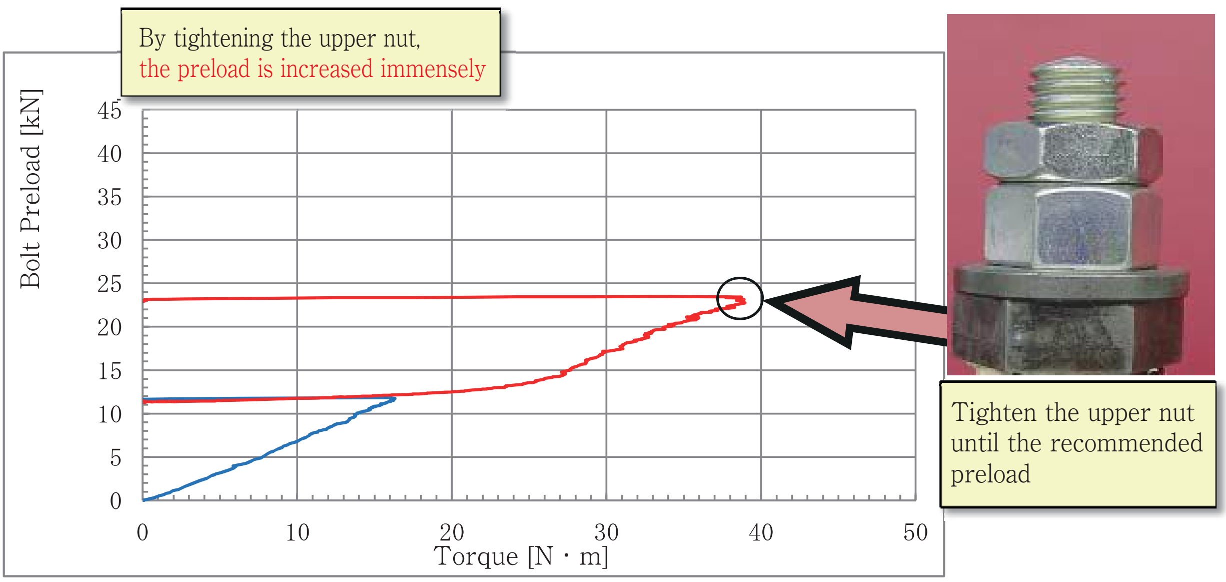
Double Nut Tightening Method

Upper Nuts correct tightening Method : Tighten the lower nut, then upper nut while fixing the lower nut. Tighten the lower nut to 40% of the yield point and the upper nut to 80% of the yield point

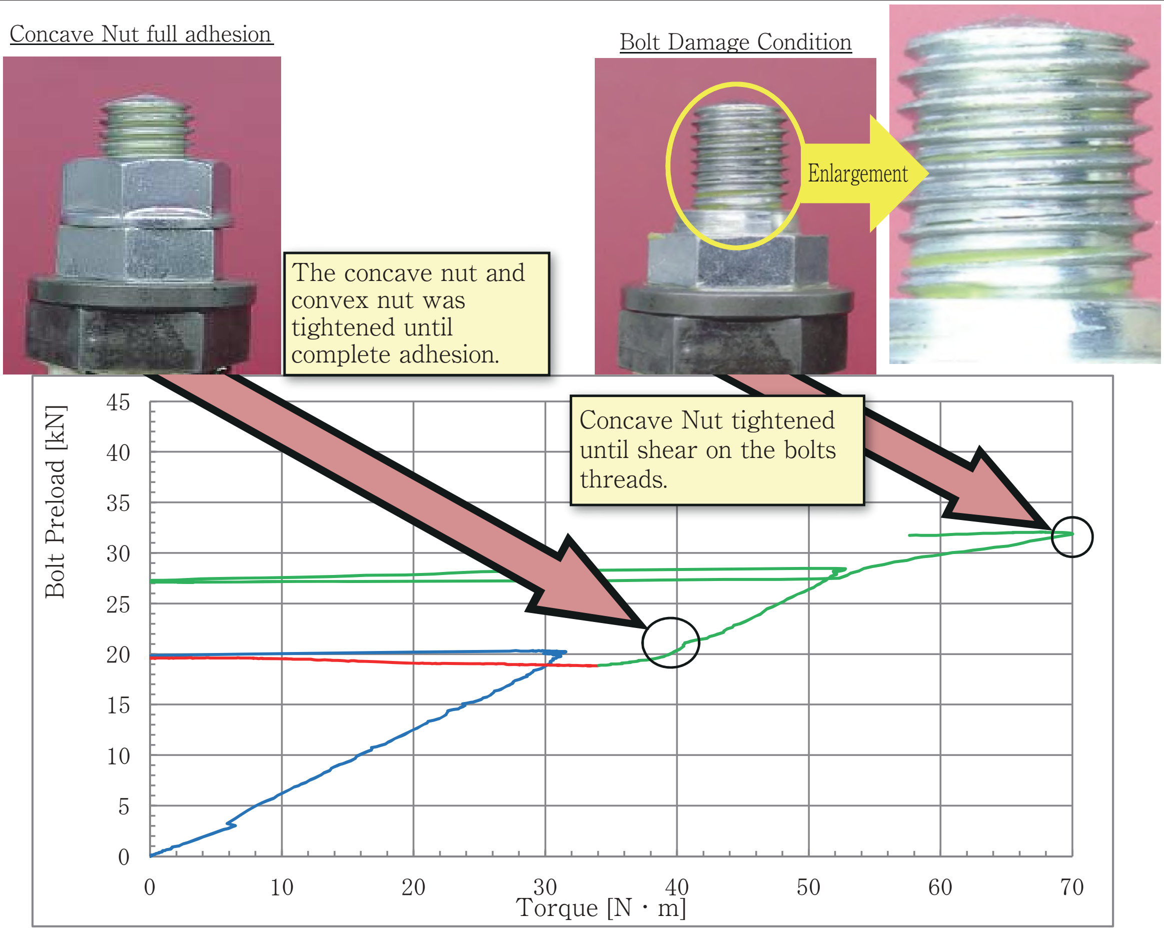
Graph (3) Double nut (Lower) : Hexagon nut (Type 1) Tightening Method



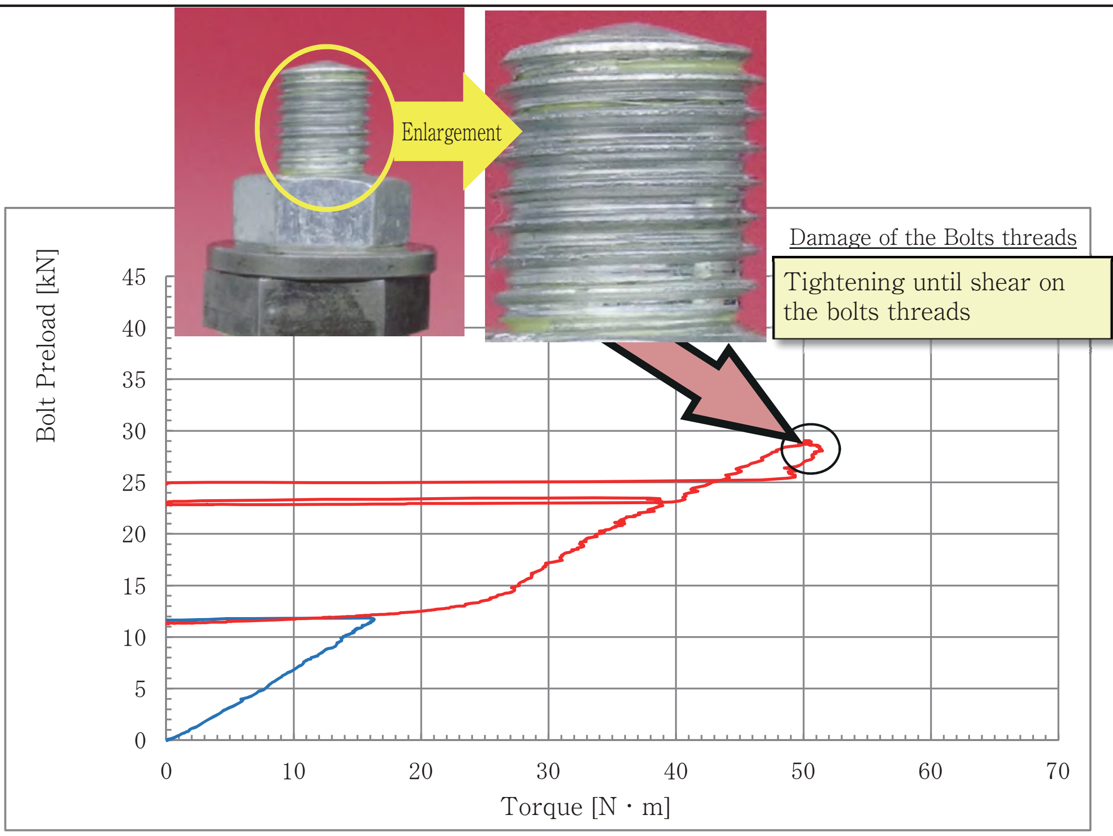
Graph (4) Double nut (upper) : Hexagon nut (Type 3) Tightening Method



Graph (5) HARDLOCK Convex Nut : Tightening until damage on the bolts threads



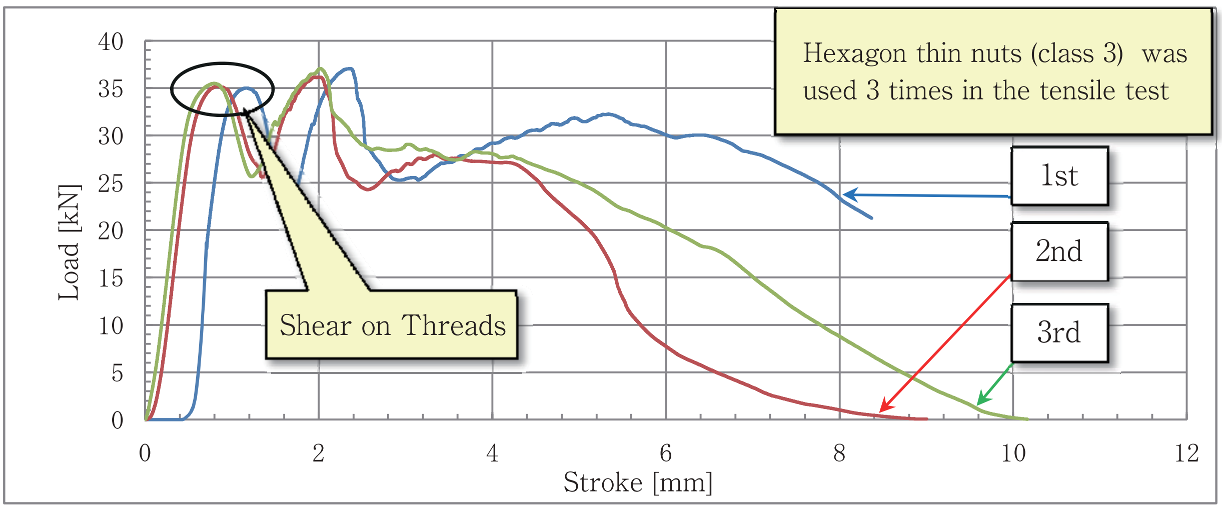
Graph (6) Double Nut (Upper) : Tightening until damage on the bolts threads



By observing changes in Torque and Preload when tightening the Concave Nut in Graph (2), it is seen that there is no significant change in Clamp Load when tightening within the Recommended Torque Range.
Accordingly, in case of HARDLOCK Nuts, the user can control the Clamp Load by tightening the Concave Nut within the Recommended Torque Range after tightening the Convex Nut to the appropriate torque required for each individual application.
On the other hand, looking at Graph (4) for double nuts, the preload is increased when tightening the upper nut. In other words, in practice it is said to be difficult to control the clamp load when utilizing dubbel nuts.
Looking at Graph (5), you can see that the Recommended Torque Range for the Concave Nut is about half of the Thread Shear Torque. Therefore, as long as the HARDLOCK Nuts are installed correctly, there will be no shear on the threads when tightening the Concave Nut.
With this in mind, you can see that the HARDLOCK Nut is capable of bolt clamp load control, and that there is no risk reaching the Bolts Yield Point even if slightly tightening the Concave Nut beyond the Recommended Torque Range.

Reference Case

In general, when comparing the breaking load of simply pulling the threads, and when twisting the threads by tightening (torsion applied tensile breaking load), the twisting is said to be about 85% of the bolts breaking load.
The breaking load for Double Nuts and HARDLOCK Nuts for this Destruction Test is the same, around 30kN.
As seen in the graph below, the Hex Jam Nut's (Type 3) threads got damaged after applying approximately 35kN. 85% of 35kN is around 30kN so the below Thread Destruction Test Results can be said to be accurate.



Test Conditions

Bolt : M12x70 Strenght Class 4.8, Surface Treatment: Trivalent Chromate (Same conditions as present test)
Nut : Hexagon Jam Nut (Type 3), Strenght Class 4, Surface Treatment: Trivalent Chromate(Same conditions as present test)

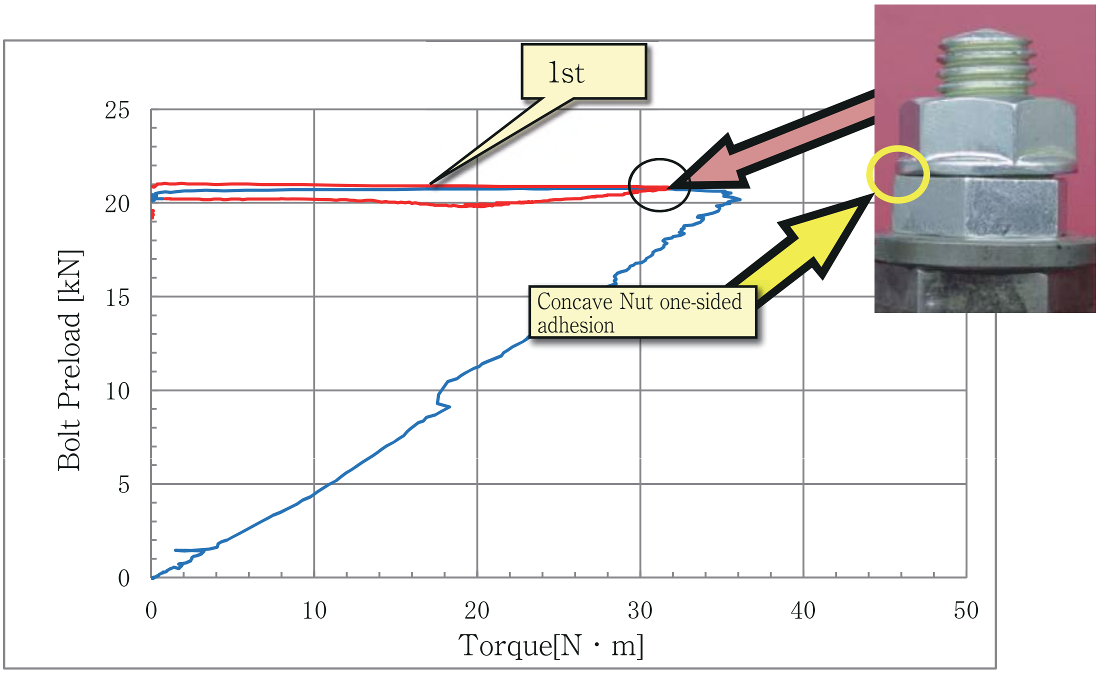
3 POSSIBLE TO REUSE

One of the feature of the HARDLOCK products is that they can be re-used several times. Performance after repeated usage and information relating to torque and clamp load is seen below.

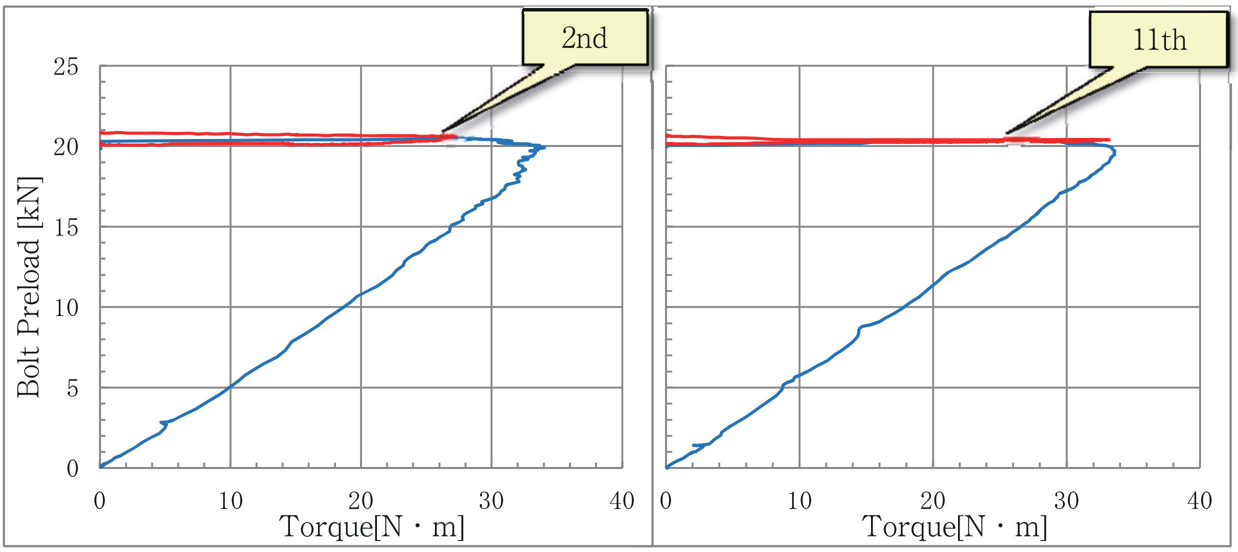
Test Conditions

EUT
Bolt : M12x70 Strenght Class 4.8, Surface Treatment: Trivalent Chromate
Nut : HLN, Strenght Class 4, Surface Treatment: Trivalent Chromate

1st Tightening



2nd & 11th Tightening



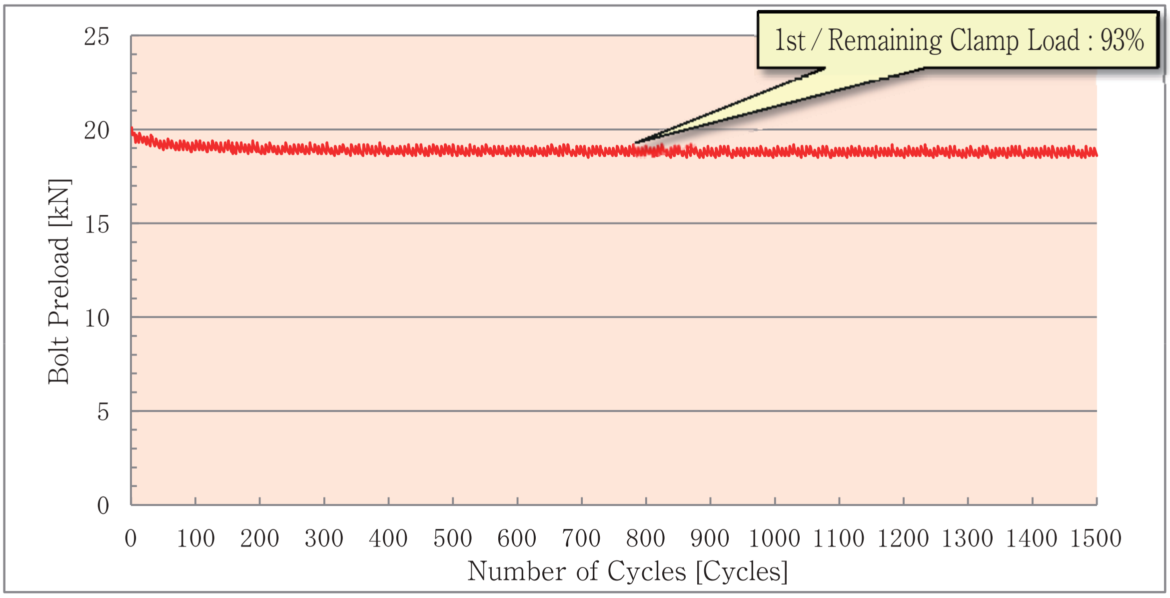
Test Method

(1) Tighten the HLN and commence the tightening test.
(2) Conduct the Junker test to confirm self-locking results.
(3) After conducting the Junker test, conduct the tightening test.
(4) Attaching and detaching 8 times and perform re-tightening test.
(5) Repeat (1)~(4), Reapeat (2) until you have attatched and detatchedthe nut 51times.

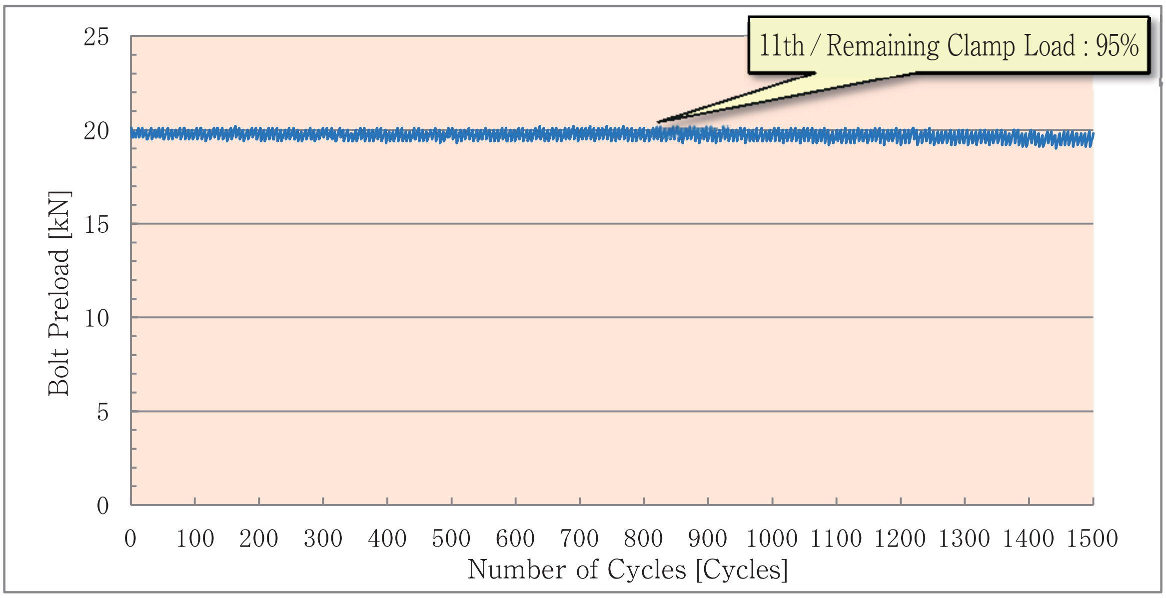
Tightening Method

Tighten Convex Nut to 70% of the yield point
Tighten Concave Nut until one-sided adhesion

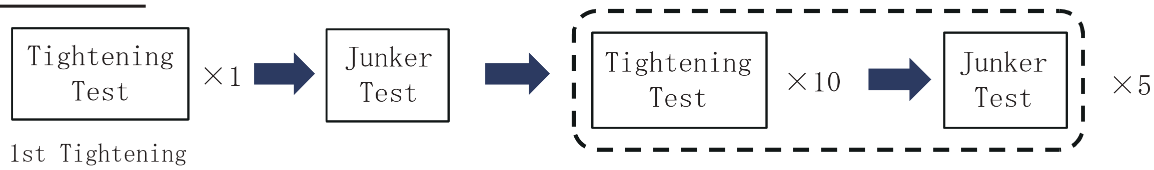
Junker Test Result after 1st Tightening



Junker Test Result after 11th Tightening

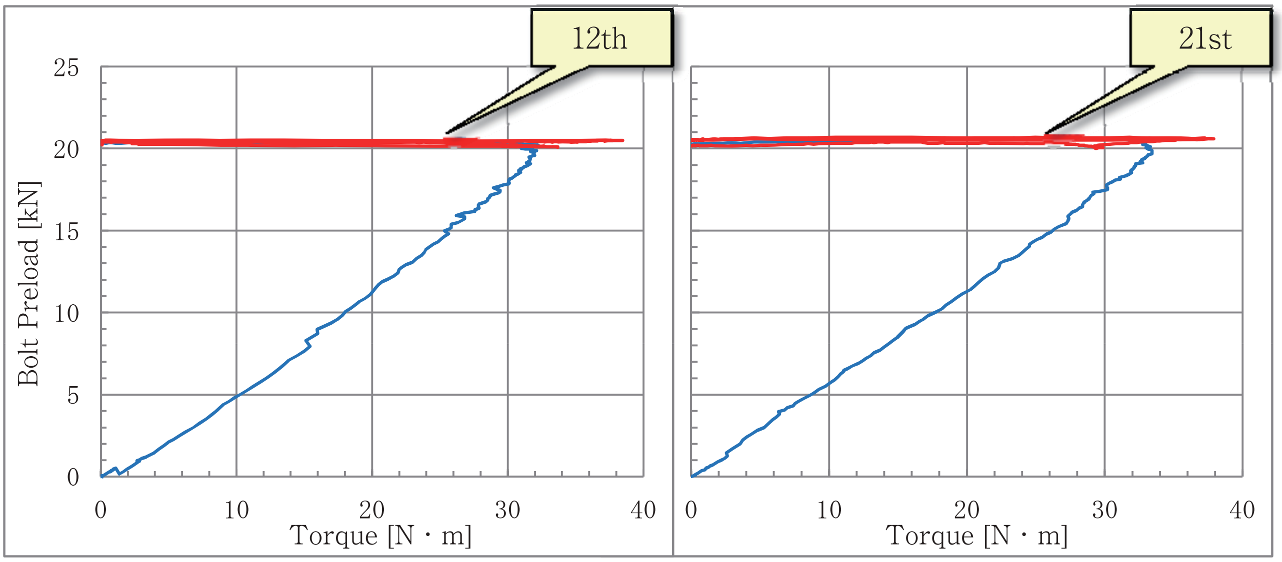


Test Schematics

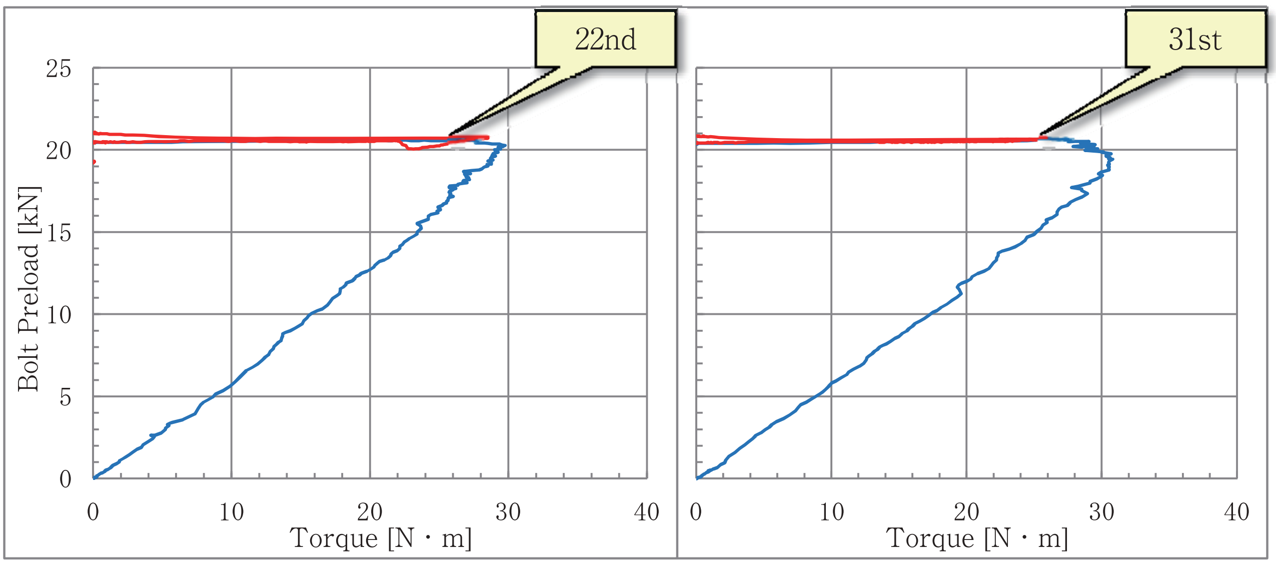


The Junker Test was conducted 6 times and the nuts where tightened a total of 51 times. Below, we show 10 before and after test results of the tightening test and before and after test results of the Junker test

12th & 21st Tightening



22nd & 31st Tightening

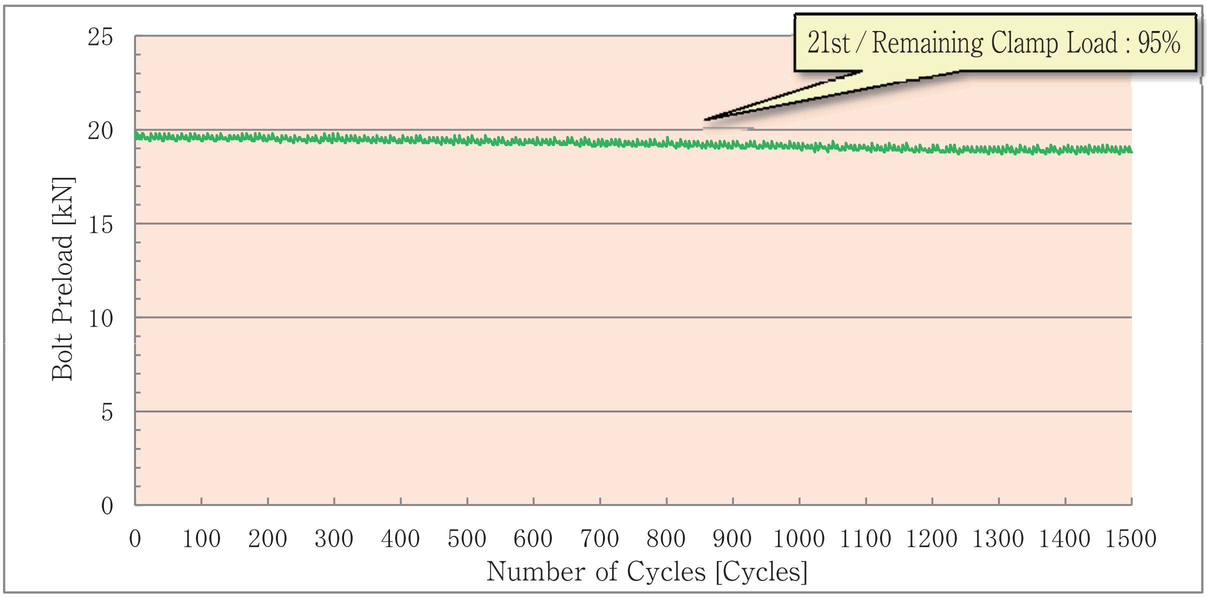


Junker Test Results

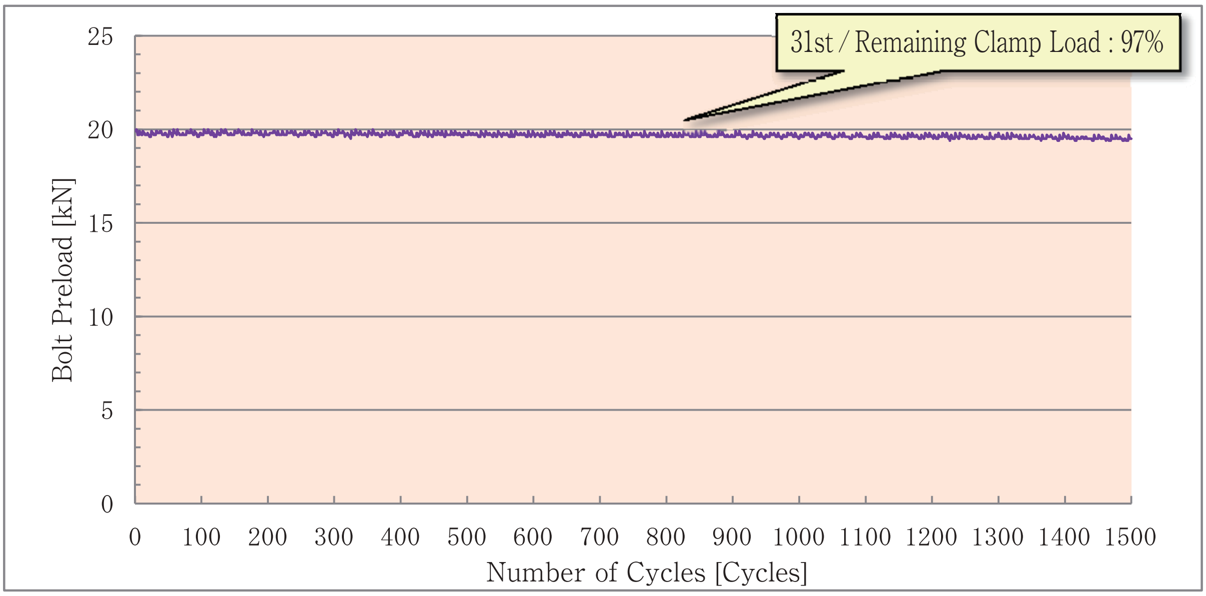
- Amplitude : ±0.35mm
- Preload : 70% of Yield Point
- Vibration Cycles : 1500 Cycles

When conducting the Junker test, lubricant is applied. This is to avoid residual clamp load due to factors other than the self-locking function and to prevent thread seizure. For example, if there is thread seizure, dents on the bolt or if the nut gets caught on the roughness of the bearing surface, rotational loosening may not occur. By applying a lubricant to eliminate these influences, it is possible to measure the pure sef-locking performance.

Junker Test Results after 21st Tightening



Junker Test Results after 31st Tightening

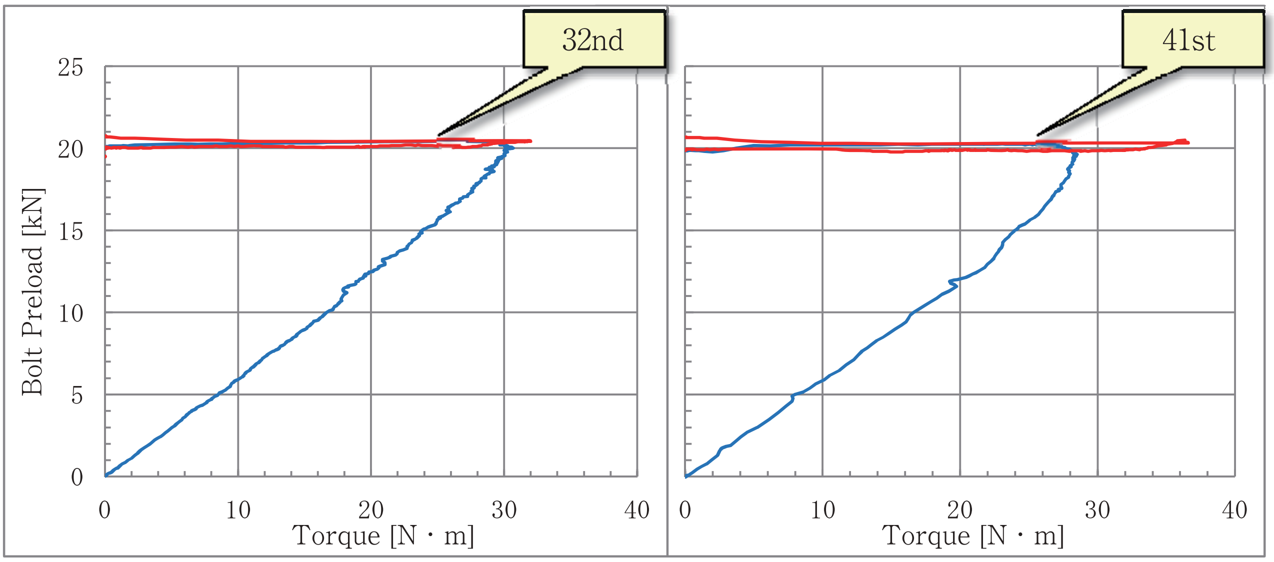


Junker Test Results

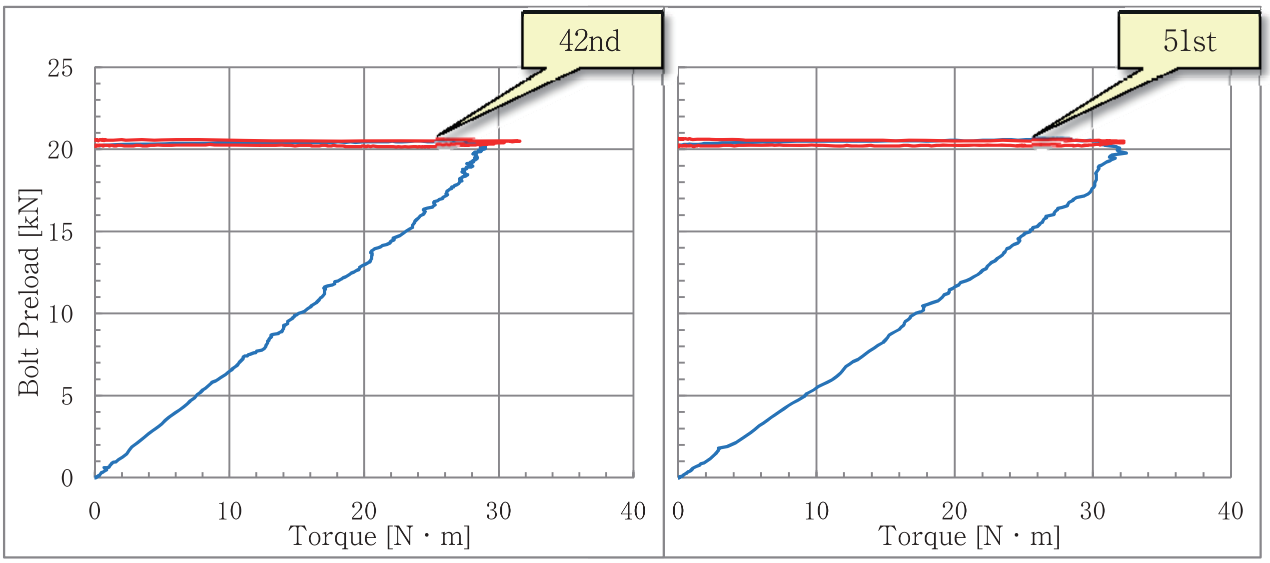
- ･Amplitude : ±0.35mm
- ･Preload : 70% of Yield Point
- ･Vibration Cycles : 1500 Cycles

When conducting the Junker test, lubricant is applied. This is to avoid residual clamp load due to factors other than the self-locking function and to prevent thread seizure. For example, if there is thread seizure, dents on the bolt or if the nut gets caught on the roughness of the bearing surface, rotational loosening may not occur. By applying a lubricant to eliminate these influences, it is possible to measure the pure sef-locking performance.

32nd & 41st Tightening

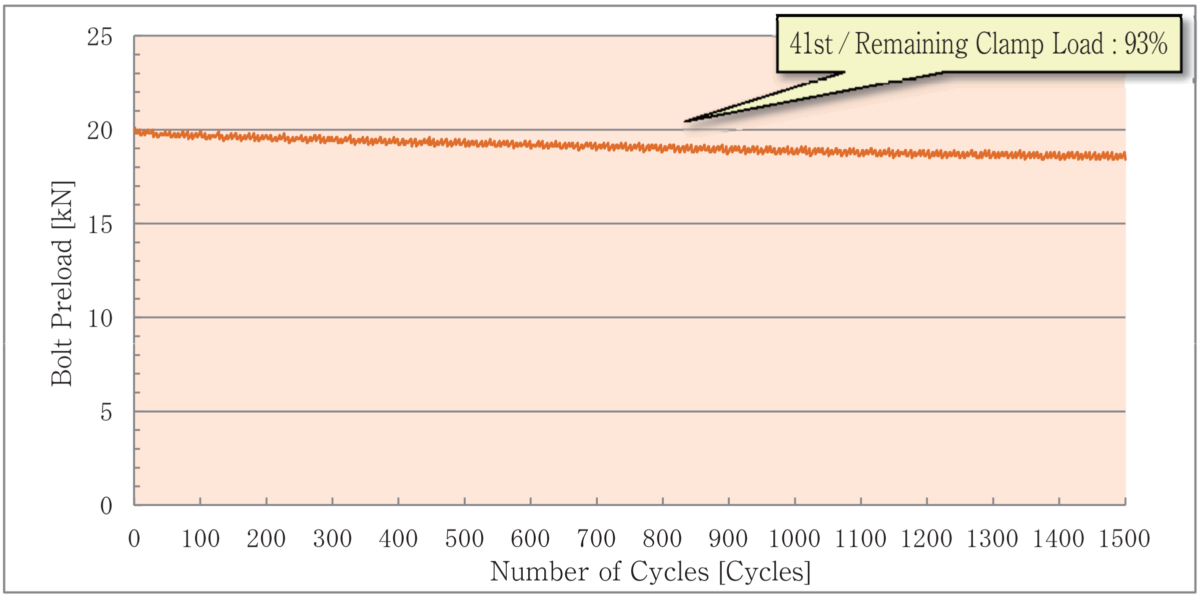


42nd & 51st Tightening

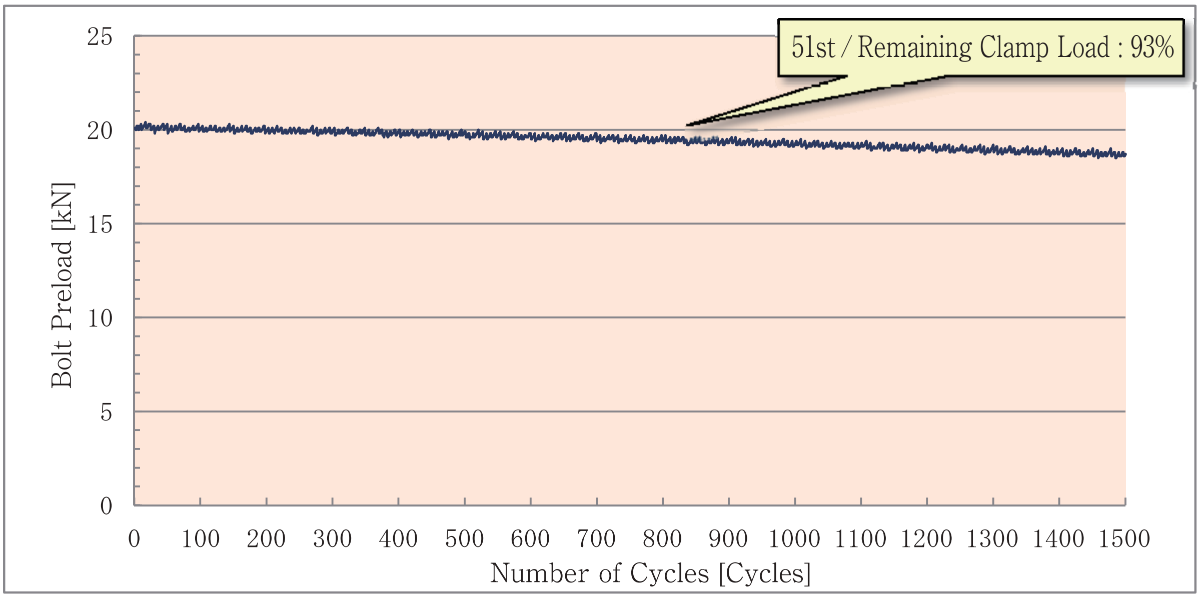


By looking at the results of the reapted attaching and detaching test so far, you can see that there are no major changes in tightening characteristics of the HARDLOCK Nut even after repeated usage.
Take notice to the change in clamp load when tightening the Concave Nut. When tightening the Concave nut you can see that there is almost no change in the preload.

Junker Test Results after 41st Tightening



Junker Test Results after 51st Tightening



Safety is Power
HARDLOCK Industry Co., Ltd.
Head Office : 1-6-24, Kawamata, Higashi-Osaka, Osaka, Japan 577-0063
TEL : +81-6-6784-1131 FAX : +81-6-6784-1161
Tokyo Office : 2-5-9, Higashi-Ueno, Taito, Tokyo, Japan 110-0015
TEL : +81-3-3833-1491 FAX : +81-3-3833-1438
URL : http://www.hardlock.co.jp/ E-mail : h.office@hardlock.co.jp