

LIGHTWEIGHT AND COMPACT

single-position  
multi-position

# SAFETY COUPLINGS

SERIES SL | 5 – 700 Nm



**R+W**<sup>®</sup>  
COUPLING TECHNOLOGY

THE ULTIMATE COUPLING FROM 5 – 700 Nm

[www.rwcouplings.com](http://www.rwcouplings.com)

single-position  
multi-position

optional  
stainless  
steel

# SERIES SL

## DESIGN / FEATURES



- **Extremely lightweight construction**
- Up to 60 % weight reduction in comparison to the standard series
- Torque rating increased by 50 %
- Good dynamic characteristics
- Spring tensioned ball-detent principle with absolutely zero backlash
- Corrosion resistant
- Very simple torque setting

## TORQUE SETTING

These safety couplings are preset by R+W to the customer's specified values.

**Changes to the preset value are very simple to make:**

- Loosen the adjustment nut's clamp screw.
- Turn the adjustment nut until the reference mark indicates the desired value. (see Torque scale)
- Tighten down the adjustment nut's clamp screw.



## MODELS

## FEATURES

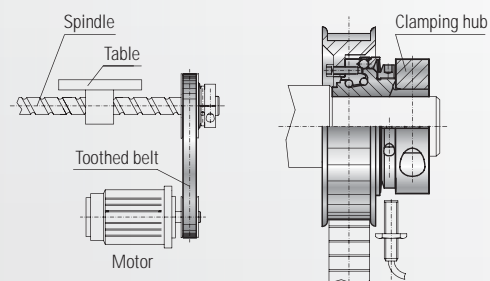
## POSSIBLE APPLICATIONS

### SLN



#### With clamping hub for indirect drives

- Integral bearing for timing belt pulley or sprocket
- Compact, simple construction
- Torque setting is continuously variable
- Frictional clamp connection
- Simple to install



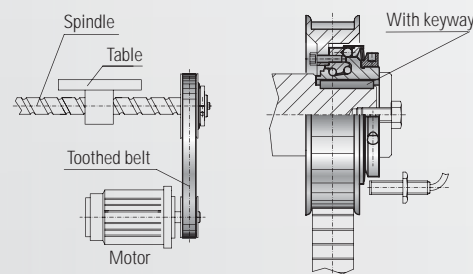
see page 4

### SLP



#### With keyway connection for indirect drives

- Integral bearing for timing belt pulley or sprocket
- Compact, simple construction
- Torque setting is continuously variable
- Simple keyed connection



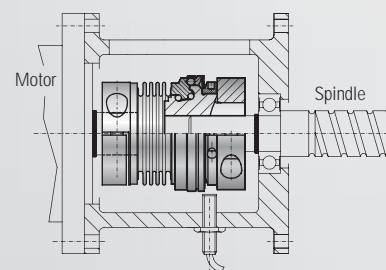
see page 5

### SL 2



#### With clamping hub for direct drives

- Easy to install
- Low moment of inertia
- Small space requirement
- Misalignment compensation
- Torque setting is continuously variable



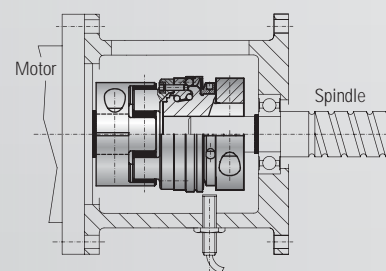
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### SLE



#### With clamping hub for direct drives

- Easy to install
- Vibration damping
- Misalignment compensation
- Torque setting is continuously variable

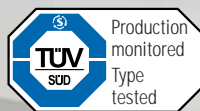


see page 7



single-position  
multi-position

# MODEL SLN



## BACKLASH FREE TORQUE LIMITER

with clamping hub

### Design:

With clamp collar and screw per ISO 4762  
Components of compact and rigid design with  
backlash free interface

**Temperature range:** -30 to +120°C

### Service life:

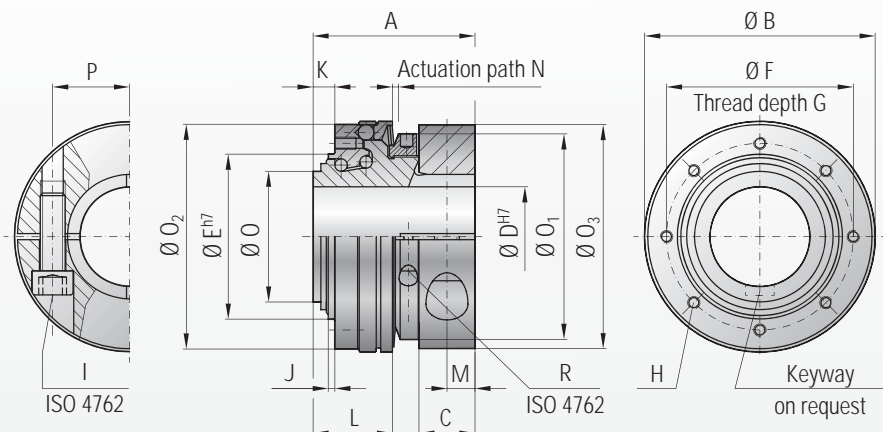
These couplings are maintenance free and stable  
over their entire service life if technical limits are  
not exceeded

### Fit tolerance:

Overall clearance between shaft and hub  
0.01-0.05 mm

### Function system:

W = single position engagement (standard)  
D = multi position engagement every 60°  
(30, 45, 90° optional)



Model SLN			Series												
			30			60			150			300			
Adjustment range* from - to	(Nm)	T <sub>KN</sub>	5-40	30-80	40-135	30-80	60-120	100-200	30-100	80-200	100-300	200-350	300-450	400-550	550-700
Overall length	(mm)	A	45			53			63			72			
Actuation ring Ø	(mm)	B	62			74			92			118			
Clamping fit length	(mm)	C	15			18			22			24			
Bore diameter from Ø to Ø H7	(mm)	D	12-30			16-35			19-48			22-60			
Bore diameter with keyway DIN 6885 from Ø to Ø H7		D	12-25.4			16-32			19-44			22-54			
Centering diameter h7	(mm)	E	43			53			68			85			
Bolt-hole circle diameter ± 0.2	(mm)	F	48			60			75			95			
Thread depth +1	(mm)	G	5			6			7			9			
Fastening threads		H	8x M4			8x M4			8x M5			8x M6			
ISO 4762 screw		I	M6			M8			M10			M12			
Tightening torque	(Nm)		15			40			75			130			
Centering length -0.2	(mm)	J	2			2			3			3			
Distance	(mm)	K	6			7			9			9			
Distance to actuation ring edge	(mm)	L	23			26			32			36			
Distance	(mm)	M	7.5			9			11			12			
Actuation path	(mm)	N	1.3			1.5			1.8			2			
Base element Ø	(mm)	O	35			42			54			70			
Adjustment nut Ø	(mm)	O <sub>1</sub>	55			66			82			100			
Flange Ø -0.2	(mm)	O <sub>2</sub>	58			72			87			110			
Clamping hub Ø	(mm)	O <sub>3</sub>	59			72			90			112			
Distance between centers	(mm)	P	21.5			25			33			41			
Adjustment nut's clamp screw ISO 4762		R	M3			M3			M3			M4			
Tightening torque	(Nm)		2			2			2			4.5			
Approx. weight	(kg)		0.3			0.5			0.8			1.5			
Approx. moment of inertia at D max	(10 <sup>-3</sup> Kqm²)	J <sub>ges</sub>	0.15			0.3			1			3			

\* max. transmittable torque depends on the bore diameter; see table below:

(1Nm = 8.85 in lbs)

### Maximum transmittable torque in relation to bore diameter

Series	Ø 12	Ø 15	Ø 20	Ø 25	Ø 30	Ø 35	Ø 40	Ø 45	Ø 50	Ø 55	Ø 60
30	30	55	80	110	130						
60		80	120	160	200	220					
150			200	250	300	350	400	450			
300				350	430	510	590	670	750	830	910

Higher torque ratings possible with key / keyway

optional  
stainless  
steel

single-position  
multi-position

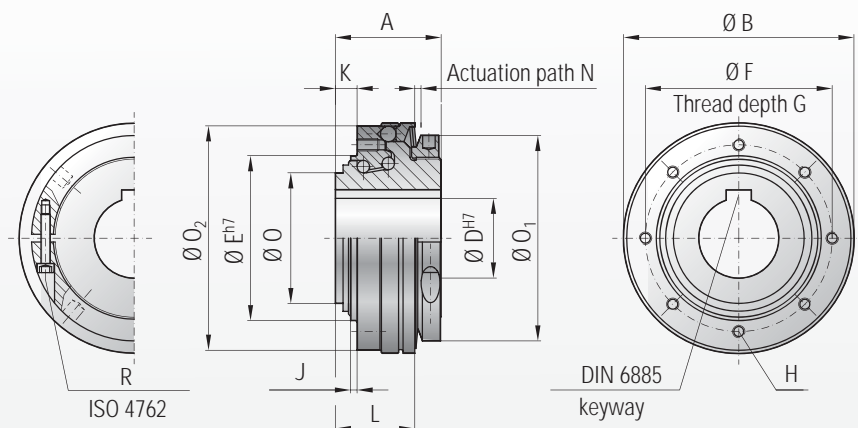
# MODEL SLP



## BACKLASH FREE TORQUE LIMITER



with pure keyway connection



### Design:

Keyway per DIN 6885 or ANSI standard dimensions  
Components of compact and rigid design with backlash free interface

**Temperature range:** -30 to +120°C

### Service life:

These couplings are maintenance free and stable over their entire service life if technical limits are not exceeded

### Fit tolerance:

Overall clearance between shaft and hub  
0.01-0.05mm

### Function system:

W = single position engagement (standard)  
D = multi position engagement every 60°  
(30, 45, 90° optional)

Model SLP			Series												
			30			60			150			300			
Adjustment range from - to	(Nm)	T <sub>KN</sub>	5-40	30-80	40-135	30-80	60-120	100-200	30-100	80-200	100-300	200-350	300-450	400-550	550-700
Overall length	(mm)	A	30			35			41			48			
Actuation ring diameter	(mm)	B	62			74			92			118			
Bore diameter from Ø to Ø H7	(mm)	D	12-25.4 (28)*			16-32 (34)*			19-44 (46)*			22-54 (58)*			
Centering diameter h7	(mm)	E	43			53			68			85			
Bolt-hole circle diameter ± 0.2	(mm)	F	48			60			75			95			
Thread depth +1	(mm)	G	5			6			7			9			
Fastening threads		H	8x M4			8x M4			8x M5			8x M6			
Centering length -0.2	(mm)	J	2			2			3			3			
Distance	(mm)	K	6			7			9			9			
Distance to actuation ring edge	(mm)	L	23			26			32			36			
Actuation path	(mm)	N	1.3			1.5			1.8			2			
Base element Ø	(mm)	O	35			42			54			70			
Adjustment nut Ø	(mm)	O <sub>1</sub>	55			66			82			100			
Flange Ø -0.2	(mm)	O <sub>2</sub>	58			72			87			110			
Adjustment nut's clamp screw		R	M3			M3			M3			M4			
Tightening torque	(Nm)		2			2			2			4.5			
Approx. weight	(kg)		0.2			0.35			0.7			1.1			
Approx. moment of inertia at D max.	(10 <sup>-3</sup> kam <sup>2</sup> )	J <sub>ges</sub>	0.1			0.4			1.1			2.3			

\* max. possible bore diameter if (shallow) keyway per DIN 6883/3 is used

(1Nm = 8.85 in lbs)

## Ordering specifications

SLN/060 / W / 30 / 80 / 60-120/ XX

Model  
Series  
Function system  
Bore Ø D H7  
Disengagement torque (Nm)  
Adjustment range (Nm)  
Special feature, e.g. stainless steel

All data is subject to change without notice.

SLP /060 / W / 30 / 80 / 60-120/ XX

Model  
Series  
Function system  
Bore Ø D H7 with DIN 6885 keyway  
Disengagement torque (Nm)  
Adjustment range (Nm)  
Special feature, e.g. stainless steel

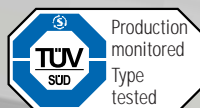




single-position  
multi-position

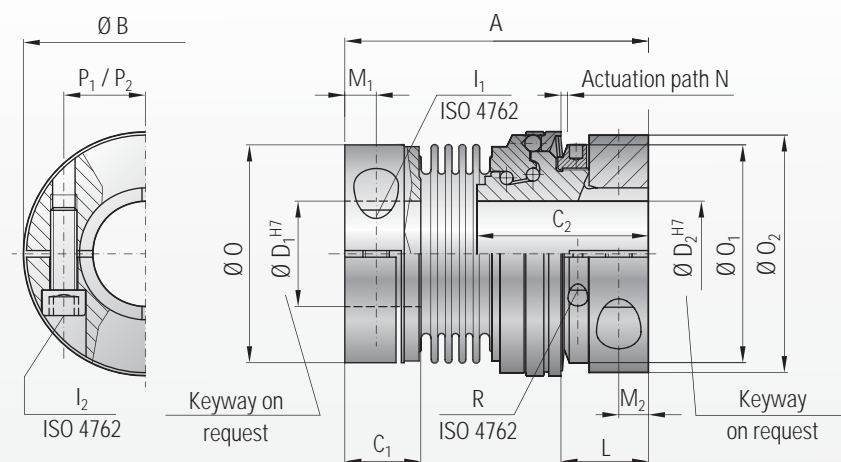


# MODEL SL2



## BACKLASH FREE TORQUE LIMITER

with clamping hubs and metal bellows



### Design:

Clamping hub with one ISO 4762 screw per hub. Components of compact and rigid design with backlash free interface. Misalignment compensation via torsionally rigid bellows

**Temperature range:** -30 to +100°C


**Service life:** These couplings are maintenance free and stable over their entire service life if technical limits are not exceeded

### Fit tolerance:

Overall clearance between shaft and hub  
0.01-0.05mm

### Function system:

W = single position engagement (standard)  
D = multi position engagement every 60°  
(30, 45, 90° optional)

Model SL2			Series								
			30		60		150		300		
Adjustment range* from - to	(Nm)	T <sub>KN</sub>	5-40	30-80	20-50	40-100	30-100	80-200	100-250	200-350	300-400
Overall length	(mm)	A	80		93		112		126		
Actuation ring diameter	(mm)	B	62		74		92		118		
Hub length	(mm)	C <sub>1</sub> /C <sub>2</sub>	21/45		23/53		28 / 63		34/72		
Bore diameter from Ø to Ø H7	(mm)	D <sub>1</sub> /D <sub>2</sub>	12-32/12-30		16-35 / 16-35		19-42 / 19-48		22-60 / 22-60		
ISO 4762 screw	(mm)	I <sub>1</sub> /I <sub>2</sub>	M6		M8		M10		M12		
Tightening torque	(Nm)	L	15		40		75		130		
Distance to actuation ring edge	(mm)	L	22		27		32		35		
Distance	(mm)	M <sub>1</sub> /M <sub>2</sub>	7.5/7.5		9.5/9		11/11		13/12		
Actuation path	(mm)	N	1.3		1.5		1.8		2		
Clamping hub Ø, (coupling end)	(mm)	O	55.5		66		82		110		
Adjustment nut Ø	(mm)	O <sub>1</sub>	55		66		82		100		
Clamping ring Ø, (torque limiter end)	(mm)	O <sub>2</sub>	59		72		90		112		
Distance between centers, bellows side/safety element	(mm)	P <sub>1</sub> /P <sub>2</sub>	20/21.5		23 / 25		27/33		39/41		
Adjustment nut's clamp screw		R	M3		M3		M3		M4		
Tightening torque	(Nm)		2		2		2		4.5		
Approx. weight	(kg)		0.4		0.7		1.2		2.8		
Approx. moment of inertia at D max. (10 <sup>-3</sup> Kgm²)		J <sub>ges</sub>	0.2		0.8		1.4		6.2		
Torsional stiffness (10 <sup>-3</sup> Nm/rad)			31		72		141		157		
Lateral ±  max. (mm)			0.2		0.2		0.2		0.25		

\* max. transmittable torque depends on the bore diameter; see table on page 4. (1Nm = 8.85 in lbs)

### max. misalignment for bellows



**Angular misalignment**  
± 1°



**Axial misalignment**  
± 2 mm



**Lateral misalignment**  
see table above

### Ordering specifications

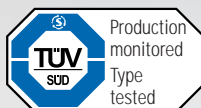
SL2 / 060 / W / 30 / 20 / 80 / 40-100 / XX

Model  
Series  
Function system  
Bore Ø D1H7  
Bore Ø D2H7  
Disengagement torque (Nm)  
Adjustment range (Nm)  
Special feature, e.g. stainless steel

optional  
stainless  
steel

single-position  
multi-position

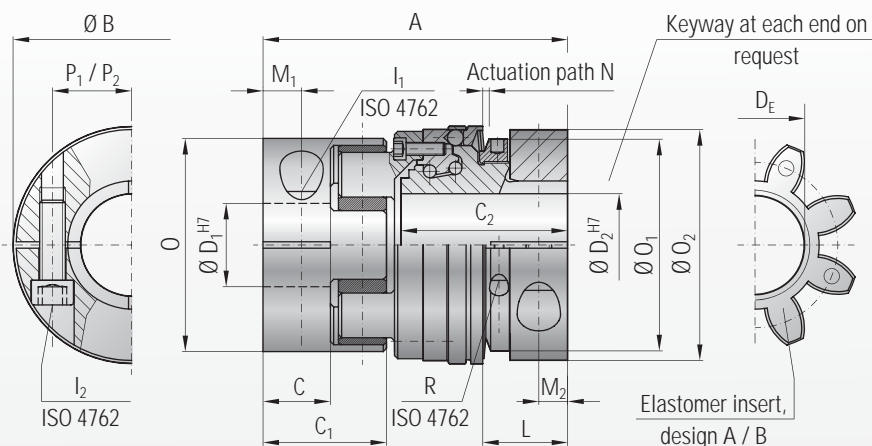
# MODEL SLE



## BACKLASH FREE TORQUE LIMITER



with clamping hubs and elastomer insert



### Design:

Clamping hub with one ISO 4762 screw per hub. Components of compact and rigid design with backlash free interface. Misalignment compensation via elastomer insert

**Temperature range:** -30 to +100°C

**Service life:** These couplings are maintenance free and stable over their entire service life if technical limits are not exceeded

### Fit tolerance:

Overall clearance between shaft and hub 0.01-0.05mm

### Function system:

W = single position engagement (standard)

D = multi position engagement every 60° (30, 45, 90° optional)

Model SLE		Series							
		30		60		150		300	
Type (elastomer insert)		A	B	A	B	A	B	A	B
Rated torque	$T_{KN}$	60	75	160	200	325	405	530	660
Max. torque	$T_{KN max}$	120	150	320	400	650	810	1060	1350
Adjustment range* from - to (Nm)	$T_{KN}$	5-40	30-80	40-135	30-80	60-120	100-200	30-100	80-200
Overall length (mm)	A	85		93		122		135	
Actuation ring diameter (mm)	B	62		74		92		118	
Hub length (pure coupling end) (mm)	C/C1	20 / 36		21 / 39		31 / 52		34 / 57	
Hub length (torque limiter end) (mm)	C2	45		53		63		72	
Bore diameter from Ø to Ø H7 (mm)	D1/D2	12-32 / 12-30		16-36 / 16-35		19-45 / 19-48		22-60 / 22-60	
Inner diameter (elastomer insert) (mm)	Di	26,2		29,2		36,2		46,2	
ISO 4762 screw, coupling side / torque limiter side	I1/I2	M6		M8		M10		M12	
Tightening torque (Nm)		15		40		75		130	
Distance to actuation ring edge (mm)	L	22		26		32		35	
Distance (mm)	M1/M2	10 / 7,5		12 / 9		15 / 11		17,5 / 12	
Actuation path (mm)	N	1,3		1,5		1,8		2	
Clamping hub Ø, elastomer coupling	O	56		66,5		82		102	
Adjustment nut Ø	O1	55		66		82		100	
Clamping hub Ø, safety coupling	O2	59		72		90		112	
Distance to clamping screw, coupling side / torque limiter side (mm)	P1/P2	21 / 21,5		24 / 25		29 / 33		38 / 41	
Adjustment nut's clamp screw	R	M3		M3		M3		M4	
Tightening torque (Nm)		2		2		2		4,5	
Approx. weight (kg)		0,4		0,8		1,5		2,9	
Approx. moment of inertia at D max. (10 <sup>-3</sup> Kg·m <sup>2</sup> )	J <sub>ges</sub>	0,3		1		1,8		5	
Static torsional rigidity (Nm/rad)		3290	9750	4970	10600	12400	18000	15100	27000
Dynamic torsional rigidity (Nm/rad)		7940	11900	13400	29300	23700	40400	55400	81200
Lateral ± max. (mm)		0,12	0,1	0,15	0,12	0,18	0,14	0,2	0,18

Static torsional rigidity at 50%  $T_{KN}$  Dynamic torsional rigidity at  $T_{KN}$

\* max. transmittable torque depends on the bore diameter; see table on page 4.

(1Nm = 8.85 in lbs)

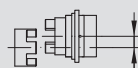
### max. offsets for elastomer insert



**Angular misalignment**  
± 1°



**Axial misalignment**  
± 2 mm



**Lateral misalignment**  
see table above

### Ordering specifications

SLE / 060 / A / W / 30 / 20 / 80 / 40-100 / XX

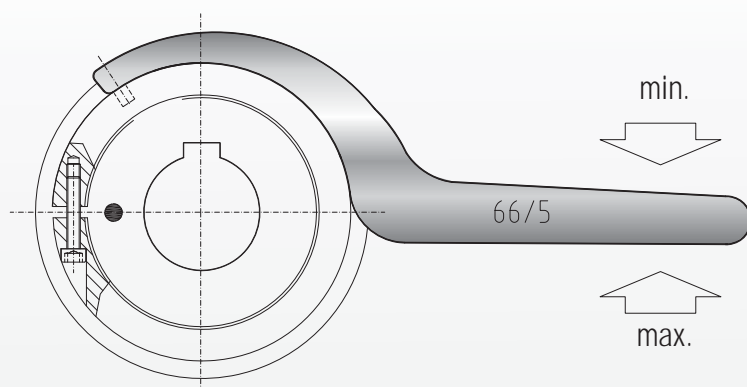
Model  
Series  
Elastomer insert design  
Function system  
Bore Ø D1H7  
Bore Ø D2H7  
Disengagement torque (Nm)  
Adjustment range (Nm)  
Special feature, e.g. stainless steel



# ACCESSORIES

## BACKLASH FREE TORQUE LIMITER

### Spanner wrench for torque adjustment

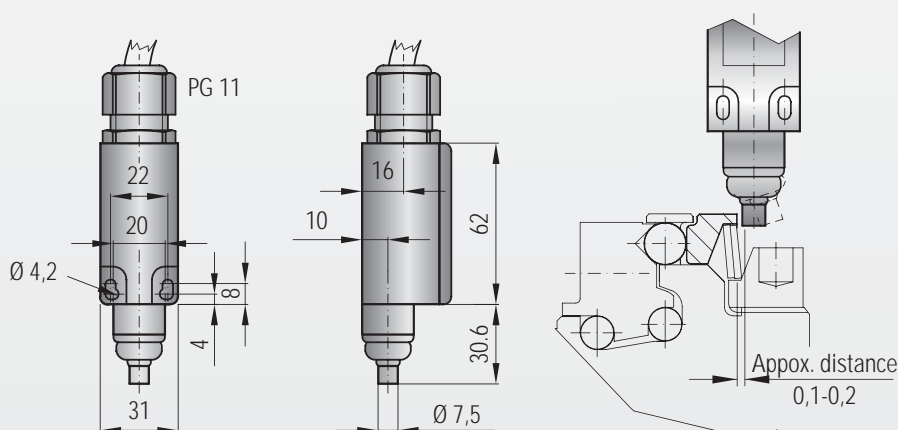


Order no.: see table

Series	30	60	150	300
Order no.:	55/4	66/5	82/5	100/6

### Mechanical limit switch (emergency OFF function)

Order no.: 618.6740.644



#### Attention:

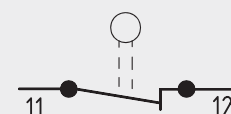
A 100 % test of the switch's functionality after it is installed is imperative.

The switch's plunger should be positioned as close to the safety couplings' actuation ring as possible (approx. 0.1-0.2mm)

#### Technical data

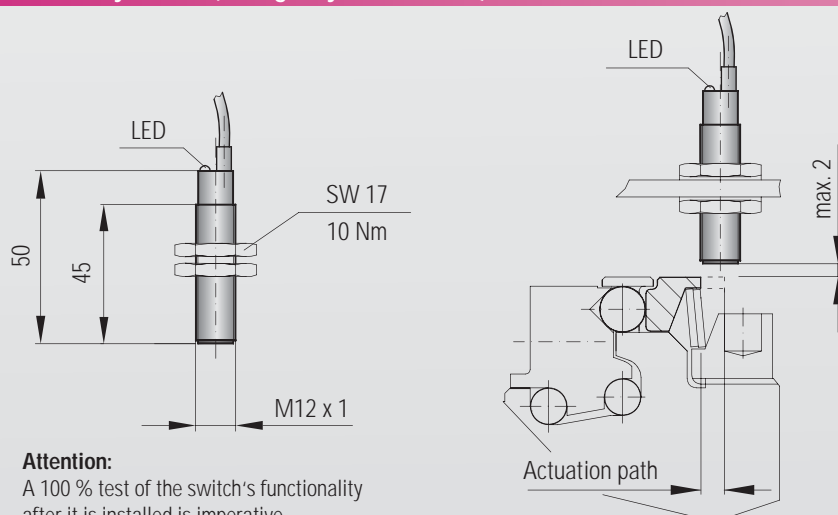
Max. voltage:	500 V AC
Max. constant current:	10 A
Protective system:	IP 65
Contact system:	Opener (forced separating)
Temperature range:	- 30 - +80 °C
Actuation:	Plunger (metal)

#### Switch diagram:



### Proximity sensor (emergency OFF function)

Order no.: 619.4711.650



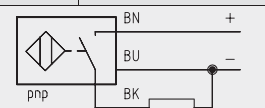
#### Attention:

A 100 % test of the switch's functionality after it is installed is imperative.

#### Technical data

Voltage:	10 to 30 V DC
Max. output current:	200 mA
Max. switch frequency:	≤ 3 KHz
Temperature range:	-25°C to +70°C
Protective system:	IP 67
Switch type:	PNP, NO
Max. detection gap:	2 mm

#### Switch diagram:







# GENERAL FUNCTION

## BACKLASH FREE TORQUE LIMITER

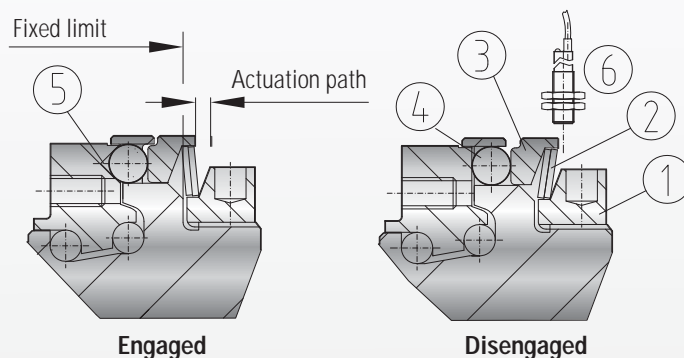
### Safety element functionality

- Torque is transmitted through hardened ball bearings (4) arranged around the coupling's circumference and loaded into conical detents (5)
- The ball bearings are loaded into the detents by an actuation ring (3) which, in turn, is held in place by disc springs (2)
- Disengagement torque is continuously adjustable through rotation of the adjustment nut (1)
- In the event of overload the actuation ring (3) moves toward the disc springs (2) which are pushed over center by the force from the balls exiting their detents. This completely disconnects the driving and driven sides of the coupling.
- As a consequence of the actuation ring's (3) axial movement, the mechanical limit switch or proximity sensor (6) is activated, signaling the drive to be shut down.

In its disengaged state this design forces the disc springs into a shape where the residual force drops off to a very small value. The residual force of the springs is insufficient to re-engage the coupling.

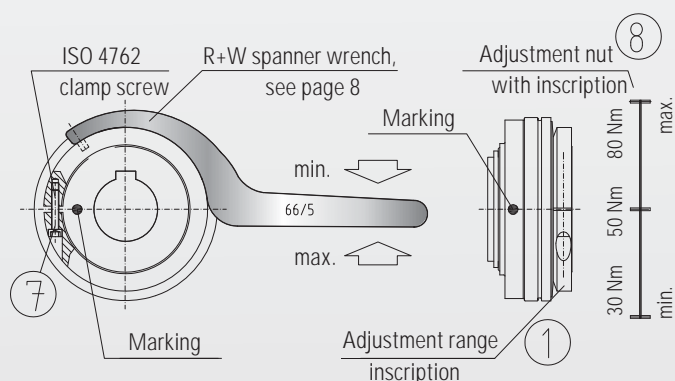
**Coupling re-engagement will only take place at very slow rotational speed.**

### Single-position / multi-position

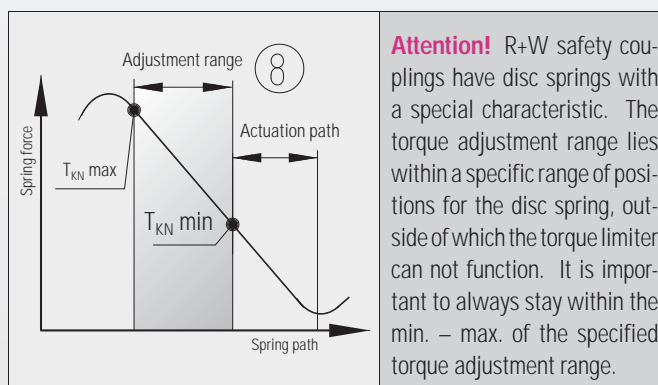


- |                  |                   |                       |
|------------------|-------------------|-----------------------|
| ① Adjustment nut | ③ Conical detents | ⑤ Conical depressions |
| ② Springs        | ④ Detent balls    | ⑥ Limit switch        |

### Disengagement torque setting



R+W safety couplings are preset and marked with the desired disengagement torque setting at the factory. The min. and max. of the torque adjustment range are then also marked on the adjustment nut (1). Disengagement torque is continuously adjustable within the range (8) though adjustment of the tension on the disc springs.



**Attention!** R+W safety couplings have disc springs with a special characteristic. The torque adjustment range lies within a specific range of positions for the disc spring, outside of which the torque limiter can not function. It is important to always stay within the min. – max. of the specified torque adjustment range.

**The adjustment range should not be exited during torque adjustment.** After loosening the clamp screw (7), the adjustment nut is rotated with an appropriate tool (e.g. R+W spanner wrench). To verify torque adjustment range, see tables on pages 4-7. Afterward the clamp screw is tightened down. The safety coupling is again operational.

### Additional information

#### Wear:

No wear takes place while the coupling is engaged. In the event of disengagement, the drive must be shut down immediately through the use of a mechanical limit switch or proximity sensor.

#### Rotational speed

The safety coupling's service life is essentially determined by the rotational speed, and the frequency and duration of disengagement events.

#### Maintenance:

Since these safety couplings are not subject to wear while they are engaged, there is not maintenance necessary. The positive connections are free of backlash and have lifetime lubrication.

#### Selection:

Safety couplings are generally selected by the desired disengagement torque value. This value must be greater than the torque required for normal acceleration and deceleration of the equipment. The safety coupling's disengagement torque is typically determined by the data from the drive, motor, and / or gearbox.



# MOUNTING INSTRUCTIONS

## MOUNTING AND DISMOUNTING OF TORQUE LIMITERS

### Installation preparation

The shafts and hub bores to be connected must be free of contaminants and burrs. Check shaft dimensions and tolerances (including key width and height dimensions). The bores of the R+W safety couplings are machined to an ISO H7 fit. For a clamp connection the overall clearance between shaft and hub must be between 0.01-0.05mm. This fit clearance, along with oiling of shaft journals assists in installation and removal without reducing clamping force. Fretting corrosion is thus avoided.



#### Attention!

Oils and greases containing molybdenum disulphide or other high-pressure additives as well as anti-seize pastes must not be used.

### Installation instructions, SLN / SLP

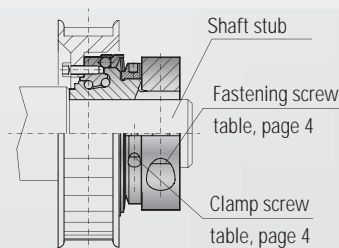
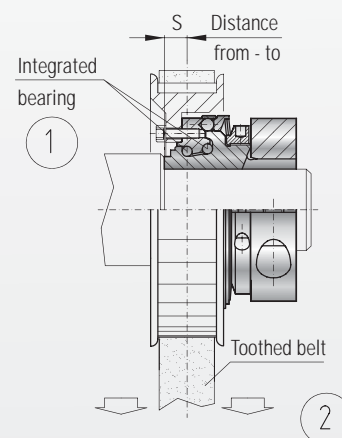
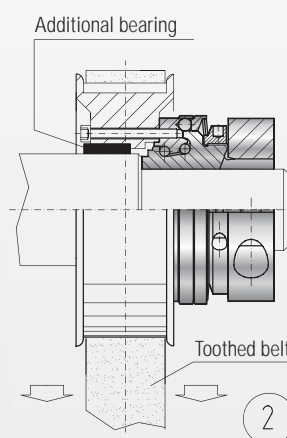
Model SLN / SLP have an integral bearing (1) for support of the attached component (e.g. timing belt pulley, sprocket, etc). The max. radial force (2) must not be exceeded. See table.

When dimension (S) is maintained, the load is placed between the two bearing races. In this case, a separate bearing is not necessary. An offset attachment requires an additional bearing. This is recommended especially when the diameter is small or the attachment is very wide.

Depending on the situation, ball bearings, needle bearings or plain bearings are suitable.

Series	30	60	150	300
Belt tension, max. (N)	1800	2300	3000	4500
Distance (S) from - to (mm)	4-14	5-18	6-20	6-23

(1N = 0.2248 lbs.)

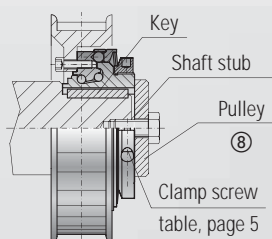


#### Mounting:

Slide the complete coupling onto the shaft and place it in the correct axial position. Tighten down the fastening screw to its specified torque according to the table (page 4).

#### Dismounting:

To remove the R+W safety coupling, it is only necessary to loosen the fastening screw.



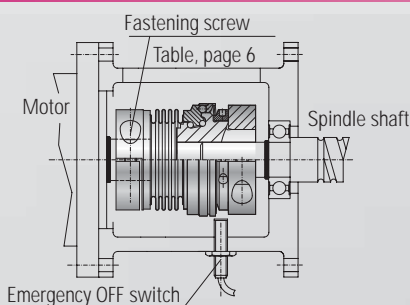
#### Mounting:

Use an appropriate aid to pull the complete coupling onto the shaft journal. The final position must be secured axially, e.g. with a washer (8).

#### Dismounting:

Remove the coupling's axial fixation and pull the complete coupling off the shaft with an appropriate aid.

### SL2 installation instructions



#### Mounting:

Slide the safety coupling onto the spindle shaft. When the correct axial position has been reached, tighten down the fastening screw with a torque wrench to the torque specified in the table (page 6). Insert the motor shaft, and at the correct axial position, with no axial force on the metal bellows, tighten the clamping hub's fastening screw as described above.

#### Dismounting:

To remove the R+W safety coupling, it is only necessary to loosen the fastening screw.

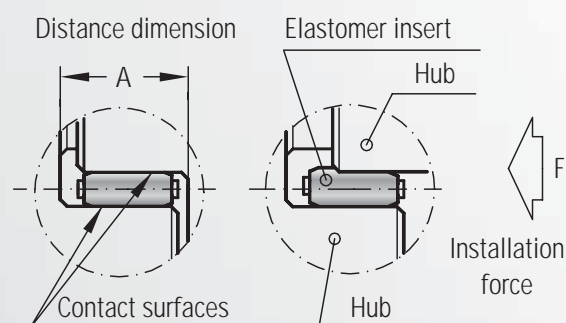
## MOUNTING AND DISMOUNTING OF TORQUE LIMITERS

### SLE elastomer insert

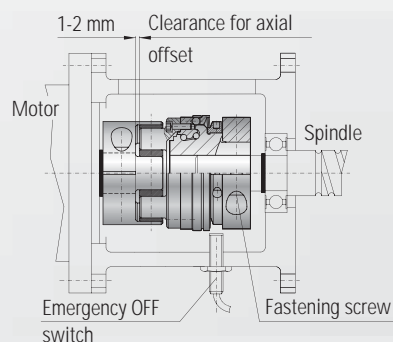
The elastomer insert is the compensating element in an SLE coupling. It transmits torque without backlash and damps shock and vibration. The SLE couplings elastomer insert determines the hysteresis characteristics of the entire rotational axis, and is available in two different designs.

When the coupling hubs are pushed together during installation, axial force is needed to overcome the elastomer insert's preload tension. The amount of force required can be reduced by cleaning the elastomer insert then applying a coat of light oil to its contact surfaces.

Design	Color	Material	Temperature range	Characteristics
A / 98 Sh A	red	TPU	-30°C - +100°C	good damping
B / 64 Sh D	green	TPU	-30°C - +120°C	high torsional rigidity



### SLE installation instructions



#### Mounting:

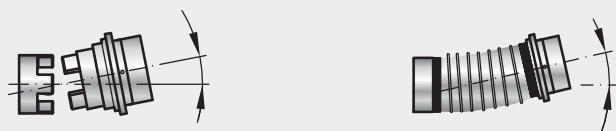
Slide the safety coupling onto the spindle shaft. When the correct axial position has been reached, tighten down the fastening screw, with a torque wrench, to the torque specified in the table (page 7). Insert the motor shaft, and at the correct axial position, tighten the fastening screw as described above.

#### Dismounting:

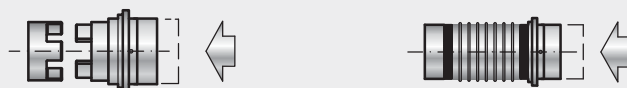
To remove the R+W safety coupling, it is only necessary to loosen the fastening screw.

### Coupling max. misalignment compensation

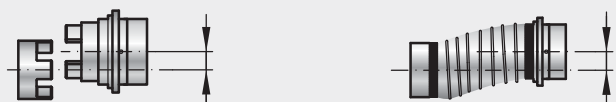
#### Angular misalignment $\Delta K_w$



#### Axial misalignment $\Delta K_a$



#### Lateral misalignment $\Delta K_r$



#### Attention!

Exact alignment of R+W safety couplings increases their service life.

The stress on adjacent bearings becomes negligible and the entire drive train runs more smoothly.

For very high speed drive systems alignment with a dial indicator is recommended.

Maximum misalignment values can be found in the tables of the individual models.

**Expertise and  
Know-how for  
your particular  
application.**

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## THE R+W-PRODUCT RANGE



### **TORQUE LIMITERS** **Series SK + ST**

From 0.1 – 160,000 Nm, Bore diameters 3 – 290 mm  
Available as a single position, multi-position, load holding, or full disengagement version  
Single piece or press-fit design



### **BELLOWS COUPLINGS** **Series BK**

From 2 – 10,000 Nm  
Bore diameters 10 – 180 mm  
Single piece or press-fit design



### **LINE SHAFTS** **Series ZA / ZAE / EZ / EZV**

From 10 – 25,000 Nm  
Bore diameters 10 – 100 mm  
Available up to 6 mtr. length



### **MINIATURE BELLOWS COUPLINGS** **Series MK**

From 0.05 – 10 Nm  
Bore diameters 1 – 28 mm  
Single piece or press-fit design



### **SERVOMAX®** **ELASTOMER COUPLINGS** **Series EK**

From 2 – 25,000 Nm, Shaft diameters 3 – 170 mm  
backlash-free, press-fit design



### **ECOLIGHT®** **ELASTOMER COUPLINGS** **Series TX 1**

From 2 – 810 Nm  
Shaft diameters 3 – 45 mm



### **LINEAR COUPLINGS** **Series LK**

From 70 – 2,000 N  
Thread M5 – M16



### **POLYAMID COUPLINGS** **MICROFLEX** **Series FK 1**

Rated torque 1 Ncm  
Bore diameters 1 – 1.5 mm