
HEICO

- **HEICO Group of Companies**
  - History und Structure
  - HEICO Worldwide
  - Product Range and Quality
  - Manufacturing and Engineering
  - References
- **HEICO-LOCK Wedge Lock Washers**
  - The Concept behind the Wedge Lock Washer
  - Technical Information on HEICO-LOCK
  - HEICO-LOCK Quality Assurance (Junker Vibration Test, etc.)
  - Product List and Availability of HEICO-LOCK
  - Typical Applications for Heico-Lock Wedge Lock Washers

Tradition and Innovation

Founder Theo Heimann

1900
HEICO was founded in Niederense (Germany)
(Nails, Upholstery Nails, Thumb Tacks)

1986
HEICO France S.A.R.L. was founded

1990
Opening of new plant in Höingen
(Germany)

1993
Start of the production of cold forming parts

1995
Integration of UMEC S.A., Barcelona

1997
HEICO Fasteners Inc., USA was founded

1998
Addition to the plant in Höingen
Certification acc. to DIN ISO 9001

2001
HEICO China Ltd. founded;
Certification acc. to ISO TS 16949

2003
6-die transfer presses go into production

2007
HEICO 2es in Czech Rep. founded

2008
Heico Fasteners UK Ltd was founded

2009
HEICO Fasteners Vietnam Ltd. founded

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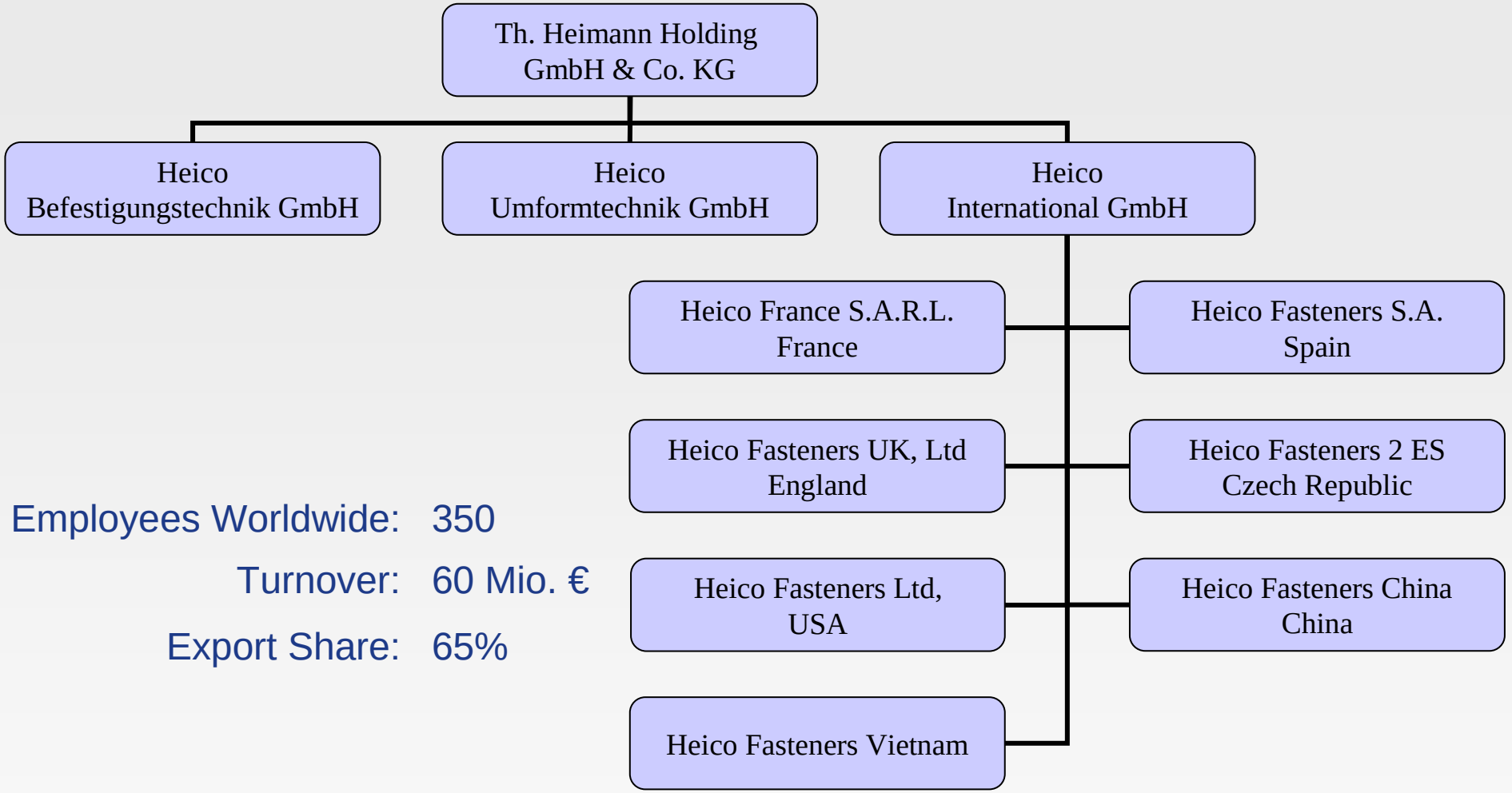
HEICO Group of Companies

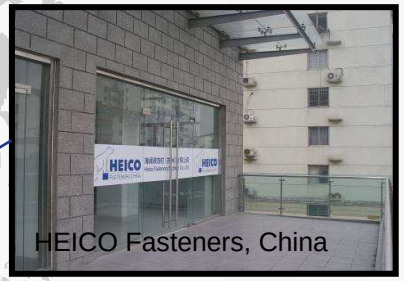


Employees Worldwide: 350

Turnover: 60 Mio. €

Export Share: 65%

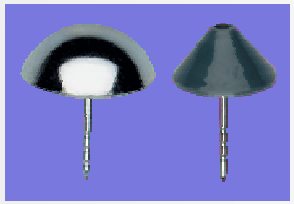
HEICO Worldwide



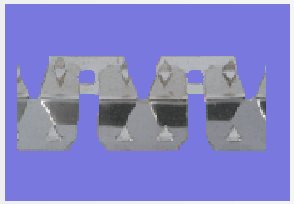
Product Range

- Upholstery Nails (furniture industry)

- Security Nails (theft protection - apparel industry)



- Stampings (miscellaneous applications)



- Riveted Bolts

- Poly-Bagging (furniture and sanitary industry)

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Product Range

- Rivets made of
  steel, stainless steel, copper, brass, aluminum,
  and a variety of other alloys
- Semi-tubular and tubular rivets
- Threaded parts
- Shoulder rivets
- Ball studs / ball pins
- Metal/Plastic Combinations

… ca. 80 % of all products: Automotive Industry

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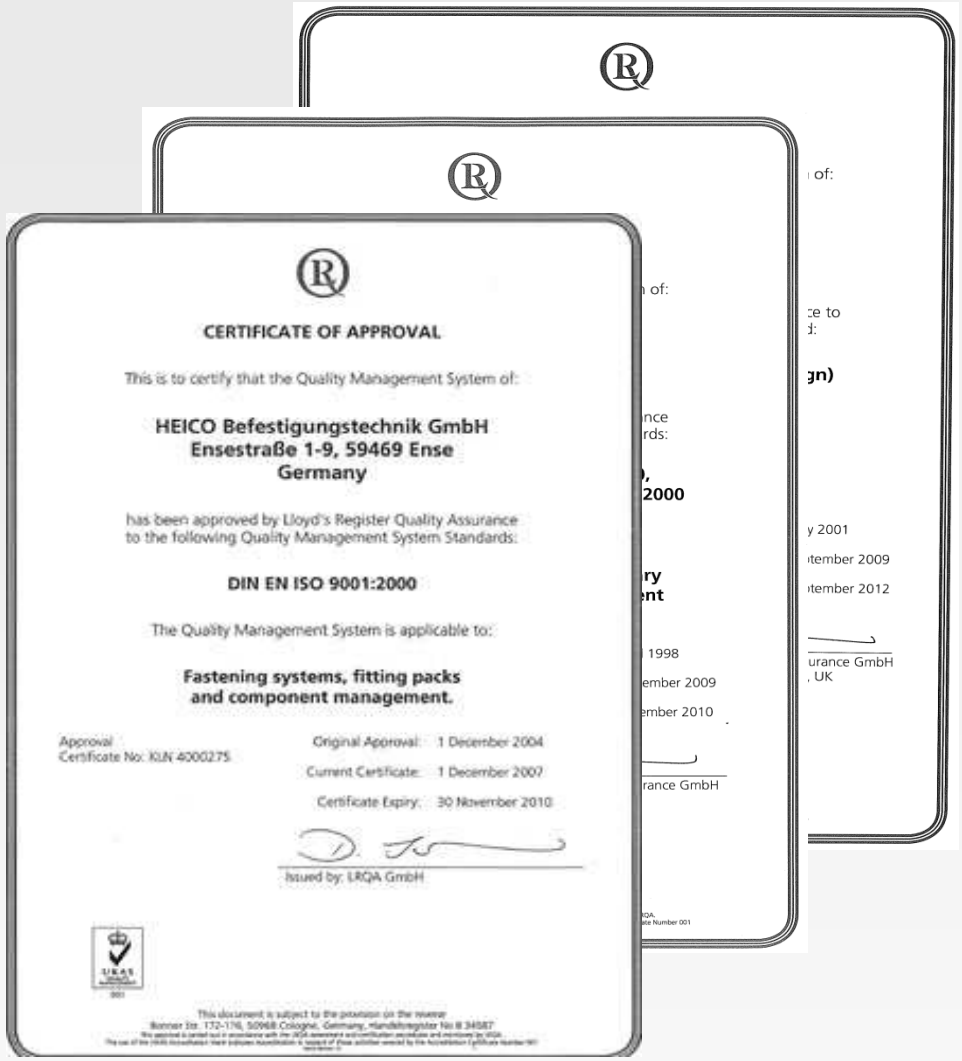
Quality for the most demanding applications

Equipment

- Böhme & Weihs CAQ system
- CNC-Measuring Projector
- Hardness Testers
- Metallographic Research
- APQP-Module



CERTIFICATE OF APPROVAL

This is to certify that the Quality Management System of:

HEICO Befestigungstechnik GmbH
Ensestraße 1-9, 59469 Ense
Germany

has been approved by Lloyd's Register Quality Assurance to the following Quality Management System Standards:

DIN EN ISO 9001:2000

The Quality Management System is applicable to:

Fastening systems, fitting packs and component management.

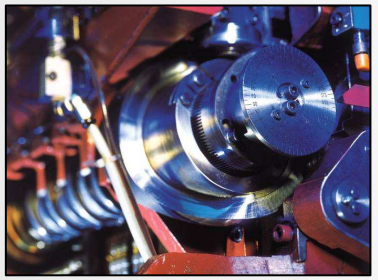
Approval Certificate No: KUN 4000275

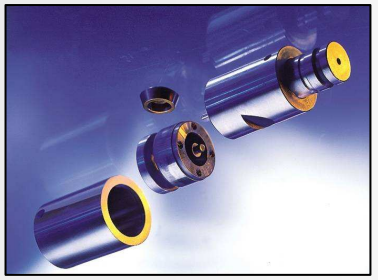
Original Approval: 1 December 2004
Current Certificate: 1 December 2007
Certificate Expiry: 30 November 2010

Issued by: LRQA GmbH

Production and Engineering

- ✓ **In-house Mechanical Engineering**
  - Strong partnership with University of Applied Sciences Soest (2009: Best diploma thesis in the field of engineering)
  - 2008: Advancement through German Federal Ministry of Economic Affairs and Industry (BMWI))
- ✓ **Toolmaking & Design**
  - Mazak Machining center
  - Mazak CNC lathe
- ✓ **Press Plant**
  - 44 presses
  - 52 press- and punching machines
- ✓ **Secondary Operations**
  - 12 CNC automatic lathes
  - 27 drilling, threading and rolling machines
- ✓ **Surface Treatments**
  - Washing system
  - Nickel, brass, copper, zinc yellow and zinc-blue plating
  - Annealing furnaces





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HEICO-LOCK Wedge Lock Washers

The HEICO-LOCK WEDGE LOCK WASHERS consists of a pair of washers with a wedge-locking action, which is a unique method that uses tension instead of friction. The key is the difference in angels. Since the cam angle is larger than the thread pitch, the pair of washers expand more than the corresponding pitch of the thread.

HEICO-LOCK washers positively lock the fastener in a joint which is subjected to extreme vibration or dynamic loads.

Withdrawn DIN Norm for Locking Fasteners

DIN, the German Institute for Standardization (Deutsches Institut für Normung e.V.), has withdrawn the following standards concerning locking fasteners

Spring washers (DIN 127, DIN 128 and DIN 6905)

Wave washers (DIN 127, DIN 128 and DIN 6905

Tooth lock washers (DIN 6797)

Serrated lock washers (DIN 6798 and DIN 6908)

Safety plates (DIN 93, DIN 432 and DIN 463)

Safety cups (DIN 526)

Locknuts (DIN 7967)

Crown nuts with split pin (DIN 937)

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Withdrawn DIN Norm for Locking Fasteners

Quote:
NASA Fastener Design Manual RP-1228, March 1990:
"The lockwasher serves as a spring while the bolt is being tightened. However, the washer is normally flat by the time the bolt is fully torqued. At this time it is equivalent to a solid flat washer, and its locking ability is nonexistent. In summary, a lockwasher of this type is useless for locking."
”Belleville washers (fig. 12) are conical washers used more for maintaining a uniform tension load on a bolt than for locking. If they are not completely flattened out, they serve as a spring in the bolt joint. However, unless they have serrations on their surfaces, they have no significant locking capability.”

Quote:
NASA Fastener Design Manual RP-1228, March 1990:
”Tooth lock washers (fig, 15) are used with screws and nuts for some spring action but mostly for locking action. The teeth are formed in a twisted configuration with sharp edges. One edge bites into the boltbead (or nut) while the other edge bites into the mating surface. Although this washer does provide some locking action, it damages the mating surfaces. These scratches can cause crack formation in highly stressed fasteners, in mating parts, or both, as well as increased corrosion susceptibility."

Quote:
Naval Ships' Technical Manual, Chapter 75:
"Although lock washers may be encountered, using the flat washers with self locking nuts, self-locking fasteners, self-locking inserts, or thread sealants such as MIL-S-22473 anaerobic compounds is preferable.“

Quote (ASME B18.21.1):
The ASME also has a standard for lock washers. In that standard it states:
"The word lock appearing in the names of products in this standard is a generic term historically associated with their identification and is not intended to imply an indefinite permanency of fixity in attachments where the fasteners are used."

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HEICO-LOCK Wedge Lock Washers

- HEICO-LOCK wedge lock washers offer high quality, high value bolting system for demanding bolted fastening applications
- A certified fastening system, working at low and high preload levels
- A bolt securing system providing exceptional resistance to vibration loosening and dynamic loads – safe in both dry and lubricated conditions.
- Consistent reusability without loss of function and quality

HEICO-LOCK Wedge Lock Washers

- Ease of assembly and disassembly
  (already pre-assembled pair of washers)

- Working with structual grade and high tensile bolts and nuts
  (8.8, 10.9, 12.9, ASTM 574)

- Readily available in steel and stainless steel –
  other materials available on request

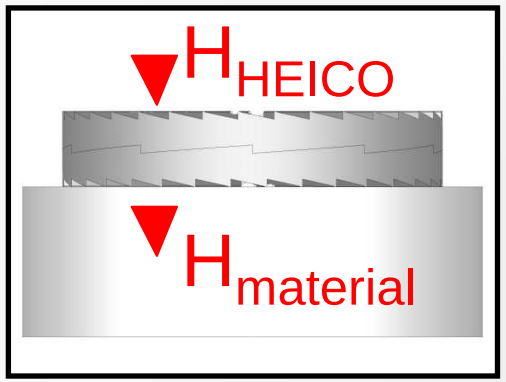
- Avaible in two versions – standard (S) and enlarged outside diameter (O.D.)

Concept of HEICO-LOCK wedge lock washers

- Cams with blocking wedge effect on inner surface of the lock washer, radial teeth on the outer surface
- Washers already glued in pairs (to avoid assembly errors)
- Gripping and seating of radial teeth in mating surfaces when tightening
- Stress only appears inside the inner key faces
- Enhanced clamping force

key faces on inner surface	radial teeth on the outer surface

Concept of HEICO-LOCK Wedge Lock Washers



1. Hardness differences between HEICO-Lock and mating surfaces: $H_{HEICO} > H_{material}$

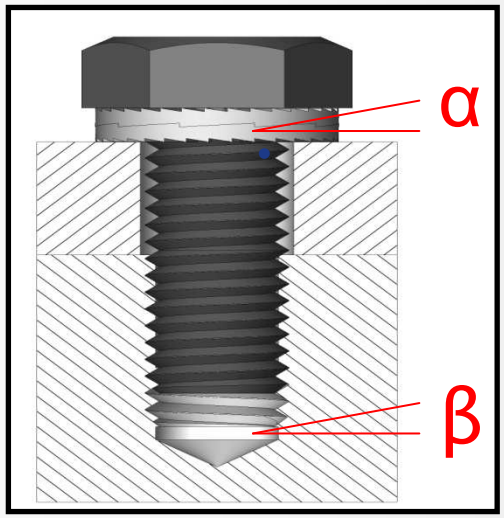
- The hardness of the Heico-Lock washer should not exceed the hardness of the mating surfaces and is higher than structural grade and high tensile bolts and nuts (8.8, 10.9 an 12.9).
- Radial teeth/ridges on the outside of the washer grip into and seat the mating surface in the tightening process.

HEICO-LOCK Hardness Table

Material	Sizes	Zinc-Laminate-Finish	Non Coated
Standard-Steel (through hardened)	HLS-3 - HLS-42 HLB-3 - HLB-42	485 ±25 HV0.3	
316 Stainless Steel (surface hardened)	HLS-3SS - HLS-42SS HLB-3SS - HLB-42SS		> 520 HV0.05

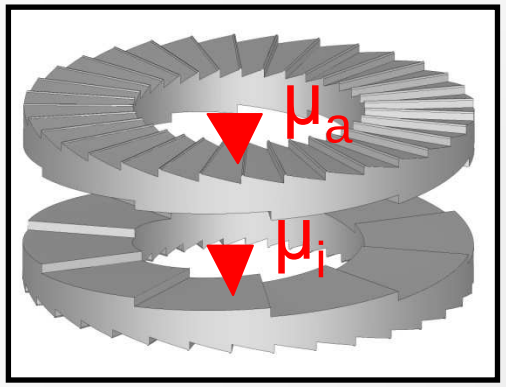
Concept of HEICO-LOCK wedge lock washers

2. Difference in the rise of HEICO-Lock cams and the pitch of the bolt: α > β



- The rise of the cams α between HEICO-LOCK wedge lock washers is greater that the pitch β of the bolt.
- The elongation of the thickness of HEICO-LOCK wedge lock washers is larger than the potential movement of the the bolt along the pitch. The lock washer prevents the bolt/nut from loosening due to vibration and the bolt/nut is locked safely in place.

Concept of HEICO-LOCK wedge lock washers



3. Differing Friction Coefficient between HEICO-LOCK cams and radial ridges : $\mu_a > \mu_i$

- The cams on the separation plane (joint face) of the individual washers of the pair show a much lower friction coefficient μi than the friction coefficient on the radial ridges on the outside of the pair of washers μa)

- Any loosening through a dynamic load will always lead to movement only across the face of the cams of the washers

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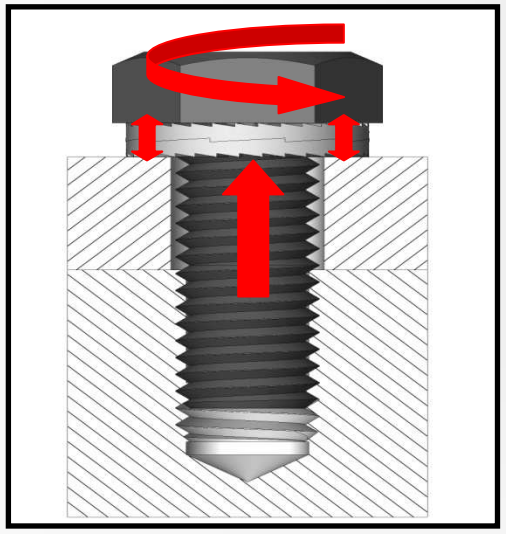
Concept of HEICO-LOCK wedge lock washers

4. Securing the bolted joint through post tensioning:

$F_{dyn} > F_{stat}$

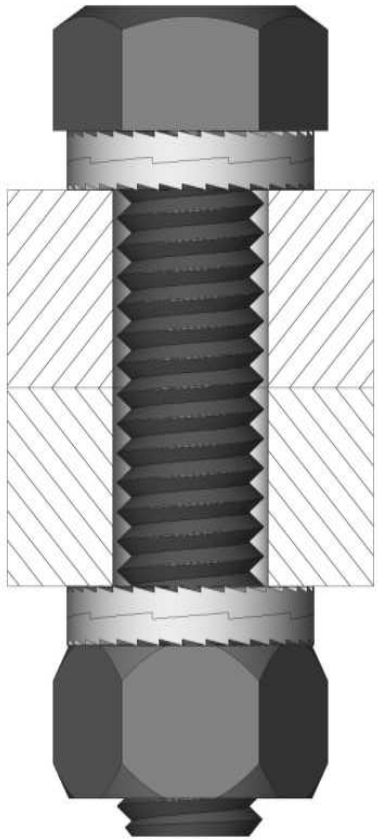
- Loosening the bolt causes the pair of HEICO-LOCK wedge lock washers to expand, thus actually increasing the clamping force. The result is an increase in the clamping force.



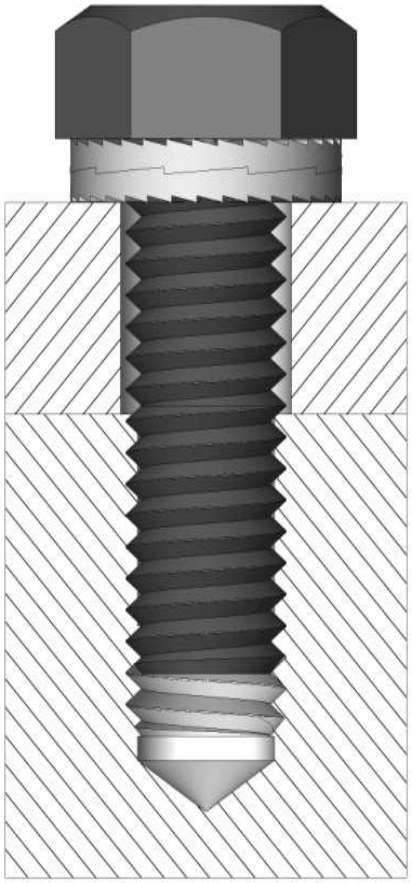
- The expansion of the pair or washers increases the pre-load and locks the fastener securely, even when subjected to etreme vibration and dynamic loads.

- Large I.D. HEICO-LOCK wedge lock washers are recommended for use on large/long holes (for example with flange nuts or screws), painted surfaces or soft materials, for example aluminum.

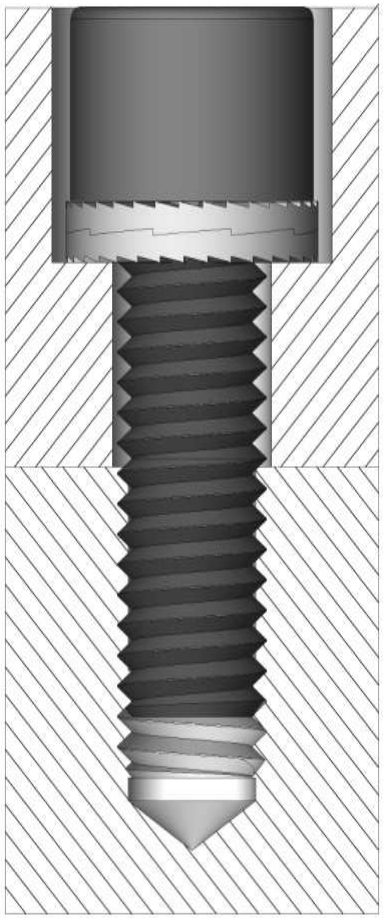
Typical Wedge Lock Washers Application



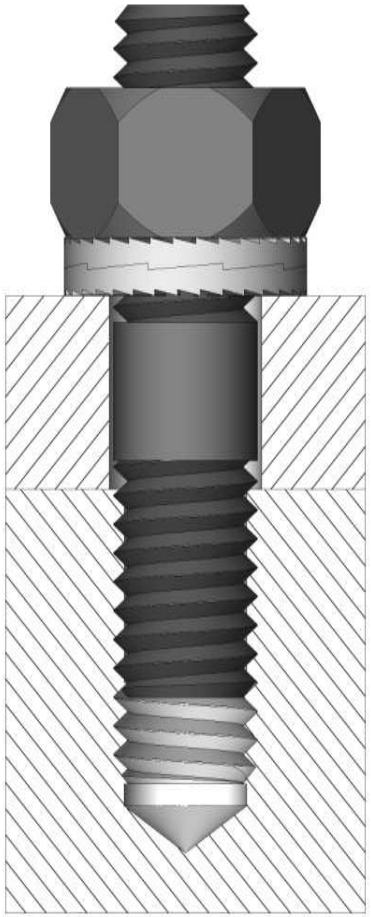
Hexagon bolt in a clearance hole – both sides
- secured by HEICO-Lock



Hexagon bolt in a tapped hole
– secured by HEICO-Lock



Countershank Cylinder Head Screw
- Secured by HEICO-Lock



Stud bolt
– secured by HEICO-Lock

Images of HEICO-LOCK Wedge Lock Washers



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Advantages of HEICO-LOCK wedge lock washers

- ✓ Optimal solution for vibration protection, both at low and at high pre-load
- ✓ Dependable functionality when fasteners are subjected to dynamic loads
- ✓ Function not affected by lubrication
- ✓ Re-use possible without loss of quality or comfort
- ✓ Wedge lock washers glued in pairs for easiest assembly and disassembly
- ✓ Efficiency also given at high-strength screws (8.8, 10.9 and 12.9) and corresponding nuts
- ✓ Application with almost any types of screws possible, e.g. Allen head screw and stud screw
- ✓ No hydrogen embrittlement and no chromate contamination

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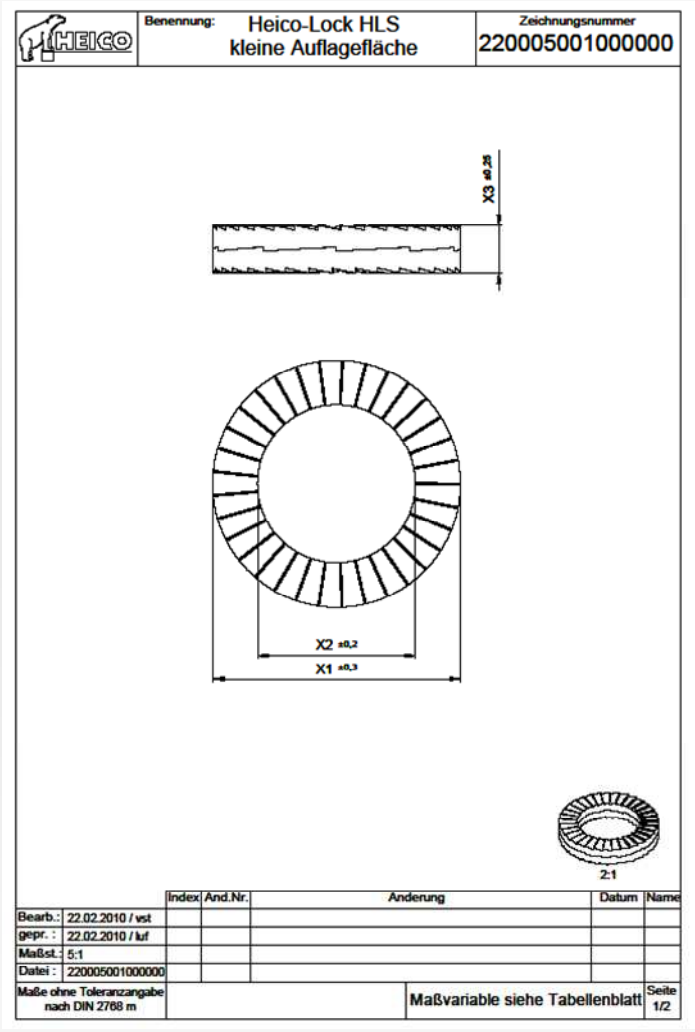
HEICO-LOCK dimensions

M	HEICO-Lock (narrow)				HEICO-Lock (broad)			
	steel	stainless steel	inner-Ø [mm]	outer-Ø [mm]	steel	stainless steel	inner-Ø [mm]	outer-Ø [mm]
3	HLS-3	HLS-3S	3,4	7,0	-	-	-	-
3,5	HLS-3,5	HLS-3,5S	3,9	7,6	HLB-3,5	HLB-3,5S	3,9	9,0
4	HLS-4	HLS-4S	4,4	7,6	HLB-4	HLB-4S	4,4	9,0
5	HLS-5	HLS-5S	5,4	9,0	HLB-5	HLB-5S	5,4	10,8
6	HLS-6	HLS-6S	6,5	10,8	HLB-6	HLB-6S	6,5	13,5
8	HLS-8	HLS-8S	8,6	13,5	HLB-8	HLB-8S	8,6	16,6
10	HLS-10	HLS-10S	10,7	16,6	HLB-10	HLB-10S	10,7	21,0
11	HLS-11	HLS-11S	11,4	18,5	-	-	-	-
12	HLS-12	HLS-12S	13,0	19,5	HLB-12	HLB-12S	13,0	25,4
14	HLS-14	HLS-14S	15,2	23,0	HLB-14	HLB-14S	15,2	30,7
16	HLS-16	HLS-16S	17,0	25,4	HLB-16	HLB-16S	17,0	30,7
18	HLS-18	HLS-18S	19,5	29,0	HLB-18	HLB-18S	19,5	34,5
20	HLS-20	HLS-20S	21,4	30,7	HLB-20	HLB-20S	21,4	39,0
22	HLS-22	HLS-22S	23,4	34,5	HLB-22	HLB-22S	23,4	42,0
24	HLS-24	HLS-24S	25,3	39,0	HLB-24	HLB-24S	25,3	48,5
27	HLS-27	HLS-27S	28,4	42,0	HLB-27	HLB-27S	28,4	48,5
30	HLS-30	HLS-30S	31,4	47,0	HLB-30	HLB-30S	31,4	58,5
33	HLS-33	HLS-33S	34,4	48,5	HLB-33	HLB-33S	34,4	58,5
36	HLS-36	HLS-36S	37,4	55,0	HLB-36	HLB-36S	37,4	63,0
39	HLS-39	HLS-39S	40,4	58,5	-	-	-	-
42	HLS-42	HLS-42S	43,2	63,0	-	-	-	-
Inch	**steel**	**stainless steel**	**inner-Ø [mm]**	**outer-Ø [mm]**	**steel**	**stainless steel**	**inner-Ø [mm]**	**outer-Ø [mm]**
1/4"	HLS-1/4"	HLS-1/4"S	7,2	11,5	HLB-1/4"	HLB-1/4"S	7,2	13,5
3/8"	HLS-3/8"	HLS-3/8"S	10,3	16,6	HLB-3/8"	HLB-3/8"S	10,3	21,0
1/2"	HLS-1/2"	HLS-1/2"S	13,5	19,5	HLB-1/2"	HLB-1/2"S	13,5	25,4
3/4"	HLS-3/4"	HLS-3/4"S	20,0	30,7	HLB-3/4"	HLB-3/4"S	20,0	39,0
1"	HLS-1"	HLS-1"S	27,9	39,0	HLB-1"	HLB-1"S	27,9	48,5

Drawing of HEICO-LOCK Wedge Lock Washer

(HEICO-LOCK HLS-… , standard)



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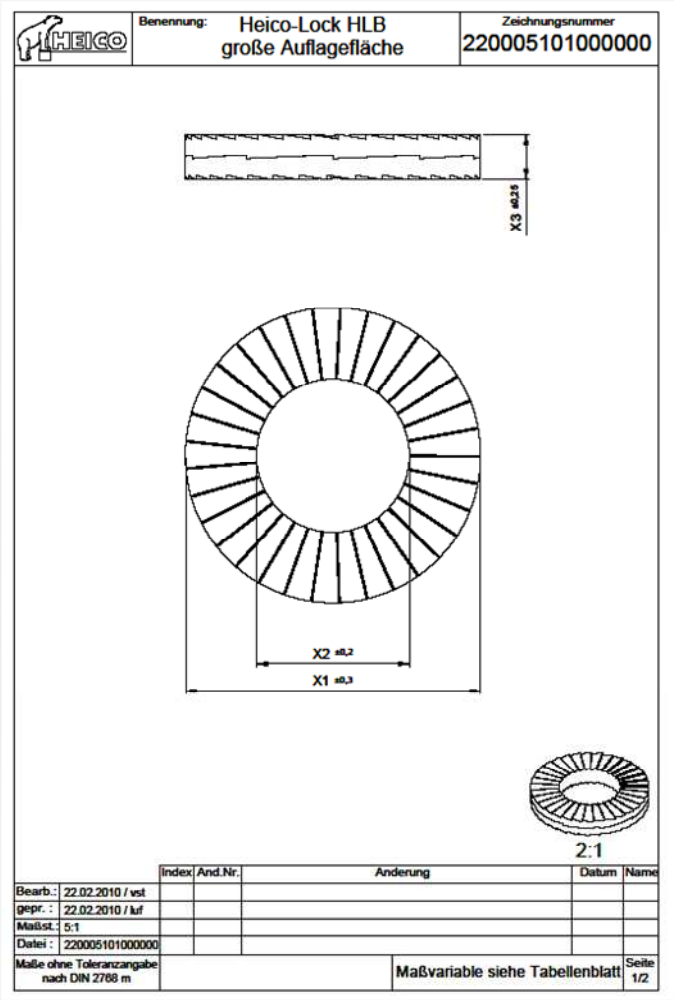
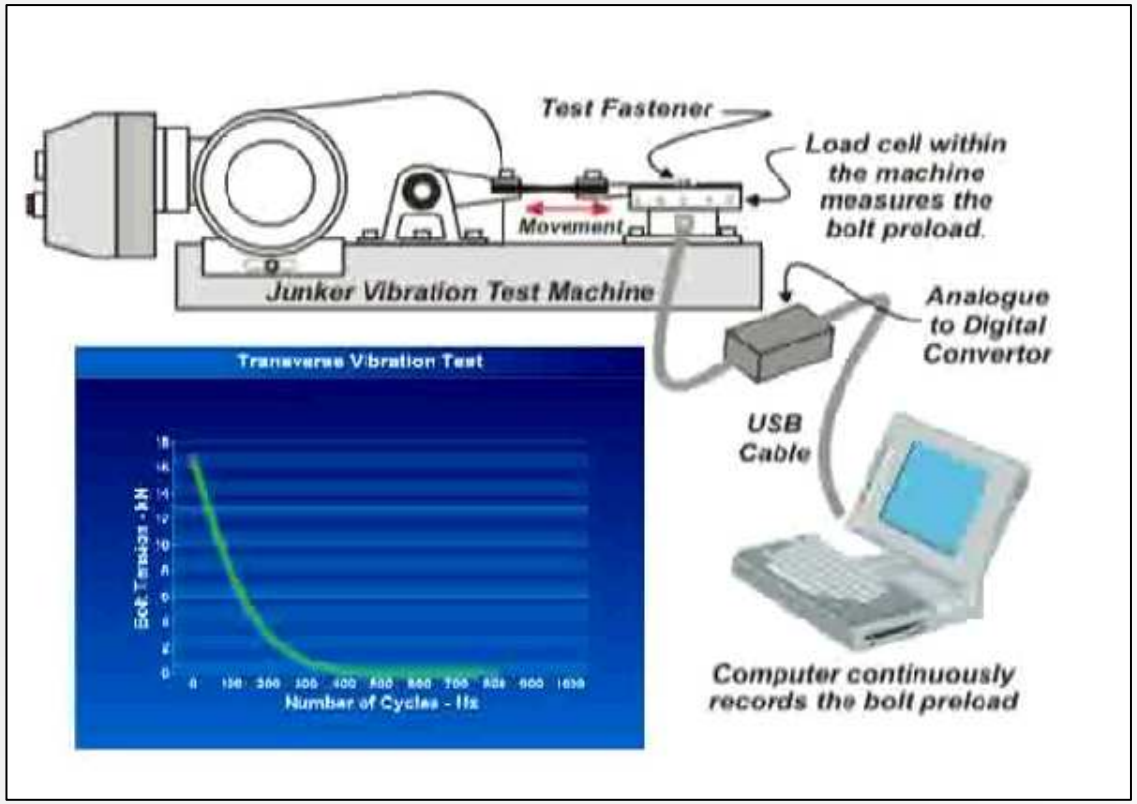
Drawing of HEICO-LOCK wedge lock washer

(HEICO-LOCK HLB-… , large O.D.)



The Junker Vibration Test

The **Junker Vibration Test meeting DIN 65151** (Dynamic testing of the locking characteristics of fasteners under transverse loading conditions vibration test) standards is a common and reliable method for testing and comparing the security of bolted joints.



The Junker Vibration Test Concept

The "Junker's" transverse vibration-loosening test provides a simplified method for broad scale testing and inspection of the transverse vibration (loosening) properties of fasteners. The test machine is able to generate relative motion in the clamped parts perpendicular to the axis of the fasteners.The Junkers method provides quantitative results relating the variables of clamp-load, number of cycles, and amplitude.

The Junkers test is considered a 'severe' test of the loosening characteristics of fasteners, particularly when compared to previously introduced test methods which rely on axial dynamic loading to induce loosening. Junker largely established the viability of the current method in a paper entitled, 'Investigations of the Mechanism of Self-Loosening and Optimal Locking of Bolted Connections'.

A comparison transverse vibration test is designed to expose two or more fastener sets to the same test parameters to determine the effects of the differences.The present research compared nut-bolt-washer assemblies with nut-bolt-DTI assemblies. To better understand vibration loosening, Junker's provides us with models of bolted joints under static conditions and under transverse vibration.

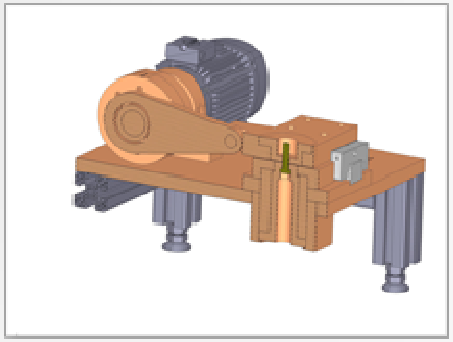
Results of transverse vibration-loosening tests are useful for deployment of bolting strategies which reduce or prevent the risk of vibration loosening in service, or mitigate its effects where it cannot be avoided entirely. According to Gerhard H. Junker, originator of this test, "It is well established that a dynamically loaded joint fails in most cases either by fatigue failure or by rotation loosening of the fastener. Even the fatigue failure is often initiated by partial loosening."

Results of HEICO-Lock Washer Junker Test

Vibration loosening of the fasteners which did not include Heico-Lock washers was clearly evident. Vibration loosening of the fasteners set with Heico-Lock washers was noticeable less than those with other locking fasteners. The retained clamp load after cycling was higher with Heico-Lock washers than with other fastening methods.

Conclusion:
Under the conditions of the subject test, there was a significant difference in the loss of clamp load between fastener sets with and without Heico-Lock wedge lock washers. Fasteners without Heico-Lock washers lost a large percentage of their initial clamp force after cycling contrasted with a much smaller loss in the fasteners set with Heico-Lock washers. Under the test parameters and conditions of the study, Heico-Lock washers provide improved resistance to vibration-loosening.

As stated above, the test was conducted in accordance with DIN 65151. In addition, the exact test method and testing sequence was specified and will be added to **DIN 25201** ('Design guide for railway vehicles and their components - Bolted joints - Part 2: Design - Mechanical applications'). These parameters were designed and verified in an industry promoted research project that was conducted by the Fachhochschule Koeln (University of Applies Science Cologne, Germany) and the IMA Research Institute, Dresden, Germany. This process will become part of **DIN 25201 in an addendum named DIN 25201-4.**



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DIN 25201-4: 2010-03 Test Procedures

- Tighten the bolted joint at 50 % of recommended preload as shown in VDI 2230
- Use light lubricant with a viscosity similar to SAE 30
- Tread surface, threads and washers with molythane disulfide
- Run vibration test until either total loss of preload or stop after 2,000 cycles
- Measure and collect preload, axial movement and vibration cycles
- Determine function of wedge lock washer either by total loss of preload under 2000 cycles
- Or measure and establish the percentage of loss of preload after 2,000 cycles
- Durability of the bolted joint is sufficient if 80 % of initial preload is retained •
- And the graded index shows that a total loss of preload is highly unlikely

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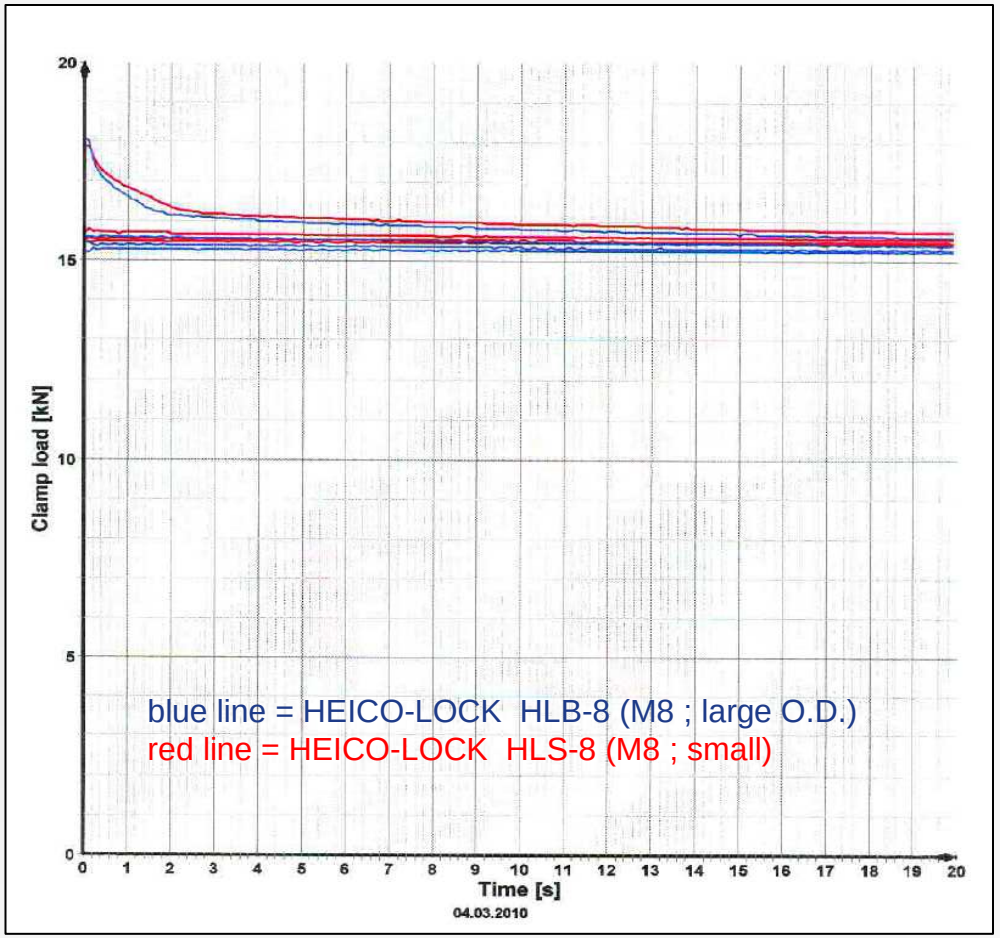
Junker Vibration Test (Hamburg, 2010-03-04)

→ HEICO-LOCK M8 (narrow & broad) ←

Junker Vibration Test

- Illustration at full pre-load (18 kN)
- Every washer was tested four times in succession
  - HEICO-LOCK HLS-8 → red line
  - HEICO-LOCK HLB-8 → blue line
- The results are continuous – the recoverability is proven



Summary:

- **In full accordance with the only existing DIN Norm for lock washers, DIN 25201-4:2010-03**
- **Heico-Lock washers meet the most demanding requirements of DIN 25201-4:2010-03**
- **HEICO-LOCK washers, at 50 % of recommended preload values retain over 80 % of initial preload at 2,000 cycles!**
- **Wedge lock washers, the only products meeting DIN 25201-4:2010-03 requirements**
- **Heico-Lock Wedge Lock Washers... better, more reliable.**

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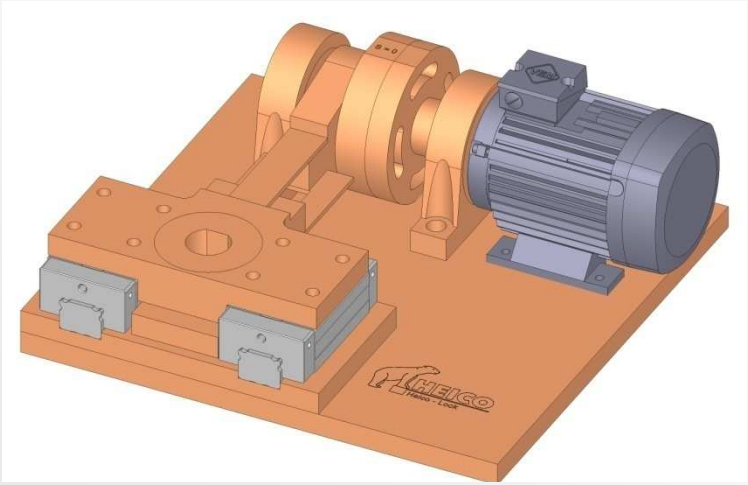
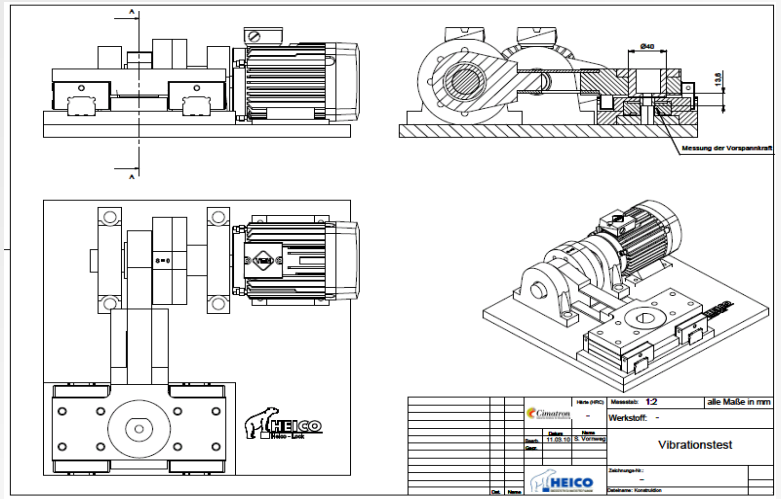
HEICO Junkertest Equipment

- HEICO‘s own test bench is up and running since Mid September 2010
- This test bench enables HEICO and Heico distributors to ensure fast and easy support for their end users.
- Official tests can be addressed and arranged in co-operation with the University of Applied Sciences Cologne.





HEICO-LOCK wedge lock washers product list

M	HEICO-Lock (narrow) steel	HEICO-Lock (narrow) stainless steel	HEICO-Lock (broad) steel	HEICO-Lock (broad) stainless steel
3	HLS-3	HLS-3S	-	-
3,5	HLS-3,5	HLS-3,5S	HLB-3,5	HLB-3,5S
4	HLS-4	HLS-4S	HLB-4	HLB-4S
5	HLS-5	HLS-5S	HLB-5	HLB-5S
6	HLS-6	HLS-6S	HLB-6	HLB-6S
8	HLS-8	HLS-8S	HLB-8	HLB-8S
10	HLS-10	HLS-10S	HLB-10	HLB-10S
11	HLS-11	HLS-11S	-	-
12	HLS-12	HLS-12S	HLB-12	HLB-12S
14	HLS-14	HLS-14S	HLB-14	HLB-14S
16	HLS-16	HLS-16S	HLB-16	HLB-16S
18	HLS-18	HLS-18S	HLB-18	HLB-18S
20	HLS-20	HLS-20S	HLB-20	HLB-20S
22	HLS-22	HLS-22S	HLB-22	HLB-22S
24	HLS-24	HLS-24S	HLB-24	HLB-24S
27	HLS-27	HLS-27S	HLB-27	HLB-27S
30	HLS-30	HLS-30S	HLB-30	HLB-30S
33	HLS-33	HLS-33S	HLB-33	HLB-33S
36	HLS-36	HLS-36S	HLB-36	HLB-36S
39	HLS-39	HLS-39S	-	-
42	HLS-42	HLS-42S	-	-

Inch	HEICO-Lock (narrow) steel	HEICO-Lock (narrow) stainless steel	HEICO-Lock (broad) steel	HEICO-Lock (broad) stainless steel
1/4"	HLS-1/4"	HLS-1/4"S	HLB-1/4"	HLB-1/4"S
3/8"	HLS-3/8"	HLS-3/8"S	HLB-3/8"	HLB-3/8"S
1/2"	HLS-1/2"	HLS-1/2"S	HLB-1/2"	HLB-1/2"S
3/4"	HLS-3/4"	HLS-3/4"S	HLB-3/4"	HLB-3/4"S
1"	HLS-1"	HLS-1"S	HLB-1"	HLB-1"S

…additional sizes up to M130 are available upon request. Other alloys are available as well.

Application examples for wedge lock washers

→ Industrial Vehicles


→ Processing Machinery


→ Mining & Forestry


→ Wind Power & Turbins


→ Railway & Transportation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Application examples for wedge lock washers

→ Automotive Industry


→ Miscellaneous Applications






HEICO

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