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Agenda

• Global Key Trends
• Aramids in the middle East

• Stopping the bullet
  • 550dtex f1000 ballistic yarn
  • LFT SB1 Plus
  • SRM
  • Microflex

• Twaron and Endumax in helmets

• Our research capabilities
• Sustainable strength
Global Key Trends
Global key trends

• In recent years, there have been significant changes in the requirements placed on both consumer and industrial goods around the world

• There is a growing demand for products that combine high performance with durability and low maintenance

• At the same time, these products need to be cost-effective, use less energy, enhance safety, and they should ideally have a smaller lifecycle ecological footprint
Sharing our customers’ ambitions

- Our prime aim is to add value to the bottom line of our customers
- Co-creation and open innovation with customers on advanced products and applications
- Loyalty to customers
- Long-term relationships
- Sharing knowledge & expertise
Global presence
Aramid in the middle East
Our product portfolio

Para-aramid
- Twaron
- Technora

Meta-aramid
- Teijinconex

Poly-ethylene
- Endumax
Different types to fit application requirements

**Twaron**
- Short-cut fiber
- Staple fiber
- Pulp
- Fabrics
- Tape
- Powder

**Technora**
- Short-cut fibers
Endumax, UHMWPE Tape and X-ply

- Ropes, cables and slings
- Ballistic protection
- Robotics / Force transmission
Technora, for enhanced properties

- High tensile strength
  - Weight for weight, Technora is eight times stronger than steel and three times stronger than fiberglass, polyester or nylon yarns
- Good fatigue resistance
- Long-term dimensional stability
- Excellent resistance to corrosion, heat, chemicals and seawater
Technora, gives Curiosity a soft landing

Facts:
- 80 cords
- packed 60kg, 1x1m bundle
- slow down from 1400 km/h to 290 km/h in less than two minutes
- withstand a force of at least 9gs
- tested to withstand 72,500 kilos
Twaron, a unique combination of properties

- High strength
  - Weight for weight, it’s five times stronger than steel
- High modulus
- High dimensional stability
- Excellent heat, cut and chemical resistance
- No melting point
- Low flammability
- Non-conductivity
- Available in yellow and black
Twaron, applications

Reinforcements with Twaron
Adhesion activating finish for rubber applications

Protective gloves made with Twaron yarns

Twaron water-blocking yarn Reinforces the cable
Twaron and Endumax

stopping the bullet
Full range protection

Twaron in vests

- Low weight, greater comfort and longer lifetimes
- Protection against penetration of bullets, fragments as well as stabbing
Full range protection

Twaron in helmets

- Low weight, comfortable
- Long-lasting
- Protects against penetration of bullets, shrapnel and hot bomb fragments
- Lower Back Face Deformation (BFD)
- Non-inflammable
Full range protection

Twaron laminates for vehicle armor

- High ballistic protection
- Weight savings of 60 to 70%
- Enhanced speed and allowance for heavier payloads
- Easy to install – even after vehicle construction
Twaron, a unique combination of properties

- High strength
  - Weight for weight, it’s five times stronger than steel
- High modulus
- High dimensional stability
- Excellent heat, cut and chemical resistance
- No melting point
- Low flammability
- Non-conductivity
- Available in yellow and black
Twaron, a unique combination of properties

- High strength
  - Weight for weight, it’s five times stronger than steel
- High modulus
- High dimensional stability

→ High energy absorption capabilities

- Excellent heat, cut and chemical resistance
- No melting point
- Low flammability
- Non-conductivity
- Available in yellow and black
Stopping Mechanism

The ballistic panel has to absorb the kinetic energy of the bullet by converting the energy into fracture and work of deformation.

- Bullet fracture and deformation
- Panel penetration (fibre fracture) and deformation

“Mushroomed” DM 11 Projectile in a CT 709 panel
Today’s requirements for soft ballistic protection

- Market requirements:
  - Optimized bullet resistant vests
  - Optimized fragment resistant vests
  - Bullet + fragment resistant vests
  - Bullet + stab resistant vests
  - Bullet + fragment + stab resistant vests
  - Stab resistant vests

To meet these requirements new materials and optimized hybrid-solutions are necessary
Our solution to optimize fragment resistant vests:
Twaron 550f1000 Ultra microfilament
Our solution to optimize fragment resistant vests:
Twaron 550f1000 Ultra microfilament
Our solution to optimize fragment resistant vests:
Twaron 550f1000 Ultra microfilament

About 15% weight reduction
Our solution for vests offering good ballistic protection at reduced trauma
Twaron LFT SB1 PLUS
Our solution for vests offering good ballistic protection at reduced trauma
Twaron LFT SB1 PLUS

Twaron CT 709

Twaron LFT SB1

No crimp and cross-over-points → better energy dissipation resulting in improved bullet resistance

Twaron LFT UD41
Our solution for vests offering good ballistic protection at reduced trauma

Twaron LFT SB1 PLUS
Our solution for vests offering good ballistic protection at reduced trauma
Twaron LFT SB1 PLUS

Trauma and V50
NIJ 0101.04 .357 Mag

- 100% LFT SB1 Plus: 70%
- 70% LFT SB1 + 30% LFT SB1 plus: 81%
- 100% LFT SB1: 100%

Yellow: Trauma  Red: V50

The power of Aramid
Our solution for vests offering Stab and Knife resistance
Twaron SRM
Our solution for vests offering Stab and Knife resistance

Twaron SRM

REFERENCE

- Ballistic panel: 23 layers of Twaron CT 709
- Test: VPAM level 1, 25 J, max. 20mm perforation

Blade P1B

- 24 mm penetration at 4.2 J
- 14 mm penetration at 3.5 J

Spike

- 23 mm penetration at 2.2 J
- 16 mm penetration at 1.5 J
Our solution for vests offering Stab and Knife resistance

Twaron SRM

The construction of Twaron SRM

SiC coating which provides high friction to the stabbing weapon
Our solution for vests offering Stab and Knife resistance
Twaron SRM
Our solution for vests offering Stab and Knife resistance
Twaron SRM
Our solution for vests offering Stab and Bullet resistance
Twaron Microflex

Dense woven 550 dtex Twaron fabric provided with a special after-treatment
Our solution for vests offering Stab and Bullet resistance
Twaron  Microflex
Twaron and Endumax in Ballistic Helmets
Helmets made with Twaron and Endumax

Development and Future Trends of Combat helmets

- M1 steel
- Nylon
- PASGT BWB ACH/MICH

v50 STANAG 2920 17 gr FSP [m/s]

Year


ECH

The power of Aramid
Helmets made with Twaron and Endumax

cutted pinwheels
pre-mold
press mold
Twaron helmet shell
Endumax helmet shell
Helmets testing, Trauma and V50
Research & Development
Long-term behavior of Twaron

1. Mechanical aging

   NIJ 0101.06 Tumbler

2. Hydrolytic aging

   Is it possible to calculate the results derived by accelerated aging to realistic wear conditions, in order to obtain information for the long-term resistance quickly?
Sustainable strength
Our view on sustainability

We want to create value in a sustainable way by developing, together with our customers and suppliers, durable, protective, eco-friendly and above all profitable and cost-effective solutions, that improve the quality of life, securing the ability of future generations to meet their needs.
Preconditioning of aramid scrap

**Sorting**

Scrap is delivered in boxes and may contain various qualities as well as foreign stuff like paper, foil, etc.

**Cutting**

Old vests and scrap which do not fit in size are cut and, if applicable, dismantled to obtain as possible 100% aramid.

**Baling**

Sorted scrap is compressed into bales using special aramid wrappings according to our requirements.
Our sustainability contribution in the chain

Governments / Local communities / NGOs / Other chain partners
(knowledge institutes, financial partners, consultants, etc)

Cradle → Suppliers → Production → Sales & Marketing → Converters → Recycling → Customers → End users → End of life

Employees → Research

The power of Aramid
Ballistics material handbook
### Yarn List

<table>
<thead>
<tr>
<th>Linear Density</th>
<th>Filaments</th>
<th>Twaron-Type</th>
<th>Strength at Break</th>
<th>Tenacity at Break</th>
<th>Elongation at Break</th>
<th>Chord Modulus</th>
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<tbody>
<tr>
<td>Dtex (effective)</td>
<td>No.</td>
<td>N</td>
<td>mN/tex</td>
<td>%</td>
<td>GPa</td>
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<tr>
<td>420 (415)</td>
<td>500</td>
<td>2040</td>
<td>105</td>
<td>2.350</td>
<td>3.5</td>
<td>91</td>
</tr>
<tr>
<td>550</td>
<td>1000</td>
<td>2640</td>
<td>148</td>
<td>2.600</td>
<td>3.5</td>
<td>100</td>
</tr>
<tr>
<td>550 (570)</td>
<td>500</td>
<td>2040</td>
<td>135</td>
<td>2.350</td>
<td>3.45</td>
<td>91</td>
</tr>
<tr>
<td>840 (860)</td>
<td>1000</td>
<td>2000</td>
<td>215</td>
<td>2.500</td>
<td>3.50</td>
<td>92</td>
</tr>
<tr>
<td>930 (960)</td>
<td>1000</td>
<td>2040</td>
<td>225</td>
<td>2.350</td>
<td>3.45</td>
<td>89</td>
</tr>
<tr>
<td>1100 (1135)</td>
<td>1000</td>
<td>2040</td>
<td>267</td>
<td>2.350</td>
<td>3.45</td>
<td>91</td>
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<tr>
<td>1680 (1640)</td>
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<td>2000 or 2040</td>
<td>385</td>
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<td>91</td>
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<td>3360 (3460)</td>
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<td>3360 (3280)</td>
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<td>2000</td>
<td>770</td>
<td>2.350</td>
<td>3.45</td>
<td>91</td>
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<table>
<thead>
<tr>
<th>Spin-finish content</th>
<th>Type 2000/2040/2640</th>
<th>Type 1000: 0.8%</th>
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<tbody>
<tr>
<td>Tube length x diameter (mm)</td>
<td>290 x 94</td>
<td>216 x 94</td>
</tr>
<tr>
<td>Winding height/stroke (mm)</td>
<td>260</td>
<td>192</td>
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<tr>
<td>Packing (bobbins x kg)</td>
<td>420 dtex 90 x 2.2</td>
<td>52 x 9.2</td>
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<tr>
<td></td>
<td>550 dtex 90 x 5</td>
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</tr>
<tr>
<td></td>
<td>550 Ultra 138 x 2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>930 dtex 69 x 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1100 dtex 90 x 4.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1680 dtex 54 x 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3360 dtex 48 x 10</td>
<td></td>
</tr>
</tbody>
</table>

### Twaron ballistic yarns

The history of protecting man against weapons goes back to ancient times. For hundreds of years, metal materials have been used not only for body armor but also for the protection of larger objects such as vehicles, providing what is called ‘hard protection’. However, it was only a few decades ago, at the end of WWII, that softer constructions in the form of ballistic nylon vests first began appearing. But these vests could not come close to offering the present level of ballistic protection afforded by Twaron para-aramid filament yarns and the fabrics that can be made from them.

This extraordinary level of ballistic protection has been made possible thanks to intensive R&D at Teijin Aramid, combined with tens of thousands of empirical evaluations. Twaron high-tenacity (CT) microfilament yarns represent a milestone in the development of high-performing soft ballistic protection gear. They offer a higher level of protection than ever before, thanks to their unique absorption of the kinetic energy caused by intruding projectiles. The myriads of nearly invisible filaments increase the “working” surface of the yarns, so the required stopping energy, or friction, can be obtained with less material.

The ultrafine filaments in the yarn also provide another benefit: they give fabrics an extraordinary softness, translating to a high level of comfort for the wearer.

What’s more, countless weaving tests on various creels, warping machines and different weaving machines have been carried out to ensure the optimum processability of Twaron. No wonder, then, that para-aramid ballistic filament yarns from Teijin Aramid have come to dominate the global markets.
Recently, Teijin Aramid introduced the world’s finest filament yarn called Twaron 550f1000. This enhanced tenacity, ultra microfilament yarn enables the production of very lightweight ballistic vests and is available in 550dtex with 1000 filaments.

High-tenacity microfilament Twaron yarns (with counts of 420, 550, 840, 930 and 1100dtex) are used all over the world to provide the highest protection to comfort ratio for ballistic fabric constructions.

The high-tenacity Twaron filament yarns offer a high protection to economy ratio for various ballistic protection items within both soft and hard (including composite) applications.

The Twaron standard-tenacity fibers provide a perfect balance of performance and economy, and are an attractive alternative for numerous up-armoring projects within the hard-ballistic protection market. Compared with other ballistic protection materials, Twaron para-aramid filament yarns excel in chemical and thermal stability, as well as resistance to various aggressive environments.

The superb quality of all Twaron para-aramid ballistic filament yarns starts at the very beginning – with the basic chemistry used at the birthplace of Twaron in Delfzijl, the Netherlands. Here, the monomeric (and later the polymeric) basic materials for Twaron yarns are produced in chemical processes that meet the most stringent quality requirements, generating the highest value possible.

Our spinning and polymer production facilities comply with ISO 9001 and ISO 14001 standards. Multiple quality controls are performed daily, not only to guarantee the high performance and reliability of our products, but also to keep our promise to our customers: ‘Perfect protection for safety and satisfaction.’

<table>
<thead>
<tr>
<th>Twaron yarn type</th>
<th>Dtex</th>
<th>Key attributes</th>
<th>Primary applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twaron CT – enhanced tenacity – microfilament</td>
<td>550</td>
<td>High protection/lowest weight ratio</td>
<td>Soft protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very lightweight</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enhanced comfort</td>
<td></td>
</tr>
<tr>
<td>Twaron CT – high-tenacity microfilament</td>
<td>420</td>
<td>High protection/comfort ratio</td>
<td>Soft protection</td>
</tr>
<tr>
<td></td>
<td>550</td>
<td>Light weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>840</td>
<td>High comfort</td>
<td></td>
</tr>
<tr>
<td></td>
<td>930</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twaron CT – high-tenacity</td>
<td>1680</td>
<td>High protection/cost ratio</td>
<td>Soft protection</td>
</tr>
<tr>
<td></td>
<td>3360</td>
<td>Standard weight</td>
<td>Hard protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good comfort</td>
<td></td>
</tr>
<tr>
<td>Twaron T – standard-tenacity</td>
<td>1680</td>
<td>Balance between performance and cost efficiency</td>
<td>Hard protection</td>
</tr>
<tr>
<td></td>
<td>3360</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Twaron ballistic fabrics**

Whenever the combination of high functionality, comfort and economy is required, you will find advanced para-aramid Twaron yarns being used in sophisticated fabric constructions tailored for specific end uses. In general, ballistic threats emanate either from bullets or fragments. Bullets can be defined as projectiles of various shapes and consistencies shot from weapons such as pistols, revolvers and rifles. Fragments, on the other hand, can originate from explosions (e.g., grenade detonations) or as pellets from shotguns. The manifold kinetic characteristics and deformation behaviors of such a broad range of bullets and fragments mean that a number of different stopping mechanism are required for full ballistic protection.

Soft-core (e.g., lead) bullets can be stopped with soft panels, i.e., textile fabrics layered on top of one another. However, specifications today often have to cover different types of bullets with different physical characteristics. Some of these require a customized and dedicated textile solution. Thanks to the high flexibility and wearing comfort that is possible today, such solutions can now be incorporated into body armor applications.

Hard-core (AP) ammunition is fragmentized by steel or ceramic plates, and these fragments are then “caught” by resin-impregnated textile layers. While these hard plates can be used in body armor, they are mainly employed for vehicle and other hard-protection purposes.

The available Twaron fabric styles are designated with the codes CT (high tenacity) or T (standard tenacity), followed by a 3-digit number. This classification, used all over the world, is applied by high-quality weavers that are selected, authorized and approved by Teijin Aramid.

Most current Twaron ballistic materials used for personal protection are woven, mainly for the following reasons:

- Fabrics offer very good stability, as well as flexibility
- Fabrics are easy to handle, to cut and to process into finished product
- Fabrics can be finished to be water-repellent, making them superior to other materials when exposed to moisture
- On ballistic impact, threads are not pulled out or pushed aside
- The required production technology is widely available
- A matrix can be easily applied to a fabric, allowing the use of laminates for even higher levels of protection if required.
### A wide variety of solutions

The range of ballistic fabrics covers different key attributes and characteristics:

<table>
<thead>
<tr>
<th>Fabric Code</th>
<th>Dtex</th>
<th>Primary Application</th>
<th>Key attributes/characteristics</th>
</tr>
</thead>
</table>
| **CT 612**  | 550   | Body armor          | - 125 g/m² ballistic fabric, based on one of the thinnest yarns ever made in the para-aramid spinning process  
- Dedicated to providing maximum protection against bullets and fragments  
- Successfully used in military vests, providing a lightweight and comfortable solution  
- Available in Water Repellent Treated (WRT) finish or loom state |
| **CT 704**  | 840   | Body armor          | - Based on one of the finest filament titters ever made in the para-aramid spinning process  
- Dedicated to providing maximum protection against very small fragments  
- The 180 g/m² also exhibits a bullet protection level that is very similar to that of Twaron CT 709 |
| **CT 709**  | 930   | Body armor          | - 200 g/m² ballistic fabric, based on unique Twaron microfilament yarn  
- Excellent ballistic protection combined with a high level of comfort  
- Good cost/performance ratio  
- Proven product, used by countless police departments around the world  
- Enables the production of seamless ballistic packages providing the wearer with a surprising freedom of movement combined with high ballistic protection  
- Particularly suitable for body armor vests for women  
- Available in Water Repellent Treated (WRT) finish or loom state |
| **CT 714**  | 1100  | Body armor          | - 190 g/m², plain-woven fabric, based on first microfilament fiber type  
- Excellent fragmentation protection  
- Used for fragmentation jackets by most of the armed forces around the world  
- Good protection against specific types of projectiles  
- Cost-effective solution  
- Available in Water Repellent Treated (WRT) finish or loom state |
| **CT 716**  | 1100  | Body armor          | - 280 g/m², plain-woven fabric based on high tenacity (CT) Twaron yarn  
- This tightly woven fabric offers very good ballistic protection against projectiles combined with advantageous blunt trauma behavior  
- Reflects the weight/performance ratio prevalent in the late 1980s |
| **CT 736**  | 1680  | Body armor          | - 410 g/m² ballistic fabric  
- Used for the production of modern, state-of-the-art ballistic helmets  
- Typically used in mine boots sandwich constructions  
- Available in loom state or scoured as standard  
- Good processability with different resin systems |
| **T717**    | 1680  | Body armor          | - 125 g/m² ballistic fabric  
- Designed for economy-driven ballistic protection solutions requiring good projectile and fragmentation resistance |
| **T750**    | 3360  | Hard Ballistics     | - 460 g/m², plain-woven fabric  
- Widely used in hard ballistic applications  
- Typically used in spall liners  
- Numerous helmet shells are made out of this fabric (wet process)  
- Typical finish used: scoured |
Cross sections

Cross sections of fabrics (200g/m²) containing standard aramid yarn (upper part) and Twaron microfilament yarn (lower part)

Cross section of LFT SB1 fabric containing Twaron microfilament yarn.

Cross section of LFT GF4 unidirectional material. Fourfold structure (shield).

T 760

3360 dtex

Primary application
Hard Ballistics

Key attributes/characteristics
- 635 g/m² ballistic fabric
- Heavy and very flexible fabric for up-armoring of vehicles
- Excellent shaping possible, therefore suitable for manufacturing process

Microflex

550 dtex

Primary application
Body armor

Key attributes/characteristics
- 220 g/m² ballistic fabric, dedicated to providing maximum protection to correctional officers
- A patented puncture-resistant fabric made from Twaron microfilament yarn, woven to stringent specifications and finished by a proprietary process yielding unsurpassed performance against the NIJ 0115 engineered spike
- Microflex outperforms existing puncture-resistant fabric technology by offering a softer and more comfortable solution than current technology
- The most wearable, cost-effective solution available to correction officers faced with the daily threat of attack
- The extraordinary NIJ Spike Level 3 (E2) 65 Joule strike energy is easily defeated with Microflex in a lightweight concealable vest construction

Felt No.9

stable fiber 1.6

Primary application
Body armor

Key attributes/characteristics
- Based on Twaron microfilament staple fiber
- Very soft textile surface, offering a degree of ballistic protection combined with additional mechanical properties and a high level of comfort
- Surfaces of 350 g/m² aerial density proved optimally effective for different ballistic constructions - improving the stopping behaviour of specific ammunition and creating an excellent intermediate layer for stab protection
- Contributing functionality into stab protection

Key attributes/characteristics
- 635 g/m² ballistic fabric
- Heavy and very flexible fabric for up-armoring of vehicles
- Excellent shaping possible, therefore suitable for manufacturing process
Twaron LFT SB1

The past years have brought many improvements in ballistic protection materials. Teijin Aramid’s approach, combining low-crimp woven products with low resin content, has resulted in Twaron Laminated Fabric Technology SB1 (LFT SB1) – a thin, very flexible laminate comprising two fabric layers sandwiched with three layers of ultra-thin PE film. The two fabrics are made from Twaron para-aramid microfilament yarn running in one direction, and very fine PES threads running in a second direction. This fabric construction system prevents an intruding bullet from pushing the yarns apart – a distinct advantage over typical shield materials.

For the user, this translates into significantly improved bullet resistance compared with traditional ballistic fabrics. The same level of ballistic protection can be achieved with less material, which increases comfort and mobility for the wearer. What’s more, the weight of the entire ballistic pack can be further reduced by as much as 25% to meet the requirements of certain standards (e.g., TR 2003, NIJ 01.01.04).

The materials and the new laminating technology used in Twaron LFT SB1 result in a soft surface that offers a relatively high permeability – comparable with tightly woven fabrics. This aids in the sweat management of the wearer and, again, provides added comfort.

These sandwiched low-crimp woven constructions will, without a doubt, be the future of ballistic protective fabrics used in high-end body armor.

Twaron LFT SB1 plus

The reduction of Back Face Deformation (BFD) has become a key priority for latest-generation soft ballistic vests. That’s why Teijin Aramid has developed Twaron LFT SB1 plus: an integrated solution that combines high ballistic performance with comfort, flexibility and substantially reduced BFD.

LFT SB1 plus consists of four layers of Twaron, arranged in 0°, 90°, +45° and -45° orientations, and laminated together with a small amount of resin. This reduces BFD by up to 30% compared to standard solutions that do not contain an anti-trauma system. At the same time, it offers similar ballistic performance without additional weight. Twaron LFT SB1 plus is a soft and flexible material, offering wearers both protection and comfort – an essential feature when the ballistic vest is worn intensively.

Another advantage of Twaron LFT SB1 plus is that it can be used either on its own or in combination with other Twaron-based soft ballistic materials. Hybrids can be created using LFT SB1 or other Twaron Ballistic products to optimize protection against a specific threat.

Twaron UD41

Today’s lightweight protective vests need to meet a complex set of requirements, including both bullet and stab protection. Solutions based on Twaron Unidirectional Laminate UD41 – or those combining UD41 with other Twaron materials – offer several advantages for engineering these modern ballistic protective vests. They provide enhanced protection against bullets and fragments, as well as more comfort and excellent performance/weight ratios.

Twaron UD41 is a Unidirectional (UD) laminate suitable for soft body armor. Consisting of four plies of unidirectional Twaron fiber lines (plied in a 0°/90°/0°/90° configuration), it makes full use of Twaron’s high fiber tenacity and avoids the crimping of typical woven material. Smart UD technology aligns the parallel Twaron fibers in each layer, and each layer is constructed in a resin matrix. The top and bottom UD plies are then laminated to ensure maximum abrasion resistance.

Hybrid solutions are becoming increasingly important in today’s ballistic protection engineering. The complementary qualities of Twaron UD41 mean that it can be combined with other fabrics, laminates, shields and coated materials – all based on Twaron – to ensure enhanced performance. That way, Twaron UD41 can be used in a wide range of state-of-the-art responses to ballistic threats.

Twaron UD21

Today’s armored vehicles, aircraft and naval vessels also face a range of blast and ballistic threats. These call for new hard armor solutions that are lighter and stronger. In addition, they need to resist high temperatures and extreme cold.

Teijin Aramid’s Twaron UD21 is a UD laminate hard armor solution designed specifically for armored vehicles. It can be applied internally as a spall liner, or externally as part of bolt-on or add-on armor. It is light enough for use as an add-on solution, but its high stiffness and structural integrity mean it can act as a support for steel or ceramic plates. Furthermore it is resistant to variations in temperature. In fact, Twaron UD21 offers effective protection against bullets, fragments and projectiles within a wide temperature range.

Twaron UD21 consists of two layers of unidirectional Twaron fiber plied in a 0° and 90° configuration, and it makes full use of Twaron’s high fiber tenacity while avoiding the crimping typical of woven material. In combination with other materials, Twaron offers protection against bullets, fragments and projectiles according to STANAG 4569, levels 1-4.

This strong, lightweight laminate also offers customers a whole new world of hybrid ballistic solutions. It is designed for use in combinations with other materials: with steel, ceramic and titanium. These composite armor solutions can be adapted to any need, and offer high levels of protection with better flexibility and far lower weight. This, in turn, contributes to greater vehicle maneuverability and fuel economy.
**Twaron Sideguard®**

In the past, thickly layered and quilted ballistic fabrics provided protection against bullets and shrapnel (hot weapons), but not against blades, knives and needles (cold weapons). The answer was the next generation of laminate technology - specially coated, layered fabrics that could prevent both hot and cold weapons from penetrating. But a problem persisted: there was an increased risk of the bullet punching through the first few laminate layers, hitting the tough surface of each successive layer at such an extreme angle that it would deflect back toward the outside of the vest. To solve this deflection problem, Teijin Aramid introduced Twaron Sideguard.

Twaron Sideguard is a cover pulled over the vest’s laminate layers that can catch a bullet as it exits the vest. As a knitted fabric, Twaron Sideguard is flexible enough to absorb and lead off a bullet’s latent energy, preventing it from bursting through the fabric and bringing it to a standstill. To add extra protection, Teijin Aramid’s unique textile-manufacturing software designs Twaron Sideguard into seamless structures of virtually any shape. Twaron Sideguard is the first and only knitted structure offering ballistic protection on the market today.

---

**Twaron LFT-AT/AT Flex**

The primary objective of a ballistic pack is clear – to stop the bullet. But in a number of situations, the resultant blunt trauma remains an obvious and unwelcome problem.

In light of this, Teijin Aramid Ballistic Engineering has developed a material permitting an effective reduction of the impact depth. By combining Curv® (made by Propex Fabrics), an extraordinary hit-resistant polypropylene woven surface, with Twaron CT 707 high-tenacity fabric, a unique material was created. This material is light, thin and has sufficient flexibility to reduce blunt trauma behind the ballistic pack.

Depending on the type of bullet and its speed, one or two layers of Twaron LFT-AT/AT Flex may lessen trauma by 30% to 60% – even near the edges of the target. Environmental and functional stability, combined with easy handling, are further benefits of the new material.

Adding only a few hundred grams per square meter to the ballistic pack, Twaron LFT AT/AT Flex offers the optimum combination of weight, volume and performance currently available.

---

12 13
Twaron for stabbing protection

Twaron SRM®

Along with the need for protection against ballistic impact, protection against attacks by sharp and pointed weapons has become a matter of increasing priority. In more and more countries, police officers are facing the growing threat of a wide range of stabbing weapons.

Against this background, Teijin Aramid has developed Twaron SRM, a unique material providing superior protection against a broad array of weapons. Twaron SRM incorporates Twaron CT microfilament fabric with a functional silicon carbide coating that is bonded by a special matrix system. The functional coating absorbs and dulls the thrust from the blade or needle just as if it were solid rock, and the energy from the impact is then absorbed by the high-impact resistance and tenacity of the para-aramid yarn in the fabric underneath. Thanks to the special matrix, the material is flexible and almost as soft as a non-coated fabric. This functionality is achieved by having a density that is only one-quarter of the standard steel used in stab protection.

Twaron prepregs for helmets and hard ballistic solutions

The monumental success of composite ballistic protection helmets in modern armies started with the use in their manufacture of plain-woven 460 g/m² fabric. Today, Twaron T750 and Twaron CT 736 are both very basic fabric styles for this kind of light composite up-armingoring. Although CT 736 is the more advanced fabric style and is widely used, both fabric styles can be used either neat – in what is called the ‘wet process’ – or impregnated with PVB resin for composite shell applications so as to offer the highest levels of performance. Impregnated Twaron fabrics are also part of the range of Teijin Aramid ballistic protection materials.

Twaron T750 is the ideal fabric for a variety of products for hard ballistic protection, including spall liners, multilayer laminates and lightweight, high-tenacity backings, as well as supporting steel, ceramics and various other front materials in complex composite solutions.

Twaron ladies’ vest

While the advancement of aramid yarns and fabrics has resulted in an ever-improving level of protection performance, progress on the comfort side failed for a long time to acknowledge the special needs of female wearers. Although the number of female officers has been rising significantly in Europe and North America, these women have to rely, in general, on body armor designed for the male physique rather than the comfort requirements of the female body.

To meet this demand, Teijin Aramid and Triumph International, a global leader in the manufacture of underwear and lingerie, devised a unique manufacturing concept offering the first body armor for women that is both comfortable to wear and able to offer maximum ballistic protection.

In a molding process performed at Triumph, the CT709 fabric style has proved to be best suited for the production of a ballistic pack that comprises several layers shaped to match the female bust. The method used is a kind of deep drawing process, where the Twaron fabric is molded with the aid of pressure and heat. The final product requires neither additional finishing operations nor the use of chemicals to fix the deep drawn shape. Subsequently, the molded fabric layers are placed on top of each other to obtain a garment part, then joined by a base seam, e.g., in the middle of the panel.

There are currently five molds available, each a different volume size, and these can be combined with the various vest sizes and design patterns. In this way, this system allows for as much variation as possible in order to match each woman’s individual torso shape. The result of this is a comfort level for the wearer unparalleled by any other female ballistic protection vest system on the market.

This product, as well as the process support for its manufacture, is available only from Teijin Aramid.
**Endumax**

Today’s police and defense forces rely increasingly on advanced digital and communications technology, and their equipment needs are changing accordingly. In addition to requiring improved ballistic protection, they now need to carry more equipment into daily service. This does not mean, however, that they should carry more weight. Instead, both body protection and vehicle armor need to be highly effective, flexible and lightweight.

Endumax fits exactly these needs. Endumax is a pure UHMWPE (ultra-high molecular-weight-poly-ethylene) tape - the strongest available at its weight. Protective uni-directionals and composites made from this material have a very high degree of braking energy, and therefore particularly high stopping power for bullets and fragments.

Endumax is also extremely lightweight and resilient. Since it is produced in wide, thin tapes, you only need 25% of the amount of matrix material conventionally used to produce a UD or composite (compared with conventional thin multifilament yarns) - resulting in a considerable reduction of weight.

At the same time, the material’s high stiffness and dimensional stability mean that shaped plates retain their original form and performance levels even if they have been exposed to temperatures and or moisture levels above the normal working range (e.g., during storage). The stiffness, shape and low matrix content of Endumax also means that the chemical quantities and pressure needed to produce a shaped anti-ballistic plate are significantly lower than for other UHMWPE materials.

Lightweight, flexible and with excellent ballistic protection properties, Endumax is the material of choice for modern protection equipment.

---

**Twaron in hard ballistic protection**

A wide range of materials are used for different hard ballistic applications. These materials include ceramics, special metal alloys, honeycomb structures and even simple car-body steel combined with Twaron fabric. Thousands of firing and blasting tests performed by our engineers have established an enormous body of knowledge and experience about the application of Twaron materials, making our staff highly valued professional partners for the up-armoring industry.

Thousands of light and heavy military vehicles have add-on armoring systems for higher protection levels, as well as interior spill liner applications for better protection against fragments. Numerous airplane cockpits protect their pilots against hits or high-energy AP ammunition, thanks to the unique behavior of the Twaron/Ceramic composites in their up-armored plane bodies. Navy frigates and fast patrol boats significantly increase their ballistic safety by having parts of their hulls manufactured with Twaron laminates. Thousands of security cars all over the world rely on dedicated lightweight composite solutions to protect drivers and passengers against a wide range of threats from bullets, fragments and blasts.

Nor is vehicle and object protection the only use for Twaron-based composites. Police officers around the world count on their light ballistic shields containing Twaron materials to offer them the highest ballistic protection possible against rioters, criminals or terrorist attacks. Effective personal protection is unthinkable without light ceramic/Twaron panels capable of withstanding multiple hits of high-energy AP ammunition. To meet personal protection needs, various high performing ballistic inserts can be supplied that comply with the requirements of different international standards.

At the heart of all of these ballistic protection applications are products from Teijin Aramid. These products include Twaron fabrics CT 736, CT 737, T 750, T 751 and T 760; multilayer rubberized Twaron laminates such as Twaron LFT HB1; and even very complex composites of different materials bonded together with Twaron. Applied in accordance with the recommendations of our engineering department, they provide optimum ballistic protection.
## Fabric List

<table>
<thead>
<tr>
<th>Style</th>
<th>Main Application</th>
<th>Linear Density [dtex]</th>
<th>Twaron-Type</th>
<th>Total weight [g/m²]</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB1</td>
<td>Bullet resistant vests</td>
<td>930 f1000</td>
<td>2040</td>
<td>220</td>
<td>2 layers Twaron woven fabric + 3 layers thermoplastic film</td>
</tr>
<tr>
<td>SB1 plus</td>
<td>Bullet resistant vests Anti-Trauma</td>
<td>930 f1000</td>
<td>2040</td>
<td>430</td>
<td>4 layers Twaron, arranged in 0°, 90°, +45° and -45° orientations, laminated with small amount of resin</td>
</tr>
<tr>
<td>UD41</td>
<td>Bullet resistant vests</td>
<td>1100 dtex</td>
<td>2040</td>
<td>238</td>
<td>4 plies of Twaron UD in a 0°/90°/0°/90° configuration, constructed within resin matrix and laminated together with thermoplastic film</td>
</tr>
<tr>
<td>Microflex</td>
<td>Spike resistant vests</td>
<td>550 f500</td>
<td>2040</td>
<td>220</td>
<td>Woven fabric with special densification treatment</td>
</tr>
<tr>
<td>SRM</td>
<td>Stab resistant vests</td>
<td>930 f1000</td>
<td>2040</td>
<td>430</td>
<td>CT 709 woven Twaron fabric + silicon carbide coating</td>
</tr>
<tr>
<td>AT</td>
<td>Anti-trauma</td>
<td>930 f1000</td>
<td>2040</td>
<td>780</td>
<td>Laminate of CT 707 woven Twaron fabric + PP-Fabrics</td>
</tr>
<tr>
<td>AT Flex</td>
<td>Anti-trauma</td>
<td>930 f1000</td>
<td>2040</td>
<td>490</td>
<td>Laminate of CT 707 woven Twaron fabric + PP-Fabrics</td>
</tr>
<tr>
<td>UD21</td>
<td>Hard ballistics</td>
<td>3360 dtex</td>
<td>1000</td>
<td>271</td>
<td>2 plies of Twaron UD in a 0°/90° configuration</td>
</tr>
<tr>
<td>Endumax</td>
<td>Hard ballistics, shields</td>
<td>-</td>
<td>-</td>
<td>200</td>
<td>-</td>
</tr>
</tbody>
</table>

Recyclable

Ballistic materials are recyclable, and at Teijin Aramid we buy them back. We also guarantee the demilitarization of the recycled material. Read more about our recycling and buy back activities on [www.teijinaramid.com/recycling](http://www.teijinaramid.com/recycling).

More information on Teijin Aramid's ballistic solutions can be found in the dedicated Body Armor, Hard Ballistics and Helmets leaflets or through our Sales Department via ballistics@teijinaramid.com.

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### Fabric List

<table>
<thead>
<tr>
<th>Style</th>
<th>Linear Density [dtex]</th>
<th>Twaron-Type</th>
<th>Weave Set [per 10 cm]</th>
<th>Set [per inch]</th>
<th>Areal Density [g/m²]</th>
<th>Thickness [mm]</th>
<th>Minimum Breaking Strength [N/cm x 1,000]</th>
<th>Minimum Breaking Strength [lb/in x 1,000]</th>
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<tbody>
<tr>
<td>CT 612</td>
<td>550 f1000</td>
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<td>Plain</td>
<td>110</td>
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<td>Plain</td>
<td>107</td>
<td>28</td>
<td>180</td>
<td>5.31</td>
<td>0.30</td>
</tr>
<tr>
<td>CT 706</td>
<td>840 f1000</td>
<td>2000</td>
<td>Plain</td>
<td>126</td>
<td>30</td>
<td>215</td>
<td>6.34</td>
<td>0.31</td>
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<td>CT 707</td>
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<td>Plain</td>
<td>105</td>
<td>27</td>
<td>200</td>
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<td>2040</td>
<td>Plain</td>
<td>105</td>
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<td>17</td>
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<td>0.34</td>
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<td>CT 737</td>
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<td>2000</td>
<td>Twill 2X2</td>
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<td>32</td>
<td>410</td>
<td>12.09</td>
<td>0.60</td>
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<tr>
<td>CT 747</td>
<td>3360 f2000</td>
<td>2000</td>
<td>Plain</td>
<td>63</td>
<td>16</td>
<td>410</td>
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<td>CT 750</td>
<td>3360 f2000</td>
<td>2000</td>
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<td>CT 730</td>
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<tr>
<td>CT 750</td>
<td>3360 f2000</td>
<td>2000</td>
<td>Plain</td>
<td>67</td>
<td>17</td>
<td>460</td>
<td>13.57</td>
<td>0.65</td>
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<tr>
<td>CT 751</td>
<td>3360 f2000</td>
<td>1000</td>
<td>Plain</td>
<td>45</td>
<td>11</td>
<td>300</td>
<td>8.85</td>
<td>0.53</td>
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<tr>
<td>CT 760</td>
<td>3360 f2000</td>
<td>1000</td>
<td>Twill 4X4</td>
<td>92</td>
<td>23</td>
<td>635</td>
<td>18.73</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Depending on performance requirements fabrics may be used woven, scoured or scoured and Water Repellent Treated (WRT- soft or hard).
About Teijin Aramid

We are Teijin Aramid, a subsidiary of the Teijin Group with a passion for aramid. Our commitment both to our products and to our customers has made us a global leader in aramids. Wherever strength, safety, heat or flame resistance, low weight or sustainability is required, you will find our Twaron®, Sulfron®, Teijinconex® or Technora®. Our products are used worldwide in many different applications and markets, including automotive, ballistic protection, marine, civil engineering, protective clothing, optical fiber cables, and oil & gas. With our four high performance aramids – produced at our plants in The Netherlands and Japan – we offer the widest range of products. And, with unrivalled expertise and experience we are able to continuously work on further innovations. Often in cooperation with customers and partners through our worldwide sales and marketing organization. That’s the power of aramid. If you would like to learn more about the world of aramid or to exchange ideas on developing new solutions, please go to:

www.teijinaramid.com or e-mail us at: ballistics@teijinaramid.com
Twaron – a versatile high-performance fiber
Twaron is Teijin Aramid’s flagship para-aramid, a high-performance man-made fiber. Offering well-balanced performance in terms of mechanical properties, chemical resistance and thermal stability, it is widely recognized in many industries as an extremely valuable component with excellent durability. Our experience of more than 30 years, not only guarantees a technically mature product, it is also the basis for developments – often in close cooperation with our customers to tailor Twaron to the specific requirements in various applications.

Twaron is suitable for a virtually unlimited range of challenging applications, including ballistic protection, heat and cut protection, the oil and gas industry, the automotive industry and optical fiber cables to name just a few of its many uses.

Twaron combines the following characteristics, which distinguishes it from other synthetic fibers:
- High strength (excellent strength-to-weight properties)
- High modulus
- High dimensional stability
- Excellent heat, cut and chemical resistance
- No melting point
- Low flammability
- Non-conductivity

These unique characteristics are the result of a 100% paracrystalline structure with molecular chains preferentially oriented along the fiber axis.

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<td>What types of Twaron are available?</td>
<td>6</td>
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<td>8</td>
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<td>Sustainability is the future</td>
<td>10</td>
</tr>
<tr>
<td>How does Twaron compare to other fibers?</td>
<td>11</td>
</tr>
</tbody>
</table>
Dedicated specialists in our manufacturing departments continually monitor the production of Twaron, which is made from monomers in three stages. These stages are polymerization, filament yarn spinning and converting.

How is Twaron produced?

Polymerization
During the first stage, the monomers are converted into a firm fine-grained polymer. This material has the typical heat resistance and chemical properties of para-aramid. However, it has not yet acquired the reinforcing properties of yarn or pulp. Such material is used as a fine powder to improve the properties of plastic components.

Filament yarn spinning
The second stage involves dissolving the polymer in sulfuric acid, which produces a liquid crystalline solution. This solution is then spun into fine, natural yellow or dope-dyed black filament yarn. (the diameter of each filament is as small as 12 μm). The resulting structure is virtually 100% paracrystalline, with molecular chains running parallel to the axis of the fiber. It is this high degree of orientation which contributes to the extraordinary properties of Twaron filament yarns.

Converting to staple and short-cut fiber
To produce staple or short-cut fibers, the yarn is crimped and treated with a finishing agent. After drying, the fibers are cut to the desired length and packaged.

Converting to pulp
To produce pulp, the yarn is first cut, suspended in water and fibrillated. Then it is either packed directly and marketed as wet pulp or dehydrated and dried for sale in the form of dry pulp.

Spinning solution
- liquid crystalline solution
- local orientation of molecules in domains

Yarn structure
- highly crystalline structure
- molecules are highly oriented
- fibrillar morphology

‘I feel proud when I see the results of my work’; Michel Vinke, operator
What types of Twaron are available?

Twaron yellow filament yarn
As filament yarn, Twaron can be supplied in the following forms:
- Standard modulus filament yarn (twisted or untwisted) with 250-10,000 filaments
- High-modulus filament yarn with 250-15,000 filaments
- High-tenacity filament yarn with 500-2,000 filaments

As filament yarn, the power of Twaron has proven itself in numerous applications, including optical fiber cables, hoses, tires, rubber products, ballistic protection, linear tension members, composites and belts. To help our customers find optimal solutions, our Research & Development experts have also developed special surface treatments such as water-blocking finishes for optical fiber cables or adhesion activation finishes for rubber products in order to further improve product properties and/or processability.

<table>
<thead>
<tr>
<th>Twaron yellow yarn types</th>
<th>Linear density (dtex)</th>
<th>Tenacity (mN/tex)</th>
<th>Modulus (GPa)</th>
<th>Elongation at break (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>420 - 3,360</td>
<td>1,650 - 2,200</td>
<td>60 - 80</td>
<td>3.0 - 4.4</td>
</tr>
<tr>
<td>High modulus</td>
<td>420 - 24,150</td>
<td>2,100 - 2,300</td>
<td>100 - 120</td>
<td>2.2 - 3.0</td>
</tr>
<tr>
<td>High-tenacity</td>
<td>420 - 3,360</td>
<td>2,350 - 2,500</td>
<td>85 - 95</td>
<td>3.3 - 4.0</td>
</tr>
</tbody>
</table>

* preliminary values

Twaron black filament yarn
Twaron black filament can be supplied as high modulus filament yarn which is optimized for composite applications in two linear densities: 1210 dtex and 1610 dtex. For heat protective applications it is also available in standard modulus and 3360 dtex. Both types are dope-dyed and therefore offering a good color fastness.

<table>
<thead>
<tr>
<th>Twaron black yarn types</th>
<th>Linear density (dtex)</th>
<th>Tenacity (mN/tex)</th>
<th>Modulus (GPa)</th>
<th>Elongation at break (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>3,360</td>
<td>1,828 - 1,950*</td>
<td>64 - 81*</td>
<td>3.2 - 3.8*</td>
</tr>
<tr>
<td>High modulus</td>
<td>1,210 - 1,610*</td>
<td>2,000*</td>
<td>100*</td>
<td>2.8*</td>
</tr>
</tbody>
</table>

Twaron yellow staple fiber
Twaron staple fibers are used in many heat- and cut protective applications. In its natural yellow color Twaron staple fibers are available in a range of yarn counts and fiber lengths for textile applications in protective apparel and for industrial applications.

<table>
<thead>
<tr>
<th>Twaron staple fiber length (mm)</th>
<th>Linear density (dtex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40, 50, 60</td>
<td>1.7</td>
</tr>
<tr>
<td>50</td>
<td>0.9</td>
</tr>
<tr>
<td>60</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Twaron black staple fiber
To support our customers to develop solutions providing the optimum protection combined with comfort for heat and flame protection we also offer Twaron black staple fiber in 1.7 dtex and 50 mm fiber length.

Twaron short-cut fiber
Twaron filament yarn can also be converted into chopped fibers or dipped chopped fibers with fiber lengths from 0.25 – 12 mm for use e.g. in engineering plastics applications.

Twaron powder
Twaron is available in different powder forms, differentiated by particle size. These products are used amongst others in engineering plastics, specialty coatings as well as rubber compounds.

Twaron pulp
To produce pulp, Twaron filament yarn is first cut, suspended in water and then fibrillated. The characteristic properties of the pulp are determined by the fiber length and the specific surface area (degree of fibrillation).

Due to its chemical and physical properties, Twaron pulp improves stability and increases the strength of compounds in which it is used.

To help our customers find optimal solutions, we provide both dry and wet pulp in different fiber lengths and degrees of fibrillation. With the broadest product range on the market, we offer tailor-made solutions for many different applications such as friction products, sealing materials and specialty paper products.

Twaron jet-spun fibrids or pulp
Twaron jet-spun fibrids and pulp are made by a newly developed and patented manufacturing process. They differ from conventional pulp thanks to their adjustable specific structure from film-like to very fine, which improves network formation and ensures superior binding. Twaron jet-spun fibrids and pulp can be processed on conventional paper machines, e.g. for the production of specialty paper products.

Special product types are available on request. For more detailed information please contact us for the relevant datasheets.
**Twaron – a unique combination of properties**

**Mechanical properties**
Twaron yarns are very strong, their tensile strength being two to three times higher than that of high-strength polyester and polyamide yarns and five times higher than that of steel (on weight basis). The table on page 7 shows the mechanical properties in detail.

The stress/strain curves are visualized in the graph below.

**Chemical resistance**
Twaron’s high crystallinity and strong intermolecular interactions prevent chemicals from penetrating the polymer. Resistance to organic chemicals is good to excellent, while resistance to inorganic chemicals varies with their pH value. Highly acidic or alkaline chemicals may cause hydrolytic degradation.

**Thermal properties**
Twaron neither burns nor melts. The graphs below show that Twaron can survive brief exposure to temperatures up to 500°C (932°F) without any significant loss of mass. This is significantly better than the thermal properties of other synthetic fibers.

When used as heat resistant material, however, it is not recommended to exceed 250°C. Twaron carbonizes in the absence of oxygen and approximately 30% of its mass is retained.

**Chemical resistance**
- Twaron resistance to chemical attack, exposure time: 3 months in water at room temperature.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Unit</th>
<th>Typical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability (LOI)</td>
<td>%</td>
<td>29 - 37²</td>
</tr>
<tr>
<td>Specific heat</td>
<td>kg • K</td>
<td>1420</td>
</tr>
<tr>
<td>Shrinkage in hot air (190°C/374°F, 15 min.)</td>
<td>%</td>
<td>0</td>
</tr>
<tr>
<td>Decomposition temperature</td>
<td>°C/F</td>
<td>500/932</td>
</tr>
<tr>
<td>Heat resistance (i.e. strength retention)</td>
<td>%</td>
<td>90</td>
</tr>
</tbody>
</table>

¹ fabric measurement ² filament yarn measurement

**Thermogravimetric analysis of Twaron at a heating rate of 10°C/min.**

**UV resistance/weathering**
Twaron is susceptible to UV light. It is necessary to protect aramid from exposure to direct sunlight.

**Hydrolysis**
Aramid and other condensation polymers are sensitive to acids and bases.

If you’re interested in more detailed information about Twaron properties or testing methods, please contact us.
Sustainability is our future

The scarcity of natural resources and the need for clean energy will be the most important limiting factors regarding the quality of life in the future. Sooner or later, we will reach that tipping point when our current lifestyles and business practices hit the boundary conditions of what the Earth is able to provide. Our current way of living will no longer be viable. We need to take the lead.

Value throughout the chain

Therefore we see sustainability as a joint responsibility, and we are actively seeking to take responsibility for our part. That’s why we’re looking for new ways of contacting, interacting and cooperating with our partners in the value chain.

The aramid products in our portfolio are intrinsically capable of enabling sustainability. For example, with its exceptional resistance to extreme conditions, Twaron contributes to global trends in sustainability like saving weight, conserving scarce raw materials and making products that are tougher and more durable. Also, through its extensive recycling program, Teijin Aramid is committed to safeguarding the value of its aramid wherever possible.

Over the past few years, Teijin Aramid has invested in sustainability by executing Eco-Efficiency Analyses (EEAs). Using these analyses, we are able to quantify the potential eco-footprint reductions of certain products and solutions containing Twaron throughout their lifecycle. These can then be compared with other solutions in the market and potentially create value for you, your customer and the customer of your customer.

Partnering on sustainability

Sustainability benefits strongly from innovation and cooperation. In our Central Research Facilities, at the Technical Textile Institute (TTI), as well as in our Application Competence Center, we are constantly improving our products and working towards innovative and environmental friendly solutions. For existing markets and for new markets. We aim to do these developments together with our customers and other partners in the value chain.

Quality, Health, Safety and Environment (QHSE)

Teijin Aramid has been certified to ISO 9001 (Quality) since 1993, to ISO 14001 (Environment) since 1996, and to OHSAS 18001 (Health & Safety) since 2002. Operations at our sites are governed by procedures documented in our QHSE management system. We make continues improvements and carry out several audits each year. In 2009 Lloyds Register Quality assurance certified that our operations meet the requirements of the new (2008) version of the ISO 9001 standard.

If you are interested in cooperating with us or would like to discuss issues regarding sustainability, please don’t hesitate to contact us via sustainability@teijinaramid.com

How does Twaron compare to other fibers?

Twaron’s unique combination of properties makes it the fiber of choice in numerous applications.

<table>
<thead>
<tr>
<th></th>
<th>Twaron</th>
<th>Technora</th>
<th>UHMW PE</th>
<th>Carbon (PAN-based)</th>
<th>E-Glass</th>
<th>PBI Oxidized PAN</th>
<th>Teijin-conex</th>
<th>PET</th>
<th>PA-6</th>
<th>PA-66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm³)</td>
<td>1.44-1.45</td>
<td>1.39</td>
<td>0.97-0.98</td>
<td>1.78</td>
<td>2.55</td>
<td>1.43</td>
<td>1.35-1.40</td>
<td>1.38</td>
<td>1.37-1.4</td>
<td>1.13</td>
</tr>
<tr>
<td>Tensile strength (GPa)</td>
<td>2.4-3.6</td>
<td>3.4</td>
<td>2.2-3.9</td>
<td>3.5-7</td>
<td>1.5-3</td>
<td>0.32</td>
<td>0.2-0.3</td>
<td>0.62-0.69</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Tenacity (N/tex)</td>
<td>1.65-2.5</td>
<td>2.5</td>
<td>2.3-4.0</td>
<td>2.0-3.9</td>
<td>0.6-1.2</td>
<td>0.24</td>
<td>0.15-0.2</td>
<td>0.45-0.5</td>
<td>0.6-0.8</td>
<td>0.7-0.75</td>
</tr>
<tr>
<td>Modulus (GPa)</td>
<td>60-120</td>
<td>74</td>
<td>52-132</td>
<td>230-540</td>
<td>72</td>
<td>5.1</td>
<td>7-11</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>2.2-4.4</td>
<td>4.5</td>
<td>3-4</td>
<td>0.7-2.0</td>
<td>1.8-3.2</td>
<td>27</td>
<td>15-23</td>
<td>35-45</td>
<td>10-15</td>
<td>20-25</td>
</tr>
<tr>
<td>Moisture (wt%)</td>
<td>3.2-5</td>
<td>1.9</td>
<td>&lt;0.1</td>
<td>0</td>
<td>0.1</td>
<td>15</td>
<td>10</td>
<td>5-5.5</td>
<td>0.4</td>
<td>3.5-4.5</td>
</tr>
<tr>
<td>Glass transition (°C)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1140</td>
<td>&gt;400</td>
<td>-</td>
<td>-</td>
<td>280</td>
<td>82</td>
</tr>
<tr>
<td>Decomposition or Melting (°C)</td>
<td>500</td>
<td>932</td>
<td>500</td>
<td>932</td>
<td>-</td>
<td>3700</td>
<td>6692</td>
<td>-</td>
<td>450</td>
<td>-</td>
</tr>
<tr>
<td>LOI (%)</td>
<td>29-37</td>
<td>25</td>
<td>&lt;20</td>
<td>-</td>
<td>-</td>
<td>&gt;41</td>
<td>55</td>
<td>29-32</td>
<td>18-21</td>
<td>20-21</td>
</tr>
</tbody>
</table>

1 in a matrix structure
2 fabric measurement
3 filament yarn measurement

N.B. As these data originate from a variety of sources, they may be subject to deviations resulting from different test methods and/or conditions.

We do not accept any liability for the results of the use of these products. The technical data in this brochure reflects our best knowledge at the time of publication. The content of this leaflet is subject to change, depending on new developments and findings, and a similar reservation applies to the properties described in it.
About Teijin Aramid
We are Teijin Aramid, a subsidiary of the Teijin Group with a passion for aramid. Our commitment both to our products and to our customers has made us a global leader in aramids. Wherever strength, safety, heat or flame resistance, low weight or sustainability is required, you will find our Twaron®, Sulfron®, Teijinconex® or Technora®. Our products are used worldwide in many different applications and markets, including automotive, ballistic protection, marine, civil engineering, protective clothing, optical fiber cables, and oil & gas. With our four high performance aramids – produced at our plants in The Netherlands and Japan – we offer the widest range of products. And, with unrivalled expertise and experience we are able to continuously work on further innovations. Often in cooperation with customers and partners through our worldwide sales and marketing organization. That’s the power of aramid. If you would like to learn more about the world of aramid or to exchange ideas on developing new solutions, please go to:

www.teijinaramid.com or e-mail us at: info@teijinaramid.com

Twaron®
The power of Aramid
Thank you for your attention

In case of questions, please let me know

For more information you can also visit www.teijinaramid.com
or email ballistics@teijinaramid.com