

Technical environment:

- Fire resistance
- Radiation
- Weathering
- Cold, heat
- Explosion areas
- Vacuum
- Hot chips
- Dirt, dust
- Cleanroom
- Chemicals

Resistance to radiation

igumid G is very resistant to high energy radiation. Under gamma radiation, in the range of 8×10^4 rd, the mechanical properties of igumid G change very little.

Technical environment and igumid G

The igumid G material, from which igus® Energy Chains® are made, possesses the following wide ranging features to cope with a variety of environments: the ability to handle pressure and strenuous loads, abrasion resistance, sturdiness, stable behavior at high and low temperatures, and suitability for outdoor use. Numerous application examples, from refrigerator blocks to steel mills, prove this. In extreme cases, we also offer modifications and other igus compounds as a solution. Please consult igus®.

Flammability of igumid G

The flame retardant characteristics of igumid G can be described using various classifications: Test procedure VDE 0304 parts 3 5.70 classification IIc. Tested according to UL 94 "Standard Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" classification 94 HB for .13 and .06 in. (3.2 and 1.6 mm) thickness of the body. Tested according to DIN 4102 "Fire Behavior of Building Materials and Parts" classification materials class B 2. For further requirements, please consult igus® for special solutions, such as materials with self extinguishing properties (UL V2 or UL V0). All Energy Chains® (except for the E Z Chains and Series 14 Chains) are made of from igumid G.

Flammability of igumid NB

All E Z Chains and Series 14 Chains are made from the flame retardant igumid NB material. These chains have the following flame retardant classifications:
 UL 94 classification V2
 VDE 0304 Parts 3 5.70 classification IIb
 DIN 4102 flammability of materials B2
 Please consult igus regarding material availability "V0."

Temperature resistance

igumid G is very suitable for outdoor applications. In our experience, the mechanical properties of the chain are not impaired. igumid G is also UV resistant. igus® Energy Chains® are used in applications as cold as 40°F (40°C). Installation may be eventually compromised at temperatures below 13°F (25°C). In such cases, we offer special solutions made from cold elastic materials. 266°F (130°C) continuous temperatures are possible. However, the mechanical values are reduced and the service life is impaired. Please consult igus® if you need temperature stabilized solutions.



igus® factory; automatic compounding and conveyor belt for igumid G



igumid G has the classification UL 94 HB; igumid NB has the classification UL 94-V2; V0 upon request



igumid G:
UL 94 HB

igumid NB:
UL 94 V2
UL 94 V0



This robot is used for test purposes in British nuclear power plants;



Live broadcast from the Winter Olympics in Lillehammer; 246 ft (75 m) travel at -13°F (-25°C)

Design: Technical Environment: Dirty Environment with igus® Energy Chains®



igus® Energy Tubes in the chip area of machine tools



tests with 1652°F
(900°C) hot chips

Spatter, hot chips

Laboratory tests and numerous field applications prove that igus® Energy Chains® and Tubes reliably protect cables in welding robots and machine tools. Although welding spatter leaves some visible traces, it does not impair the material or the function. igus® Energy Tubes have successfully withstood tests at 1,652°F (900°C) with medium sized hot metal chips. They are in use worldwide in the chip area of machine tools. (Please note: igumid G in direct contact with large amounts of melted aluminum is **not** recommended.)



igus® Energy Chains® have proven their durability; shown here with wood chips

Dirt, dust, chips

Materials and design make igus Energy Chains® excellent problem solvers in harsh environments. Experience and application references are available upon request. Please consult igus with your application.

Vacuum

igus® Energy Chains® made of igumid G can be used in vacuum applications. Very little out gassing occurs.

Chemical resistance

igumid G is resistant to fuel, lubricants, oils, fats, alcohol, ester, ketone, and aliphatic and aromatic hydrocarbons. Oxidants and acids are damaging. The **Material Data** table on page 1.39 shows an excerpt of the precise details concerning resistance to chemicals. Acid resistant Energy Chains® are available upon request.



Compost sludge - numerous related references available upon request

Table on resistance to chemicals

► Page 1.40

Coolant resistance

Energy Chains®/Tubes have proven resistant to cooling agents. However, we are always willing to perform individual tests if you have particular problems or advanced developments.

Preferred series for dirty environment applications

- System E4
- E2 Tubes
- E2/000

Igumid ESD is RAL 7015 slate-gray.



ESD & ATEX

Special ESD products and ESD tools must be used in numerous industrial sectors in order to protect sensitive electronic components against electrostatic discharge. Consequently an electrostatic discharge function applies in particular to energy ducting systems with a central role in automated sequences. igus® has developed the ESD E Chain® for these demanding applications. They are made of material igumid ESD, which immediately discharges permanent electrostatic charges in a controlled manner.

igumid ESD consists of the igus® E Chain® material with special additives. For instance, the higher rigidity and the 15% lower density can be used to implement a longer unsupported length, depending on the application. The ESD Energy Chain® features longer service life due to the material. Unlike temporary applied conductive coatings or volatile, antistatics, the additives used provide durable and maintenance free conductivity. Another advantage is the resistance to adverse ambient conditions.

System E6 - 2nd generation ESD chains without pin and bores, long-term conductivity guaranteed

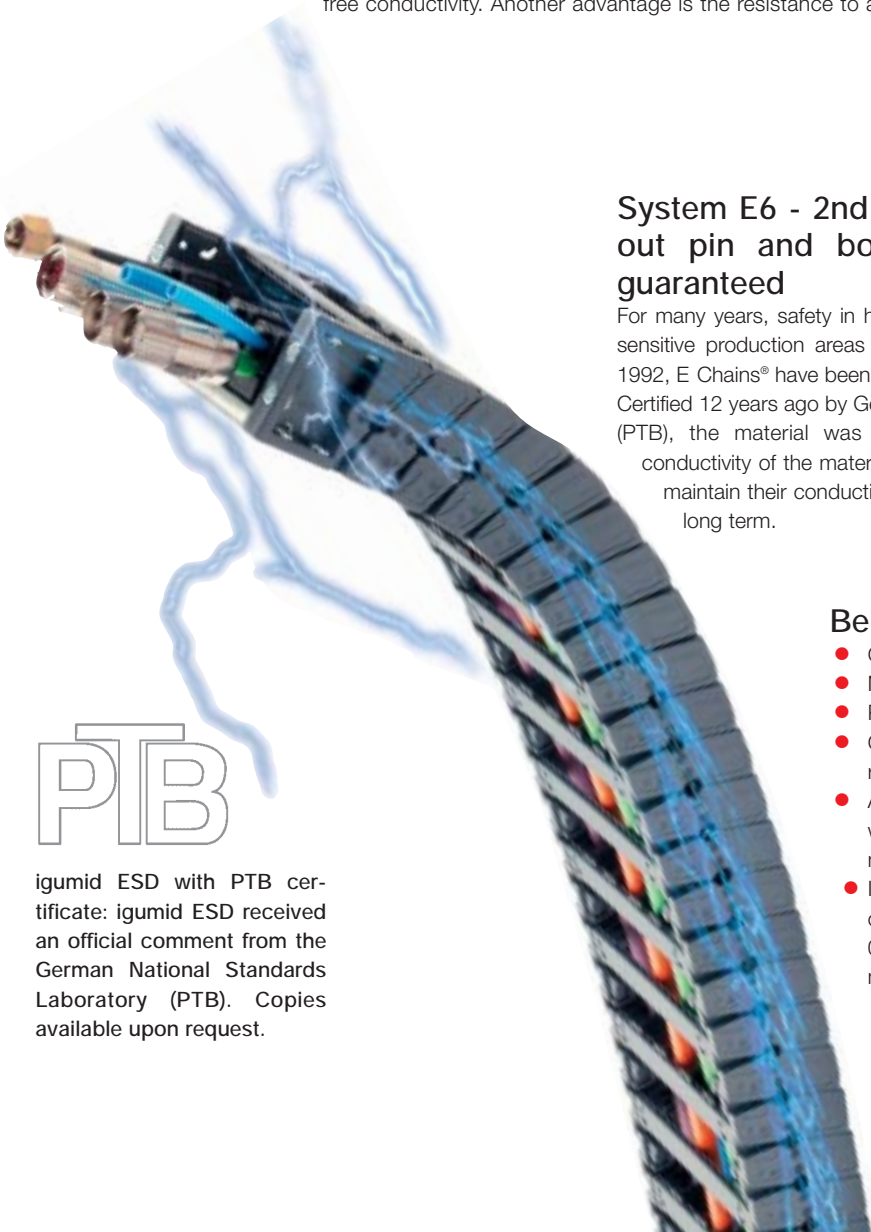
For many years, safety in hazardous environments and ESD protection in sensitive production areas have been given high priority at igus®. Since 1992, E Chains® have been manufactured from igus' special "GC" material. Certified 12 years ago by German federal office for Physics and Technology (PTB), the material was modified in 2002. In spite of homogenous conductivity of the material, common pin/bore design chains can hardly maintain their conductivity within normal conductivity tolerances in the long term.

Benefits:

- Constant long term conductivity values
- No contact surface wear
- Proven standard product, now also conductive
- Cycle life in lab test ≥10 million cycles (more upon request)
- Adheres to heightened QC procedures with and without mounting brackets and in various install modes
- IPA Fraunhofer institute certifies "Level 1" discharge performance, according to SEMI E78 0998 ESD, even for off the shelf standard E6 material.



igumid ESD with PTB certificate: igumid ESD received an official comment from the German National Standards Laboratory (PTB). Copies available upon request.



Design: Technical Environment:

igus® goes cleanroom - qualification of E6 and other igus® Energy Chains®

In many applications where cumbersome special solutions are used, a simple standard Energy Chain® can be used instead. A comprehensive test program was devised and performed for both gliding use and unsupported use. For many applications, the Energy Chains® in special materials are practically abrasion free. Detailed test results are available upon request.

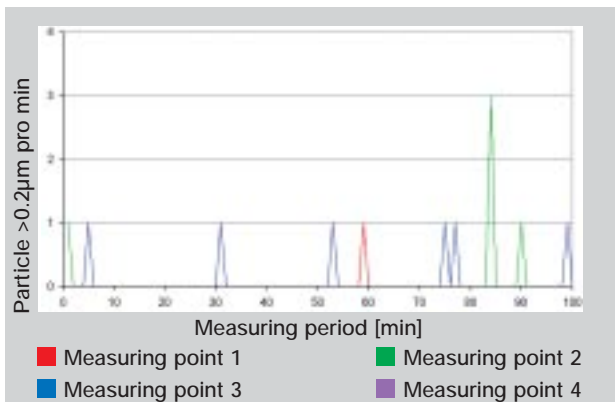
IPA tests confirm that standard igus® Energy Chains® meet clean room requirements. Iigus® Energy Chains® were tested extensively and delivered a superior performance. Clean room applications demand very high wear resistance of moving parts and Energy Chain® is able to meet this need, even in the extremely sensitive environment.. IPA Fraunhofer Institute has tested igus® Series E6 and E14 as follows:

- ISO class 2, as per stringent norm DIN EN ISO 14644 1 for Series EasyChain® E14 3 038 at v 3.28 ft/s (1 m/s)
- ISO class 3, as per stringent norm DIN EN ISO 14644 1 for System E6, Series E6 29 050 at v 3.28 and 6.56 ft/s (1 and 2 m/s)
- ISO class 4, as per stringent norm DIN EN ISO 14644 1 for System E4, Series 280 100 at v 6.56 ft/s (2 m/s)

Test setup "Cleanroom" with E14-3-038-0 particle generation measurement



Measurement result:
Particle generation E14-3-038-0



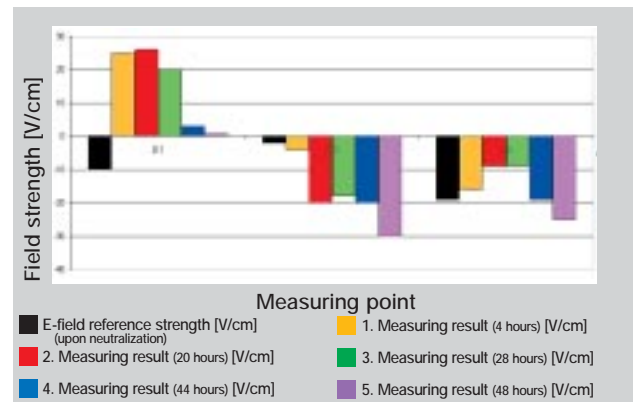
ISO Class 2

acc. to DIN EN ISO 14644-1
for E14-3-038-0

Test setup "ESD" with E6-29-050-055-0 field strength measurement



Measurement result:
Field strength E6-29-050-055-0



Level 1

ESD-compatibility acc. to SEMI E78-0998
for E14-3-038-0 and E6-29-050-055-0

Classification chart

Class per DIN	Equivalent to VDI 2083	Equivalent to US Fed.Std. 209E
EN ISO 14644-1	VDI 2083	US Fed.Std. 209E
ISO class 1	no comparable classification	no comparable classification
ISO class 2	no comparable classification	no comparable classification
ISO class 3	class 1	class 1
ISO class 4	class 2	class 10
ISO class 5	class 3	class 100
ISO class 6	class 4	class 1,000
ISO class 7	class 5	class 10,000
ISO class 8	class 6	class 100,000

Classification E14-3-038-0 at v = 3.28 ft/s (1 m/s)

Classification E6-29-050-055-0 at v = 3.28 ft/s (1 m/s)
and v = 6.56 ft/s (2 m/s)

Examples for test certificates and approvals of igus®-products

Certified
ISO 9001:2000

ISO 9001:2000

igus® has been certified since May 2002



Quality inspection of every E-Chain® production



TÜV construction test

igus® Energy Chains® and Energy Tubes are construction tested by TÜV Rheinland. igus® Energy Chains® were tested and passed by TÜV Rheinland in accordance with the valid machine guidelines. As a result, the user of igus® Energy Chains® need not worry about meeting CE requirements through testing for this portion of the machinery.

The construction test 2PFG 1036 / 10/97 for protective equipment includes the following:

- Application/safety
- Assembly
- Fatigue strength
- Resistance to external influences
- Sharp corners and edges



Test location for ESD-E-Chains®



ESD/ATEX

igus® Energy Chains® made of standard material igumid G correspond to the German federal office of Physics and Technology (PTB) to classification Ex II 3 GD according to ATEX RL 94/9/EG. igus® Energy Chains® made of igumid ESD correspond according to the German federal office of Physics and Technology (PTB) to classification Ex II 2 GD according ATEX RL 94/9/EG.



IPA Cleanroom

A lot of Energy Chains® are suitable for the use in cleanrooms according to DIN EN ISO 14644 1. Confirmed by the IPA Fraunhofer Institute.

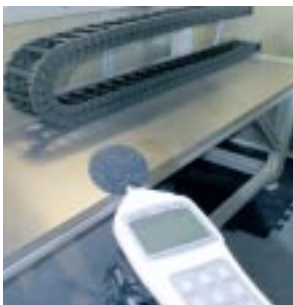


Chainflex® cables with many certificates for e.g. DESINA



UL, CSA, CEI, CE, VDE, Interbus and DESINA

All igumid materials for Energy Chains® and E Tubes have got the UL material approval. The material igumid NB has got the fire protection class approval IIb according to the test VDE 0304 Part 3/5.70, the approval V2 according UL 94 and the construction material class B2 according DIN 4102. Chainflex® cables are produced according to a lot of international standards: **Interbus certification:** For Interbus certification of certain CF11 bus cables. **DESINA:** Many Chainflex® cables are Desina compliant.



Noise level tests in igus® own acoustic laboratory



Clearly quieter

igus® Energy Chain Systems® are clearly quieter. In the acoustic laboratory of the TÜV and the igus® GmbH different Energy Chains® were compared. The igus® System E3, E6 and E4/00 (Series E4/101) are measurably (and clearly) quieter than other products of comparable size (see also noise optimized Energy Chains®)



igumid

The material igumid is free from toxins, according 2002/95/EC (RoHS).



iF Design Award

13 iF Design Awards since 1984

Design: Material Data igumid and Energy Chain® colors

Material data table	Units of Measure	Values igumid G	Values igumid NB	Values igumid N	Values igumid ESD	Values igumid TE
Yield stress	Mpa	190/130	78/40			
Elongation at break	%	004/006	20/210			
Elasticity module (tensile test)	MPa	9000/7000	2900/1200			
Impact strength +23°C	kJ/m²	55/65/55				
Impact strength 40°C	kJ/m²	40	90			
Ball indentation hardness H 961/30	MPa	230/160	150/60			
Head conductivity W/k * m	Ω/k * m	0.23				
Dielectric constant	10 ⁶ Hz	3.9/6.2				
special transitional resistance	Ω*cm	>10 ¹¹	>10 ¹¹	>10 ¹²	<10 ⁹	
Impact strength density 0.6 0.8 mm	kV/mm	80	16 18			
Surface resistance ROA	Ω	>10 ¹¹	>10 ¹¹	>10 ¹¹	<10 ⁹	
Density	g/cm³	1.37	1.14	1.14	1.2	1.02
Absorption of humidity 23/50 RF	%	1.4	3.4	1.4	1.9	1.1
Coefficient of sliding friction		0.3	0.3	0.3	0.3	0.3
Fire resistance as per VDE		FH2				
Fire resistance as per UL		94 HB	94 V 2	HB	HB	HB
Color		■ ≈ RAL 9004	■ ≈ RAL 9004	■ ≈ RAL 9004	■ ≈ RAL 7015	■ ≈ RAL 9004
Maximum water absorption		5.6	7.6	7.6	7.3	
Limit of elasticity in bending		7.800 Mpa	3.000 MPa	3.000 MPa	9.500 Mpa	
Bending strength		240 Mpa	120 MPa	110 MPa	230 Mpa	
Hardness Shore D		79	79	79	83	
Upper long term application temperature		120°	80°	80°	80°	100°
Upper short term application temperature		180°	170°	170°	150°	130°
Lower application temperature		40°C	40°C	40°C	40°C	30°

Colors and special solutions

All E Chains® made from igumid G are available in the colors listed below. Additional colors are usually feasible. Colored E Chains® are basically not available from stock. Contact igus® for more information regarding colored E Chains®. All values listed apply to stability (e.g. unsupported lengths) and material characteristics for black E Chains® only. Colored E Chains® may have altered characteristics. This also applies for all E Chains made from special materials (e.g. conductive E Chains® made from igumid GC or other special materials).

"RAL" Numbers

	Black	≈ RAL 9004	Index .0
	White	≈ RAL 9003	Index .1
	Magenta	≈ RAL 4010	Index .13
	Yellow	≈ RAL 1018	Index .4
	Orange	≈ RAL 2003	Index .2
	Red	≈ RAL 3002	Index .6
	Blue	≈ RAL 5005	Index .8
	Green	≈ RAL 6011	Index .7
	Grey	≈ RAL 7023	Index .3 for Chains
	Silver-grey	≈ RAL 7037	Index .3 for Tubes
	Grey	≈ RAL 7038	Index .11
	Light grey	≈ RAL 7035	Index .14
	Schist-grey	≈ RAL 7015	only ESD-E-Chain®
	Yellow/black	-	Index .9



Colors for design coding

Medium	Concentration Weight %	igumid G and NB
Acetone	100	A
Formic acid (aqueous)	2	B
Ammonia (aqueous)	10	A
Gasoline	100	A
Benzole	100	A
Bitumen	100	B
Boric acid (aqueous)	10	A
Butyric acid	100	B
Calcium chloride (aqueous)	Sat. aq. sol.	A
Chlorinated hydrocarbons		
Chlorine water	Sat. aq. sol.	C
Chromic acid (aqueous)	1	B
Diesel oil	100	A
Iron II cyanide	30	B
Acetic acid	2	A
Color		A
Fats, cooking		A
Fluorinated hydrocarbons		A
Formaldehyde (aqueous)	30	B
Hydraulic oils		A
Caustic potash	10	A
Potassium carbonate (aqueous)	60	A
Potassium sulphate (aqueous)	100	A
Methyl acetate	100	A
Milk		A
Mineral oil		A
Sodium carbonate (aqueous)	50	A
Oil, cooking		A
Oil, lubricating oil		A
Oleic acid	100	A
Paraffin oil		A
Perchlorethylene	100	A
Polyester resins (with styrene)		A
Propane gas		A
Mercury		A
Hydrochloric acid	pH2	B
Hydrochloric acid	2	C
Hydrochloric acid	10	D
Ink, printing ink		A
Vaseline		A
Tartaric acid		B
Zinc sulfate (aqueous)	10	A

Resistance classes

A:	resistant
B:	conditionally resistant
C:	partially resistant
D:	non-resistant
E:	soluble
Sat. aq. sol.:	saturated aqueous solution
Conc. aq. sol.:	concentrated aqueous solution

The values specified are values determined by laboratory tests and are material specific. All specifications apply to black E Chains®.