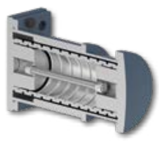
Partner for Performance

RINGFEDER

Protecting People, Securing Structures:

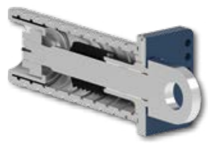
Earthquake Protection

Friction Springs



Buffers

Push-Pull Units



Draw Gears

EN 09.2024

www.ringfeder.com

Functionality of RINGFEDER® Friction Springs

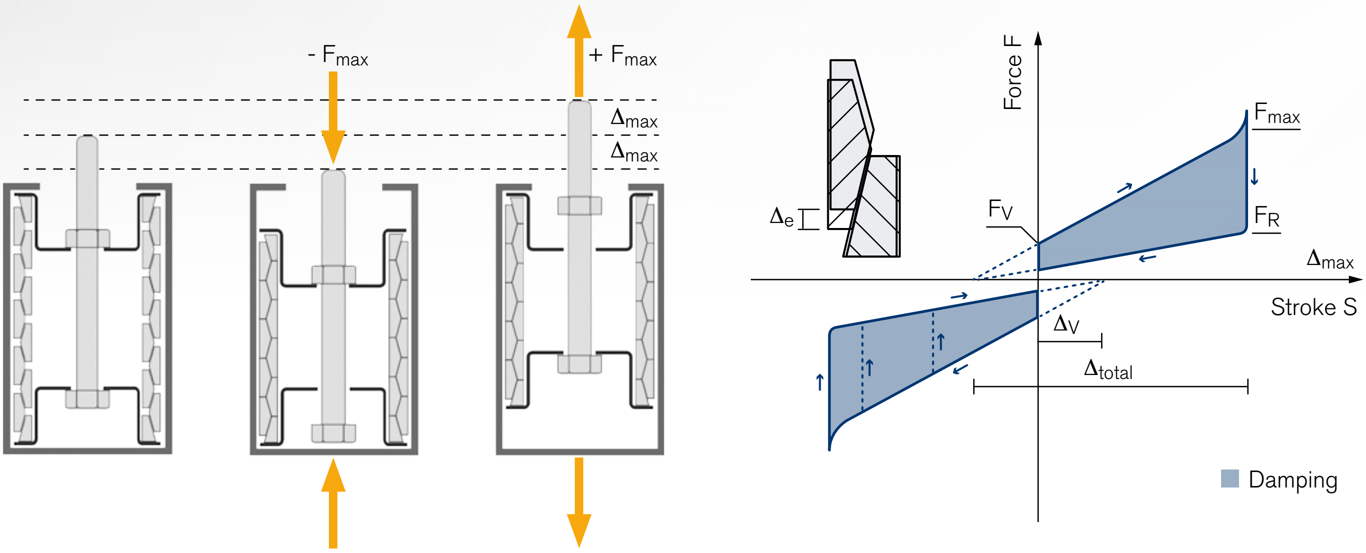


Fig. 1: Functionality of Friction Springs & Force-Stroke Diagram

Friction Springs are cyclic loaded steel springs consisting of outer and inner rings with conical contact surfaces. They are loaded axially with only elastic deformation. The energy dissipation is the result of the friction between the conical surfaces between the rings. The recoil force of the Friction Spring is much lower than the deformation force, usually with a reduction of around 66 %.

Figure 1 shows the idealised flag-shaped Force-Stroke Diagram (hysteresis curve) of a Push-Pull Unit. The area highlighted in blue represents the hysteresis damping. There is a direct relationship between the end force F_{max} and the associated recoil force F_R as given below:

$$F_R = (1 - D_{rel})\ F_{max}$$

The hysteresis damping D_{rel} depends on the grease used, so that in addition to the typical value of approximately 66 %, a relative damping of e.g. 55 %, 45 % and 35 % is also possible. The sliding surfaces are typically lubricated when delivered and generally do not require re-lubrication during operation (lifetime lubrication).

As the rings themselves are not fixed, the spring must be pretensioned to secure the position. This must be at least 5-10 % of the spring's end force and can be increased to up to 60 % if required for emergency applications.

Friction Springs themselves only absorb compressive forces, but a suitable design also enables tensile forces to be absorbed by redirecting the force.

Once the maximum spring travel has been reached, the spring is in a blocked position. Even greater loads are now transmitted. This results in a high level of safety because the greatest transmissible static force is limited by the design and not by the Friction Spring.

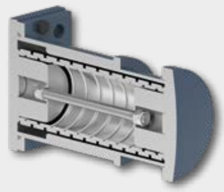
Friction Springs

Complete spring columns consisting of precisely machined inner and outer rings

Industrial Dampers

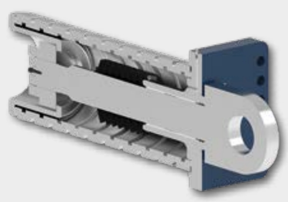
Friction Springs as application-specific damper versions (examples)

Buffers



Push-Pull Units

Draw Gears



Advantages of Dampers with RINGFEDER® Friction Springs

1. **Longevity** – Dampers with Friction Springs are designed to endure many load cycles and remain reusable. If one of the rings of a Friction Spring breaks inside a damper, it will lose some spring travel and the stiffness will increase slightly, but it will continue to function.

2. **Damping** – Using RINGFEDER® Standard Grease F-S1, 2/3 of the induced energy will be absorbed. If less damping is required, a customized solution can be used, reducing the damping to 1/3 of the induced energy. This is a simple solution to purposefully modify the characteristics of the damper.

3. **Fire and High Temperature** – Friction Springs are manufactured from special spring steel and lubricated with grease. In the event of fire, rubber products and viscous dampers are destroyed, but Friction Springs will withstand. Only re-greasing is required afterwards and the damper can be used further.

4. **Self-Centering** – Thanks to the custom-made design of dampers with Friction Springs, the optimum restoring force is always achieved for the particular application. This can be realized, for example, by using a different grease, increasing the outer diameter, or changing the taper angle.

5. **Environmental Sustainability** – Dampers with Friction Springs withstand seismic events. They are engineered to endure many load cycles while maintaining their beneficial functionality and performance. Friction Springs are maintenance-free.

6. **Velocity** – Friction Springs work independently from loading rates and, unlike hydraulic dampers, react in the same way to very slow or very fast occurrences.

7. **Installation Space** – For a given diameter, Friction Springs provide the largest spring forces compared to other spring types.

Earthquake-Resistant Construction: Low Damage Design

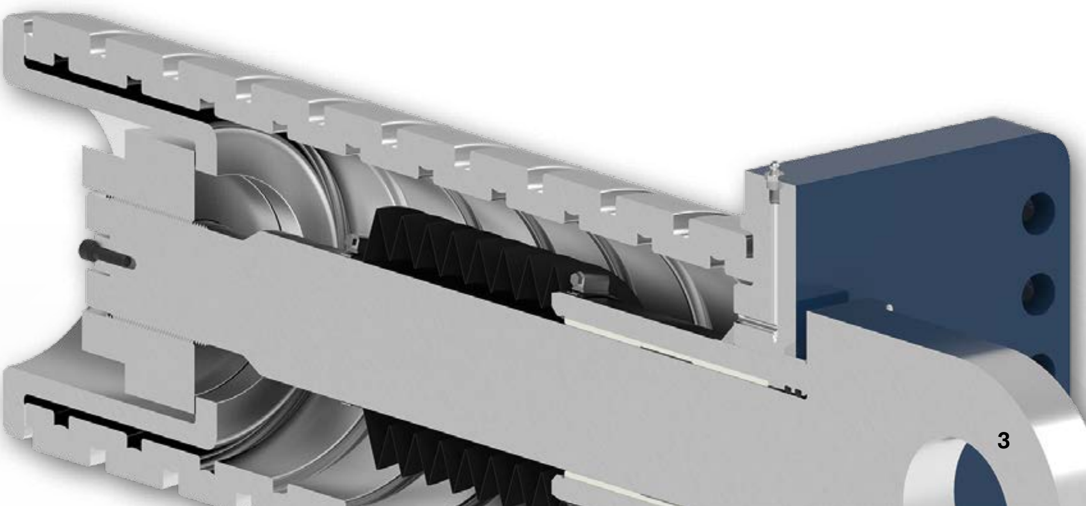
In standard earthquake design, the intention is to keep escape routes open and exclude any risk to people. The ductile loadbearing behaviour is used, whereby the earthquake energy is absorbed via plastic deformations in the building. The resulting damage must then be repaired or even results in a complete economic loss.

However, it is also possible to ensure functional integrity immediately after a seismic event. In this case, only the elastic structural behaviour is used to secure the structure and the damage to a building during an earthquake is minimised. Reliability is particularly important for security-relevant buildings and infrastructure facilities, such as hospitals, fire stations, electricity and water supplies. With Low Damage Design, the advantages of the Friction Spring are optimally utilised and the otherwise expensive construction method becomes an economical concept with Friction Springs:

1. **Increased Safety** – By designing buildings with low damage potential, the risk of injury or death during an earthquake is minimised. Additional safety is only activated by ductile load-bearing behaviour in the event of earthquakes that overload the design of the structure.

2. **Lower Maintenance Costs** – As damage to buildings is minimised, less repairs or renovations are required after an earthquake. This reduces maintenance costs and protects the investment.

3. **Operational Continuity** – Buildings constructed according to Low Damage Design can be put back into operation more quickly after an earthquake, since less time is needed for repairs and reconstruction.



Design Principles

Friction Springs are available in almost any stiffness combined with high damping. This results in a wide range of possible applications for earthquake-resistant construction.

Cross-Bracing

Cross-Bracings are typically used in steel or timber constructions to absorb horizontal forces. If a Friction Spring is installed at the end of the strut, the deformability and damping of the structure are increased. Both are advantageous for earthquake-resistant design. The struts absorb either only tensile or compressive and tensile forces.

Existing reinforced concrete structures are also reinforced with retrofitted struts.

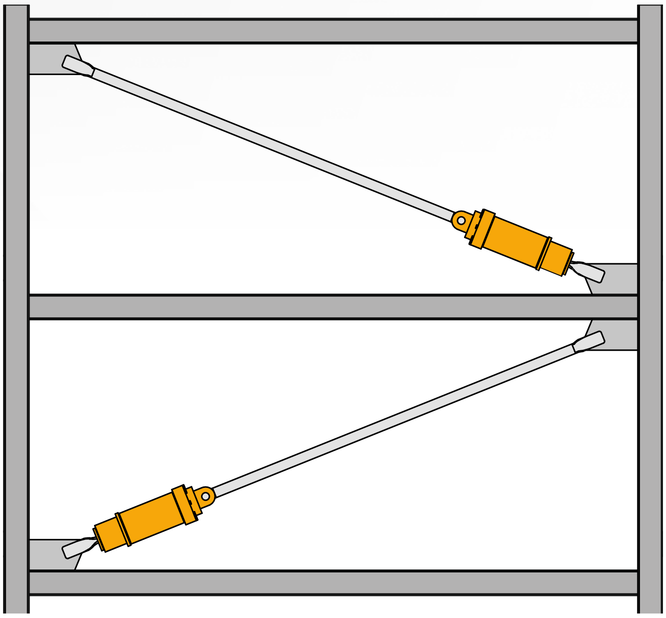


Fig. 2: Installation of RINGFEDER® Push-Pull Units

“Rocking”

During “rocking”, Friction Springs enable a swinging movement of the structure to be protected. Horizontal forces are absorbed by vertical dampers and the forces and accelerations acting on the structure are reduced. This method has already proven its worth in the use within electrical switchgears and substations.

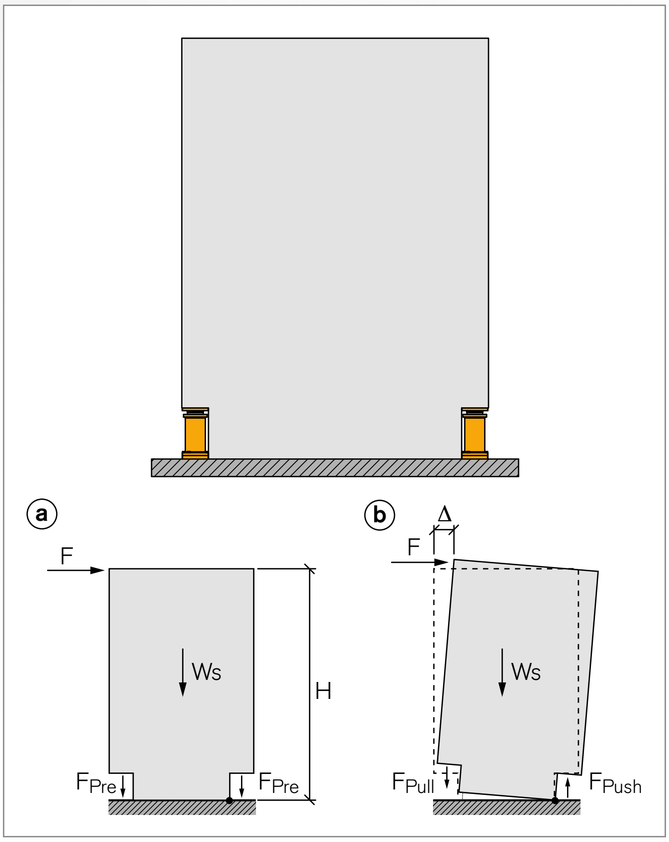
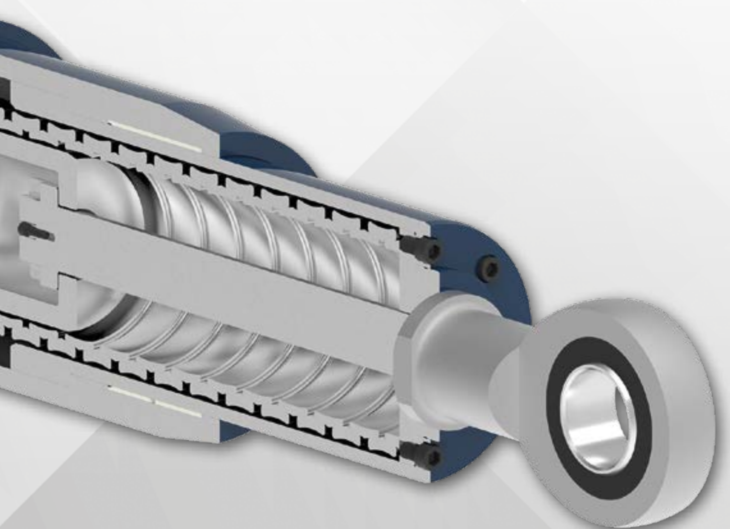


Fig. 3: “Rocking” Shear Wall

With “rocking” shear walls in reinforced concrete or timber construction, the earthquake forces of the building are redirected into the Friction Spring. These also allow the wall to lift in a controlled manner, which increases its deformability without causing cracks and damage.

Fig. 4: Push-Pull Units for protection against earthquake-induced damage by decoupling surge arresters from the base foundation



For safe protection against earthquake damages, the steel support frame of the Te Puni Village student residence in New Zealand's capital Wellington is equipped with RINGFEDER® Friction Springs. These operate in conjunction with special sliding hinge joints, which are located between the supports and traverses of the frame. By applying the Friction Spring technology, a self-centering sliding hinge joint is created that gives the building flexibility and reliably balances ground accelerations occurring in the event of an earthquake. The energy induced is absorbed and the building is also moved back to its initial position.

RINGFEDER®
Standard Draw Gears

The standard dampers are designed as a Draw Gear with a preload of 20 %. The connection is realized via head plates on both sides. Other connections, such as rod ends and clevises, are also possible.

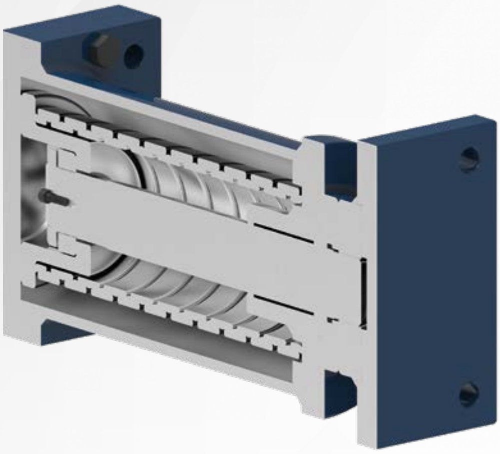


Fig. 5: RINGFEDER® Standard Draw Gear

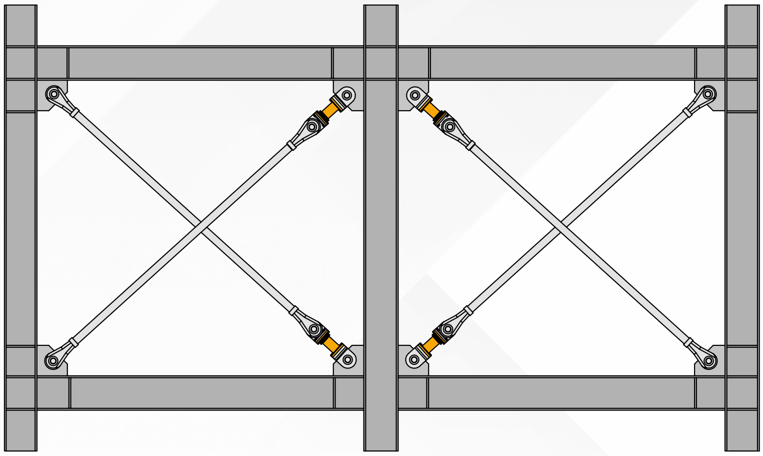


Fig. 6: Draw Gear in X-Bracing

End Force F_{max}	Preload Force F_V	Recoil Force F_R	Spring Travel Δ_{max}	Length l	Width/Height b
kN	kN	kN	mm	mm	mm
26	5.2	8.8	16	150	100
54	10.8	18.4	22.4	215	120
100	20	34	32	290	150
200	40	68	41.6	410	220
510	102	173	62.4	605	300
1000	200	340	84.8	940	480

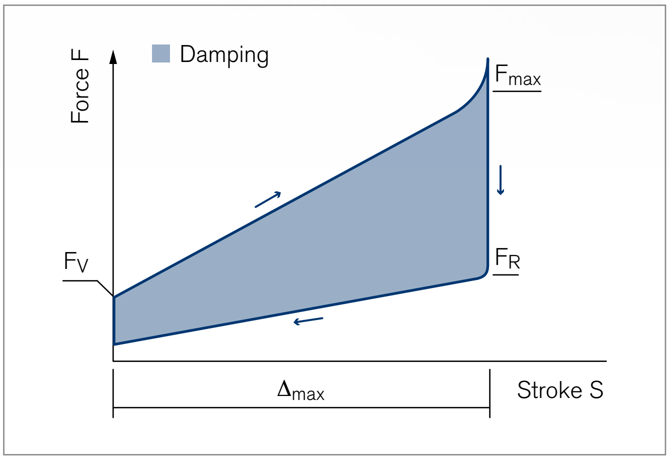


Diagram 1: Standard Draw Gear

The dampers can be individually configured as as Draw Gear, Buffer or Push-Pull Unit. The force range of individual dampers is between 5 and 1800 kN, whereby the maximum spring travel and stiffness can be flexibly controlled by the number of rings. The blue marked area in Figure 7 shows the possible maximum spring travel. Higher forces and spring strokes are also possible by combining several spring types.

With a parallel connection, the end force is further increased while the spring stroke remains the same. If the friction springs are connected in series, the stroke is increased while the end force remains the same. The connections to the construction are customizable to the requirements of the project after consultation. The safety against stability failure must be verified for struts subjected to compressive loads.

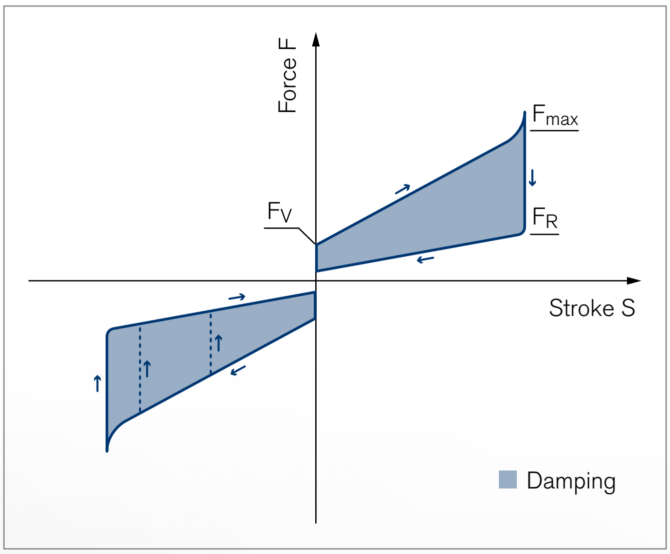
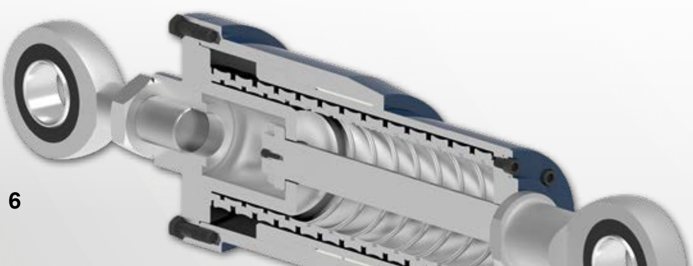


Diagram 2: Standard Push-Pull Unit



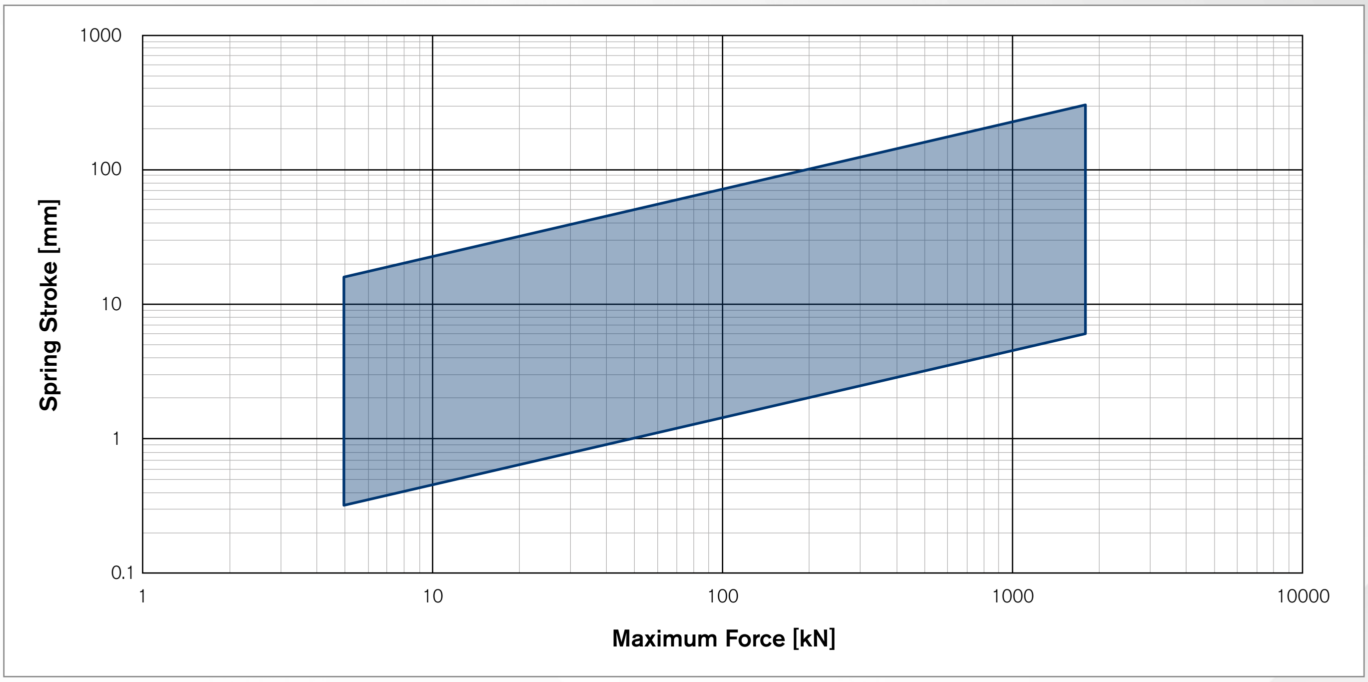
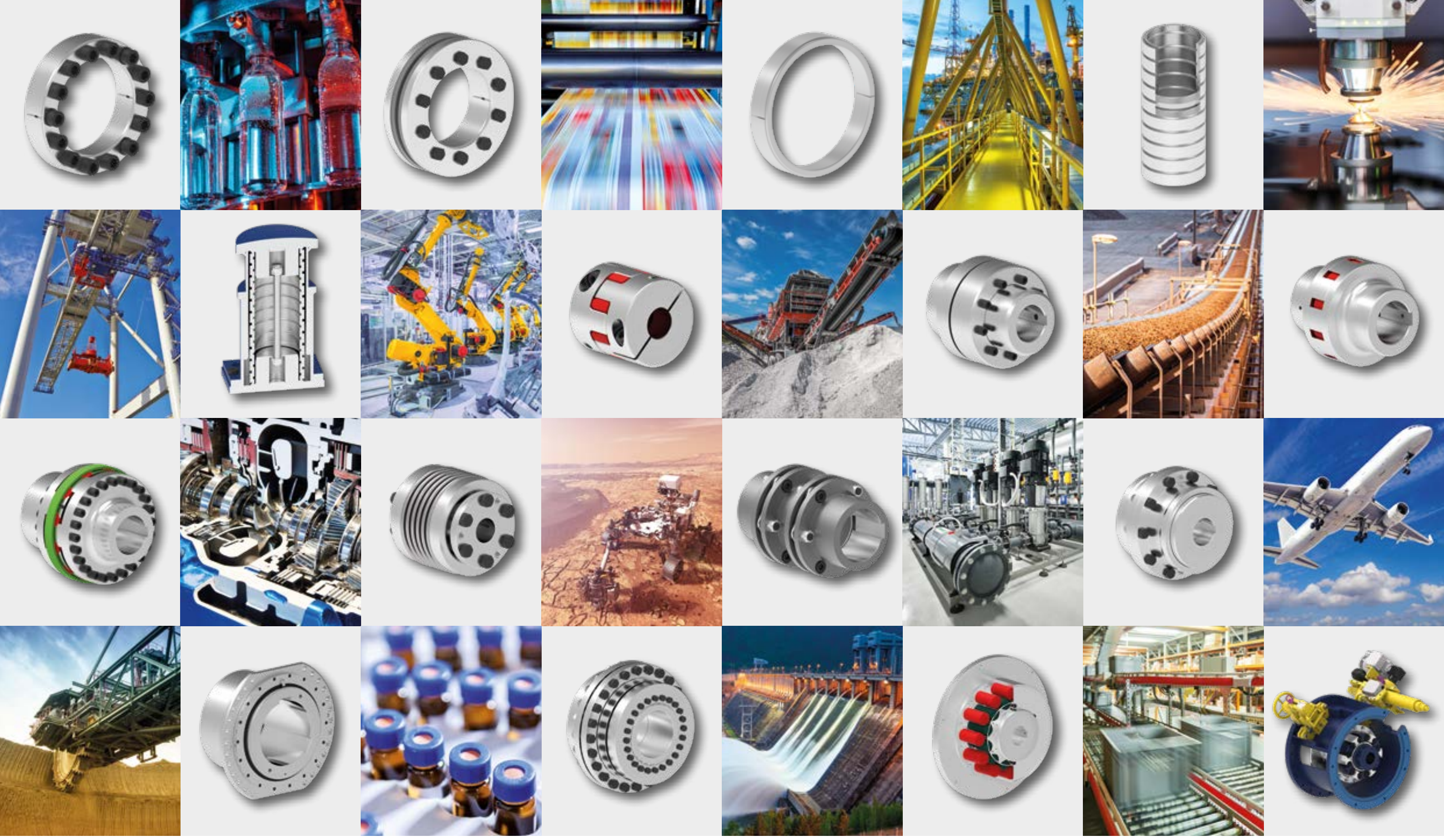


Fig. 7: Range of Force and Stroke of RINGFEDER® Standard Friction Springs

Whether as cross bracing to maximize ultimate loads, as base isolation for decoupling from the foundation, or for shear walls, RINGFEDER® Friction Springs serve as a highly effective, maintenance- and wear-free protection system against earthquake damage in buildings and other critical infrastructure. In the event of an earthquake, they absorb the occurring energy and, through their restoring force, ensure a safe so-called "Re-Centering" of the structure back to its original position.



RINGFEDER POWER TRANSMISSION GMBH
Werner-Heisenberg-Straße 18, 64823 Groß-Umstadt, Germany · Phone: +49 6078 9385-0 · Fax: +49 6078 9385-100
E-Mail: sales.international@ringfeder.com

RINGFEDER POWER TRANSMISSION SP. Z O. O.
Ul. Szyby Rycerskie 6, 41-909 Bytom, Poland · Phone: +48 32 301 53 00 · Fax: +48 32 722 44 44 · E-Mail: sales.poland@ringfeder.com

RINGFEDER POWER TRANSMISSION USA CORP.
291 Boston Turnpike, Bolton, CT 06043, USA · Toll Free: +1 888 746-4333 · Phone: +1 201 666-3320 · Fax: +1 860 646-2645
E-Mail: sales.usa@ringfeder.com

CARLYLE JOHNSON MACHINE COMPANY, LLC.
291 Boston Turnpike, Bolton, CT 06043, USA · Phone: +1 860 643-1531 · Fax: +1 860 646-2645 · E-Mail: info@cjmco.com

HENFEL INDÚSTRIA METALÚRGICA LTDA.
Av. Maj. Hilário Tavares Pinheiro 3447, Pq. Ind. Carlos Tonanni, CEP 14871-300, Jaboticabal, SP, Brazil · Phone: +55 (16) 3209-3422
E-Mail: vendas@henfel.com.br

RINGFEDER POWER TRANSMISSION INDIA PVT. LTD.
Falcon Heights, 4th Floor, Plot No. 30, Industrial Estate, Perungudi, Chennai, 600 096, India · Phone: +91 44 2679-1411
E-Mail: sales.india@ringfeder.com

KUNSHAN RINGFEDER POWER TRANSMISSION CO. LTD.
No. 406 Jiande Road, Zhangpu 215321, Kunshan, Jiangsu Province, China · Phone: +86 512 5745-3960 · Fax: +86 512 5745-3961
E-Mail: sales.china@ringfeder.com

Partner for Performance

www.ringfeder.com

RINGFEDER
POWER TRANSMISSION