chainflex®

MAGAZINE

Fail-safe cables for motion in e-chains®
World's No. 1 in terms of choice, testing and guarantee

plastics for longer life®

igus®.eu...

www.igus.eu/chainflex

igus® has been producing cables for the e-chain® for more than 28 years

Your technical innovator and cost reducer,

Richard Habering
Product manager for chainflex® cables
Phone: +49-2203 9649-9806
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Your technical innovator and cost reducer,

Rainer Rössel
Head of Business Unit chainflex® cables
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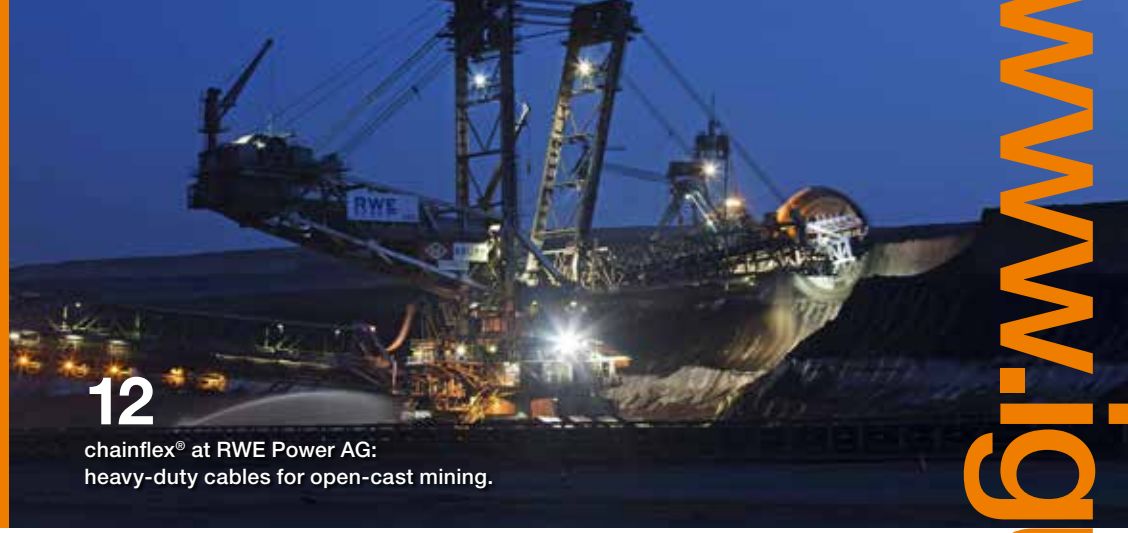
chainflex® - cables for motion with guarantee

We have been developing, testing and producing cables for use in energy chains® for more than 28 years. When it comes to flexible cables, our experience grants us the highest level of development expertise. Our chainflex® cables function reliably and are highly durable. They work so well that we are the only manufacturer who offers you a **guarantee for our cables**: 36 months or over 10 million double strokes. We offer you the best service to ensure that you can quickly find the right chainflex® cable: online tools such as a product finder or service life calculator as well as an extensive network of sales partners.

The chainflex® cables meet the requirements for EMC safety as well as the standards and guidelines such as UL, CSA, VDE, EAC, CTP, Interbus and Profibus. Additionally, various jacket materials are available. The product range includes everything from control cables, servo cables, motor cables and robot cables to bus cables, data cables, encoder cables and fibre optic cables. The chainflex® cables for energy chains® work flawlessly over long periods even with many cycles, high speeds and accelerations as well as very extreme ambient conditions. Convince yourself - in this magazine.

www.igus.eu/chainflex

Contents



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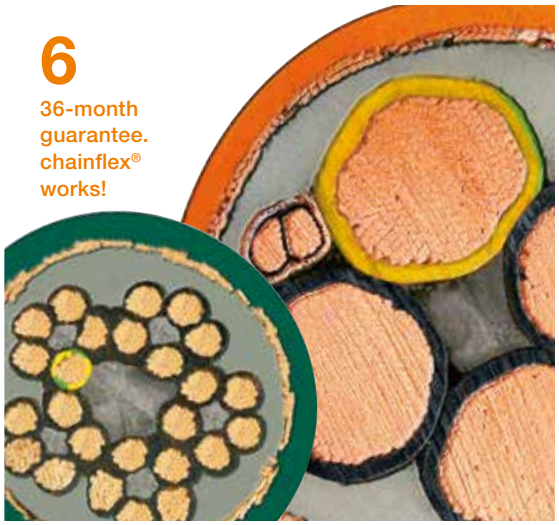
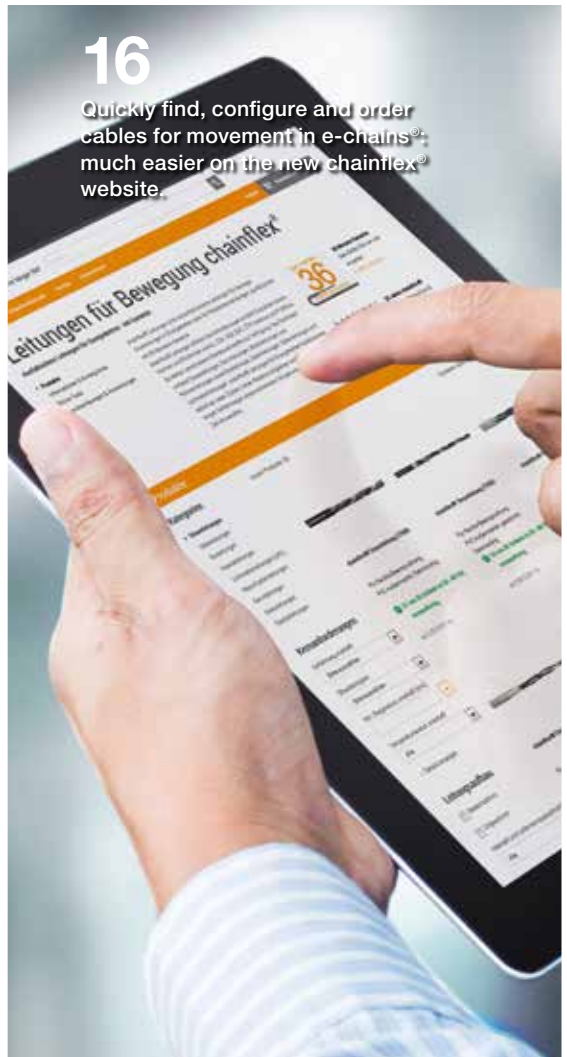
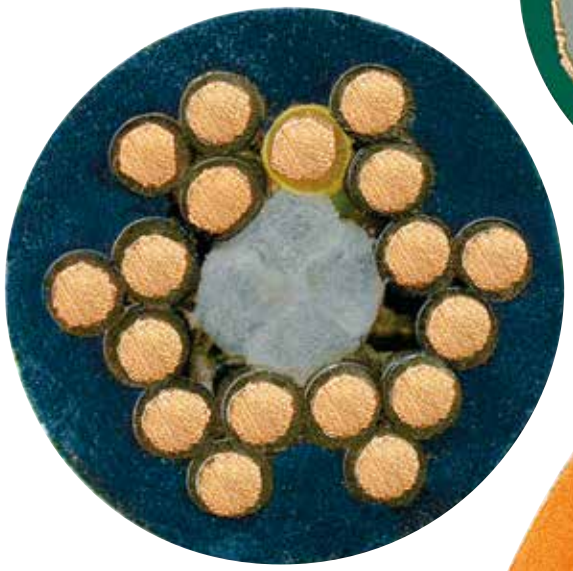
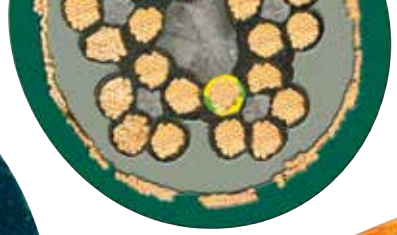




36 month guarantee. chainflex® works!





The tricks and ingenious features of the chainflex® design and why we have felt so confident about it for more than 28 years.

chainflex® is unique

From the customer's point of view, a flexible energy supply system only needs to function properly. However, this demand presupposes the perfect operation of all components, including the cables being used in this system. And this is exactly where problems came up in the early 1980s. In extreme cases, failures caused by "corkscrews" and core ruptures brought the entire production process to a standstill and resulted in high costs. igus® was the first company to develop complete e-chainsystems®. chainflex® cables and e-chains® are tested and optimised in conjunction. Based on the increasing know-how gained since 1989 and on the very sophisticated series of tests that have been conducted since then, design principles were and are still being created that help prevent machine downtimes in factories throughout the world today.

chainflex® - the special cables for energy chain systems®

In complex applications with high cycle rates, speeds and rates of acceleration, as well as adverse ambient conditions, cables used to supply energy must always be reliable. A high degree of EMC reliability and adherence to standards and directives such as UL, CSA or VDE are essential. A reliable function of bus properties in the area of Profibus, Profinet or Ethernet is required. Ultimately, our customers expect a consistent response to different forms of movement, because they require the same electrical characteristics in both long linear chains and small torsional movements. It is our mission to guarantee this worldwide and non-stop.

Avoid failures, guaranteed - more than 2 billion test strokes and 1.4 million electrical measurements per year. For more than 25 years, igus® has been carrying out tests in the industry's largest laboratory for moving cables and energy chains®.

www.igus.eu/chainflex

Tested, tested, tested. Eight features of igus® chainflex® cables

8 basic rules for a good cable for use in e-chains®

In over 2 billion test cycles per year in the igus® laboratory (2,750 m²), we have gained a unique knowledge of cables in the area of e-chains®. The rules for extremely durable cables are based on this.

1 Tensile stress-resistant centre element
Made of real core element: supports the core structure around it and prevents movement of the cores into the middle of the cable.

2 Optimised core design
Long series of tests found a specific combination of strand wire diameter, strand pitch and direction to be the best bending-resistant solution.

3 High quality core insulation
To support the individual strands of the conductor. Made of very high-quality PVC or TPE materials, extruded under high pressure.

4 Braiding in bundles with short pitches
The braided or layered structure must be formed around a strong, tension-proof centre with an optimised short pitch length.

5 Gusset-filling extruded inner jacket
Reliable guidance of the core structure in a longitudinal direction. Moreover, the structure cannot fall apart or move around.

6 Total shield with optimised braiding angle
Made secure with optimised braiding angle over the extruded inner jacket. Torsion protection for the core structure.

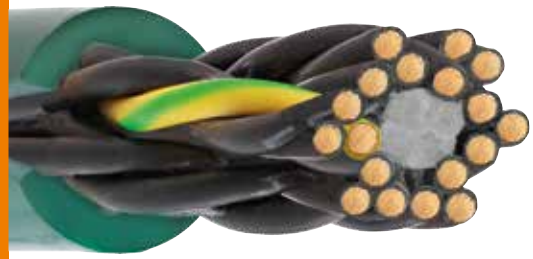
7 Pressure extruded, abrasion-resistant outer jacket
Flexible jacket materials for very different requirements: UV-resistant, flexible at low temperatures, or the best low-cost solution.

8 CFRIP® tear strip
With the CFRIP® technology, you save up to 50 % of the time spent stripping cables. A total of 569 chainflex® cables now come with CFRIP®.

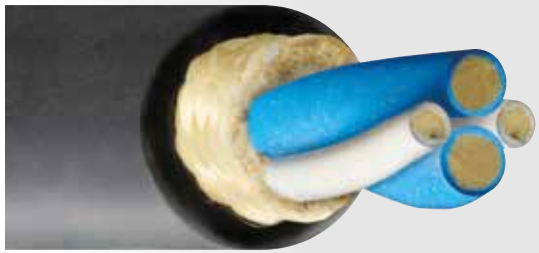
Guarantee igus chainflex 36 month guarantee

www.igus.eu/chainflex

1,354 chainflex® types available from stock



Control cables



Fibre optic cables

Motor cables

Ordered today, delivered tomorrow. The igus® delivery service: ready for delivery in 24-48h

The goods leave igus® within 24 hrs. On request we can deliver via express or special delivery.

- Available from stock
- No minimum order
- No minimum order quantity
- No costs for cutting cables
- Delivery and consultation daily from 7 am to 8 pm, Saturday from 8 am to 12 pm
- Online order tracking
- Invoices and confirmations by post, fax, or e-mail
- Emergency service "around-the-clock"
- Certification according to ISO 9001:2008 and ISO/TS 16949:2009

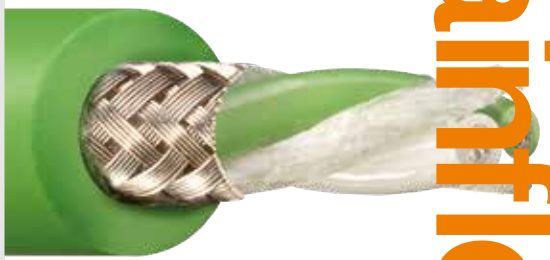
Bus cables

Data/Coax cables

Control cables

Measuring system cables

Twistable cables



Special cables

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chainflex® at RWE Power AG: heavy-duty cables for open-cast mining

In the Garzweiler open-cast mine, brown coal is to be found in three seams, which, together, are 40 metres thick on average. The coal is at a depth of between 40 and a maximum of 210 metres beneath the surface.

The high load that the electric cables in the open-cast coal mine is subjected to becomes clear immediately when you look at one of the powerful bucket-wheel excavators operating in the Rhine mining district. After extensive tests, RWE Power AG decided to include igus® chainflex® cable as one of the company's standard products used. Customised, optimised cables are used that are especially resistant to mechanical loads.

www.igus.eu/chainflex

Repairs of bucket-wheel excavators usually involve a lot of work.

igus® develops special cables for bucket-wheel excavators

Bucket-wheel excavator: high load on the electric cables.
A "medium-sized" excavator extracts 110,000 metric tons per day. The mining equipment and the associated electrical components such as sensors and cables are subjected to extreme levels of mechanical stress. The resulting dust has an abrasive effect and is accompanied by moisture, temperature fluctuations and continuous movement. Components of other relevant suppliers would fail quickly under these conditions. As the operator of the three open-cast mines Garzweiler, Hambach and Inden RWE, Power AG has defined extensive company standards on the basis of which purchasing and technical decisions are made.

Customised cables for mining. For each of these cables, requirement profiles were drawn up with exactly 20 criteria such as UV-resistance, non-flammability, tear-resistance, resistance to oil, bio-oil and lye as well as flexibility. Gunther Busch explains: "As our experience with the chainflex® cables from igus® since 2006 has been good, these cables were put on the short list." igus® indicated its willingness to develop special cables for the special requirements of open-cast mining. The bus cables of the CFBUS series, which had been proving their worth for years in the face of extremely high dynamic loads and with very small bend radii, were used as the basis.

Inclusion in company standard after successful tests. After successful completion of the tests - including a practical test with the large machines - the tested chainflex® cables were included as special cables in the RWE-Power-company standard for electric cables. Gunther Busch: "We have now stocked up with four of the five types of cable and defined a minimum stock level. The cables are always available and the small number of procurement transactions reduces costs and the amount of work required." As a result, logistics has also been improved in that igus® supplies the cables on especially robust drums.

From left to right: Jürgen Lenz, Project Engineer in the Technical Centre for Open-cast Mine of RWE Power AG, Gunther Busch, Technical Support Electrical Engineering of the Garzweiler Open-cast Mine and Andreas Muckes, Product Manager chainflex®.

Production processes must be constantly adapted to new requirements in order to increase the efficiency and flexibility.

Robotic bolting systems with igus® catalogue cables

Delivery from stock, no minimum order quantity, no cutting costs - these are the benefits of chainflex® robot cables from igus®. In addition they are tested for many millions of cycles in torsion applications, thus ensuring a long service life in everyday operation. They are used in bolting systems with automatic feeding for example in the automotive industry. Originally developed as special cables, they are available today as catalogue items and also prove their usefulness in other joining techniques including welding applications.

In use for years: reliable and safe systems from igus®

The automation is controlled by proven and reliable systems from igus®. With a multi-axis moving energy supply system all the necessary cables and hoses are routed safely. The rugged energy chain® and the torsion-resistant robotic cables for 3D applications guarantee a long service life and are available ex works. Both companies have been collaborating closely for many years. A number of further developments in the field of energy supply and cable technology can be traced to the complex requirements of the provider's customised screwdriving robots.

From left: Wolfgang Wagenstaller, Erwin Pfaffenroth, Michael Steidl (all WEBER), Richard Habering (igus®), Florian Hinterauer (WEBER).

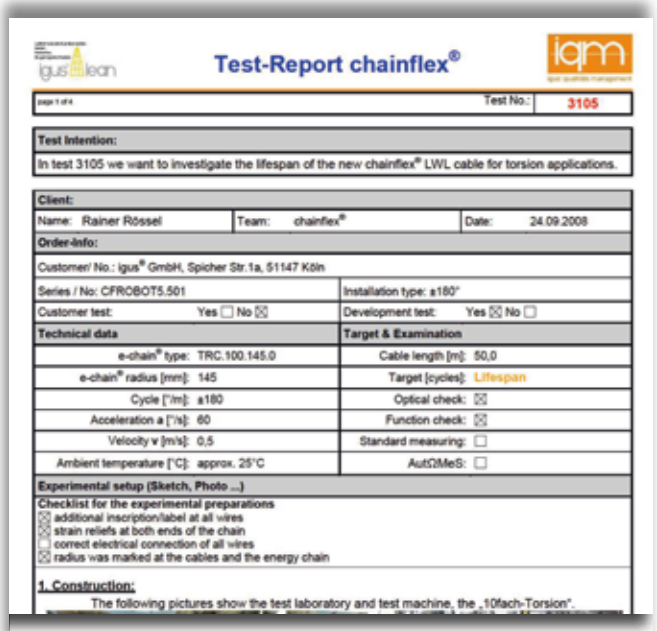
The WEBER Schraubautomaten GmbH with around 250 employees produces annually more than 1,000 machines for assembly automation, mainly in the area of bolting technology**.** The products range from the handy screwdriver to extremely sophisticated system solutions for customer-specific tasks. Particular emphasis is placed on providing advice and service. For electronics development of a special high-end control system, right down to mechanics, our in-house expertise is available on your site. Representatives worldwide provide for the distribution and smooth service. WEBER makes use of the entire product range of igus®.

chainflex® works: fibre optic cable twisted 27.5 million times

Moving energy made easy: chainflex® fibre optic cable CFROBOT5.501 lasts for more than 27 million cycles. Proven in test 3105, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 3105
- Cable type: CFROBOT5.501
- Test parameter: torsion test ± 180°/m
- Service life: 27.5 million cycles
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test3105



igus lean — Test-Report chainflex® — iqm

Test No.: 3105

Test intention:

In test 3105 we want to investigate the lifespan of the new chainflex® LWL cable for torsion applications.

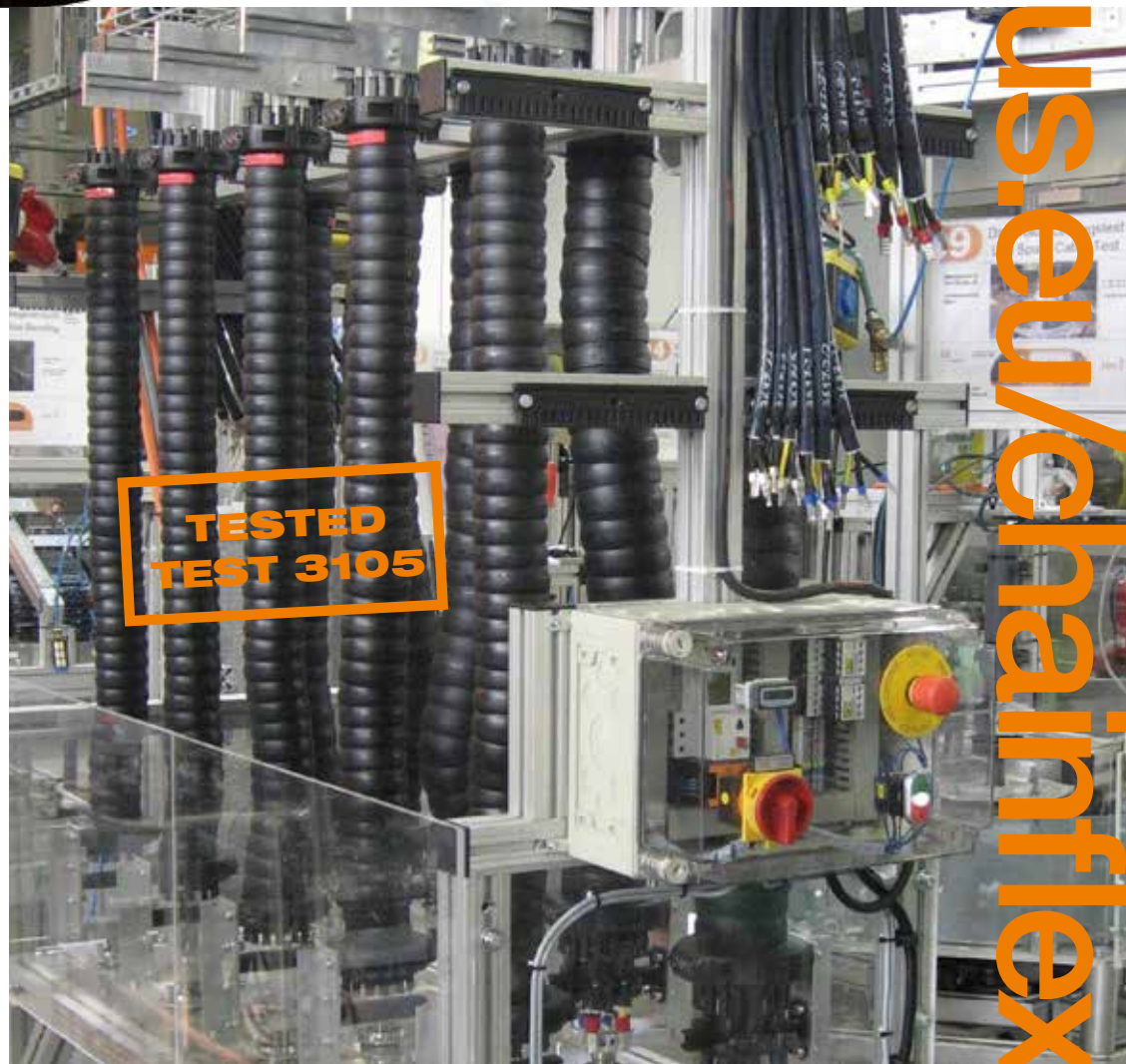
Client:			
Name: Rainer Rössel		Team: chainflex®	Date: 24.09.2008
Order-Info:			
Customer/ No.: igus® GmbH, Spicher Str.1a, 51147 Köln			
Series / No: CFROBOT5.501		Installation type: ±180°	
Customer test:	Yes ☐ No ☒	Development test:	Yes ☒ No ☐
Technical data		**Target & Examination**	
e-chain® type:	TRC.100.145.0	Cable length [m]:	50,0
e-chain® radius [mm]:	145	Target [cycles]:	Lifespan
Cycle [°/m]:	±180	Optical check:	☒
Acceleration a [°/s]:	60	Function check:	☒
Velocity v [m/s]:	0,5	Standard measuring:	☐
Ambient temperature [°C]:	approx. 25°C	Aut/Meß:	☐

Experimental setup (Sketch, Photo ...)

Checklist for the experimental preparations
- ☒ additional inscription/label at all wires
- ☒ strain reliefs at both ends of the chain
- ☐ correct electrical connection of all wires
- ☒ radius was marked at the cables and the energy chain

1. Construction:

The following pictures show the test laboratory and test machine, the „10fach-Torsion".



www.igus.eu/chainflex

chainflex® in "high-speed" use at HEKUMA GmbH

The high number of cables places stringent requirements on their availability. A cable break - and the machine shuts down. chainflex® CF9 cables ensure high productivity.

HEKUMA GmbH high-performance automation systems for the plastics industry work with cycle times in the second range.
For the energy supply of the grippers, this means that the first million strokes are reached after just four to six weeks - in tough environmental conditions including heat, high acceleration and motion in two axes. This is where chainflex® cables prove their value and are subjected to loads almost as great as those in the igus® in-house test lab.

Fast - faster - fastest: in this continuum, HEKUMA's systems are, without a doubt, some of the fastest anywhere. The company, based in the Munich suburb of Eching, is known for high-performance and maximum-performance automation of injection moulding processes. HEKUMA develops and manufactures complete systems for plastics processing used primarily in medical technology, the automotive industry and in consumer goods. HEKUMA systems all have one thing in common: they work at extreme speeds.

Image left:
Holger Weber, electrical engineering designer at HEKUMA (left), with chainflex® product manager Andreas Muckes (centre) and igus® sales consultant Andreas Dengler (right).

With chainflex® to the limits of the possible

Mechanical engineering with IPC control systems

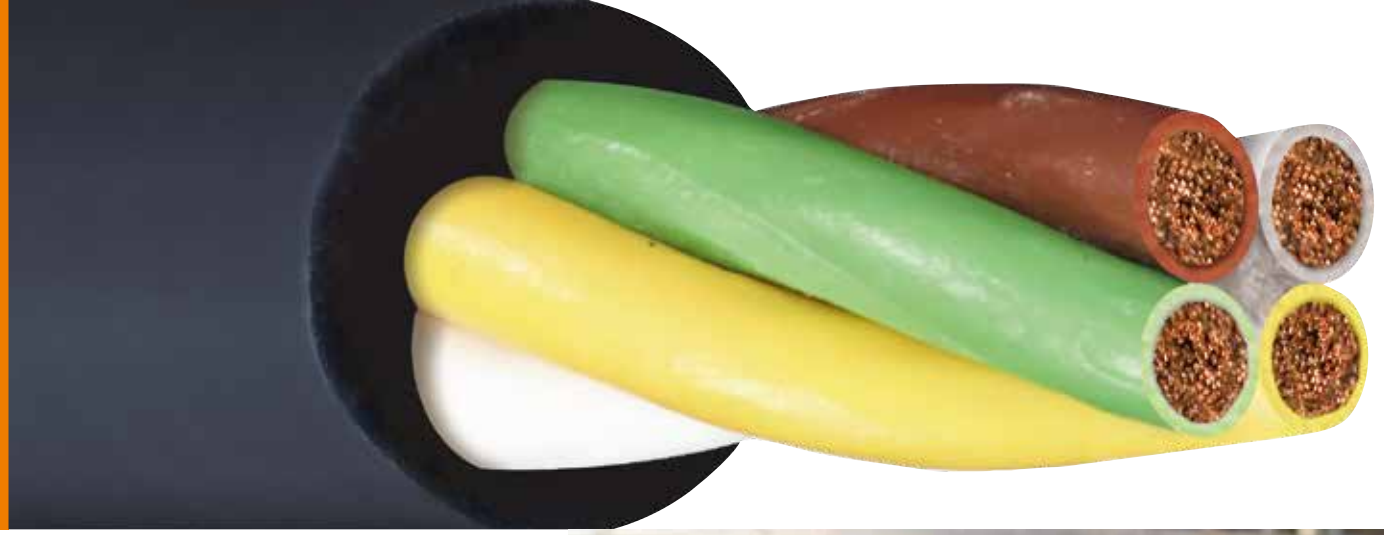
From the standpoint of HEKUMA's design engineers, the high rate of production on the systems means that in many cases, limits are imposed by the mechanical system. In many cases, however, the electronics set the limits. Therefore, the latest and greatest IPC control systems with the shortest processing speeds are used throughout. Without this high performance, it would be impossible to achieve cycle times of two or three seconds. In this way HEKUMA is pushing mechanical engineering to the (speed) limit. And this means careful choices about what cables and energy chains® the grippers are equipped with.

The perfect cable for high-speed robotics

Obviously, standard cables are not nearly good enough for this application. At the typical cycle times, several million double strokes take place within a few short months and at very high accelerations of up to 10 g. Under this strain, a conventional cable would fail after just a few days. HEKUMA chose a solution that lasts for years. Holger Weber: **"**For about ten years now, we have been using cables from the igus® chainflex® product range. Our standard in-house cable is the CF9 series with cross sections from 0.25 to 0.34 mm² as an INI cable. We've had great experience with this cable.**"**

The CF9 chainflex® is the "high end" cable from igus®. A shielded option is also available as the CF10 series.

chainflex® works: control cable tested for 138 million strokes

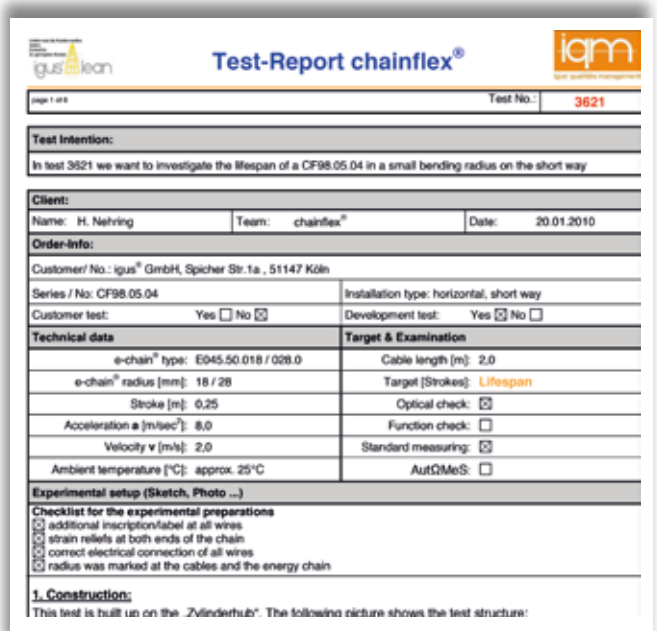


Moving energy made easy: chainflex® control cable CF98.05.04 lasts for more than 138 million strokes. Proven in test 3621, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 3621
- Cable type: bus cable CF98.05.04; 4x0.5
- Test parameter: bend radius 18 mm
- Service life: 138 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test3621

The new chainflex® data cables CF298 and CF299 with TPE outer jacket for the smallest bend radii down to 4 x d .



Test-Report chainflex®

	Test No.: 3621
Test Intention:	
In test 3621 we want to investigate the lifespan of a CF98.05.04 in a small bending radius on the short way	
Client:	
Name: H. Nehring	Team: chainflex® / Date: 20.01.2010
Order-Info:	
Customer/ No.: igus® GmbH, Spicher Str.1a , 51147 Köln	
Series / No: CF98.05.04	Installation type: horizontal, short way
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐
Technical data	**Target & Examination**
e-chain® type: E045.50.018 / 028.0	Cable length [m]: 2,0
e-chain® radius [mm]: 18 / 28	Target [Strokes]: Lifespan
Stroke [m]: 0,25	Optical check: ☒
Acceleration a [m/sec²]: 8,0	Function check: ☐
Velocity v [m/s]: 2,0	Standard measuring: ☒
Ambient temperature [°C]: approx. 25°C	AutΩMeS: ☐
Experimental setup (Sketch, Photo ...)	
Checklist for the experimental preparations ☒ additional inscription/label at all wires ☒ strain reliefs at both ends of the chain ☒ correct electrical connection of all wires ☒ radius was marked at the cables and the energy chain	
1. Construction: This test is built up on the „Zylinderhub". The following picture shows the test structure:	

www.igus.eu/chainflex

Quickly find, configure and order cables for movement in e-chains®: much easier on the new chainflex® website.
www.igus.eu/chainflex

Quick search online for the most cost-effective e-chain® cable that works reliably

New website from igus® makes it easy to find, configure and order cables for motion.

The search for the right product often takes a lot of time due to a high diversity in supply and a large amount of available data. In order to provide information quickly and easily, igus® has further improved its chainflex® website for e-chain® cables by using new filters and an intuitive page navigation. The customer can not only find the right cable for their application quickly and order it through the online shop, but also has the unique possibility to calculate the service life of the selected cables directly online.

Click on www.igus.eu/chainflex, select cable type and core requirements, and order the desired product from 1 metre in length - in just a few steps, the customer can get the correct cable for their moving application in the igus® online shop. On the new website for highly flexible cables, the user can easily and quickly choose from a range of 1,354 cable types. Sorting of the product selection can be not only by to core requirements, but also on the basis of price or delivery time. When choosing the right cable, the new website structure now enables the customer to immediately get all technical data, chainflex® data sheets in PDF format, as well as online tools such as configurators and service life calculators. In addition, product recommendations are displayed. With **more than two billion test strokes tested per year in the 2,750 square metre in-house test lab**, igus® is the only supplier who is not only able to provide a 36-month guarantee on its cables, but also give three specifications on the appropriate bend radius and the permissible temperature for each cable, online and offline. "In our technical data sheets we do not only provide information on the temperatures at which a cable is suitable for fixed installation or for moving applications," explains Rainer Rössel, head of the chainflex® cables division at igus®, "we can also define for every chainflex® cable the temperature and the radius at which the cable can safely be moved in an e-chain®." This information is possible as igus® operates the only climate laboratory in which cables are tested in moving e-chain® applications. In a 40 foot climate chamber, tests are carried out at temperatures down to -40°C and in a second chamber at temperatures up to +60°C.

www.igus.eu/chainflex

Good guidance: energy chains®, delivered as readychain® products, undertake the orderly supply of energy and signals to the individual axes of the IMAGIC flex.

Challenging application at IMA Klessmann GmbH: hybrid cables from igus® used in drilling machine applications

Energy AND bus signals in a moving cable.

Up to fifty servo axes in a small space, high dynamics, high demands on service life and small bend radii: can one-cable technology function under these adverse conditions? IMA Klessmann GmbH did not just try it out but thoroughly tested it together with igus®. Result: the hybrid cables of the chainflex® product range are tried and tested and are used in the new flexible IMAGIC flex drilling systems.

60 metres per minute: **IMA Klessmann GmbH**'s wood processing machines are clocked at this speed. This applies to numerous processes in the fully automated flow production of residential, office, kitchen and bathroom furniture - for example for edge processing with sawing, chamfering and/or gluing.

For drives of up to fifty servo axes within a restricted space.

www.igus.eu/chainflex

Flexible drilling at high speed

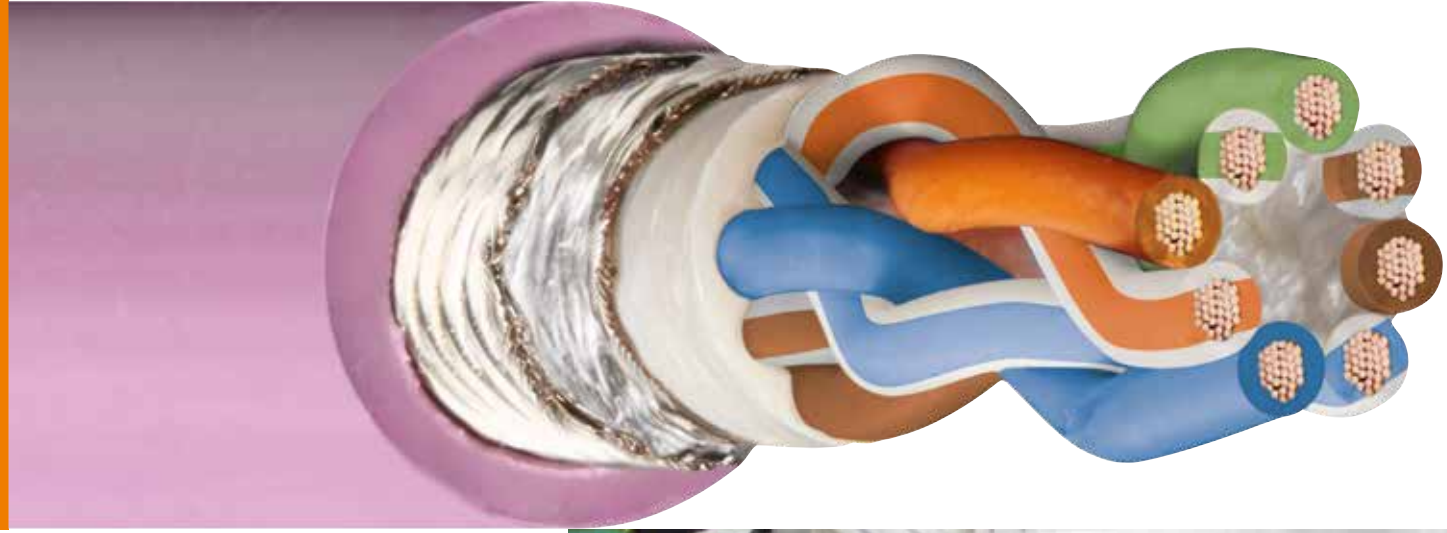
However, this speed also dictates the material processing rate of the drilling stations that have been integrated into the machinery. They have to drill at high speed, even if the components are manufactured according to specific orders and have different drilling patterns.
IMA Klessmann GmbH developed the flexible IMAGIC flex drilling system precisely for this purpose. It offers the user real added value in production. The individually controllable drilling spindles enable horizontal and vertical drilling as well as dowelling, and promise minimum set-up times even for complex drilling patterns - and at a remarkably high speed.

All in one: encoder cable integrated into servo cable. One of the highlights of the new automation system is the innovative energy and signal supply system. The new one-cable technology combines the power and feedback system in the same servo cable. This greatly reduces the cost of materials and the time needed for commissioning.

The chainflex® hybrid cables have a built-in bus element - and they have been designed for a long service life in highly dynamic applications.

www.igus.eu/chainflex

chainflex® works: bus cable tested for 76 million strokes

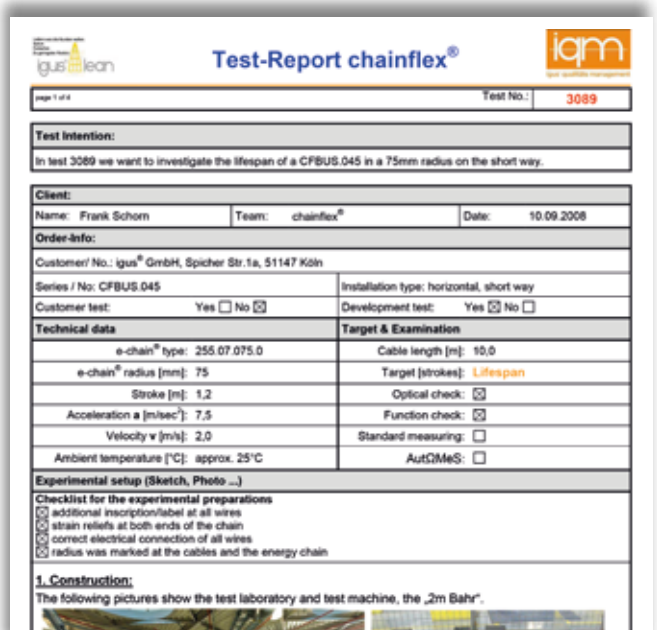


Moving energy made easy: chainflex® Ethernet CAT5e CFBUS.045 lasts for more than 76 million cycles. Proven in test 3089, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 3089
- Cable type: bus cable CFBUS.045
- Test parameter: bend radius 75 mm
- Service life: 76 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test3089

igus® offers harnessed chainflex® BUS cables with original MFP8 RJ45 plug-in connectors from Telegärtner. Flexible RJ45 industrial cabling tested by igus® and Telegärtner under application conditions.



Test-Report chainflex®

Test No.:	3089

Test intention:

In test 3089 we want to investigate the lifespan of a CFBUS.045 in a 75mm radius on the short way.

Client:

Name: Frank Schorn	Team: chainflex®	Date: 10.09.2008

Order-Info:

Customer/ No.: igus® GmbH, Spicher Str.1a, 51147 Köln

Series / No: CFBUS.045	Installation type: horizontal, short way
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐

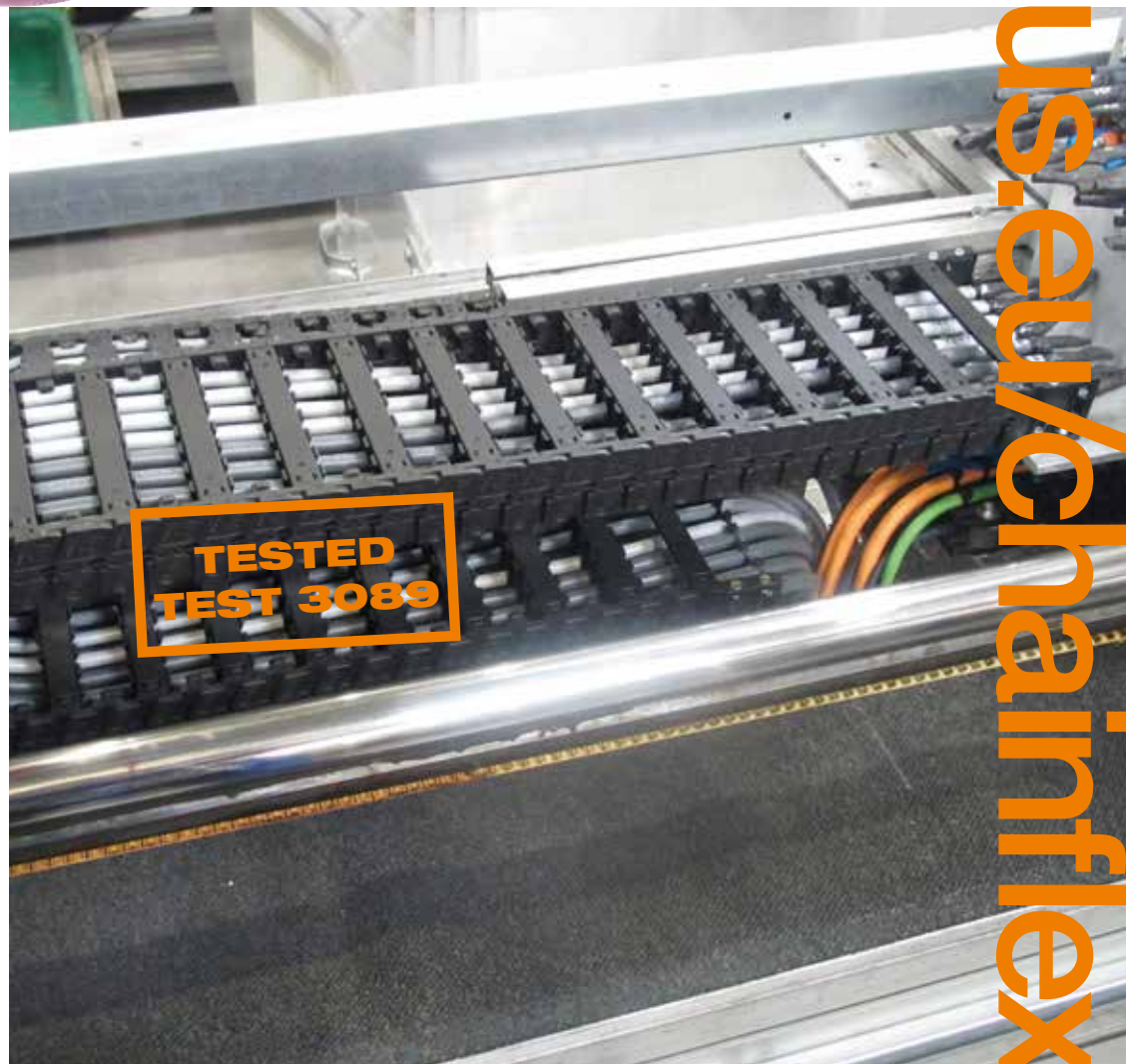
Technical data		Target & Examination	
e-chain® type:	255.07.075.0	Cable length [m]:	10,0
e-chain® radius [mm]:	75	Target [strokes]:	Lifespan
Stroke [m]:	1,2	Optical check:	☒
Acceleration a [m/sec²]:	7,5	Function check:	☒
Velocity v [m/s]:	2,0	Standard measuring:	☐
Ambient temperature [°C]:	approx. 25°C	AutQMeS:	☐

Experimental setup (Sketch, Photo ...)

Checklist for the experimental preparations
- ☒ additional inscription/label at all wires
- ☒ strain reliefs at both ends of the chain
- ☒ correct electrical connection of all wires
- ☒ radius was marked at the cables and the energy chain

1. Construction:

The following pictures show the test laboratory and test machine, the „2m Bahr".



www.igus.eu/chainflex

chainflex® works - world's No. 1 when it comes to service life guarantee

Fail-safe cables for energy chains® - with a guarantee

- Avoids wire breakages and short circuits
- No corkscrew effects
- Minimal abrasion, for difficult environments
- For the best EMC results and twistable movements, e.g. when connected to robots
- Reliable data transmission CAT5, CAT5e, CAT6, CAT6$_A$, CAT7, Profinet, Profibus

www.igus.eu/chainflex

chainflex® works - with a 36 month guarantee

We test our chainflex® cables in over 2 billion test strokes and 1.4 million electrical measurements per year. These tests reveal the functional reliability and durability level of the chains. Our promise to you: guarantee of 36 months or 10 million double strokes. This provides you with planning security.

www.igus.eu/chainflex

Compact build - 20% less installation space needed with the chainflex® CF29.D

At 6.8 x d, the world's smallest bend radius for servo cables in e-chains®
The chainflex® CF29.D servo cable series is a further new chainflex® cable with a highly abrasion-resistant outer jacket made of TPE. This cable is suitable for temperatures down to -35 °C as well as for extremely small bend radii of up to 6.8 x d. How does the customer benefit from this? A comparison with the previous tried-and-tested series shows that, if users choose a cable from the chainflex® CF27.D series (in this example, the CF27.25.15.02.01.D), an e-chain® of the E2/000 series with a chain radius of 125 mm is needed so that the cable can be moved in accordance with the recommended bend radii. The total installation space required is therefore 250 mm. If they use the electrically identical cable from the new chainflex® CF29.D series, users can choose an e-chain® with a chain radius of only 100 mm, which means that the installation space needed is only 200 mm. In the case of very restricted space availability, this possibly avoids the necessity for design adaptations, as a result of which considerably less effort is required and lower costs are incurred.

Quality connects: 36-month guarantee on igus® cables. A total of 4,200 different drive cables are available and can be purchased as finished readycables® cut to the required length, whereby there is no minimum order quantity.

www.igus.eu/chainflex

Guaranteed safety in the case of extremely small bend radii and extremely low temperatures

igus® series CF29 servo cables with the world's smallest bend radius. Safe movement in energy chains® with a bending factor of 6.8 x d , even in temperatures of -35 °C.

A core structure optimised for motion combined with a gusset-filling extruded TPE inner jacket as well as a highly flexible TPE outer jacket are the features of the new chainflex® CF29. The high-end series is suitable for the smallest bending factors for servo cables down to 6.8 x d and is therefore unique on the market. The new series offers a guaranteed solution in a temperature range of -35°C so can be even used for deep-freeze warehouses.

www.igus.eu/chainflex

chainflex® cables supply KESSLER lead screws with energy and signals

What a Brembo brake is to a sports car drive or a Cohiba is to a cigar smoker is the same as what a KESSLER spindle is to the builder of machine tools.

The company in Bad Buchau has succeeded in achieving what many suppliers in the mechanical engineering sector strive for: the company's name has become a brand that stands for outstanding performance and quality and continues to be in worldwide demand, for example in the production factories of the automotive industry.

Permanent ability to move on all axes. For maximum possible reliability and precision.

www.igus.eu/chainflex

From left to right:
igus® Sales Consultant Oliver Seibold, Florian Gehrmann, Product Manager Motor Spindles at Kessler, and Markus Kogelmann, igus® Industry Manager, Machine Tools.

chainflex® guarantees maximum fail-safety in respect of energy supply

Great care in selection of the energy supply system. The fact that KESSLER takes great care in selecting products for the supply of energy and signals to workpiece axes and rotary pivoting tables goes without saying. Florian Gehrmann, product manager for motor spindles & pivoting systems: "As the heads and axes are very compact, there does not remain very much space for the cables. This means that the cables, which are continuously and frequently being moved at short intervals, must be all the more wear-resistant." Resistance to cooling lubricants is yet another requirement.

No problems for more than ten years.
KESSLER has been using chainflex® cables from igus® since 2003. No problems or failures have ever been reported to the responsible design engineers. This is why KESSLER always uses chainflex® cables - even in non-moving applications. Florian Gehrmann: "For us, what counts is fail-safety. Our customers expect high-performance systems with a very long service life. According to these criteria, all components - especially the ones for moving applications - have to be carefully selected."

Image left:
If the housing of the pivoting spindle head is opened, the chainflex® cables can be seen.

Space-saving alternative to 4-core motor cables: PUR lead screw cable

Lead screw drives for machining equipment and machine tools are become bigger and bigger and more powerful as well. Accordingly, larger cable cross sections are needed to carry the high levels of energy supplied. The consequence: the servo cables used are becoming thicker and thicker, as a result of which the radius of the energy chain® is becoming too big for the permissible machine-tool installation space. The shielded single-core cable from igus® provides a solution to this: conceived as a lead screw cable, **the CF270.UL.D chainflex® single-core cable is considerably thinner** and, for this reason, is ideal for use in an energy chain® that has a small radius and is used for a machine tool. **High-quality and, at the same time, cost-effective single cores.** The structure of the lead screw cable from igus® is simple but nevertheless complies with the igus® quality criteria for moving cables: **a braided conductor** consisting of fine conductor strands is shielded by flexible, fine-mesh copper wire braiding which provides around **80 per cent optical cover**. In this way, very good and long-lasting electromagnetic compatibility is ensured. In accordance with the requirements for use in energy chains®, its outer jacket is made of a low-adhesion mixture on a PUR basis. As a result, it is **oil-resistant, resistant to scoring** and **halogen-free**, and can also be used for low-temperature applications. Due to its orange jacket colour and its approval according to UL and NFPA79.2012, it meets all the requirements of the machine tool industry.

Conceived as a lead screw cable, the CF270.UL.D. chainflex® single core has an extremely flexible braided conductor made of fine stranded wires. The single core is therefore substantially thinner than a servo cable and, as a result, is ideal for moving use in constricted machine-tool installation spaces.

www.igus.eu/CF270UL

Different types of shield

The shield of a cable is used to prevent interference from the inside to the outside and vice versa. Optimally, a metal tube would be used, but this will make a movement of the cable impossible. It is therefore necessary to find a compromise between swarf-tightness and good mobility. **chainflex® cables** for linear movements are made in such a way that the braided shield, which has an **optimised braid angle**, fits tightly around the stranded cores. In torsion cables, however, the shield wires must be able to slip and glide, whereby the shield is loosely placed around here. Movements in all directions are thus enabled and, at the same time, **reliable permanent EMC protection** is provided.

Cables for linear movements: the shield is braided and fits tightly around the stranded cores.

Robot cable: in torsion cables, the shield is loosely wrapped around.

Thanks to the loosely wrapped around shield, movements in all directions are made possible.

www.igus.eu/chainflex

chainflex® works: control cable tested for 41 million strokes

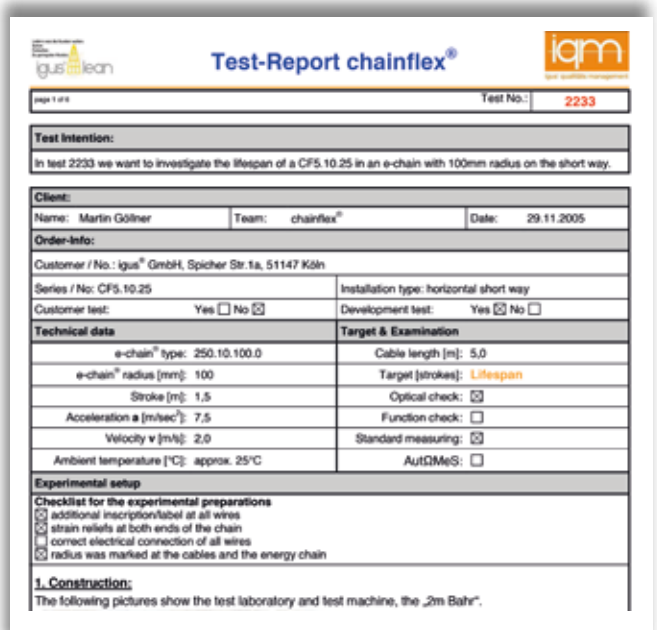
www.igus.eu/chainflex

Moving energy made easy: chainflex® control cable CF5.10.25 lasts for more than 41 million strokes. Proven in test 2233, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 2233
- Cable type: CF5.10.25
- Test parameter: bend radius 100 mm
- Service life: 41 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test2233

igus® offers harnessed chainflex® cables with original Harting plug-in connectors. A total of 112 different control cables are available.



Test-Report chainflex®

Test No.:	2233

Test Intention:

In test 2233 we want to investigate the lifespan of a CF5.10.25 in an e-chain with 100mm radius on the short way.

Client:		
Name: Martin Göllner	Team: chainflex®	Date: 29.11.2005

Order-Info:

Customer / No.: igus® GmbH, Spicher Str. 1a, 51147 Köln

Series / No: CF5.10.25	Installation type: horizontal short way
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐

Technical data	Target & Examination
e-chain® type: 250.10.100.0	Cable length [m]: 5,0
e-chain® radius [mm]: 100	Target [strokes]: Lifespan
Stroke [m]: 1,5	Optical check: ☒
Acceleration a [m/sec²]: 7,5	Function check: ☐
Velocity v [m/s]: 2,0	Standard measuring: ☒
Ambient temperature [°C]: approx. 25°C	AutΩMeS: ☐

Experimental setup

Checklist for the experimental preparations
- ☒ additional inscription/label at all wires
- ☒ strain reliefs at both ends of the chain
- ☐ correct electrical connection of all wires
- ☒ radius was marked at the cables and the energy chain

1. Construction:

The following pictures show the test laboratory and test machine, the „2m Bahr".

igus® WHITE PAPER

Bearing current: Exploring a myth

Or: what do spinach and bearing current have in common?

Anyone who remembers their childhood dinner table will recollect a vegetable that was revered by mothers for generations, but to which infants were vehemently opposed: spinach. Even the valiant smashing of the spoon against the wall or the spitting of the green mash all over the place did not help - because the endlessly repeated argument of the mother that spinach contains iron has been doing the rounds for a century and prevailed over the child's argument that there are better tasting things.

Now toddlers everywhere have been proved right, because it has become evident that spinach has no more or less iron than other vegetables. The reason for the myth was a mistake in a nutritional table. Due to a simple decimal place in a table, a significantly higher iron value was attributed to spinach. While spinach is still healthy, it has been displaced by that decimal point.

Bearing current: a story of misunderstandings

igus® has been confronted with a very similar myth in port crane technology for almost 20 years now, where very large frequency converter powered drives are used. The present state of the art technology is that the trolley drives on crane facilities, RTG, RMG and STS cranes, are supplied energy by energy chains®. In these energy chains®, beside data and FOC, a large number of motor cables with large cross sections are often required, to supply large hoist and trolley motors with the necessary energy.

In order to ensure the supply of electrical power, there are now two different technical approaches. The solution with "balanced cables" and the solution with "single cores", shielded or unshielded respectively. Both solutions have different advantages and disadvantages, especially when they are used in energy chains®.

The advantages of the single core solutions are obvious.
They are less expensive to manufacture and have a lower additional load in the energy chain® compared to solutions with symmetrical cables. But the biggest advantage is the longer service life with a much smaller space requirement: thus when comparing identical cross-sections, up to 35 percent smaller installation space can be gained for the chain. And besides the low cost of steel structures, this will also reduce the wind load, and have a shorter energy chain® and greater durability. So, everything appears to point to the single core solution being best.

However, these advantages of single cores in moving application in energy chains® are not utilised in full by all crane manufacturers, since the industry has been "haunted" by the myth of bearing current for many years. For, just like the incorrect iron content in spinach, the claim of "reduced bearing current through symmetrical cables" has led to uncertainties for years. The result: some crane manufacturers decided to play it safe, while accepting higher costs, space drawbacks and shorter service life of the energy supply.

Bearing current: how it occurs and how to avoid it.
The principle cause for current flow through the machine bearing in mains operation is the shaft voltage. The term "shaft voltage" means the voltage which is induced in a conductor loop, consisting of shaft, the two bearings, the bearing shields and the housing. It can be measured between the two shaft ends and is considered critical if it exceeds a limit of 500 m Vpeak. The "classical shaft voltage" has physical causes; asymmetries within the machine do not reduce the magnetic partial fluxes to zero can therefore cause a magnetic ring flow. This results in the induction of a voltage in the electrical circuit between the shaft, bearing, bearing shield and housing. Another electrical stress on the bearing occurs when connected to a pulse inverter. Pulse inverters are required to allow a variable-speed operation. The converters used sometimes have very high clock frequencies, at which they feed the machine. The feeding at a high clock frequency allows an almost sinusoidal machine current, a minimisation of the additional losses in the winding strands and a reduction in magnetic noise and torque fluctuations.

Here, the bearing voltage is capacitively coupled. This has its physical cause in the steep voltage edges at the inverter output. These are caused by the fast switching operations and the control method of the pulse inverter and thus the common mode voltage. This voltage is influenced by the switching frequency of the converter. At frequencies above 1 kHz, the capacitances between the different machine components play a crucial role. Due to the short switching times, a high change du/dt of the voltage up to 10 kV/µs is reached. At this rate of voltage rise, the capacitances of the winding against the stator core (CWG), winding against the rotor pack (CWR) and stator against rotor (CRG) cannot be neglected.

The bearing currents resulting from it can be subdivided as follows:

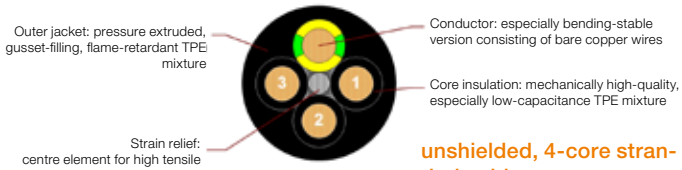
EDM currents: discharge currents that arise by the building up of a voltage via the bearing grease, on reaching their threshold value (8-15V) abruptly discharge.

Circular currents: circular currents occur in both bearings at the same time, have an opposite polarity to each other and nearly the same amplitude in magnitude. The frequency amounts to several kHz.

Rotor ground currents: if the shaft and thus the rotor above it is connected conductively to the ground through the attached component, a rotor currents can occur. This may be greater, the more the earth impedance (impedance of the converter to the ground) differs from the impedance of the rotor and the impedance to the stator housing. The rotor ground current can amount to amplitudes of several amperes, at frequencies of a few kHz.

Capacitive bearing currents: small currents are caused by the voltage applied on the bearing and the capacitance of the bearing. According to current knowledge, these are not considered as critical to the service life of a machine bearing.

symmetrical cable



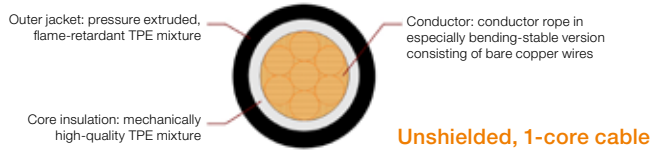
unshielded, 4-core stranded cable

And what does the cable type have to do with the bearing current?
This question was examined by igus® in a comprehensive, 6-month study. The issue was very simple and complex at the same time.

1. Does bearing current actually occur in practice in large drives powered by frequency converters?
2. Can bearing current be influenced in its amount and intensity in practice through special measures, installations or even cable types?

Practical test facilities.
To perform a practical review of bearing currents, igus® recreated in its in-house testing ground an RTG crane with frequency converter, 580kVA engine, 30m energy chain® and the associated control system. Here, additional extensive alterations were necessary: to measure the bearing currents flowing through the bearings of the asynchronous motor, the motor had to be set up accordingly. In order to prevent these flows from distributing over the bearing shield, an insulated bearing was installed to insulate the bearing shield. To measure the currents, pantographs were mounted on the shaft in order to then determine the bearing currents via a measuring transformer.

Shielded, 4-core stranded cable



Unshielded, 1-core cable

Shielded, 1-core cable

Test series in the 2,750 sq.m large igus® test laboratory.
The test facility, which was connected to the public utility grid with a dedicated transformer, could now simulate crane travels for the most varied evaluations, for which a load motor was used as an appropriate container load replacement. In this way, the test series evaluated the emergence period, the nature and magnitude of bearing currents by using different types of cables, installation methods and grounding practices. To obtain meaningful results in relation to the use of cables in crane facilities, the various cable types were tested under the same conditions. Here, movement cycles were simulated, which were typical for crane travels, characterised by frequent changes in rotation direction and speed. Also, the continuous stress and the concomitant heating were observed.
Incorrect or poor grounding concepts were also performed. Here, the extremely heavy 580kVA engine was lifted from the steel frame with much effort and rebuilt with insulation. In this way different potential states between the stator and the entire system could be simulated.

After 6 months, the results were determined:

1. The highest bearing current occurs at low speed and high temperature. At high speed, a bearing current forms with increasing temperature as time goes by.
2. If the speed or direction of rotation changes, the bearing current drops.
3. The build-up of the bearing current takes place over time and at a constant speed, reaches its maximum after about 50-100s. At a constant speed over a long period, a lower bearing current forms with symmetrical cables.
4. Very high bearing currents occur with "unequal" grounding between motor and converter.

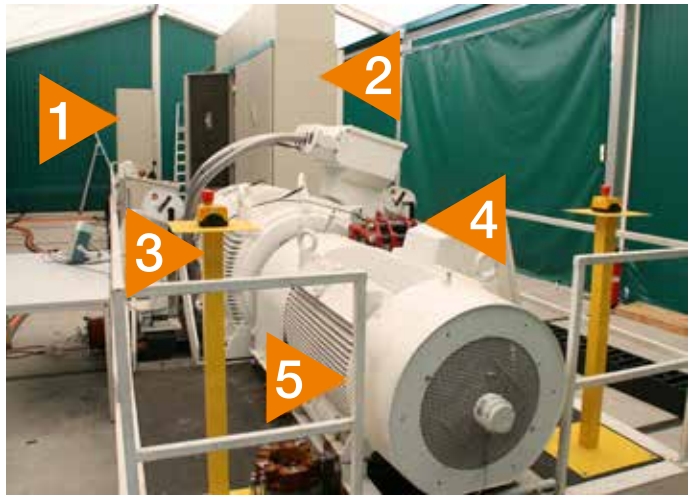
Use of an energy chain® including chainflex® cables in a port crane

Is the bearing current myth a reality now?

The extensive series of testing with the simulation of a crane system, with realistic drives, converters and loads in the igus® in-house test laboratory is conclusive: if there is a good potential equalisation, and if the drive is operated with a typical operating profile for cranes, then the use of the cable type "symmetrical" or "single core" does not affect the magnitude of the bearing current. This is because the typical operating profile of cranes involves the constant alteration of the speed and direction of rotation of the drive motor. And the bearing current drops again before it can have a destructive effect on the bearing.

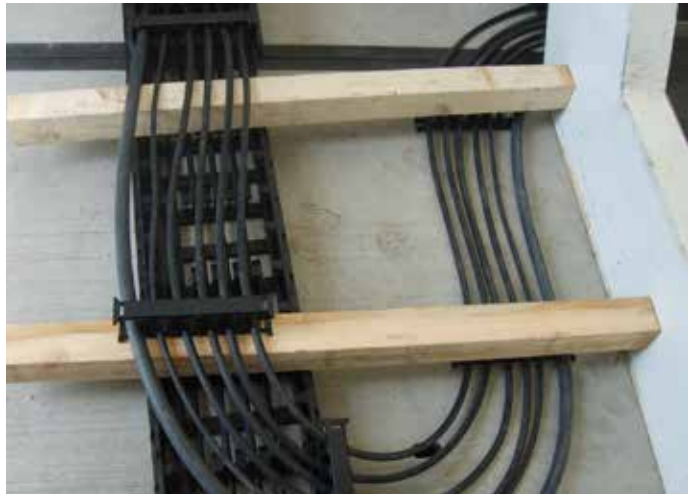
However, the symmetrical cable actually provides advantages in many other technical, non-crane applications in reducing bearing currents, especially in applications where the same rotation directions and speeds are needed over a long period. For example, in large pumping or pressure drives, which are operated in a widely distributed manner in a production hall and potentially not optimally grounded. There, the symmetrical cable can actually lead to a reduction.

For the use in crane facilities, however, there is another extra reason to use single cores. Besides the advantage that single cores are cheaper to buy, the overall system comes at a lower cost, demands small installation spaces and lasts longer, they do not have a higher or lower bearing current than the symmetrical cables mentioned above.



Test facility: 1) Control system, 2) Converter, 3) "Crane motor", 4) Brake, 5) "Load motor"

Transport container and test field at the igus® headquarters in Cologne



The energy chain® equipped with the test cables

chainflex® works: fibre optic cable tested for 50 million strokes

www.igus.eu/chainflex

Moving energy made easy: chainflex® fibre optic cable CFLG.2LB lasts for more than 50 million strokes. Proven in test 4011, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 4011
- Cable type: CFLG.2LB.50/125
- Test parameter: bend radius 75 mm
- Service life: 50 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test4011

Test-Report chainflex®

Test No.: 4011

Test intention:

In test 4011 we want to investigate the lifespan of the CFLG.2LB.50/125 and CFLG.2LB.62,5/125 in a small bending radius.

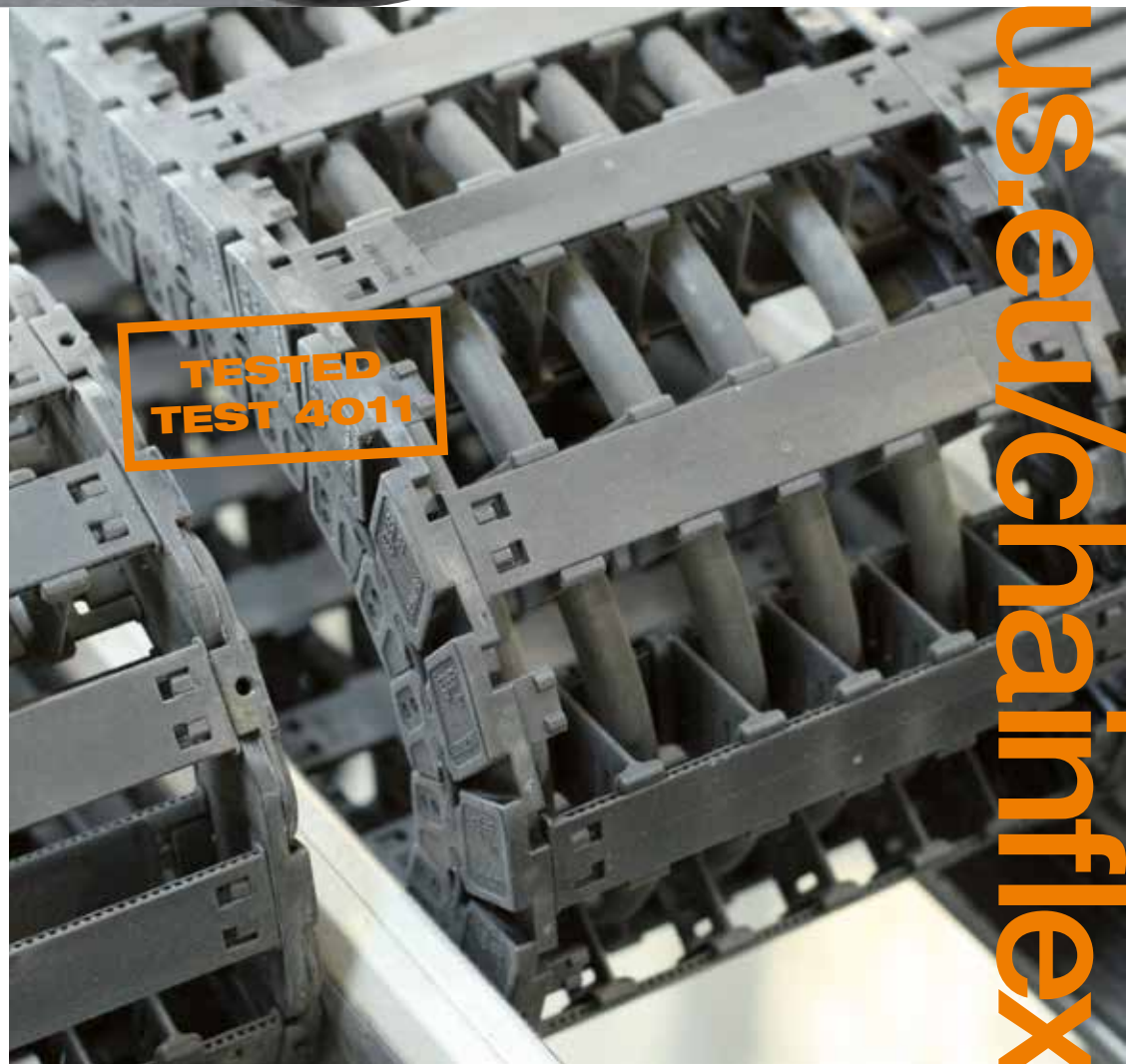
Client:		
Name: Rainer Rössel	Team: chainflex®	Date: 31.01.2011
Order-Info:		
Customer/ No.: igus® GmbH, Spicher Str.1a 51147 Köln		
Series / No: CFLG.2LB	Installation type: Horizontal, short way	
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐	

Technical data	Target & Examination
e-chain® type: 1500.100.035	Cable length [m]: 11,0
e-chain® radius [mm]: 35	Target [strokes]: Lifespan
Stroke [m]: 0,8	Optical check: ☒
Acceleration a [m/sec²]: 4,0	Function check: ☒
Velocity v [m/s]: 1,5	Standard measuring: ☐
Ambient temperature [°C]: approx. 25°C	AutΩMeS: ☐

Experimental setup (Sketch, Photo ...)

Checklist for the experimental preparations
☒ additional inscription/label at all wires
☒ strain reliefs at both ends of the chain
☒ correct electrical connection of all wires
☒ radius was marked at the cables and the energy chain

1. Construction:
This test is built up on the „kleine Bahn". The following picture shows the test structure:



Port of Hamburg: clean energy with igus® on board

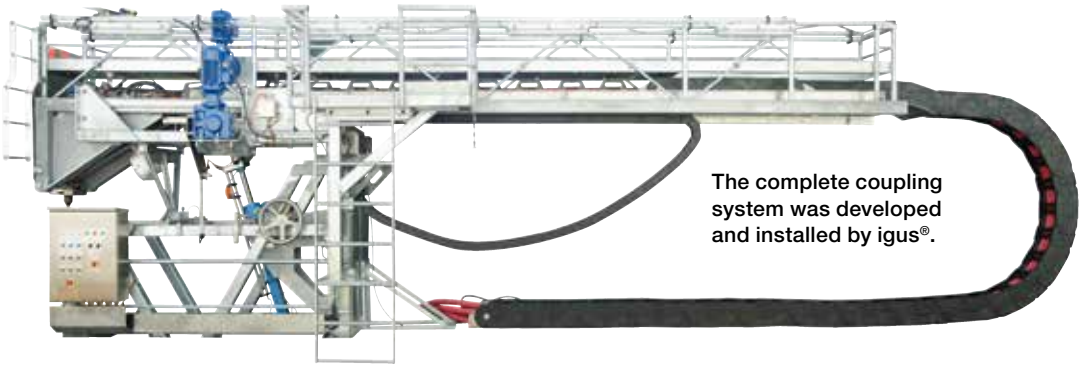
Automatic coupling with the floating power station in the Port of Hamburg (Germany) makes it possible to reduce emissions.

Clean solution - LNG HYBRID barge "Hummel". Thanks to the floating LNG power station, in future cruise ships will be supplied with power while docked at the port. This power is created using environmentally friendly liquefied natural gas. Thanks to this procedure, cruise ships save marine diesel fuel and reduce emissions (including particle emissions). Automated connection process from barge to quay due to a complete solution from igus®.

10 kV from floating power station with automated coupling

Usually, the on-board generators must continue operating **so that current flows through the cables on board a cruise ship even when the ship is moored in the harbour**. As a result, large amounts of diverse pollutants are discharged into the air in the harbour. In order to be able to prevent this in future, Becker Marine Systems designed and built the LNG HYBRID barge called the "Hummel" for the port of Hamburg - a floating liquid-gas power station that supplies the huge cruise liners with power. In order to transfer energy from the barge to the quay, from where it is passed on to cruise ships, igus® was brought on board.

The flexible coupling solution from igus® was also very visible during the naming ceremony.



The complete coupling system was developed and installed by igus®.

For the experts at igus®, special solutions are a part of their everyday work but what was new in this case was that the entire electronics and steel construction were designed and implemented by igus®. As soon as the barge has reached its docking station, a gangway automatically extends which allows people to move between the shore and the ship. energy chains® from igus® are located below this gangway. These energy chains® primarily guide four thick 6/10 kV cables with connectors. These are connected to large power supply boxes on the wharf as soon as the gangway is docked and the chain has been extended.

chainflex® certification by German Lloyd

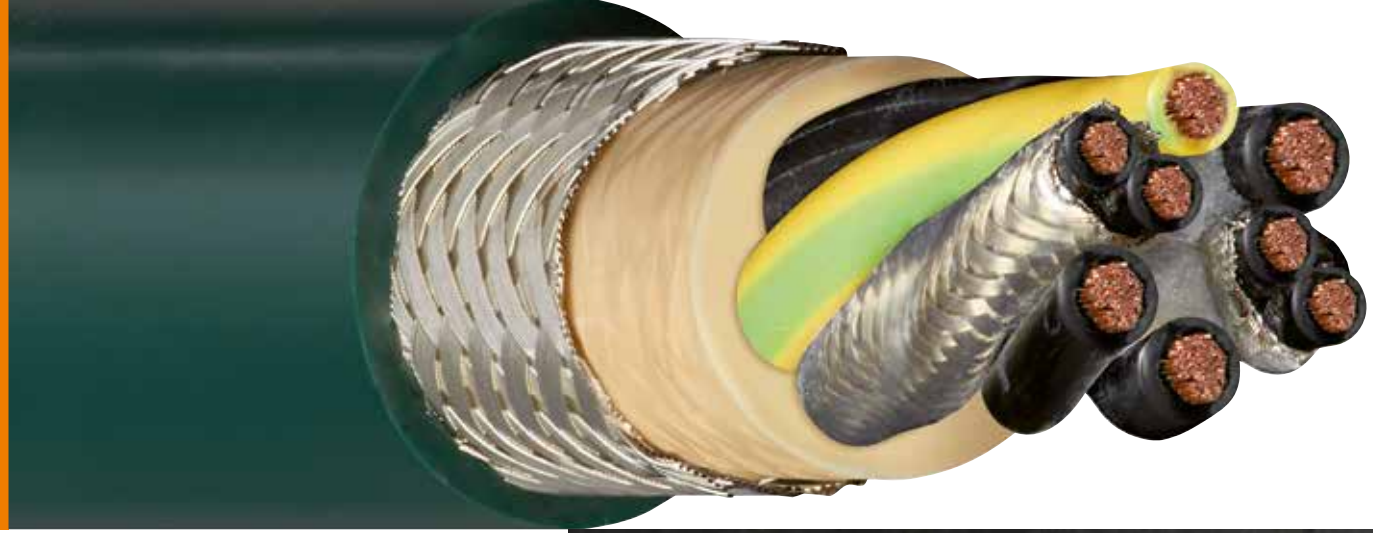
A good reason to celebrate. New test standard for dynamic cables in moving applications guarantees the reliability of maritime equipment.

igus® GmbH and the classification agency German Lloyd worked together to develop a new test standard in order to enable the use of cables for applications relating to motion control on ships and offshore units without expensive and cost-intensive customers certificates. In the meantime, a total of 403 chainflex® cables from igus® with DNV-GL certification have been certified for e-chain® cables in continuous operation. These are the world's first cables which have received this certificate specifically for applications in energy chains®.

CERTIFIED BY DNV·GL MARITIME

www.igus.eu/chainflex

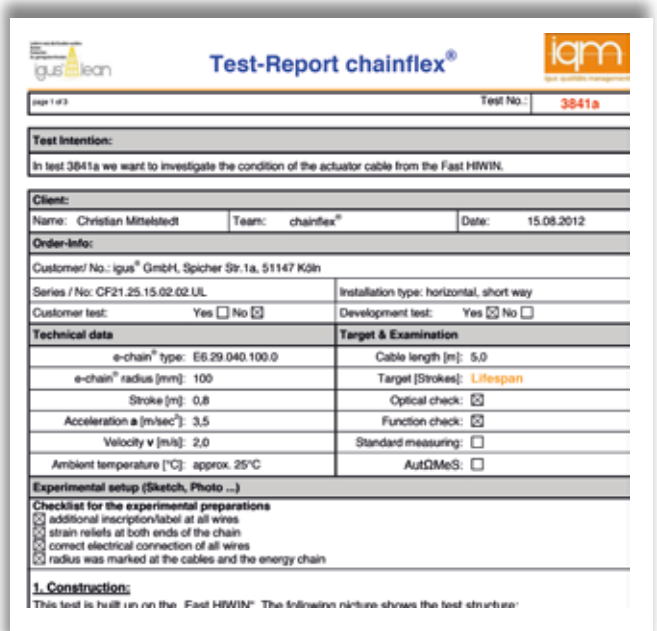
chainflex® works: servo cable tested for 53 million strokes



Moving energy made easy: chainflex® servo cable CF21 lasts for more than 53 million strokes. Proven in test 3841a, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 3841a
- Cable type: CF21.25.15.02.02.UL
- Test parameter: bend radius 100 mm
- Service life: 53 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test3841



Test-Report chainflex®

Test No.:	3841a

Test Intention:

In test 3841a we want to investigate the condition of the actuator cable from the Fast HIWIN.

Client:

Name: Christian Mittelstedt	Team: chainflex®	Date: 15.08.2012

Order-Info:

Customer/ No.: igus® GmbH, Spicher Str.1a, 51147 Köln

Series / No: CF21.25.15.02.02.UL	Installation type: horizontal, short way
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐

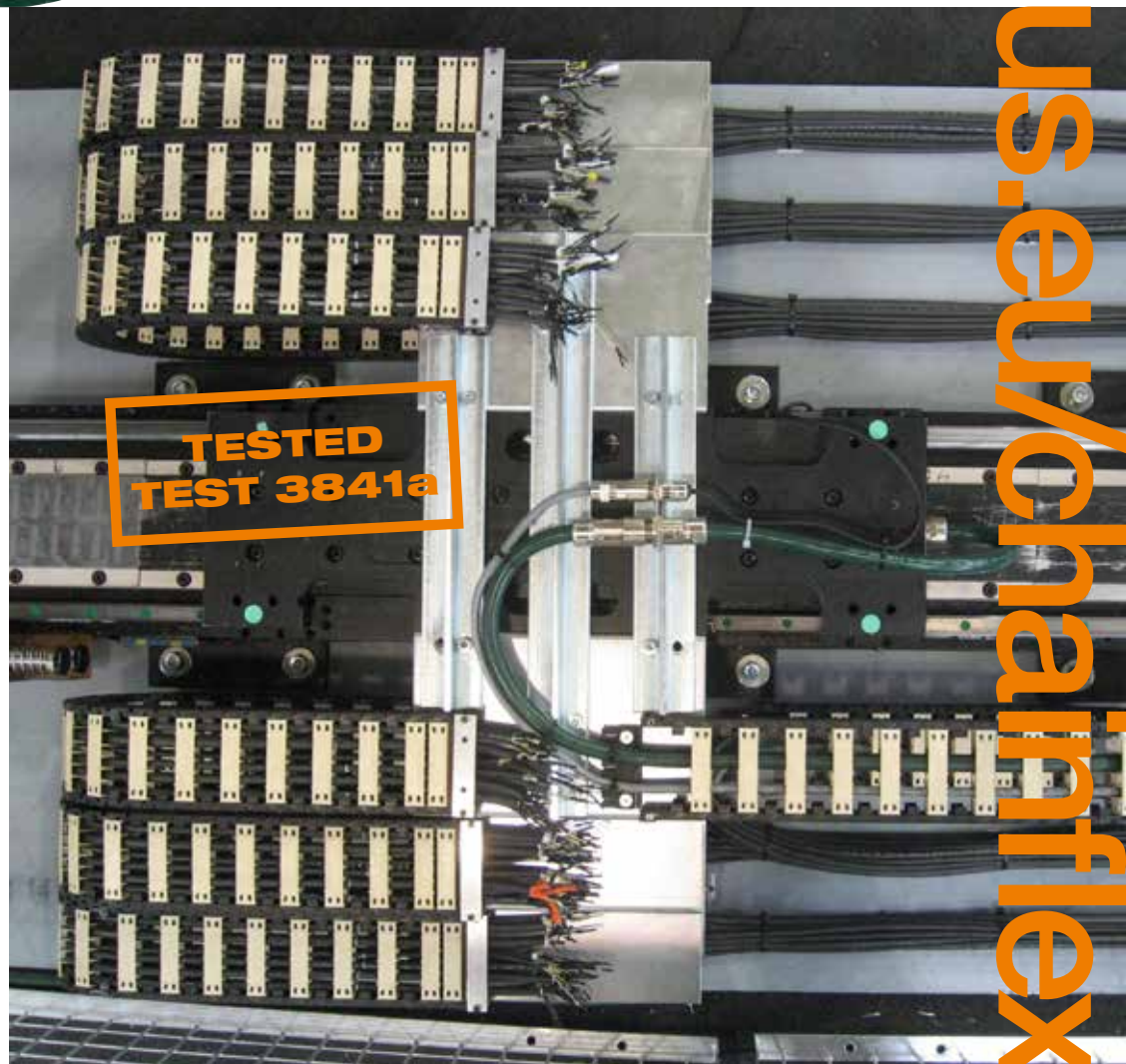
Technical data		Target & Examination	
e-chain® type:	E6.29.040.100.0	Cable length [m]:	5,0
e-chain® radius [mm]:	100	Target [Strokes]:	Lifespan
Stroke [m]:	0,8	Optical check:	☒
Acceleration a [m/sec²]:	3,5	Function check:	☒
Velocity v [m/s]:	2,0	Standard measuring:	☐
Ambient temperature [°C]:	approx. 25°C	AutΩMeS:	☐

Experimental setup (Sketch, Photo ...)

Checklist for the experimental preparations
- ☒ additional inscription/label at all wires
- ☒ strain reliefs at both ends of the chain
- ☒ correct electrical connection of all wires
- ☒ radius was marked at the cables and the energy chain

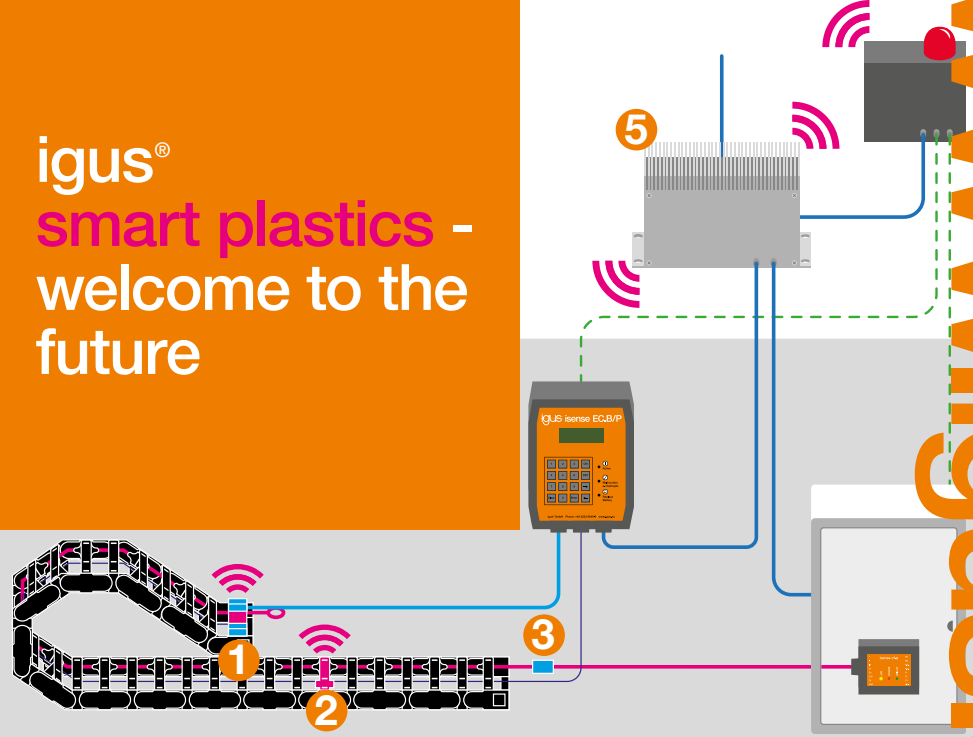
1. Construction:

This test is built up on the „Fast HIWIN". The following picture shows the test structure:



www.igus.eu/chainflex

igus®
smart plastics - welcome to the future



1 Motion sensor with wireless transmission
2 Abrasion sensor with wireless transmission
3 Temperature sensor
4 Compact control and switching units
5 Communication module
6 Customer control and alarm function

igus® smart plastics increase the fail-safety of your machine tools. Intelligent products forecast the maintenance date ahead of time and can be integrated seamlessly into your processes (predictive maintenance).

The isense family of igus® products consists of various sensors and monitoring modules. They detect wear during ongoing operation and **issue an alarm** as soon as **repair or replacement** is necessary. Networking by means of the igus® Communication Module (icom) enables direct integration into your company-wide IT infrastructure. This enables scenarios such as continuous monitoring or **automatic triggering of maintenance work**. An optional connection with the igus® data centre widens the options: individual lifetime optimisations and faster operational processes like automatic ordering of external maintenance teams or ordering of spare parts. These include maintenance commissioning or spare parts ordering. Thanks to smart plastics your equipment runs continuously and your maintenance costs go down.

- Reduce maintenance costs
- Eliminate unplanned downtime
- Long service life
- Increase equipment efficiency
- Detect anomalies quickly
- Reduction of energy consumption

www.igus.eu/industry4-0

www.igus.eu/chainflex

smart plastics in use at an Austrian automotive supplier

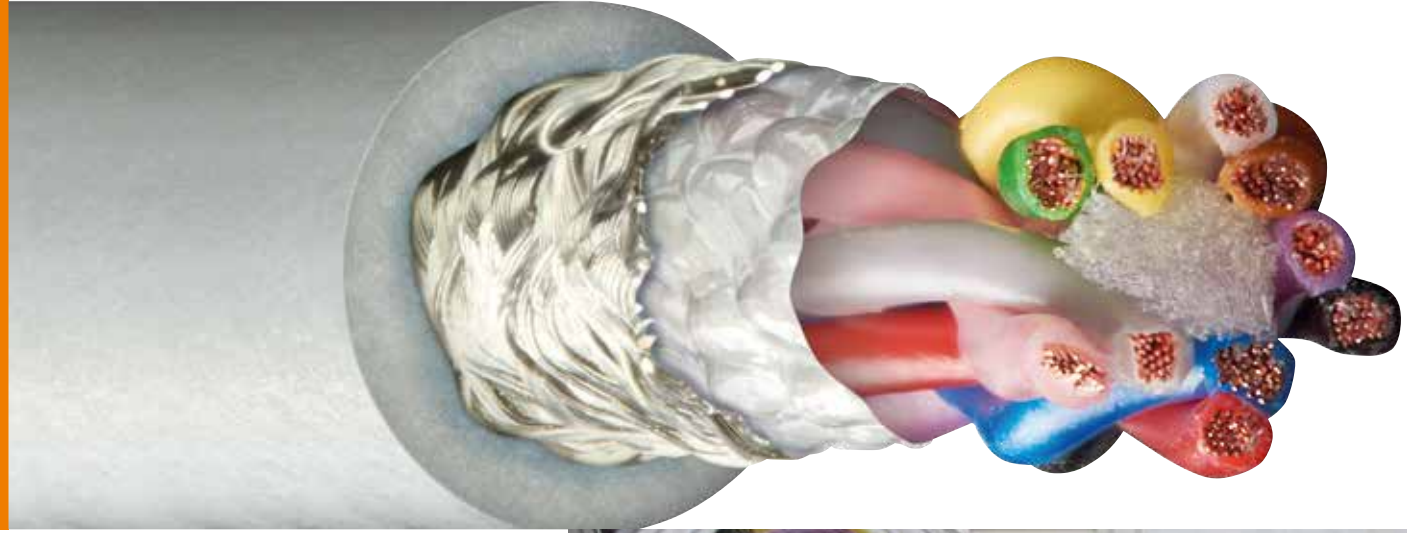
This engine factory is the biggest and most important engine factory of a large German car manufacturer.

On average, an engine comes off the assembly line every 14 seconds - in peak periods, more than 6,000 engines are produced every workday. This output can only be achieved with a high degree of automation and with reliable components. This is why companies rely on smart plastics from igus® in order to avoid unforeseen failures and machine shutdowns.

With the help of a polymer wire (inside the energy chain®) and a sensor unit, **isense EC.B modules** monitor the condition of the chain. In the event of a chain breakage, the machine is stopped automatically to prevent consequential damage.

isense EC.W modules have also been built in. A sensor built into the crossbar signals advanced wear of the chain. The measurement of wear data means that a chain's remaining service life can be predicted and replacement can be planned at an early stage.

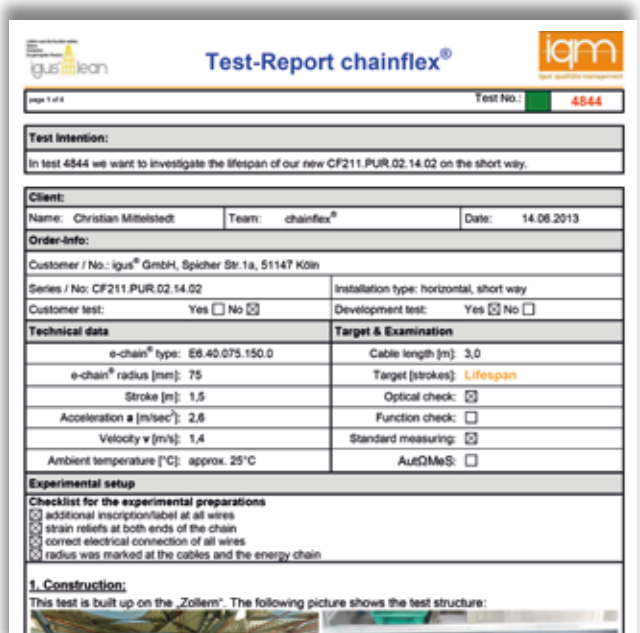
chainflex® works: data cable tested for 24 million strokes



Moving energy made easy: chainflex® data cable CF211.PUR lasts for more than 24 million strokes. Proven in test 4844, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 4844
- Cable type: CF211.PUR.02.014.02
- Test parameter: bend radius 75 mm
- Service life: 24 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test4844



Test-Report chainflex®

Test No.: 4844

Test intention:

In test 4844 we want to investigate the lifespan of our new CF211.PUR.02.14.02 on the short way.

Client:		
Name: Christian Mittelstedt	Team: chainflex®	Date: 14.06.2013
Order-Info:		
Customer / No.: igus® GmbH, Spicher Str.1a, 51147 Köln		
Series / No: CF211.PUR.02.14.02	Installation type: horizontal, short way	
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐	

Technical data	Target & Examination
e-chain® type: E6.40.075.150.0	Cable length [m]: 3,0
e-chain® radius [mm]: 75	Target [strokes]: Lifespan
Stroke [m]: 1,5	Optical check: ☒
Acceleration a [m/sec²]: 2,6	Function check: ☐
Velocity v [m/s]: 1,4	Standard measuring: ☒
Ambient temperature [°C]: approx. 25°C	AutΩMeS: ☐

Experimental setup

Checklist for the experimental preparations
- ☒ additional inscription/label at all wires
- ☒ strain reliefs at both ends of the chain
- ☒ correct electrical connection of all wires
- ☒ radius was marked at the cables and the energy chain

1. Construction:

This test is built up on the „Zollern". The following picture shows the test structure:

www.igus-eu/chainflex

Think laterally: going at things from a new angle with the ibow® connector

New angle adapter from igus® enables easy and low-cost angling of Hummel M16-plug-in connectors.

At Hannover Messe 2017, igus® presented its **ibow®** angle adapter - It can be attached to straight plug-in connectors easily and quickly, as a result of which cables can be angled without any great effort. This new product arose from a customer's request for an angled version of the Hummel M16 plug-in connector.

A difference of up to 40 per cent - this is how much more expensive an angled plug-in connector is compared to a straight one. The price for the additional connector as well as the associated work and process costs also play a role. This is why igus® developed the **ibow®** angle adapter.

Push in the connector, bend the cable, fix and ready to use: with the new igus® ibow®, cables can be installed with angled plug connectors and save space in just a few steps.

Plug-in connectors and measuring system cable for large machining centres.

Measuring system cables for large scale machining centres

The machining of large components such as diesel engines, turbines, generators or ships' propellers means that machining centres are becoming bigger and bigger. This is also having an impact on machine-tool technology itself. One builder of these complex machine relies on the latest generation of controls. For this control system, a special overall solution with a measuring system cable that continuously transfers signals reliably even over very large distances while ensuring a high degree of machine availability has been developed.

The specialist in large machining centres decided to use new control technology in its machines. The modern control system is equipped with the **Drive-Cliq open encoder interface**. This interface inside the drive enables components of different manufacturers to be coupled with each other and reliably transmits the measuring system signal in real time. The changeover necessitated new measuring system cables as well. As the Coburg mechanical engineering company was already very satisfied with the CF113.D family of cables, the CF113.028.D, which was specially developed for this interface, was chosen for connection of the Drive-Cliq systems.

From left to right: Andreas Muckes (igus® GmbH), Thomas Bätz, Thomas Bischoff (both from WALDRICH COBURG GmbH).

The company WALDRICH COBURG GmbH is one of the world's leading mechanical engineering companies for large machine tools. "Extremely high quality standards and a consistent orientation to the customer are our fundamental guiding principles", says Dipl.-Ing. (TH), Thomas Bätz, Group Leader Electrical Design, in clarification. Horizontal and vertical milling machines, vertical lathes and grinding machines are produced at the production site in Coburg. "We see ourselves as a reliable partner of our customers around the world who have special requirements regarding complex technologies, levels of precision, metal cutting performance, workpiece dimensions and productivity."

A large number of chainflex® cables are kept in stock in Coburg.

chainflex® works: measuring system cable tested for 66 million strokes

www.igus.eu/chainflex

Moving energy made easy: chainflex® measuring system cable CF11.D lasts for more than 66 million strokes. Proven in test 3479, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 3479
- Cable type: CF11.002.D
- Test parameter: bend radius 75 mm
- Service life: 66 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test3479

igus lean

Test-Report chainflex®

iqm

Test No.: 3479

Test intention:

In test 3479 we want to investigate the life span of the CF11.002.D cable on the short way.

Client:

Name: Sascha Voshaar	Team: chainflex®	Date: 10.09.2009

Order-Info:

Customer / No.: igus® GmbH, Spicher Str.1a, 51147 Köln

Series / No: CF11.002.D	Installation type: horizontal, short way
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐

Technical data	Target & Examination
e-chain® type: 255.07.075.0	Cable length [m]: 5,0
e-chain® radius [mm]: 75	Target [double strokes]: Lifespan
Stroke [m]: 1,2	Optical check: ☒
Acceleration a [m/sec²]: 7,5	Function check: ☐
Velocity v [m/s]: 2,0	Standard measuring: ☒
Ambient temperature [°C]: approx. 25°C	AutΩMeS: ☐

Experimental setup

Checklist for the experimental preparations
- ☒ additional inscription/label at all wires
- ☒ strain reliefs at both ends of the chain
- ☒ correct electrical connection of all wires
- ☒ radius was marked at the cables and the energy chain

1. Construction:

This test is built up on the „2m Bahn". The following picture shows the test structure:

New generation of twistable cables for fast and secure data transfer

igus® extends its range of Ethernet cables for motion with new robot cables in accordance with the CAT6$_A$ and CAT7 standards.

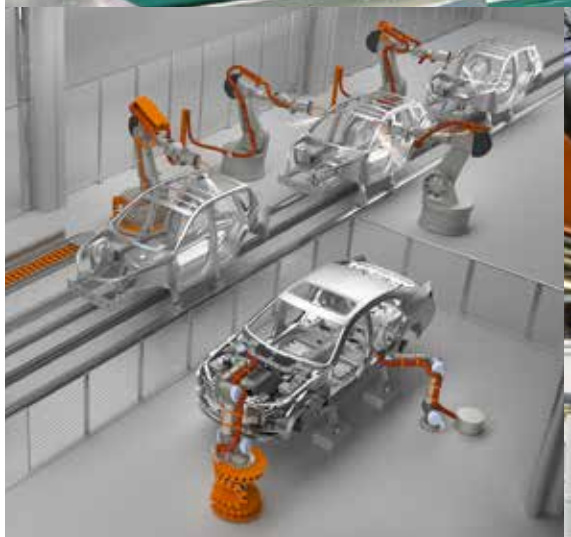
The world's first Ethernet bus cables specially made for three-dimensional movement that comply with the CAT6$_A$ or CAT7 standard. In this way igus® guarantees fast and secure data transfer during operation, even under extreme conditions of mechanical stress, for example where industrial robots are supplied with data. The new cables from igus® are a further addition to the already extensive range of Ethernet cables for continuous movement in energy chains®.

Today, there are approximately three million industrial robots, which work with increasingly high quantities of data and are an integral part of modern production facilities. Durable cables made of special materials and featuring advanced technical characteristics ensure fail-safe data transfer and are essential in manufacturing if cost-intensive production outages are to be avoided.

www.igus.eu/CFROBOT

chainflex® CFROBOT cables for torsional motion in the e-chain®.

Multi-robot plants operate within the cycle of a blow moulding machine. The fuel tanks change the station here, for example, in a 65-second cycle.



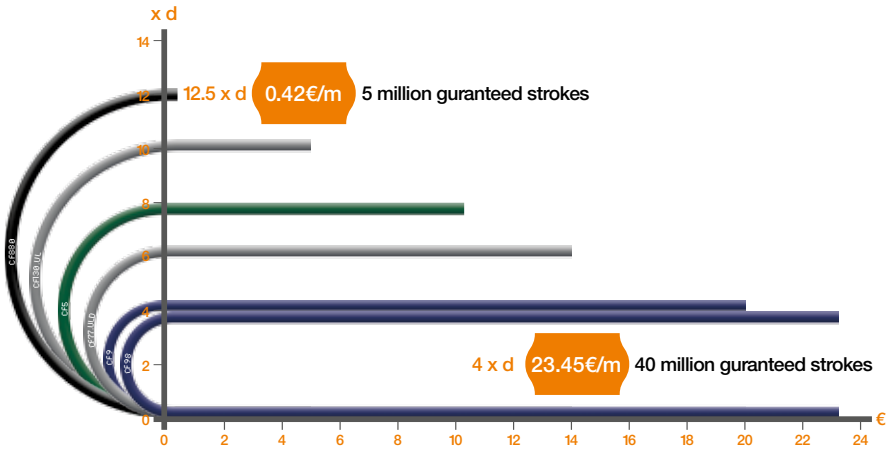
www.igus.eu/chainflex

The biggest and the smallest for cables in motion

High-performance cables with extremely small bend radii require less installation space and have an extremely long service life

igus®, the world's No. 1 supplier of highly flexible cables for use in e-chains®, supplies the most consistent range of products for extremely small bend radii and is thus in line with the trend towards increasingly compact machines and smaller installation spaces. The **"low bending" concept** ensures bend radii that are as small as a mere four times the cable diameter - without having to do without the accustomed load-bearing capacity and reliability. Elaborate tests in the industry's largest test laboratory guarantee reliable service-life information for any application. Automobile manufacturers, companies in the electronics industry as well as metal-working enterprises - they **all have to save installation space**, whereby the floor space for machines and equipment is regarded as a decisive criterion for decisions to buy. This also applies to, for example, machine tools and the energy chains® with the associated cables that are used for them. In this context, however, dynamic applications with very small bend radii cause conventional so-called "chain-compatible cables" to come up quickly against their limits in respect of the amount of mechanical stress they can cope with. This is where igus® has **just the right cable for all needs** - for short, very fast movements, for example in automatic component-mounting machines or in other rapid handling applications. Their high resistance to chemicals and oil, and their ability to withstand temperatures down to -35 °C are some of the special characteristics that are made possible by the structure of the cables and the TPE outer jacket used. The product line that is offered by igus®, has been supplemented with the "low bending" variant and is available over the entire product range and for all relevant types of cable - including control, bus, motor, FOC or servo cables - and is a complete product range for developers. Here, **bend radii that can be as small as a mere four times the cable diameter** are possible. This saves space and enables design engineers to build even smaller and smarter for high speeds and - in spite of extremely high bending stress - the cables have the same long service life plus a guarantee covering **36 months or 10 million strokes.** In the case of industrial Ethernet cables, igus® offers a product range of 34 different cables, from CAT5e, CAT6 to CAT7. In this special Ethernet product range as well, igus® offers the so-called "low bending" variant.

With this completely rounded-off concept, igus® offers all its customers the unique advantage of the chainflex® cable range, namely the ability to select the appropriate mechanically designed cable with all the electrical characteristics of a normal cable. **In the case of chainflex® specifically, enabling every customer to find the most cost-effective and technically best product is the top priority of igus®.**



www.igus.eu/chainflex

chainflex® Ethernet cables

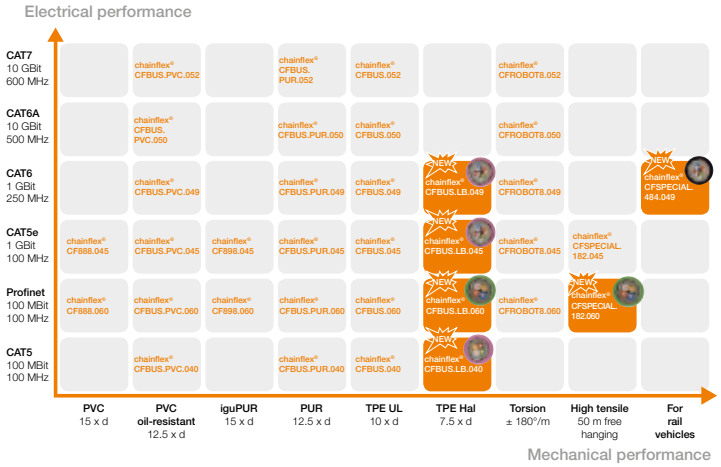
Are you equipping your machine with a bus system or are you busy changing over to a new system?

If so, you will undoubtedly be confronted with one of the innumerable Ethernet derivates on the market. The choice here is overwhelming. This includes GigE and Sercos, Profinet is also popular and I prefer CAT5, CAT5e or even perhaps CAT6A. Or should I simply use a CAT7 solution?

The good news is: irrespective of which system you like, the cable technology is always similar from an electrical point of view. The **frequency** and the amount of data are always the decisive factors when it comes to the quality of the cables to be used. What is important is that the cables are downward compatible. The easiest way to go about this is to base your choice on the cable categories that have been a fixed component of the definitions in standards for years.

The Profinet technology and Ethercat technology are for example very similar to each other as both are based on CAT5 as a precondition for their use. They are **different in terms of the cross section of the cores** and the **colours of the jacket** and **core insulation**. What is important when a cable is being chosen is that you also consider the mechanical properties such as **bend radius** and **the type of movement**. These are the parameters which ensure that data transmission is guaranteed for as long as possible. If a CAT5e cable, for example, has been chosen for chain movement whereby it is twisted, the data transmission properties change quickly. This results in bus faults that often entail long searches for the problem. At this point, we would like to point out a big trap that can be fallen into and often becomes a very expensive affair. In the area of permanently laid cables, things are built to last, which in this case means using a cable of much too high a quality for a project so that it does not have to be replaced at great cost when the quality is actually needed. As the cable does not age electrically and the **high-quality cable** is relatively inexpensive, this makes good sense. Unfortunately, this does not fully apply in cases where dynamic movements are involved. If a packaging machine was to be equipped with a camera today, for example, a GigE cable would probably be used, i.e. CAT5e. If the cable were to be replaced with a CAT6A cable, considerably higher costs would be incurred but the amount of work involved in changing the cable - should a data volume of 10 GB actually be needed - would be considerably less than that involved in the replacement of cables permanently installed in walls in buildings.

For all data volumes and types of movement



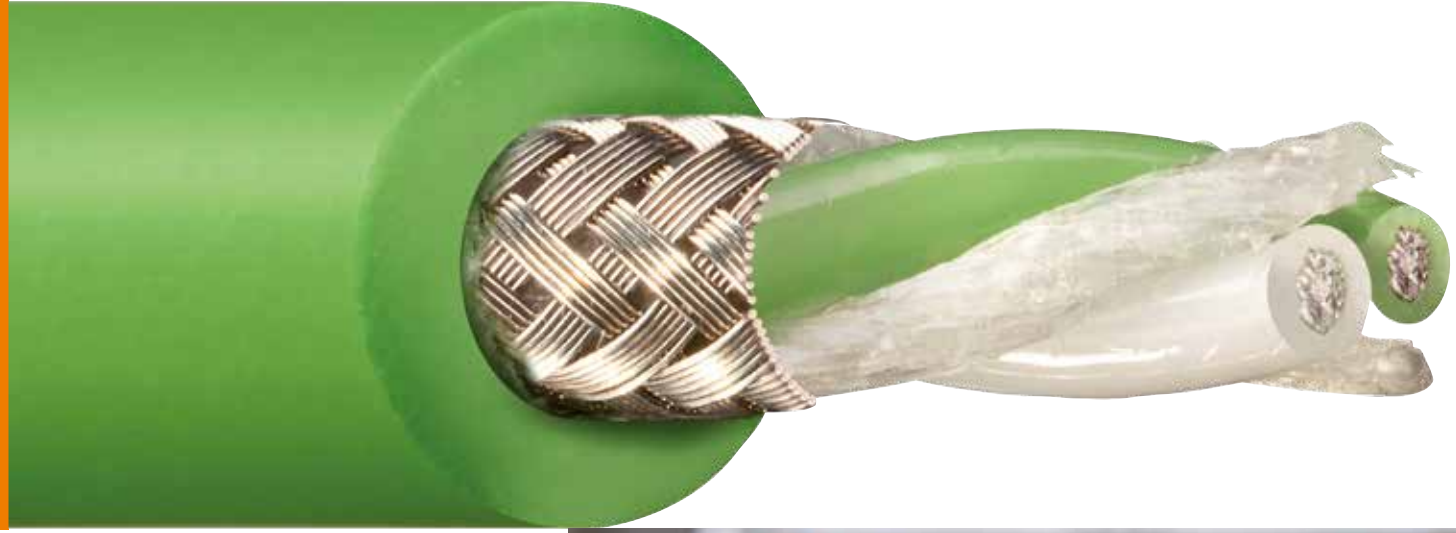
From CAT5 to CAT7, we can supply you with exactly the Ethernet cable you need for your moving application. With that you can safely use Bus systems such as Ethernet/IP, Profinet, EtherCAT, Sercos and many other derivatives. The individual grading of the classes of cable means that there are opportunities for very large **savings** or for the cabling of your equipment in a way that meet the needs of the future.

We deliver on drums or in coils of **your required length - of course, without any cutting charges.** Upon request, we also harness your cable with suitable plug-in connectors. No minimum quantity, with your individual dimensions and designs. **New additions to the product range** are our **CFSPECIAL484.049 cable for the railways** and the **CFBUS.LB** for especially small radii of 7.5 x d .

www.igus.eu/Ethernet

www.igus.eu/chainflex

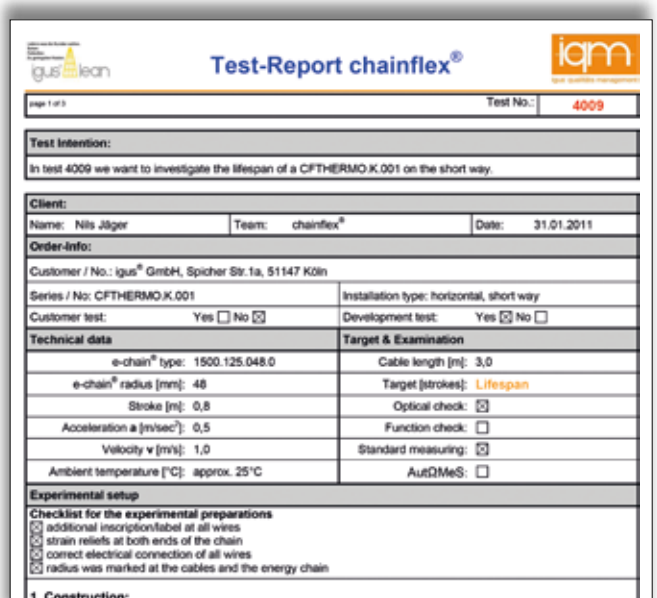
chainflex® works: thermo-couple cable tested for 97 million strokes



Moving energy made easy: chainflex® thermocouple cable CFTHERMO. K001 lasts for more than 97 million strokes. Proven in test 4009, part of 700 parallel test programs in the largest test laboratory for flexible cables (2,750 m²).

- Test number: 4009
- Cable type: CFTHERMO.K.001
- Test parameter: bend radius 48 mm
- Service life: 97 million strokes
- Online calculation available
- One metre or more from stock without cutting charges

www.chainflex.eu/test4009



Test-Report chainflex®

Test No.:	4009

Test Intention:

In test 4009 we want to investigate the lifespan of a CFTHERMO.K.001 on the short way.

Client:

Name: Nils Jäger	Team: chainflex®	Date: 31.01.2011

Order-Info:

Customer / No.: igus® GmbH, Spicher Str. 1a, 51147 Köln

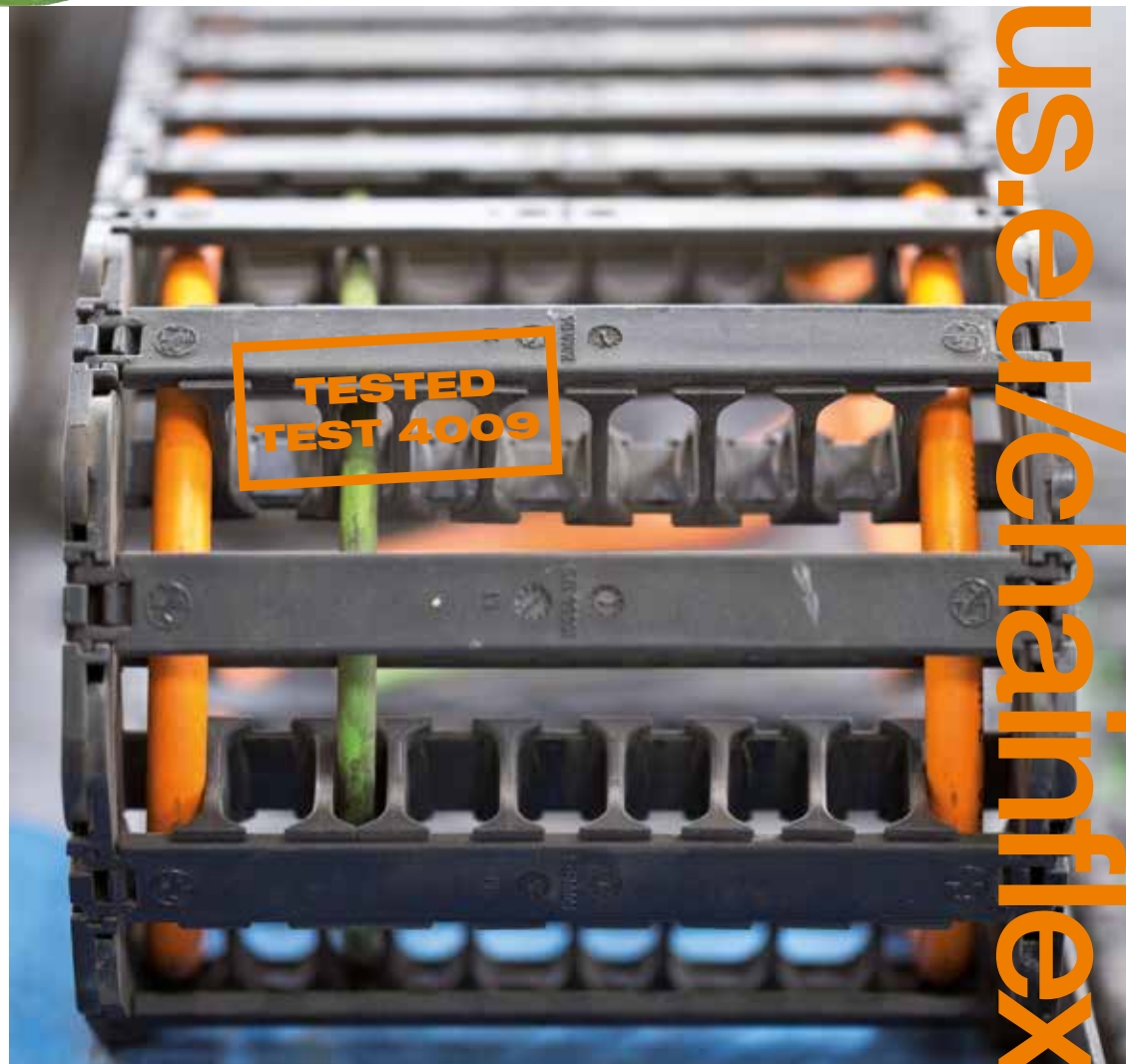
Series / No: CFTHERMO.K.001	Installation type: horizontal, short way
Customer test: Yes ☐ No ☒	Development test: Yes ☒ No ☐

Technical data		Target & Examination	
e-chain® type:	1500.125.048.0	Cable length [m]:	3,0
e-chain® radius [mm]:	48	Target [strokes]:	Lifespan
Stroke [m]:	0,8	Optical check:	☒
Acceleration a [m/sec²]:	0,5	Function check:	☐
Velocity v [m/s]:	1,0	Standard measuring:	☒
Ambient temperature [°C]:	approx. 25°C	AutΩMeS:	☐

Experimental setup

Checklist for the experimental preparations
☒ additional inscription/label at all wires
☒ strain reliefs at both ends of the chain
☒ correct electrical connection of all wires
☒ radius was marked at the cables and the energy chain

1. Construction:



www.igus.eu/chainflex

Harnessed cables with a guarantee - readycable®

The portfolio includes an extensive range of catalogue products

- 4,200 harnessed drive cables in accordance with 24 manufacturer standards and diverse industrial standards
- Individually customised or serial production
- Numerous types of cable of different qualities, with different approvals and certificates of conformity
- Extensive quality checks and functional tests for all components

www.igus.eu/readycable

Reduce throughput times

readycable® harnessed cables are ready-to-connect cables for use in energy chains®. As manufacturer and harnesser, igus® provides everything from a single source, thus reducing throughput times and the number of suppliers.

Ready to install and industrially harnessed: www.igus.eu/readychain

Always the right harness for your application. Ready-to-assemble readychain® e-chainsystem® configured and delivered in 3-8 days.
Possible due to the large selection of energy chains® for all kinds of motion, cables for the e-chain® with 36 month guarantee plus the relevant connectors. Reduce the number of suppliers and orders by 75%. Minimise machine downtimes. System guarantee - depending on the application.

www.igus.eu/readychain

3 ... 6 ... 9 ... 13 ... Productivity accelerator

readychain® basic:
3 ... of 13
readychain® benefits

1 ONE supplier
2 Reduce assembly time
3 Reduce failures

readychain® standard:
6 ... of 13
readychain® benefits

1 ONE supplier
2 Reduce assembly time
3 Reduce failures
4 No electrical termination needed
5 100% digitally tested
6 No cable surplus

readychain® standard+:
9 ... of 13
readychain® benefits

1 ONE supplier
2 Reduce assembly time
3 Reduce failures
4 No electrical termination needed
5 100% digitally tested
6 No cable surplus
7 Reduce interfaces
8 Optimise interfaces
9 Ready to install multi-axis system

readychain® premium:
13 ... of 13
readychain® benefits

1 ONE supplier
2 Reduce assembly time
3 Reduce failures
4 No electrical termination needed
5 100% digitally tested
6 No cable surplus
7 Reduce interfaces
8 Optimise points of connection / interfaces
9 Ready to install multi-axis system
10 Optimise your transport / assembly
11 One single assembly
12 One Part No. / Product group
13 Plug & Play

chainflex® tested - the largest test lab for moving cables worldwide

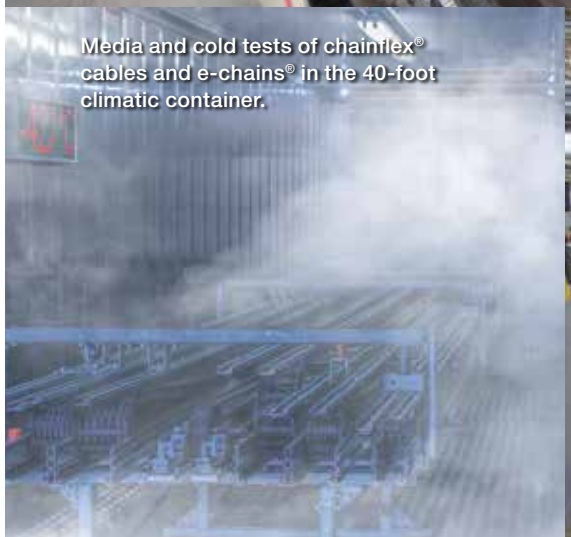
Over 2 billion test strokes every year in the lab

Anyone who wants to carry out systematic, comparative and reproducible tests with a volume of more than 2 billion double strokes and 1.4 million electrical measurements must, of course, provide the necessary spatial, technical and personnel requirements. On a total of 64 test facilities, various test series are carried out according to the special igus® test standards. The laboratory team consisting of technically qualified and committed employees tests and monitors thousands of measuring points in e-chains® and cables on a wide range of travel paths, in horizontal or hanging applications and always under the most real-life conditions possible in field experience. Multi-dimensionally moving e-chains® such as the triflex® series from the robotics range are also tested for torsional strength on special test rigs.

Special test equipment for the special something

In addition to the normal quality and service life tests, special testing rigs are also available for custom tests. Thus, for example, abrasion and media tests for materials are carried out under considerably more accurate experimental conditions than in tests for storage and aging carried out according to UL or VDE standards. The optimum matching of igus® outer jacket materials to the materials in the energy supply systems is a tribologically clearly noticeable result. The influence of thermal factors on moving cables can be analysed in two special climatic containers for a temperature curve of -40°C to + +60°C. Both are equipped with a 6 m long axis, which can be operated with different radii and e-chains®. In contrast to the standard winding mandrel test according to VDE, one can test the aging in very different temperature curves in continuous motion in e-chains®.

Guarantee
igus chainflex
36
month guarantee



Media and cold tests of chainflex® cables and e-chains® in the 40-foot climatic container.

Test for complex movements by simulating multi-axis applications on the robot.

www.igus.eu/chainflex

What is the point of 1,354 different cables in the catalogue?

Saves cash and is easy to use.
The chainflex® catalogue.
On 960 pages.

The portfolio includes an extensive range of catalogue products

- 1,354 chainflex® cable types from stock
- For use in e-chainsystems®
- No minimum order
- No costs for cutting cables
- Available from 24h or today
- On a drum, in a coil or fully connectorised

www.igus.eu/chainflex

How can a price of more than 20 euros per metre be justified for a control cable measuring 4x0.5 mm² that does the same as another cable that costs only 0.42 euros per metre? The answer: the mechanical parameters that such a control cable makes possible. For its chainflex® CF98 high-end control cable, for example, igus® gives a guarantee of 40 million double strokes. Absolute fail-safety, even for highly dynamic applications with extremely small radii, is guaranteed. This has been tested and proven in tests and practical applications. However, igus® also offers the other extreme: with the low-cost chainflex® M product range, igus® offers cables for price-sensitive applications. The CF880, for example - as well as the CF98 high-end cable - also has a core/cross-section combination of 4x0.5 mm², but only costs 0.42 euros per metre. And lasts for at least 36 months or five million double strokes in combination with a bend radius of 12.5 x d .

Altogether, the chainflex® catalogue now contains 1,381 cables, 1,354 of which igus® can supply directly from stock and deliver within 24 hours.

igus® is thus committed to greater variety - more variety for **optimum energy and data transmission** in moving applications. Always thoroughly tested in the igus® laboratory and always with the unique 36-month chainflex® guarantee.

Tested ...

- Ethernet bus cable Cat 5e, CFBUS.045
- More than 76 million strokes in e-chain® tested
- With a bend factor of 9.4 x d

Extensive test data-base

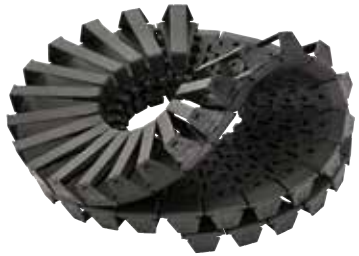
Tested ...

- Measuring system cable CF11.D
- More than 65 million strokes in e-chain® tested
- With a bend factor of 9.4 x d

Tested ...

- Servo cable CF27.D
- Tested for 53 million strokes
- Gusset-filling extruded inner jacket

Tested ...



- twisterband with chainflex® cables
- Test for torsion and twisting
- Rotate up to 7,000°

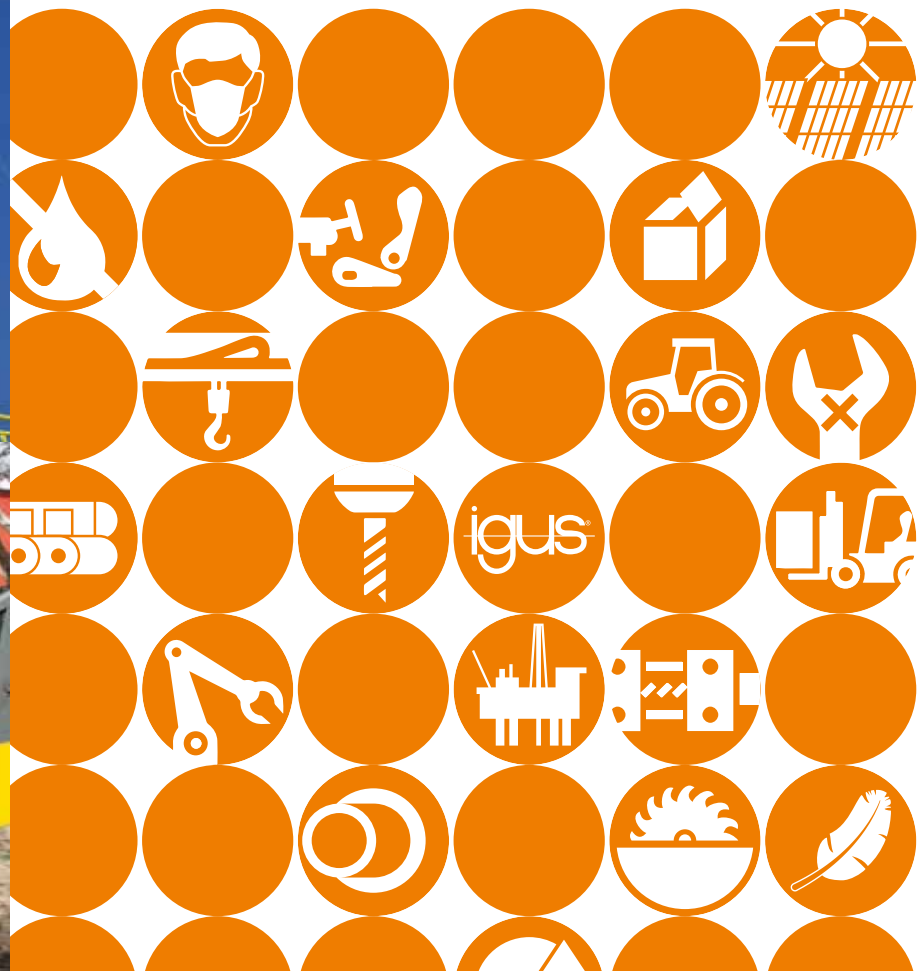
From more than 15,000 tests per year was created, what is probably the world's largest test database. This database gives us the ability to select always the right product for your specific application. Individual tests for your branch of industry are also possible.

www.igus.eu/test

www.igus.eu/chainflex

Always the right solution for more than 60 industries: www.igus.eu/industry

igus® motion plastics® solutions for almost any industry.
Different industries need different solutions. From mechanical engineering, automotive assembly or medical technology, to the robotics industry - igus® offers customised solutions for specific applications. igus® possesses many years of experience in most branches of industry and has competent specialists that can be contacted when necessary.



www.igus.eu/chainflex

Lots of room for innovation - the flexible igus® factory

From a garage in Cologne to the global market with ideas and Tribo polymers.

What began in 1964 in a back yard in Cologne with a single injection moulding machine and confidence in the potential of polymer materials grew to be a globally active enterprise in 54 years.

Today, 3,180 employees come up with new ideas daily, while making high-quality products, ensuring streamlined processes, guaranteeing short delivery times and, above all, maintaining close proximity to the customer. igus® dispatches around 5,500 deliveries every day. To ensure speedy service and individual consulting, 14 storage and assembly centres around the world are available to customers.

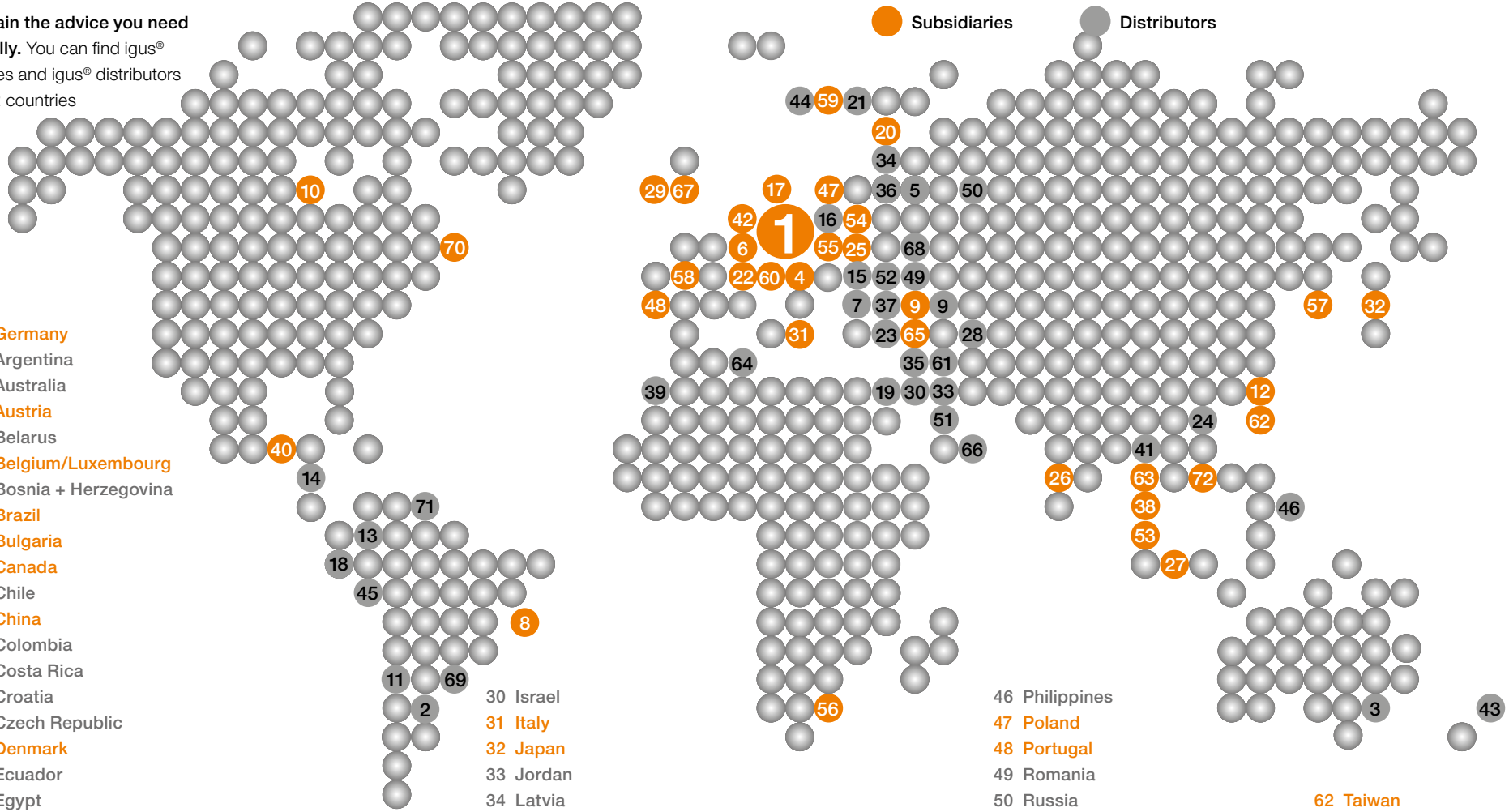
3,180 employees in
35 branch offices
worldwide

www.igus.eu/chainflex

igus® offices and distributors worldwide

www.igus.eu/contact

Obtain the advice you need locally. You can find igus® offices and igus® distributors in 72 countries



1 Germany
2 Argentina
3 Australia
4 Austria
5 Belarus
6 Belgium/Luxembourg
7 Bosnia + Herzegovina
8 Brazil
9 Bulgaria
10 Canada
11 Chile
12 China
13 Colombia
14 Costa Rica
15 Croatia
16 Czech Republic
17 Denmark
18 Ecuador
19 Egypt
20 Estonia
21 Finland
22 France
23 Greece
24 Hong Kong
25 Hungary
26 India
27 Indonesia
28 Iran
29 Ireland
30 Israel
31 Italy
32 Japan
33 Jordan
34 Latvia
35 Lebanon
36 Lithuania
37 Macedonia, Albania, Kosovo
38 Malaysia
39 Morocco
40 Mexico
41 Myanmar
42 Netherlands
43 New Zealand
44 Norway
45 Peru
46 Philippines
47 Poland
48 Portugal
49 Romania
50 Russia
51 Saudi Arabia
52 Serbia + Montenegro
53 Singapore
54 Slovakia
55 Slovenia
56 South Africa
57 South Korea
58 Spain
59 Sweden
60 Switzerland
61 Syria
62 Taiwan
63 Thailand
64 Tunisia
65 Turkey
66 United Arab Emirates
67 United Kingdom
68 Ukraine
69 Uruguay
70 USA
71 Venezuela
72 Vietnam

www.igus.eu/chainflex

igus.de/8pm

Buy online - 24h!

igus® is certified in accordance with ISO 9001:2008 and ISO/TS 16949:2009 in the field of energy supply systems, cables and harnessing, as well as plastic bearings.

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Phone: +49-2203 9649-800
Fax: +49-2203 9649-222
info@igus.de
www.igus.eu

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