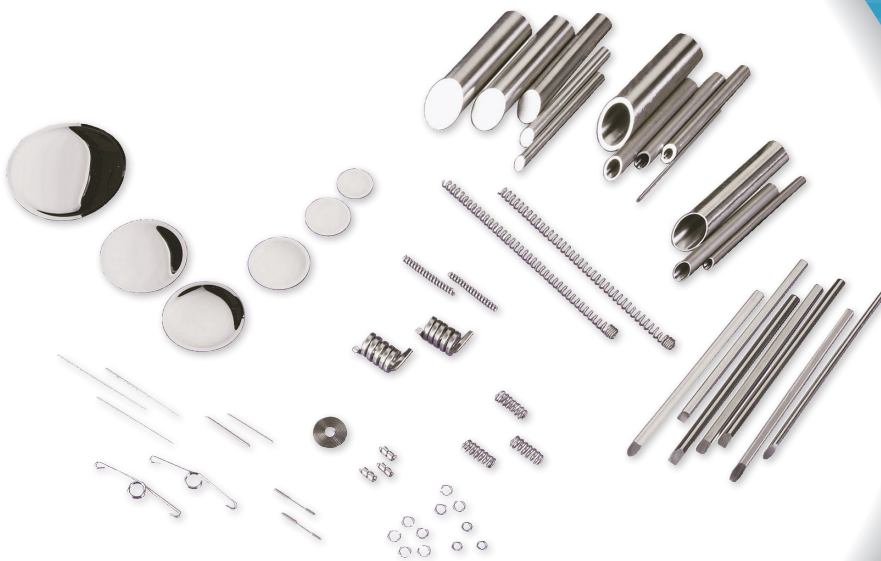


Superior performance Co-Ni Alloy Product (SPRON)[®]



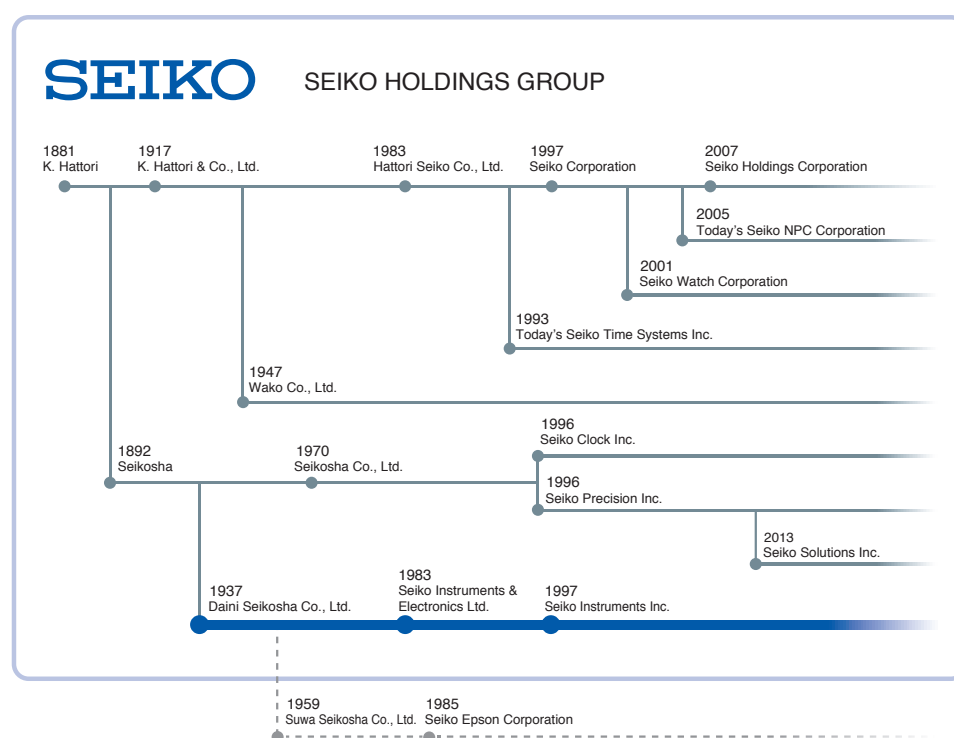
Creating Time - Optimizing Time - Enriching Time

Seiko Instruments Inc. (SII), founded in 1937 as a member of the Seiko Group specializing in the manufacture of watches, has leveraged its core competency in high precision watches to create a wide range of new products and technologies.

Over the years SII has developed high-precision processed parts and machine tools that pride themselves on their sub-micron processing capability, quartz crystals that came about as a result of our quartz watch R&D, and electronic components such as micro batteries.

Optimizing our extensive experience and expertise, we have since diversified into such new fields as compact, lightweight, exceedingly quiet thermal printers, and inkjet printheads, a key component in wide format inkjet printers for corporate use.

SII, in the years to come, will maintain an uncompromised dedication to its time-honored technologies and innovations of craftsmanship, miniaturization, and efficiency that meet the needs of our changing society and enrich the lives of those around us.



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Superior performance Co-Ni Alloy Product (SPRON)[®]

It all started with the precision spring.
With its **evolution** came the Co-Ni alloy product
that is paving the way of the **future**.



Power spring in
mechanical watches



The Grand Seiko is
equipped with the SPRON

■ History of SPRON

The Sendai Precision Materials Laboratory – the predecessor of the Sendai Unit where production of SPRON is based – began collaborating in 1953 with the Institute of Materials Research, Tohoku University to develop the spring that serves as a power source for mechanical watches. In 1956, we succeeded in developing SPRON 100, a strain age-hardening type, high-elastic and high-corrosion-resistant alloy that leverages the work-hardening properties of the cobalt base.

In 1957, Sendai Precision Materials Laboratory began producing watch springs as a watch spring manufacturing company. Combining the material's properties with the precision processing technology allowed SPRON to be used in a wide range of high-precision springs and as spring material in medical instruments.

Later, growing needs for enhancements in super-miniaturization technology and high-performance spring material led to the development of SPRON 510, featuring material strength and corrosion resistance surpassing that of SPRON 100.

Originating as a part with a dimension of only a few millimeters, the SPRON 510 is now used for precision spring material in fields related to semiconductors, dental, medical, and others.

The SPRON also serves as a part of the power spring in the Grand Seiko and other mechanical watches under the Seiko brand.

■ The origin of the name “SPRON”

The name SPRON is coined from “SPRING + MICRON.” As the name implies, our precision springs boast outstanding material properties and are machined to a precision finish controlled to the micron level.

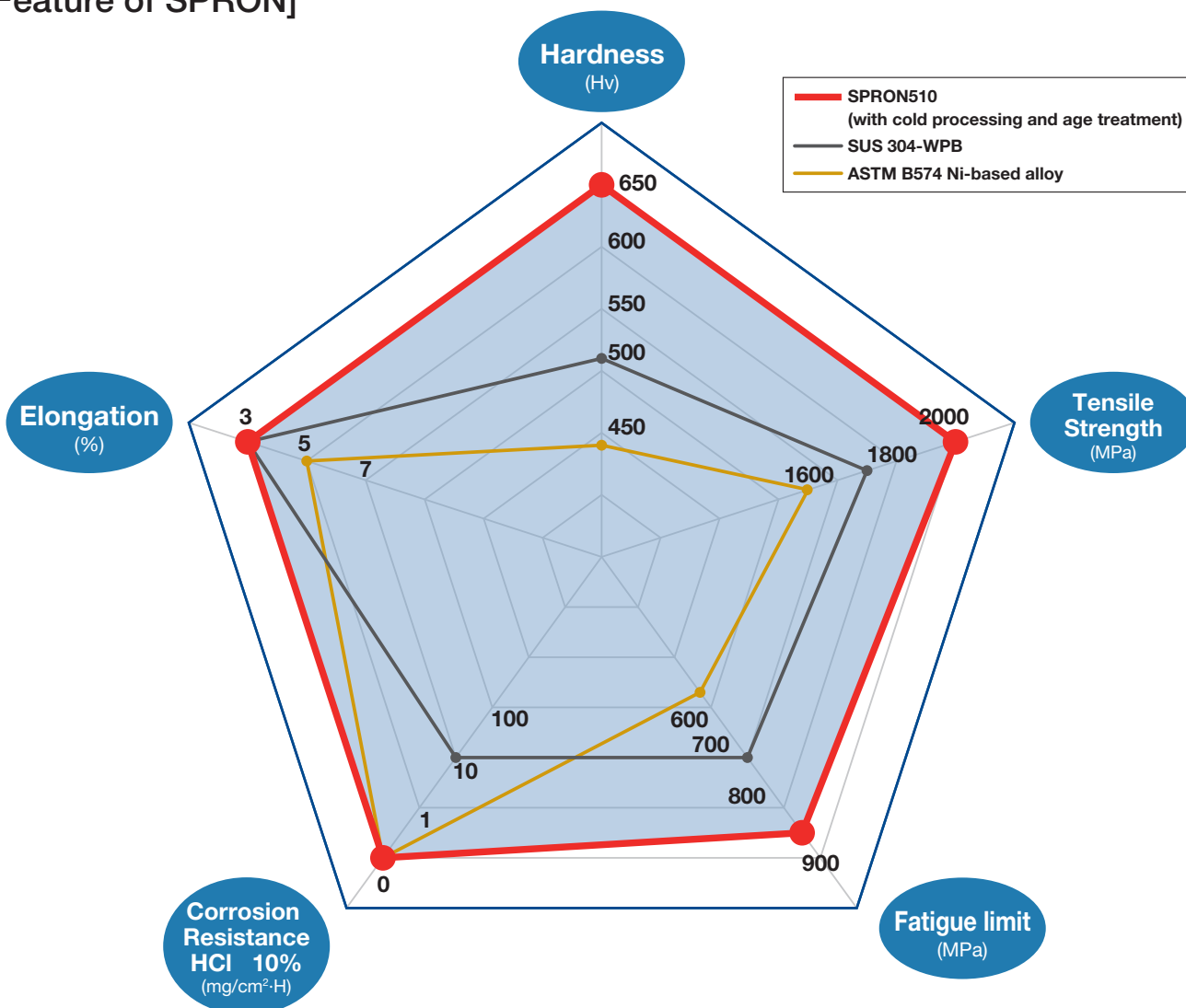
* SPRON is a registered trademark of Seiko Instruments Inc.

■ SPRON510

In 1956, the superior performance Co-Ni alloy product (SPRON) was developed as spring material in “Grand Seiko”, the high grade mechanical watch, through collaboration with the Institute of Materials Research, Tohoku University.

SPRON510 is corrosion resistant and significantly excellent at every aspect of mechanical characteristics below.

[Feature of SPRON]

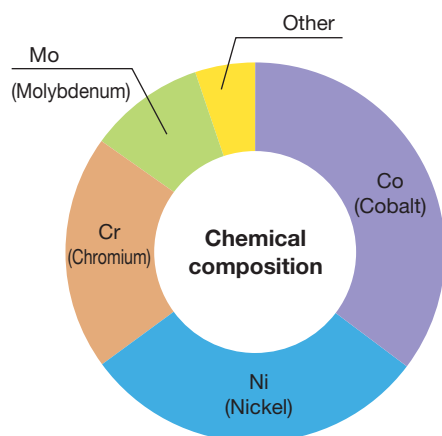


[Mechanical and physical characteristics]

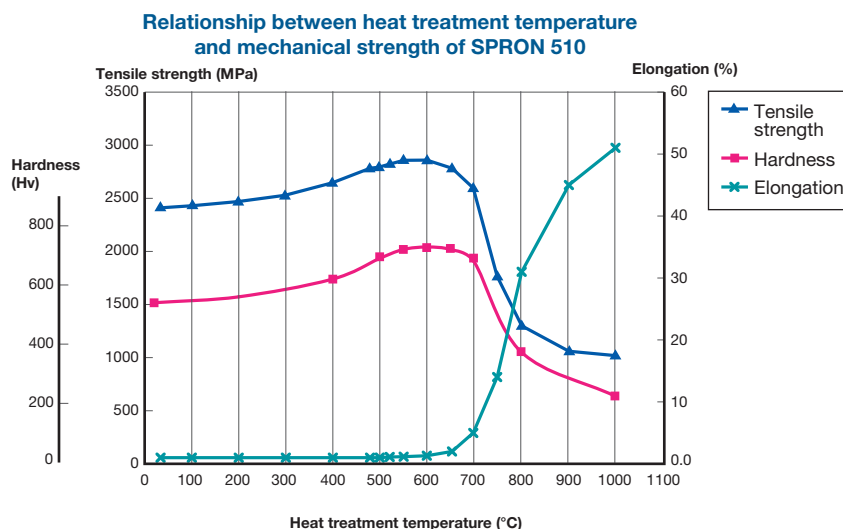
Tensile strength	Stiffness	Elongation	Hardness	Density	Young's modulus	Modulus of rigidity	Linear expansion coefficient (20 to 50°C)	Electrical resistivity	Intensity of magnetization (5kOe)	Poisson's ratio
Up to 2940MPa (Up to 300kg/mm ²)	Up to 5684MPa (Up to 580kg/mm ²)	3%	Hv. to 800	8.5 to 8.7 g/cm ³	216 to 225GPa (22 to 23×10 ³ kg/mm ²)	83.3GPa (8.5×10 ³ kg/mm ²)	12 to 13×10 ⁻⁶ /°C	98 to 100μΩ-cm	0	0.33

<Measured a wire drawing material with cold processing and age treatment>

Chemical components



Relationship between mechanical characteristics and heat treatment temperature



* The above graph shows the tensile strength, hardness, and elongation when a material with 90% processing rate of wire-drawing is heat-processed at each temperature for two hours.

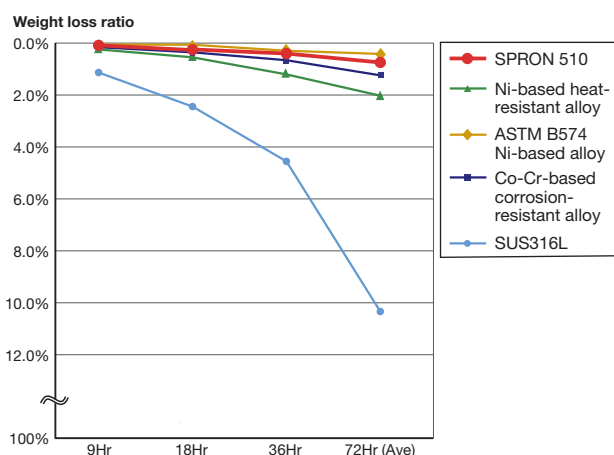
Five advantages of SPRON

1. No Corrosion

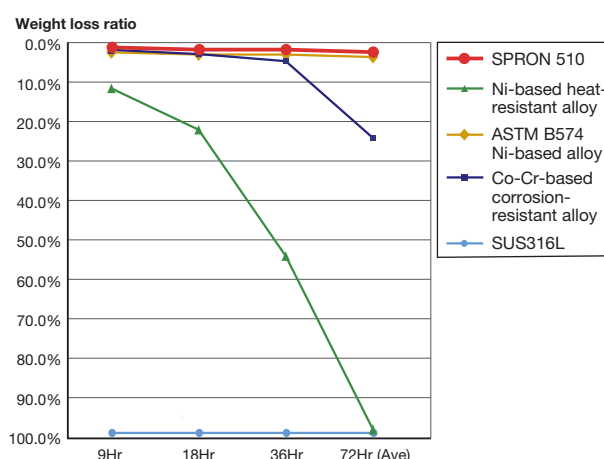
Results of corrosion tests in 48% hydrogen bromide (HBr) and 36% hydrochloric acid (HCl) show that SPRON 510's corrosion resistance is superior to that of the corrosion-resistant metal materials shown below.

Corrosion resistance of SPRON510 and other Metals

Immersion: 48%HBr (Hydrogen bromide)



Immersion: 36%HCl (hydrochloric acid)



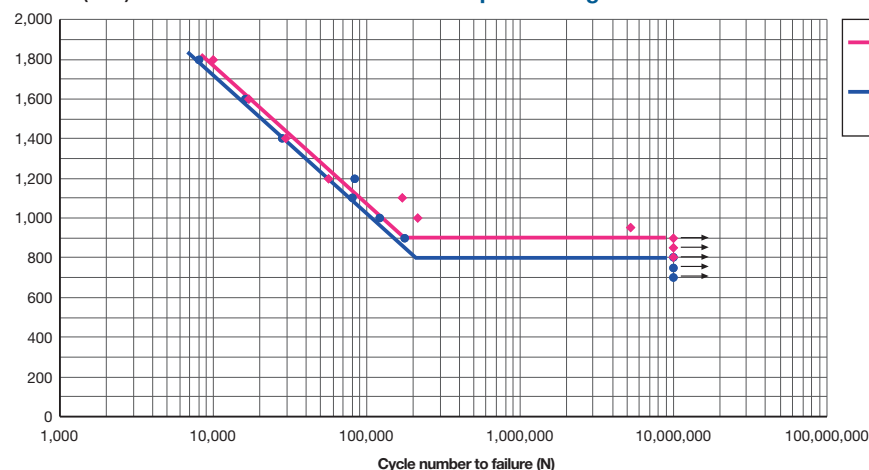
[Measurement conditions] ■ Test piece: $\phi 20\text{mm}$, Mass 0.2 to 0.3g
 ■ Immersion: 48%HBr (60°C) / 36%HCl (60°C)

2. Strong

The fatigue limit of SPRON510 (processing rate when rolled: 73%, age treatment: 525°C) is 900MPa.

S-N Curve

Stress σ (MPa) S-N curve of SPRON510 with processing rate of 73%



Fatigue Test

[Measurement conditions]

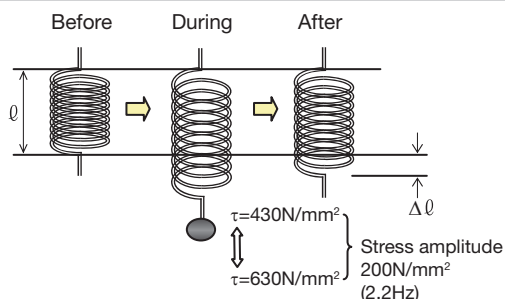
- JIS Z 2273-1978
- Stress ratio $R=0.1$

* The graph shows that the fatigue limit is 900MPa when age treatment is performed at 525°C.

3. Elastic

Fatigue due to both statistical and dynamic loads is very small, achieving large spring load by a fine spring. Relaxation rate after 1,000,000 times of tensile spring tests of SPRON510 is one-fifth or one-sixth as much as that of piano wire.

Relaxation and Number of repetition due to tensile spring test

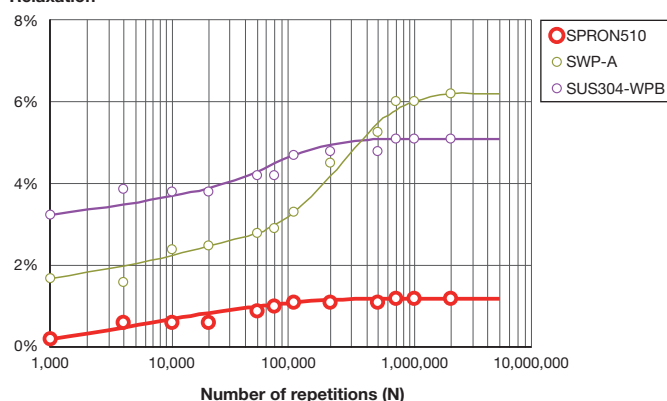


Repeated Stress×N ($\tau \times N$)

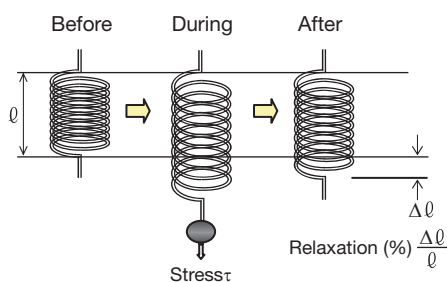
[Measurement conditions]

- Wire diameter: $\phi 0.3\text{mm}$ ■ Center diameter: $\phi 3\text{mm}$
- Number of coils: 33-35 ■ Free length: 16.0mm

Relaxation



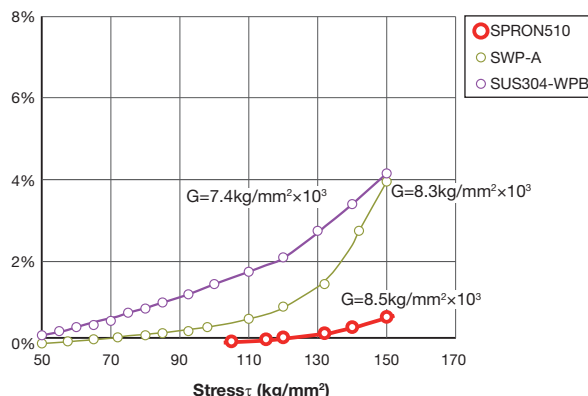
Relaxation and Stress due to tensile spring test



[Measurement conditions]

- Wire diameter: $\phi 0.3\text{mm}$ ■ Center diameter: $\phi 3\text{mm}$
- Number of coils: 35 ■ Free length: 16.5mm

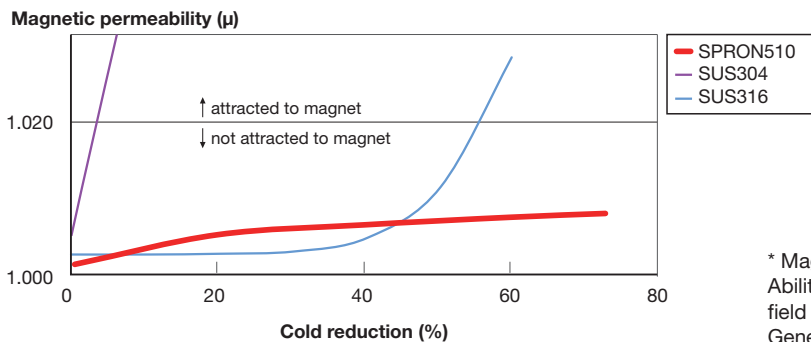
Relaxation



4. No Magnetization

SPRON is suitable for parts in measurement/analysis equipment that will not welcome magnetism.

Magnetic characteristic (permeability)



* Magnetic permeability (μ)

Ability of a material to support the formation of a magnetic field within itself.

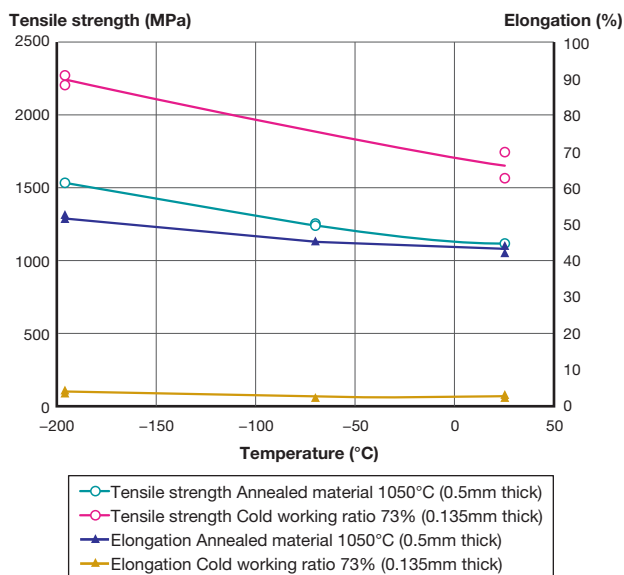
Generally, a material with $\mu < 1.02$ is regarded as non-magnetic.

5. Heat resistant (both hot and cold)

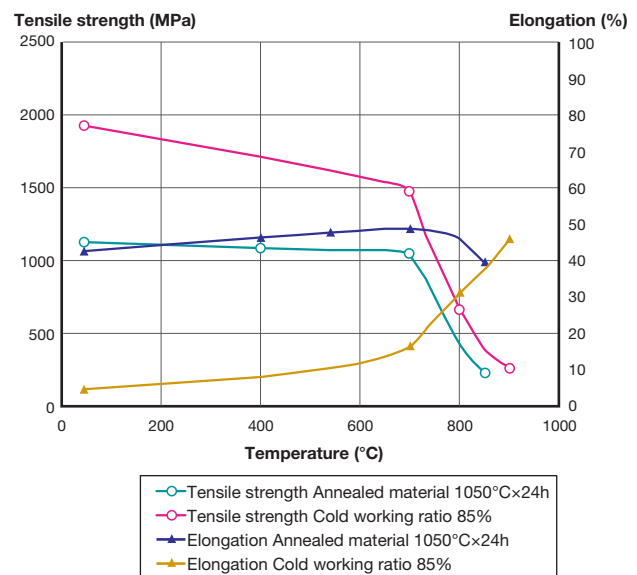
SPRON 510 has excellent characteristics in both high and low temperature ranges.

Low-/high-temperature characteristics

SPRON510 low temperature tensile testing
Relationship between tensile strength and elongation at low temperature



SPRON 510 high temperature tensile testing
Relationship between tensile strength and elongation at high temperature



Applications

Evaluated highly for its corrosion resistance and durable quality, SPRON is used for key devices in various fields like valves, dental wire, pressure sensor, mass flow controller, and various kinds of fine spring.

- Metal diaphragm and pipe in pressure sensor
- Corrosion-resistant fine parts
- Fine parts for medical use
- Several kinds of fine spring (coil, torsion, plate)

Pressure sensor, mass flow control device, diaphragm
→ **Strength, corrosion resistance, durability**



Fine springs
→ **Elasticity, durability, corrosion resistance**



SII supplies SPRON as custom-made machined products, featuring its strong characteristics. Mirror surface polishing and fine cutting is possible with SPRON.

Overview

SPRON 100 is a strain age-hardening type Co-Ni alloy that makes the most of the work-hardening properties of cobalt-based alloys. High mechanical strength and corrosion resistance combined with excellent precision processing technologies make it ideal for precision devices, medical precision parts, and precision screws, as well as mechanical watches.

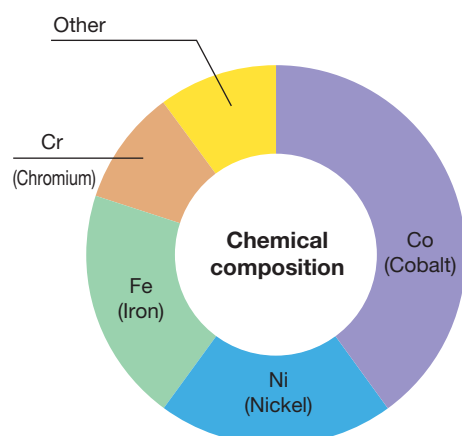
Characteristics

[Mechanical and physical characteristics]

Tensile strength	Elongation	Hardness	Density	Young's modulus	Modulus of rigidity	Linear expansion coefficient (20 to 50°C)	Electrical resistivity
Up to 2156 MPa (Up to 220 kg/mm ²)	3%	Hv. to 600	8.3 to 8.6 g/cm ³	206 to 216 GPa (21 to 22×10 ³ kg/mm ²)	80.4 GPa (8.2×10 ³ kg/mm ²)	12 to 13×10 ⁻⁶ /°C	98 to 100 μΩ-cm

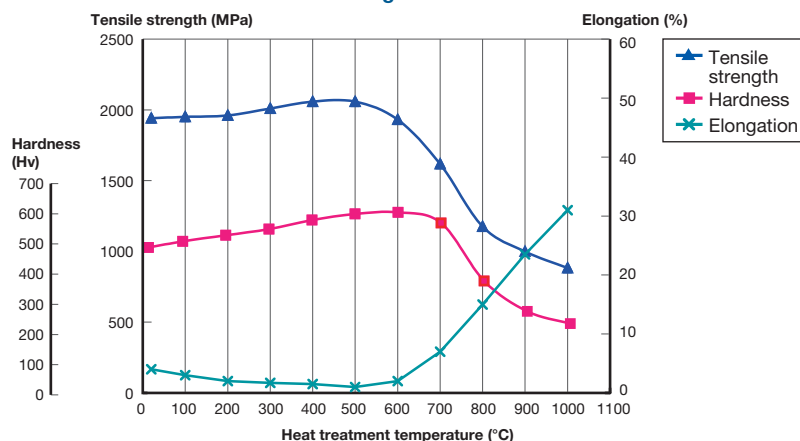
<Measured a wire drawing material with cold processing and age treatment>

Chemical components



Relationship between mechanical characteristics and heat treatment temperature

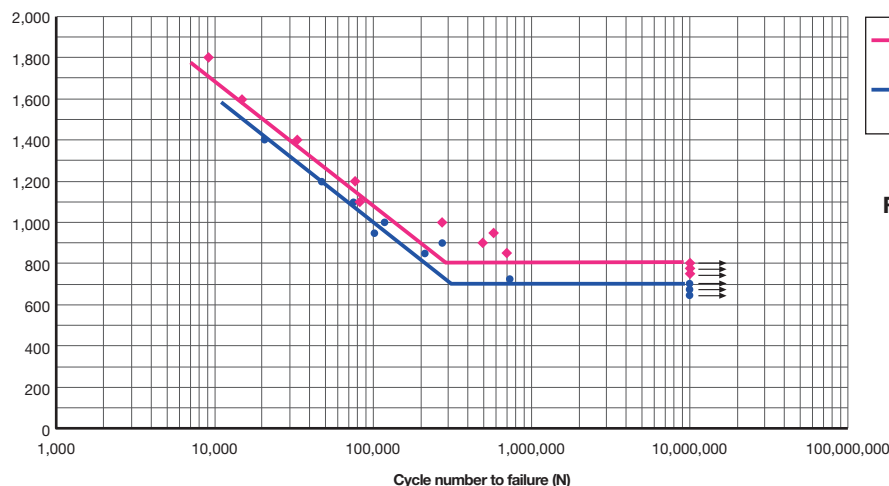
Relationship between heat treatment temperature and mechanical strength of SPRON 100



* The above graph shows the tensile strength, hardness, and elongation when a material with 90% processing rate of wire-drawing is heat-processed at each temperature for two hours.

S-N curve

Stress σ (MPa) S-N curve of SPRON 100 with processing rate of 74%



— SPRON100 thickness: 0.130mm
(processing rate: 74%, age treatment: 525°C×2h)

— SPRON 100 thickness: 0.130mm
(processing rate: 74%)

Fatigue Test

[Measurement conditions]

- JIS Z 2273-1978
- Stress ratio R=0.1

* The graph shows that the fatigue limit is 800MPa when age treatment is performed at 525°C.

Glossary

Term	Unit	Description
As rolling		Roll drawing has completed.
S-N curves		Graph showing the results of bending fatigue test. (Stress and repetition counts are logarithmically expressed in the vertical and horizontal axes, respectively.)
Stress	MPa	Stress value in fatigue test.
Rate of work		Degree of cold deformation processing, such as wire drawing and rolling. Also known as cold working ratio. The working ratio is the quotient of the sectional area divided by the difference between the sectional areas of the material before and after working, expressed in percentage (%).
Vickers hardness	Hv.	The quotient of the force applied for the indent divided by the surface area of the indent which was produced on the test piece by an indenter (diamond square cone of which angle of opposite faces is 136°).
Strength		Mechanical strength such as tensile strength and hardness
Cycle number to failure	N	Number of repetitions for fatigue test.
Stiffness	MPa (kg/mm ²)	Maximum stress value in transverse test
Electrical resistivity	μΩ-cm	Electrical resistance ratio specific to a substance
Intensity of magnetization	G	Magnetic flux density in a 5 KOe magnetic field
Aging treatment		Heat processing to improve mechanical characteristics by applying a specified temperature
Coefficient of linear Expansion	1/K (1/°C)	The rate of length change in accordance with the temperature change
Durability		Fatigue characteristics (characteristics resistant against repeated loads)
Corrosion resistance		Durability against corrosive gases and solvent
Heat resistance		Resistance to degradation of characteristics, such as mechanical strength, in a high temperature environment
Young's modulus	GPa (kg/mm ²)	Proportional constant existing between vertical stress and vertical strain
Elasticity		Young's modulus and modulus of rigidity
Heat treatment		Heat application and cooling of metallic materials in appropriate conditions to gain desired characteristics
Non-magnetic material		Property of barely being influenced, if at all, by magnetism
Tensile strength	MPa (kg/mm ²)	Maximum stress value for tensile test
Modulus of relaxation		Relaxation degree due to repeated loading by tensile coil spring model
Poisson's ratio		The ratio of the lateral contraction strain to the longitudinal extension strain when a material is stretched elastically uniaxially.
Modulus of rigidity	GPa (kg/mm ²)	Proportional constant between stress and shear strain when shear force is applied
Cold working		Deformation processing performed at normal temperature

* The above glossary was created based on terms appearing in the SII catalogues and does not certify the contents and products.

Environmental Activities at Micro-Energy Division

Environment & Quality Policy

Seiko Instruments Inc., Micro-Energy Division is located in Ayashi, a city with beautiful nature, in Miyagi Prefecture. Our aim is to provide customer satisfaction and harmony with the environment through all our products, from Micro battery to other electronic products, and sales activities.

1. We adhere firmly to laws, regulations and customers' specified requirements.
2. We aim to prevent pollution, to reduce CO₂, and to conserve biodiversity.
3. We set goals, take actions, conduct regular reviews, and improve the system and performance continuously.
4. We contribute to the society by supporting green procurement, developing green products, and promoting green life activity.
5. We adhere to regulations and accommodations regarding Chemical substance content in our products and will promote reduction and replacement.
6. We vigorously educate ourselves and try to engage voluntarily in green life activity.

1. Enrich the line up of Eco-Products

- We introduced the SII Green Product Label System which is equivalent to the ISO 14021 Type II environmental label. At the end of FY2006, 100% of our products are certified as SII Green Products. In addition, 42 products are certified as SII "High Grade" Green Products.

2. Reduction of Greenhouse Gas

- We practice various CO₂ reduction measures like using Eco-machinery. Since 1997, we have successfully reduced a total of 62,800 tons of CO₂. We believe our efforts contribute to the prevention of global warming.

3. 3R Promotion Activity

- We have promoted the "reduce and reuse" activities and also promoted recycling at the end of the production process. With these activities, we achieved "Zero-emission" in 2004. We have reduced the non-recyclable wastes to less than 1 ton - less than 1% of our 1997 results.

4. Biodiversity Conservation

- We endeavor to deepen our understanding on the relevancy between biodiversity and our business activities, and to contribute to the conservation of biodiversity by participating local community activities.

5. Green Purchasing

- We adhere to a green purchasing campaign through the purchase of ingredients, manufacturing materials, and other necessary products, whenever appropriate.

6. Green Life

- With the participation of all of Micro-Energy Division members, we deploy a clean-up and beautification campaign in all areas surrounding our factory once a year. In addition, we participate in the clean up activity at Hirose River once a year.

7. Conflict Minerals

- Recognizing the international importance of conflict minerals issue, we prohibit the use of such minerals.

PRECISION, CRAFTSMANSHIP and MINIATURIZATION

Leveraging Watch Making Technology

🕒 With Precision, we apply our Craftsmanship to provide Miniaturization advantages to customers' product development around the world.

Stable and reliable
Rechargeable Battery & Capacitor

For the IoT
product

No corrosion, strong,
ultra high elasticity and
no magnetization
Superior material

"SPRON"

For material
used in harsh
environments

For magnetic
applied sensor
components

Excellent heat and
corrosion resistance
**Samarium-cobalt
Magnet**
"DIANET"

Precise Timing
with
Lowest Power
consumption

Precise Timing for
Electronic Devices
**Tuning Fork Quartz
Crystal Resonator**

For wearable
devices

Small and powerful
Silver Oxide Battery
**Silver Oxide
Battery**
"SEIZAIKEN"

Electronic Components and High-performance Materials

SII's electronic components were originally derived from the development and manufacturing of quartz watches.



For material
used in harsh
environments

Since 1953

**No corrosion, strong,
ultra high elasticity
Co-Ni alloy product**

"SPRON"

The sophisticated metal product, "SPRON", was born as a material to be used in a "mainspring", which is a drive source of mechanical watches. "SPRON" has been used for over 50 years as a drive source of watches by utilizing its high elasticity, high strength, and high heat resistance. Evaluated highly for its corrosion resistance and durable quality, "SPRON" is used for key devices in various fields.



For wearable
devices

Since 1975

**Small and powerful
Silver Oxide Battery
"SEIZAIKEN"**

A small-sized primary battery that features a large electrical capacity and almost no voltage drop until the last stage of electrical discharge even though its minimum diameter is 4 mm. Since the birth of quartz watches, we have developed batteries to increase their electrical capacity. We have also pursued better leakage resistance and long term reliability characteristics. It is expected to be used as a power supply for disposable, wearable, IoT, and the low energy Bluetooth products.



Precise Timing
with
Lowest Power

Since 1976

**Precise Timing for
Electronic Devices
Tuning Fork Quartz
Crystal Resonator**

Tuning Fork Quartz Crystal Resonators were developed as the basis for accuracy in the Quartz Watch. Our high quality and reliability was prioritized to meet the stringent requirements for watches. Recent demand in IoT developments where devices are required to operate with low power consumption and accurate communication protocol timing have increased the demand for smaller components with the same rugged reliability as is required in watches. For applications which require absolute lowest power consumption, our Timing Crystals are available in our Low CL specifications.



For magnetic
applied sensor
components

Since 1979

**Excellent heat and
corrosion resistance
Samarium-cobalt
Magnet
"DIANET"**

"DIANET", which has its origin in rotor magnets of quartz watches, has superior heat resistance and strong magnetic force even though its outside diameter is only 1 mm or less. The Sendai Unit acquired IATF 16949 Quality Management System for the automotive production industry. "DIANET" is used for a wide range of automotive products, and its advanced quality and performance are highly recognized. In addition, "DIANET" is also used in actuators of cameras for smart phones and medical devices.



For the IoT
sensor
product

Since 1988

**Stable and reliable
Rechargeable Battery
and Capacitor**

The rechargeable batteries supporting a wide temperature range of -40°C to 85°C are available in our lineup. They are suitable for operating very low power consumption devices, for backup power supply of clock and memory functions of a wide range of products. The capacitor will correspond to the new needs of energy harvesting devices. Capacitors are extremely useful in various applications.



Micro-Energy Division who manufactures the products described in this catalog holds the ISO 9001 quality management system certificate, and the ISO 14001 environmental management systems certificate.



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(Specifications are subject to change without notice.)

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