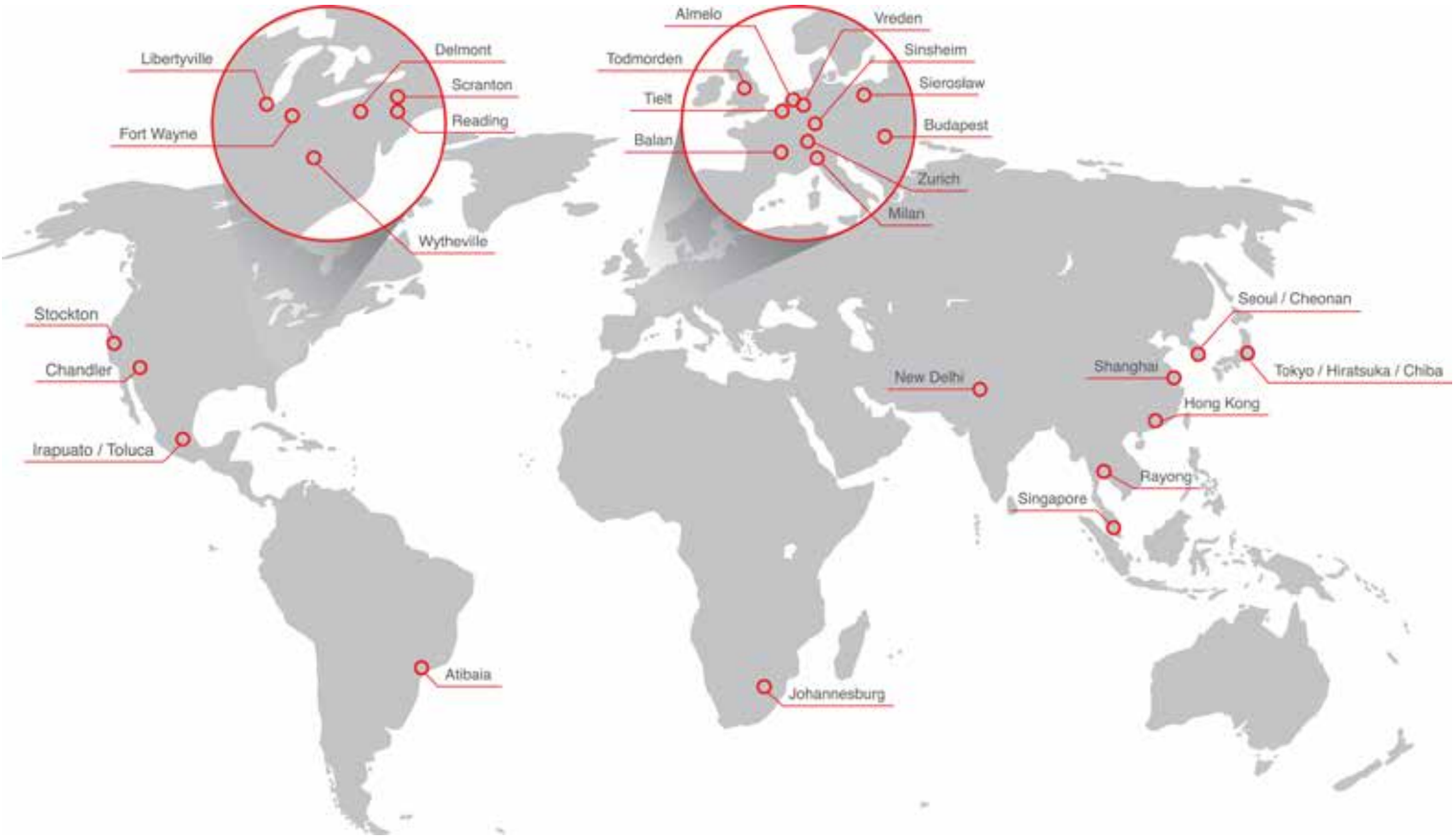
MITSUBISHI CHEMICAL
ADVANCED MATERIALS

Engineering Plastics
Product Guide

Mitsubishi Chemical Advanced Materials
Global Scope



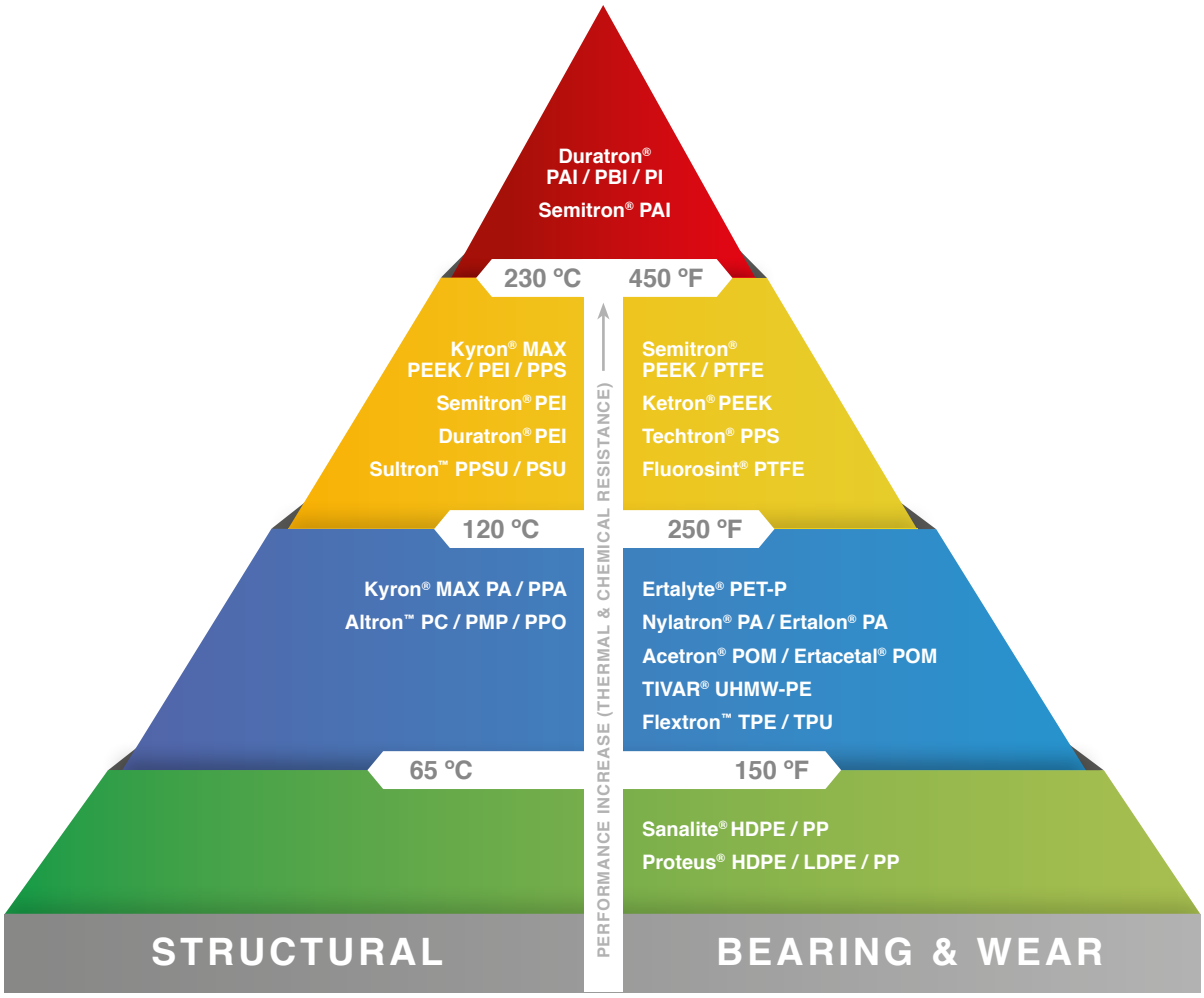
With more than 80 years of experience, 30 branch offices in 20 countries, and a team of technical service experts, engineers, and application development managers, Mitsubishi Chemical Advanced Materials is the global leader for researching, developing, and manufacturing high-performance engineered polymer materials. Our products make the world a safer place by providing solutions across all industries:

- food processing and packaging
- aerospace and defense
- semiconductor
- chemical and Oil & Gas processing
- medical and life sciences
- renewable energy
- construction and heavy equipment
- linings
- transportation and rail

Built on a foundation of KAITEKI, Mitsubishi Chemical Advanced Materials strives to realize KAITEKI by enhancing and improving our high-performance thermoplastic materials with the sustainability of people, society, and the environment in mind. KAITEKI is an original concept of the Mitsubishi Chemical Holdings Group that proposes a way forward in the sustainable development of society and the planet Earth, in addition to serving as a guide for solving environmental and social issues.

Classification of Plastics

The materials performance pyramid ranks the most common thermoplastics according to their temperature performance. Amongst these materials, different “families” can be recognized, all exhibiting high value in use within numerous applications.



Classification of Plastics

Semi-crystalline Ertalon®/Nylatron® PA grades offer good mechanical strength and stiffness, high toughness, low friction and very good wear resistance. These properties make them ideal replacements for a wide variety of materials from metal to rubber.

Ertacetal® POM provides high mechanical strength and stiffness coupled with enhanced dimensional stability. As a semi-crystalline material, Ertacetal is characterised by a low coefficient of friction and good wear properties [wet environment].

Unreinforced, semi-crystalline Ertalyte® PET offers very good dimensional stability in combination with excellent wear resistance, low friction, high strength, creep resistance and resistance to moderate acidic solutions.

Although exhibiting considerably lower mechanical strength, stiffness and creep resistance than Ertalon®/ Nylatron®, Ertacetal® and Ertalyte®, the range of TIVAR® UHMW-PE grades meets the demands of many industries and this from cryogenic temperatures up to about 85 °C. These materials show outstanding impact strength, excellent wear and abrasion resistance, low friction and excellent release properties.

Duratron® PBI, Duratron® PI and Duratron® PAI are designed for top performance in both structural and friction & wear applications. Characterised by an extreme temperature resistance [up to 310 °C continuously for Duratron® PBI], these materials perform where others would fail.

The semi-crystalline Ketron® PEEK, Techtron® PPS and Fluorosint® PTFE typically offer a combination of excellent chemical and mechanical properties, also at elevated temperatures. These materials can be used for both structural and friction & wear applications.

The amorphous Sultron™ PPSU, Sultron™ PSU and Duratron® PEI exhibit an outstanding retention of their mechanical properties up to the glass transition temperature and excellent electrical properties. Additionally, their hydrolysis resistance [autoclavability] offers great possibilities for structural parts in medical, pharmaceutical and dairy industries.

From Semitron® ESd 225 – a static dissipative acetal grade – up to Semitron® ESd 520HR – a static dissipative polyamide-imide grade – a comprehensive range of Semitron® ESd grades are available to service static dissipative needs over a broad range of temperatures and mechanical loading conditions.

Duratron® PBI Polybenzimidazole [PBI]

Duratron® PBI is the highest performance engineering thermoplastic available today. Thanks to its unique property profile, Duratron® PBI might bring the ultimate solution when no other plastics material can.

Main Characteristics

- Extremely high maximum allowable service temperature in air [310 °C continuously, up to 500 °C for short periods of time]
- Excellent retention of mechanical strength, stiffness and creep resistance over a wide temperature range
- Excellent wear and frictional behaviour
- Extremely low coefficient of linear thermal expansion
- Excellent resistance against high energy radiation [gamma- and X-rays]
- Inherent low flammability
- High purity in terms of ionic contamination
- Good electrical insulating and dielectric properties

Grades

Duratron® CU60 PBI [PBI; black]
Duratron® CU60 PBI offers the highest temperature resistance and best mechanical property retention over 200 °C of all unfilled thermoplastics. Duratron® CU60 PBI is very “clean” in terms of ionic impurity and does not outgas [except water]. These characteristics make this material extremely attractive to high-tech industries such as semiconductor and aerospace industries.

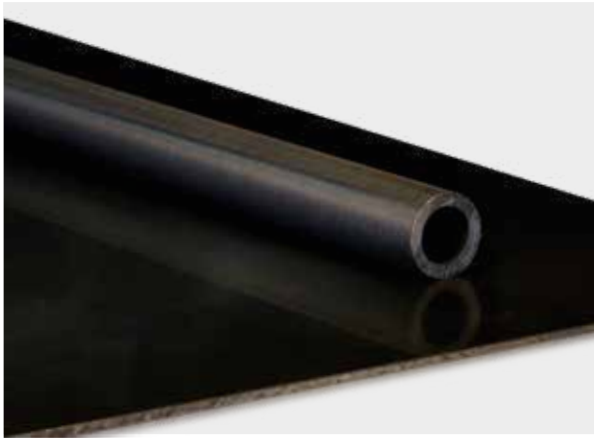
Usually Duratron® CU60 PBI is used in critical components to decrease maintenance costs and to gain valuable production “uptime”. It is used to replace metals and ceramics in pump components, valve seats [high tech valves], bearings, rollers, high temperature insulators.

Tech Notes:

High tolerance fabricated components should be stored in sealed containers [usually polybags with desiccant] to avoid dimensional changes due to moisture absorption. Components rapidly exposed to temperatures above 200 °C should be “dried” prior to use or kept dry to avoid deformation from thermal shock.

Duratron® PI Polyimide [PI]

Duratron® PI offers a combination of properties that allows it to excel in applications requiring low wear and long life in harsh environments. Duratron® PI is an exceptional value for applications where thermal requirements exclude Duratron® PAI and do not require the extraordinary thermal resistance of Duratron® PBI. Consequently, Duratron® PI parts are put to use for very demanding applications in the automotive, aerospace, defence, electrical, glass, nuclear and semiconductor industries.



Main Characteristics

- Extremely high max. allowable service temperature in air [240 °C continuously, with short term excursions up to 450 °C]
- Excellent retention of mechanical strength, stiffness and creep resistance over a wide range of temperatures
- Good sliding properties and excellent wear resistance
- Very good dimensional stability
- Inherent low flammability
- Good electrical insulating and dielectric properties [only applies to Duratron® D7000 PI]
- Low outgassing in vacuum [dry material]
- High purity in terms of ionic contamination [Duratron® D7000 PI]
- Excellent resistance against high energy radiation

Applications

Valve and pump seats, seals and wear surfaces, structural and wear parts for semiconductor and electronics manufacturing, fixtures and handling parts for glass and plastics manufacturing, metal replacement for aerospace components.

Grades

Duratron® PI is available in several grades for structural and wear applications and in the broadest range of shapes - particularly thick sheets, larger sheet geometries and heavy-wall tubes.

Duratron® D7000 PI [PI; natural (chestnut)]
Duratron® D7000 PI - the basic grade within the Duratron® PI family - is made from unfilled polyimide resin and provides maximum physical properties and best electrical and thermal insulation.

Duratron® D7015G PI [PI + graphite; grey-black]
This grade contains 15 % graphite, added to provide long wear and low friction.

Duratron® PAI Polyamide-imide [PAI]

With its versatile performance capabilities and proven use in a broad range of applications, Duratron® polyamide-imide [PAI] shapes are offered in extruded and compression moulded grades. For high temperature applications, this advanced material offers an excellent combination of mechanical performance and dimensional stability.

Main Characteristics

- Very high maximum allowable service temperature in air [250 °C continuously]
- Excellent retention of mechanical strength, stiffness and creep resistance over a wide temperature range
- Superb dimensional stability up to 250 °C
- Excellent wear & frictional behaviour [particularly Duratron® T4301 & T4501 PAI]
- Very good UV-resistance
- Exceptional resistance against high energy radiation [gamma- and X-rays]
- Inherent low flammability

Main Grades

Duratron® T4203 PAI [extruded] [PAI; yellow-ochre]
Duratron® T4503 PAI [compression moulded] [PAI; yellow-ochre]
Duratron® T4203 PAI offers the best toughness and impact strength of all Duratron® PAI grades. This extruded Duratron® PAI grade is very popular for precision parts in high-tech equipment. In addition, its good electrical insulating ability provides numerous possibilities in the field of electrical components. Compression moulded Duratron® T4503 PAI is similar in composition to Duratron® T4203 PAI, and is selected when larger shapes are required.

Duratron® T4301 PAI [extruded] [PAI + graphite + PTFE; black]
Duratron® T4501 PAI [compression moulded] [PAI + graphite + PTFE; black]
The addition of PTFE and graphite provides higher wear resistance and lower coefficient of friction compared to the unfilled grade as well as a lower tendency to stick-slip. Duratron® T4301 PAI also offers excellent dimensional stability over a wide temperature range. This extruded Duratron® PAI grade excels in severe wear applications such as non-lubricated bearings, seals, bearing cages and reciprocating compressor parts. Compression moulded Duratron® T4501 PAI is similar in composition to Duratron® T4301 PAI, and is selected when larger shapes are required.

Duratron® T5530 PAI [compression moulded] [PAI-GF30; khaki-grey]
This 30 % glass fibre reinforced grade offers higher stiffness, strength and creep resistance than the Duratron® PAI grades mentioned above. It is well suited for structural applications supporting static loads for long periods of time at high temperatures. In addition, Duratron® T5530 PAI exhibits superb dimensional stability up to 250 °C making it extremely popular for precision parts in e.g. the electronical and semiconductor industries. The suitability of Duratron® T5530 PAI for sliding parts, however, is to be carefully examined since the glass fibres tend to abrade the mating surface.

Tech Notes:

As Duratron® PAI shows a relatively high moisture absorption, parts used in high temperature service or made to tight tolerances should be kept dry prior to installation. Thermal shock resulting in deformation can occur if moisture laden parts are rapidly exposed to temperatures above 200 °C.

Ketron® PEEK Polyetheretherketone [PEEK]

The Ketron® PEEK family of materials is based on polyetheretherketone resin. This semi-crystalline advanced material exhibits a unique combination of high mechanical properties, temperature resistance and excellent chemical resistance making it the most popular advanced plastics material.

Main Characteristics

- Very high maximum allowable service temperature in air [250 °C continuously, up to 310 °C for short periods of time]
- High mechanical strength, stiffness and creep resistance, also at elevated temperatures
- Excellent chemical and hydrolysis resistance
- Excellent wear and frictional behaviour
- Very good dimensional stability
- Excellent resistance to high energy radiation [gamma- and X-rays]
- Inherent low flammability and very low levels of smoke evolution during combustion
- Good electrical insulating and dielectric properties [except for Ketron® HPV PEEK and CA30 PEEK]

Applications

Ketron® PEEK is often used to replace PTFE when higher mechanical load bearing capacity, or when superior wear resistance are needed. Ketron® PEEK is widely selected as a replacement for metal components. Examples of components made from PEEK grades: pump components, valve seats, bearings, rollers, gears, high temperature insulators, components exposed to boiling water or steam.

Grades

Ketron® 1000 PEEK [PEEK; natural (brownish-grey) or black - available as "Food Grade", details see page 35]
Ketron® 1000 PEEK stock shapes are produced from virgin polyetheretherketone resin and offer the highest toughness and impact strength of all Ketron® PEEK grades. Both Ketron® 1000 PEEK natural & black can be sterilised by all conventional sterilisation methods [steam, dry heat, ethylene oxide and gamma irradiation]. Additionally, Ketron® 1000 PEEK stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ketron® 1000 PEEK stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ketron® HPV PEEK [PEEK + CF + PTFE + graphite; black]
The addition of carbon fibres, PTFE and graphite to virgin PEEK results in a Ketron® PEEK "bearing grade". Its excellent tribological properties [low friction, long wear and high pressure-velocity capabilities] make this grade especially suited for wear and friction applications.

Ketron® GF30 PEEK [PEEK + glass fibre; natural (brownish-grey)]
This 30 % glass fibre reinforced grade offers a higher stiffness and creep resistance than Ketron® 1000 PEEK and has a much better dimensional stability. This grade is very appropriate for structural applications carrying high static loads for long periods of time at elevated temperatures. The suitability of Ketron® GF30 PEEK for sliding parts, however, is to be carefully examined since the glass fibres tend to abrade the mating surface.

Ketron® PEEK Polyetheretherketone [PEEK]

Ketron® CA30 PEEK [PEEK + CF30; black]
This 30 % carbon fibre reinforced grade combines even higher stiffness, mechanical strength and creep resistance than Ketron® GF30 PEEK with an optimum wear resistance. Moreover, compared with unreinforced PEEK, the carbon fibres considerably reduce thermal expansion and provide 3.5 times higher thermal conductivity – dissipating heat from the bearing surface faster, improving bearing life and pressure-velocity capabilities.

Ketron® TX PEEK [PEEK + solid lubricant; blue - available as "Food Grade", details see page 35]
This member of the Ketron PEEK family has been developed especially for the food industry. Like Ketron® 1000 PEEK, this internally lubricated material has a food contact compliant composition, but offers far superior wear and frictional performance making it especially suitable for a wide variety of bearing and wear applications in the 100 to 200 °C service temperature range.

Additionally, Ketron® TX PEEK stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ketron® TX PEEK stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ketron® MD PEEK [PEEK + metal detectable additive; blue - available as "Food Grade", details see page 35]
This Ketron® PEEK grade, containing a metal detectable additive, has been specifically tailored for use in the food processing and packaging industries where it can easily be traced by the conventional metal detection systems installed to detect contamination of the foodstuffs (results may vary depending on the sensitivity of the metal detection system used). Ketron® MD PEEK also presents good mechanical strength, stiffness and impact strength in high temperature environments (higher than 130 °C), and it also features a food contact compliant composition.
Additionally, Ketron® MD PEEK stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ketron® MD PEEK stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ketron® CC PEEK [PEEK + carbon fibers]
This specifically developed grade is a unique engineering PEEK based material which offers a high performance profile due to its woven carbon reinforced structure. This material is manufactured by means of compression moulding. Basically the composite contains 57% Carbon fibers and 43% Impregnated PEEK Polymer pressed into layers (laminates) of 0.325 mm. Its key properties include superior mechanical strength and stiffness at elevated temperatures, outstanding friction and wear resistance, excellent performance in chemical and irradiated environments.

Tech Notes:

From 150 °C onwards [above the glass transition temperature], the mechanical properties of all Ketron® PEEK grades drop off significantly and the coefficient of linear thermal expansion increases considerably. Consequently, a material like Duratron® PAI could be better suited for close tolerance parts operating under high loads at temperatures over 150 °C.

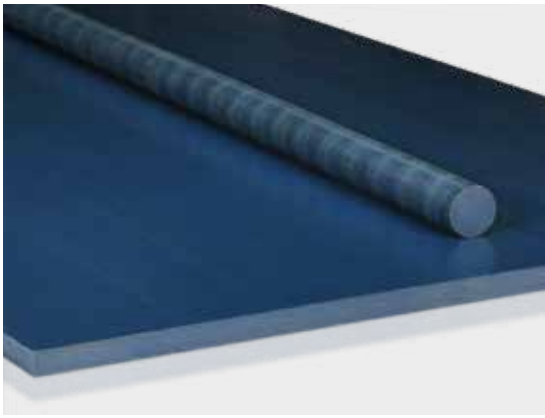
Like most reinforced materials, Ketron® GF30 PEEK, HPV PEEK, CA30 PEEK and TX PEEK exhibit a moderate toughness and impact strength. Therefore, all "internal" corners of parts made from these materials should be radiused [R > 1 mm] and edges chamfered to maximise part toughness.

Techtron® PPS Polyphenylene Sulfide [PPS]

The Techtron® PPS family – based on semi-crystalline polymer polyphenylene sulfide – was developed to close the gap both in performance and price between the standard thermoplastic materials [e.g. PA, POM, PET] and the high-end advanced engineering plastics [e.g. PBI, PI, PAI, PEEK].

Main Characteristics

- Very high maximum allowable service temperature in air [220 °C continuously, up to 260 °C for short periods of time]
- High mechanical strength, stiffness and creep resistance, also at elevated temperatures
- Excellent chemical and hydrolysis resistance
- Very good dimensional stability
- Excellent wear and frictional behaviour [Techtron® HPV PPS]
- Physiologically inert [suitable for food contact]
- Excellent resistance to high energy radiation [gamma- and X-rays]
- Good UV-resistance
- Inherent low flammability
- Good electrical insulating and dielectric properties



Tech Notes:

From 100 °C onwards [above the glass transition temperature], the mechanical properties of Techtron® HPV PPS drop off significantly and the coefficient of linear thermal expansion increases considerably. Ketron® PEEK and Duratron® PAI may be suitable alternatives to overcome these inconveniences.

Grades

Techtron® 1000 PPS [PPS; natural (cream)]
This unfilled polyphenylene sulfide based material is ideal for structural applications in corrosive environments or as a PEEK replacement at less demanding temperatures. Very good dimensional stability [minimal moisture absorption and a low coefficient of linear thermal expansion], combined with easy machinability to close tolerances, make Techtron® 1000 PPS very well suited for precise tolerance machined components. This material is generally not used for wear applications.
Additionally, the composition of the raw materials used for the manufacture of Techtron® 1000 PPS stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Techtron® HPV PPS [PPS + solid lubricant; deep blue - available as "Food Grade", details see page 35]
As a reinforced, internally lubricated PPS grade, Techtron® HPV PPS demonstrates an excellent combination of properties including wear resistance, load-bearing capabilities and dimensional stability when exposed to chemicals and high temperature environments. Techtron® HPV PPS is found in applications where PA, POM, PET and other plastics fall short or where PI, PEEK and PAI are over-engineered and a more economical solution must be found.
Thanks to the uniformly dispersed internal lubricant, Techtron® HPV PPS exhibits an excellent wear resistance and a low coefficient of friction. It overcomes the disadvantages of virgin PPS caused by a high coefficient of friction and of a glass fibre reinforced PPS which causes premature wear of the counterface in moving-part applications.
Additionally, Techtron® HPV PPS stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Techtron® HPV PPS stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.
Techtron® HPV PPS can be used in all kinds of industrial equipment such as industrial drying and food processing ovens [bearings, rollers], chemical process equipment [pump, valve & compressor components] and electrical insulating systems and sliding parts.

Sultron™ PSU Polysulfone [PSU]

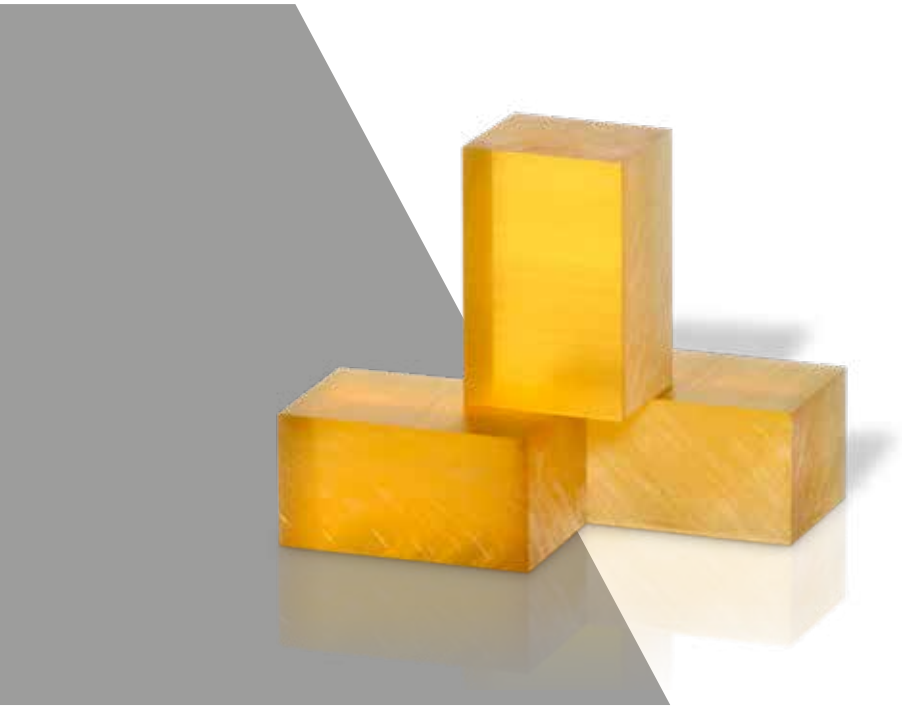
Sultron™ PSU is a slightly yellow, translucent [non-optical quality] amorphous thermoplastic material, offering a combination of excellent mechanical, thermal and electrical properties. It often replaces polycarbonate whenever higher temperature resistance, improved chemical resistance or autoclavability are required.

Main Characteristics

- High maximum allowable service temperature in air [150 °C continuously]
- Good hydrolysis resistance [suitable for repeated steam sterilisation]
- High strength and stiffness over a wide temperature range
- Good dimensional stability
- Physiologically inert [suitable for food contact per FDA regulations]
- Very good resistance against high energy radiation [gamma- and X-rays]
- Good electrical insulating and dielectric properties

Applications

Sultron™ PSU is commonly used in food processing equipment [milk machines, pumps, valves, filtration plates, heat exchangers], for analytical instrumentation and all kinds of components which are subjected to repeated cleaning and sterilisation.
Additionally, the composition of the raw materials used for the manufacture of Sultron™ PSU stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.



Tech Notes:

Amorphous thermoplastics like Sultron™ PSU are sensitive to stress cracking when in contact with polar organic solvents [e.g. ethyl alcohol]. Environments which might be completely harmless to unstressed parts may cause stress cracking with highly stressed parts [this also applies to Duratron® U1000 PEI and to a lesser extent also to Sultron™ PPSU].

Duratron® U1000 PEI Polyetherimide [PEI]
Sultron™ LSG PPSU Polyphenylensulfone [PPSU]

Duratron® U1000 PEI is an amber translucent [non-optical quality] amorphous thermoplastic material, offering high strength and heat resistance. It performs continuously to 170 °C, making it ideal for high strength / high heat applications, and also for applications requiring consistent dielectric properties over a wide frequency and temperature range.

Tech Notes:

Cooling liquids of the soluble oil type should not be used when machining Duratron® U1000 PEI since they are likely to induce environmental stress cracking. For this material, the most suitable coolants are pure water or compressed air [this also applies to Sultron™ PPSU and Sultron™ PPSU].

Main Characteristics

- High maximum allowable service temperature in air [170 °C continuously]
- Very good hydrolysis resistance [suitable for repeated steam sterilisation]
- High strength and stiffness over a wide temperature range
- Inherent low flammability and low levels of smoke evolution during combustion
- Good dimensional stability
- Physiologically inert [suitable for food contact per FDA regulations]
- Very good resistance against high energy radiation [gamma- and X-rays]
- Very good electrical insulating and dielectric properties

Applications

Duratron® U1000 PEI is extremely suitable for electrical / electronic insulators [including many semiconductor process components] and a variety of structural components requiring high strength and rigidity at elevated temperatures. Thanks to its good hydrolysis resistance, Duratron® U1000 PEI is capable of withstanding repeated autoclaving cycles.
Additionally, the composition of the raw materials used for the manufacture of Duratron® U1000 PEI stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Duratron® U2300 PEI [PEI, 30% glass-reinforced; natural]
Duratron® U2300 PEI is a glass-reinforced (30%) version of Duratron® U1000 PEI which provides even greater rigidity and improved dimensional stability while maintaining many of the useful characteristics of basic Duratron® U1000 PEI.

Sultron™ LSG PPSU Polyphenylensulfone [PPSU]
Sultron™ LSG PPSU stock shapes come in different colors which are all produced from genuine RADEL® polyphenylensulfone resins. Sultron™ LSG PPSU offers a better impract strength and chemical resistance than Duratron® LSG PEI and LSG PSU natural and has also superior hydrolysis resistance as measured by steam autoclaving cycles to failure. Sultron™ LSG PPSU stock shapes have successfully been tested on compliance with USP and ISO 10993-1 guidelines for biocompatibility of material (see page 36 - 39). They come with full traceability from resin to stock shape. The material is used in applications in the medical, pharmaceutical and biotechnology markets.

Fluorosint® Polytetrafluoroethylene [PTFE]

The Fluorosint® family of materials comprises several enhanced PTFE materials developed to fill the performance gaps where unfilled and low-tech, filled PTFE based polymers underperform. Each Fluorosint® grade was specifically developed to excel in demanding bearing and seal applications. While all of the Fluorosint® grades possess the chemical resistance and compliance of PTFE, each grade offers some special benefits that give the designer clear performance advantages.

Main Characteristics

- Very high maximum allowable service temperature in air [260 °C continuously]
- Moderate mechanical strength and stiffness
- Good dimensional stability
- Excellent chemical and hydrolysis resistance
- Low deformation under load [particularly Fluorosint® MT-01]
- Low coefficient of friction and good wear resistance
- Outstanding UV- and weather resistance
- Physiologically inert [suitable for food contact per FDA regulations]
- Inherent low flammability

Applications

High performance bearings, bushings and seals where higher loads and minimal wear are required.

Fluorosint® Polytetrafluoroethylene [PTFE]

Grades

Fluorosint® 500 [PTFE + mica; ivory]
Reinforced with a proprietary synthetic mica, this material exhibits, in addition to its inherent outstanding chemical and hydrolysis resistance, very good mechanical and tribological properties. Fluorosint® 500 has nine times greater resistance to deformation under load than unfilled PTFE. Its coefficient of linear thermal expansion approaches the expansion rate of aluminium and is 1/4 that of virgin PTFE, often eliminating fit and clearance problems. It is considerably harder than virgin PTFE, has better wear characteristics and maintains low frictional properties. Fluorosint® 500 enhanced PTFE offers an ideal combination of stability and wear resistance for sealing applications where tight dimensional control is required.

Fluorosint® 207 [PTFE + mica; white]
This material has a food contact compliant composition which, in combination with the good mechanical performance, dimensional stability, sliding and wear properties and inherent outstanding chemical and hydrolysis resistance of Fluorosint®, opens numerous application possibilities in food, pharmaceutical and chemical processing industries.
Fluorosint® 207 lasts far longer than unfilled PTFE in wear applications and has a very low coefficient of friction. It is a preferred material for lower pressure seats and seals where virgin PTFE fails and food contact compliance may be required.
Additionally, the composition of the raw materials used for the manufacture of Fluorosint® 207 stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Fluorosint® HPV [PTFE + additives; tan]
FDA compliant Fluorosint® HPV is a high performance Fluorosint® bearing grade, optimized for high pressure-velocity capabilities and very low wear. Fluorosint® HPV was developed for bearing applications where other, low-tech PTFE formulations exhibit premature wear or simply cannot perform. FDA compliance gives food and pharmaceutical equipment manufacturers new design options and all benefit from its excellent load bearing and wear characteristics.
The composition of the raw materials used for the manufacture of Fluorosint® HPV stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Fluorosint® MT-01 [PTFE + additives; dark grey]
Fluorosint® MT-01 is an extreme service grade developed specifically for applications where the benefits of PTFE-based materials also require strength, stiffness and stability. Fluorosint® MT-01 delivers high mechanical performance at elevated temperature and as a result is often specified in seat, seal and wear applications where extreme conditions are present.

Fluorosint® 135 [PTFE + additives; black]
Fluorosint® 135 offers high performance at an extremely competitive price position. It is a perfect blended material grade which provides extreme performance for seals, bearings and wear applications. Fluorosint® 135 is the lowest coefficient of friction material along with low deformation and provides superior performance over typical filled PTFE compounds.

Semitron® ESd

The Semitron® ESd family of static dissipative plastics is designed for applications where electrical discharge in operation is a problem. They provide a controlled bleed-off of static charges.

Main Characteristics

- Permanently static dissipative
- Dissipate static charges [5kV] in less than 2 seconds
- No metal or graphite powder used
- Depending on the base polymer, thermal performance from 90 to 260 °C [continuous use]

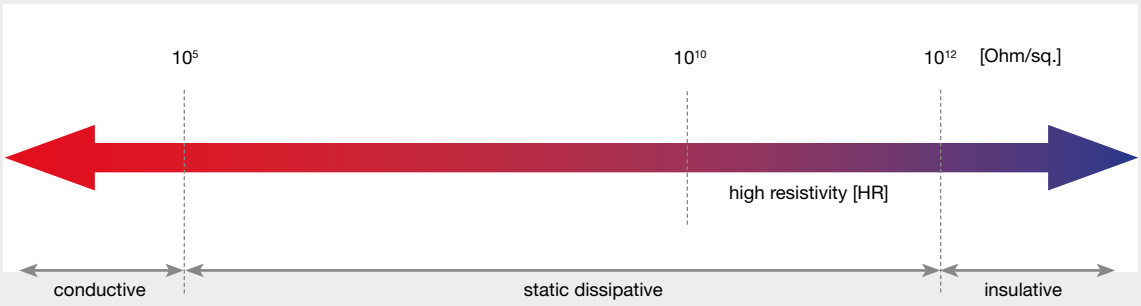
Tech Notes:

The Semitron® ESd products are inherently dissipative and do not rely on atmospheric phenomena [e.g. humidity] to activate, nor are surface treatments used to achieve dissipation.

Applications

There are eight Semitron® ESd grades servicing static dissipative needs over a broad range of temperatures and mechanical loading conditions.
The Semitron® ESd materials are commonly used in manufacturing and handling equipment of sensitive electronic components such as integrated circuits, hard disk drives and circuit boards. They are also an excellent choice for material handling applications and components in high speed electronic printing and reproducing equipment.

Surface Resistivity [Ohm/Sq.] and Conductivity Spectrum



Semitron® ESd grades	Surface resistivity [Ohm/sq.] acc. to ANSI/ESD STM 11.11	Max. allowable service temperature in air [°C] for short periods | continuously [*]
Semitron® ESd 225	10^9 - 10^{11}	140 | 90
Semitron® ESd 410C	10^4 - 10^6	200 | 170
Semitron® ESd 480	10^6 - 10^9	310 | 250
Semitron® ESd 490HR	10^{10} - 10^{12}	310 | 250
Semitron® ESd 500HR	10^{10} - 10^{12}	280 | 260
Semitron® ESd 520HR	10^{10} - 10^{12}	270 | 250
Semitron® MPR1000	> 10^{13}	- | 260
Semitron® HPV	10^6 - 10^9	310 | 250

[*] for more details, see the property list on page 47-48.

Semitron® ESd

Grades

Semitron® ESd 225 [static dissipative POM; beige]
Semitron® ESd 225 is an acetal based static dissipative material ideal for material handling operations. It is also an excellent choice for fixtures used in the manufacturing of hard disk drives or for handling in-process silicon wafers.

Semitron® ESd 410C [static dissipative PEI; black]
Having an excellent mechanical performance up to 210 °C, Semitron® ESd 410C provides ESd solutions at higher temperatures. Additionally, Semitron® ESd 410C exhibits excellent dimensional stability [low coefficient of linear thermal expansion and small water absorption], ideal for handling equipment in the electrical/ electronic or semiconductor industries.

Semitron® ESd 480 [static dissipative PEEK; black]
This PEEK based static dissipative material provides a dissipative range of 10^6 - 10^9 ohms/sq. Semitron® ESd 480 is highly dimensionally stable, making it ideal for critical test fixture applications. Its exceptional chemical resistance makes it well suited for use in wafer handling and other structural applications in wet process tools where static dissipation is important. Like all Mitsubishi Chemical Advanced Materials Semitron® ESd materials, Semitron® ESd 480 is not subject to dielectric breakdown.

Semitron® ESd 490HR [static dissipative PEEK; black]
This is a slightly higher resistivity PEEK based material that offers similar physical properties as Semitron® ESd 480. Its surface resistivity is 10^{10} - 10^{12} ohms/sq.

Semitron® ESd 500HR [static dissipative PTFE; white]
Reinforced with a proprietary synthetic mica, Semitron® ESd 500HR offers an excellent combination of low frictional properties, good dimensional stability and electrostatic dissipation. Whenever virgin PTFE causes electrical discharge problems, Semitron® ESd 500HR will provide a controlled bleed-off of static charges while maintaining typical PTFE-properties such as broad chemical resistance and low coefficient of friction.

Semitron® ESd 520HR [static dissipative PAI; khaki grey]
Semitron® ESd 520HR has an industry first combination of electrostatic dissipation [ESd], high strength and heat resistance. This ESd material is ideal for making nests, sockets and contactors for test equipment and other device handling components in the semiconductor industry.
The key feature of Semitron® 520HR is its unique ability to resist dielectric breakdown at high voltages [>100 V]. Whereas e.g. typical carbon fibre enhanced products become irreversibly more conductive when exposed to even moderate voltages, Semitron® ESd 520HR maintains its electrical performance throughout the voltage range 100 to 1000 V, while offering the mechanical performance needed to excel in demanding applications.

Semitron® MPR1000 [brownish]
Semitron® MPR1000 is a new engineering material developed for semiconductor applications and more specifically for use in vacuum chamber applications such as these found in Etch, CVD and Ion Implant. The material was developed based on three key premises:
1. Longevity - Increased life in plasma chambers over traditional plastics such as polyimide (up to 25x over polyimide in ozone);
2. Clean - Low ionic metal content and low out-gassing;
3. Value - Lower overall cost in use compared to traditional materials used in vacuum chamber applications such as quartz, ceramics, and engineering plastics.

Semitron® HPV [static dissipative PEEK; black]
The addition of specific fillers makes this grade excellent for the use in wear and friction applications but also in applications where antistatic properties are needed.

Ertalon® | Nylatron® Polyamide [PA]

Within the polyamides, commonly referred to as “nylons”, we distinguish different types. The most important ones are: PA 6, PA 66, PA 11 and PA 12. The differences in physical properties which exist between these types are mainly determined by the composition and the structure of their molecular chains.

Main Characteristics

- High mechanical strength, stiffness, hardness and toughness
- Good fatigue resistance
- High mechanical damping ability
- Good sliding properties
- Excellent wear resistance
- Good electrical insulating properties
- Good resistance to high energy radiation [gamma- and X-rays]
- Good machinability

Applications

Sleeve and slide bearings, wear pads, support and guide wheels, conveyor rollers, tension rollers, sleeves for wheels and rollers, pulleys and pulley-linings, cams, buffer blocks, hammer heads, scrapers, gear wheels, sprockets, seal-rings, feed screws, star wheels, cutting and chopping boards, insulators.

Extruded Nylon Grades

Ertalon® 6 SA [PA 6; natural (white) / black - colour natural available as “Food Grade“, details see page 35]
This material offers an optimal combination of mechanical strength, stiffness, toughness, mechanical damping properties and wear resistance. These properties, together with good electrical insulating properties and a good chemical resistance make Ertalon® 6 SA a “general purpose” grade for mechanical construction and maintenance.
Additionally, Ertalon® 6 SA natural stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertalon® 6 SA natural stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ertalon® 66 SA [PA 66; natural (cream) / black - colour natural available as “Food Grade“, details see page 35]
Material with a higher mechanical strength, stiffness, heat and wear resistance than Ertalon® 6 SA. It also has a better creep resistance but its impact strength and mechanical damping ability are reduced. Well suited for machining on automatic lathes. Please note that the Ertalon® 66 SA natural rods over dia. 150 mm are made from a modified polyamide 66 resin [see the property values given on page 50 under Ertalon® 66 SA-C].
Additionally, Ertalon® 66 SA natural stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertalon® 66 SA natural stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ertalon® | Nylatron® Polyamide [PA]

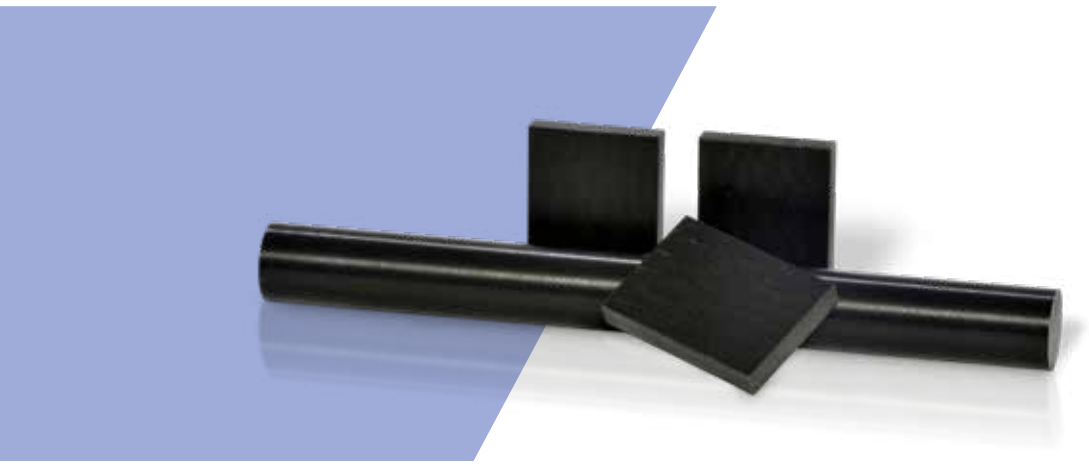
Ertalon® 4.6 [PA 4.6; reddish brown]
Compared with conventional nylons, Ertalon® 4.6 features a better retention of stiffness and creep resistance over a wide range of temperatures as well as superior heat ageing resistance. Therefore, applications for Ertalon® 4.6 are situated in the "higher temperature area" [80 – 150 °C] where stiffness, creep resistance, heat ageing resistance, fatigue strength and wear resistance of PA 6, PA 66, POM and PET fall short.

Ertalon® 66-GF30 [PA 66-GF30; black]
Compared with virgin PA 66, this 30 % glass fibre reinforced nylon grade offers increased strength, stiffness, creep resistance and dimensional stability whilst retaining an excellent wear resistance. It also allows higher maximum service temperatures.

Nylatron® GS [PA 66 + MoS_2; grey-black]
The addition of MoS_2 renders this material somewhat stiffer, harder and dimensionally more stable than Ertalon® 66 SA, but results in some loss of impact strength. The nucleating effect of the molybdenum disulphide results in an improved crystalline structure enhancing bearing and wear properties.

Nylatron® MD [PA 6; dark blue - available as "Food Grade", details see page 35]
This nylon 6 grade contains a metal detectable additive and has been specifically tailored for use in the food processing and packaging industries where it can easily be traced by the conventional metal detection systems installed to detect contamination of the foodstuffs [results may vary depending on the sensitivity of the metal detection system used].
Nylatron® MD is a material with higher wear and fatigue resistance and shows lower moisture absorption than standard PA 6. It is applied in temperature environments of up to 80 °C.
Additionally, Nylatron® MD stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Nylatron® MD stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Nylatron® 66 SA FR [PA 66 flame retardant; black]
This grade has been developed to fulfil the requirements as set out in the test program conducted on plastic materials to measure flammability characteristics. It determines the material's tendency either to extinguish or to spread the flame once the specimen has been ignited. This program is described in UL 94 and this grade fulfils the V-0 criteria as from 1 mm thickness. The product is currently in the certification process for compliance with EN 45545-2. – a standard specifically applicable for railway applications – for fire protection on railway vehicles.



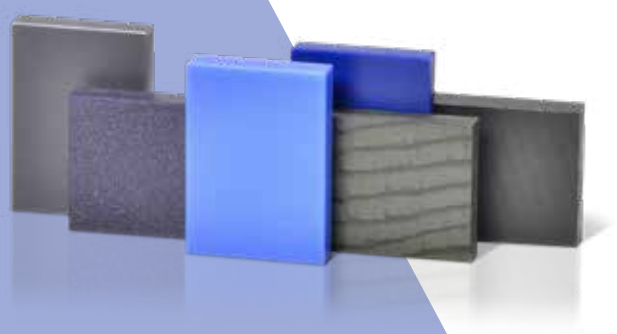
Ertalon® | Nylatron® Polyamide [PA]

Nylatron® FST [PA 66 flame, smoke, toxicity retardant; natural]
Nylatron® FST is a specifically designed polymer for aircraft interior applications.
With its unique features it is absolutely reliable fire, smoke and toxicity (FST) retardant and withstands extreme temperatures up to 175 °C. The material is particularly suitable for any kind of application where metal parts (e. g. brackets, seal bushings, slide rails and duct seals) or high performance polymers have traditionally been specified in aircraft design. Nylatron® FST complies to FAR 25.853 a (1) (i) as from 3 mm thickness and FAR 25.853 a (1) (ii) as from 1 mm thickness. The material complies to FAR 25.853 d appendix F part V concerning the Specific Optical Smoke Density as from 3 mm thickness.

Cast Nylon Grades

Ertalon® 6 PLA [PA 6; natural (ivory) / black / blue - colour natural and blue available as "Food Grade", details see page 35]
Unmodified cast nylon 6 grade exhibiting characteristics which come very close to those of Ertalon® 66 SA. It combines high strength, stiffness and hardness with good creep and wear resistance, heat ageing properties and machinability.
Additionally, Ertalon® 6 PLA natural and blue stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertalon® 6 PLA natural and blue stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

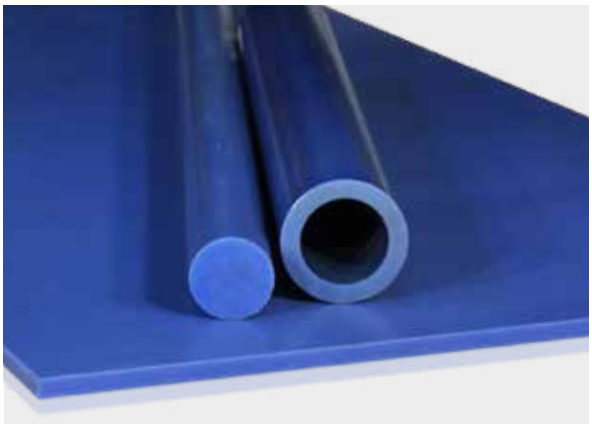
Ertalon® 6 XAU+ [PA 6; black]
Ertalon® 6 XAU+ is a heat stabilised cast nylon grade with a very dense and highly crystalline structure. Compared with conventional extruded or cast nylons, Ertalon® 6 XAU+ offers superior heat ageing performance in air [much better resistance to thermal oxidative degradation], allowing 15 - 30 °C higher service temperature.
Ertalon® 6 XAU+ is particularly recommended for bearings and other mechanical parts subject to wear which are operating in air for long periods of time at temperatures over 60 °C.



Tech Notes:

Nylons can absorb up to 9% of weight by water under high humidity or submerged in water. This results in dimensional changes and a corresponding reduction of physical property values. Proper design techniques can frequently compensate this factor.

Ertalon® | Nylatron® Polyamide [PA]



Ertalon® LFX [PA 6 + oil; green]
This internally lubricated cast nylon 6 is self-lubricating in the real meaning of the word. Ertalon® LFX, especially developed for unlubricated, highly loaded and slow moving parts applications, yields a considerable enlargement of the application opportunities compared to standard cast nylons. It offers a reduced coefficient of friction [up to 50 % lower], considerably increasing the pressure-velocity capabilities, and a vastly improved wear resistance [up to 10 times better].

Nylatron® MC 901 [PA 6; blue]
This modified cast nylon 6 grade with its distinctive blue colour exhibits higher toughness, flexibility and fatigue resistance than Ertalon® 6 PLA. It has proved to be an excellent material for gear wheels, racks and pinions.

Nylatron® GSM [PA 6 + MoS_2; grey-black]
Nylatron® GSM contains finely divided particles of molybdenum disulphide to enhance its bearing and wear behaviour without impairing the impact and fatigue resistance inherent to unmodified cast nylon grades. It is a very commonly used grade for gears, bearings, sprockets and sheaves.

Nylatron® NSM [PA 6 + solid lubricants; grey]
Nylatron® NSM is a proprietary cast nylon 6 formulation containing solid lubricant additives which grant this material self-lubricity, excellent frictional behaviour, superior wear resistance and outstanding pressure-velocity capabilities [up to 5 times higher than conventional cast nylons]. Being particularly suited for higher velocity, unlubricated moving parts applications it is the perfect complement to the oil-filled grade Ertalon® LFX.

Nylatron® SLG [PA 6 + oil; natural (ivory) / blue]
Nylatron® SLG is self-lubricating in the real meaning of the word. Nylatron® SLG has been specially developed for non-lubricated, highly loaded and slowly moving parts. Compared to standard cast nylons, it offers lower maintenance costs and longer service life.

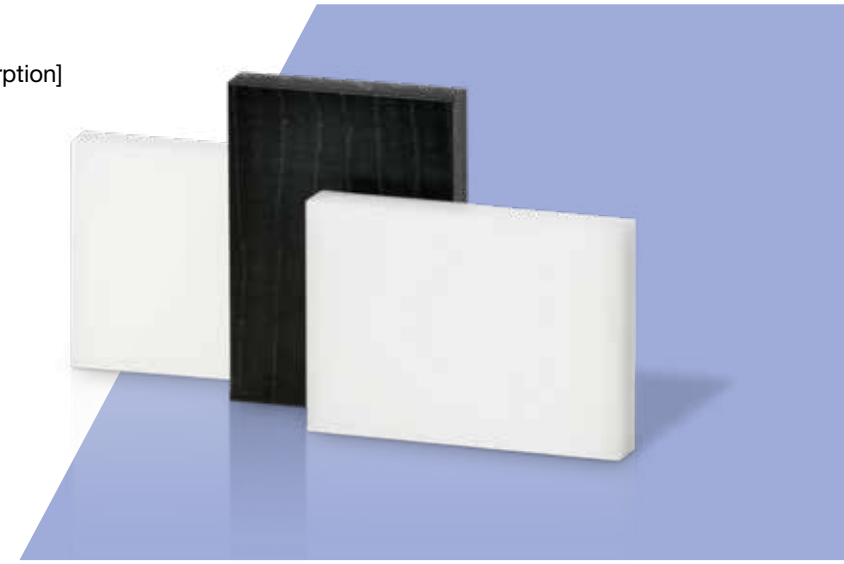
Nylatron® 703 XL [PA 6 + internal lubricants; purple]
This high performance cast nylon 6 bearing grade provides an even better wear resistance than Nylatron® NSM, combined with superior pressure-velocity capabilities and a near zero level of “stick-slip”. The elimination of stick-slip, mostly associated with chatter or squeaking, provides an extraordinary amount of motion control for high-precision applications.

Ertacetal® | Acetron® Polyacetal [POM]

Mitsubishi Chemical Advanced Materials offers both homopolymer and copolymer grades of Polyacetal including an enhanced bearing grade material.

Main Characteristics

- High mechanical strength, stiffness and hardness
- Excellent resilience
- Good creep resistance
- High impact strength, even at low temperatures
- Very good dimensional stability [low water absorption]
- Good sliding properties and wear resistance
- Excellent machinability
- Good electrical insulating and dielectric properties
- Physiologically inert [several grades are suitable for food contact]
- Not self-extinguishing



Applications

Gear wheels with small modulus, cams, heavily loaded bearings and rollers, bearings and gears with small clearances, valve seats, snap-fit assemblies, dimensionally stable precision parts, electrically insulating components.

Grades

Ertacetal® C [POM-C; natural (white) / black / colours - natural, blue and black available as "Food Grade", details see page 35]
Ertacetal® C is Mitsubishi Chemical Advanced Materials' copolymer acetal grade. The acetal copolymer is more resistant against hydrolysis, strong alkalis and thermal oxidative degradation than the acetal homopolymer.
Additionally, Ertacetal® C stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertacetal® C stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs [applies to natural, blue, black and other colours].

Ertacetal® | Acetron® Polyacetal [POM]

Ertacetal® C LQ [POM-C laser markable; natural - available as "Food Grade", details see page 35]
Ertacetal® C LQ is Mitsubishi Chemical Advanced Materials' copolymer acetal grade which is specifically developed for its laser writability on natural (white) material. The acetal copolymer itself is more resistant against hydrolysis, strong alkalis and thermal-oxidative degradation than the acetal homopolymer. Additionally, Ertacetal® C LQ stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertacetal® C LQ stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ertacetal® C ELS [POM-C; black]
Ertacetal® C ELS is Mitsubishi Chemical Advanced Materials' copolymer conductive acetal grade. This grade is specifically developed for the use in applications where you need the main benefits of POM-C in combination with a good electrical conductivity, e. g. electrical areas and explosion sensitive areas.

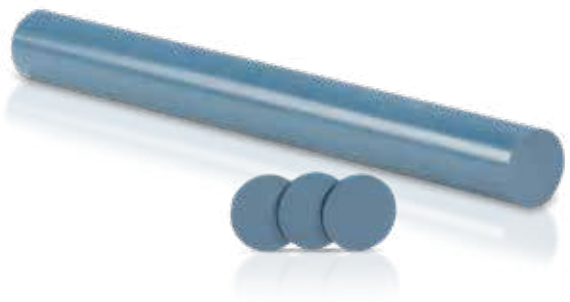
Acetron® MD [POM-C; blue - available as "Food Grade", details see page 35]
This copolymer acetal grade, containing a metal detectable additive, has been specifically tailored for use in the food processing and packaging industries where it can easily be traced by the conventional metal detection systems installed to detect contamination of the foodstuffs [results may vary depending on the sensitivity of the metal detection system used]. Acetron® MD presents good mechanical strength, stiffness and impact strength.Additionally, Acetron® MD stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Acetron® MD stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ertacetal® H [POM-H; natural (white) / black]
Ertacetal® H is Mitsubishi Chemical Advanced Materials' homopolymer acetal grade. It offers a higher mechanical strength, stiffness, hardness and creep resistance as well as a lower thermal expansion rate and often also a better wear resistance than the acetal copolymer.

Ertacetal® H-TF [POM-H + PTFE; deep brown]
Ertacetal® H-TF is a DELRIN® AF Blend, a combination of PTFE fibres evenly dispersed in a DELRIN acetal resin. Much of the strength that is inherent in Ertacetal® H is retained. Some properties change due to the addition of PTFE fibre which is softer, less stiff and slipperier than virgin acetal resin. Compared with Ertacetal® C and H, this material offers superior sliding properties. Bearings made of Ertacetal® H-TF show low friction, long wear and are essentially free of stick-slip behaviour.

Tech Notes:

When it comes to outdoor applications Ertacetal® is not recommended because of its poor UV-resistance.



Ertalyte® Polyethylene Terephthalate [PET]

Mitsubishi Chemical Advanced Materials' stock shapes made of crystalline thermoplastic polyester are marketed under the trade names Ertalyte® [virgin grade] and Ertalyte® TX [bearing grade].

Main Characteristics

- High mechanical strength, stiffness and hardness
- Very good creep resistance
- Low and constant coefficient of friction
- Excellent wear resistance [comparable with or even better than nylon grades]
- Moderate impact strength
- Very good dimensional stability [better than polyacetal]
- Excellent stain resistance
- Better resistance to acids than nylon or polyacetal
- Good electrical insulating properties
- Physiologically inert [suitable for food contact]
- Good resistance to high energy radiation [gamma and X-rays]

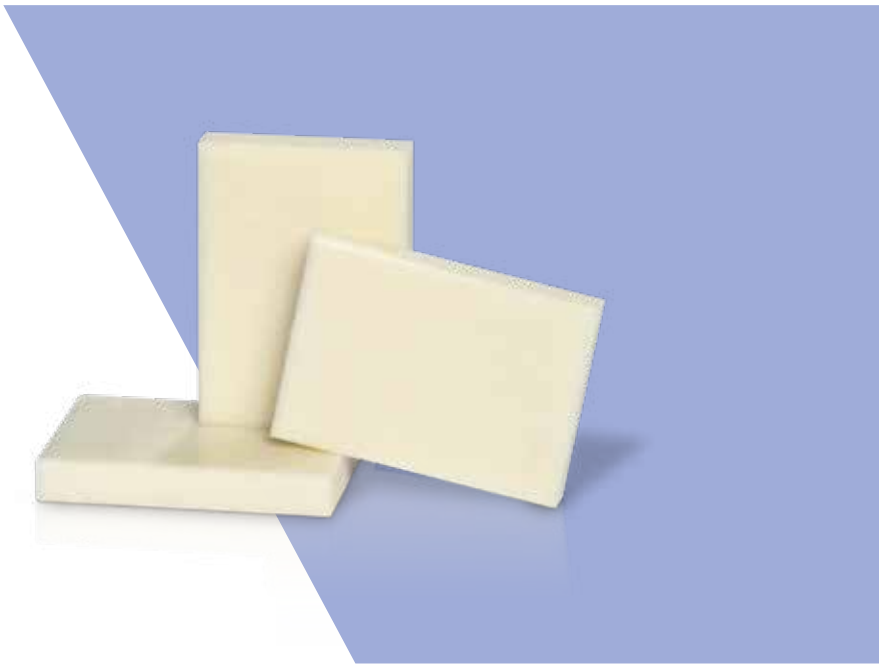
Applications

Heavily loaded bearings [bushings, thrust washers, guides, etc.], dimensionally stable parts for mechanisms of precision [bushings, slideways, gears, rollers, pump components, etc.], insulating components for electrical engineering.

Tech Notes:

Since Ertalyte® tends to be rather notch and impact sensitive, all “internal” corners should be radiused [R > 1 mm] and to avoid chipping the edges during turning, boring or milling, chamfered edges are advantageous, providing a smoother transition between the cutting tool and the plastics work.

Ertalyte® Polyethylene Terephthalate [PET]



Grades

Ertalyte® [PET; natural (white) / black - available as “Food Grade“, details see page 35]
The specific properties of this virgin crystalline PET make it especially suitable for the manufacture of mechanical precision parts which have to sustain high loads and/or are subject to wear.
Additionally, Ertalyte® stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertalyte® stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Ertalyte® TX [PET + solid lubricant; pale grey - available as “Food Grade“, details see page 35]
Ertalyte® TX is a polyethylene terephthalate compound incorporating a uniformly dispersed solid lubricant. Its specific formulation makes it a premium internally lubricated bearing grade. Ertalyte® TX not only has got an outstanding wear resistance, but offers in comparison with Ertalyte® an even lower coefficient of friction as well as higher pressure-velocity capabilities.
Additionally, Ertalyte® TX stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of Ertalyte® TX stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Altron™ PC Polycarbonate [PC]

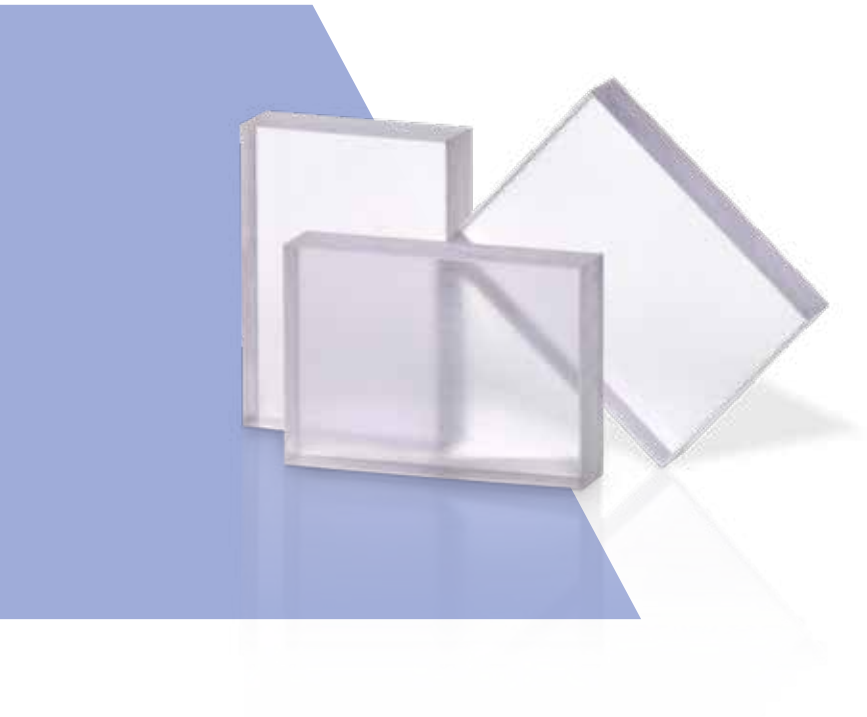
Mitsubishi Chemical Advanced Materials is marketing non-UV-stabilized polycarbonate stock shapes under the trade name Altron™ PC. It is a natural, “non-optical” industrial quality [clear, translucent]. Additionally, the composition of the raw materials used for the manufacture of Altron™ PC stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Main Characteristics

- High mechanical strength
- Good creep resistance
- Very high impact strength, even at low temperatures
- Stiffness retention over a wide range of temperatures
- Very good dimensional stability [very low water absorption and low CLTE]
- Natural colour [clear, translucent]
- Good electrical insulating and dielectric properties
- Physiologically inert [suitable for food contact per FDA regulations]

Applications

Components for precision engineering, safety glazing, insulating parts for electrical engineering, components for medical and pharmaceutical devices.



Tech Notes:

Altron™ PC stock shapes show an “as extruded” surface which is not optically clear. Finished parts can be both mechanically and vapour polished to improve optical clarity. Caution: during machining, do not use water-soluble coolants but preferably pure water or compressed air.

Flextron™ TPE Thermoplastic Elastomer

Nylatron® RIM Polyamide [PA 6]

Flextron™ TPE products are a group of copolymers which consist of materials with both thermoplastic and elastomeric properties. They are outstanding in applications where superior performance over conventional elastomers is required.
Nylatron® RIM is an elastomer reinforced Nylon thermoplastic for industrial Reaction Injection Molding (RIM) process. The stiffness/toughness combination of Nylon-6 and elastomer gives excellent impact resistance and repetitive load (fatigue) endurance.

Main Characteristics of Flextron™ TPE

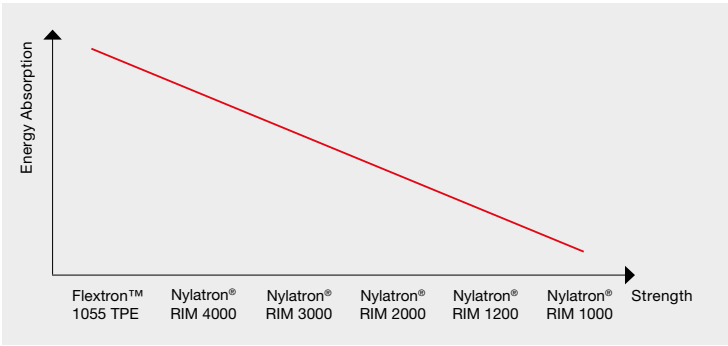
- Good chemical resistance
- Good temperature resistance (both high and low temperatures)
- Constant mechanical behaviour over wide temperature ranges
- Flexibility (Fatigue)
- High energy absorbtion

Main Characteristics of Nylatron® RIM

- Highly improved impact resistance, even at low temperatures
- Between 10% and 40% rubber added
- High wear and abrasion resistance
- Extreme fatigue resistance
- Lower tensile and compressive strength
- Generally not available as stock shape but only as cast finished part

Applications

- Elastomer bumpers
- Engine mounts
- Protectors
- Rollers



Mitsubishi Chemical Advanced Materials' Elastomer Solutions
In applications where rubber materials are too unstable and soft, and age too fast, and where engineering plastics are too hard and brittle, the Flextron™ TPE and Nylatron® RIM materials can be the solution.
Mitsubishi Chemical Advanced Materials offers a wide range of thermoplastic elastomers that enable engineers to achieve high design flexibility.

Rubber
- Unstable
- Too soft
- Ageing

Mitsubishi Chemical Advanced Materials' Elastomer Solutions

Engineering Plastic
- Too brittle
- No low temperatures

Flextron™ 1055 TPE
- 2000 x dia. 120 mm
- 3000 x 610 mm, thickness up to 80 mm

Nylatron® RIM
- Finished part weight from 0.16 to 16 kgs
- Quantity: > 50 pcs. or > 500 kgs

Flame Retardant Products

To prevent the risk of ignition and diffusion of flames in enclosed spaces such as skyscrapers, boats, airplanes and trains, fire resistant materials like concrete, steel or ceramics are used. Once ignited, however, the materials in the environment determine how quickly the flames spread, the level of smoke generation, and the time available to control the fire - or the time period to leave the scene. To increase the safety level and broaden the application opportunities of the use of plastics, Mitsubishi Chemical Advanced Materials has developed flame retardant plastic materials. These are defined by various testing methods and standards, which usually determine the self-extinguishing properties under certain conditions. Flame retardant properties can be achieved through specific formulation of the plastic compounds.

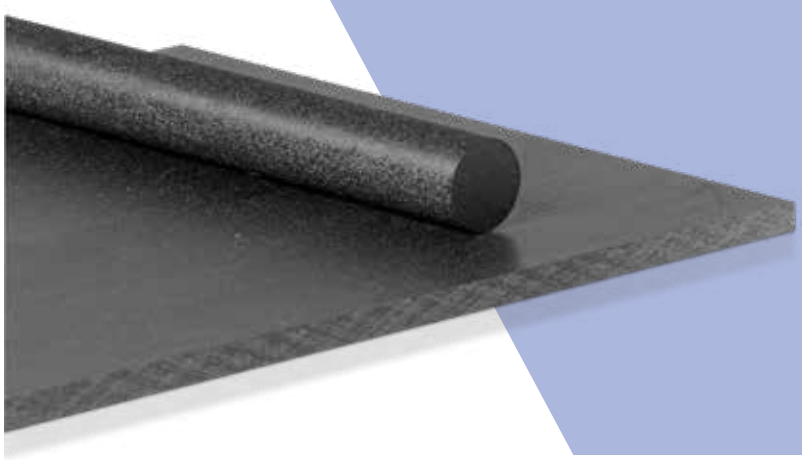
Main Characteristics

- Flame, smoke and toxicity retardant
- Balanced property profile
- Beneficial cost-performance-ratio
- Lightweight (60% weight saving compared to aluminum)
- Very low noise development
- Wear-friendly to mating surfaces

Applications

- Cable holders, clamps, channels
- Connectors
- Seating equipment
- Brackets
- Seal bushings
- Slide rails
- Duct seals

Standard methods for testing polymer flammability vary among countries. All materials used in enclosed spaces and interiors must comply with various national and international regulations. Mitsubishi Chemical Advanced Materials' portfolio of flame-retardant polymers complies with the most important global industrial standards.



Flame Retardant Products

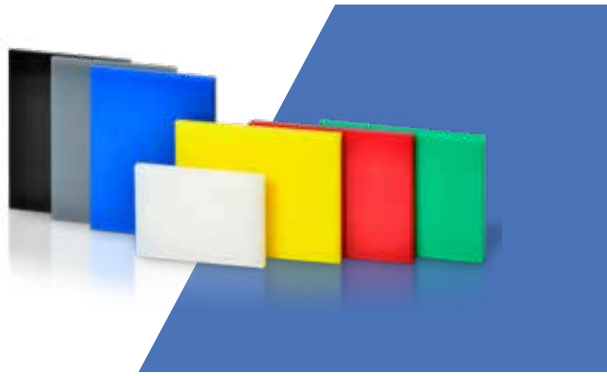
Flammability, Smoke, Toxicity (FST characteristics) and Heat Release

	Flammability		Smoke density test	Smoke toxicity test	Heat release test	Approval for Railway Industry
	Small burner test vertikal (60s)	Small burner test vertikal (12s)				
Airbus test method	AITM2.002A	AITM2.002B	AITM2.0007 A (flaming mode)	AITM3.0005	AITM2.0006	
Boeing test method	BSS 7230: F1	BSS 7230: F2	BSS 7238 (flaming mode)	BSS 7239	BSS 7332	
FAR25.853 ref	FAR25.853 Appendix F part I	FAR25.853 Appendix F part I	FAR25.853 Appendix F part V	not mentiones	FAR25.853 Appendix F part IV	
Other						EN 45545 (in testing) | NFPA 130
Nylatron® FST	✓	✓	✓	✓	-	-
Nylatron® 66 SA FR	-	✓	-	-	-	✓
Sultron™ PPSU Black	-	✓	✓	✓	-	-
Techtron® 1000 PPS	✓	-	✓	-	-	-
Duratron® U1000 PEI	✓	-	✓	✓	-	✓
Duratron® U23000 PEI	✓	-	✓	✓	-	-
Ketron® 1000 PEEK	✓	-	✓	✓	-	✓
Ketron® HPV PEEK	✓	-	✓	✓	✓	-
Ketron® GF30 PEEK	✓	-	✓	✓	✓	-
TIVAR® Burnguard	-	-	-	-	-	✓

TIVAR® Ultra High Molecular Weight Polyethylene [UHMW-PE]

TIVAR® | Ultra High Molecular Weight Polyethylene [UHMW-PE]
TIVAR® is the brand name of Mitsubishi Chemical Advanced Materials or its extensive range of virgin, partially reprocessed, coloured or modified Ultra High Molecular Weight Polyethylene stock shapes, manufactured by compression moulding or ram-extrusion.

Main Characteristics



- Very good wear and abrasion resistance
- High impact strength, even at low temperatures
- Excellent chemical resistance
- Low density compared to other thermoplastics [≈ 1 g/cm³]
- Low coefficient of friction
- Excellent release properties
- Very low water absorption
- Moderate mechanical strength, stiffness and creep resistance
- Very good electrical insulating and dielectric properties [except static dissipative grades]
- Excellent machinability
- Physiologically inert [several grades are suitable for food contact]
- Good resistance to high energy radiation [gamma- and X-rays]
- Not self-extinguishing [except TIVAR® Burnguard]

Applications

Gears, bearings, wear plates, support-, tension- and deflecting rollers, rope pulleys, chain sprockets, bumpers, scraper blades, piston rings and packings, seals, valves, hammer-heads, conveyor screws, star wheels and bends, corner tracks, parcel chutes, pumps, filter plates, pickers, beater caps, linings for bunkers, silos, chutes and funnels for bulk materials, punching plates, cutting and chopping boards.

Standard Grades

TIVAR® 1000 [UHMW-PE; natural (white), green, black, colours - partially available as "Food Grade", details see page 35]
TIVAR® 1000 exhibits a very well balanced property profile. It combines a very good wear and abrasion resistance with outstanding impact strength, even at temperatures below -200 °C.
Additionally, various colours of TIVAR® 1000 stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011.

TIVAR® 1000 antistatic [UHMW-PE + carbon black; black - available as "Food Grade", details see page 35]
By incorporating an effective carbon black grade, TIVAR® 1000 antistatic offers the electrostatic dissipative properties often required for PE-UHMW components operating at high line speeds and conveying rates, maintaining the inherent key characteristics of UHMW-PE.
Additionally, TIVAR® 1000 antistatic stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011.

TIVAR® ECO green [UHMW-PE; green]
This grade, partially composed of reprocessed PE-UHMW material, has an overall lower property level than the virgin TIVAR® 1000 and a lower cost. Compared to virgin PE 500, however, it has a much better impact strength and wear resistance. TIVAR® ECO green shows a favourable price-performance ratio for applications in many kinds of industries with less demanding requirements.

TIVAR® Ultra High Molecular Weight Polyethylene [UHMW-PE]

TIVAR® ECO black antistatic [UHMW-PE; black]
This grade, partially composed of reprocessed PE-UHMW material, has an overall lower property level than the virgin TIVAR® 1000 and a lower cost. Compared to virgin PE 500, however, it has a much better impact strength and wear resistance. The incorporation of an effective carbon black grade offers electrostatic dissipative properties to this material. TIVAR® ECO black antistatic shows a favourable price-performance ratio for applications in many kinds of industries with less demanding requirements.

Speciality Grades

Mitsubishi Chemical Advanced Materials focuses on innovation by modification of TIVAR® 1000 standard materials in order to meet specific market requirements. The TIVAR® speciality grades offer improved sliding and wear properties, static dissipative characteristics, enhanced release properties or other improved characteristics.

TIVAR® DrySlide [UHMW-PE + internal lubricant + other additives; black]
Thanks to the lubricant built into a UHMW-PE matrix with higher molecular weight, TIVAR® DrySlide offers a lower coefficient of friction and enhanced wear and abrasion resistance than TIVAR® 1000. The additives used also make this material static dissipative and considerably improve UV-resistance.

TIVAR® HPV [UHMW-PE + internal lubricant + other additives; blue - available as "Food Grade"*, details see page 35]
This high performance TIVAR® grade provides a better wear resistance than TIVAR® 1000, combined with a near zero level of "stick-slip". The elimination of stick-slip, mostly associated with chatter and/or squeaking, provides an extraordinary amount of motion control for high precision applications.

TIVAR® TECH [UHMW-PE + MoS_2; grey-black]
This UHMW-PE grade with extremely high degree of polymerization contains molybdenum disulphide, resulting in a material with improved wear resistance and sliding properties over TIVAR® 1000.

TIVAR® DS [UHMW-PE + additives; yellow - available as "Food Grade"*, details see page 35]
TIVAR® DS is a modified UHMW-PE with extremely high molecular weight. The latter in combination with a particular manufacturing process result in a UHMW-PE grade with superior wear and abrasion resistance over TIVAR® 1000.

TIVAR® Cestidur [UHMW-PE + additives; grey - available as "Food Grade"*, details see page 35]
TIVAR® Cestidur is a modified UHMW-PE with extremely high molecular weight. The latter in combination with a particular manufacturing process result in a UHMW-PE grade with superior wear and abrasion resistance over TIVAR® 1000.

TIVAR® Ceram P [UHMW-PE + micro glass beads + other additives; yellow-green]
TIVAR® Ceram P is a wear improved UHMW-PE material with incorporated micro glass beads, specifically developed for use in the dewatering zone of paper machinery equipped with plastic wires and manufacturing paper with high abrasive filler content.

*Additionally, these TIVAR® specialty grade stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of these TIVAR® specialty grade stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

PE

Polyethylene Grades for Low Temperature Range

TIVAR® Ultra High Molecular Weight Polyethylene [UHMW-PE]

TIVAR® SuperPlus [UHMW-PE + specific additives; grey]
TIVAR® SuperPlus is a wear optimized, partially cross-linked UHMW-PE material with extremely high degree of polymerization for use in most demanding applications and environments. When used for drainage elements in paper machinery, this TIVAR® grade generally also offers better wear and sliding performance than TIVAR® Ceram P.

TIVAR® H.O.T. [UHMW-PE + specific additives; bright white - available as "Food Grade"* / **, details see page 35]
TIVAR® H.O.T. [Higher Operating Temperature] is formulated to maintain inherent UHMW-PE key properties over an extended service temperature range, in this way considerably increasing part life in low load bearing applications up to temperatures as high as 125 °C. Special additives reduce the oxidation rate of the material at higher temperatures thereby slowing down material degradation and extending wear-life. TIVAR® H.O.T. also features a food contact compliant composition.

TIVAR® Burnguard [UHMW-PE + flame retardant + other additives; black with silver coloured spots]
TIVAR® Burnguard is a UHMW-PE grade containing a very effective non-halogenated flame retardant. Specifically developed to improve the poor flammability behaviour of straight forward virgin polyethylene, it meets the requirements of UL 94 V-0 as of 6 mm thickness and is self-extinguishing. The additives used also render this material static dissipative and considerably improve UV-resistance.

TIVAR® CleanStat [UHMW-PE + specific additives; black - available as "Food Grade"* / **, details see page 35]
TIVAR® CleanStat is a UHMW-PE grade for use in food processing and pharmaceutical industries. It exhibits static dissipative properties and has a food contact compliant composition.

TIVAR® CleanStat White [UHMW-PE + specific additives; white - suitable for food contact per FDA regulations]**
TIVAR® CleanStat White offers the electrostatic dissipative properties often required for UHMW-PE components operating at high line speeds and conveying rates. TIVAR® CleanStat White with permanent ESd properties and white colour has specifically been developed for the food and pharma industry. The composition of the raw materials used for the manufacture of TIVAR® CleanStat White stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

TIVAR® 1000 ASTL [UHMW-PE + specific additives; black - available as "Food Grade", details see page 35]
TIVAR® 1000 ASTL, based on a UHMW-PE grade with extremely high molecular weight, has been specifically developed for tough anti-abrasion applications. TIVAR® 1000 ASTL shows a higher wear and abrasion resistance and a lower surface resistivity than TIVAR® 1000 antistatic. The additives used also render this material static dissipative and highly UV-resistant.

TIVAR® 1000 EC [UHMW-PE + specific additives; black - available as "Food Grade"* / **, details see page 35]
TIVAR® 1000 EC is a UHMW-PE grade containing specific additives rendering this material a lower surface resistivity than TIVAR® 1000 antistatic and also TIVAR® ASTL, improving electrical conductivity and UV-resistance.

* Additionally, these TIVAR® specialty grade stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011.

** The composition of the raw materials used for the manufacture of these TIVAR® specialty grade stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

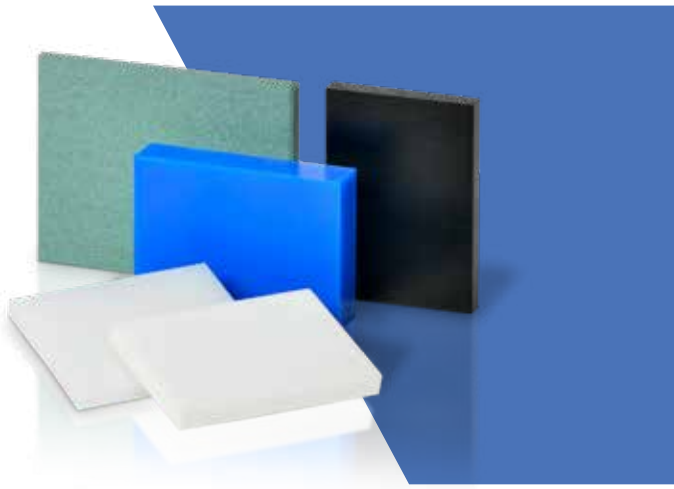
TIVAR® Ultra High Molecular Weight Polyethylene [UHMW-PE]
Proteus® Polypropylene [PP]

TIVAR® MD [UHMW-PE + metal detectable additive; blue - available as "Food Grade", details see page 35]
This PE-UHMW grade with extremely high degree of polymerization contains a metal detectable additive which does hardly affect the inherent UHMW-PE key properties. TIVAR® MD presents excellent toughness and impact strength, an even improved wear and abrasion resistance when compared with TIVAR® 1000, and it also features a food contact compliant composition. TIVAR® MD has been specifically tailored for use in the food processing and packaging industries where it can easily be traced by the conventional metal detection systems installed to detect contamination of the foodstuffs [results may vary depending on the sensitivity of the metal detection system used].
Additionally, TIVAR® MD stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011. The composition of the raw materials used for the manufacture of TIVAR® MD stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

TIVAR® Oil Filled [UHMW-PE + oil; grey; suitable for food contact per FDA regulations]
TIVAR® Oil Filled is a self-lubricating UHMW-PE material in the real meaning of the word. Next to an enhanced wear resistance, the incorporated and evenly dispersed oil renders this material a considerable lower coefficient of friction than TIVAR® 1000. In conveying equipment, it yields a significant reduction of the required driving force and, in addition, noise reduction. Additionally, the composition of the raw materials used for the manufacture of TIVAR® Oil Filled stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

TIVAR® Cestigreen [UHMW-PE + specific additives; green]
This permanently static dissipative material with extremely high molecular weight has been specifically developed as an alternative for standard static dissipative UHMW-PE grades and more particularly for those applications where a green and non-sloughing [without graphite or carbon powder] static dissipative UHMW-PE is required.

Borotron® UH015 / UH030 / UH050 [UHMW-PE + boron based additive; natural (off-white)]
Borotron® HM015 / HM030 / HM050 [HMW-PE + boron based additive; natural (off-white)]
Borotron® UH and Borotron® HM are boron loaded [U]HMW-PE grades, specifically developed for neutron shielding purposes in nuclear installations. The high hydrogen content of [U]HMW-PE makes it very suitable for slowing down fast neutrons to lower energy thermal [slow] neutrons, which are then absorbed by the added boron compound. Whereas both HMW-PE and UHMW-PE are suitable for neutron shielding, UHMW-PE is often preferred because of its better deformation behaviour at high temperatures and its superior impact strength and wear resistance. Several grades are available with boron loads of 1.5, 3 and 5 % [015 / 030 / 050].



Proteus® LSG H PP [Polypropylene; natural (white)]
Proteus® natural stock shapes are manufactured by means of compression moulding from polypropylene homopolymer resin. The composition of the raw materials used for the manufacture of Proteus® LSG H PP natural stock shapes complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

PE 500
High Molecular Weight Polyethylene [HMW-PE]

PE 500 [HMW-PE; natural (white), green, black, colours - available as "Food Grade", details see page 35]
This grade exhibits a good combination of stiffness, toughness, mechanical damping ability with wear and abrasion resistance and can easily be welded. In less demanding applications with respect to wear and impact resistance, PE 500 may present an economical alternative for the TIVAR® standard grades.
PE 500 is a versatile polyethylene grade used mainly in the food industry [meat and fish processing] but it is also put to use in all kinds of mechanical, chemical and electrical applications. Additionally, PE 500 stock shapes are also available in our Food Grade programme, which means that they can be supplied with a declaration of compliance, confirming they comply with the requirements mentioned in the European Regulation (EU) 10/2011 (colour black is not compliant). The composition of the raw materials used for the manufacture of PE 500 stock shapes also complies with the regulations of the United States of America [FDA] for plastic materials and articles intended to come into contact with foodstuffs.

Polyethylene Selection Table

FEATURES / PRODUCTS	Mol. weight (1)	Colours	Additives	Sliding properties (coeff. of friction)	Wear resistance (plastics pin on steel disk	Abrasion resistance (sand-slurry)	UV-resistance	ESd-properties	Food contact compliant composition [EU & US FDA]
PE 500	0.5	natural, green, black, colours	none or pigments	good	poor	poor	moderate	no	natural: yes (EU & USA) (2): yes (EU)
TIVAR® 1000	5	natural, green, black, colours	none or pigments	good	good	good	moderate	no	natural: yes (EU & USA) (2): yes (EU)
TIVAR® 1000 antistatic	5	black	SDA	good	good	good	good	yes	yes (EU)
TIVAR® ECO green	4.5	green	pigments	good	moderate	moderate	moderate	no	no
TIVAR® ECO black antistatic	4.5	black	pigments	good	moderate	moderate	moderate	yes	no
TIVAR® DrySlide	9	black	IL + SDA	very good	very good	very good	good	yes	no
TIVAR® TECH	9	grey-black	MoS_2	good	excellent	very good	moderate	no	no
TIVAR® DS	9	yellow	pigments	good	very good	very good	moderate	no	yes (EU & USA)
TIVAR® Cestidur	9	grey	pigments	good	very good	very good	moderate	no	yes (EU & USA)
TIVAR® Ceram P	9	yellow-green	GB+ pigments	good	excellent	excellent	moderate	no	no
TIVAR® SuperPlus	9	grey	IL + pigments + other	good	excellent	excellent	moderate	no	no
TIVAR® H.O.T.	9	bright-white	HS + pigments	good	very good	excellent	moderate	no	yes (EU & USA)
TIVAR® Burnguard	5	black	FR	good	good	moderate	good	yes	no
TIVAR® CleanStat	5	black	SDA	good	good	very good	good	yes	yes (EU & USA)
TIVAR® CleanStat White	5	white	SDA	good	good	very good	good	yes	yes (USA)
TIVAR® 1000 ASTL	9	black	SDA	good	very good	very good	very good	yes	yes (EU)
TIVAR® 1000 EC	5	black	SDA	good	good	good	very good	yes	yes
TIVAR® MD	9	blue	MDA	good	very good	excellent	moderate	no	yes (EU & USA)
Borotron® UH	5	natural	B_2O_3	good	good	moderate	moderate	no	no
Borotron® HM	0,5	natural	B_2O_3	good	poor	poor	moderate	no	no
TIVAR® Oil Filled	9	grey	oil + pigments	excellent	very good	very good	moderate	no	yes (USA)
TIVAR® Cestigreen	9	green	SDA + pigments	good	very good	very good	moderate	yes	no
TIVAR® HPV	> 6	blue	IL	good	excellent*	good	moderate	no	yes (EU & USA)

(1) average molecular weight 10^6 g/mol
(2) black and standard colours
Abbreviations: SDA = static dissipative additive; GB = glass beads; IL = internal lubricant(s); HS = heat stabilizer; FR = flame retardant

Food Contact Compliance Status

Mitsubishi Chemical Advanced Materials Stock Shape	Base Polymer	DoC acc. to (EU) 10/2011 Food Grade [1]	FDA compliant [2]
Ketron® 1000 PEEK natural	PEEK	+	+
Ketron® 1000 PEEK black	PEEK	+	+
Ketron® TX PEEK blue	PEEK	+	+
Ketron® MD PEEK blue	PEEK	+	+
Techtron® 1000 PPS natural	PPS	NT	+
Techtron® HPV PPS blue	PPS	+	+
Sultron™ PPSU black	PPSU	+	+
Sultron™ 1000 PSU natural	PSU	NT	+
Duratron® U1000 PEI natural	PEI	NT	+
Fluorosint® 207 white	PTFE	-	+
Fluorosint® HPV tan	PTFE	NT	+
Ertacetal® C LQ natural	POM-C	+	+
Ertalon® 6 SA natural	PA 6	+	+
Ertalon® 66 SA natural	PA 66	+	+
Ertalon® 6 PLA natural / blue	PA 6	+ / +	+ / +
Nylatron® MD blue	PA 6	+	+
Ertacetal® C natural / blue / black	POM-C	+ / + / +	+ / + / +
Ertacetal® C - other colours	POM-C	NT	+
Acetron® MD blue	POM-C	+	+
Ertalyte® natural / black / blue	PET	+ / + / +	+ / + / -
Ertalyte® TX pale grey	PET	+	+
TIVAR® 1000 natural / blue 7020 / green 3010 / red 2030 / yellow 6030	PE-UHMW	+ / + / + / + / +	+ / + / + / + / +
TIVAR® 1000 antistatic black	PE-UHMW	+	-
TIVAR® DS yellow	PE-UHMW	+	+
TIVAR® Cestidur, grey	PE-UHMW	+	+
TIVAR® H.O.T. white	PE-UHMW	+	+
TIVAR® CleanStat black	PE-UHMW	+	+
TIVAR® 1000 ASTL black	PE-UHMW	+	-
TIVAR® 1000 EC black	PE-UHMW	+	-
TIVAR® MD blue	PE-UHMW	+	+
TIVAR® OilFilled grey	PE-UHMW	NT	+
TIVAR® CleanStat White	PE-UHMW	-	+
TIVAR® HPV blue	PE-UHMW	+	+
PE 500 natural / blue 7020 / green 3060 / red 2025 / yellow 6030	PE-UHMW	+ / + / IT / + / +	+ / + / + / + / +

\+ Complies with the requirements of the regulations.

\- Does not comply with the requirements of the regulations.

NT Has not been tested according to the requirements of the regulations.

IT Tests according to the requirements of the regulations are on-going

[1] Food Grade: Mitsubishi Chemical Advanced Materials' European “Food Grade” designated products comply with the requirements mentioned in the Regulation [EC]
No 1935/2004 and the Regulation (EU) 10/2011. Further our “Food Grade” products are manufactured according to Good Manufacturing Practice [GMP] as set out in Regulation [EC] No 2023/2006.

[2] This column gives the compliance of the raw materials used for the manufacture of the Mitsubishi Chemical Advanced Materials Stock Shapes with respect to their composition as set out in the United States of America (FDA) for plastic materials and articles intended to come into contact with foodstuffs.

LSG

Life Science Grades [LSG]

Products for the Life Science Industry

Mitsubishi Chemical Advanced Materials offers Life Science Grades which have been specifically developed for applications in the medical, pharmaceutical and biotechnology industries. The Mitsubishi Chemical Advanced Materials' Life Science Grades portfolio includes plastics which comply with ISO 10993 and USP guidelines for biocompatibility testing of materials – saving testing costs and time – while providing full traceability from raw material to stock shape.

Key benefits of the Life Science Grades:

Performance
Using the cutting edge material portfolio from Mitsubishi Chemical Advanced Materials will replace existing solutions made of stainless steel, titanium and glass or ceramics due to a combination of properties like weight reduction, resistance to commonly used sterilisation methods, X-ray transparency, design flexibility, antistatic performance and resistance to high energetic radiation.

Biocompatibility
The LSG portfolio includes plastics which comply with ISO 10993 and USP guidelines for biocompatibility testing of materials.

Full traceability
Mitsubishi Chemical Advanced Materials provides OEMs with assurance of full traceability for its comprehensive LSG product porfolio.

Quality assurance
In line with its ISO 9001:2008 certified Quality Assurance System, Mitsubishi Chemical Advanced Materials thoroughly monitors and controls the entire manufacturing process of its Life Science Grades.

Products for the Life Science Industry

Within its portfolio of Life Science Grade Engineering Plastic Products - specifically developed for applications in the medical, pharmaceutical and biotechnology industries - Mitsubishi Chemical Advanced Materials offers the following biocompatible plastic stock shapes for machining with certified USP Class VI and ISO 10993 compliance [see also page 39]:

Ketron® CLASSIX™ LSG PEEK [PEEK; for Life Science Applications; white]

Ketron® LSG CA30 PEEK [PEEK; for Life Science Applications; black]

Ketron® LSG GF30 PEEK [PEEK; for Life Science Applications; blue (RAL 5019)]

Ketron® LSG PEEK [PEEK; for Life Science Applications; natural, black, red, blue, green]

Sultron™ LSG PPSU [PPSU; for Life Science Applications;
black, red, yellow, grey, brown, blue, green, orange]

Duratron® LSG PEI [PEI; for Life Science Applications; natural]

Sultron™ LSG PSU [PSU; for Life Science Applications; natural]

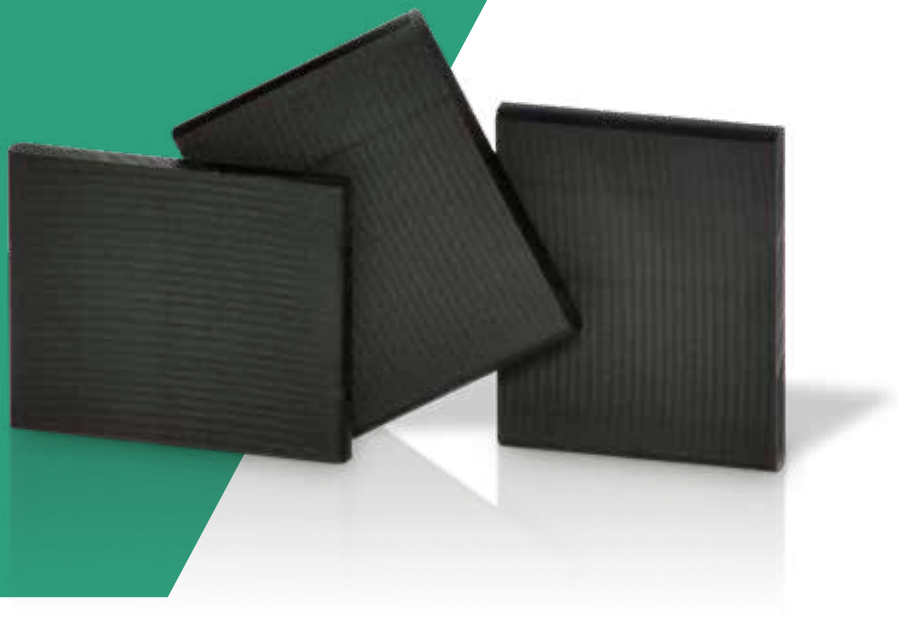
Altron™ LSG PC [PC; for Life Science Applications; natural]

Acetron® LSG [POM-C; for Life Science Applications; natural / black]

Proteus® LSG H PP [PP; for Life Science Applications; white]

LSG

Life Science Grades [LSG]



Biocompatibility Status USP and ISO 10993

A comprehensive biocompatibility type testing programme was run by an independent, internationally renowned and accredited testing organization on the Mitsubishi Chemical Advanced Materials LSG stock shapes in order to check their compliance with both United States Pharmacopeia [USP] and ISO 10993 guideline requirements for Biocompatibility Testing of Materials.

Biocompatibility Testing

MATERIALS \ TESTS (1)(2)	1. Cytotoxicity Ref.: ISO 10993-5 and USP <87> Biological Reactivity Tests, In Vitro Elution Test	2. Sensitization Ref. ISO 10993-10, Magnusson & Kligman Maximization Method	3. Intracutaneous Reactivity Ref.: ISO 10993-10 and USP <88> Biological Reactivity Tests, In Vivo - Intracutaneous Test	4. Acute Systemic Toxicity Ref.: ISO 10993-11 and USP <88> Biological Reactivity Tests, In Vivo - Systemic Injection Test	5. Implantation Test Ref.: USP <88> Biological Reactivity Tests, In Vivo - Implantation Test (7 days)	6. Human blood compatibility Ref.: ISO 10993-4, Indirect Hemolysis (in vitro)	7. USP-Physicochemical Tests for Plastics Ref.: USP<661> Containers, Ultra Pure Water extract, 70°C/24h	USP Class VI (conclusion from tests 3, 4 and 5)
Ketron® CLASSIX™ LSG PEEK white	✓	✓	✓	✓	✓	✓	✓	✓
Ketron® LSG CA30 PEEK	✓	✓	✓	✓	✓	✓	✓	✓
Ketron® LSG GF30 PEEK blue (RAL 5019)	✓	✓	✓	✓	✓	✓	✓	✓
Ketron® LSG PEEK natural, black, red, blue, green	✓	✓	✓	✓	✓	✓	✓	✓
Sultron™ LSG PPSU black	✓	✓	✓	✓	✓	✓	✓	✓
Sultron™ LSG PPSU natural (ivory)	✓	NT	✓	✓	NT	NT	✓	✓
Sultron™ LSG PPSU blue, brown, green, grey, orange, red, yellow	✓	NT	NT	NT	NT	NT	✓	NT
Duratron® LSG PEI natural	✓	✓	✓	✓	✓	✓	✓	✓
Sultron™ LSG PSU natural	✓	✓	✓	✓	✓	✓	✓	✓
Altron™ LSG PC natural	✓	✓	✓	✓	✓	✓	✓	✓
Acetron® LSG natural & black	✓	NT	NT	NT	NT	NT	✓	NT (3)
Proteus® LSG H PP natural	✓	NT	NT	NT	NT	NT	✓	NT

✓ This test was carried out and the material passed the test.

NT Not Tested

(1) All tests were run on test specimens machined from stock shapes shortly after manufacture.

(2) Mitsubishi Chemical Advanced Materials performs testing on its Life Science Grades in order to facilitate evaluation by its customers of their biocompatibility with regard to the requirements applicable to the specific use of the finished product. Mitsubishi Chemical Advanced Materials does not possess expertise in evaluating the suitability of its tested materials for use in specific medical, pharmaceutical, or biotechnological applications. **It remains the customer's sole responsibility to test and assess the suitability of Mitsubishi Chemical Advanced Materials' Life Science Grades for its intended applications, processes and uses.** Mitsubishi Chemical Advanced Materials makes no warranties or representations whatsoever that its materials are manufactured in accordance with the quality standards appropriate and necessary for materials intended for use in implantable medical device applications and in applications that are essential to the restoration or continuation of a bodily function important to the continuation of human life.

Mitsubishi Chemical Advanced Materials' Life Science Grades should not be used for applications involving medical devices that are intended to remain implanted in the human body continuously for a period exceeding 24 hours (30 days*), or that are intended to remain in contact with internal human tissue or bodily fluids for more than 24 hours (30 days*). They should not be used either for the manufacture of critical components of medical devices that are essential to the continuation of human life.

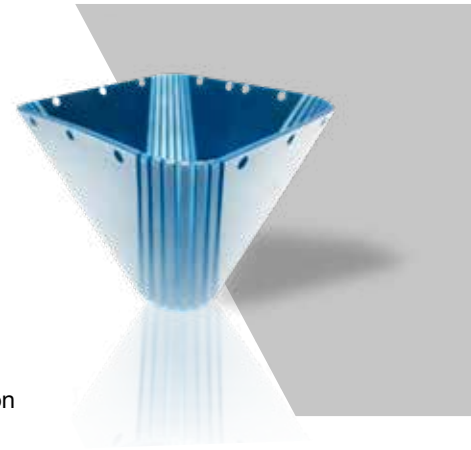
***: '30 days' applies to Ketron® CLASSIX™ LSG PEEK white only.**

(3) Please note that the virgin, natural coloured POM Copolymer resins used in the manufacture of the Acetron® LSG natural & black stock shapes meet the requirements of USP Class VI (according to biocompatibility tests carried out on behalf of the resin suppliers).

Mitsubishi Chemical Advanced Materials' lining solutions are designed to perform with powdery, liquid, gaseous or bulky goods and media. Regardless whether in chemical, power, transport, mining, semi-conductor or other industries, they fulfill manifold functions in the handling of sticky bulk materials of various natures.
Key for a successful lining application is an appropriate choice of the best suited lining material and the optimal way of application. Mitsubishi Chemical Advanced Materials offers the full technical support service around the lining products and their application, even reaching to design works and complete turn-key solutions for the TIVAR® line of products.

Engineered Plastic Lining Solutions to Drive Flow & Protection
Mitsubishi Chemical Advanced Materials offers engineered plastic lining solutions to make bulk handling processes safer, faster and more efficient.

System TIVAR® Engineering



System TIVAR® Engineering Solutions for Bulk Material Flow Solutions
Mitsubishi Chemical Advanced Materials offers materials and fully engineered lining solutions to provide mass flow by preventing blockages, buildups and funnel flow, to boost efficiency of bulk material handling processes.
Features and Benefits:

- Non-stick, non-wearing surface promotes flow, ensures a reliable and safe operation and prevents costly downtime, maintenance and repair
- Custom designed, prefabricated kits fit even challenging geometries and reduce on-site installation time and cost
- Global turnkey project management experience ensures seamless and efficient integration in workflow
- System TIVAR® Engineering includes on-site analysis, liner design, pre-fabrication of kits, optional supervision or turnkey installation, anywhere around the globe, from small to large scale.

Materials

TIVAR® 88
Product Overview

- Promotes reliable, steady bulk material flow
- Abrasion-, chemical- and corrosion-resistant
- No moisture absorption
- Reduces or eliminates arching, ratholing and erratic flow

Recognized worldwide as the premium lining material for bulk material handling, TIVAR® 88 is noted for its performance in promoting bulk solids flow of cohesive or non-free flowing materials due to its low surface friction. TIVAR® 88 liners are the perfect solution when you need to reduce or eliminate arching, ratholing and erratic material flow challenges in bins, bunkers, hoppers and chutes, railcars, etc.
For applications in outdoor environments that receive high exposure to ultra violet rays, TIVAR® 88 UV Resistant prevents premature degradation of material. In dusty or volatile environments, TIVAR® 88 ESd protects against the build-up of electrical charges.

TIVAR® 88-2
TIVAR® 88-2 can be fabricated - and welded - to provide a solution for nearly any application, whether it‘s a seamless drop-in liner, a framed-in liner or even a replacement liner.

TIVAR® 88 with BurnGuard™
For applications in which the TIVAR® 88® liner might be exposed to combustion, TIVAR® 88 with BurnGuard™ has flame retardant properties. When the source of the combustion is removed, TIVAR® 88 with BurnGuard™ self extinguishes and experiences no further impact. TIVAR® 88 with BurnGuard™ meets MSHA 1C-112/1 for underground mining and has a UL94 V-0 Flammability Rating.

TIVAR® CleanStat is a UHMW-PE grade for use in food processing and pharmaceutical industries. It exhibits static dissipative properties and is available as a “Food Grade” [see page 35].

TIVAR® H.O.T. [Higher Operating Temperature] is formulated to maintain inherent UHMW-PE key properties over an extended service temperature range, in this way considerably increasing part life in low load bearing applications up to temperatures as high as 125 °C. Special additives reduce the oxidation rate of the material at higher temperatures thereby slowing down material degradation and extending wear-life.
Additionally, TIVAR® H.O.T. stock shapes are also available in our “Food Grade” programme [see page 35].

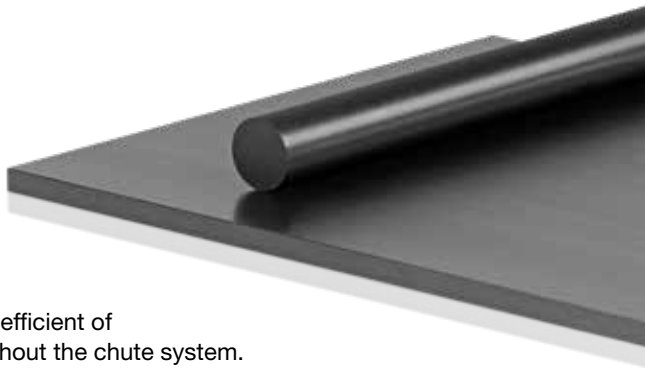
QuickSilver® Truck Liners

QuickSilver® Truck Liners for Quick Release and Protection
QuickSilver® is an extremely tough, super-slick-polymer giving safer (and better) release at much lower tipping angles and allowing operators to run more loads per day.

Features and Benefits:
- Better non-stick properties of the body
- Weight savings over steel liners
- Complete and constant unloading
- No freezing of bulk
- Safe tipping, even on uneven ground
- No separation and purification means necessary
- High impact strength
- Maintenance-free

Examples of bulk materials:
- Stone, rubble, gravel, crushed stone
- Earth, sand, (sewage) sludge, loam
- Topsoil, clay
- Coal, limestone, gypsum
- Salts, ores, ashes
- Grain and fertilizers

TIVAR® DrySlide Parcel Handling



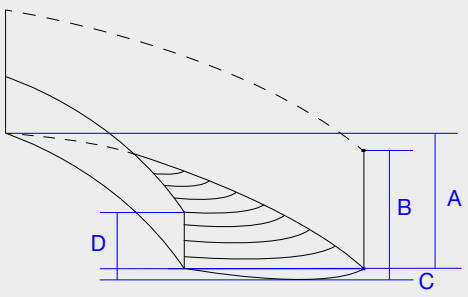
TIVAR® DrySlide promotes a consistent flow throughout the chute system
TIVAR® DrySlide is a PE-UHMW material with optimized sliding and wear properties. Due to its anti-static properties and extremely low coefficient of friction TIVAR® DrySlide is used to promote a safe, steady flow throughout the chute system.

TIVAR® DrySlide has a built-in dry lubricant which eliminates the need for silicone sprays, graphite and waxes and reduces ongoing maintenance costs within the hub.

Features:
TIVAR® DrySlide is an effective lining material, available to suit any style of chute - straight, bends or spiral. It reduces blockages within the system and promotes consistent parcel and package flow.
TIVAR® DrySlide chute linings are available as complete turnkey solutions, from design to installation in new or retro-fit. This excellent wear material is superior with both light or heavier packages in dry, dusty or dirty environments.

Benefits:
- Extremely low coefficient of friction reduces sticking and parcel hang-ups
- Packages containing magnets do not stick to chutes
- Not affected by humidity; no more jams on your line
- Reduced sorting times as there is no need to polish or lubricate the chutes
- Increased speed and productivity
- Material is anti-static and UV stabilized for outdoor use
- Minimize health & safety issues from blocked chutes

Individual design and turnkey installation solutions for any new or retro-fit parcel chute.



AEP

Physical Properties (indicative values)

PROPERTIES	Test methods	Units	Duratron® CU60 PBI	Duratron® D7000 PI	Duratron® D7015G PI	Duratron® T4203 PAI (16)
Colour	-	-	black	natural (chest-nut)	grey-black	yellow-ochre
Density	ISO 1183-1	g/cm³	1.30	1,38	1.46	1.41
Water absorption:						
- after 24/96 h immersion in water of 23 °C (1)	ISO 62	mg	60 / 112	66 / 128	46 / 100	29 / 55
	ISO 62	%	0.74 / 1.37	0.73 / 1.41	0.48 / 1.04	0.35 / 0.67
- at saturation in air of 23 °C / 50 % RH	-	%	7.5	2.2	1.3	2.5
- at saturation in water of 23 °C	-	%	14	4	3	4.4
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)	ISO 11357-1/-3	°C	NA	NA	NA	NA
Glass transition temperature (DSC, 20 °C/min) - (3)	ISO 11357-1/-2	°C	415	365	365	280
Thermal conductivity at 23 °C	-	W/(K.m)	0.40	0.22	0.39	0.26
Coefficient of linear thermal expansion:						
- average value between 23 and 100 °C	-	m/(m.K)	25 x 10^{-6}	40 x 10^{-6}	36 x 10^{-6}	40 x 10^{-6}
- average value between 23 and 150 °C	-	m/(m.K)	25 x 10^{-6}	42 x 10^{-6}	38 x 10^{-6}	40 x 10^{-6}
- average value above 150 °C	-	m/(m.K)	35 x 10^{-6}	52 x 10^{-6}	47 x 10^{-6}	50 x 10^{-6}
Temperature of deflection under load:						
- method A: 1.8 MPa	ISO 75-1/-2	°C	425	355	365	280
Max. allowable service temperature in air :						
- for short periods (4)	-	°C	500	450	450	270
- continuously: for min. 20,000 h (5)	-	°C	310	240	240	250
Min. service temperature (6)	-	°C	-50	-50	-20	-50
Flammability (7):						
- „Oxygen Index“	ISO 4589-1/-2	%	58	51	47	45
- according to UL 94 (1.5 / 3 mm thickness)	-	-	V-0 / V-0	V-0 / V-0	V-0 / V-0	V-0 / V-0
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield / tensile stress at break (10)	ISO 527-1/-2	MPa	NYP / 130	NYP / 115	NYP / 67	150 / -
- tensile strength (10)	ISO 527-1/-2	MPa	130	115	67	150
- tensile strain at yield (10)	ISO 527-1/-2	%	NYP	NYP	NYP	9
- tensile strain at break (10)	ISO 527-1/-2	%	3	4	2	20
- tensile modulus of elasticity (11)	ISO 527-1/-2	MPa	6000	3700	4900	4200
Compression test (12):						
- compressive stress at 1 / 2 / 5 % nominal strain (11)	ISO 604	MPa	58 / 118 / 280	35 / 69 / 145	44 / 81 / 145	34 / 67 / 135
Charpy impact strength - unnotched (13)	ISO 179-1/1eU	kJ/m²	20	65	10	no break
Charpy impact strength - notched	ISO 179-1/1eA	kJ/m²	2.5	4.5	1.5	15
Ball indentation hardness (15)	ISO 2039-1	N/mm²	375	235	225	200
Rockwell hardness (14)	ISO 2039-2	-	E 120	E 95 (M 120)	E 84 (M 115)	E 80 (M 120)
Electrical Properties at 23 °C						
Electric strength (15)	IEC 60243-1	kV/mm	28	28	13	24
Volume resistivity	IEC 60093	Ohm.cm	> 10^{14}	> 10^{14}	-	> 10^{14}
Surface resistivity	ANSI/ESD STM 11.11	Ohm/sq.	> 10^{13}	> 10^{13}	< 10^{4}	> 10^{13}
Relative permittivity ε_r:						
- at 100 Hz	IEC 60250	-	3.3	3.4	-	4.2
- at 1 MHz	IEC 60250	-	3.2	3.2	5.5	3.9
Dielectric dissipation factor tan δ:						
- at 100 Hz	IEC 60250	-	0.001	0.006	-	0.026
- at 1 MHz	IEC 60250	-	-	0.005	0.007	0.031
Comparative tracking index (CTI)	IEC 60112	-	-	125	-	175

Note: 1 g/cm³ = 1,000 kg/m³ ; 1 MPa = 1 N/mm² ; 1 kV/mm = 1 MV/m. NA: not applicable NYP: there is no yield point

Advanced Engineering Plastic Stock Shapes

Duratron® T4301 PAI (16)	Duratron® T5530 PAI	Ketron® 1000 PEEK	Ketron® HPV PEEK	Ketron® GF30 PEEK	Ketron® CA30 PEEK	Ketron® TX PEEK	Ketron® MD PEEK	Ketron® CC PEEK
black	khaki-grey	natural (brownish grey) / black	black	natural (brownish grey)	black	blue	dark grey	black
1.45	1.61	1.31	1.45	1.51	1.40	1.39	1.39	1.53
26 / 48	25 / 50	5 / 10	4 / 9	5 / 10	4 / 9	4 / 9	4 / 9	-
0.30 / 0.55	0.26 / 0.52	0.06 / 0.12	0.05 / 0.11	0.05 / 0.10	0.05 / 0.11	0.05 / 0.10	0.05 / 0.11	-
1.9	1.7	0.20	0.16	0.16	0.16	0.18	0.16	-
3.8	3.2	0.45	0.35	0.35	0.35	0.40	0.35	-
NA	NA	340	340	340	340	340	340	343
280	280	-	-	-	-	-	-	-
0.54	0.36	0.25	0.78	0.43	0.92	0.25	0.25	0.5
35×10^{-6}	35×10^{-6}	50×10^{-6}	35×10^{-6}	30×10^{-6}	25×10^{-6}	55×10^{-6}	51×10^{-6}	5×10^{-5}
35×10^{-6}	35×10^{-6}	55×10^{-6}	40×10^{-6}	30×10^{-6}	25×10^{-6}	60×10^{-6}	55×10^{-6}	-
40×10^{-6}	40×10^{-6}	130×10^{-6}	85×10^{-6}	65×10^{-6}	55×10^{-6}	140×10^{-6}	131×10^{-6}	10×10^{-5}
280	280	160	195	230	260	155	-	-
270	270	310	310	310	310	310	310	-
250	250	250	250	250	250	250	250	-
-20	-20	-50	-20	-20	-20	- 20	-	-
44	50	35	43	40	40	40	40	-
V-0 / V-0	V-0 / V-0	V-0 / V-0	V-0 / V-0	V-0 / V-0	V-0 / V-0	V-0 / V-0	- / V-0	-
NYP / 110	NYP / 125	115 / -	NYP / 78	80 / -	NYP / 144	90 / -	114 / -	NYP
110	125	115	78	80	144	90	114	680
NYP	NYP	5	NYP	3.5	NYP	5	4.4	-
5	3	17	3	4.5	3.5	6	12	20
5500	6400	4300	5900	7000	9200	3750	4100	55000
39 / 72 / 130	55 / 104 / 190	38 / 75 / 140	46 / 80 / 120	54 / 103 / 155	69 / 125 / 170	31 / 61 / 120	41 / 81 / 142	89 / 175 / 418
45	30	no break	25	25	50	30	50	65
4	3.5	3.5	3	3	5	3	3.4	35
200	275	210	215	250	310	195	277	-
M 106 (E 70)	E 85 (M125)	M 105	M 85	M 100	M 102	M 97	M 108	M 114
-	28	24	-	24	-	22	-	-
$> 10^{13}$	$> 10^{14}$	$> 10^{14}$	-	$> 10^{14}$	$< 10^{5}$	$> 10^{14}$	-	-
$> 10^{13}$	$> 10^{13}$	$> 10^{13}$	-	$> 10^{13}$	$< 10^{5}$	$> 10^{13}$	-	$\leq 10^{3}$
6.0	4.4	3.2	-	3.2	-	3.2	-	-
5.4	4.2	3.2	-	3.6	-	3.2	-	-
0.037	0.022	0.001	-	0.001	-	0.001	-	-
0.042	0.050	0.002	-	0.002	-	0.002	-	-
175	175	150	-	175	-	150	-	-

AEP

Physical Properties (indicative values)

PROPERTIES	Test methods	Units	Techtron® 1000 PPS	Techtron® HPV PPS	Sultron™ PSU	Duratron® U1000 PEI
Colour	-	-	natural (cream)	deep blue	natural (yellow, translucent)	natural (amber, translucent)
Density	ISO 1183-1	g/cm³	1.35	1.42	1.24	1.27
Water absorption:						
- after 24/96 h immersion in water of 23 °C (1)	ISO 62	mg	1 / 2	1 / 2	19 / 38	16 / 34
	ISO 62	%	0.01 / 0.02	0.01 / 0.02	0.24 / 0.48	0.19 / 0.40
- at saturation in air of 23 °C / 50 % RH	-	%	0.03	0.05	0.30	0.70
- at saturation in water of 23 °C	-	%	0.10	0.20	0.80	1.30
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)	ISO 11357-1/-3	°C	280	280	NA	NA
Glass transition temperature (DSC, 20 °C/min) - (3)	ISO 11357-1/-2	°C	-	-	190	215
Thermal conductivity at 23 °C	-	W/(K.m)	0.30	0.30	0.26	0.24
Coefficient of linear thermal expansion:						
- average value between 23 and 100 °C	-	m/(m.K)	60 x 10^{-6}	50 x 10^{-6}	55 x 10^{-6}	50 x 10^{-6}
- average value between 23 and 150 °C	-	m/(m.K)	80 x 10^{-6}	60 x 10^{-6}	55 x 10^{-6}	50 x 10^{-6}
- average value above 150 °C	-	m/(m.K)	145 x 10^{-6}	100 x 10^{-6}	70 x 10^{-6}	60 x 10^{-6}
Temperature of deflection under load:						
- method A: 1.8 MPa	ISO 75-1/-2	°C	115	115	170	195
Max. allowable service temperature in air :						
- for short periods (4)	-	°C	260	260	180	200
- continuously: for min. 20,000 h (5)	-	°C	220	220	150	170
Min. service temperature (6)	-	°C	-30	-20	-50	-50
Flammability (7):						
- „Oxygen Index“	ISO 4589-1/-2	%	44	44	30	47
- according to UL 94 (1.5 / 3 mm thickness)	-	-	V-0 / V-0	V-0 / V-0	HB / HB	V-0 / V-0
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield / tensile stress at break (10)	ISO 527-1/-2	MPa	102 / -	NYP / 78	88 / -	129 / -
- tensile strength (10)	ISO 527-1/-2	MPa	102	78	88	129
- tensile strain at yield (10)	ISO 527-1/-2	%	3.5	NYP	5	7
- tensile strain at break (10)	ISO 527-1/-2	%	12	3.5	10	13
- tensile modulus of elasticity (11)	ISO 527-1/-2	MPa	4000	4000	2850	3500
Compression test (12):						
- compressive stress at 1 / 2 / 5 % nominal strain (11)	ISO 604	MPa	39 / 77 / 122	33 / 65 / 105	25 / 49 / 101	31 / 61 / 137
Charpy impact strength - unnotched (13)	ISO 179-1/1eU	kJ/m²	no break	25	no break	no break
Charpy impact strength - notched	ISO 179-1/1eA	kJ/m²	2	4	3.5	3.5
Ball indentation hardness (15)	ISO 2039-1	N/mm²	205	160	115	165
Rockwell hardness (14)	ISO 2039-2	-	M 100	M 82	M 89	M 115
Electrical Properties at 23 °C						
Electric strength (15)	IEC 60243-1	kV/mm	18	24	30	27
Volume resistivity	IEC 60093	Ohm.cm	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}
Surface resistivity	ANSI/ESD STM 11.11	Ohm/sq.	> 10^{13}	> 10^{13}	> 10^{13}	> 10^{13}
Relative permittivity ε_r:						
- at 100 Hz	IEC 60250	-	3.0	3.3	3.0	3.0
- at 1 MHz	IEC 60250	-	3.0	3.3	3.0	3.0
Dielectric dissipation factor tan δ:						
- at 100 Hz	IEC 60250	-	0.002	0.003	0.001	0.002
- at 1 MHz	IEC 60250	-	0.002	0.003	0.003	0.002
Comparative tracking index (CTI)	IEC 60112	-	125	100	150	175

Note: 1 g/cm³ = 1,000 kg/m³ ; 1 MPa = 1 N/mm² ; 1 kV/mm = 1 MV/m. NA: not applicable NYP: there is no yield point

Advanced Engineering Plastic Stock Shapes

Fluorosint® 500	Fluorosint® 207	Fluorosint® 135	Fluorosint® HPV	Fluorosint® MT-01	Semitron® ESd 225	Semitron® ESd 410C	Semitron® ESd 480	Semitron® HPV
ivory	white	black	tan	dark grey	beige	black	black	black
2.32	2.30	1.89	2.06	2.27	1.33	1.41	1.46	1.45
- / -	- / -	-	10 / 20	- / -	392 / 705	-	- / -	4 / 9
- / -	- / -	-	0.07 / 0.15	- / -	5 / 9	-	0.18 / -	0.05 / 0.11
< 0.1	< 0.1	-	0.1 - 0.2	-	0.8	0.60	-	0.16
1.5 - 2.5	1 - 2	-	0.5 - 1	1.5 - 2.5	10	1.10	1.65	0.35
327	327	330	327	327	165	NA	344	340
-	-	-	-	-	-	215	NA	-
0.77	-	-	-	-	-	0.35	0.34	0.78
50 x 10^{-6}	85 x 10^{-6}	-	75 x 10^{-6}	60 x 10^{-6}	150 x 10^{-6}	40 x 10^{-6}	37 x 10^{-6}	35 x 10^{-6}
55 x 10^{-6}	90 x 10^{-6}	-	80 x 10^{-6}	65 x 10^{-6}	-	40 x 10^{-6}	40 x 10^{-6}	40 x 10^{-6}
85 x 10^{-6}	155 x 10^{-6}	-	135 x 10^{-6}	100 x 10^{-6}	-	45 x 10^{-6}	76 x 10^{-6}	85 x 10^{-6}
130	100	-	80	95	-	200	-	195
280	280	-	280	300	140	200	310	310
260	260	260	260	260	90	170	250	250
-20	-50	-	-50	-20	-50	-20	-20	-20
≥ 95	≥ 95	NT	≥ 95	≥ 95	< 20	47	-	43
V-0 / V-0	V-0 / V-0	V-0	V-0 / V-0	V-0 / V-0	HB / HB	V-0 / V-0	- / V-0	V-0 / V-0
7 / -	10 / -	11 / -	10 / -	14 / -	NYP / 38	NYP / 62	NYP / 55	NYP / 57
7	10	11	10	14	38	62	56	57
5	4	3	6	6	NYP	NYP	NYP	NYP
15	> 50	3.1	> 50	20	15	2	1	3
1750	1450	1230	1200	1900	1500	5850	5900	4900
12 / 19 / 25	10.5 / 15 / 20	19 / 25 / 30 / 32	10 / 14.5 / 19	11 / 17 / 29	14 / 25 / 38	44 / 76 / 114	42 / 83 / 141	46 / 80 / 120
8	30	5.4	55	20	no break	20	7	25
4.5	7.5	3.5	12	4	8	4	1	3
60	40	65	45	55	70	-	272	214
R 55	R 50	R 67	R 45	R 74	R 106	M 115	M 103	M 90
11	8	-	-	-	-	-	-	-
> 10^{13}	> 10^{13}	-	-	-	10^{9} - 10^{11}	10^{4} - 10^{6}	-	-
> 10^{13}	> 10^{13}	< 10^{3}	> 10^{13}	< 10^{5}	10^{9} - 10^{11}	10^{4} - 10^{6}	10^{6} - 10^{9}	10^{6} - 10^{9}
-	-	-	-	-	-	-	-	-
2.85	2.65	-	-	-	4.3	3.3	-	-
-	-	-	-	-	-	-	-	-
0.008	0.008	-	-	-	0.036	0.002	-	-
-	-	-	-	-	-	-	-	-

AEP

Physical Properties (indicative values)

PROPERTIES	Test methods	Units	Semitron® ESd 490HR	Semitron® ESd 500HR	Semitron® ESd 520HR	Semitron® MPR1000
Colour	-	-	black	white	khaki grey	brownish
Density	ISO 1183-1	g/cm³	1.50	2.30	1.58	1.47
Water absorption:						
- after 24/96 h immersion in water of 23 °C (1)	ISO 62	mg	- / -	- / -	56 / 110	- / -
	ISO 62	%	0.18 / -	- / -	0.60 / 1.18	0.28 / -
- at saturation in air of 23 °C / 50 % RH	-	%	-	< 0.1	2.6	-
- at saturation in water of 23 °C	-	%	1.65	1 - 2	4.6	3.4
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)	ISO 11357-1/-3	°C	342	327	NA	NA
Glass transition temperature (DSC, 20 °C/min) - (3)	ISO 11357-1/-2	°C	NA	-	280	277
Thermal conductivity at 23 °C	-	W/(K.m)	-	-	0.34	0.50
Coefficient of linear thermal expansion:						
- average value between 23 and 100 °C	-	m/(m.K)	34×10^{-6}	85×10^{-6}	35×10^{-6}	29×10^{-6}
- average value between 23 and 150 °C	-	m/(m.K)	36×10^{-6}	90×10^{-6}	35×10^{-6}	30×10^{-6}
- average value above 150 °C	-	m/(m.K)	63×10^{-6}	155×10^{-6}	40×10^{-6}	36×10^{-6}
Temperature of deflection under load:						
- method A: 1.8 MPa	ISO 75-1/-2	°C	-	100	280	278
Max. allowable service temperature in air :						
- for short periods (4)	-	°C	310	280	270	-
- continuously: for min. 20,000 h (5)	-	°C	250	260	250	260
Min. service temperature (6)	-	°C	-20	-50	-20	-
Flammability (7):						
- „Oxygen Index“	ISO 4589-1/-2	%	-	≥ 95	48	-
- according to UL 94 (1.5 / 3 mm thickness)	-	-	V-0 / -	V-0 / V-0	V-0 / V-0	- / V-0
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield / tensile stress at break (10)	ISO 527-1/-2	MPa	NYP / 48	10 / -	NYP / 83	NYP / 99
- tensile strength (10)	ISO 527-1/-2	MPa	48	10	83	99
- tensile strain at yield (10)	ISO 527-1/-2	%	NYP	4	NYP	NYP
- tensile strain at break (10)	ISO 527-1/-2	%	1	> 50	3	3.5
- tensile modulus of elasticity (11)	ISO 527-1/-2	MPa	6350	1450	5500	6050
Compression test (12):						
- compressive stress at 1 / 2 / 5 % nominal strain (11)	ISO 604	MPa	49 / 91 / 146	10.5 / 15 / 20	42 / 80 / 145	47 / 79 / 130
Charpy impact strength - unnotched (13)	ISO 179-1/1eU	kJ/m²	3.5	30	20	62
Charpy impact strength - notched	ISO 179-1/1eA	kJ/m²	1	7.5	4	5
Ball indentation hardness (15)	ISO 2039-1	N/mm²	274	40	250	240
Rockwell hardness (14)	ISO 2039-2	-	M 105	R 50	M 110 (E73)	M 102
Electrical Properties at 23 °C						
Electric strength (15)	IEC 60243-1	kV/mm	-	-	-	-
Volume resistivity	IEC 60093	Ohm.cm	-	10^{10} - 10^{12}	10^{10} - 10^{12}	-
Surface resistivity	ANSI/ESD STM 11.11	Ohm/sq.	10^{10} - 10^{12}	10^{10} - 10^{12}	10^{10} -10^{12}	> 10^{13}
Relative permittivity ε_r:						
- at 100 Hz	IEC 60250	-	-	3.1	5.8	-
- at 1 MHz	IEC 60250	-	-	-	-	-
Dielectric dissipation factor tan δ:						
- at 100 Hz	IEC 60250	-	-	-	-	-
- at 1 MHz	IEC 60250	-	-	0.075	0.18	-
Comparative tracking index (CTI)	IEC 60112	-	-	-	-	-

Note: 1 g/cm³ = 1,000 kg/m³ ; 1 MPa = 1 N/mm² ; 1 kV/mm = 1 MV/m. NA: not applicable NYP: there is no yield point

Advanced Engineering Plastic Stock Shapes

(1) According to method 1 of ISO 62 and done on discs Ø 50 mm x 3 mm.
(2) The figures given for these properties are for the most part derived from raw material supplier data and other publications.
(3) Values for this property are only given here for amorphous materials and for materials that do not show a melting temperature (PBI & PI).
(4) Only for short time exposure (a few hours) in applications where no or only a very low load is applied to the material.
(5) Temperature resistance over a period of min. 20,000 hours. After this period of time, there is a decrease in tensile strength – measured at 23 °C – of about 50 % as compared with the original value.
The temperature values given here are thus based on the thermal-oxidative degradation which takes place and causes a reduction in properties. Note, however, that the maximum allowable service temperature depends in many cases essentially on the duration and the magnitude of the mechanical stresses to which the material is subjected.
(6) Impact strength decreasing with decreasing temperature, the minimum allowable service temperature is practically mainly determined by the extent to which the material is subjected to impact. The values given here are based on unfavourable impact conditions and may consequently not be considered as being the absolute practical limits.
(7) These estimated ratings, derived from raw material supplier data and other publications, are not intended to reflect hazards presented by the materials under actual fire conditions. There are no 'UL File Numbers' available for the Advanced Engineering Plastic stock shapes.
(8) Most of the figures given for the mechanical properties of the extruded materials are average values of tests run on dry test specimens machined out of rod Ø 40 - 60 mm. Except for the hardness tests, the test specimens were then taken from an area mid between centre and outside diameter, with their length in longitudinal direction of the rod (parallel to the extrusion direction).
(9) Test specimens: Type 1 B
(10) Test speed: 5 or 50 mm/min [chosen acc. to ISO 10350-1 as a function of the ductile behaviour of the material (tough or brittle) ; all materials showing a tensile strain at break ≥ 10% were tested at 50 mm/min].
(11) Test speed: 1 mm/min
(12) Test specimens: cylinders Ø 8 mm x 16 mm
(13) Pendulum used: 4 J
(14) Measured on 10 mm thick test specimens (discs), mid between centre and outside diameter.
(15) Electrode configuration: Ø 25 mm / Ø 75 mm coaxial cylinders; in transformer oil according to IEC 60296; 1 mm thick test specimens. Please note that the electric strength of Sultron™ R PPSU black can be considerably lower than the figures listed in the table which refer to natural material.
(16) It has to be noted that the property values of compression moulded Duratron® T4503 PAI, resp. Duratron® T4501 PAI stock shapes can significantly differ from those given in this table for extruded Duratron® T4203 PAI, resp. Duratron® T4301 PAI stock shapes. They have to be considered on an individual shape and dimension related basis. Please consult us.

- This table, mainly to be used for comparison purposes, is a valuable help in the choice of a material. The data listed here fall within the normal range of product properties of dry material. However, they are not guaranteed and they should not be used to establish material specification limits nor used alone as the basis of design.

  It has to be noted that several of the products listed in this table are fibre reinforced and/or filled, and hence show an anisotropic behaviour (properties differ when measured parallel and perpendicular to the extrusion or compression direction).

As a result of our internal continuous improvement programmes, of availability and gathering of new and/or additional technical data, of increasing knowledge and experience, as well as of changing market requirements and revised internationally recognised material/test standards, Mitsubishi Chemical Advanced Materials is extending and updating its literature and technical information on a continuous basis. We therefore invite and recommend our customers to consult our website for the latest and up to date information on our materials.

Physical Properties (indicative values)

PROPERTIES		Test methods	Units	Ertalon® 6 SA	Ertalon® 66 SA	Ertalon® 66 SA-C
Colour		-	-	natural (white)/ black	natural (cream)/ black	natural (white)
Density		ISO 1183-1	g/cm³	1.14	1.14	1.14
Water absorption:						
- after 24/96 h immersion in water of 23 °C (1)		ISO 62	mg	86 / 168	40 / 76	65 / 120
		ISO 62	%	1.28 / 2.50	0.60 / 1.13	0.97 / 1.79
- at saturation in air of 23 °C / 50 % RH		-	%	2.6	2.4	2.5
- at saturation in water of 23 °C		-	%	9	8	8.5
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)		ISO 11357-1/-3	°C	220	260	240
Glass transition temperature (DSC, 20 °C/min) - (3)		ISO 11357-1/-2	°C	-	-	-
Thermal conductivity at 23 °C		-	W/(K.m)	0.28	0.28	0.28
Coefficient of linear thermal expansion:						
- average value between 23 and 60 °C		-	m/(m.K)	90 x 10^{-6}	80 x 10^{-6}	85 x 10^{-6}
- average value between 23 and 100 °C		-	m/(m.K)	105 x 10^{-6}	95 x 10^{-6}	100 x 10^{-6}
Temperature of deflection under load:						
- method A: 1.8 MPa	+	ISO 75-1/-2	°C	70	85	75
Max. allowable service temperature in air :						
- for short periods (4)		-	°C	160	180	170
- continuously : for 5,000 / 20,000 h (5)		-	°C	85/70	95/80	90/75
Min. service temperature (6)		-	°C	-40	-30	-30
Flammability (7):						
- „Oxygen Index“		ISO 4589-1/-2	%	25	26	24
- according to UL 94 (3 / 6 mm thickness)		-	-	HB / HB	HB / HB	HB / HB
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield / tensile stress at break (10)	+	ISO 527-1/-2	MPa	80 / -	90 / -	86 / -
	++	ISO 527-1/-2	MPa	45 / -	55 / -	50 / -
- tensile strength (10)	+	ISO 527-1/-2	MPa	80	93	86
- tensile strain at yield (10)	+	ISO 527-1/-2	%	4	5	5
- tensile strain at break (10)	+	ISO 527-1/-2	%	> 50	50	> 50
	++	ISO 527-1/-2	%	> 100	> 100	> 100
- tensile modulus of elasticity (11)	+	ISO 527-1/-2	MPa	3300	3550	3350
	++	ISO 527-1/-2	MPa	1425	1700	1475
Compression test (12):						
- compressive stress at 1 / 2 / 5 % nominal strain (11)	+	ISO 604	MPa	31 / 59 / 87	32 / 62 / 100	31 / 60 / 89
Charpy impact strength - Unnotched (13)	+	ISO 179-1/1eU	kJ/m²	no break	no break	no break
Charpy impact strength - Notched	+	ISO 179-1/1eA	kJ/m²	5.5	4.5	5
Ball indentation hardness (14)	+	ISO 2039-1	N/mm²	150	160	155
Rockwell hardness (14)	+	ISO 2039-2	-	M 85	M 88	M 87
Electrical Properties at 23 °C						
Electric strength (15)	+	IEC 60243-1	kV/mm	25	27	26
	++	IEC 60243-1	kV/mm	16	18	17
Volume resistivity	+	IEC 60093	Ohm.cm	> 10^{14}	> 10^{14}	> 10^{14}
	++	IEC 60093	Ohm.cm	> 10^{12}	> 10^{12}	> 10^{12}
Surface resistivity	+	IEC 60093	Ohm	> 10^{13}	> 10^{13}	> 10^{13}
	++	IEC 60093	Ohm	> 10^{12}	> 10^{12}	> 10^{12}
Relative permittivity ε_r:						
- at 100 Hz	+	IEC 60250	-	3.9	3.8	3.8
	++	IEC 60250	-	7.4	7.4	7.4
- at 1 MHz	+	IEC 60250	-	3.3	3.3	3.3
	++	IEC 60250	-	3.8	3.8	3.8
Dielectric dissipation factor tan δ:		IEC 60250	-			
- at 100 Hz	+	IEC 60250	-	0.019	0.013	0.013
	++	IEC 60250	-	0.13	0.13	0.13
- at 1 MHz	+	IEC 60250	-	0.021	0.020	0.020
	++	IEC 60250	-	0.06	0.06	0.06
Comparative tracking index (CTI)	+	IEC 60112	V	600	600	600
	++	IEC 60112	-	600	600	600

Note: 1 g/cm³ = 1,000 kg/m³ ; 1 MPa = 1 N/mm² ; 1 kV/mm = 1 MV/m. NYP: there is no yield point

General Engineering Plastic Stock Shapes

Ertalon® 4.6	Ertalon® 66-GF30	Nylatron® GS	Nylatron® MD	Nylatron® 66 SA FR (17)	Nylatron® FST	Ertalon® 6 PLA	Ertalon® 6 XAU+
reddish brown	black	grey-black	dark blue	black	natural	natural (ivory)/ black	black
1.19	1.29	1.15	1.21	1.16	1.14	1.15	1.15
90 / 180	30 / 56	46 / 85	60 / 118	-	0.53 / 1.03	44 / 83	47 / 89
1.30 / 2.60	0.39 / 0.74	0.68 / 1.25	0.78 / 1.53	-	-	0.65 / 1.22	0.69 / 1.31
2.8	1.7	2.3	2.5	-	-	2.2	2.2
9.5	5.5	7.8	6.9	-	7.4	6.5	6.5
290	260	260	220	264	260	215	215
-	-	-	-	-	-	-	-
0.30	0.30	0.29	0.28	-	0.28	0.29	0.29
80×10^{-6}	50×10^{-6}	80×10^{-6}	85×10^{-6}	80×10^{-6}	80×10^{-6}	80×10^{-6}	80×10^{-6}
90×10^{-6}	60×10^{-6}	90×10^{-6}	100×10^{-6}	-	95×10^{-6}	90×10^{-6}	90×10^{-6}
160	150	85	85	100	85	80	80
200	200	180	160	-	180	170	180
150/130	120/110	95/80	85/70	-	95/80	105/90	120/105
-40	-20	-20	-25	-	-30	-30	-30
24	-	26	25	-	-	25	25
HB / HB	HB / HB	HB / HB	HB / HB	V-0 (1 mm thickness)	V2	HB / HB	HB / HB
105 / -	NYP / 85	93 / -	87 / -	79 / -	90 / -	86 / -	84 / -
55 / -	-	55 / -	50 / -	-	-	55 / -	55 / -
105	85	95	87	79	90	88	86
18	NYP	5	4	6.6	6.6	5	5
25	5	20	25	9	15	25	25
> 50	-	> 50	> 50	-	-	> 50	> 50
3400	5000	3600	4000	3900	3500	3600	3500
1350	2700	1725	1800	-	-	1750	1700
31 / 60 / 102	43 / 77 / 112	32 / 62 / 100	35 / 67 / 92	35 / 65 / 98	30 / 60 / 99	34 / 64 / 93	34 / 64 / 93
no break	50	no break	80	50	no break	no break	no break
8	6	4	3	3	4.9	3	3
165	165	165	170	195	165	165	165
M 92	M 76	M 88	M 85	M 87	M 88	M 88	M 87
25	27	26	-	-	27	25	29
15	18	17	-	18	-	17	19
$> 10^{14}$	$> 10^{14}$	$> 10^{14}$	$> 10^{12}$	-	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$
$> 10^{12}$	$> 10^{12}$	$> 10^{12}$	$> 10^{12}$	-	-	$> 10^{12}$	$> 10^{12}$
$> 10^{13}$	$> 10^{13}$	$> 10^{13}$	$> 10^{11}$	$> 10^{14}$	$> 10^{14}$	$> 10^{13}$	$> 10^{13}$
$> 10^{12}$	$> 10^{12}$	$> 10^{12}$	$> 10^{10}$	-	-	$> 10^{12}$	$> 10^{12}$
3.8	3.9	3.8	-	-	3.8	3.6	3.6
7.4	6.9	7.4	-	-	-	6.6	6.6
3.4	3.6	3.3	-	-	3.3	3.2	3.2
3.8	3.9	3.8	-	-	-	3.7	3.7
0.009	0.012	0.013	-	-	0.013	0.012	0.015
0.13	0.19	0.13	-	-	-	0.14	0.15
0.019	0.014	0.020	-	-	0.020	0.016	0.017
0.06	0.04	0.06	-	-	-	0.05	0.05
400	475	600	-	-	600	600	600
400	475	600	-	600	-	600	600

Physical Properties (indicative values)

PROPERTIES		Test methods	Units	Ertalon® LFX	Nylatron® MC 901	Nylatron® GSM
Colour		-	-	green	blue	grey-black
Density		ISO 1183-1	g/cm³	1.135	1.15	1.16
Water absorption:						
- after 24/96 h immersion in water of 23 °C (1)		ISO 62	mg	44 / 83	49 / 93	52 / 98
		ISO 62	%	0.66 / 1.24	0.72 / 1.37	0.76 / 1.43
- at saturation in air of 23 °C / 50 % RH		-	%	2	2.3	2.4
- at saturation in water of 23 °C		-	%	6.3	6.6	6.7
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)		ISO 11357-1/-3	°C	215	215	215
Glass transition temperature (DSC, 20 °C/min) - (3)		ISO 11357-1/-2	°C	-	-	-
Thermal conductivity at 23 °C		-	W/(K.m)	0.28	0.29	0.30
Coefficient of linear thermal expansion:						
- average value between 23 and 60 °C		-	m/(m.K)	80 x 10^{-6}	80 x 10-6	80 x 10^{-6}
- average value between 23 and 100 °C		-	m/(m.K)	90 x 10^{-6}	90 x 10-6	90 x 10^{-6}
Temperature of deflection under load:						
- method A: 1.8 MPa	+	70		75	80	80
Max. allowable service temperature in air :						
- for short periods (4)		-	°C	165	170	170
- continuously : for 5,000 / 20,000 h (5)		-	°C	105/90	105/90	105/90
Min. service temperature (6)		-	°C	-20	-30	-30
Flammability (7):						
- „Oxygen Index“		ISO 4589-1/-2	%	-	25	25
- according to UL 94 (3 / 6 mm thickness)		-	-	HB / HB	HB / HB	HB / HB
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield / tensile stress at break (10)	+	ISO 527-1/-2	MPa	72 / -	82 / -	80 / -
	++	ISO 527-1/-2	MPa	45 / -	50 / -	50 / -
- tensile strength (10)	+	ISO 527-1/-2	MPa	73	84	82
- tensile strain at yield (10)	+	ISO 527-1/-2	%	5	5	5
- tensile strain at break (10)	+	ISO 527-1/-2	%	25	35	25
	++	ISO 527-1/-2	%	> 50	> 50	> 50
- tensile modulus of elasticity (11)	+	ISO 527-1/-2	MPa	3000	3300	3400
	++	ISO 527-1/-2	MPa	1450	1600	1650
Compression test (12):						
- compressive stress at 1 / 2 / 5 % nominal strain (11)	+	ISO 604	MPa	31 / 58 / 85	32 / 61 / 90	33 / 62 / 91
Charpy impact strength - Unnotched (13)	+	ISO 179-1/1eU	kJ/m²	50	no break	no break
Charpy impact strength - Notched	+	ISO 179-1/1eA	kJ/m²	4	3	3
Ball indentation hardness (14)	+	ISO 2039-1	N/mm²	145	160	160
Rockwell hardness (14)	+	ISO 2039-2	-	M 82	M 85	M 84
Electrical Properties at 23 °C						
Electric strength (15)	+	IEC 60243-1	kV/mm	22	25	24
	++	IEC 60243-1	kV/mm	14	17	16
Volume resistivity	+	IEC 60093	Ohm.cm	> 10^{14}	> 10^{14}	> 10^{14}
	++	IEC 60093	Ohm.cm	> 10^{12}	> 10^{12}	> 10^{12}
Surface resistivity	+	IEC 60093	Ohm	> 10^{13}	> 10^{13}	> 10^{13}
	++	IEC 60093	Ohm	> 10^{12}	> 10^{12}	> 10^{12}
Relative permittivity ε_r:						
- at 100 Hz	+	IEC 60250	-	3.5	3.6	3.6
	++	IEC 60250	-	6.5	6.6	6.6
- at 1 MHz	+	IEC 60250	-	3.1	3.2	3.2
	++	IEC 60250	-	3.6	3.7	3.7
Dielectric dissipation factor tan δ:		IEC 60250	-			
- at 100 Hz	+	IEC 60250	-	0.015	0.012	0.012
	++	IEC 60250	-	0.15	0.14	0.14
- at 1 MHz	+	IEC 60250	-	0.016	0.016	0.016
	++	IEC 60250	-	0.05	0.05	0.05
Comparative tracking index (CTI)	+	IEC 60112	V	600	600	600
	++	IEC 60112	-	600	600	600

General Engineering Plastic Stock Shapes

Nylatron® NSM	Nylatron® SLG	Nylatron® 703 XL	Ertacetal® C	Ertacetal® C LQ	Ertacetal® C ELS	Acetron® MD	Ertacetal® H	Ertacetal® H-TF	Ertalyte® (16)
grey	natural (ivory)/ blue	purple	natural (white)/ black	natural (white)	black	blue	natural (white)/ black	deep brown	natural (white)/ black
1.14	1.135	1.11	1.41	1.43	1.41	1.46	1.43	1.50	1.39
40 / 76	44 / 83	40 / 76	20 / 37	-	-	19 / 37	18 / 36	16 / 32	6 / 13
0.59 / 1.12	0.66 / 1.24	0.61 / 1.16	0.24 / 0.45	-	-	0.21 / 0.40	0.21 / 0.43	0.18 / 0.36	0.07 / 0.16
2	2	2	0.20	-	0.20	0.19	0.20	0.17	0.25
6.3	6.3	6.3	0.80	< 0.1	0.80	0.75	0.80	0.72	0.50
215	215	215	165	170	173	165	180	180	245
-	-	-	-	-	-	-	-	-	-
0.29	0.28	0.30	0.31	-	-	0.31	0.31	0.31	0.29
80×10^{-6}	80×10^{-6}	85×10^{-6}	110×10^{-6}	110×10^{-6}	110×10^{-6}	115×10^{-6}	95×10^{-6}	105×10^{-6}	60×10^{-6}
95×10^{-6}	90×10^{-6}	100×10^{-6}	125×10^{-6}	125×10^{-6}	125×10^{-6}	130×10^{-6}	110×10^{-6}	120×10^{-6}	80×10^{-6}
75	75	70	100	100	105	100	110	100	80
165	165	160	140	140	140	140	150	150	160
105/90	105/90	105/90	115/100	115/110	115 / 110	105/90	105/90	105/90	115/100
-30	-20	-20	-50	-50	-	-30	-50	-20	-20
-	-	< 20	15	NT	-	< 20	15	-	25
HB / HB	HB / HB	HB / HB	HB / HB	HB / HB	HB / HB	HB / HB	HB / HB	HB / HB	HB / HB
78 / -	72 / -	60 / -	66 / -	66 / -	NYP / 30	66 / -	NYP / 78	NYP / 55	90 / -
50 / -	45 / -	40 / -	66 / -	-	-	66 / -	78 / -	NYP / 55	90 / -
80	73	60	66	66	30	66	78	55	90
5	5	6	15	12	-	14	NYP	NYP	4
25	25	15	40	50	8	15	25	10	15
> 50	> 50	> 25	50	-	-	15	50	10	15
3150	3000	2750	3000	3100	1500	2950	3700	3100	3500
1525	1450	1350	3000	-	-	2950	3700	3100	3500
31 / 59 / 87	31 / 58 / 85	26 / 48 / 69	23 / 40 / 72	27 / 45 / 78	14 / - 37	25 / 44 / 76	29 / 49 / 85	26 / 44 / 77	33 / 64 / 107
75	50	25	no break	no break	89	70	no break	30	50
3.5	4	4	8	7	5	5	10	3	2
150	145	120	140	145	77	155	160	140	170
M 81	M 82	R 109 (M 59)	M 84	M 83	M 45	M 86	M 88	M 84	M 96
25	22	-	20	NT	-	-	20	20	22
17	14	-	20	NT	-	-	20	20	22
$> 10^{14}$	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$	$> 10^{13}$	-	$> 10^{13}$	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$
$> 10^{12}$	$> 10^{12}$	$> 10^{12}$	$> 10^{14}$	NT	-	$> 10^{13}$	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$
$> 10^{13}$	$> 10^{13}$	$> 10^{13}$	$> 10^{13}$	NT	$> 10^{4}$	$> 10^{12}$	$> 10^{13}$	$> 10^{13}$	$> 10^{13}$
$> 10^{12}$	$> 10^{12}$	$> 10^{12}$	$> 10^{13}$	NT	-	$> 10^{12}$	$> 10^{13}$	$> 10^{13}$	$> 10^{13}$
3.6	3.5	-	3.8	-	-	-	3.8	3.6	3.4
6.6	6.5	-	3.8	-	-	-	3.8	3.6	3.4
3.2	3.1	-	3.8	-	-	-	3.8	3.6	3.2
3.7	3.6	-	3.8	-	-	-	3.8	3.6	3.2
0.012	0.015	-	0.003	-	-	-	0.003	0.003	0.001
0.14	0.15	-	0.003	-	-	-	0.003	0.003	0.001
0.016	0.016	-	0.008	-	-	-	0.008	0.008	0.014
0.05	0.05	-	0.008	-	-	-	0.008	0.008	0.014
600	600	-	600	-	-	-	600	600	600
600	600	-	600	-	-	-	600	600	600

Physical Properties (indicative values)

PROPERTIES		Test methods	Units	Ertalyte® TX	Altron™ PC	Flextron™ 1055 TPE
Colour		-	-	pale grey	natural (clear, translucent)	natural (white)
Density		ISO 1183-1	g/cm³	1.44	1.20	1.20
Water absorption:						
- after 24/96 h immersion in water of 23 °C (1)		ISO 62	mg	5 / 11	13 / 23	-
		ISO 62	%	0.06 / 0.13	0.18 / 0.33	-
- at saturation in air of 23 °C / 50 % RH		-	%	0.23	0.15	0.2
- at saturation in water of 23 °C		-	%	0.47	0.40	0.65
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)		ISO 11357-1/-3	°C	245	-	210
Glass transition temperature (DSC, 20 °C/min) - (3)		ISO 11357-1/-2	°C	-	150	-
Thermal conductivity at 23 °C		-	W/(K.m)	0.29	0.21	0.19
Coefficient of linear thermal expansion:						
- average value between 23 and 60 °C		-	m/(m.K)	65 x 10^{-6}	65 x 10^{-6}	150 x 10^{-6}
- average value between 23 and 100 °C		-	m/(m.K)	85 x 10^{-6}	65 x 10^{-6}	-
Temperature of deflection under load:						
- method A: 1.8 MPa	+	70		75	130	60
Max. allowable service temperature in air :						
- for short periods (4)		-	°C	160	135	170
- continuously : for 5,000 / 20,000 h (5)		-	°C	115/100	130/120	-
Min. service temperature (6)		-	°C	-20	-50	-40
Flammability (7):						
- „Oxygen Index“		ISO 4589-1/-2	%	25	25	-
- according to UL 94 (3 / 6 mm thickness)		-	-	HB / HB	HB / HB	-
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield / tensile stress at break (10)	+	ISO 527-1/-2	MPa	76 / -	74 / -	20
	++	ISO 527-1/-2	MPa	76 / -	74 / -	-
- tensile strength (10)	+	ISO 527-1/-2	MPa	76	74	-
- tensile strain at yield (10)	+	ISO 527-1/-2	%	4	6	27
- tensile strain at break (10)	+	ISO 527-1/-2	%	5	> 50	> 350
	++	ISO 527-1/-2	%	5	> 50	-
- tensile modulus of elasticity (11)	+	ISO 527-1/-2	MPa	3300	2400	310
	++	ISO 527-1/-2	MPa	3300	2400	-
Compression test (12):						
- compressive stress at 1 / 2 / 5 % nominal strain (11)	+	ISO 604	MPa	31 / 60 / 102	21 / 40 / 80	4 / - / 14
Charpy impact strength - Unnotched (13)	+	ISO 179-1/1eU	kJ/m²	30	no break	no break
Charpy impact strength - Notched	+	ISO 179-1/1eA	kJ/m²	2.5	9	90P
Ball indentation hardness (14)	+	ISO 2039-1	N/mm²	160	120	-
Rockwell hardness (14)	+	ISO 2039-2	-	M 94	M 75	-
Electrical Properties at 23 °C						
Electric strength (15)	+	IEC 60243-1	kV/mm	21	28	20
	++	IEC 60243-1	kV/mm	21	28	-
Volume resistivity	+	IEC 60093	Ohm.cm	> 10^{14}	> 10^{14}	> 10^{14}
	++	IEC 60093	Ohm.cm	> 10^{14}	> 10^{14}	-
Surface resistivity	+	IEC 60093	Ohm	> 10^{13}	> 10^{13}	> 10^{13}
	++	IEC 60093	Ohm	> 10^{13}	> 10^{13}	-
Relative permittivity ε_r:						
- at 100 Hz	+	IEC 60250	-	3.4	3	-
	++	IEC 60250	-	3.4	3	-
- at 1 MHz	+	IEC 60250	-	3.2	3	4
	++	IEC 60250	-	3.2	3	-
Dielectric dissipation factor tan δ:		IEC 60250	-			
- at 100 Hz	+	IEC 60250	-	0.001	0.001	-
	++	IEC 60250	-	0.001	0.001	-
- at 1 MHz	+	IEC 60250	-	0.014	0.008	0.04
	++	IEC 60250	-	0.014	0.008	-
Comparative tracking index (CTI)	+	IEC 60112	V	600	350 (225)	600
	++	IEC 60112	-	600	350 (225)	-

General Engineering Plastic Stock Shapes

+ : values referring to dry material
++: values referring to material in equilibrium with the standard atmosphere 23 °C / 50 % RH (mostly derived from literature)

(1) According to method 1 of ISO 62 and done on discs Ø 50 mm x 3 mm.
(2) The figures given for these properties are for the most part derived from raw material supplier data and other publications.
(3) Values for this property are only given here for amorphous materials and not for semi-crystalline ones.
(4) Only for short time exposure (a few hours) in applications where no or only a very low load is applied to the material.
(5) Temperature resistance over a period of 5,000/20,000 hours. Afterthese periods of time, there is a decrease in tensile strength – measured at 23 °C – of about 50 % as compared with the original value. The temperature values given here are thus based on the thermal-oxidative degradation which takes place and causes a reduction in properties. Note, however, that the maximum allowable service temperature depends in many cases essentially on the duration and the magnitude of the mechanical stresses to which the material is subjected.
(6) Impact strength decreasing with decreasing temperature, the minimum allowable service temperature is practically mainly determined by the extent to which the material is subjected to impact. The values given here are based on unfavourable impact conditions and may consequently not be considered as being the absolute practical limits.
(7) These estimated ratings, derived from raw material supplier data and other publications, are not intended to reflect hazards presented by the materials under actual fire conditions. There are no 'UL File Numbers' available for the General Engineering Plastic stock shapes.
(8) The figures given for the properties of dry material (+) are for the most part average values of tests run on test specimens machined out of rods Ø 40 - 60 mm. Except for the hardness tests, the test specimens were then taken from an area mid between centre and outside diameter, with their length in longitudinal direction of the rod. Considering the very low water absorption of Ertacetal®, Ertalyte® and Altron™ 1000 PC, the values for the mechanical and electrical properties of these materials can be considered as being practically the same for dry (+) and moisture conditioned (++) test specimens.
(9) Test specimens: Type 1 B
(10) Test speed: 5 or 50 mm/min [chosen acc. to ISO10350-1 as a function of the ductile behaviour of the material (tough or brittle); only Ertalon 66-GF30, Ertacetal H-TF and Ertalyte TX were tested at 5 mm/min.
(11) Test speed: 1 mm/min
(12) Test specimens: cylinders Ø 8 mm x 16 mm
(13) Pendulum used: 4 J
(14) Measured on 10 mm thick test specimens (discs), mid between centre and outside diameter.
(15) Electrode configuration: Ø 25 mm / Ø 75 mm coaxial cylinders; in transformer oil according to IEC 60296; 1 mm thick test specimens. Please note that the electric strength of black extruded material (Ertalon 6 SA, Ertalon 66 SA, Ertacetal and Ertalyte) can be considerably lower than the figure listed in the table which refers to natural material. Possible microporosity in the centre of polyacetal stock shapes also significantly reduces the electric strength.
(16) The property-values given below do not apply to the 2 – 6 mm thick Ertalyte sheets.
(17) Nylatron® 66 SA FR fulfils the requirements as set out in the DIN EN 45545-2 regulation at which it is qualified according to thefollowing tests and hazardous Levels: R17HL1; R23HL1; R24HL1,2,3; R26HL1,2,3

- This table, mainly to be used for comparison purposes, is a valuable help in the choice of a material. The data listed here fall within the normal range of product properties. However, they are not guaranteed and they should not be used to establish materialspecification limits nor used alone as the basis of design.

  It has to be noted that Ertalon 66-GF30 is a fibre reinforced material and hence shows an anisotropic behaviour (properties differ when measured parallel and perpendicular to the extrusion direction).

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PE

Physical Properties (indicative values)

PROPERTIES	Test methods	Units	TIVAR® 1000	TIVAR® 1000 antistatic	TIVAR® ECO green (17)	TIVAR® ECO black antistatic (17)
Colour	-	-	natural (white)/ green/ black / colours	black	green	black
Average molar mass (average molecular weight) - (1)	-	10^6 g/mol	5	5	≥ 4.5	≥ 4.5
Density	ISO 1183-1	g/cm³	0.93	0.935	0.94	0.94
Water absorption at saturation in water of 23 °C	-	%	< 0.1	< 0.1	< 0.1	< 0.1
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)	ISO 11357-1/-3	°C	135	135	135	135
Thermal conductivity at 23 °C	-	W/(K.m)	0.40	0.40	0.40	0.40
Average coeff. of linear therm. exp. between 23 and 100 °C	-	m/(m.K)	200 x 10^{-6}	200 x 10^{-6}	200 x 10^{-6}	200 x 10^{-6}
Temperature of deflection under load : - method A: 1.8 MPa	ISO 75-1/-2	°C	42	42	42	42
Vicat softening temperature - VST/B50	ISO 306	°C	80	80	80	80
Max. allowable service temperature in air :						
- for short periods (3)	-	°C	120	120	120	120
- continuously : for 20,000 h (4)	-	°C	80	80	80	80
Min. service temperature (5)	-	°C	-200 (6)	-150	-150	-150
Flammability (7):						
- „Oxygen Index“	ISO 4589-1/-2	%	< 20	< 20	< 20	< 20
- according to UL 94 (6 mm thickness)	-	-	HB	HB	HB	HB
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield (10)	ISO 527-1/-2	MPa	19	20	20	20
- tensile strain at yield (10)	ISO 527-1/-2	%	15	15	15	15
- tensile strain at break (10)	ISO 527-1/-2	%	> 50	> 50	> 50	> 50
- tensile modulus of elasticity (11)	ISO 527-1/-2	MPa	750	790	775	775
Compression test (12):						
- compressive stress at 1 / 2 / 5% nominal strain (11)	ISO 604	MPa	6.5 / 10.5 / 17	7 / 11 / 17.5	7 / 11 / 17.5	7 / 11 / 17.5
Charpy impact strength - unnotched (13)	ISO 179-1/1eU	kJ/m²	no break	no break	no break	no break
Charpy impact strength - notched	ISO 179-1/1eA	kJ/m²	115P	110P	90P	90P
Charpy impact strength - Notched (double 14° notch) - (14)	ISO 11542-2	kJ/m²	170	140	100	100
Ball indentation hardness (15)	ISO 2039-1	N/mm²	33	34	34	34
Shore hardness D (15)	ISO 868	-	60	61	60	60
Relative volume loss during a wear test in „sand/water-slurry“ ; TIVAR® 1000 = 100	ISO 15527	-	100	105	200	200
Electrical Properties at 23 °C						
Electric strength (16)	IEC 60243-1	kV/mm	45	-	-	-
Volume resistivity	IEC 60093	Ohm.cm	> 10^{14}	-	-	-
Surface resistivity	IEC 60093	Ohm	> 10^{12}	< 10^8	-	< 10^8
Relative permittivity ε_r: - at 100 Hz	IEC 60250	-	2.1	-	-	-
Relative permittivity ε_r: - at 1 MHz	IEC 60250	-	3.0	-	-	-
Dielectric dissipation factor tan δ: - at 100 Hz	IEC 60250	-	0.0004	-	-	-
Dielectric dissipation factor tan δ: - at 1 MHz	IEC 60250	-	0.0010	-	-	-

Note: 1 g/cm³ = 1,000 kg/m³ ; 1 MPa = 1 N/mm² ; 1 kV/mm = 1 MV/m.

(1) These are the average molar masses of the PE-(U)HMW resins (irrespective of any additives) used for the manufacture of the materials. They are calculated by means of the Margolies-equation M = 5.37 x 104 x [η]1.49, with [η] being the intrinsic viscosity (Staudinger index) derived from a viscosity measurement according to ISO 1628-3:2001, using decahydronaphtalene as a solvent (concentration of 0.001 g/cm³ for PE-HMW and 0.0002 g/cm³ for PE-UHMW).
(2) The figures given for these properties are for the most part derived from raw material supplier data and other publications.
(3) Only for short time exposure (a few hours) in applications where no or only a very low load is applied to the material.
(4) Temperature resistance over a period of 20,000 hours. After this period of time, there is a decrease in tensile strength – measured at 23 °C – of about 50 % as compared with the original value. The temperature values given here are thus based on the thermal-oxidative degradation which takes place and causes a reduction in properties. Note, however, that the maximum allowable service temperature depends in many cases essentially on the duration and the magnitude of the mechanical stresses to which the material is subjected.
(5) Impact strength decreasing with decreasing temperature, the minimum allowable service temperature is practically mainly determined by the extent to which the material is subjected to impact. The values given here are based on unfavourable impact conditions and may consequently not be considered as being the absolute practical limits.
(6) Because of its outstanding toughness, this material withstands even the temperature of liquid helium (-269 °C) at which it still maintains a useful impact resistance without shattering.
(7) These estimated ratings, derived from raw material supplier data and other publications, are not intended to reflect hazards presented by the materials under actual fire conditions. There are no ‘UL File Numbers’ available for the PE-(U) HMW stock shapes.
(8) The figures given for these properties are average values of tests run on test specimens machined out of 20 - 30 mm thick plates.
(9) Test specimens: Type 1 B

PE-[U]HMW Stock Shapes

TIVAR® DrySlide	TIVAR® HPV	TIVAR® TECH	TIVAR® DS / Cestidur	TIVAR® Ceram P	TIVAR® SuperPlus	TIVAR® H.O.T.	TIVAR® Burnguard	TIVAR® CleanStat	TIVAR® CleanStat white
black	blue	grey-black	yellow / grey	yellow-green	grey	bright white	black	black	white
9	> 6	9	9	9	9	9	5	5	5
0.935	0.95	0.935	0.93	0.96	0.96	0.93	1.01	0.94	0.95
< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1
135	135	135	135	135	135	135	135	135	135
0.40	-	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
200 x 10^{-6}	-	200 x 10^{-6}	200 x 10^{-6}	200 x 10^{-6}	180 x 10^{-6}	200 x 10^{-6}	180 x 10^{-6}	200 x 10^{-6}	220 x 10^{-6}
42	-	42	42	42	42	42	42	42	40
80	-	80	80	80	80	80	84	80	80
120	-	120	120	120	120	135	120	120	120
80	-	80	80	80	80	110	80	80	80
-150	-200 (6)	-150	-200 (6)	-150	-150	-200 (6)	-125	-150	-200 (6)
< 20	< 20	< 20	< 20	< 20	< 20	< 20	28	< 20	< 20
HB	HB	HB	HB	HB	HB	HB	V-0	HB	HB
18	20	19	19	18	17	19	16	19	18
20	16	15	15	15	20	15	15	15	11
> 50	> 50	> 50	> 50	> 50	> 50	> 50	25	> 50	> 50
650	800	725	700	750	600	700	1000	750	580
6 / 10 / 16	6.8 / 10.7 / 17.2	6.5 / 10.5 / 17	6 / 10 / 16	7 / 11 / 17.5	5 / 8.5 / 14.5	6 / 10 / 16	7 / 11 / 17	6.5 / 10.5 / 17	5.8 / 9.7 / 15.9
no break	no break	no break	no break	no break	no break	no break	no break	no break	no break
100P	108P	105P	100P	105P	90P	100P	70P	110P	20
130	-	120	130	125	115	130	70	120	-
32	35	32	31	33	31	31	34	33	27
59	61	59	58	60	58	58	58	60	60
85	-	85	85	75	80	80	130	85	95
-	-	45	45	45	-	45	-	-	-
-	-	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	-	-	10^{9} - 10^{10}
< 10^{8}	-	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	< 10^{5}	< 10^{7}	≤ 10^{9}
-	-	-	2.1	-	-	-	-	-	8.26
-	-	-	3.0	-	-	-	-	-	2.49
-	-	-	0.0004	-	-	-	-	-	1.78
-	-	-	0.0010	-	-	-	-	-	0.028

(10) Test speed: 50 mm/min
(11) Test speed: 1 mm/min
(12) Test specimens: cylinders Ø 8 mm x 16 mm.
(13) Pendulum used: 15 J
(14) Pendulum used: 25 J
(15) Measured on 10 mm thick test specimens.
(16) Electrode configuration: Ø 25 mm / Ø 75 mm coaxial cylinders ; in transformer oil according to IEC 60296 ; 1 mm thick test specimens. Please note that the electric strength of black material (PE 500 black and TIVAR 1000 black) can be considerably lower than the figure listed in the table which refers to natural material.
(17) Taking into consideration the varying composition of these grades which are partially composed of reprocessed PE-UHMW material, their physical properties can differ more from batch to batch than those of the other PE-UHMW grades.

- This table, mainly to be used for comparison purposes, is a valuable help in the choice of a material. The data listed here fall within the normal range of product properties. However, they are not guaranteed and they should not be used to establish material specification limits nor used alone as the basis of design.

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PE

Physical Properties (indicative values)

PROPERTIES	Test methods	Units	TIVAR® 1000 ASTL	TIVAR® 1000 EC	TIVAR® MD	TIVAR® Oil Filled
Colour	-	-	black	black	grey	grey
Average molar mass (average molecular weight) - (1)	-	106 g/mol	9	5	9	9
Density	ISO 1183-1	g/cm³	0.95	0.945	0.995	0.93
Water absorption at saturation in water of 23 °C	-	%	< 0.1	< 0.1	< 0.1	< 0.1
Thermal Properties (2)						
Melting temperature (DSC, 10 °C/min)	ISO 11357-1/-3	°C	135	135	135	135
Thermal conductivity at 23 °C	-	W/(K.m)	0.40	0.40	0.40	0.40
Average coeff. of linear therm. exp. between 23 and 100 °C	-	m/(m.K)	200 x 10^{-6}	200 x 10^{-6}	200 x 10^{-6}	200 x 10^{-6}
Temperature of deflection under load : - method A: 1.8 MPa	ISO 75-1/-2	°C	42	42	42	42
Vicat softening temperature - VST/B50	ISO 306	°C	82	82	82	80
Max. allowable service temperature in air :						
- for short periods (3)	-	°C	120	120	120	120
- continuously : for 20,000 h (4)	-	°C	80	80	80	80
Min. service temperature (5)	-	°C	-150	-150	-150	-150
Flammability (7):						
- „Oxygen Index“	ISO 4589-1/-2	%	< 20	< 20	< 20	< 20
- according to UL 94 (6 mm thickness)	-	-	HB	HB	HB	HB
Mechanical Properties at 23 °C (8)						
Tension test (9):						
- tensile stress at yield (10)	ISO 527-1/-2	MPa	21	21	19	16
- tensile strain at yield (10)	ISO 527-1/-2	%	15	15	15	40
- tensile strain at break (10)	ISO 527-1/-2	%	> 50	> 50	> 50	> 50
- tensile modulus of elasticity (11)	ISO 527-1/-2	MPa	800	825	775	375
Compression test (12):						
- compressive stress at 1 / 2 / 5% nominal strain (11)	ISO 604	MPa	7 / 11.5 / 18	7.5 / 12 / 19	7 / 11.5 / 18	4 / 6 / 10.5
Charpy impact strength - unnotched (13)	ISO 179-1/1eU	kJ/m²	no break	no break	no break	no break
Charpy impact strength - notched	ISO 179-1/1eA	kJ/m²	90P	105P	90P	80P
Charpy impact strength - Notched (double 14° notch) - (14)	ISO 11542-2	kJ/m²	80	110	105	140
Ball indentation hardness (15)	ISO 2039-1	N/mm²	34	35	30	24
Shore hardness D (15)	ISO 868	-	61	62	62	54
Relative volume loss during a wear test in „sand/water-slurry“ ; TIVAR® 1000 = 100	ISO 15527	-	85	100	75	95
Electrical Properties at 23 °C						
Electric strength (16)	IEC 60243-1	kV/mm	-	-	-	-
Volume resistivity	IEC 60093	Ohm.cm	-	-	> 10^{14}	> 10^{14}
Surface resistivity	IEC 60093	Ohm	< 10^{6}	< 10^{5}	> 10^{12}	> 10^{12}
Relative permittivity ε_r: - at 100 Hz	IEC 60250	-	-	-	-	-
Relative permittivity ε_r: - at 1 MHz	IEC 60250	-	-	-	-	-
Dielectric dissipation factor tan δ: - at 100 Hz	IEC 60250	-	-	-	-	-
Dielectric dissipation factor tan δ: - at 1 MHz	IEC 60250	-	-	-	-	-
Comparative tracking index (CTI)	IEC 60112	V	-	-	-	-

Note: 1 g/cm³ = 1,000 kg/m³ ; 1 MPa = 1 N/mm² ; 1 kV/mm = 1 MV/m.

PE-[U]HMW Stock Shapes

TIVAR® Cestigreen	TIVAR® SuperPlus	Borotron® UH015	Borotron® UH030	Borotron® UH050	Borotron® HM015	Borotron® HM030	Borotron® HM050	Proteus® H PP	PE 500
green	grey	natural (off-white)	natural (off-white)	natural (off-white)	natural (off-white)	natural (off-white)	natural (off-white)	natural (white)	natural (white) / green / black / colours
9	9	5	5	5	0.5	0.5	0.5	-	0.5
0.96	0.96	0.96	0.98	1.005	0.99	1.01	1.035	0.91	0.96
< 0.1	< 0.1	-	-	-	-	-	-	<0.1	< 0.1
135	135	135	135	135	135	135	135	165	135
0.40	0.40	≥ 0.50	≥ 0.65	≥ 0.80	≥ 0.50	≥ 0.65	≥ 0.80	0.22	0.40
200 x 10^{-6}	180 x 10^{-5}	190 x 10^{-6}	185 x 10^{-6}	180 x 10^{-6}	145 x 10^{-6}	140 x 10^{-6}	135 x 10^{-6}	150 x 10^{-6}	150 x 10^{-6}
42	42	42	42	42	45	45	45	57	44
80	80	82	83	84	82	83	84	90	80
120	120	120	120	120	120	120	120	140	120
80	80	80	80	80	80	80	80	90	80
-150	-150	-100	-75	-50	-30	-25	-20	-	-100
< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
HB	HB	HB	HB	HB	HB	HB	HB	HB	HB
20	17	18	17	16	25	23	21	34	28
15	20	18	18	18	9	8	6.5	6	10
> 50	> 50	> 50	> 50	> 50	20	15	7	> 25	> 50
770	600	850	875	900	1500	1550	1600	1800	1300
7 / 11 / 17.5	5 / 8.5 / 14.5	7.5 / 12 / 18.5	8 / 12.5 / 19	8.5 / 13 / 19.5	13 / 20 / 28	13.5 / 20.5 /28.5	14 / 21 / 29	15 / 26 / 43	12 / 18.5 / 26.5
no break	no break	no break	no break	80	35	25	15	116	no break
60P	90P	50P	40P	30P	7C	6C	5C	5	105P
70	115	25	20	15	9	8.5	8	-	25
33	31	34	35	36	52	55	58	85	48
61	58	62	63	64	64	65	66	72	62
90	80	135	140	150	225	275	350	-	350
-	-	-	-	-	-	-	-	35	45
-	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}
< 10^{9}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{12}	> 10^{2}
-	-	-	-	-	-	-	-	2.3	2.4
-	-	-	-	-	-	-	-	2.3	2.4
-	-	-	-	-	-	-	-	0.0003	0.0002
-	-	-	-	-	-	-	-	0.0004	0.0002
-	-	-	-	-	-	-	-	600	600

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Mitsubishi Chemical Advanced Materials

Europe
Mitsubishi Chemical Advanced Materials Europe NV
Galgenveldstraat 12
8700 Tielt, Belgium
T +32[0] 51 42 35 11
F +32[0] 51 42 33 10
contact@mcam.com

North America
Mitsubishi Chemical Advanced Materials Inc.
2120 Fairmont Avenue
PO Box 14235 - Reading, PA 19612-4235
T 800 366 0300 | +1 610 320 6600
F 800 366 0301 | +1 610 320 6638
contact@mcam.com

Asia-Pacific
Mitsubishi Chemical Advanced Materials Asia Pacific Ltd.
Unit 7B, 35/F, Cable TV Tower,
9 Hoi Shing Road, Tsuen Wan, Hong Kong
T +852 2470 26 83
F +852 2478 99 66
contact@mcam.com

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