Twaron®

The all-round high performer

TEIJIN ARAMID

Twaron®

Contents

Materializing ambitions

At Teijin Aramid, we partner with industries to make ambitious ideas a reality. Twaron® is at the heart of this, helping companies across sectors like automotive, aerospace, and protective wear push boundaries with stronger, lighter, and more durable materials.

By working together, we co-create solutions that not only meet today's challenges but set new standards for performance and sustainability. With Twaron®, our partners can count on reliability and innovation, helping them turn vision into action.

What is Twaron®?

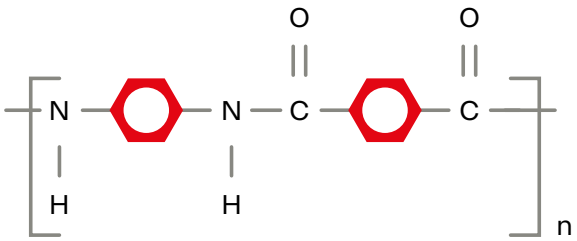
Twaron® is Teijin Aramid's flagship para-aramid. This high-performance material is known for its robust mechanical properties, chemical resistance, and thermal stability. Twaron® stands out in numerous industries for its exceptional durability. With over 30 years of expertise in aramid production, we offer a technically advanced product as well as the ability to customize Twaron® in partnership with our customers to meet diverse application needs.

Twaron® para-aramid yarn excels in demanding environments, from ballistic defense to heat and cut protection. It serves critical roles in the oil and gas, automotive, and telecommunications sectors. The yarn's exceptional qualities stem from its 100% paracrystalline structure, with molecules aligned along the filament axis. This design ensures superior performance across diverse applications.

Twaron® stands apart from other synthetic yarns with its unique blend of features:

- High strength: exceptional strength-to-weight ratio
- High modulus for stiffness and rigidity
- Dimensional stability: low creep and negative thermal expansion
- Excellent thermal stability, even at high temperatures
- High cut resistance for improved durability
- Good resistance to chemicals
- Low flammability for enhanced safety
- Electrically non-conductive
- Long, predictable lifetime

Structure of Twaron®



Polyparaphenylene terephthalamide (aramid)

How is Twaron® produced?

Dedicated specialists closely oversee Twaron® production, a three-stage process: polymerization, spinning into continuous filament yarn, and converting.

1. Polymerization

In the first stage, monomers are combined to form a robust, fine-grained para-aramid polymer, known for its heat resistance and chemical resilience. This fine powder improves the quality of the plastic components. However, at this point, it does not possess the unique mechanical properties of yarn or pulp.

2. Continuous filament yarn spinning

In the second stage, we dissolve the polymer in sulfuric acid, creating a liquid crystalline solution. This solution spins into fine, natural yellow or dope-dyed black yarns. Typically, each filament measures as thin as 12 µm in diameter. These yarns boast a 100% paracrystalline structure, with molecular chains aligned parallel to the filament axis. This precise orientation is key to the remarkable properties of Twaron® yarns.

3.Converting to staple and short-cut fiber

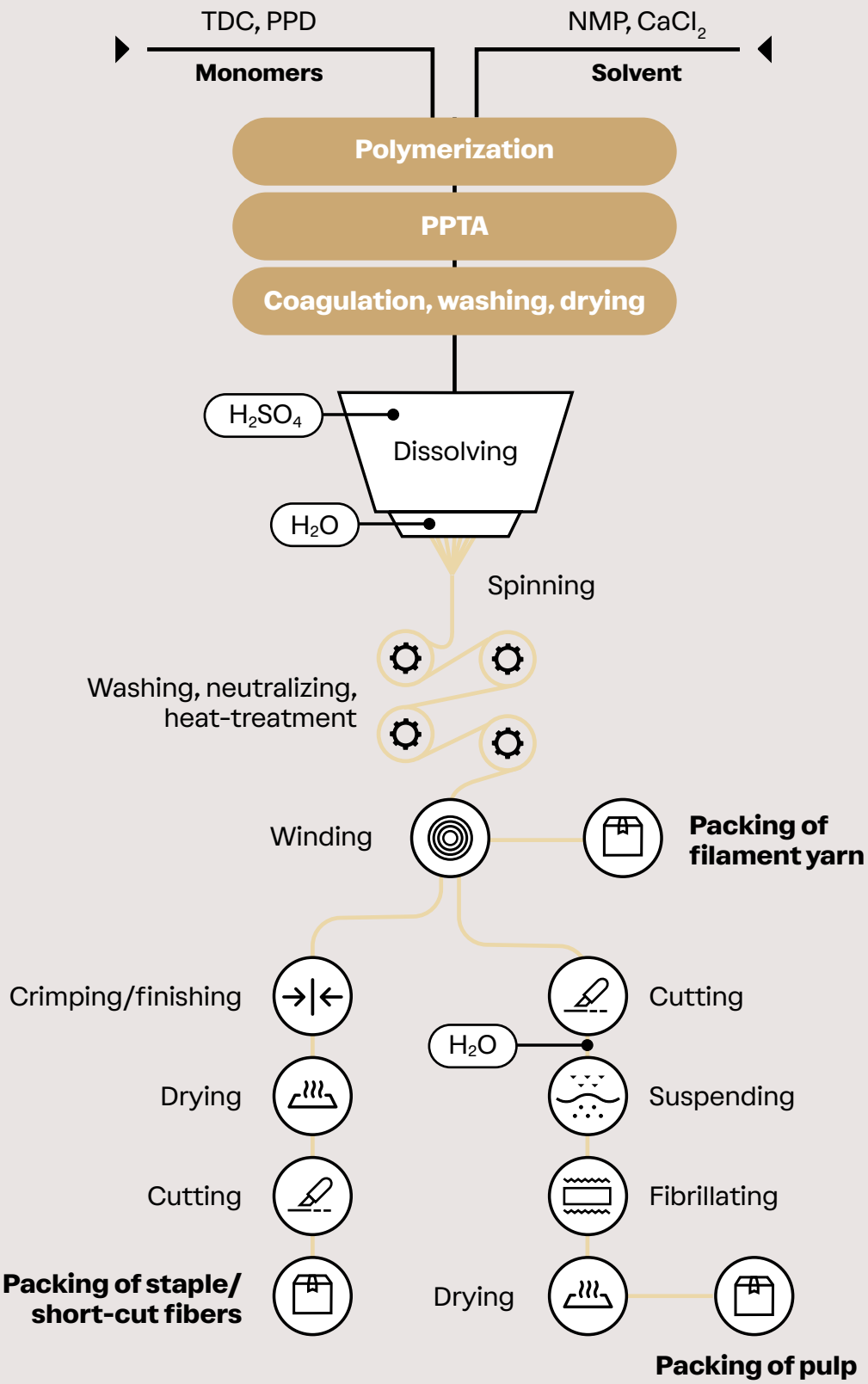
To create Twaron® staple fiber, we crimp the continuous filament yarns, applying a finishing agent if needed. After drying, yarns are cut to the desired length.

Converting to pulp

To make Twaron® pulp, we cut the filament yarns, then suspend and fibrillate them in water. The pulp is marketed as wet pulp or dehydrated and dried for sale as dry pulp.

Customization of Twaron®

We offer further customization of Twaron® continuous filament yarns, including high linear densities tailored to client needs. We can apply additional functional coatings to improve product utility. Moreover, untwisted yarns can be twisted to meet specific application requirements, optimizing performance.


TDC, PPD
NMP, $CaCl_2$
Monomers
Solvent
Polymerization
PPTA
Coagulation, washing, drying
H_2SO_4
Dissolving
H_2O
Spinning
Washing, neutralizing, heat-treatment
Winding
Packing of filament yarn
Crimping/finishing
Drying
Cutting
Packing of staple/ short-cut fibers
Cutting
H_2O
Suspending
Fibrillating
Drying
Packing of pulp

What types of Twaron® do we offer?

Twaron® filament yarn

Twaron® filament yarn comes in a variety of mechanical properties, categorized simply as:

- Standard modulus with high elongation
- High modulus
- High tenacity

Tailored for high performance

Twaron® has proven its value across a wide range of applications, including optical fiber cables, hoses, tires, rubber goods, ballistic protection, protective clothing, ropes and cables, composites, and belts. Our yarns, available in linear densities starting from 400 dtex and can be tailored to meet specific requirements. Whether in twisted or untwisted constructions, we customize Twaron® yarns to optimize performance. Special surface treatments improve both application performance and processability.

Finishes and color options

We apply a water-blocking finish to high-modulus Twaron® yarn for optical fiber cables and use adhesion-activated fibers for rubber products. While Twaron® typically comes in its natural yellow, we also offer black yarns for applications where appearance is key, such as composite fabrics, boat sails, and protective clothing. This deep black is achieved through dope-dying, ensuring lasting color fastness to meet aesthetic and performance needs.

Twaron® yarn product property ranges

Twaron® yarn	Tenacity (mN/tex)	Modulus (GPa)	Elongation at break (%)
High elongation / standard modulus	1,650 - 2,250	50 - 85	3 - 5
High modulus	2,100 - 2,600	100 - 145	2 - 3
High tenacity	2,350 - 2,600	85 - 95	3 - 4

Twaron® staple fiber

Twaron® staple fibers are ideal for making gloves and apparel that protect against heat and cuts. These fibers come in both the standard yellow para-aramid color and black. We offer several specific lengths (40, 50, 60 mm) and a range of cut lengths from 76 mm to 100 mm. Choose from linear densities of 0.9, 1.7, and 2.5 dtex. For black fibers, options include 1.7 and 2.5 dtex densities. Beyond staple fibers, Twaron® is also available as stretch-broken yarns.

Twaron® short-cut fiber

Twaron® filament yarn can be processed into short-cut or dipped chopped fibers, ranging in length from 0.25 mm to 12 mm. These are ideal for use in engineering plastic applications, among others.

Twaron® powder

Twaron® is also offered in powder form, defined by particle size. This form is ideal for engineering plastics, coatings, and rubber compounds.

Twaron® pulp

To create Twaron® pulp, we cut the filament yarn, suspend it in water, and then fibrillate it. The pulp's unique qualities, like fibril length and specific surface area, define its level of fibrillation.

Thanks to its chemical and physical properties, Twaron® pulp increases stability and boosts the strength of the compounds it's added to.

We offer both dry and wet pulp in various fibril lengths and degrees of fibrillation, catering to a wide array of applications. These include friction products, sealing materials, and specialty papers, ensuring our customers have the best solutions at their disposal.

A unique combination of properties

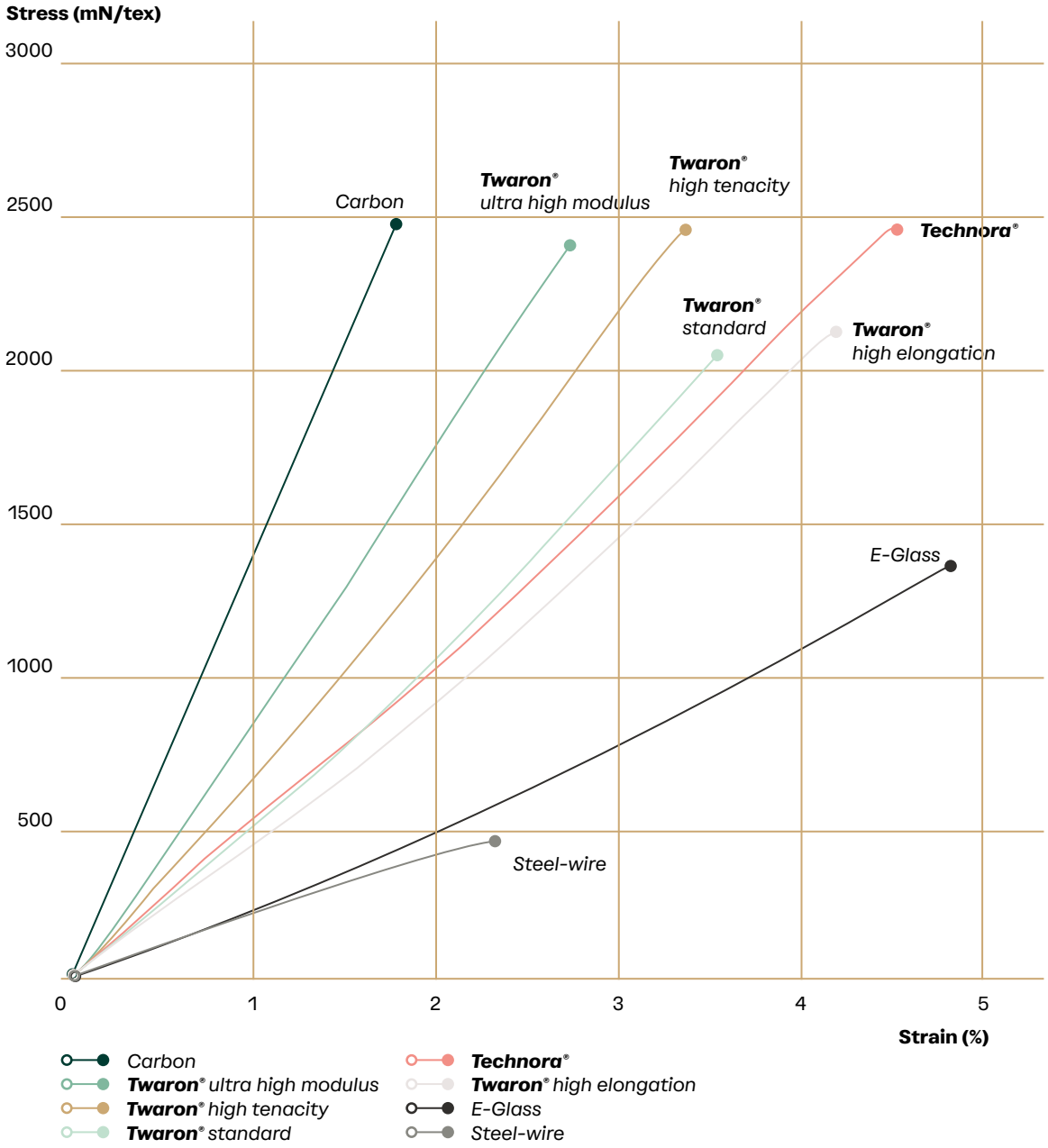
Mechanical properties

Twaron® yarns boast exceptional strength, with tensile strength two to three times higher than polyester and polyamide yarns, and up to six times higher than steel, when compared weight for weight. They maintain their key mechanical properties over a broad temperature range, ensuring durable reinforcement for a well-defined product lifetime. This lifetime varies based on load and temperature – higher loads and temperatures may shorten it. However, with proper safety factors, Twaron® significantly extends the economic lifespan of products. While prolonged UV and blue light exposure can discolor and weaken individual fibers, this effect is often negligible for thicker applications like ropes or fabrics.

Dimensional stability

Dimensional stability is critical for many applications, and the high modulus of Twaron® ensures minimal deformation under load. With very low and rapidly diminishing creep, products reinforced with Twaron® retain their dimensions over time. Its low, negative thermal expansion coefficient of just a few ppm/°C further improves stability under temperature variations. Additionally, Twaron® resists shrinkage when exposed to hot air, maintaining the integrity of the final product in demanding conditions.

Stress/strain curve of various materials



N.B. As the data in the table above originate from a variety of sources, they may be subject to deviations resulting from different test methods and/or conditions. Exact values depend on type and application (please contact your Teijin Aramid representative for advice on product type selection).

Thermal properties

Twaron® lacks a melting point and begins to decompose only at temperatures above 500 ˚C (932 ˚F). For heat-resistant uses, it's advised to keep short-peak temperature exposures below 250 ˚C (482 ˚F) and long-term exposures under 100 ˚C (212 ˚F) to maintain its strength. Twaron® also preserves its mechanical properties at extremely low temperatures, down to -150 ˚C (-238 ˚F), making it versatile for a wide temperature range. Additionally, Twaron® excels in thermal insulation due to its low heat conductivity. With a high limiting oxygen index (LOI), Twaron® stops burning once removed from flame, effectively limiting fire spread in reinforced applications.

Chemical resistance

Twaron® features high crystallinity and strong intermolecular bonds that prevent chemicals from penetrating its polymer structure. It offers good to excellent resistance to organic chemicals, while its resistance to inorganic chemicals depends on pH. However, exposure to concentrated strong acids or bases can lead to hydrolytic degradation.

How does Twaron® compare to other fibers?

Table of material properties		Twaron®	Technora®	Teijinconex®	UHMWPE	Carbon	Glass fiber	PBI	PBO	Oxidized PAN	Steel wire*
Density	g/cm3	1.44 – 1.45	1.39	1.38	0.95 - 0.98	1.73 – 1.91	2.11 – 2.72	1.4	1.54 – 1.56	1.37 – 1.41	7.5 – 8.0
Tensile strength	GPa	2.4 – 3.7	3.1 – 3.6	0.51 – 0.86	1.6 – 4.0	3.3 – 6.0	2.5 – 4.9	0.4	5.8	0.2 – 0.3	3.5
Tenacity	N/tex	1.7 – 2.6	2.2 – 2.6	0.37 – 0.62	1.7 – 4.2	1.9 – 3.5	1.2 – 2.0	0.27	3.7	0.15 – 0.20	0.45
Modulus	GPa	50 – 145	66 – 84	-	34 – 190	230 – 550	55 - 89	5.6	180 – 270	7 – 11	180
Elongation at break	%	2 - 5	3 – 5	28 - 45	1.5 – 8.0	0.7 – 2.1	4.5 – 5.5	30	2.5 – 3.5	15 – 23	2.2
Moisture	%	2 - 7	1.9	5.3	< 0.1	0	0.1	15	0.6 – 2.0	4 – 10	0
Decomposition or melting temperature for UHMPE & steel	° C ° F	500 932	500 932	> 400 > 752	145 293	3,700 6,700	830 - 1,056 1,525 - 1,935	550 1,022	650 1,202	300 572	> 1,400 > 2,600
Limiting Oxygen Index (LOI)	%	29 - 40	25 - 40	27 - 38	17 – 18	-	-	41	68	50 - 55	-

**Ultra Tensile Steel belt wire (12500 dtex)*

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How is Twaron® used?

Ballistics

Twaron® offers durable, sustainable ballistic protection for military and law enforcement personnel and vehicles.

Body armor: soft vests and insert plates

Meeting ballistic safety standards is paramount. Yet, weight, comfort, mobility, and durability are also crucial in choosing protective armor materials.

- Exceptionally strong and tough
- High resistance to bullets, shrapnel, and sharp object threats
- Effective at dispersing impact force to minimize injury
- Lightweight and flexible for better mobility
- Durable against temperature changes and chemicals
- Sustainable, with recyclable options at end-of-life

Helmets

Advanced helmets are essential for soldiers and police, offering protection from grenade fragments, blasts, and impacts. Helmets with Twaron® feature:

- High ballistic protection
- Lightweight construction
- Durable with minimal Back Face Deformation (BFD)
- Minor damage is repairable

Hard ballistic protection – armored vehicles

Twaron®-based hard ballistic solutions lighten the overall system, improving maneuverability and payload capabilities, and enhancing survivability to meet top ballistic resistance and weight standards.

- Shields against various threats, from gunfire to heavy explosives
- Up to 60% lighter than steel for increased agility
- Can be integrated during or after vehicle construction


POLICE

How is Twaron® used?

Automotive

Hybrid, electric and autonomous vehicles need innovative, sustainable solutions. As the demand for lighter, stronger, and more durable vehicles grows, our aramids help advance these developments, enabling the automotive industry to achieve greater efficiency and sustainability.

Tire reinforcement

Twaron® provides exceptional heat resistance and strength, making tires lighter, stronger, and more eco-friendly.

- High strength, reduced weight
- Enhanced high-speed performance
- Lower rolling resistance: less fuel consumption, fewer emissions
- Superior tire shape consistency

Brake reinforcement

Twaron® para-aramid pulp boosts brake system performance while reducing brake dust emissions. This improves driver comfort and safety.

- Fewer brake dust emissions than metallic options
- Straightforward processing
- Durable wear

Hose reinforcement

Our aramids Twaron®, Technora®, and Teijinconex® deliver exceptional reinforcement, resisting thermal, dynamic, and chemical damage. Aramid-reinforced hoses are stronger and more durable, ideal for maintenance-free vehicles. Heat resistance up to 250 ˚C (Teijinconex®)

- High resistance to chemicals (fuel, coolants, etc.)
- Reduced leaks and tears
- Maintains integrity under high pressure and temperature

How is Twaron® used?

Oil and gas

The oil and gas sector demands durable, reliable solutions for transport infrastructure. Twaron® is used in the reinforcement of thermoplastic pipes, offering a lightweight yet strong alternative to steel due to its excellent chemical and corrosion resistance. These reinforced pipes are easier to handle and install, reducing environmental disruption.

Reinforced thermoplastic pipes (RTP)

Twaron®-reinforced RTP pipes for oil and gas applications provide long-lasting durability in demanding environments. Unlike traditional steel pipes, RTP pipes can be respooled and reallocated for use at new sites, offering greater flexibility and efficiency in operations.

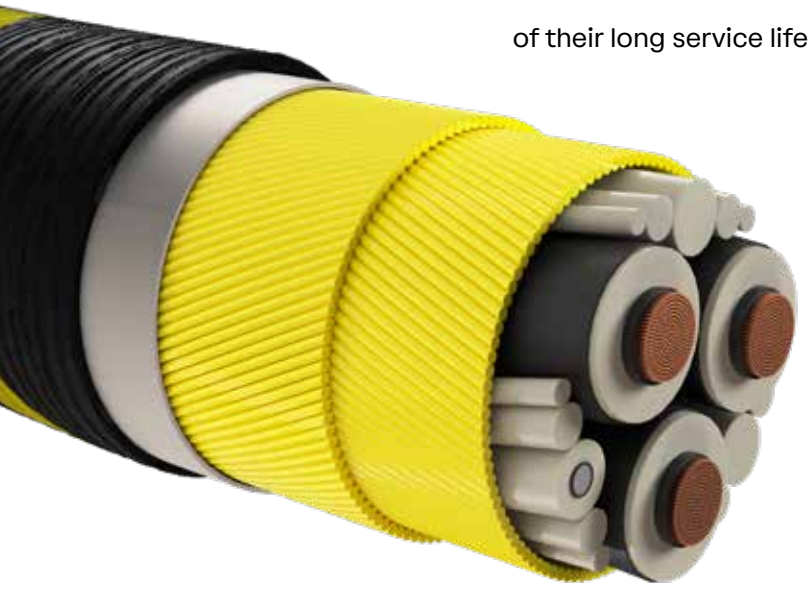
How is Twaron® used?

Renewable energy

Building on our trusted track record in traditional energy transport, including oil and gas, we are well-positioned to support the next generation of energy solutions. From floating wind farms and hydrogen transport to carbon capture and deep-sea installations, our expertise and strong partnerships enable us to meet the evolving demands of the energy sector.

Submarine power cables

Reinforced with Twaron®, submarine power cables are lightweight, strong, and resistant to elongation – a critical feature for cables laid at depths beyond 1,000 meters. Designed to withstand powerful ocean forces such as motion, temperature, and pressure, Twaron®-reinforced cables offer a reliable solution for deep-sea installations. Plus, their recyclability at the end of their long service life makes them a more sustainable armoring option.



Permanent mooring

Floating wind platforms need materials that are strong, stiff, and durable. Mooring tendons created from Twaron® meet these requirements, offering very low creep and high fatigue resistance. Their low maintenance demands make them perfect for deep-sea tension-based mooring systems.

Reinforced thermoplastic pipes (RTP)

Aramid-reinforced RTPs are well-suited for future hydrogen infrastructure due to their excellent chemical and corrosion resistance. RTPs utilizing Twaron® can make a significant contribution to building a reliable and future-ready infrastructure for hydrogen transport. With a threefold lower environmental impact compared to steel pipes, they are a more sustainable choice for supporting the energy transition.

How is Twaron® used?

Aerospace

In the aerospace industry, every gram matters, especially as the sector pushes for greater fuel efficiency and sustainability. Twaron® helps address key challenges like weight reduction, minimizing fire risks in cargo, and supporting the development of more sustainable material practices. Our material's versatility makes it a valuable component in achieving these critical goals.

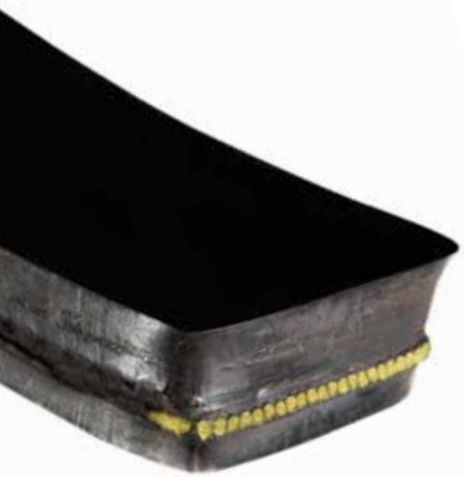
Unit loading device panel reinforcement

Aramid-reinforced container panels are used to achieve the secure and reliable transport of air cargo. Lighter than aluminum, they reduce weight and fuel consumption while offering greater durability, extending the service life of the container fleet. These panels are especially important for transporting high-risk items, like batteries, which can pose fire hazards during transit.

How is Twaron® used?

Mining

As the mining industry pushes for greater efficiency and sustainability, Twaron® helps address key challenges. Its lightweight, high-strength properties enhance the durability and performance of mining equipment, supporting longer lifetimes, lower energy use, and reduced costs. By helping to streamline operations, Twaron® plays a valuable role in advancing more sustainable and efficient mining practices.



Conveyor belts

Reinforcing conveyor belts with Twaron® offers key benefits over traditional steel. The belts become lighter, more durable, and less prone to breakage, reducing downtime and extending operational life. This leads to lower energy consumption, reduced CO_2 emissions, and long-term savings, making Twaron® an effective solution for more sustainable material transport in mining.

Hoisting and cable technologies

For hoisting operations, Twaron® provides strength and durability in demanding conditions. Its resistance to abrasion and low creep ensures reliable performance in large-scale mining cables, supporting safe and efficient lifting. The stability of Twaron® in tough environments helps mining operations stay productive while reducing maintenance and operational costs.

How is Twaron® used?

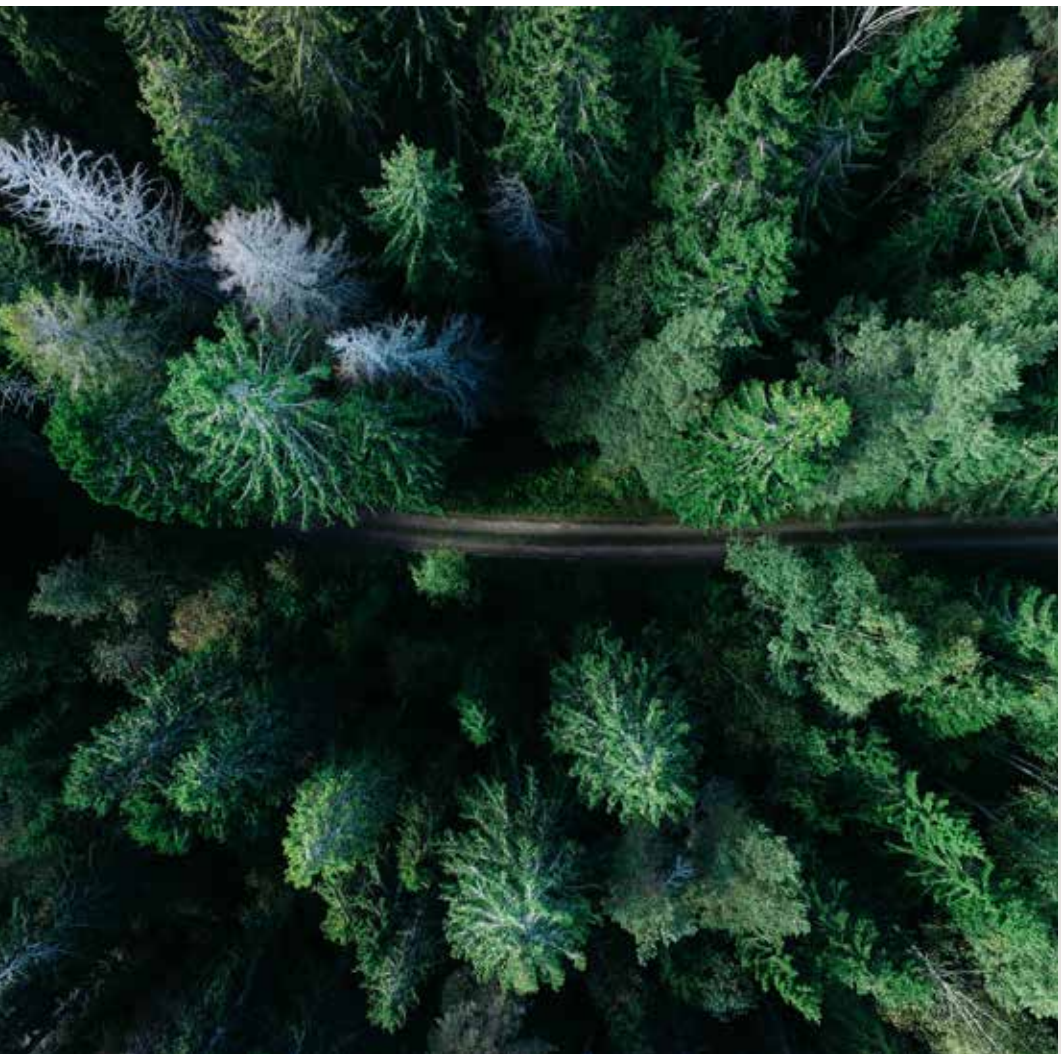
Other applications

While the use of Twaron® is already improving industries like ballistic protection, renewable energy, automotive solutions, and protective apparel, its versatility means it can bring strength, lightness, and durability to countless other projects. Whatever your challenge, Twaron® can help take your performance to the next level.

Building a sustainable future

Our sustainability goals are clear: to benefit people, the planet, and our business partners. We actively work to protect the environment by reducing waste, cutting energy use, and investing in clean technologies. Sustainability is a collaborative effort, and we partner with others to ensure it positively impacts both the environment and business profitability.

Our commitment to a sustainable future, including achieving net zero by 2050, is backed by tangible actions. We are dedicated to a circular economy for aramids, focusing on maximizing the recovery and reuse of aramids from end-of-life applications. By repurposing these materials, we contribute to the production of new aramid products, helping to close the loop on material use.



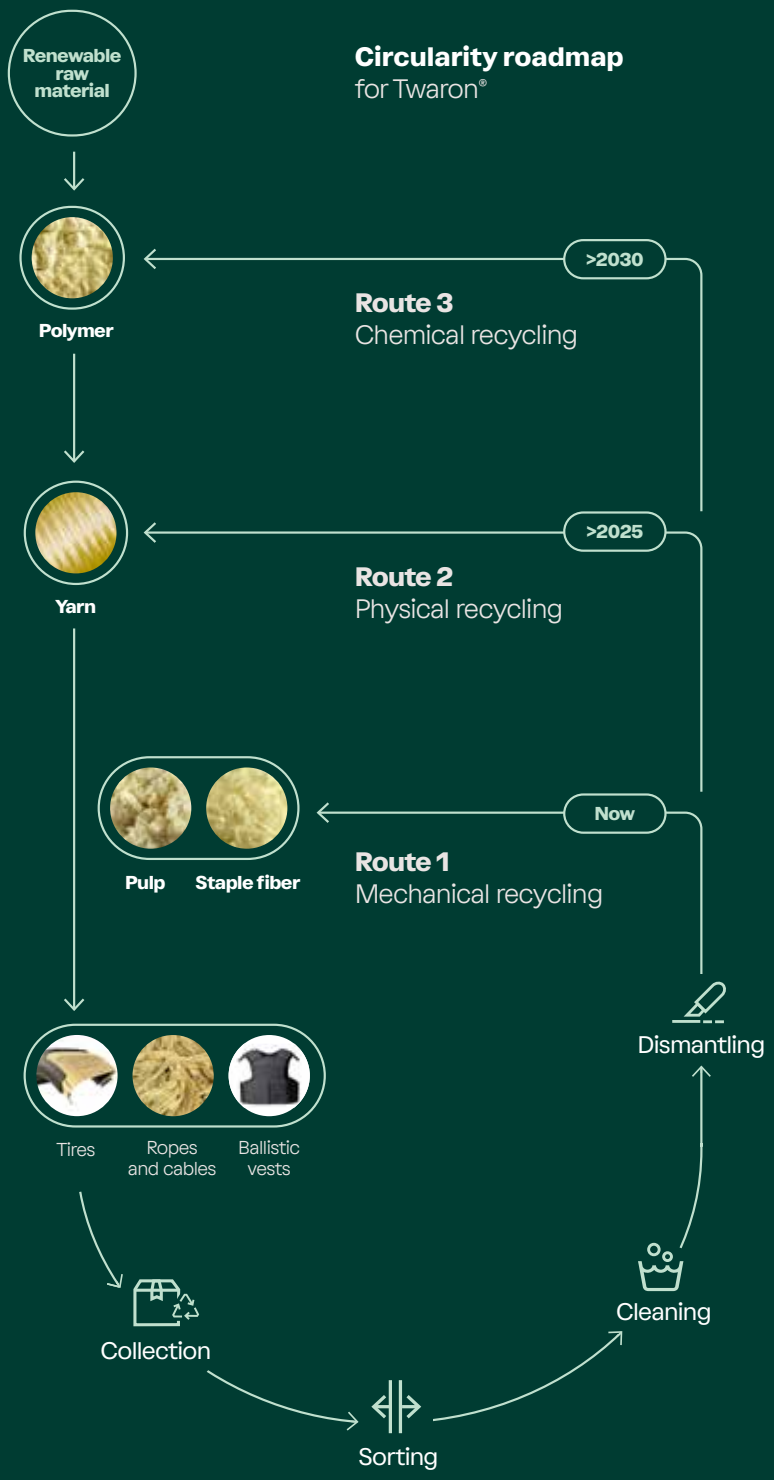
Circularity

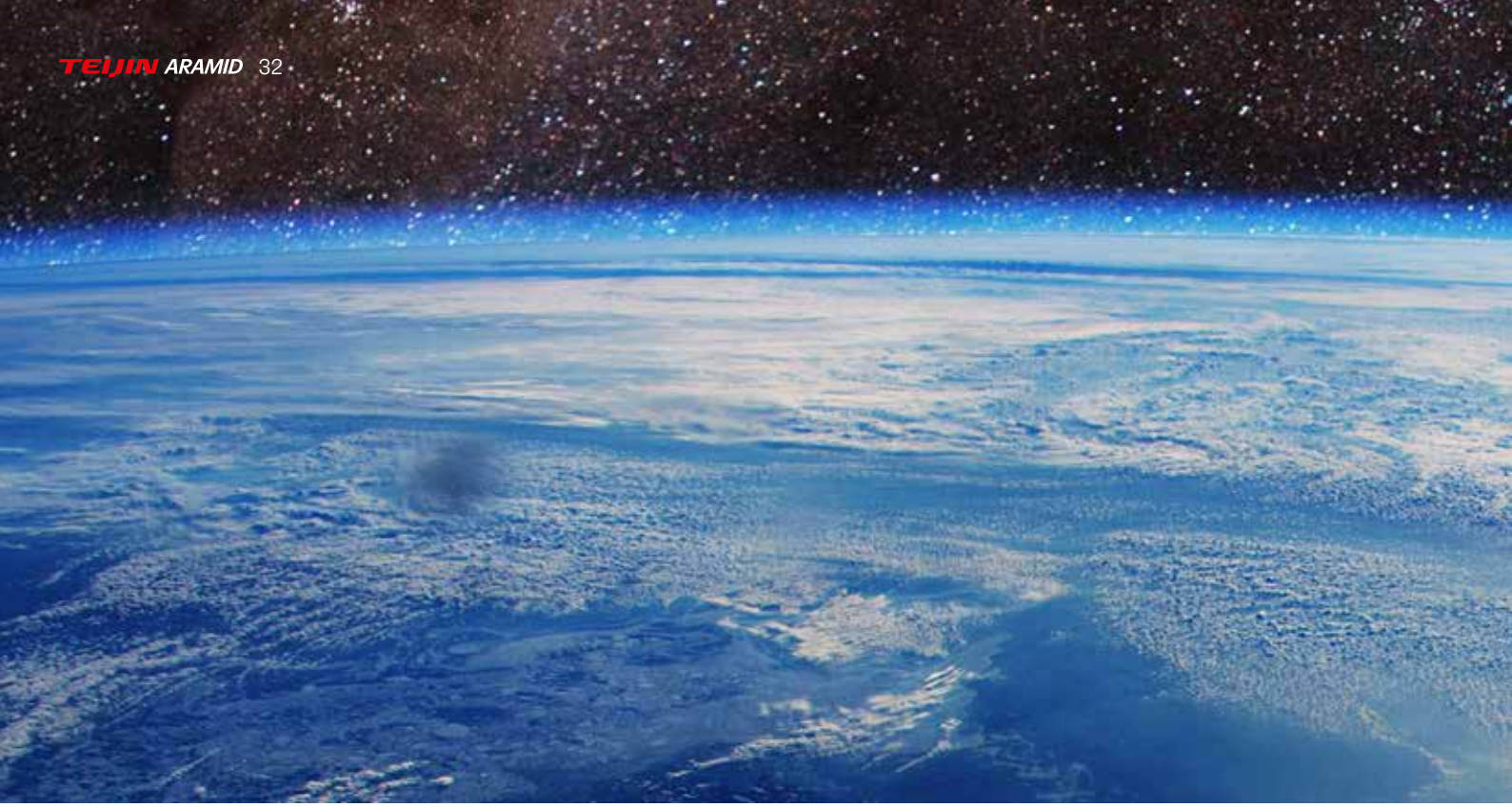
Circular material use involves reducing production waste and recycling any leftovers into new raw materials. The challenge lies in managing the circularity of end-of-life products from both commercial and technological perspectives.

The possibilities for recycling aramid materials include mechanical, physical, and chemical processes. Collecting used products is the first step, with quality control for impurities being a critical challenge. After collection, materials must be separated and prepared for recycling, a process that benefits from design-for-recycling strategies.

Mechanical recycling uses reclaimed para-aramid for pulp production. Physical recycling mixes reclaimed aramid with virgin polymer for new yarn. Chemical recycling breaks down aramid into monomers for new materials.

With over 20 years of experience in mechanical recycling of aramid, we have a proven track record in sustainable practices. As we continue to develop physical and chemical recycling methods, these advancements are essential to achieving full aramid circularity and reinforcing our long-standing commitment to sustainability.





Twaron® environmental impact

At Teijin Aramid, we're taking meaningful steps to reduce our environmental impact and make our operations more sustainable. With transparency and accountability at the core of our approach, we provide clear data to our partners, supporting responsible practices across the industries we serve.

Twaron® carbon footprint

Product	Average CO_2-eq/kg
Twaron® yarn (filament)	8.7
Twaron® staple fiber	8.7
Twaron® pulp	8.8

The total carbon footprint [kg CO_2 eq/kg], based on PEF version 2.0, is calculated according to ISO standards 14040/44. This cradle-to-factory-gate approach includes raw materials, transportation, energy

and water use during production, emissions, and waste disposal. The eco-profile report has been peer-reviewed by an independent third party.

Additional impact categories are available upon request.

Recyclability

Twaron® is recyclable. In addition to producing recycled pulp, we are able to produce Twaron® filament yarn with recycled content on an industrial scale. Teijin Aramid is actively seeking partnerships to help retrieve and recycle end-of-life materials, working towards closing the loop.

Compliance with chemical regulations

Twaron® filament yarn and pulp comply with the REACH regulation and the RoHS Directive.

Sustainability standards and assessments

Teijin Aramid adheres to the following sustainability standards:

- ISO 14001
- ISO 45001
- OEKO-TEX® Standard 100
- Energy efficiency standards for the Netherlands, in line with ISO Standard 50001

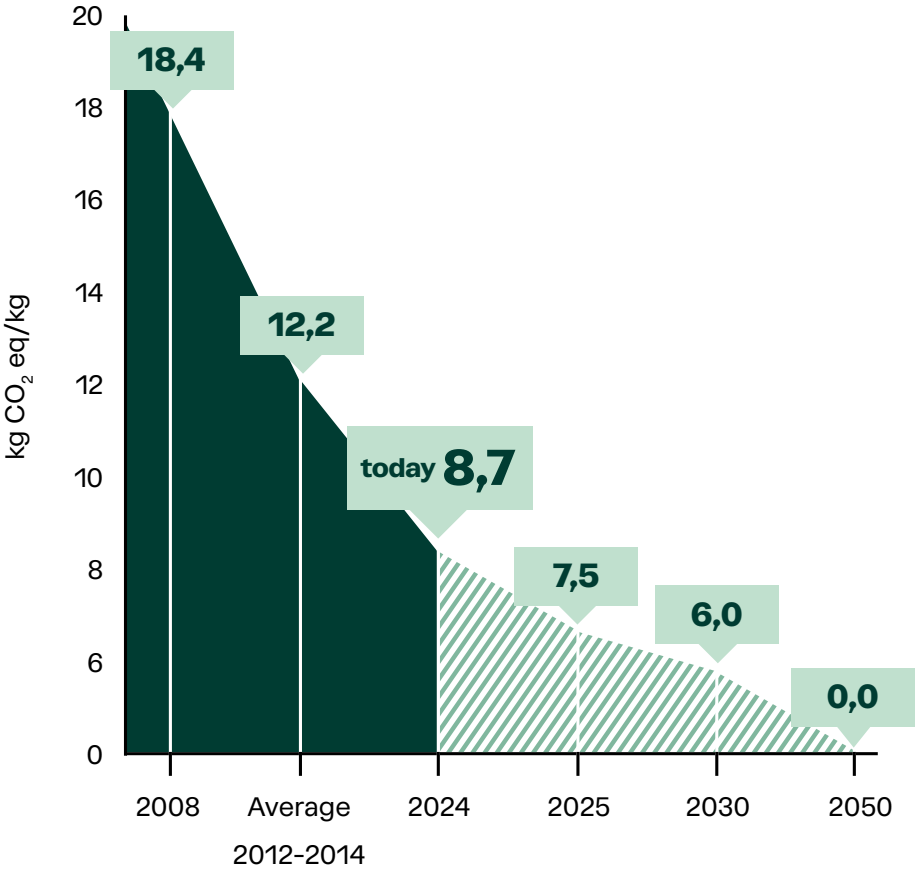
We have also received EcoVadis ‘Gold Partner’ certification following the latest sustainability assessment.

Emission data for manufacturing locations

We prioritize minimizing environmental emissions across all production locations and consistently remain well below legally permitted levels year after year. Detailed information on emissions related to Twaron® production can be found in our Sustainability Report at

www.teijinaramid.com/en/sustainability

The Twaron® carbon footprint




TEIJIN

Building trust through expertise

Over the years, we have invested in facilities and talent that have made us the industry authority on the application of aramid materials. We believe that sustainable value creation and cost awareness are critical success factors for both ourselves and our customers. This means making products that match customers' needs as efficiently as possible while ensuring that they meet the required performance level.

Teijin Aramid is constantly improving products and working towards innovative solutions with our partners at our R&D locations. Our wide knowledge of collaborative partnerships means we have unique, hands-on experience in complex projects that deliver real value to end users. Partnerships are handled with professional discretion.

Make informed choices with the Customer Benefit Model

Teijin Aramid has focused on an eco-efficiency methodology, which has now been translated into a concrete model: The Customer Benefit Model (CBM). Together with the customer or end user, Teijin Aramid can use the CBM to calculate the effect of applying aramid, both in terms of financial cost savings and the reduced impact on the environment. Our official certification with TÜV Rheinland LGA Products GmbH gives us a model that is internationally recognized and which, in collaboration with customers, Teijin Aramid can apply to all relevant aramid applications.

The CBM empowers the customer to make an informed decision: It's a tool that provides data and transparency regarding costs and environmental burdens.

Quality, Health, Safety and Environment (QHSE)

All our global site operations are underpinned by a rigorous system that ensures compliance with relevant laws and regulations. As such, our operations meet high quality, health, and environmental standards with the following certificates being awarded:

- ISO 9001
- ISO 14001
- ISO 45001
- OEKO-TEX statements
- EcoVadis Gold Recognition Level

Get in touch

At Teijin Aramid, we carry half a century of expertise applying aramids to enhance projects. Our skilled R&D team, local technicians, and global market managers are equipped with deep and diverse skill sets ready to tackle your challenges.

Whether it's improving protective garments or advancing industrial and automotive applications, we are here to help. Your ambition, our technology.

Contact us today at information@teijinaramid.com

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Twaron®