



PRESENTATION OF TESTS ON **TENKEEP**[®] SAFETY WASHER



Growermetal carry-out in-house zinc flake coatings using exclusively original Dörken MKS® products offering a wide range of base-coats and top-coats.

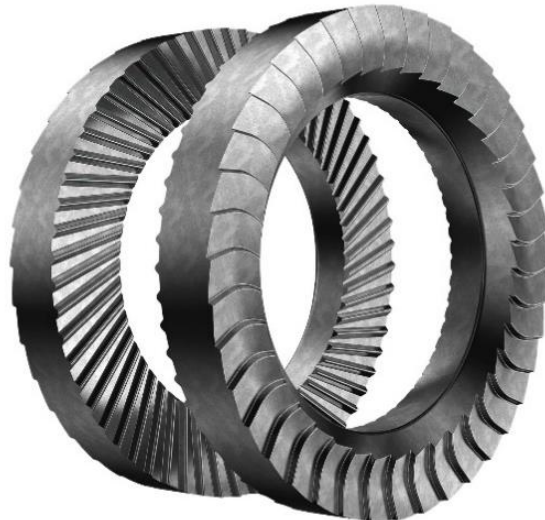
Growermetal's coating line has been specifically designed for carrying out surface coatings on washers and flat parts with the best quality result.

 **DÖRKEN MKS®**
THE CORROSION EXPERTS

NEW SAFETY WASHER

The R&D department of Growermetal has developed an innovative safety flat washer, which assures a very high performing anti-loosening effect in bolted-joint connections, even in the most demanding applications, in presence of vibrations and dynamic loads.

GROWER
TENKEEP®



TenKeep safety flat washer shows an innovative geometry with 2 different serrations on the 2 sides.

Side A - "Boomerangs"

Side in contact with the under-head of the bolt

Serrations with saw-tooth section

Chamfer on the hole of this side

The chamfer has 2 main functions:

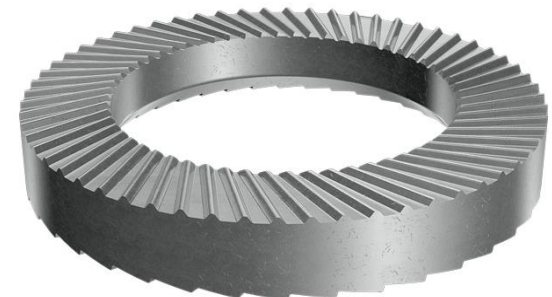
- Avoid any interference of the hole of the washer with the radius under the head of every DIN and ISO bolt
- Help the user to position correctly the washer



Side B - "Teeth"

Side in contact with the bearing surface

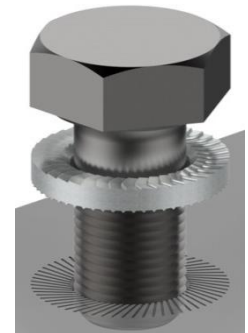
Serration with triangular section



- ❑ During the tightening and untightening of the bolted joint, the TenKeep washer does not rotate and thus **does not damage** the bearing surface (Steel <300 HV, Aluminum, KTL...).
- ❑ The friction conditions are **defined and uniform**, not depending on the material and on the mechanical features of the bearing surface. As a consequence the tightening torque to be applied in order to achieve the desired screw preload is always the same.
- ❑ The untightening torque is **significantly higher** (+40% minimum) than the tightening torque.
- ❑ **Stick-slip** effect is significantly reduced.

NEW SAFETY WASHER

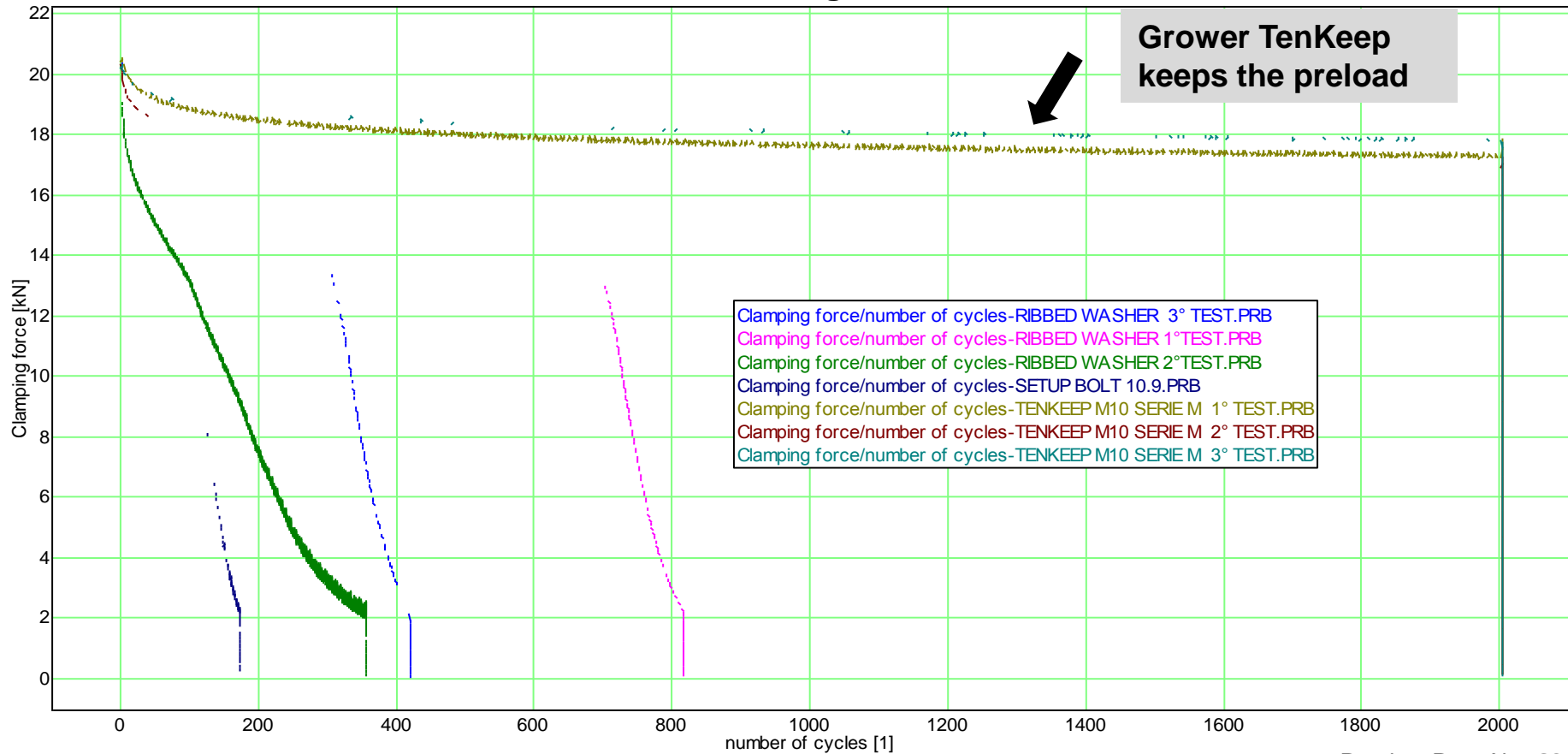
- ❑ TenKeep is a **safety flat washer** with an innovative geometry
- ❑ **High anti-loosening effect** in bolted joint connections
- ❑ **Keeps the preload** in presence of external stress, such as vibrations and dynamic loads
- ❑ The working principle is based on **friction**
- ❑ Usable with up to **12.9 bolt** class
- ❑ **Reusable** several times without loss in performance
- ❑ Standard coating Delta Protekt KL120 – min **1000 hours NSS**



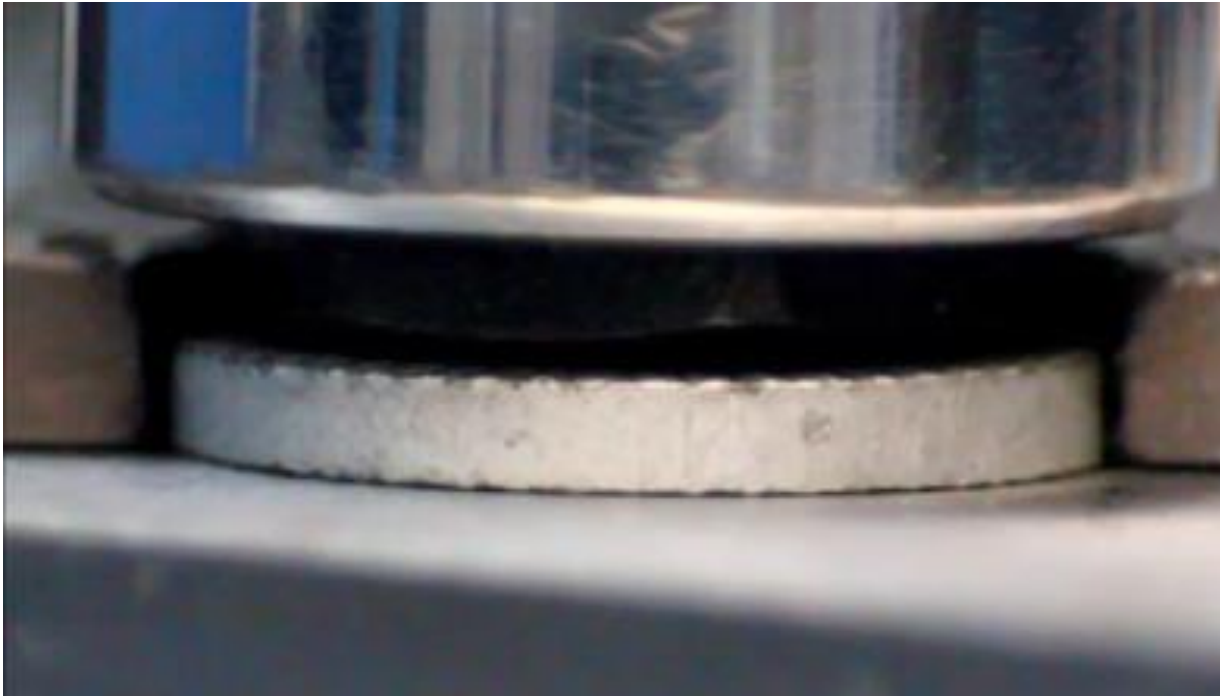
TenKeep washer Junker Test

TEST PARAMETERS			
Specification	DIN 65151 – DIN 25201-4	Bolt	M10 10.9 KL100 + VH302 GZ
Clamping load	21,2 kN	TenKeep washer	M10 L KL120
Test plate	Steel 200 HV	Clamp length	40 mm

Loosening test



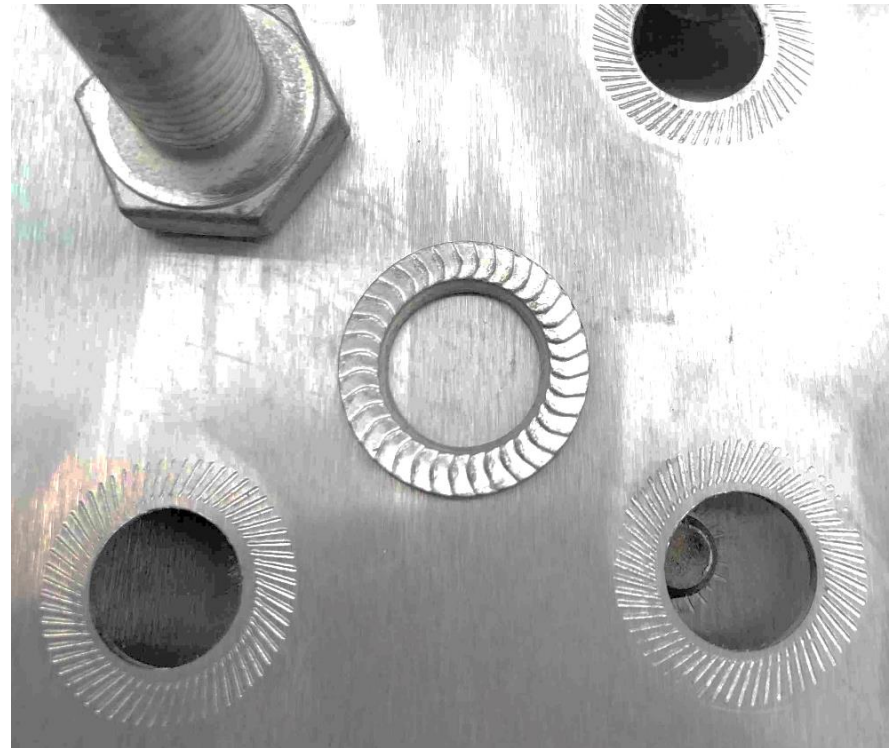
TenKeep washer functional test



- ❑ The slow motion shows that the TenKeep washer does not slip during tightening and untightening on materials with hardness lower than 300 HV

TenKeep washer functional test vs other ribbed washer

Bearing surface 200 Hv grinded steel



- The TenKeep washer clearly indent the bearing surface and does not slip during tightening and untightening

Coefficient of friction

Reference standard: VW 01131 / VW 01129

Bearing surfaces: Aluminum, KTL

Loosening behavior under heat strain

Reference standard: VDA 203-235 / VW 01131

Break-Away Torque

Reference standard: DIN EN ISO 16047 (0.75 Fp – 20rpm)

Reference standard: VW 01126 (55 Nm + 90° 200/20 rpm)

Stick-slip effect

TESTING THE COF



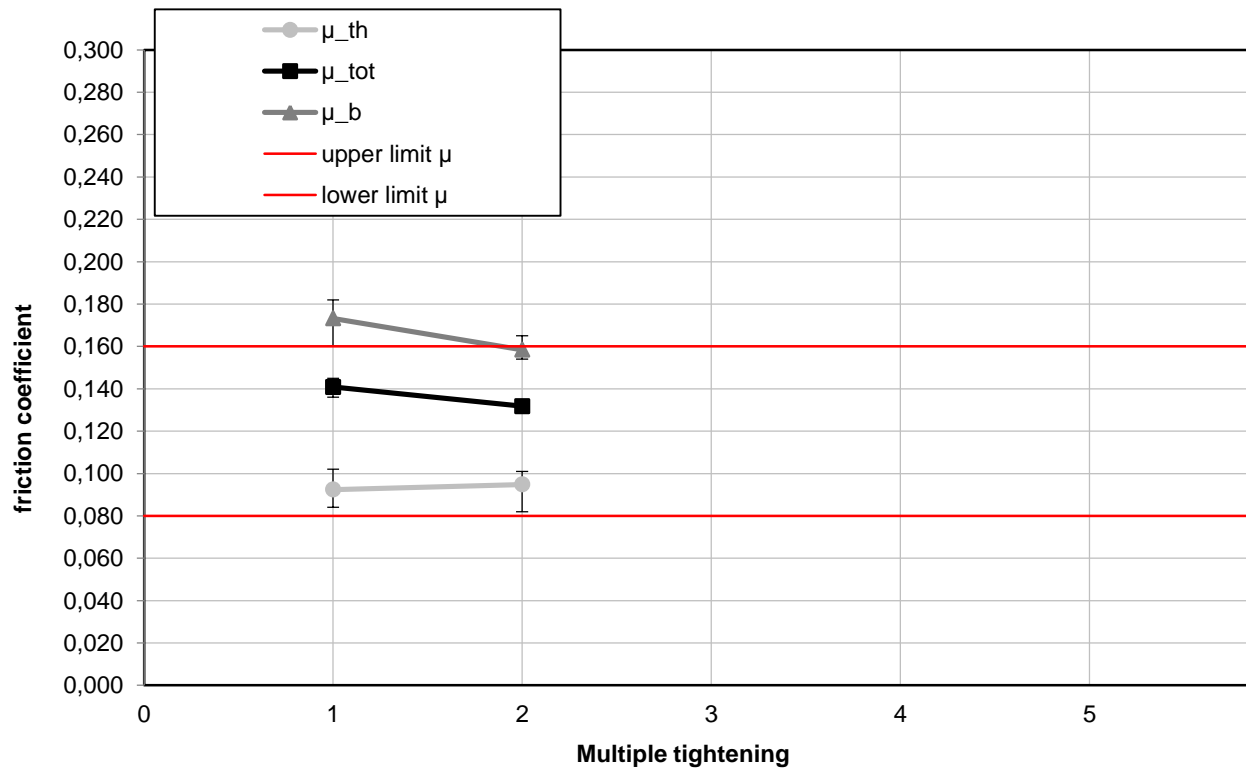
VW 01131 TenKeep on Aluminum

TEST PARAMETERS			
Specification	VW 01131 / VW 01129	Bolt	M10x65 Flange VW 10.9 KL120 + VH301.1GZ (5 bolts)
Fastening speed	200/20 rpm	Nut	VW 60449 M10 10 c340
Test plate	AlMnMgSi1 100 HB Rz15 K&K	TenKeep washer	M10 L KL120
Temperature	21 °C	Clamp length	45 mm

μ_{tot}		1,000	2,000	3,000	4,000	5,000	mean value
	1. Tightening	0,143	0,145	0,140	0,136	0,140	0,141
	2. Tightening	0,132	0,134	0,130	0,133	0,130	0,132
μ_{th}		1,000	2,000	3,000	4,000	5,000	mean value
	1. Tightening	0,084	0,089	0,096	0,102	0,091	0,092
	2. Tightening	0,082	0,098	0,092	0,101	0,101	0,095
μ_b		1,000	2,000	3,000	4,000	5,000	mean value
	1. Tightening	0,182	0,182	0,169	0,160	0,173	0,173
	2. Tightening	0,165	0,159	0,156	0,154	0,158	0,158

TESTING THE COF

VW 01131 TenKeep on Aluminum



- Bolt underhead COF above the window.
- However according to the VW specification the COF values can be higher with locking serration parts
- No stick-slip effects occurred

TESTING THE COF



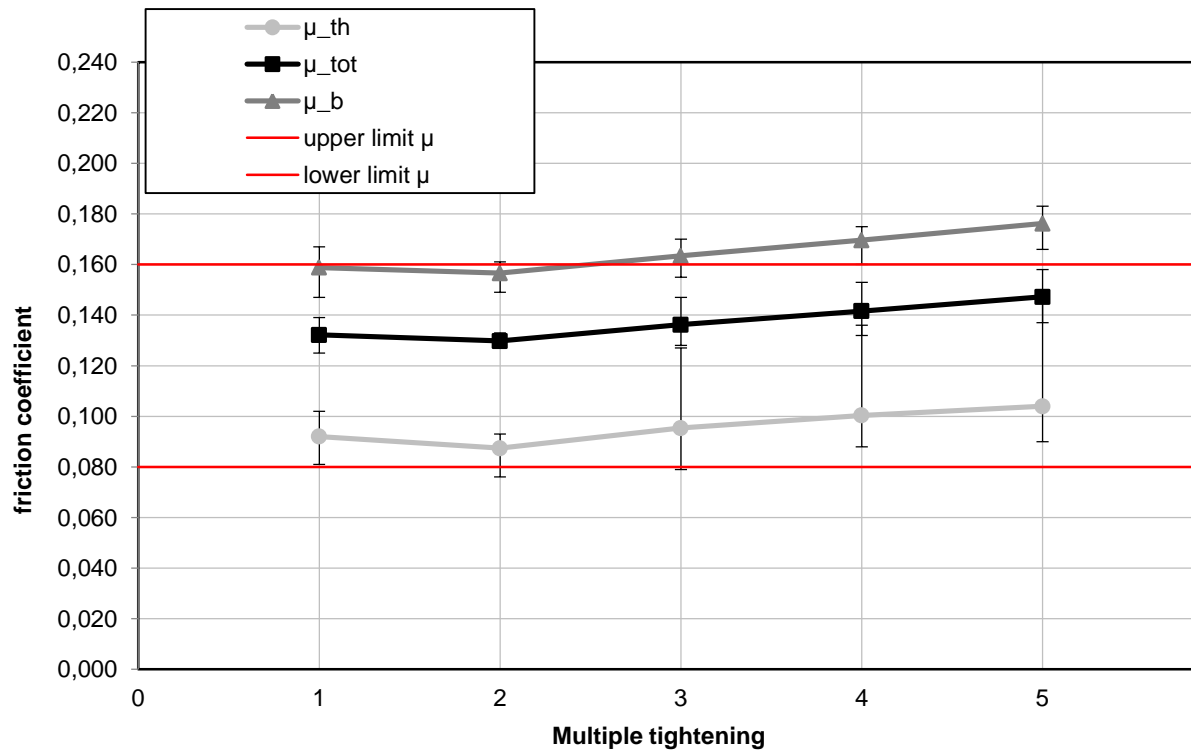
VW 01131 TenKeep on KTL

TEST PARAMETERS			
Specification	VW 01131 / VW 01129	Bolt	M10x65 Flange VW 10.9 KL120 + VH301.1GZ (5 bolts)
Fastening speed	200/20 rpm	Nut	VW 60449 M10 10 c340
Test plate	KTL Aqua EC 100HB	TenKeep washer	M10 L KL120
Temperature	21 °C	Clamp length	45 mm

		1,000	2,000	3,000	4,000	5,000	mean value
		μ_{tot}	1. Tightening	0,126	0,135	0,125	0,139
	2. Tightening	0,127	0,129	0,127	0,133	0,133	0,130
	3. Tightening	0,134	0,136	0,128	0,136	0,147	0,136
	4. Tightening	0,140	0,140	0,132	0,143	0,153	0,142
	5. Tightening	0,147	0,146	0,137	0,148	0,158	0,147
μ_{th}		1,000	2,000	3,000	4,000	5,000	mean value
	1. Tightening	0,081	0,089	0,092	0,096	0,102	0,092
	2. Tightening	0,076	0,087	0,088	0,093	0,093	0,087
	3. Tightening	0,079	0,088	0,089	0,094	0,127	0,095
	4. Tightening	0,088	0,089	0,091	0,098	0,136	0,100
	5. Tightening	0,093	0,090	0,093	0,098	0,146	0,104
μ_b		1,000	2,000	3,000	4,000	5,000	mean value
	1. Tightening	0,155	0,166	0,147	0,167	0,159	0,159
	2. Tightening	0,161	0,158	0,154	0,161	0,149	0,157
	3. Tightening	0,170	0,168	0,155	0,164	0,160	0,163
	4. Tightening	0,175	0,175	0,160	0,174	0,164	0,170
	5. Tightening	0,183	0,183	0,166	0,182	0,167	0,176

TESTING THE COF

VW 01131 TenKeep on KTL



- Bolt underhead COF above the window.
- However according to the VW specification the COF values can be higher with locking serration parts
- No stick-slip effects occurred

LOOSENING UNDER HEAT STRAIN

Loosening behavior under heat strain according to VW 01131

TEST PARAMETERS			
Specification	VDA 203-235 / VW 01131 / VW 01129	Bolt	M10x65 10.9 KL120 + VH301.1GZ (5 bolts)
Fastening speed	5 rpm	Nut	VW 60449 weld nut M10-10 c340
Test plate	HL 220HV Ra0,4	TenKeep washer	M10 L KL120
Temperature	20 °C / 150 °C	Clamp length	50 mm

HEAT STRAIN TEST WITHOUT WASHER								
Tightening (Nm)	Loosening (Nm)	%	Slope	D Ø	Db	μ_{tot} at RT	μ_{tot} loosening	mean value
55,25	22,0	40	1,5	10	13,5	0,083	0,063	0,061
55,34	21,0	38	1,5	10	13,5	0,083	0,061	
55,72	21,0	38	1,5	10	13,5	0,083	0,061	
55,25	21,0	38	1,5	10	13,5	0,083	0,061	
55,53	20,0	36	1,5	10	13,5	0,083	0,059	

Without washer loosening behaviour barely ok

- $\mu_{tot,loosening,150^\circ} \geq 0,059$
- Mean $\mu_{tot,loosening,150^\circ} = 0,061$

HEAT STRAIN TEST WITH ORIGINAL TENKEEP WASHER								
Tightening (Nm)	Loosening (Nm)	%	Slope	D Ø	Db	μ_{tot} at RT	μ_{tot} loosening	mean value
54,98	45,0	82	1,5	10	13,5	0,139	0,157	0,150
54,86	40,0	73	1,5	10	13,5	0,139	0,142	
54,97	44,0	80	1,5	10	13,5	0,139	0,154	
54,93	44,0	80	1,5	10	13,5	0,139	0,154	
54,92	40,0	73	1,5	10	13,5	0,139	0,142	

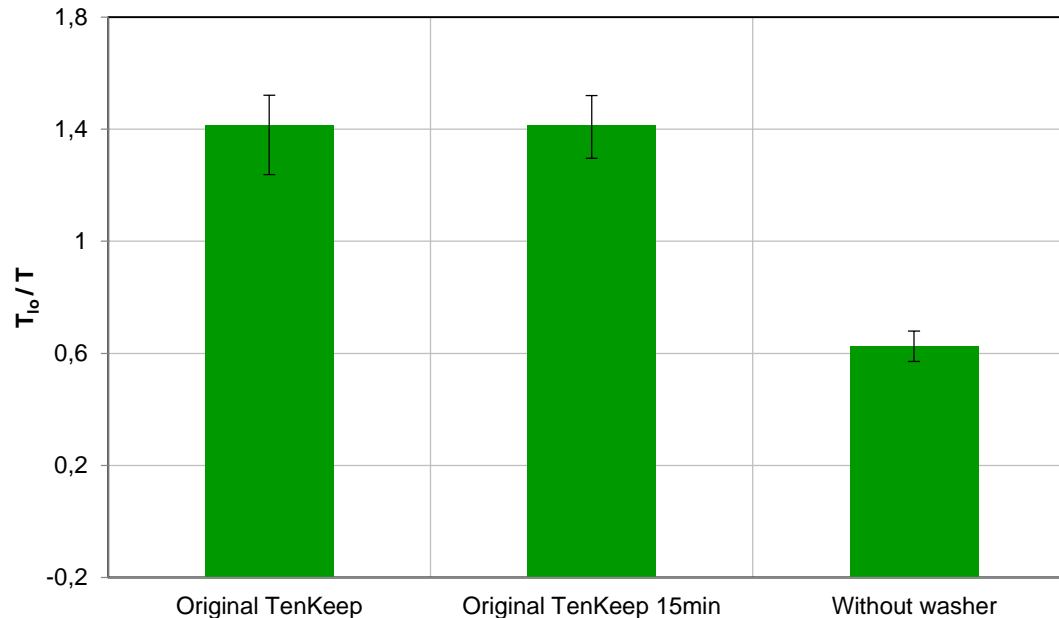
With TenKeep washer way better loosening behavior under heat strain

- $\mu_{tot,loosening,150^\circ} \geq 0,142$
- Mean $\mu_{tot,loosening,150^\circ} = 0,150$
- Loosening torque twice as high

BREAK-AWAY TORQUE

Break-Away Torque 0.75 Fp – 20rpm

TEST PARAMETERS			
Specification	DIN EN ISO 16047	Bolt	M10x65 Flange VW 10.9 KL120 + VH301.1GZ (5 bolts)
Fastening speed	20 rpm	Nut	ISO 4032 M10 10
Test plate	AlMnMgSi1 100 HB Rz15 K&K	TenKeep washer	M10 L KL120
Temperature	21 °C	Clamp length	50 mm

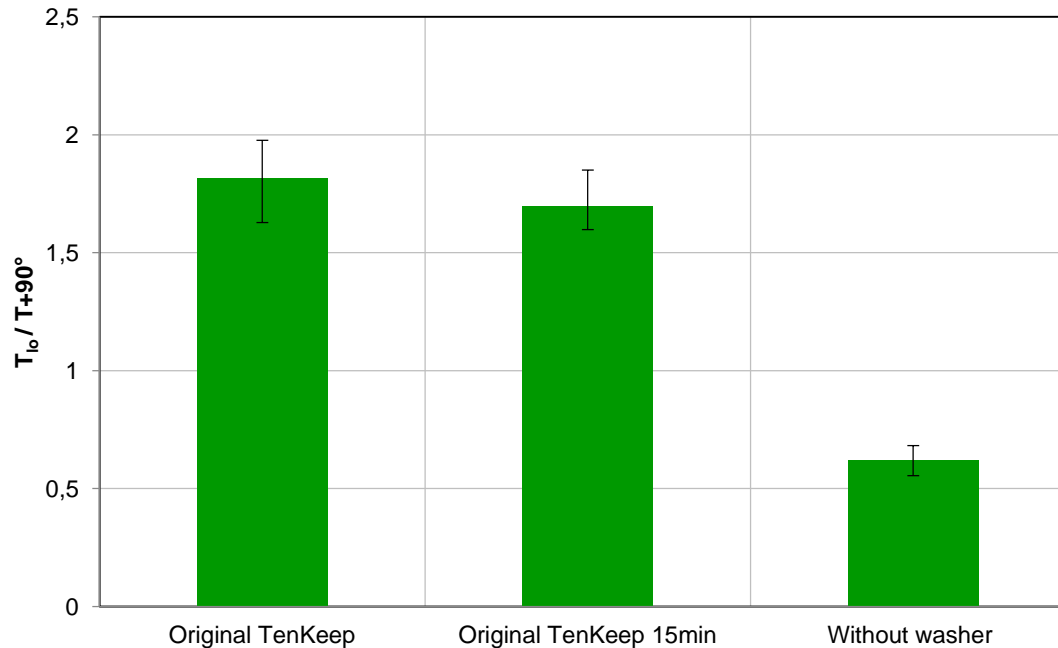


- ❑ The loosening torque measurement without a washer is low (torque ratio: 0,62)
- ❑ With the original TenKeep washer the loosening torque is substantially higher (torque ratio: 1,42)
- ❑ A waiting time between the tightening and loosening of 15 min shows no significant effect

BREAK-AWAY TORQUE

Break-Away Torque 55 Nm + 90° 200/20 rpm

TEST PARAMETERS			
Specification	VW 01126 (55 Nm + 90° 200/20 rpm)	Bolt	M10x65 Flange VW 10.9 KL120 + VH301.1GZ (5 bolts)
Fastening speed	200/20 rpm	Nut	ISO 4032 M10 10
Test plate	AlMnMgSi1 100 HB Rz15 K&K	TenKeep washer	M10 L KL120
Temperature	22 °C	Clamp length	50 mm



- ❑ With the TenKeep washer the loosening torque is much higher (torque ratio: 1,81) compare to the variant without washer (torque ratio: 0,70)
- ❑ A waiting time of 15 min with the TenKeep washer is resulting in a slightly lower loosening torque (torque ratio: 1,70)

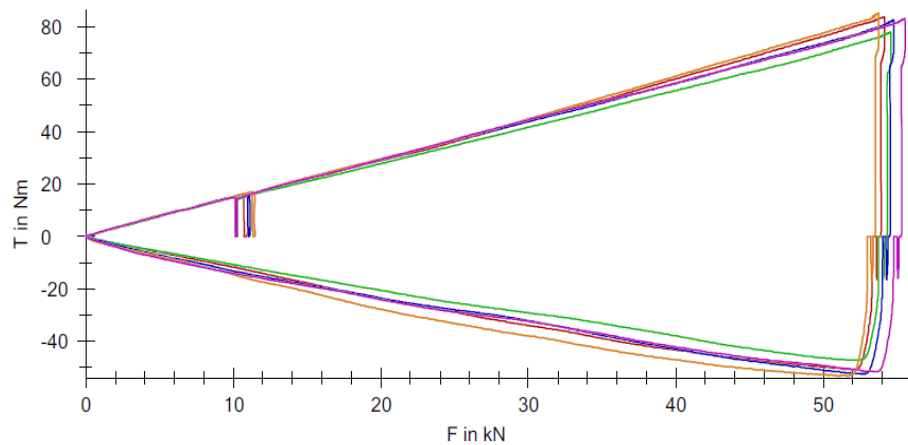
BREAK-AWAY TORQUE

Break-Away Torque 55 Nm + 90° 200/20 rpm

Without washer

Legende	Nr	0,75% F _p kN	D _b Calc mm	μ _{tot1}	μ _{b1}	μ _{th1}	T-200 Nm	T-20 Nm	T+90° Nm	T _{lo} Nm
1.1	36,1	15,5	0,096	0,077	0,125	16,2	55,2	83,8	-50,8	
1.2	36,1		0,089	0,068	0,121	14,9	55,2	77,9	-47,3	
1.3	36,1		0,094	0,074	0,124	16,4	55,3	82,5	-52,4	
1.4	36,1		0,099	0,083	0,122	17,1	55,3	85,2	-53,2	
1.5	36,1		0,095	0,076	0,124	15,0	55,2	83,2	-51,6	

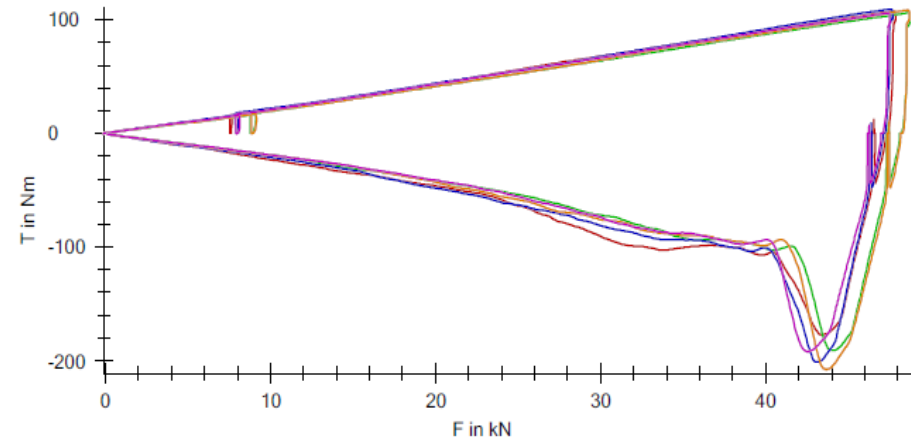
Unterserie 1 n = 5	0,75% F _p kN	D _b Calc mm	μ _{tot1}	μ _{b1}	μ _{th1}	T-200 Nm	T-20 Nm	T+90° Nm	T _{lo} Nm
x	36,1	-	0,095	0,075	0,123	15,9	55,2	82,5	-51,1
s	0,0	-	0,004	0,005	0,002	1,0	0,1	2,7	2,3
min	36,1	-	0,089	0,068	0,121	14,9	55,2	77,9	-53,2
max	36,1	-	0,099	0,083	0,125	17,1	55,3	85,2	-47,3
R	0,0	-	0,010	0,015	0,005	2,2	0,1	7,2	6,0



With Original TenKeep washer

Legende	Nr	0,75% F _p kN	D _b Calc mm	μ _{tot1}	μ _{b1}	μ _{th1}	T-200 Nm	T-20 Nm	T+90° Nm	T _{lo} Nm
1.1	36,1	15,5	0,156	0,183	0,116	15,3	55,3	106,9	-177,3	
1.2	36,1		0,149	0,170	0,117	16,9	55,3	105,3	-191,1	
1.3	36,1		0,157	0,179	0,126	17,3	55,2	108,9	-201,2	
1.4	36,1		0,152	0,180	0,110	17,2	55,3	108,0	-207,7	
1.5	36,1		0,155	0,172	0,129	16,1	55,3	105,1	-191,9	

Unterserie 1 n = 5	0,75% F _p kN	D _b Calc mm	μ _{tot1}	μ _{b1}	μ _{th1}	T-200 Nm	T-20 Nm	T+90° Nm	T _{lo} Nm
x	36,1	-	0,154	0,177	0,120	16,6	55,3	106,8	-193,8
s	0,0	-	0,003	0,005	0,008	0,9	0,0	1,7	11,5
min	36,1	-	0,149	0,170	0,110	15,3	55,2	105,1	-207,7
max	36,1	-	0,157	0,183	0,129	17,3	55,3	108,9	-177,3
R	0,0	-	0,009	0,012	0,019	2,0	0,1	3,8	30,3



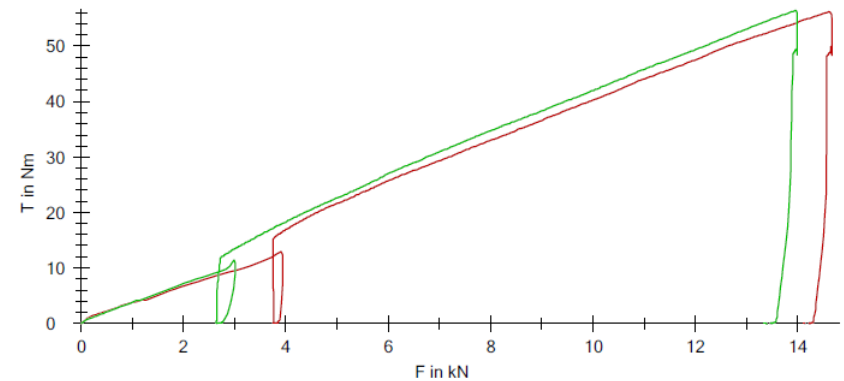
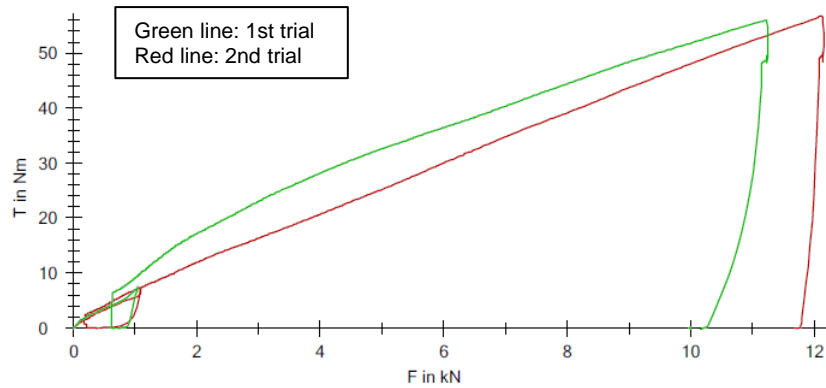
TEST PARAMETERS

Bolt	M10X80 8.8 ZiNi + Passivation	Clamp length	60 mm
TenKeep washer	M10 L Delta Protekt KL120	Temperature	21 °C
Bearing surface	KTL PPG 6 France		

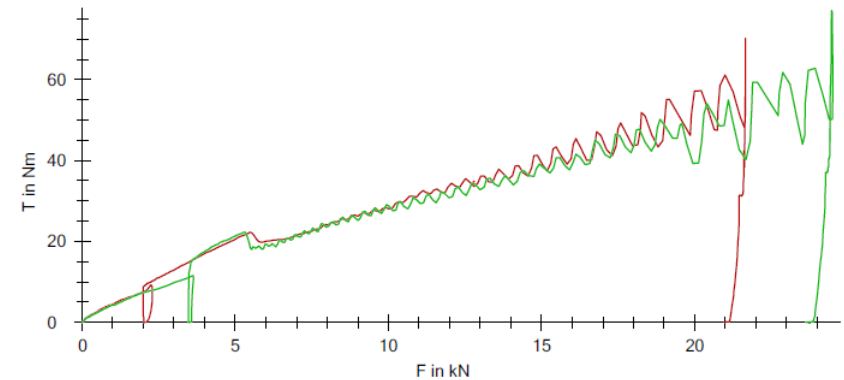
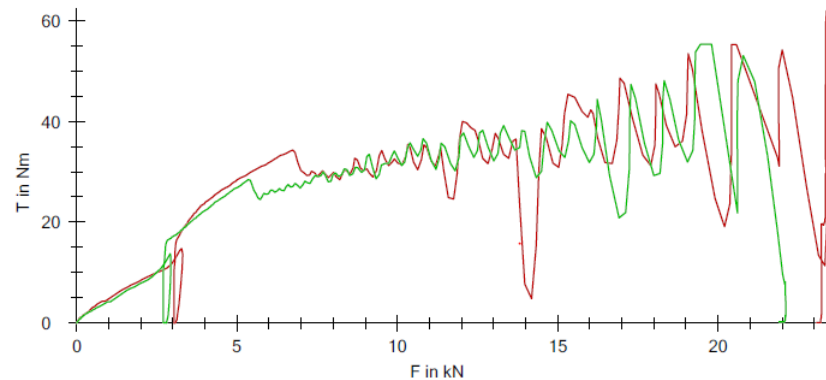
Without washer

With Original TenKeep washer

200/20
rpm



200/100
rpm



- Under normal assembly conditions (200/20 rpm) no stick slip effects occurred
- Stick slip effect was provoked by unusual assembling with 200/100 rpm
- Stick slip effect was significantly reduced by the use of the TenKeep washer

❑ **Coefficient of friction**

Reference standard: MBN 10544

Bearing surfaces: Steel 220 HV, Steel 54 HRc, Aluminum, KTL

Compare TenKeep, Flat washer, No washer

Test with concave bolt under-head geometry

Test with different top-coat

❑ **Vibration test**

Axial eccentric alternate stress - “Helicopter test”

Reference standard: NFE 25-046-2 (draft standard)



- Safety washer that keeps the preload in presence of vibrations
- Very good behavior on Aluminum, KTL and steel <300 HV
- No slipping on the bearing surface
- High break-away torque
- Good loosening behavior under heat strain
- No or improved stick-slip effect



**THANK YOU
FOR YOUR ATTENTION !**

Further information on:

www.growermetal.com