

TOKAISPRING

Tokai spring industries, Inc.

<https://www.tokaibane.com/en/>





As long as there is a need for **JUST ONE SPRING**

Tokai Spring is committed to manufacturing small-lot and custom-made spring orders because we believe that there are customers who need highly specialized, high quality spring products. Tokai Spring's mission is to satisfy and exceed our customers' requirements.

Tokai Spring protects the world's tallest broadcasting tower from the forces of nature

The 634-meter TOKYO SKYTREE® is the tallest free-standing broadcasting tower in the world. This tower is designed to withstand severe natural forces, including wind, rain, snow, and earthquakes.

The gain tower at the very top of TOKYO SKYTREE® transmits digital terrestrial TV broadcast signals as well as smartphone signals. Measuring nearly 140 meters tall—equivalent to a 30-story building—the gain tower is constantly exposed to natural forces such as wind, rain, snow, and even earthquake vibrations.

TOKYO SKYTREE® is engineered to withstand gale-force winds of up to 110 m/sec, a phenomenon estimated to occur once every 1,300 years. However, even moderate wind speeds of 10 to 15 m/sec can cause a resonance phenomenon known as "vortex-induced vibration," which may lead to significant swaying and potential structural damage.

To counteract vortex-induced vibrations, vibration-damping devices called "TMDs" (Tuned Mass Dampers) are installed at the top of the gain tower. These advanced devices utilize Tokai Spring's fitting-type springs (compression and extension springs) to mitigate vibrations. A single fitting spring is capable of dampening both "push" and "pull" forces, effectively neutralizing various types of vibrations.

Each of these exceptionally large springs weighs approximately 800 kg. When you visit TOKYO SKYTREE®, keep in mind that this iconic symbol of Japan's broadcasting innovation is supported by Tokai Spring's advanced fitting-type springs, mounted 620 meters above Tokyo's skyline.

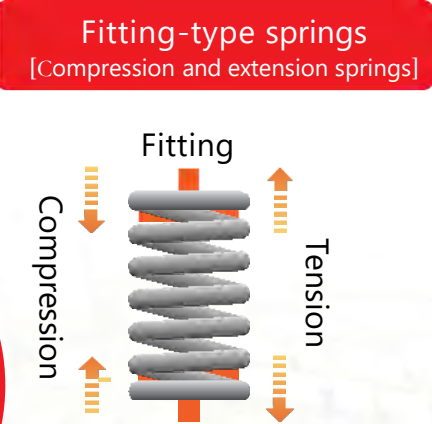
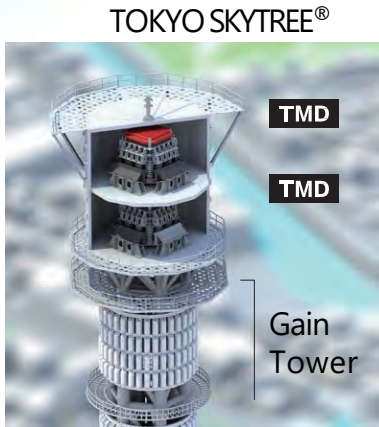
PROJECT STORY

Tokai Spring has an extensive track record of supplying compression and extension springs for large-scale TMDs, used in structures such as airport buildings and high-rise smokestacks, both domestically and internationally. This experience and expertise played a key role in securing the Tokyo Skytree project. However, the unique combination of the Skytree's unprecedented structure and size required innovative development methods beyond the ordinary.

The primary challenge was to ensure that the springs would remain securely fitted and not detach, even under the most extreme physical forces. Typically, fittings used by Tokai Spring increase the spring's free length, which can lead to buckling. To address this issue, we developed a specialized spring production method to reduce the free length and successfully engineered a fitting capable of withstanding severe conditions.

Throughout the process, we revised the engineering drawings of the spring multiple times to meet the stringent specifications. After meticulous development, we finalized a design that satisfied all requirements, ensuring the safety and reliability of the springs used in the iconic Tokyo Skytree.

Vibration control devices called **tuned mass dampers, "TMDs"** are used in buildings and machines that require vibration control. These devices utilize a damper and spring to optimally adjust, or "tune," the natural frequency of a mass. The Tokyo Skytree® cannot afford even a brief interruption in its operation. Typically, a single TMD would be sufficient to control the vibration of the gain tower. However, due to the unique requirements of the Tokyo Skytree®, two TMDs, totaling 65 tons in weight, were installed.



By attaching fittings at both ends, a single spring can handle both compression and tension forces. The spring used here has an outer diameter of approximately $\phi 600$ mm, a height of 1200 mm, and weighs about 800 kg each. Each TMD fitted to the TOKYO SKYTREE® is equipped with four fitting-type springs. The rigidity of these springs is used to set and adjust the vibration period of the TMDs.

What is "vortex induced vibration" ?



The Tacoma Narrows Bridge in Washington State, completed in 1940, was considered one of the most technologically advanced bridges of its time. However, it collapsed due to vortex-induced vibration, triggered by wind speeds of less than 20 m/second. This phenomenon occurs when vortices form around or behind a structure, creating resonance. If the frequency of these vortices matches the natural frequency of the structure or its components, it can result in violent vibrations, even at relatively low wind speeds.

Tokai Spring launches Japan's aspirations in space exploration

In the past, all rockets launched by Japan used parts made in the U.S. However, the establishment of the Japan Aerospace Exploration Agency (JAXA) greatly changed the direction of Japan's space industry. JAXA's new mission was to build rockets with parts exclusively made in Japan. Developing high-precision springs was a critical element of this mission.

The International Space Station (ISS), located in low Earth orbit at around 400 km above the Earth's surface, is a giant experimental facility roughly the size of a soccer field. In this station, 15 participating countries, including Japan, conduct experiments and research that utilize the unique environment of outer space, as well as observe Earth and celestial bodies. To transport food, supplies, and the equipment required for the experiments to the astronauts aboard the station, JAXA developed the space station supply vehicle named "Kounotori." The Kounotori is launched aboard the "H-II B Rocket," the largest rocket manufactured in Japan by Japanese companies. The rocket marked its third successful launch and supply mission in July 2012, and this achievement was highly praised internationally.

Tokai Spring's springs were used in the H-II B Rocket's engines and in its fairing, the component that houses the Kounotori vehicle. These springs are designed to function even when subjected to the tremendous forces that occur during launch, as well as in the extreme temperatures of outer space (approximately -270 degrees Celsius). Tokai Spring applied its technical and engineering expertise to develop and produce specialized springs for the rockets and fairings. A symbol of pride for the Japanese aerospace industry, the successful launch greatly raised hope for future space missions among the people of Japan. As Japanese space technology continues to evolve toward achieving manned space flight, Tokai Spring's technology will play a critical role in this development by providing high-performance springs.

Main engine for launching Japan's largest rocket First-stage engine

The two-stage rocket uses liquid oxygen and hydrogen as fuel, with four solid rocket boosters (SRB-A) mounted on each side of the main body to assist in propulsion. This configuration allows the H-IIA rockets to achieve maximum payload capacity.

Disc springs and cold-formed coil springs

HERE!



Disc spring



Cold-formed coil spring

These springs are installed in regulator valves to control the adjustment of helium gas. They must withstand extreme heat during launch and flight, both within and outside the atmosphere. The materials used are capable of tolerating the extreme temperature variations encountered throughout the mission.

Satellite fairing

shields the satellite and supply vehicle from shock waves and air pressure.

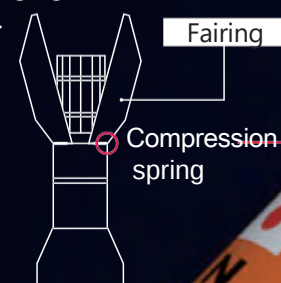
The cover protects the Kounotori vehicle, ensuring its safe delivery and that of its payload into space. Once the rocket reaches an altitude where the Earth's atmosphere no longer has an effect, the satellite fairing is jettisoned, and the payload satellite is separated from it.

Cold-formed coil springs

HERE!



Once the rocket reaches the target altitude, the satellite fairing splits into two through the operation of a compression spring and is jettisoned. The Kounotori vehicle, emerging from within, separates and utilizes springs once again to achieve its intended orbit. These springs are made from high-stress materials, allowing them to withstand the uniquely challenging environment of space.



PROJECT STORY

A number of research institutions and manufacturers participated in the development of JAXA's rocket, bringing together the best and brightest of Japanese technical and engineering talent. Initially, there was skepticism about using a domestic product for the disc springs in the first-stage rocket engine valves, but Tokai Spring gained approval with its prototypes. After approval, independent testing laboratories conducted numerous rigorous performance qualification tests, and our company was able to create a spring guaranteed to function under the extreme forces of the launch and the harsh conditions of space.

MADE IN JAPAN, Soaring into Outer Space

Tokai Spring super high-precision springs sustain power plant turbines at the heart of energy production

Electric power cannot simply be drawn directly from thermal or nuclear sources. Instead, power generation relies on a machine called a "prime mover" to convert heat energy into mechanical energy. In power plants, this vital role is performed by gas turbines and steam turbines, which are supported by springs from Tokai Spring.

Energy from high-pressure gas and steam, created by thermal and nuclear power, can only be transmitted to generators after it generates rotary motion through turbines. Turbines contain bladed rotors that operate similarly to the vanes of a windmill. However, instead of being moved by the wind, turbine rotors are driven by high-temperature, high-pressure gas and steam generated from vast amounts of energy. To efficiently use this energy, turbines must withstand immense temperature and pressure. This is where Tokai Spring's flat springs come in.

Acting as cushions between the high-speed rotating rotors and the "seal rings" that prevent steam leaks, these springs protect turbines and ensure stable, enhanced power generation. While flat springs may not be visible in our daily lives, they play a crucial, behind-the-scenes role in maintaining society's energy supply.

PROJECT STORY

Steam and gas turbine springs are consistently exposed to extremely high temperatures. The maximum temperature a turbine spring can withstand depends on the material used. While there are various heat-resistant steel materials available, only a select few possess the required properties to bend and reliably return to their original shape. This is why Tokai Spring is dedicated to continuously investing in and researching new production technologies, such as advanced heat treatment methods, to enhance the performance of springs made from normally heat-resistant steel or to meet other specific performance requirements of our customers.



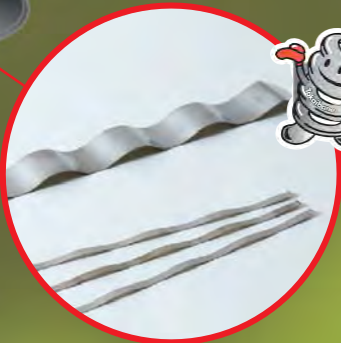
Seal rings

-Enhancing the performance of turbines-

Seal rings close the gaps in turbines, preventing steam leakage. By maintaining a tight seal, they ensure the efficient transmission of steam flow to the rotor blades, enabling optimal turbine performance.

Flat springs and disc springs

Strong spinning motion can cause a rotor shaft to be misaligned. If this happens, the springs act as cushions to prevent heavy loads from being exerted even with zero contact between the rotor and seal ring.

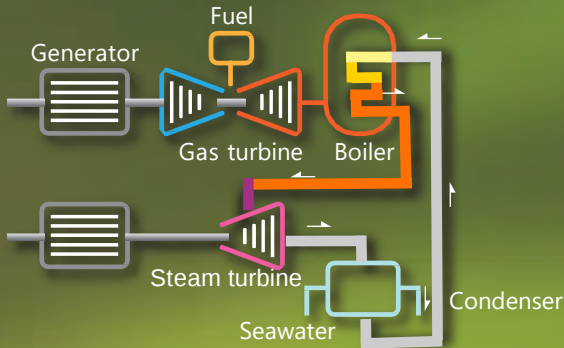


Flat springs



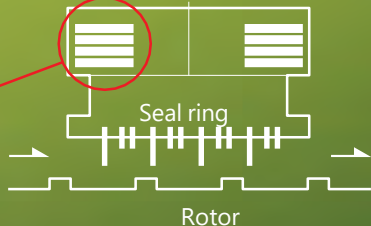
Disc springs

What is a turbine?



Steam turbines and gas turbines are referred to as "prime movers." Their function is to convert various forms of energy into mechanical motion. High-pressure gas or steam generated by thermal or nuclear power passes through these turbines, where it is transformed into electricity

Clearance control for starting/stopping and load operation



The rotor's optimum clearance within a turbine varies during startup, operation, and shutdown. Adjustments are essential at each stage to ensure maximum performance.

Chair skiing

Chair skiers request custom-made springs specifically tailored to their needs, as they do not use chair skis equipped with off-the-shelf springs.



Rough terrain vehicles

Rubber-tread crawler vehicles operate on rough terrain such as mountains and snow-covered landscapes. Springs are incorporated into their treads along with cylinders to prevent the treads from loosening or disengaging.



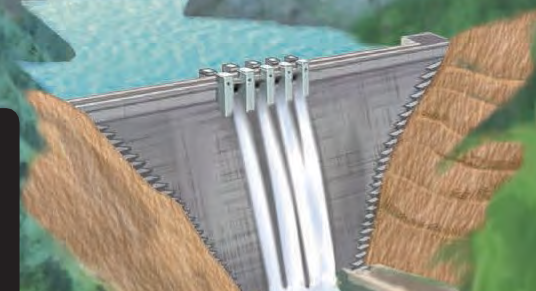
Gondola lifts

Gondola lifts require an extremely high level of quality and safety. Springs are used in components that securely clamp the gondola ropes, ensuring safety even under severe conditions such as blizzards.



Sluice gates

Devices known as "Gate-robo" are used to maintain the safety of sluice gates and continuously monitor operations to prevent abnormal forces from being applied to the ropes.



Machining centers

Main spindle disc springs are fitted to respond to the constantly changing conditions of machining centers, such as shifts in high-speed axis rotation or increases in ATC (Automatic Tool Changer) frequency.

Ironworks and steelworks facilities

Custom-made springs are used in various stages of steel production, from sizing presses to large crane presses, playing important roles in large-scale manufacturing.



Ferris wheels

Custom-made springs are used to stabilize the drive components that rotate the largest Ferris wheels in the world.



Tower buildings

Fitting-type springs, which can handle both compression and tension forces, are used in passive dampers and other components of high-rise structures.



Marine vessel valves

Valves for marine vessels require high reliability to ensure they do not fail during extended periods of operation. This functionality is supported in the background by springs.



Akashi-Kaikyo Bridge

The 3,911-meter-long Akashi-Kaikyo Bridge is the longest suspension bridge in the world. To ensure the safety of the bridge, spring-type wind shoes absorb vibrations caused by winds from various directions and speeds.



Shinkai 6500

This submersible research vehicle is currently the deepest-diving vehicle in the world. Springs with exceptional corrosion resistance are used to operate in the highly corrosive environment of the deep sea.



Hayabusa

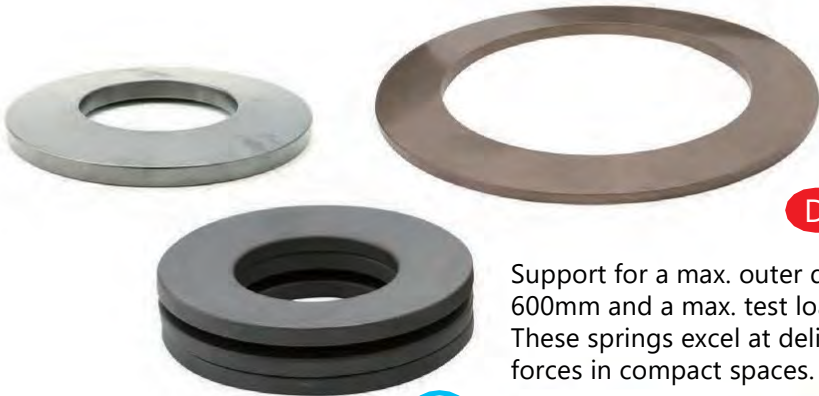
In 2010, the Hayabusa satellite completed its 6 billion km journey and returned to Earth. Many springs were used in the Hayabusa, including in its sampling devices, which were employed to collect material samples from the surface of the Itokawa asteroid.

Behind the scenes, Tokai Spring's custom-made springs provide critical support to a wide range of equipment across the globe

Tokai Spring can meet any requirement

Compression springs

It can be produced with a max. wire diameter of 90mm, a max. outer coil diameter of 600mm, and a max. free length of 1200mm!



Disc springs

Support for a max. outer diameter of 600mm and a max. test load of 300t! These springs excel at delivering large forces in compact spaces.

HII-B Rocket P5▶



i-MC springs

i-MC spring for a machining center. These springs achieve high-speed rotation stability and long life due to their precise dimensional accuracy.



Flat springs

These flat springs are used in a wide range of applications, from stacked flat springs in trucks and railway vehicles to extremely small springs incorporated into electronic devices.

Power Plant Turbines P.7▶

Friction springs

These springs have a structure that combines alternating inner and outer rings. They are capable of absorbing large amounts of energy within small dimensions.



Fitting-type springs

By inserting screw-type fittings into both ends and using rod ends or similar components depending on the application conditions, these springs are able to handle both compressive (pushing) and tension (pulling) forces.

TOKYO SKYTREE® P.3▶



Extension springs

Can be produced with a wire diameter of up to 30mm. Ideal for use with high loads.



Rectangular-wire helical springs

Compared to standard round cross-section coil springs, these remain constant even in small spaces.



"Gate-robo"

Safety devices used in sluice gates on dams and rivers constantly monitor whether abnormal loads are being applied to the ropes when the sluice gates are operated.



Spiral springs

Forces are generated in the rotational direction with minimal space, and manufacturing this type of spring requires advanced winding techniques by our skilled craftsmen.



Conical springs

Their conical shape reduces bending, and their solid height can be reduced depending on the shape, allowing them to be used in compact spaces.



Volute springs

These powerful springs feature the characteristics of 2-stage springs. They are often used in crane ends subjected to high impacts and in cushioning equipment at ironworks and steelworks facilities. These springs are handcrafted by our skilled craftsmen.



Torsion springs

These springs are made by applying a twisting force (torque) around their coil axis. They can store more energy than coil springs of the same weight, enabling a lightweight design.



【Standard material stock】

Spring steel, Stainless steel, Inconel (nickel alloy),Beryllium copper, Tungsten steel, Titanium steel

MAXIMUM wire diameter φ90mm
MAXIMUM plate thickness 40mm





Tokai Spring industries, Inc.

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Established: 1944

Number of employees: 85

Capital: 96,445,000 JPY (About 612,600 USD)

Certifications : ISO9001, ISO14001, JISQ/AS/EN9100

【Main clients】

Mitsubishi Heavy Industries, Ltd., Kawasaki Heavy Industries, Ltd., Fanuc Corporation, Yamazaki Mazak Corporation, Okuma Corporation, IHI Corporation, Kobe Steel Ltd., The Japan Steel Works, LTD., NEC, Fukui Seisakusho Co., Ltd., JTEKT Corporation, Hitachi, Ltd., Toshiba Corporation, Sumitomo Precision Products Co., Ltd., etc...

