SABIC
Innovative
Plastics™

LNP* Faradex* compounds

A thermoplastic composite for cost-effective EMI shielding.

Sharing our futures

Introduction

As electronic devices pervade every corner of society, the potential for electromagnetic interference (EMI) grows exponentially – and electromagnetic compatibility (EMC) becomes an ever more urgent need, especially in mission-critical devices from healthcare to defense. Device manufacturers, therefore, need an effective, reliable EMI shielding method that meets customer requirements and regulatory compliance standards, all while minimizing cost.

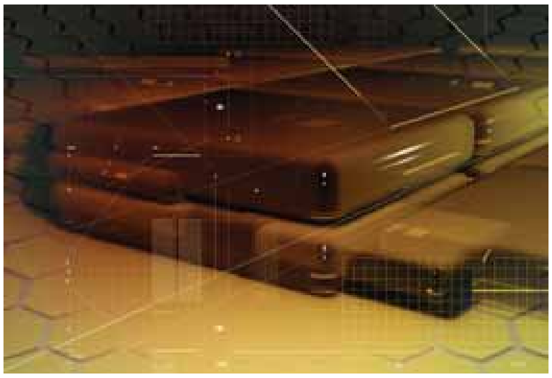
Contents

Welcome to LNP* Faradex* compounds conductive thermoplastic solutions with a blend of properties that saves processing steps, reduces total cost, permits exceptional design freedom for complex geometries and provides the right level of shielding for sensitive electronics.

Where does EMI come from?

Electromagnetic interference (EMI) occurs when the electromagnetic field or transmissions of one device disrupt, impede or degrade the operation of another electronic device. Electromagnetic disturbances can be conducted or radiated and may originate from low or high frequency sources. Disturbances can originate from commutator motors, ignition systems, arc welding equipment, switched mode power supplies, communications equipment and a broad range of digital electronic circuitry.

The skyrocketing use and ever-increasing portability of electronics has brought these devices ever closer to one another, compounding the issue. Moreover, as devices become smaller, and faster, their sensitivity increases, making them more difficult to shield and therefore more vulnerable to interference. Not surprisingly, regulatory standards have become more stringent, increasing the challenge faced by electronics, packaging and compliance engineers.



The shielding properties of LNP* Faradex* compounds make them an excellent choice for sensitive applications where high performance is a must.

Healthcare test and measurement equipment
- Delivery devices, external defibrillators, oxygen concentrators, ventilators, nebulizers, aspirators
- Patient monitoring pulse oximetry, anesthesia, cardiovascular, sleep apnea
- Medical imaging ultrasound, MRI, X-ray, gamma camera, computed tomography
- Clinical diagnostics clinical chemistry, immunoassay, hematology, hemostasis, microbiology, urinalysis, blood banking, point-of-care

Industrial test and measurement equipment
- Network analyzers
- Calibrators
- AC cycle counters
- Electric power meters
- Oscilloscopes
- Voltage testers

Military/defense electronics
- Tactical ground-based military radio
- Digital airborne navigation system
- PC with terminal management system
- Video recording/reproducing equipment
- Thermographic cameras
- Ground-based radar equipment

IT equipment
- Network servers
- Network routers
- Computers and workstations
- Storage devices
- Fax machines
- Copiers
- Other business equipment

Automotive Electronics
- Engine Control Units (ECUs)
- Airbag modules
- Cruise control modules
- Climate control modules
- Anti-lock Brake System (ABS) modules
- Power distribution box modules
- Entertainment systems
- Telematics

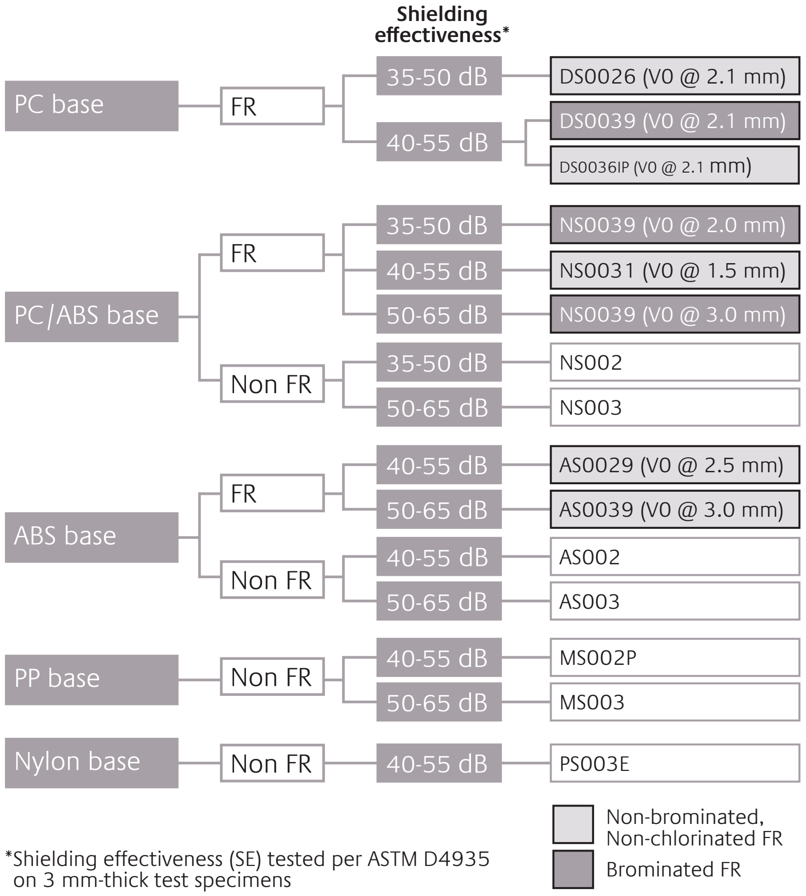
Wireless communication asset tracking/management
- Stationary RFID readers
- Mobile RFID readers

To create housings for asset tracking devices, one U.S. molder had long used fire-retardant PC with copper/nickel metallization for EMI shielding. The OEM requirements were typical for this sort of device
- EMI shielding to meet EMC requirements of FCC part 15 Class B
- Low-temperature impact
- UL 94 V-0 FR
- Low surface resistivity

To improve the customer's bottom line, SABIC Innovative Plastics suggested LNP Faradex DS0036IP compound a one-shot shielding solution with up to 40dB of shielding effectiveness. This product, built on Lexan* EXL resin, offers exceptional low-temperature impact. This grade not only fit the molder's existing tooling, but also eliminated the metallization step – reducing enclosure costs. In addition, the grade's non-brominated, non-chlorinated flame retardant system technology opened up access to critical EU markets.

Whatever the grade, all LNP* Faradex* compounds share one defining characteristic optimally dispersed conductive fibers in a polymer matrix. These fibers form a mesh that, through its bulk electrical conductivity, creates a Faraday Cage effect and provides EMI shielding performance.

LNP Faradex compounds product portfolio



*Shielding effectiveness (SE) tested per ASTM D4935 on 3 mm-thick test specimens

That performance comes with the principal advantages that set LNP* Faradex* compounds apart

- **Design freedom.** The complex geometries of many devices require materials with optimal moldability. LNP Faradex compounds work easily and efficiently with injection molding equipment, filling even small seams and openings in a way metal cannot match.

- **Light weight.** Shielding components made from LNP Faradex compounds are typically 50-80% lighter than their metal counterparts.

- **Ease of processing.** No electroplating, painting or metallization is required to create the shielding effect. This not only eliminates certain traditional challenges, like the difficulty of coating some thermoplastics, but also brings parts made from LNP Faradex compounds in compliance with stringent environmental requirements covering recyclability and disposal.

- **Cost savings.** By eliminating processing steps, which are essential to other shielding approaches, LNP Faradex compounds streamline your operations, thus generating substantial cost savings.

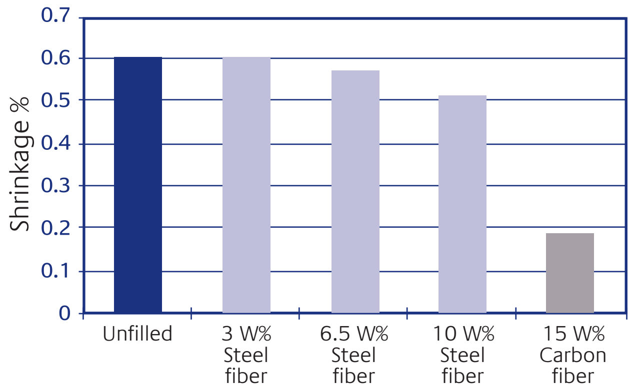
- **Colorability.** Because LNP Faradex compounds can be custom-colored, secondary finishing steps can be eliminated.LNP Faradex compounds come fully compounded and pre-colored in a broad range of base polymers, enhancing their versatility – and your design freedom – even further
- ABS (FR and non-FR)
- PC/ABS (FR and non-FR)
- PC (FR and non-FR)
- PP
- PA 6

SABIC Innovative Plastics is continually developing new grades for an ever expanding array of applications. Custom engineering of unique compounds is available for highly unusual requirements.

LNP Faradex compounds vs. standard resins

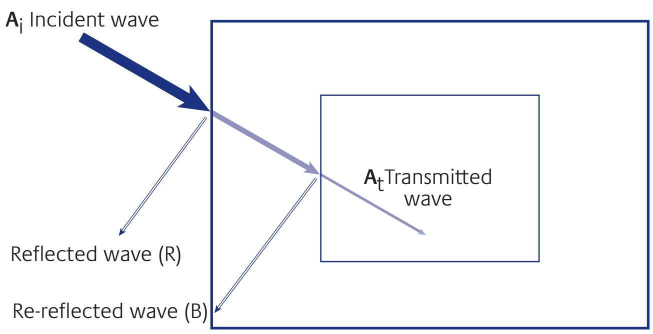
LNP Faradex compounds offer more design freedom than metal, more efficient processing than metallized plastic solutions and shielding performance to rival these alternatives.

Mold shrinkage – stainless steel fiber vs. carbon fiber in PC resin



LNP Faradex compounds' low volumetric loading of conductive filler results in near isotropic shrinkage properties very similar to the base thermoplastic the compounds are built on.

Shielding effectiveness (SE) = A + R + B



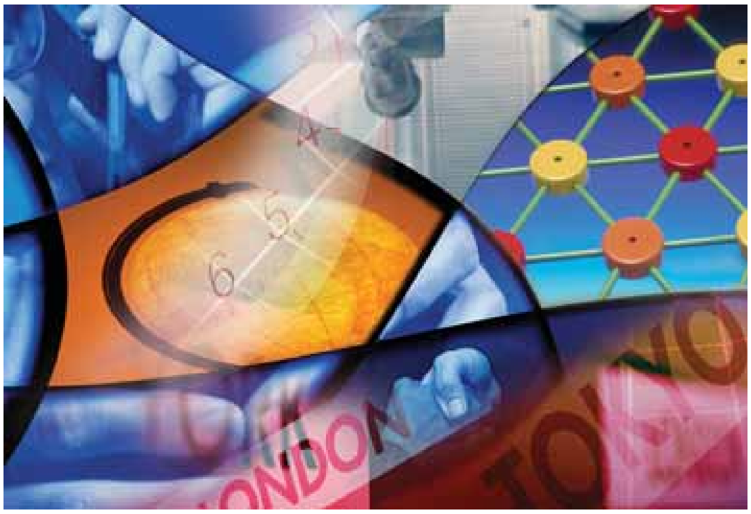
The total shielding effectiveness performance of LNP Faradex compound results from the combination of reflected and absorbed electromagnetic energy.

Behind each LNP* Faradex* compound stands the extensive product and application support for which SABIC Innovative Plastics is well known. By optimizing the use of SABIC Innovative Plastic resins for your specific applications, this support can help you achieve even greater design flexibility and cost savings, and improve your time to market with differentiated product solutions.

Customer application being set up for EMC testing at a SABIC anechoic chamber.

The SABIC Polymer Processing Development Center (PPDC) at 196,000 square feet, it is possibly the largest plastics engineering R&D center in the world. From prototype development to secondary operations, the PPDC and laboratory facilities can help validate your design on production-scale equipment.

That type of support extends throughout the globe. With over 80 manufacturing, technology and joint venture facilities, coupled with application development specialists worldwide, SABIC Innovative Plastics can help you identify solutions to meet your application requirements. SABIC's global research and development network includes centers with anechoic chambers for EMC test and measure-ment capabilities. Here materials as well as devices can be tested to ensure compliance to EMC standards such as CISPR, FCC, etc.



And our Global Application Development Centers (in Shanghai, China; Moka, Japan; Sungnam City, Korea; Bangalore, India; Bergen Op Zoom, The Netherlands; and Pittsfield, Massachusetts provide access to new process solutions and application development resources including

- EMC test and measurement to support product and application development and compliance testing
- Performance testing for mechanical, thermal and dimensional stability
- Computer-aided engineering support
- Environmental simulation, including weathering tests and heat aging
- Regional application development and technical support
- Industrial design and concept development

With their conductive fillers, LNP* Faradex* compounds need no secondary operations to deliver EMI shielding performance. However, other operations may be necessary to add aesthetic value or complete the manufacture of your end product.

The use of LNP Faradex compounds helped eliminate the need for metallization as in this housing.

LNP* Faradex* compound products can be used with a variety of conventional plastics joining methods, including

- Ultrasonic welding
- Hot staking
- Adhesive bonding
- Mechanical assembly (including snap fits and mechanical fasteners)

As a result designers can take advantage of these joining methods to improve their design for assembly and/or disassembly. For more details on these joining methods, see the SABIC Engineering Thermoplastics Design Guide.

Although LNP Faradex compound products are available in precolored form, it is possible to use conventional coating processes and materials to finish parts molded from LNP Faradex compound. The specific coating process and material will be a function of the base resin, desired appearance and performance required from the finished part. SABIC Innovative Plastics has completed coating studies on PC/ABS-based LNP Faradex compound products with favorable results, as noted below.

LNP Faradex NS0031 compound 15-20mm Black

LNP Faradex NS0031 compound 15-20mm Silver

Painting tests

Test items	Test method	STD specification	Silver	Black
Adhesion	Cross-cut with 1 mm x 1 mm grid, 3M tape, 45° pulling angle	No paint peeled off in grid	Pass	Pass
Ethanol rub	50 Cycles @ 500 g loading	Moderate deterioration/ discoloration/staining of surface	Pass	Pass
Wipe resistance	100 Cycles @ 1000 g loading, EF74 great wall eraser	Moderate deterioration/ discoloration/staining of surface	Pass	Pass
Hardness	2H Pencil, 765 g fixed load on pencil 1 cm/s	No mark and scratch on the surface	2H	2H

Suggested painting suppliers

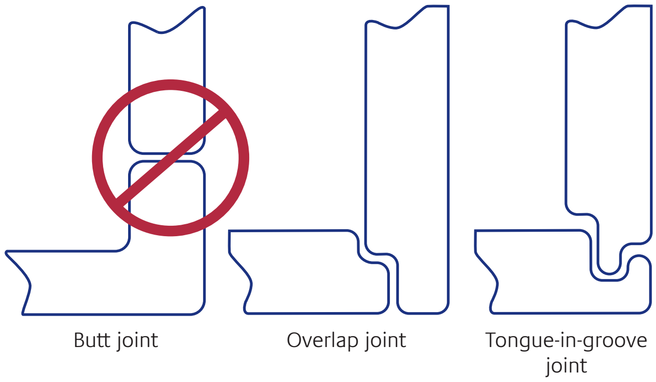
Painting supplier	Meilihua	Akzo nobel	Musashi paint	Ohashi chemical industries
Recipe	Silver PM-8000-831 Black PM-8000-6615	P-Coat 820-ZJS-483 U-Coat 822-ZJS-117 UA-Coat 824N-ZJS-047	Silver LP79 Black LP792-00NB	Polynal No. 500 211 SI Polynal No. 800 (HN) 211 SI

How can you achieve optimal shielding effectiveness with LNP* Faradex* compounds? Key factors include shield wall thickness, material conductivity and the geometry of the enclosure. Especially important is preventing EMI leakage at mating surfaces and apertures, including joints and ventilation slots. Use the following guidelines to resolve these challenges and make the most of LNP Faradex compounds in your design.

Joint design

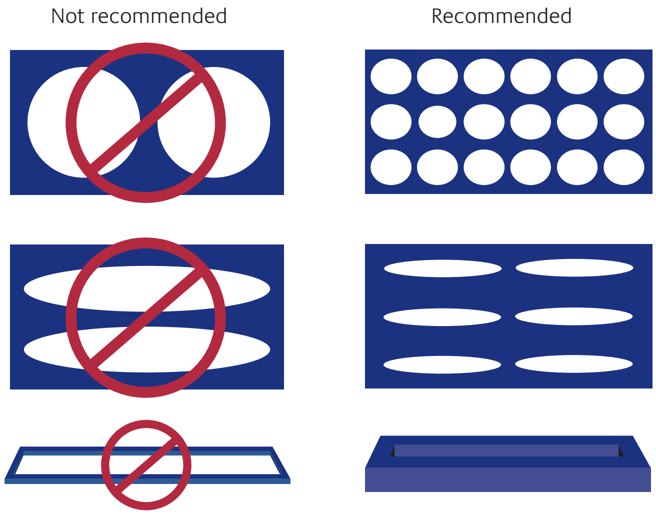
Ideally, joints should maintain electrical continuity to avoid acting as "slot antennae" that leak electromagnetic radiation. Unfortunately, the desire for good surface appearance often leads to a resin-rich surface, burying the conductive fibers within the resin matrix, reducing electrical conductivity across the joint.

To minimize this "slot antennae" effect, an interference fit using a tongue-in-groove or lap joint should be used. Such designs increase joint surface area and contact pressure, improving electrical continuity across the joint. A solvent wash can also be used to dissolve resin on the joint surface and bring fibers to the surface, increasing conductivity.



Aperture design

The size of vent and access holes has a substantial impact on EMI leakage. Narrow, short, deep slots deliver better performance than long, wide, shallow slots; similarly, the use of many small holes minimizes the disruption of induced current flows in the shield, and reduces escape and ingress of EM waves better than a large hole of the same area.



Narrow short, deep slots are better than long wide shallow slots. More small holes rather than few large one.

When MSA, a leading OEM of portable thermographic imaging equipment, wanted to enhance the robustness and reliability of their newest design, they turned to LNP* Faradex* compounds. Specific performance requirements that the housing needed to support included

- Pass IEC 60529 I.P. 67, for ingress and immersion
- Withstand a 6' drop impact test from –40°C to +40°C
- Meet EMC requirements per CE/EN 50081-2:1992, EN 50082-2, FCC Part 15
- Pass Direct Flame/Heat Exposure per NFPA 1901-12, 1.7

LNP Faradex DS0036IP compound was the answer, delivering the right balance of EMI shielding, mechanical, thermal and fire retardant properties to meet the requirements above while allowing MSA to eliminate a costly and time-consuming metallization process previously used to support the EMC requirements.

Wall thickness

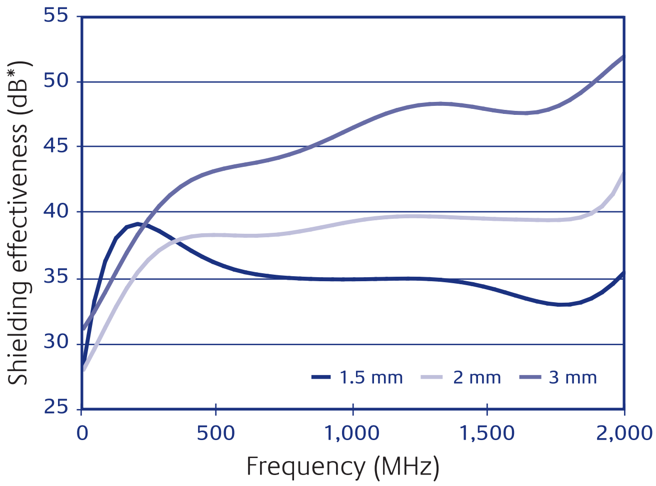
Wall thicknesses should be as uniform as possible, and should be a minimum of 2 mm in thickness. This allows for adequate formation of the conductive network in the polymer matrix and helps minimize fiber attrition (a key consideration in shielding effectiveness) that can otherwise result from high shear conditions when molding thinner wall parts. When designing corners, consider generous radii to minimize fiber attrition during fill, thus preserving the shielding performance. For similar reasons, transitions in wall thickness should be gradual.

Bosses, ribs and gussets

LNP Faradex compound products have the right balance of mechanical properties and flow characteristics, allowing them to form complex features such as ribs, gussets and bosses. When properly designed such features can significantly improve part stiffness, strength and stability and improve design for assembly.

Design bosses and ribs following design standards for plastic materials to minimize sinking and void formation. For details, see the **SABIC Engineering Thermoplastics Design Guide.**

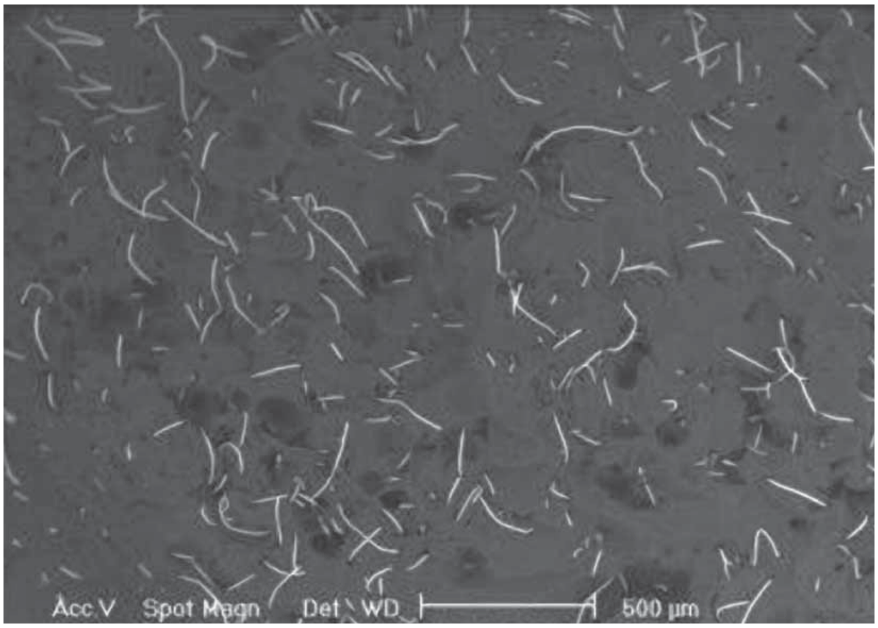
LNP Faradex DS002 compound (base resin PC)



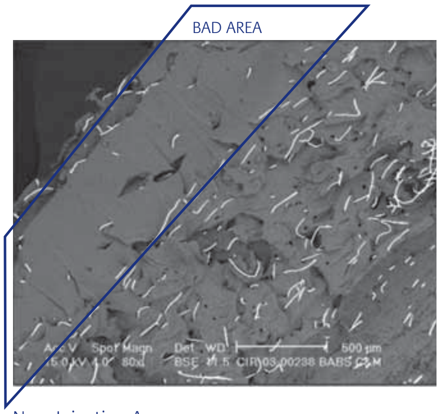
* Testing per ASTM D4935

LNP* Faradex* compounds process similarly to the base resins that they are formulated with. They can be processed on standard injection molding equipment with conventional screw and nozzle design. The key to processing LNP Faradex compound products is to minimize fiber attrition while maximizing the uniform dispersion of the fibers during plasticizing, filling and forming.

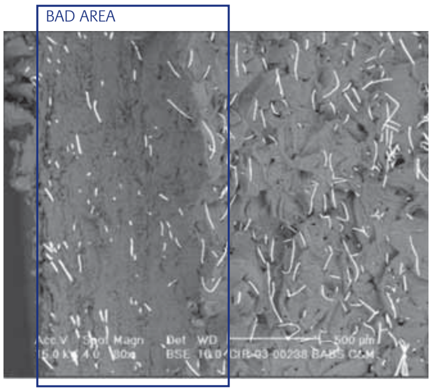
Example of optimized processing



Examples of sub-optimized processing



Near Injection Area



Far from Injection area

This is key to creating the faraday cage effect and critical to achieving the bulk conductivity essential for optimum shielding effectiveness. The following equipment guidelines and processing conditions will yield the best results

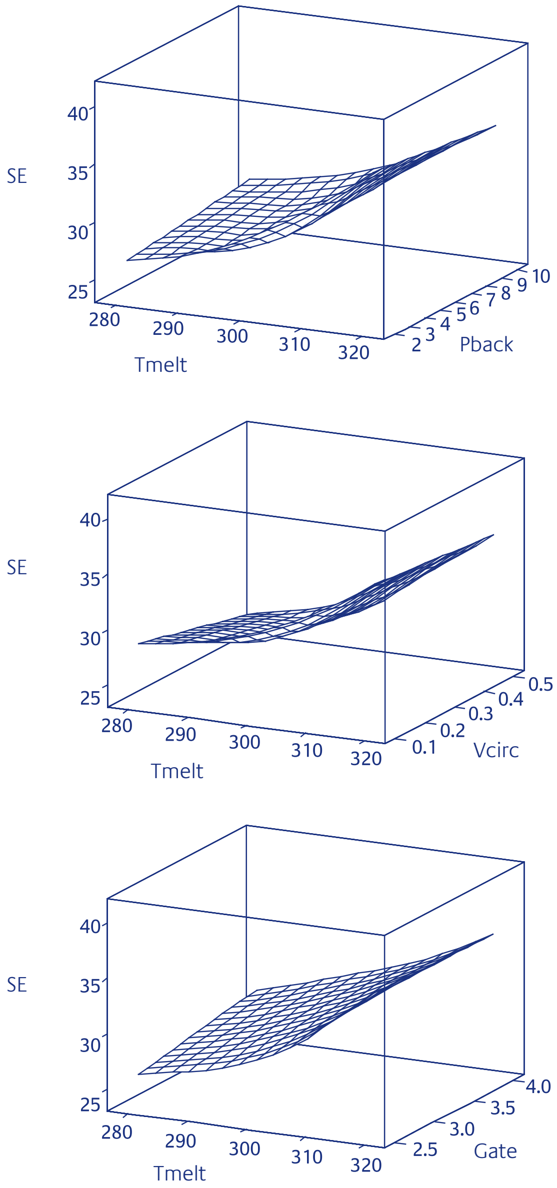
- Use a general purpose screw with a compression ratio at a maximum of 2.5:1.
- Use a “free flow” screw tip to reduce fiber breakage.
- Do not use mixing screws.
- Remove hopper magnets, which could disrupt pellet flow and feed.
- Use slower injection speeds during fill to minimize shear and fiber attrition.
- Use low back pressure (less than or equal to 50 psi) and low screw RPM during recovery.
- Use a shot size 40 – 70% of barrel capacity.
- Minimize viscosity by setting melt temperatures on the high end of the process window for the base polymer. This parameter has the greatest influence on minimizing attrition as lower melt viscosity helps to minimize shear and lower the pressure and injection speed required to fill the part cavity (see graphs below).
- Set mold temperatures relatively high to maintain low composite viscosity during cavity fill.

Sprues, runners, gating

Again, to minimize fiber attrition use sprue bushings, and full round tool runner systems with generous dimensions and no sharp corners. Additionally, minimizing pressure drops and shearing through the gating system is also critical. Therefore low shear gating systems are recommended. Do not use pinpoint gating; instead, select a generous gate size (minimum 1.8 mm). Externally heated hot runner systems can be utilized. However hot runners with open nozzles or needle shut-off valves are recommended over torpedo-shaped hot runners due to the higher shear condition that results. For specific recommendations on gating designs and sizing, please contact your local SABIC Innovative Plastics Technical Service Engineer.

Tool materials

Generally for engineering resins and LNP Faradex compounds a hardened tool steel like H-13 is recommended. Often a pre-hardened tool steel such as P-20 or NAKR-55 is used when making very large molds, as the hardening of tool steels in large applications becomes very impractical. When high melt and mold temperatures are required, the steel of choice will be H-13. H-13 is also used to produce hot runner manifolds. It has high tempering temperatures and can withstand high mold processing temperatures without loss of hardness. For more detailed recommendations on tool material selection and construction of tools for processing LNP* Faradex* compounds contact your local SABIC Innovative Plastics Technical Service Engineer.

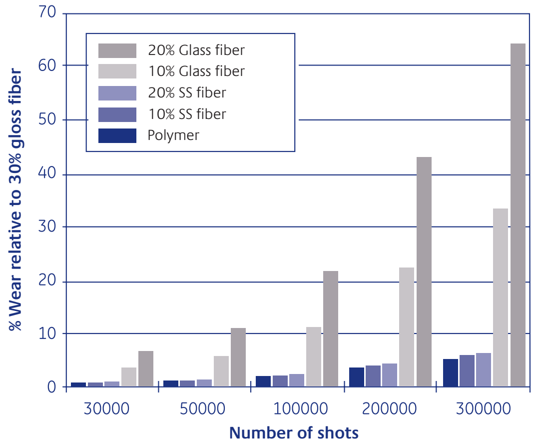


SE = Shielding effectiveness per ASTM D4935
Tmelt = Stock melt temperature °C
Pback = Back pressure in bars
Vcirc - Screw speed in m/s
Gate = Gate diameter in mm

Not a problem!
The question of wear on tooling and injection molding equipment is common among processors considering the use of filled composites such as LNP Faradex compounds. Although the mechanisms for wear are complex and influenced by a number of factors, there are some basic concepts we can refer to that illustrate LNP Faradex compounds will not cause excessive wear on tooling or molding equipment.

First, the hardness for stainless steel is approximately 4.4 Mohs within the range of many other fillers and additives used in thermoplastic compounds (typical range is 3.5 to 5.5 Mohs). Additionally, the volumetric loading of stainless steel fibers in LNP Faradex compounds is low, compared to other filled or reinforced thermoplastic compounds. Furthermore, the aspect ratio of the stainless steel fiber used in LNP Faradex compounds is much higher compared to other chopped fiber or low aspect ratio fillers. The net result of the low loading level and high aspect ratio is that there are fewer abrasive fiber ends present in the compound, which are the main source of abrasion and wear. Predictive wear studies of LNP Faradex compounds versus other filled and unfilled thermoplastic materials is shown in the table below. In this analysis the molten plastic acts as a lubricant between the fibers and the tool steel. The net result shows that processing stainless steel filled compounds does not result in significant wear on tooling or molding equipment.

A word about regrind usage
Although LNP Faradex thermoplastic compounds can be recycled and reprocessed, care must be used when incorporating regrind. This is because the granulation process combined with the reprocessing of the material breaks the stainless steel fibers, reducing the shielding effectiveness in the molded parts. Additionally, because the performance parameters of each application vary (and are affected by processing conditions and part geometry), it is recommended that individual regrind studies be conducted on each application. Regrind studies conducted by SABIC Innovative Plastics with DS0036IP on 3mm thick, 135mm diameter tab gated plaques showed only small shifts in SE and mechanical property performance when tested in accordance with standardized ASTM test methods. Although this demonstrates LNP Faradex compounds can be recycled, individual regrind studies must be conducted to confirm performance.



SABIC Innovative Plastics' enviromentally progressive initiative is a major worldwide effort to drive new business opportunities by helping customers solve their toughest environmental challenges.

As part of this company-wide initiative, SABIC Innovative Plastics leads the way in the development and manufacture of environmentally responsible engineered plastics that meet global standards for production and recyclability. Many of these products have been designed to meet the requirements of halogen-free parts, help reduce environmentally harmful substances and emissions, conserve water resources and promote energy efficiency.

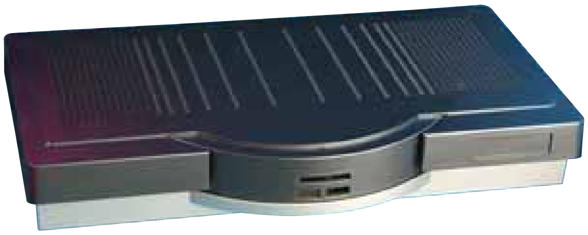
Environmental standards for electronic devices are covered under two broad standards

Restriction of Hazardous Substances (RoHS)

This EU legislation requires the elimination of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants.

Waste from Electrical and Electronic Equipment (WEEE)

The WEEE standard raises the required recycling level for electrical and electronic equipment. Hardware manufacturers are responsible for recycling costs at the end of the devices' life.



Designing this electronic housing to be made from LNP Faradex NS0039 compound allowed the OEM to address their EMC requirements while eliminating a costly, time consuming and environmentally unfriendly multi-step metallization coating process.

LNP* Faradex* compounds can help

All LNP Faradex compounds are RoHS compliant, and some grades are made with non-brominated, non-chlorinated flame retardant systems.

Furthermore, because they are available in precolored versions and because they can eliminate the need for metallization treatments, they do offer OEMs the potential to eliminate volatile organic compounds (VOCs) emitted by painting and metallization coating processes. Such processes have been shown to negatively impact air quality.

Using LNP Faradex compounds can help manufacturers increase overall productivity by eliminating the painting/plating step, minimizing or eliminating costs from emission-permitting and disposal fees, all while providing an effective EMI shielding solution. At the end of their life cycle, they can be recycled without the need to have paints or plating removed.

Electromagnetic compatibility (EMC) is the subject of numerous standards, both national and international.

The standards require performance in three ways

1. Emission standards, which define maximum levels for each device category
2. Immunity standards, which define performance requirements for products when exposed to EMI
3. ESD/ETF standards which define performance regarding Electrical Fast Transients (EFT)/Electro Static Discharge (ESD)

While the United States and European Union have their own emission and immunity standards (see table), the World Trade Organization has obliged member countries to adopt international standards wherever possible. In EMC, these standards come primarily from the International Electrotechnical Commission (IEC) and the International Special Committee on Radio Interference (CISPR). IEC standards include

- IEC 61000-1 – Introduction, terms and conditions
- IEC 61000-2 – Classification of electromagnetic environments
- IEC 61000-3 – Limits and disturbance levels
- IEC 61000-4 – Testing and measurement techniques
- IEC 61000-5 – Installation and mitigation guidelines
- IEC 61000-6 – Generic standards

Efforts continue to harmonize and/or adopt international standards, as current standards share similarities but are not 100% equivalent.

A summary of device classifications and their applicable Electromagnetic Compatibility (EMC) standards in the U.S.A and EU

1) European and U.S. standards share similarities, though they are not equivalent.
2) The FDA and their Center for Devices and Radiological Health (CDHR) encourage device manufacturers to use IEC 60601-1-2 (medical equipment, electromagnetic compatibility requirements and tests) as their EMC standard, which includes limits for both emission and immunity.
3) SAE standards are self imposed by the Automotive Industry through agreement with the FCC.

FCC regulations

The Federal Communications Commission (FCC) has its own set of EMC standards. Under these standards, a digital device is defined as an "unintentional radiator that generates and uses digital timing signals operating at > 9KHz."

These are categorized in two classes

- Class A, for industrial and commercial (central office) equipment (allowing for EMC testing at 10 meters)
- Class B, for use anywhere, especially residential environments (testing at 3 meters)

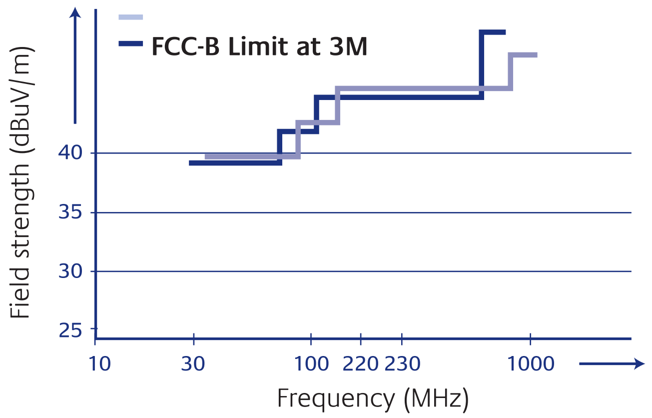
A destra è riportato il confronto di un test di emissioni su un alloggiamento a sei lati che mostra le prestazioni dei compound LNP* Faradex* DS0036IP rispetto al PC-ABS ignifugo con deposito sotto vuoto.
The testing is one example of the product and application testing SABIC Innovative Plastics can provide through our development centers, and highlights our commitment to support customers in their efforts to develop solutions to their EMC challenges using LNP Faradex compounds.

- Emissions testing per guidelines of FCC CFR 47 Part 18 (3m distance).
- Enclosure design 2 mm-thick wall and a 3 mm lap joint.
- Metallized FR PC/ABS consists of a 1 um Ni top coat over a 4 um Cu sub-coat with <5 ohm diagonal resistance, that passed a #405-type adhesive peel test.

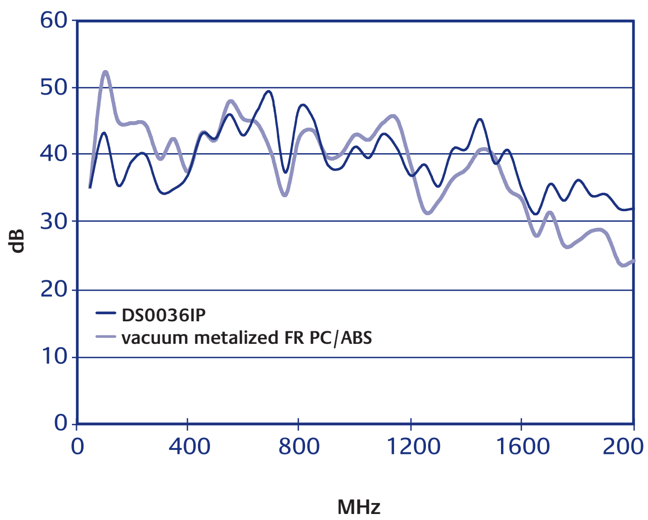
Device category	USA[1]	European union[1]
ISM equipment[2]	FCC CFR 47 Part 18	EN 55011/CISPR 11
Vehicles	SAE J551-2[3]	EN 55012/CISPR 12
Radio and TV receivers	FCC CFR 47 Part 15	EN 55013/CISPR 13
Household appliances		EN 55014/CISPR 14
Luminaries		EN 55015/CISPR 15
ITE equipment	FCC CFR 47 Part 15	EN 55022/CISPR 22

A comparison of emission limits for FCC regulated assembled digital devices

(i.e., ISM, radio and TV receivers class B devices, ITE class A devices)

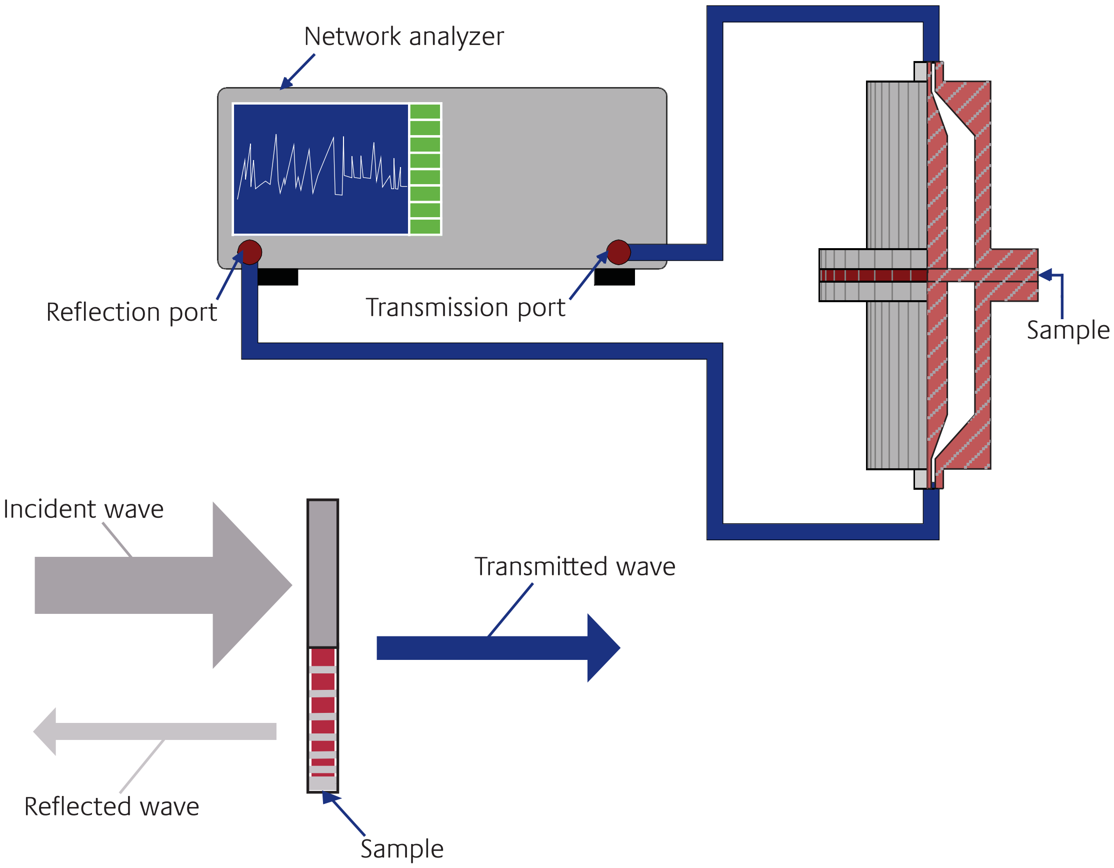


LNP Faradex DS0036IP compound vs. vacuum plated FR PC/ABS



ASTM D4935

This method is well suited for heterogeneous materials and reports SE of a material in a planar configuration, exposed to a far field electromagnetic wave. Typically, measurements are taken over a frequency range of 30MHz.–1.5GHz. This method is suitable for various materials and is useful for product development and evaluating the performance of different shield materials and different shield thicknesses. Although no longer actively maintained, ASTM D4935 is a sound standard for far field shielding effectiveness testing and shows good precision, accuracy and reproducibility.

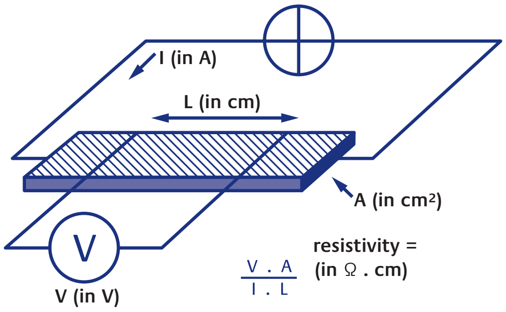


Bulk conductivity for testing shielding effectiveness

- Suitable for sheet samples
- Utilizes "four-point" probe method (ISO 3915)
- Measures square resistance (R_S), defined as the resistance from one side of a material sample to the other, expressed as

$$R_s = \frac{l}{\sigma * l * t} = \frac{1}{\sigma * t}$$

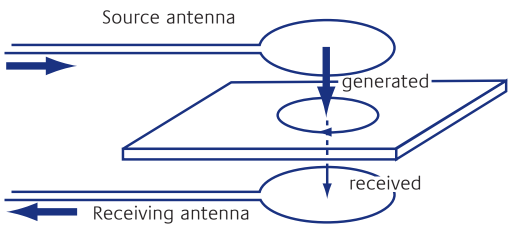
R_S is independent of sample area. Under far field conditions (shield > l/2π from source), R_S can be used to approximate Shielding Effectiveness performance by the relationship SE = 20*LOG(1+188.5/R_S). For homogeneous conductors R_S can be measured predictably and reliably. However, in heterogeneous composite materials, R_S is more difficult to measure consistently by this method due to variations in surface conductivity and will therefore **under-predict** SE. A more effective way of measuring bulk conductivity of LNP* Faradex* compounds is to use an Eddy-Current measurement technique as described at right.



Eddy-Current (LNP Faradex compound-meter) description

A two-probe method that determines the "Square Resistance" (Rs) of a sample by generating an H-field and measuring the attenuated H-field with the receiving antenna (see figure). The induced current in the sample is a direct measure of Rs.

Knowing Rs, Shielding Effectiveness (under far field conditions, i.e., shield > l/2π from source) can be calculated SE = 20*LOG (1+188.5/Rs)



Key benefits

- Method is non-destructive
- The measurement is fast (15 sec.) and requires no sample preparation
- LNP Faradex compound-meter shows good correlation with standardized method (ASTM D4935)
- Method does not require flat surfaces, so it's suitable for application testing
- Equipment is mobile, so it can be used at injection molding trials
- An effective way to monitor Shielding Effectiveness as a quality assurance tool or for application development

Test methods for ESD protection

Surface Resistivity (IEC 93, ASTM D257, ASTM D4496)

- Measures of the ability to conduct an electrical current across a surface
- Typical performance SR < 10^{12} Ω/sq

Static decay (IEC 61000-4-2, FTMS101B, Mil-B-81750B)

- Measure of the ability to discharge a specified electro static load
- Typical requirement is bleed-off time from 5000V to 0V in less than 2 seconds at 23°C and 15% RH

LNP* Faradex* compound property profiles

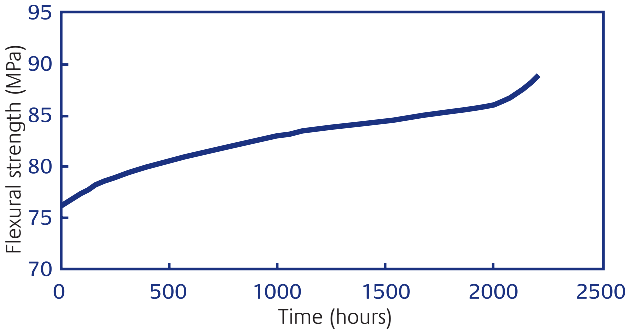
Grade			AS002	AS003	DS0036IP	MS002P	MS003	NS003	NS0039	NS0031	PS003E
Base polymer	Method	Unit	ABS	ABS	PC	PP	PP	PC/ABS	PC/ABS	PC/ABS	PA 6
Physical											
Density	ISO 1183	g/cm³	1.11	1.15	1.29	0.97	1.01	1.21	1.35	1.33	1.22
Mold shrinkage, flow, 24 hrs	ISO 294	%	0.18	0.27	0.4	1.5	1.2	0.3	0.42	0.55	0.72
Mold shrinkage 24 hr (x-flow)	ISO 294 (GM)	%	0.27	0.39	0.5	1.5	1.3	0.35	0.45	0.60	1
Moisture absorption 24 hr	ISO 62	%	0.39	0.37	0.2	0.02	0.02	0.23	0.14		2
CTE, -40°C to 40°C, flow	ISO 11359-2	1/°C	7.80E-05	7.10E-05	6.70E-05	1.16E-04	1.43E-04	5.90E-05	6.40E-05		7.10E-05
CTE, -40°C to 40°C, xflow	ISO 11359-2	1/°C	9.60E-05	9.30E-05	5.60E-05	1.56E-04	1.70E-04	8.20E-05	7.70E-05		7.10E-05
Mechanical											
Tensile stress, yield	ISO 527	MPa	39	38	57	19	21	50	58	61	54
Tensile stress, break	ISO 527	MPa	37	37	55	15	15	46	47	60	54
Tensile strain, yield	ISO 527	%	2.2	2.2	3.8	6.1	5.2	3.5	3.3	3.5	3.33
Tensile strain, break	ISO 527	%	3.3	2.8	4.00%	70	72	6	10	3.7	8.6
Tensile modulus, 1 mm/min	ISO 527	MPa	2500	2700	2889	1200	1300	2700	3200	3550	3009
Flexural stress	ISO 178	MPa	66	66	80	31	32	86	102	106	82
Flexural modulus	ISO 178	MPa	2500	2800	2600	1400	1500	2800	3400	3290	2423
Izod impact, unnotched 80*10*4 +23°C	ISO 180/1U	kJ/m²	20	18	85	100	80	32	43	41	43.5
Izod impact, notched 80*10*4 +23°C	ISO 180/1A	kJ/m²	7	7	11	25	25	9	6	6	4.2
Thermal											
HDT/Bf, 0.45 MPa Flatw 80*10*4 sp=64mm	ISO 75/Bf	°C	91	93	136	84	95	115	89		171
HDT/Af, 1.8 MPa Flatw 80*10*4 sp=64mm	ISO 75/Af	°C	78	78	125	56	56	103	82	97	58
Electrical											
Surface resistivity keithly	ohm/sq	ASTM D257	0-5	0-3	0-3	0-5	0-3	0-3	0-3	0-3	0-3
Volume resistivity keithly	ohm-cm	ASTM D257	2-6	0-4	0-4	2-6	0-4	0-4	0-4	0-5	0-4
Shielding effectiveness @ 0.125"	ASTM D 4935	dB	40 - 55	50 - 65	40 - 55	40 - 55	50 - 65	50 - 65	50 - 65	45-50	
Flammability											
UL compliant, 94V-0 Flame class rating (3)(4)	UL 94 by SABIC	mm	-	-	2.1	-	-	-	3	1.5	-

Note Please consult product marketing for additional product options available.

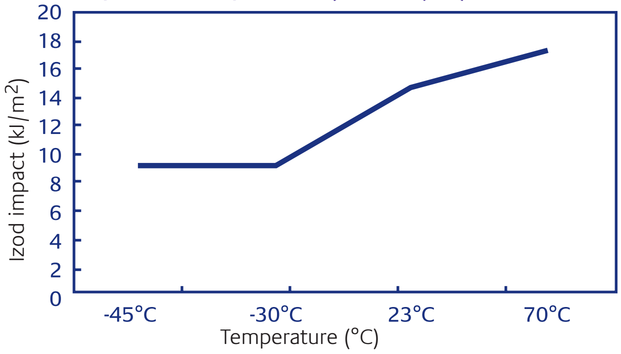
1) Typical values only. Variations within normal tolerances are possible for various colors. All values except mold shrinkage are measured after 48 hours storage at 23°C/50% relative humidity. All properties, except the melt volume and melt flow rates, are measured on injection molded samples. All samples tested under ISO test standards are prepared according to ISO 294.

The charts below highlight long-term continuous performance data that SABIC Innovative Plastics conducts to characterize products and support customer application development activities

LNP Faradex DS0036IP compound – hydrolytic stability (flexural strength vs. time @ 80°C/85% RH)



LNP Faradex DS0036IP compound –notched izod impact vs. temperature (ISO 180/1A)



Grade			AS002	AS003	DS0036IP	MS002P	MS003	NS003	NS0039	NS0031	PS003E
Base polymer	Method	Unit	ABS	ABS	PC	PP	PP	PC/ABS	PC/ABS	PC/ABS	PA 6
Physical											
Specific gravity	ASTM D792	none	1.12	1.16	1.32	0.97	1.01	1.24	1.32	1.33	1.23
Mold shrinkage 24 hr (flow)	ASTM D955	in/in	0.18	0.27	0.4	1.5	1.2	0.3	0.42	0.55	0.72
Mold shrinkage 24 hr (x-flow)	ASTM D955	in/in	0.27	0.39	0.5	1.5	1.3	0.35	0.45	0.60	1
Moisture absorption 24 hr	ASTM D570	%	0.26	0.26	0.11	0.02	0.02	0.13	0.087		1.3
CTE (flow direction)	ASTM E831	10^{-5} in/in/F	4.21	3.59	3.13	5.4	5.49	3.54	3.24		3.95
CTE (x-flow direction)	ASTM E831	10^{-5} in/in/F	4.42	4.32	3.52	6.43	5.8	4.38	3.58		4.28
Mechanical											
Tensile strength (break)	ASTM D638	psi	5762	5749	8016	2262	2213	7282	7630	8600	8048
Tensile strength (yield)	ASTM D638	psi	6235	6157	8343	3089	2996	7610	8552	8900	8077
Tensile modulus	ASTM D638	msi	0.435	0.458	0.424	0.77	0.174	0.451	0.524	0.451	0.458
Tensile elongation (break)	ASTM D638	%	8.6	6.22	4.58	183.75	88.4	4.74	7.4	4.3	23
Tensile elongation (yield)	ASTM D638	%	2.24	2.6	3.96	5.96	6.2	3.3	3.22	3.7	9.62
Flexural strength	ASTM D790	psi	11475	11162	13637	4708	4425	13351	14740	16000	12207
Flexural modulus	ASTM D790	msi	0.409	0.442	0.398	0.176	0.173	0.434	0.452	0.451	0.336
IzodiImpact - notched	ASTM D256	ft-lb/in	1.17	1	2.21	5.26	5.03	1.48	1.26	0.80	0.81
Izod impact - unnotched	ASTM D256	ft-lb/in	5.36	5.76	26.8	27.13	22.97	10.74	15.76		7.3
Multiaxial impact	ASTM D3763	J	11.9	15	26	25	22	15	16		2.12
Thermal											
HDT (66 psi)	ASTM D648	° F	207	206	276	188	198	248	198		367
HDT (264 psi)	ASTM D648	° F	190	191	255	128	129	221	187	203	144
Electrical											
Surface resistivity keithly	ASTM D257	ohm/sq	0-5	0-3	0-3	0-5	0-3	0-3	0-3	0-3	0-3
Volume resistivity keithly	ASTM D257	ohm-cm	2-6	0-4	0-4	2-6	0-4	0-4	0-4	0-5	0-4
Shielding effectiveness @ 0.125"	ASTM D4935	dB	40 - 55	50 - 65	40 - 55	40 - 55	50 - 65	50 - 65	50 - 65	45-50	testing
Flammability											
UL compliant, 94V-0 flame class r ating (3)(4)	UL 94 by SABIC	mm	-	-	2.1	-	-	-	3	1.5	-

Note Please consult product marketing for additional product options available.

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