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The tricks and features of the chainflex® design

Tested, tested, tested

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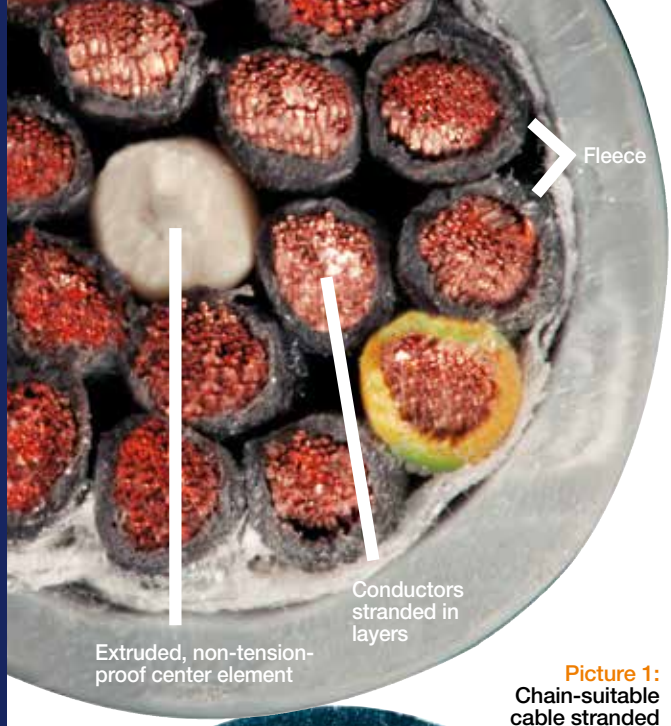
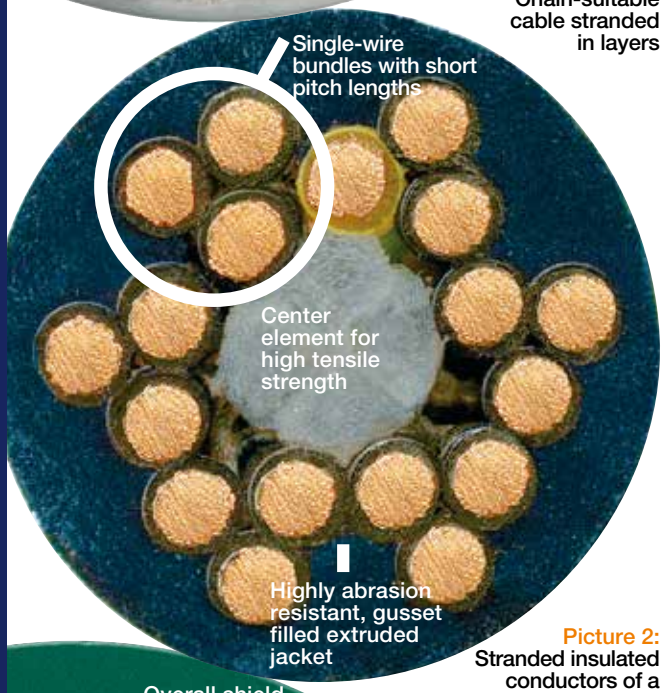
From a customer's point of view, a flexible energy supply system only needs to function properly. However, this requires all components, including cables, to be incredibly reliable. In the 1980's, constant and tremendous increases in loads in automation technology began resulting in frequent cable failure in otherwise functional energy supply systems. In extreme cases, cable corkscrewing and core ruptures had brought entire production lines to a standstill, resulting in lost profits coupled with high repair/replacement costs.

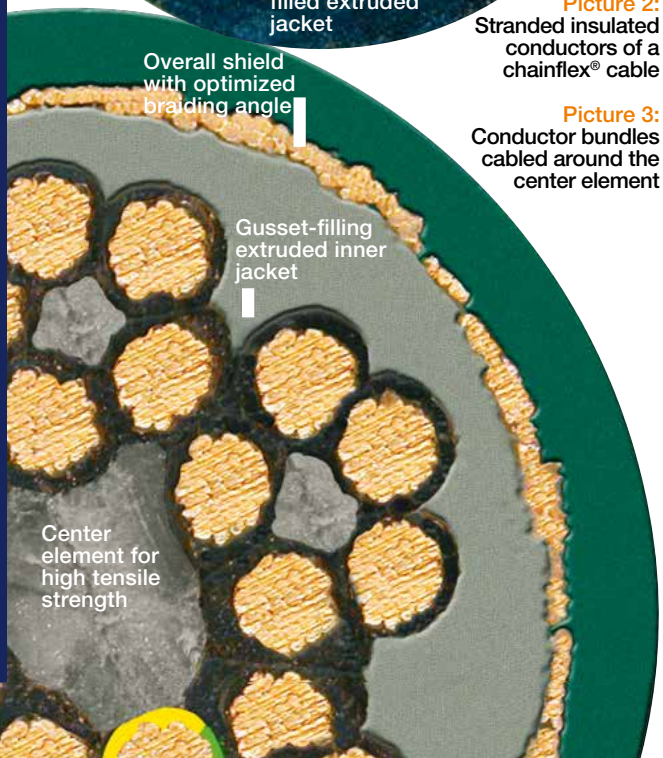
To find a solution to this problematic and expensive customer issue, igus® began the development of complete energy supply systems, including E-Chain® cable carriers and chainflex® continuous-flex cables offered from a single source. Based on more than 25 years of experience and testing, certain design principles for chainflex® cables have been developed to prevent maintenance and downtime in factories around the world



Picture 1:
Chain-suitable cable stranded in layers



Picture 2:
Stranded insulated conductors of a chainflex® cable



Picture 3:
Conductor bundles cabled around the center element

How can corkscrews be prevented?

"Corkscrewing" of a cable refers to the permanent deformation of moving cables caused by excessive stress. In almost all cases, a corkscrewed cable's core will rupture as well. An important factor in preventing corkscrews, in addition to the guidance of a cable in the proper Energy Chain System®, is the construction of the cable itself, especially in terms of stranding in bundles as opposed to layers ▶ see picture 4.

Properties of cable constructed in layers

Cabling conductors in layers is significantly easier and less expensive to produce, and are therefore available on the market as so-called "chain-suitable," low-cost cables. However tempting this may seem, these cheap cables can quickly turn expensive when a corkscrew immobilizes the system and needs emergency repairs. A visual reference of a layered, chain-suitable cable is featured in ▶ picture 1.

Cables made with layered conductors are combined in progressive layers with various pitch lengths around the center element, then a jacket material is extruded to form a tube. Shielded cables add protection in the form of fleece or foil shielding around the cores. In normal continuous-flex operation, the movement of the conductors in the inner radius is compressed, while simultaneously being stretched in the outer radius. Initially, the elasticity of the materials allows this to work quite well, but material fatigue will, over time, cause permanent deformations. At the same time, conductors are able to move from their specified paths within the jacket, creating their own compressing and stretching zones, creating the corkscrew, followed quickly by core ruptures.

... works or your money back!

...the chainflex® cable design

Properties of cables made with bundles

Cables made with bundled conductors eliminate the problems of layered cables due to the internal groups of conductors. In the bundling process, conductors are cabled in groups with a special pitch length first, then the resulting groups are cabled into bundles. For large cross-sections, this is done around a strain-relief center element. ▶ see picture 2.

The overall cable construction allows the inner and outer radius of the cable to bend at identical intervals. Pulling and compressing forces balance around the high-tensile center element, giving necessary inner stability. This keeps the stranding of the cable stable, even under maximum bending components. ▶ see picture 3.

Picture 4: **Shielded „chain-suitable“ control cable after only 400,000 cycles with a bending factor of 10 x d**

EMC problems and shield breakage

In principle, a cable's shields must fulfill two tasks: protecting the cables from external influences, and shielding interferences before transmitting them to outside the cable. Both these tasks are equally important, as faulty signals can cause considerable and consequential damage within and outside of the cable system. As incorrect shielding cannot be detected from the outside, troubleshooting EMC and other problems due to a faulty shield can be extremely difficult.

Problems with a cable's shield can arise if the cable shield is not designed specifically for continuous-bending stresses. Although it is very simple to shield a fixed cable, dynamic applications prove much more difficult.

In the chain suitable cables referred to earlier in this section, the stranding bond of an intermediate layer is wrapped with foils or fleeces. This stranding bond is supposed to ensure separation between the conductors and the braided shield. While this is sufficient for fixed or static cables, it is often not enough for moving cables, as the foils/fleeces do not create a bond between the stranding, allowing the shield and jacket to fall apart under stress. Consequently, the metallic shield can then rub on the conductor insulation causing short circuiting.

Dictionary of cable defects

Loss of continuity

The copper conductors can break or become severed causing a loss of continuity when insulated conductors are twisted with incorrect pitch length/direction. The cable core cannot absorb the mechanical load caused by the cable's flexing, transferring the force to the copper conductors and causing them to break under the increased tensile load.

Insulation damage

Insulation damage occurs when the insulation integrity of a cable's conductors are compromised. This is caused by material fatigue under constant bending stress, abrasion within the cable structure and/or conductor strand breakage, which in turn perforates the insulation.

Corkscrewing

This failure type is named for its easily recognizable mechanical deformation of the entire cable. The corkscrew, sometimes called pigtail, effect is caused when the torsional forces incurred during the cabling process are allowed to release during continuous-flexing operation. These forces are released because the cable configuration, pitch length and pitch direction are incorrect. Cables constructed using the layering process are typically more susceptible to corkscrewing

Jacket abrasion

When the outer jacket of a cable wears through to the underlying layers of shielding or conductors, jacket abrasion occurs. This mechanical failure is common when soft jacket materials or a thin jacket extrusion is used.

Jacket swelling/cracking

A cable's outer jacket usually swells because of exposure to oil or chemicals the cable was not designed to withstand. Jacket cracking occurs when the jacket breaks so that the shield can be seen, and is an effect of excessively high/low temperatures

Shielding losses/EMC problems

Increased electromagnetic interfaces (EMI) occurs when the shield designed to protect the cable signals from electromagnetic fields break and abrade due to continuous flexing.

Jacket breakage at (36x0.14²) after only 900,000 cycles with a bending factor of 7.8 x d

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As the production of a cable's shield is very time consuming and cost-intensive, open braid shields or simple wire wrappings are sometime used. However, these alternatives to the braided shield have significant disadvantages. For one, open shields only possess a limited shielding effect when used in motion, and additional movement can reduce their efficacy even further. The shielding of a cable is an important design point, but is not mentioned in some catalogs. By offering approximately 90% optical coverage of their cables, igus® eliminates these weak points by means of an optimized internal cable structure. In virtually all shielded chainflex® cables, a gusset-filled inner jacket over the cable core is used to fulfill two tasks:

- To hold the cable core together and guide individual conductors.
- To serve as a firm, round base structure for a very tight-fitting shield.

Prevent shield wire breakage

During the production of the shield, many things can be done correctly, or incorrectly, including using the correct braiding angle. In many chain-suitable cables, a tensile load of the shield wires along the outer radius of the cable must be taken into account. If an unfavorable braiding angle is added, the tensile load can increase even further causing shield wire breakage. This breakage can result in reduced shielding properties or short circuits if the sharp broken wires penetrate the protective fleeces/foils into the conductors.
Tip: If after the jacket has been stripped the shield can easily be pushed back over the insulation, the shield is generally unsuitable for use in flexible energy supply systems. igus® chainflex® cables use a direct approach to solve this problem of loose and ineffective shielding:

- Use braid angles determined in long-term testing to efficiently balance tensile forces
- Use a stable inner jacket to keep conductors in place.

Jacket abrasion/breakage

While defects of a cable's inner structure is not detectable from the outside, jacket problems are immediately visible. A cable's jacket is the first line of protection for the complicated inner structure, therefore, broken, worn, and swollen jackets should be considered a serious quality defect. To prevent these problems, igus® customers can select from 7 jacket material options to best suit the application at hand.

... works or your money back!

...the chainflex® cable design

Gusset-filled extruded jacket

In the case of standard chain-suitable cables, the cable jackets are usually extruded as a tube, which does not support the stranded conductors during constant bending, allowing the cable core to fall apart over time. To avoid this, igus® designs its chainflex® cables with an extruded jacket.
With an extruded jacket design, the jacket material is injected between the insulated conductors to ensure the cable core cannot come apart. This method of production creates intermediate spaces between conductors, which are then filled with the extruded material, creating a channel-like guidance system which allows the conductors to carry out a defined longitudinal movement.

7 basic rules for a good cable

1. Strain-relieving center element

The center core should be filled with a high-quality, high tensile strength center element to protect conductors from falling into the center of the cable.

2. Conductor structure

The copper stranding in chainflex® continuous-flex cables is chosen in accordance with tested and proven designs. The test results from the igus® lab indicate that a medium to fine conductor strand diameter is preferable. Many competitive cable manufacturers will employ an extra-fine conductor strand, which has the tendency to kink when subjected to a high number of cycles. Using findings from long-term cable testing, igus® uses a combination of conductor strand diameter, pitch-length, and pitch direction to achieve the best service life and performance, even in the most demanding applications.

3. Conductor insulation

Insulation materials within the cable must be resistant to adhering to one another. The insulation must also support the stranded individual wires of the conductor. Only the highest quality high-pressure extruded PVC or TPE materials should be used.

4. Cable core

Individual conductors are bundled into groups, which are cabled together in a single layer surrounding the cable core. This design enables pulling and compressing forces of the bending motion to balance and cancel out torsional forces. Special attention is given to pitch length and direction. The cable's inner jacket will also help to maintain the integrity of the cable core and provide a continuous surface for the shield.

5. Inner jacket

A pressure extruded inner jacket should be used for cables subjected to continuous-flexing, as opposed to inexpensive fleece wrap or filler. This extruded inner jacket both ensures that the insulated conductors are efficiently guided, as well as maintaining the integrity of the cable core and providing a continuous surface for the overall shield.

6. Shield design

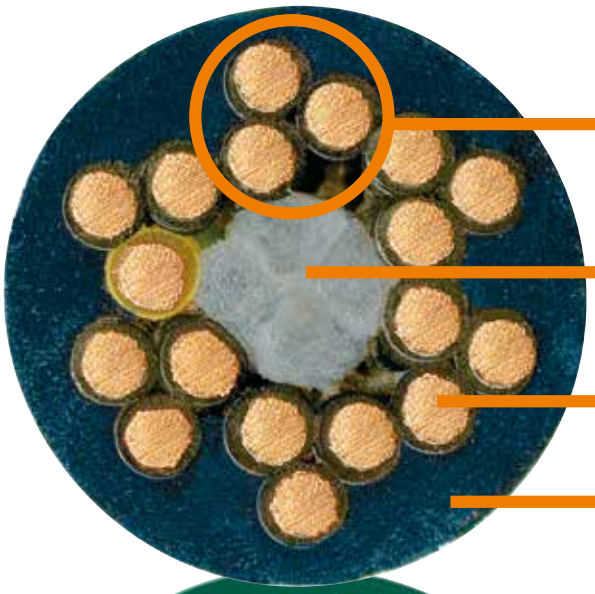
A high-quality braided shield provides electromagnetic interference (EMI) protection for the cable. An optimized braid angle prevents the shield strands from breaking over the linear axis and increases torsional stability. The shield has an optical coverage of approximately 90%, providing maximum shield effectiveness.

7. Outer jacket

The outer jacket material must be resistant to UV radiation, abrasion, oils, and chemicals, as well as being cost-effective. However, the outer jacket of a cable for dynamic applications must be resistant to abrasion, and remain flexible while providing support. For best wear rates and service life, the outer jacket should be extruded under pressure.

Sectional views through the

Detailed structure of igus® control, data, servo and motor cables



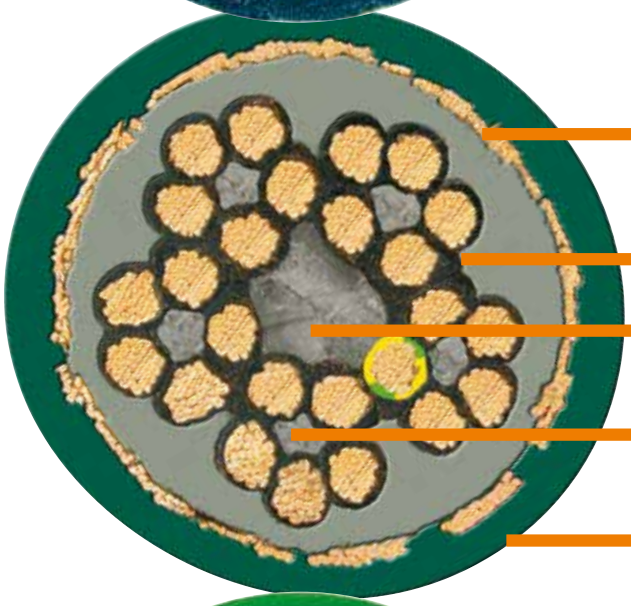
chainflex® control cable, unshielded

Individual bundles with optimized pitch length and pitch direction

Center element for high tensile strength

Single-wire diameter optimized for Energy Chains®

Highly abrasion-resistant, gusset-filled extruded jacket



chainflex® control cable, shielded

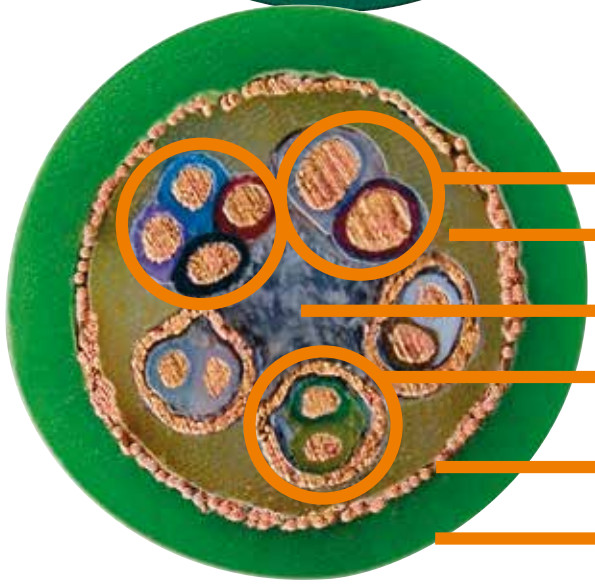
Overall shield with optimized braiding angle (covering approx. 90% optical)

Gusset-filled extruded inner jacket supports stranding

Center element for high tensile strengths

Center element for high tensile strengths in individual bundles

Tension-proof centre element in individual bundles



chainflex® data/ sensor cable, shielded

Stranded elements with optimized pitch length and pitch direction

Gusset-filled extruded inner jacket supports stranding

Center element for high tensile strength

Pair braid shield

Overall shield with optimized braiding angle (covering approx. 70% linear, approx. 90% optical)

Pressure extruded jacket

igus® cable types

chainflex® FOC gradient fiber cable

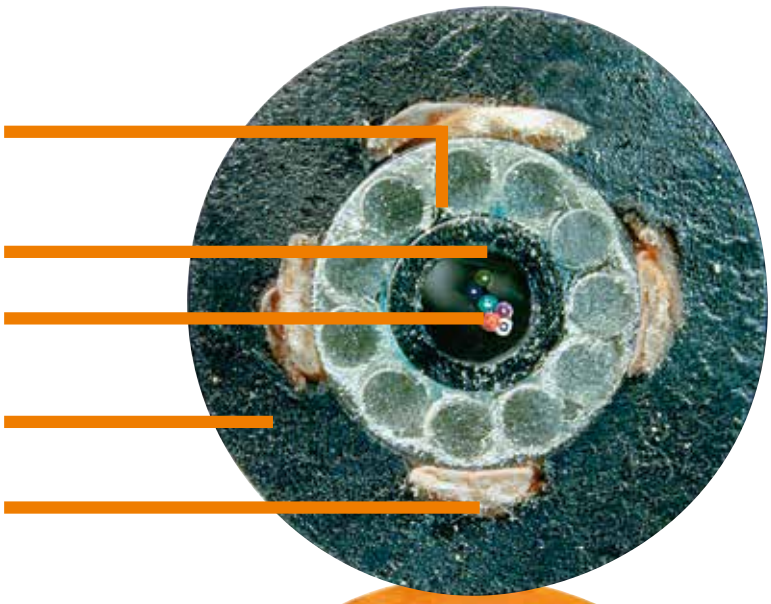
Supporting braid made of glass-yarn-stranded GRP rods

Gel-filled fiber sheath

FOC fibers

Highly abrasion-resistant TPE jacket

Integrated torsion protection



chainflex® servo cable, shielded

Overall shield with optimized braiding angle (covering approx. 90% optical)

Optimized single-wire diameter

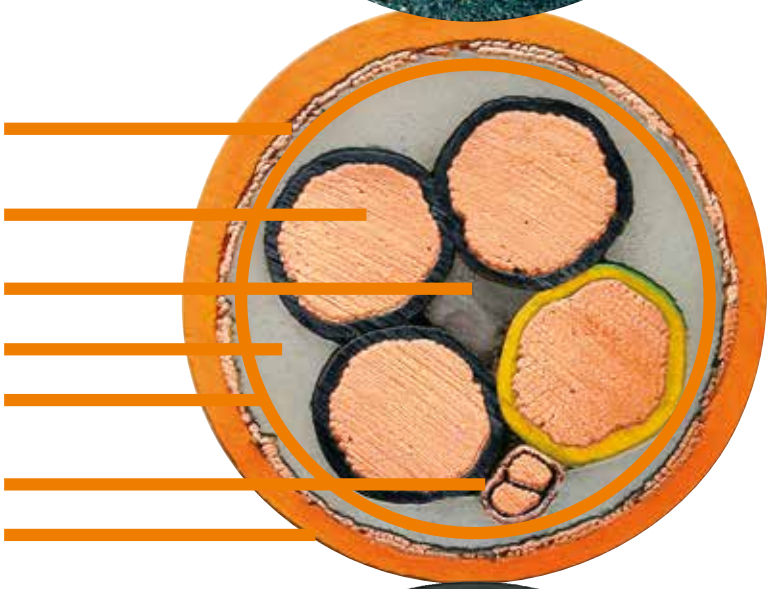
Center element for high tensile strength

Gusset-filled extruded inner jacket

Stranding with optimized pitch length and pitch direction

Pair braid shield over optimized stranded core pair

Highly abrasion-resistant pressure extruded jacket



chainflex® motor cable, shielded

Overall shield with optimized braiding angle (covering approx. 90% optical)

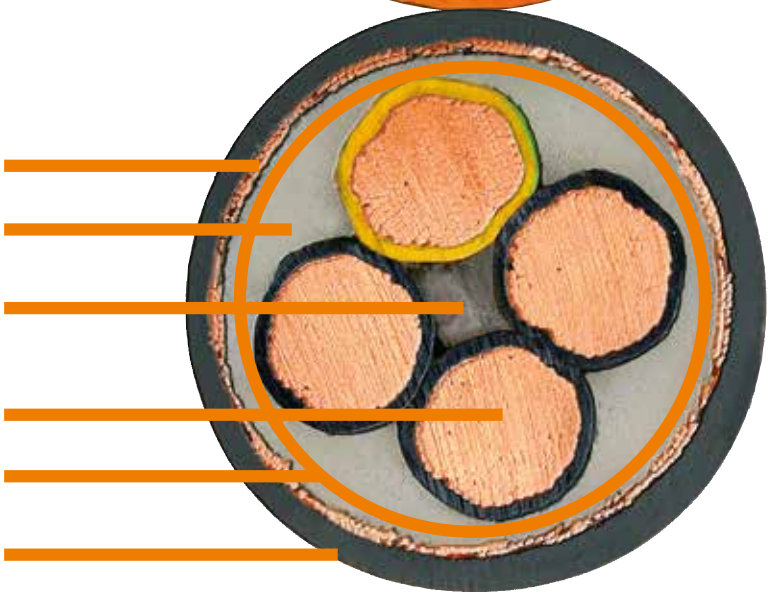
Gusset-filled extruded inner jacket

Center element for high tensile strength

Optimized single-wire diameter

Stranding with optimized pitch length and pitch direction

Highly abrasion-resistant pressure extruded jacket



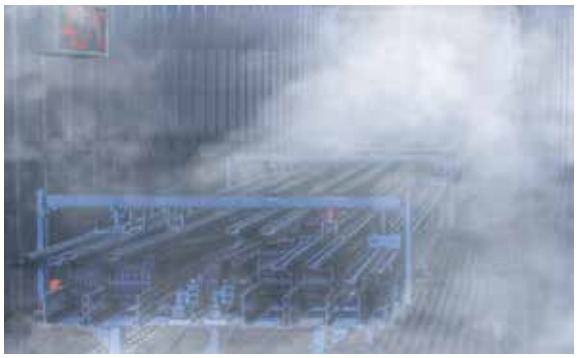
Example: Test 4876 Tested at -40°F cold

Bending tests in cold conditions in the E-Chain® with amazing results.

25 years of tests in the igus® in-house chainflex® test lab have clearly shown that internationally valid standards for the testing of cables are quite useful, but do not meet the special requirements for the continuous movement in e-chains®. Thus we also have the standard ratings for "*Mechanical tests - Low temperature bending tests for insulating sheaths and jackets*" according to IEC 60811-504.

According to this internationally recognized standard, cables, according to your outer diameter, are wound around a mandrel and cooled down for a certain time to the temperature to be tested.
After the removal, a visual inspection is carried out. For the material to be tested, the test is deemed to have been passed if the material (in this case outer jacket) does not show damage, e.g. cracks.
Based on this standard, all cables for the movement are tested in this way and the limit temperature is specified in catalogs as the lowest temperature for the moving application.
Thanks to many different series of tests, igus® has shown that these values are in accordance with the standards, but in continuous movement in the e-chain® the materials tested in this way do not withstand the temperature.

Example: igus® test 4876. Here, the so-called chain-compatible PUR cables were tested in comparison with those with chainflex® TPE jacket material.
The cables to be tested are moved in continuous motion in the igus® 40-foot cooling container in an e-chain® at -40°F with a bending factor of 6.5 x d on a travel of 16.4 ft (5 m).



Media and cold tests of chainflex® cables and E-Chains® in the 40-foot climatic container

The results of this experiment are extraordinary and representative:
Cables, which are available on the market as cold-flexible up to -40°F with a PUR outer jacket and are marketed professing a service life of 10 million cycles in the catalogues, fail in a real test in an E-Chain® at -40°F with a massive jacket break already after less than 41,000 strokes!

Jacket damage already after 41,000 strokes ...

The test of parallel running CF9-15-18, however, was discontinued after more than 520,000 double strokes since no alteration could be detected at all.
On the basis of this and many other test series, igus® is the only renowned supplier on the market that is able to list three different temperature ranges in the catalogs:
For the fixed installation, the flexible movement according to DIN EN 60811-504, as well as for the continuously moving application in the e-chain®.

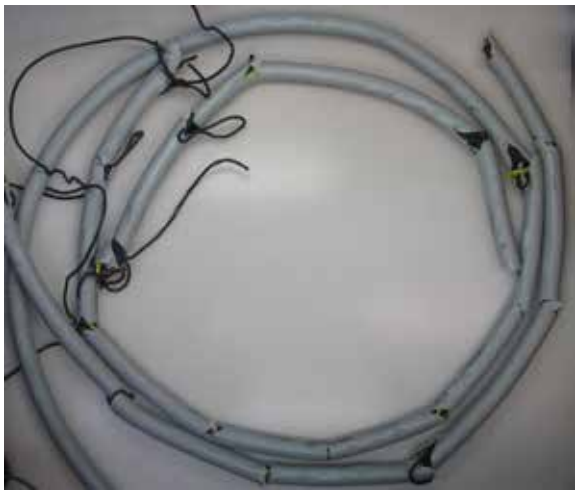
A test result from the igus® database	
Test no.	4876
Bend factor in E-Chain®	6.5 x d
Test temperature	-40°F
Result PUR jacket	Break after 41,000 strokes
Result chainflex® TPE jacket	520,000 strokes without any damage

Details of the test online:
www.chainflex.com/test4876

Calculate service life online:
www.igus.com/chainflexlife

40-foot climatic container for cable tests in continous motion at -40°F

520,000 strokes without any damage, which the CF9-15-18 managed in this test



Result PUR jacket: Break already after 41,000 strokes

Result chainflex® TPE jacket: Cable after the test with 520,000 strokes

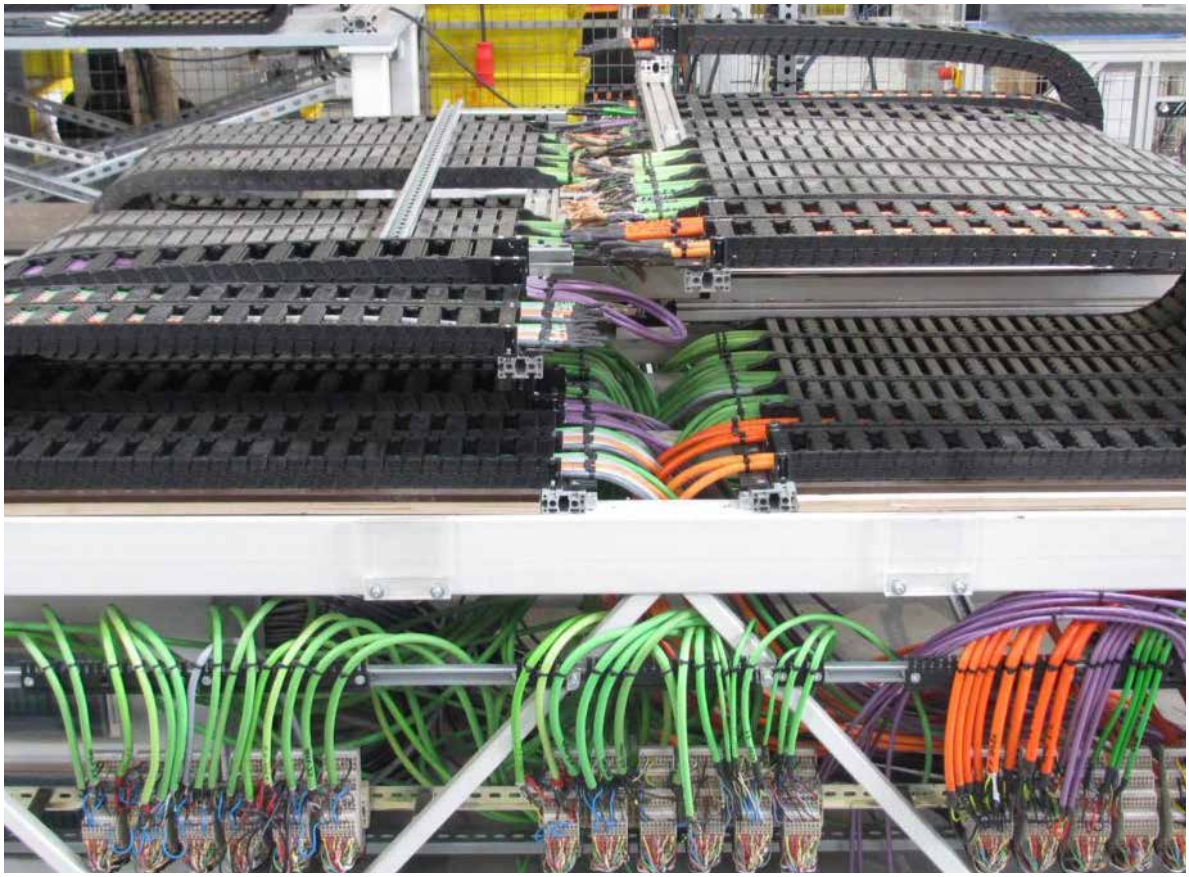
Example: Test 4866
4 years in continuous test
chainflex® Profinet

Bending tests in E-Chain® with Chainflex Profinet bus cable and over 29 million double strokes.

Due to its extensive equipment, the igus® laboratory with a floor area of 29,600 ft² offers the necessary environment to carry out continuous bending tests even over many years under real conditions. Because, only these real long-term tests lead to the necessary findings about the behaviour of cable constructions and materials.
These long-term studies are used to equip the chainflex® online service life calculator with the necessary data.
The chainflex® online service life calculator offers the user the great advantage of being able to determine the expected service life in advance so as not to be surprised by unscheduled downtime.

In test 4866, the following question should be clarified:
To what extent is the continuous bending stress of the Profinet bus cable of the chainflex® CFBUS-060 type affecting the electrical transmission quality?
Or, in other words, if a chainflex® bus cable is moved in an e-chain® for years, can a secure data transmission still be expected.

At the time of this catalogue 2018 edition, the CFBUS-060 cable has been in the long-term test for over 4 years and has covered over 29 million double strokes without a measurable change in the electrical properties.



Linear chain tests with continuous monitoring of the electrical cable parameters

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Kabelkennung: 4866-1.1

Testzusammenfassung: PASS

Datum/Uhrzeit: 03/08/2017 11:24:16 AM
Reserve 15.9 dB (NEXT 12-36)
Grenzwert: Profinet
Kabeltyp: Cat 5e F/UTP
NVP: 66.0%

Bediener: A.FINKE
Software-Version: 2.7800
Grenzwerte Version: 1.9500
Kalibrierungsdatum:
Hauptgerät (Tester): 03/03/2017
Remote (Tester): 03/03/2017

Modell: DTX-ELT
Hauptgerät S/N: 9751011
Remote S/N: 9751012
Adapter Hauptgerät: DTX-CHA002
Adapter Remote: DTX-CHA002

Länge (ft)	[Paar 12]	34
Laufzeit (ns), Grnz. 555	[Paar 12]	52
Abweichung (ns), Grnz. 20	[Paar 12]	0
Widerstand (Ohm), Grnz. 25.0	[Paar 12]	1.3
Einfüg.-Dämpf. Reserve (dB)	[Paar 12]	20.5
Frequenz (MHz)	[Paar 12]	100.0
Grenzwert (dB)	[Paar 12]	24.0

	Min. Abstand		Min. Wert	
N.A.	MAIN	SR	MAIN	SR
Schlechtest Paar	12-36	12-36	12-36	12-36
NEXT (dB)	15.9	16.4	20.8	19.7
Freq. (MHz)	11.9	11.0	86.0	90.0
Grenzwert (dB)	45.8	46.3	31.2	30.9
Schlechtest Paar	12	12	12	12
PS NEXT (dB)	18.9	19.4	23.8	22.7
Freq. (MHz)	11.9	11.0	86.0	90.0
Grenzwert (dB)	42.8	43.3	28.2	27.9

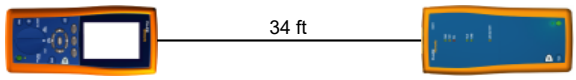
PASS	MAIN	SR	MAIN	SR
Schlechtest Paar	12-36	36-12	12-36	36-12
ACR-F (dB)	28.1	28.1	28.1	28.1
Freq. (MHz)	99.3	99.3	99.5	99.5
Grenzwert (dB)	17.5	17.5	17.4	17.4
Schlechtest Paar	36	12	36	12
PS ACR-F (dB)	31.1	31.1	31.1	31.1
Freq. (MHz)	99.3	99.3	99.5	99.5
Grenzwert (dB)	14.5	14.5	14.4	14.4

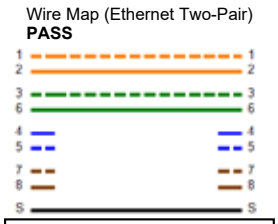
PASS	MAIN	SR	MAIN	SR
Schlechtest Paar	12-36	12-36	12-36	12-36
ACR-N (dB)	21.8	21.0	39.7	39.4
Freq. (MHz)	3.0	2.1	86.0	91.3
Grenzwert (dB)	51.6	54.0	9.1	7.9
Schlechtest Paar	12	12	12	36
PS ACR-N (dB)	24.8	24.0	42.6	42.4
Freq. (MHz)	3.0	2.1	86.0	91.3
Grenzwert (dB)	48.6	51.0	6.1	4.9

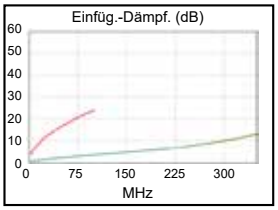
PASS	MAIN	SR	MAIN	SR
Schlechtest Paar	12	12	12	12
RL (dB)	6.9	6.7	7.2	6.7
Freq. (MHz)	85.5	89.8	99.8	89.8
Grenzwert (dB)	10.7	10.5	10.0	10.5

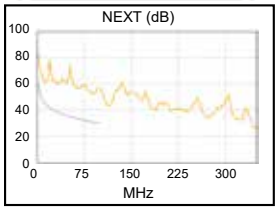
Erfüllte Network Standards:

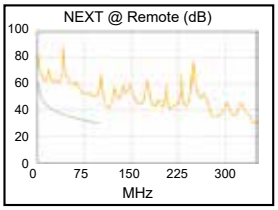
10BASE-T	100BASE-TX	100BASE-T4
1000BASE-T	ATM-25	ATM-51
ATM-155	100VG-AnyLan	TR-4
TR-16 Active	TR-16 Passive	

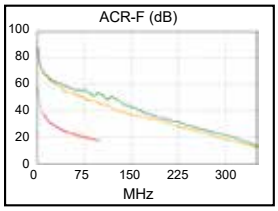


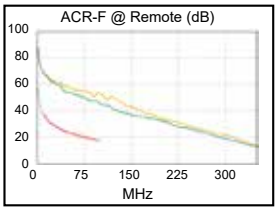


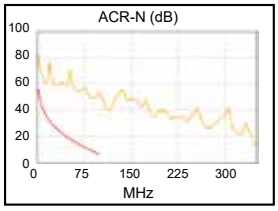


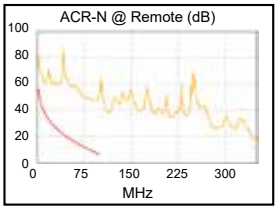


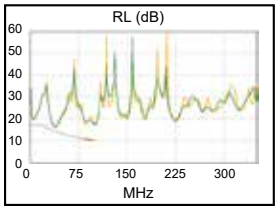


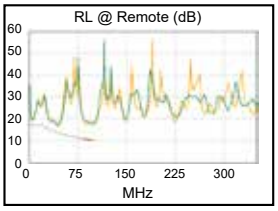












LinkWare™ PC Version 9.6

Projekt: CHAINFLEX
Unbenannt1

Ort: LABOR

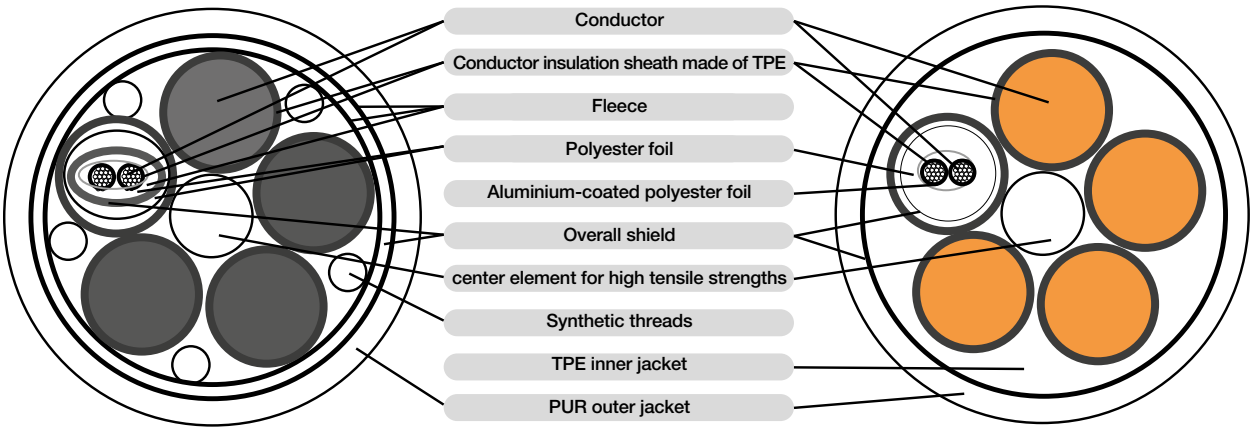
FLUKE networks

A test result from the igus® database	
Test no.	4866
Bend factor in e-chain®	8.5 x d
Measuring devices	Fluke DTX-ELT
Double strokes without damage	29 million

Details of the test online:
www.chainflex.com/test4866

Calculate service life online:
www.igus.com/chainflexlife

Example: tested, tested, tested! Servo cable structure



Sample B with fleece and filler experimental production 4x10+(2x1.0) C

Testing a servo cable's structure is done to determine advantages of more expensive internal jackets in shielded servo cables when compared to less expensive cables that utilize fleece taping with fillers.

Typically, with flexible shielded cables, the shield is separated from the composite conductor structure. This is done to create a rounder braid form as well as prevent friction between the conductor insulation and the braided shield. This separation can be achieved via an internal jacket, or a fleece taping, which is wrapped around the composite conductor structure.

More technically sophisticated, and therefore expensive, an internal jacket is extruded around the composite conductor structure after the twisting process. A fleece wrap, on the other hand, can be applied during the twisting process, and does not require its own work operation, making it a less expensive, yet less stable option.

Product information CF27-D
▶ Page 284

Sample A with inner jacket igus® chainflex® CF27-100-10-02-01-D

Comparison: chainflex® cables with extruded inner jacket vs. fleece wrapped cables

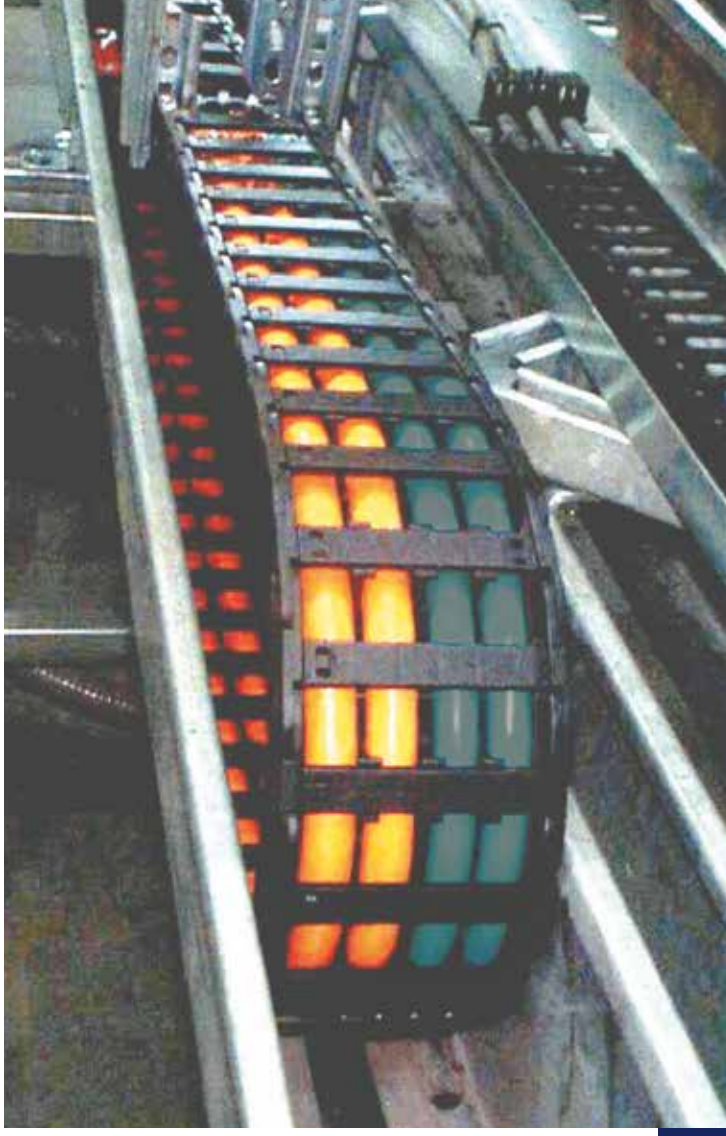
In this testing, the servo cables are highly flexible motion connection cables with complete copper shielding and an integrated, shielded pair of control conductors. With different size conductor cross sections, creating a round base for the braided shield can be problematic, emphasizing the various bending behaviors of both production methods.

- **Sample A: CF27-100-10-02-01-D (igus® GmbH) (4x 8AWG) + (2x 17AWG)**
- **Sample B: experimental (4x 8AWG) + (2x 17AWG)**

Both cables are created with identical conductor cross sections and insulation materials. Cable A is produced with an extruded inner jacket; cable B with a fleece wrapping and fillers, made up of fibrillated polyethylene. These fillers are easily compressible, and allow the conductors to move within the cable during bending.

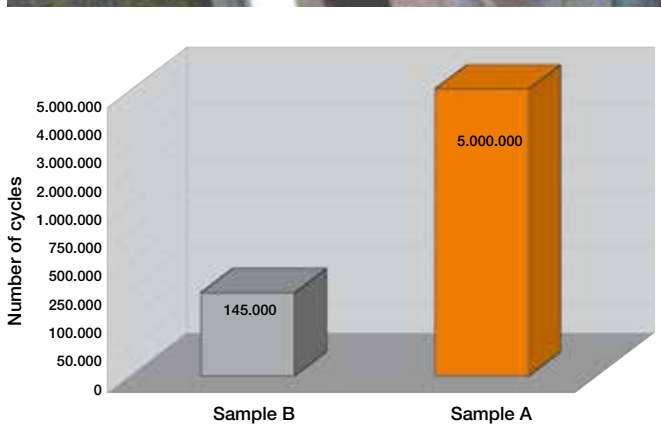
In a dynamic test setting, cable B began showing a corkscrew formation after only 145,000 cycles (see image below).The extruded inner jacket used in cable A filled all gussets, creating a structure which holds the conductors in a defined position during movement.

During the bending process, while cable A's conductors were held in place and saw no signs of corkscrewing, the conductors in cable B detached from the composite braid structure, allowing the corkscrew effect to take hold.



Assessment

Despite the low bend factor (4.76), no signs of wear could be detected in cable sample A (CF27-100-10-02-01-D), even after 5 million cycles. The fleece wrap and fillers of cable sample B, on the other hand, were not able to hold conductors in place, allowing the cable to succumb to the corkscrew effect after only 145,000 cycles, justifying the use of an extruded inner jacket, despite the higher initial cost.



Sample A: CF27-100-10-02-01-D

Sample B: experimental production

Millions of cycles in an Energy Chain®: tested!

Profibus cables in continuously moving industrial applications

Gaining a clear overview of the cable market can be difficult. Competition between suppliers is intensifying, and manufacturers are always trying to out-do each other with promises of guaranteed service life for cables used in a cable carrier. Some suppliers even go so far as to claim the ability to sustain service life of cables in carrier systems for 10-50 million flexing cycles. Close examination of these purported figures begs the question, how was this testing completed? Or, how true-to-life, in regards to travel length, test environment, bend radii, etc., are these tests?

Even information stating that cables are tested in accordance with VDE (Association of German electrical engineers) 0472, Part 603, test method H, is irrelevant when it comes to determining the service life of a cable in an Energy Chain® cable carrier, as the roller testing stand cannot provide conclusive results, and there is no VDE test for special cables in Energy Chains®.

Picture 1: Sliding application as the basis of the test structure

Differences in service life

In 2002, a test was created in the igus® laboratory to determine the service life of Profibus cables in real-world applications, with the aim to examine differences in service life between a chainflex® CFBUS-001 cable and a competitive Profibus cable (test item A). The parameters of the test were selected based on data collected from the competitor's catalog.

As Profibus cables are typically used in long travels and transmission distances due to their data integrity, a gliding application was chosen as a suitable test structure.

Details	Test item "A" Competitor Profibus	Test item "B" chainflex® CFBUS-001
Cross section	(2 x AWG24)C	(2x 24AWG)C
Recommended Bend Radius	≥ 60 mm	85 mm
Cable Diameter	8.0 mm	8.5 mm

Table 2: Test parameters according to Catalog data of the competition

In order to carry out non-destructive testing while still achieving a large number of bend cycles in a short time, a genuine Profibus transmission path was constructed. A PC configured as a Profibus master was installed at the fixed end of the test carrier, and a Profibus slave connection on the moving end. With the help of diagnosis programming, the transmission rate could be determined, and any incorrect data transmissions could be indicated. Transmission for the test was set at 12 megabits/s.

The test, started in 2002, is still being run today. Results have shown that after a relatively low number of cycles (420,000), test item A resulted in a total failure. According to the manufacturer of the test cable, however, the same cable was rated to have been able to function safely for at least 4 million cycles, deviating from the real-world testing by a factor of ten.

On the other hand, the CFBUS-001 chainflex® cable is still undergoing testing without faulty data transmissions, even after carrying out more than 14 million test cycles to date.

Structure and materials

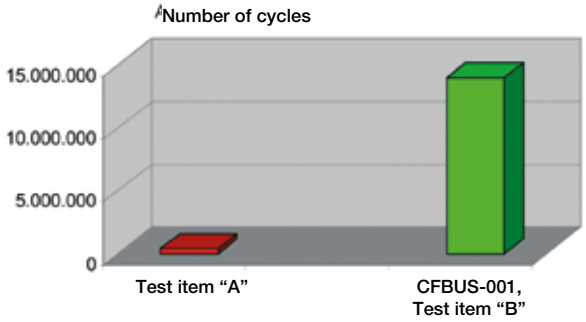
The reason for the major differences in the service life of the two cables is that the CFBUS-001 is constructed with special attention to key design factors and specially selected materials conducive to continuous flexing. In contrast, the competitor cable is constructed with attention to electrical performance only, making its design easily compromised by continuous movement.

The conductor insulation of both cables is comprised of a foam material, which is needed to achieve better transmission rates. The foam material, however, is weakened under stress. The test proved that, in order to alleviate mechanical stress on a conductor's insulation, an inner jacket is recommended to absorb forces that affect the bus pair.

Test parameters	
Distance of travel:	S=16.41 ft. (5 m)
Speed, approximate:	V=11.48 ft/s (3.5 m/s)
Acceleration, approximate:	a=24.61 ft/s² (7.5 m/s²)
Radius, approximately:	2.16" (55 mm)

Highly elastic inner jacketing

The CFBUS-001 cable was produced with an extruded TPE inner jacket, which protects the bus pair against mechanical influences in bending applications, and controls the movement of the conductors as the cable is flexed. An inner jacket must be highly elastic in order to function properly. A mechanically inferior inner jacket, such as inexpensive fillers, only serves to make the bus pair round, and is not able to protect from the high levels of mechanical stress present in the chain. These tensile and compressive forces mainly influence the parts of the cable in which there is a break in an element's jacketing. The jacketing of test item B (CFBUS-001), is produced with a mechanically superior, extruded inner TPE jacket which mechanically relieves the bus pair, fixing conductors in defined



position and bends. The extremely short pitch of the conductor strands and special bundling of the conductors also ensure that no great tensile or compression forces have an effect on a long conductor length. This allows relatively small bend radii with high cycle rates to be achieved.

New: cRUus UL AWM compliance

chainflex® CFBUS cables are now also available for all standard field bus system, complete with CDA and UL cRUus compliance, as well as DESINA compliance. The highly abrasion-resistant, flame retardant TPE outer jacket is extruded onto the fully braided shield with a twisted angle adjusted to provide the cable with additional stability.

The bus elements, braided with a particularly short strand pitch, are protected by means of extruded TPE inner jacket, which fills all gaps. The required bus parameters are fulfilled by means of a choice of coordinating insulating materials and production methods. As with all chainflex® cables, the new standard field bus cables in the CFBUS series are now available from stock with no cutting costs or minimum orders.

Product information CFBUS
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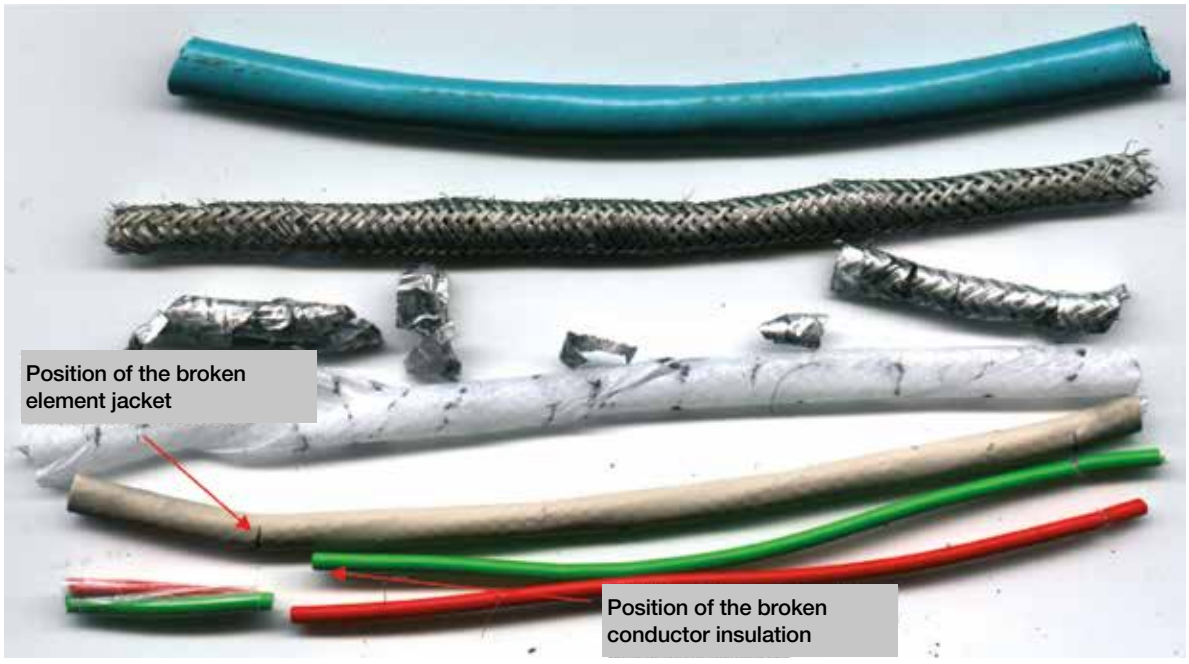


Picture 3: A mechanically low-quality element jacket can't protect the bus pair against the high mechanical loads inside the Energy Chain®.

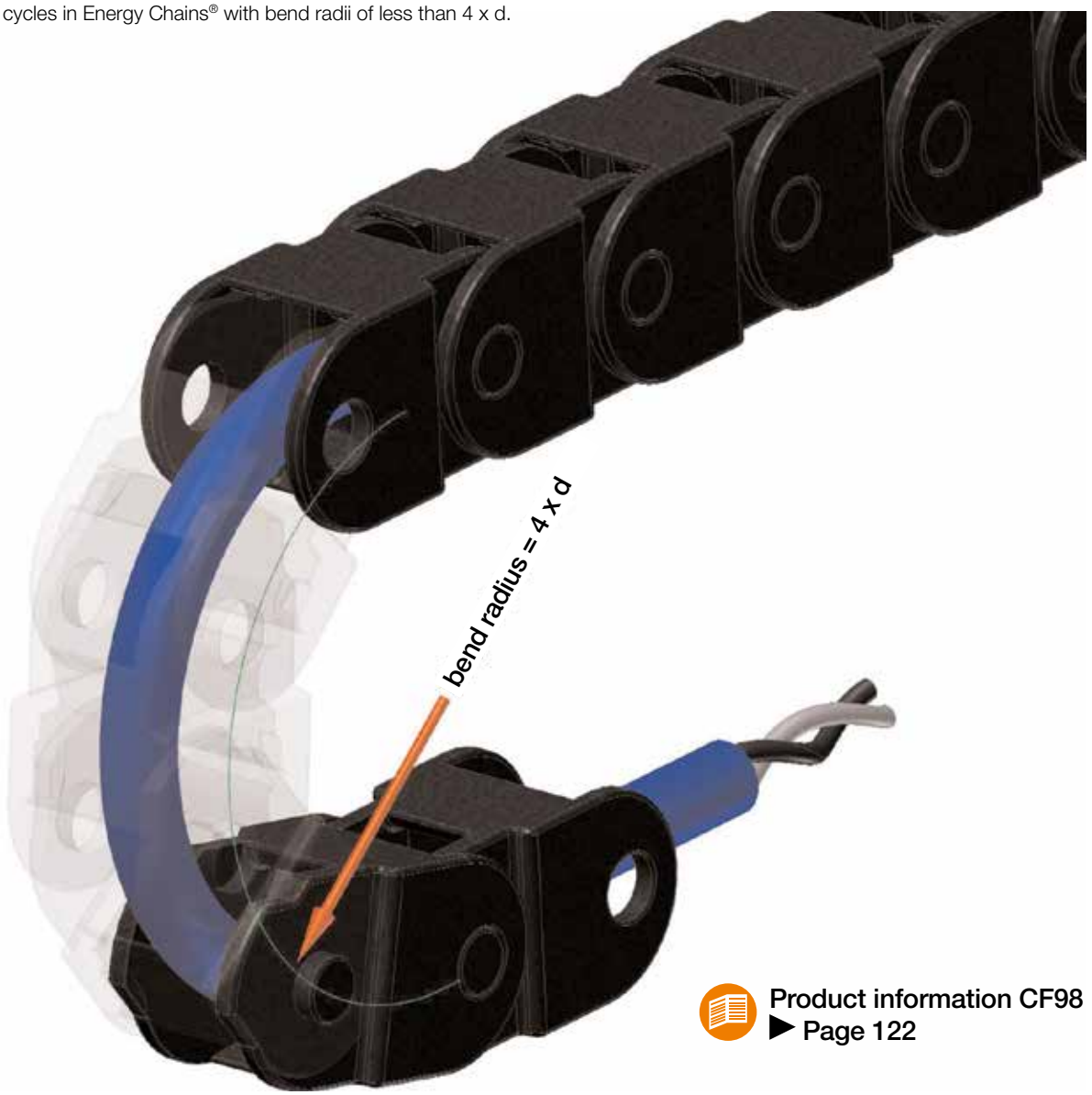
Tested, tested, tested with < 4 x d!

For users of very small cable carriers or Energy Chains® with narrow bend radii, finding a suitable cable with a long service life has been a frequent challenge in the past. At bend radii of less than 5 x d, copper quickly reaches its physical limits, necessitating the search for suitable alternative conductor materials, or for fundamentally different conductor superstructures.

Many series of tests were performed on a variety of conductor materials and superstructures in order to determine how cables must be manufactured to endure millions of flexing cycles in Energy Chains® with bend radii of less than 4 x d.

Test setup: Horizontal, short travel distance

Test parameters:	
Travel distance	S = 2.625 ft. (0.8 m)
Speed, approximate	V = 16.07 ft/s (4.9 m/s)
Acceleration, approximate	a = 5.38 ft/s² (1.64 m/s²)
Radius, approximate	0.71 inch (18 mm)



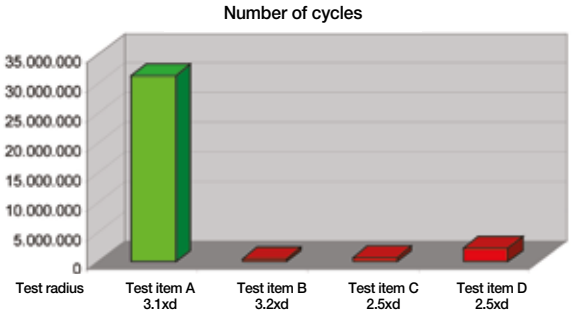
Product information CF98
▶ Page 122

Test 1:
Inspection of four cable designs

Four different cable constructions have been analyzed here:
Test Item A – Special Alloy Conductor
Test Item B – Copper Conductor
Test Item C – Copper conductor with braided structure
Test Item D – Copper conductor with concentric stranding

This long-term inspection, which was carried out over a period of two years, provided the following results:

	Number of cycles	Cross section	d [inch]	Test radius
Test item A	47,434,277	7x0.20	0.23	3.1xd = 18
Test item B	450,000	7x0.20	0.22	3.2xd = 18
Test item C	638,000	7x0.25	0.29	2.5xd = 18
Test item D	2,350,000	7x0.25	0.29	2.5xd = 18

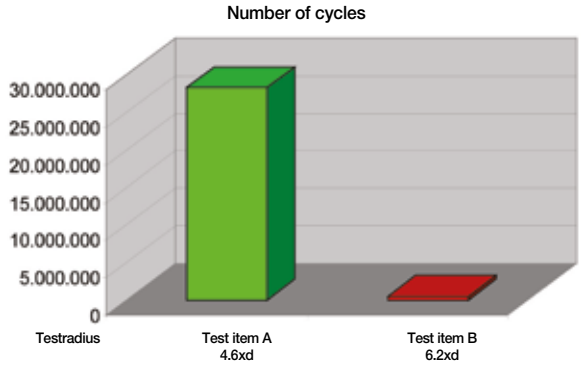


Test 2:

Two different cable designs were tested, whereby different numbers of conductors and conductor cross sections were selected and compared to test 1.
Test Item A – Conductor with special alloy
Test Item B – Conductor with copper

In this test, item B was manufactured completely identically to A, with the exception of the conductor material. The test showed that not a single case of wire breakage could be detected for test item A, even after 28 million cycles. Test item B, on the other hand, only achieved approximately 1.4 million cycles before complete destruction of the conductor was determined. This test also demonstrates that the alloy material clearly surpasses the life of the copper conductor by more than 19 times, and achieves these extraordinary results in the critical area of very small cross sections.

	Number of cycles	Cross section	d [inch]	Test radius
Test item A	28,267,000	2x0.14	0.15	4.6xd = 18
Test item B	1,450,000	2x0.14	0.11	6.2xd = 18



Conductivity of alloys

The outstanding mechanical properties of the alloyed material must make do with a reduced conductivity compared to copper, which can be compensated by slightly increasing the cross sections. This means that the cross sections mentioned in the catalog meet the electrically defined cross sections defined using the conductivity value. The diameter of an alloyed conductor increase slightly when compared to the diameter of a copper conductor. This compromise results in a 10% greater external diameter for the CF98 series when compared to a comparable CF9 cable, although the service life differences to be expected between the two speak for themselves, and increase by a multiple factor in comparison to other so-called chain-suitable cables.

As in the case of the CF9 series, further characteristics of the chainflex® CF98 include the highly abrasion-resistant gusset-filled extruded TPE outer jacket, the oil and UV resistance, as well as the absence of PVC and halogen compounds.

Especially in applications that have minimum construction space as well as the demand for a high number of cycles, chainflex® cables offer an increased degree of operational safety and efficiency. Some areas of application include semi-conductor and component part industries, as well as in automotive and automation applications. New possible applications for cables with a tight bend radius include automatic doors on motor vehicles and trains, in vending machines, and throughout the packaging industry.

Fiber and ice: tested!

chainflex® gradient fiber-optic cable in the deep freeze test

For the safe transmission of large amounts of data in bus systems at high speeds and over long distances, chainflex® gradient fiber glass CFLG cable has already become a standard in numerous crane applications. Insensitivity to electromagnetic load and resistance to rough environmental factors allow for use, alongside energy supply cables, in very long travels.

CFLG-G
TPE
10 x d

PVC | iguPUR | PUR | TPE

Fiber optic cable | TPE | Chainfl

36 10,000,000
Cycles guaranteed

5 x d
Bend radius E-Chai

- Glass-fiber cable for maximum mechanical load requirements
- TPE outer jacket
- Oil and bio-oil-resistant
- PVC
- Low
- Hyc

Dynamic Information

- Bend radius
- Temperature
- v max.
- a max.
- Travel distance

Cable structure

- Fibre Optic Cable
- Conductor construction
- Color code
- Outer jacket

Example image

What happens in crane facilities in regions with extremely low temperatures? Does the maximum possible cable length of several hundred meters increase attenuation, or does the cable jacket break at extreme low temperatures?

In these cables, sensitive glass fibers are held in a gel-filled hollow space. How does the gel behave in highly dynamic applications, and what happens in restarts after long periods of downtime? As no precise answer to these questions could be found in relevant technical journals, and little was known about the thermal features of the gel, igus®, as part of its philosophy, undertook testing to determine the reliable specifications for applications in Energy Chain® cable carriers.

For this task, the igus® test lab was equipped with a freezer able to generate temperatures of -40° F (-40°C), and a test rig was created with travels up to 22.9 ft. (7 m) at a speed of 5.2 ft/s (1.6 m/s), and accelerations up to 19.6 ft/s^2 (6 m/s^2). The chainflex® gradient fiber glass cable CFLG-6G-50/125-TC was tested at a length of approximately 50 feet in a 3500-125-200-0 Energy Chain® with a radius of 7.8 in. (200 mm). Varied and extreme temperature fluctuations served as the simulation of environmental influences, particularly when temperatures plunged to -40° F during downtime and motion was restarted afterwards.

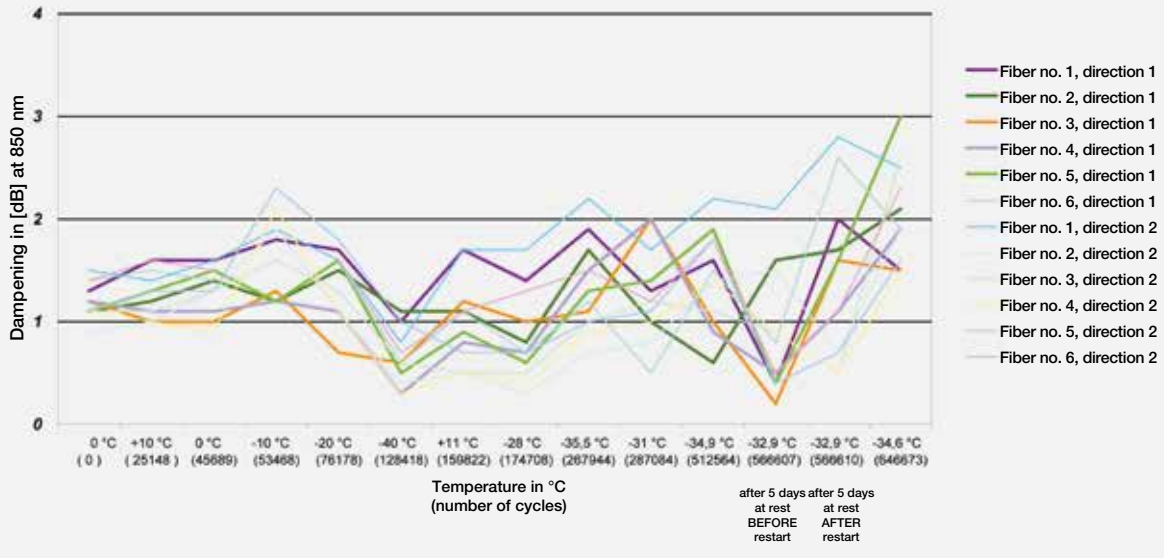
Under these application conditions, the attenuation of the cable also should not rise above 3 dB at 850 nm wave length. After one million cycles, which corresponds to an operational performance of approximately 4,350 miles (7,000 km), the maximum attenuation is reached and still remains significantly below 3 dB.

The measurements highlighted in the diagram reveal that distinct variations in temperature, combines with the constant movement in the Energy Chain® have only minor effects on the attenuation of the CFLG-6G-TC cable. The noticeable high initial attenuation is attributed to the plugs used, and also reflects reality, as in practice, approximately 90% of the cables used in automation are pluggable fiber optic cables.

Product information CFLG-G
▶ Page 220

The test with the igus® cable makes it quite clear that only realistic and absolutely very expensive tests can fetch clarity about the service life of cables.

Dampening of the fibers 1-6 of the CFLG-6G-50/125-T cable in two directions



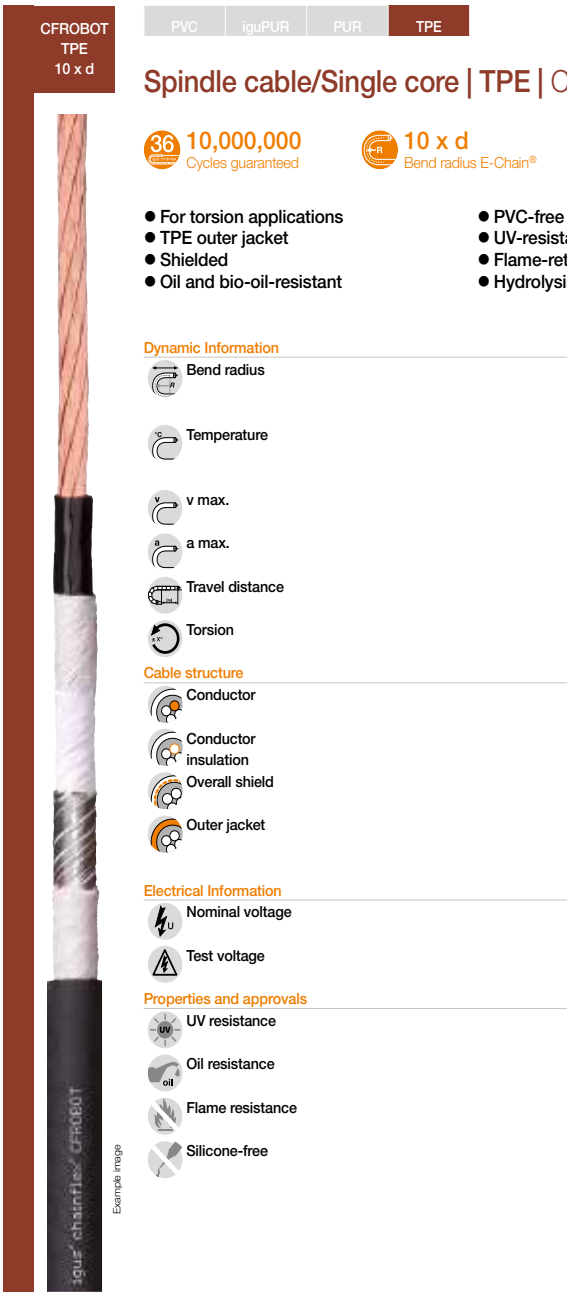
Torsion cables: tested!

chainflex® cables for Energy Chains® are designed for applications in linear movement, and their efficiency has been proven countless times in a wide variety of applications. However, as industrial applications and their necessary motion sequences are becoming more complex, special cables for torsional movements are being requested more and more. The service life of the differing constructions of these cables is harder to calculate for torsional applications, as no fixed values, such as radii, travels, etc., have been defined.

Shielded cables are very difficult to use in torsional applications. Braided shields are generally woven in opposing directions. In torsional movements, the shield's wires are drawn in one winding direction, and then turned in the other direction. The woven arrangement and the entailing constriction of each winding direction lead to quick breakage of the shield from the resulting expansion of the shield wires.

At igus®, the emphasis is not only on technology but also on aesthetically designed products. The TRC and TRE series both received the iF-Design-Award.

Unshielded cables, particularly bundled chainflex® cables, can, on the other hand, be successfully used in many torsional applications. Whether a cable can maintain torsional



Product information CFROBOT
▶ Page 392

demands is dependent strongly on the application and type of installation.

The development of a new chainflex® shielded single conductor cable picks up on this point and ensures that only the smallest possible forces act on the shield wire due to the special design and understructure of the shield.

Test setup:
The new CFROBOT cable was tested at the igus® laboratory on a test rig specially designed for torsional movement of ±270° for a total length of approximately 8.2 feet. The cable was tested in different versions of Triflex® R multi-axis cable carriers.

Fitted for the test were:
- **3 CFROBOT-037 cables**
- **3 CF310-250-01-UL cables**
- **3 CF310-250-01 cables**

igus® test lab: The cables were tested in movements of ± 270°

The initial test sample of the CF310 with braided shield, and CFROBOT were taken after 250,000 test movements at a torsional angle of ±270°.

Analysis of the cables (taken apart), show, in Picture 1, distinct damage to the overall shield, noticeable in the upper third of the cable.

Picture 1: Damaged overall shield sample of the braid version after 250,000 torsional movements

The detail inspection of the shield braid shows distinct damage on the shield wires.

The analyzed samples of the CFROBOT-037 (Picture 2), were taken at 250,000, 1.5 million, and 3 million torsional movements, and all show no damage.

Picture 2: The CFROBOT shows absolutely no damage after more than 3 million movements

The detailed analyses of the shield wires, buffer fibers, PTFE film (Picture 3) of the cable show no apparent wear. It was decided to extend the testing to determine the maximum service life of the cables.

Picture 3: Detail pictures of the CFROBOT after more than 3.0 million movements of ±270°

164 ft. container crane travel: tested!

In the crane engineering industry, energy supply systems must adapt to the ever increasing technical and economic demands of their customers. Flexibility, variability, and space-saving installation options are only a few of a number of criteria very important to crane designers and maintenance teams. A major building block of a reliable energy supply system is always the cables.

In the igus® laboratory, chainflex® cables undergo constant testing to obtain important information about the service life of particular cables, and to determine improvements for future cable designs. However, the occasional chance comes along to examine and record inspection data from cables removed from real, tough applications.

Current inspection:

The chainflex® cable CF9-60-05 was used in a container crane for many years, repeating a travel distance of approximately 154 ft. (47 m). An inspection contract commissioned by the crane owner-operator was tasked with presenting a performance balance sheet and determine when preventative maintenance should next be scheduled after more than 24,854 miles (40,000 km) of chain travel were completed.

Following the removal of the CF9-60-05 cable, inspections were performed with the following objectives:

1. Observe and record outer jacket abrasion and other damage
2. Observe and record the overall stranding and insulation of the individual conductors
3. Observe and record the structural wire design and the number of broken or possibly broken wires.

An 82 ft. igus® Energy Chain harnessed with chainflex® cables in a stainless steel trough.

The Energy Chain system® was filled with many different igus® chainflex® cables, e.g. the CF9-60-05

Inspection objective 1:
Only slight traces of abrasion could be detected on the TPE outer jacket. No failures could be expected due to jacket breakage, despite extreme environmental factors, such as temperature fluctuation and UV rays.

Inspection objective 2:
The overall stranding showed that no indications of conductor fatigue or changes in pitch length thanks to the extruded outer jacket. The large share of talc protected from any abrasion between the TPE-insulated conductors. Additionally, high voltage tests showed no changes.

Inspection objective 3:
The cable was fully opened to the copper conductor in the most stressed section of the radius. Here too, after more than 24,854 miles, no damage was seen to the individual wires.

Summary:
The chainflex® cable, used in a real crane application on the second trolley of a ship to shore crane was completely intact and no preventative maintenance was required, even after 24,854 miles of travel.


An igus® energy supply system with an approx. length of 85 ft. in a stainless steel trough.


The individual elements of the CF9 from the cable piece dissected for the test setup.


A close-up of the completely intact copper conductor. The inspection performed over the entire length shows that the conductor is still completely intact and does have any individual wire breakages.

Product information CF9
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Jacket material oil resistance: tested!

For years, specially developed tests have been utilized to obtain results tailored to customer requirements. The relatively generalized claim of “oil resistance” or “coolant resistance” are little help in selecting the right jacket material to be used in an application with exposure to oils, coolants, or lubricants.

In the igus® test lab, generally applicable tests like those set by DIN EN 60811-2-1 and IEC 60811-1-1 are run alongside tests that replicate everyday application conditions as realistically as possible. One such test mounts samples of chainflex® cables in Energy Chains® which are moved in and out of an oil bath.

Throughout and after testing, samples can be examined to determine changes in material characteristics, like material strength, swelling, or tearing, with values noted. This method of testing and examining offers customers not just a statement on the resistance of a cable against media, but also an expected service life.

If the test samples, such as the cables depicted below, do not stand up to testing, they are not advised for use in the respective application.

Cracks in the outer sheathing of materials from competitors caused by the „use of oil“ in E-Chains®.

Torsion-resistance: tested take two!

The requirement for torsion resistant cables for Energy Chains® is not new, but exact requirements are rarely specifically defined. So, how is a statement like “torsion resistant up to ±180°” to best be evaluated?

To carry out this testing, the “torsion test bench” was developed in the igus® test lab. Here, various cable types, all 3.3 ft. (1 m) in length, are subject to twisting . The degree of torsion is adjustable for testing different requirements, with standard torsional testing moving at ± 180°.

After a predetermined number of torsional movements, or a negative electrical or mechanical result, the tested cables are taken apart and inspected to determine the type and position of any damage.

The complete chainflex® CFROBOT cable series was tested to this standard before its release to the market.

Product information CFROBOT
▶ Page 392

The „torsion test bench“ especially developed according to the igus® standard

Information | **color code**

DIN 47100 color code
(however, deviating from DIN: without color repetition after 44th core)*

1	white
2	brown
3	green
4	yellow
5	gray
6	pink
7	blue
8	red
9	black
10	violet
11	gray-pink
12	red-blue
13	white-green
14	brown-green
15	white-yellow
16	yellow-brown
17	white-gray
18	gray-brown
19	white-pink
20	pink-brown
21	white-blue
22	brown-blue
23	white-red
24	brown-red
25	white-black
26	brown-black
27	gray-green
28	yellow-gray
29	pink-green
30	yellow-pink
31	green-blue
32	yellow-blue
33	green-red
34	yellow-red
35	green-black
36	yellow-black
37	gray-blue
38	pink-blue
39	gray-red
40	pink-red
41	gray-black
42	pink-black
43	blue-black
44	red-black
45	white-brown-black
46	yellow-green-black
47	gray-pink-black
48	red-blue-black
49	white-green-black
50	brown-green-black
51	white-yellow-black
52	yellow-brown-black
53	white-gray-black
54	gray-brown-black
55	white-pink-black
56	pink-brown-black
57	white-blue-black
58	brown-blue-black
59	white-red-black
60	brown-red-black
61	black-white

*Exception: 4-core cables are braided in the colour sequence white, green, brown, yellow.

The first colour indicates the basic colour of the core insulation, and the second colour indicates the colour of the printed-on ring. In the case of three colours, the second and colours are printed on the basic colour.

Information | **AWG**

Copper wire dimensions according to Anglo-American AWG numbers

AWG No.	Diameter [mm]	Cross section [mm²]	AWG No.	Diameter [mm]	Cross section [mm²]
500	17.96	253.00	16	1.29	1.31
350	15.03	177.00	18	1.024	0.823
250	12.70	127.00	20	0.813	0.519
4/0	11.88	107.20	22	0.643	0.324
3/0	10.40	85.00	24	0.511	0.205
2/0	9.27	67.50	26	0.405	0.128
1/0	8.25	53.50	28	0.320	0.0804
1	7.35	42.40	30	0.255	0.0507
2	6.54	33.60	32	0.203	0.0324
4	5.19	21.20	34	0.160	0.0200
6	4.12	13.30	36	0.127	0.0127
8	3.26	8.37	38	0.102	0.00811
10	2.59	5.26	40	0.079	0.00487
12	2.05	3.31	42	0.064	0.00317
14	1.63	2.08	44	0.051	0.00203

Information | **Load-carrying capacity of cores**

		Multi-core cables			Motor/Servo cables		Single-core cables	
chainflex® type		CF5, CF6, CF2, CF130US, CF140US	CF880, CF881, CF130.UL, CF140.UL, CF240, CF211, CF884	CF890, CF891, CF77.UL.D, CF78.UL, CF9, CF10, CF9.UL, CF10.UL, CF98, CF99, CF112, CF11, CF12, CF298, CF299, CF894, CF113.D, CF111.D, CF11.D, CFROBOT, CFROBOT6, CFROBOT7, CFROBOT9	CF885, CF886, CF30, CF31, CF887, CF897, CF210.UL, CF220.UL.H, CF21.UL , CF895, CF896	CF34.UL.D, CF35.UL, CF37.D, CF38, CF270.UL.D, CF280.UL.H, CF27.D, CF29.D	CF885, CF885.PE, CF886	CF270.UL.D, CF300.UL, CF310.UL, CF330.D, CF340, CFPE
Insulation material		PVC	TPE	TPE	TPE/XLPE	XLPE	PVC	TPE
Loaded cores		2 or 3	2 or 3	2 or 3	2 or 3	2 or 3	1	1
Nominal cross section of copper core [mm²]	AWG size	Load capacity [A]	Load capacity [A]	Load capacity [A]	Load capacity [A]	Load capacity [A]	Load capacity [A]	Load capacity [A]
0.14	**26**	2.5	2.5	2.5	-	-	-	-
0.25	**24**	4	5	5	-	-	-	-
0.34	**22**	5	7	7	-	-	-	-
0.5	**20**	8	10	10	-	11	-	-
0.75	**18**	12	13	14	-	14	-	-
1	**17**	15	15	17	-	17	-	-
1.5	**16**	18	19	21	19	21	-	25
2.5	**14**	26	27	30	27	30	30	34
4	**12**	-	37	41	37	41	41	46
6	**10**	-	48	53	48	53	53	58
10	**8**	-	-	74	69	74	74	81
16	**6**	-	-	99	92	99	99	110
25	**4**	-	-	131	121	131	131	144
35	**2**	-	-	162	152	162	162	179
50	**1**	-	-	-	191	202	202	228
70	**2/0**	-	-	-	-	-	250	285
95	**3/0**	-	-	-	-	-	301	348
120	**4/0**	-	-	-	-	-	-	394
150	**300MCM**	-	-	-	-	-	-	466
185	**350MCM**	-	-	-	-	-	-	532
240	**500MCM**	-	-	-	-	-	-	610
300	**600MCM**	-	-	-	-	-	-	754
400	**750MCM**	-	-	-	-	-	-	903

Table 1: Load-carrying capacity for chainflex® cables fixed or moving in e-chains® and e-tubes

The values in these tables have been taken from the standard DIN VDE 0298, Part 4. These values have been simplified and only apply approximately. For each application, it is advisable to obtain and comply with the regulations that apply to each individual case (e.g. measures for protection in case of indirect contact in accordance with DIN VDE 0100 Part 410, overcurrent protective devices in accordance with DIN VDE 0100 Part 430 or voltage drop in accordance with DIN VDE 0100 Part 520). It is not possible to provide all the regulations or overviews in this catalogue. Due to the harmonisation that has been carried out, it is possible that different load-carrying values may be permissible for the same cable in some cases. For the selection of the relevant cross section, the load capacity in undisturbed operation is the determining factor, i.e. the use with permissible operating temperature or permissible maximum temperature on the core.

The load-carrying capacity according to **Table 1** applies to operating-current-carrying cores.

Normally, these are 2 loaded cores in the case of 2-core and 3-core cables, as well as 3 loaded cores in the case of 4-core and 5-core cables. Please take this into account when planning for the use of multi-core cables in electrical installation conduits or energy chains. This information is based on an ambient temperature of 30°C and a non-loaded cable. Please apply the conversion factors according to **Table 2** if the air temperature is increased due to the heat loss of the cables (please take thermal radiation into account as well, e.g. effects of exposure to the sun).

The possible cable installation types in energy chains result in such a broad range of loading profiles that no generalised conversion factors can be offered for this large range of cables. The installation type and the conversion factors must be taken from **Table 3**, according to each individual application.

Ambient temperature [°C]	Conversion factor	
	PVC insulation	TPE insulation
10	1.22	1.15
15	1.17	1.12
20	1.12	1.08
25	1.06	1.04
30	1.00	1.00
35	0.94	0.96
40	0.87	0.91
45	0.79	0.87
50	0.71	0.82
55	0.61	0.76
60	0.50	0.71
65	–	0.65
70	–	0.58
75	–	0.50
80	–	0.41
85	–	0.29
90	–	0.14

Table 2: Conversion factors in case of varying ambient temperature

Loaded cores	Conversion factor
5	0.75
7	0.65
10	0.55
14	0.50
19	0.45
24	0.40
40	0.35
61	0.30

Table 3: Conversion factors for multi-core cables with cable cross sections up to 10 mm^2

Chemical resistance | **Selection chart**

Group	chainflex® cable	Jacket material	1	2	3	4	5	Page
Control cables								
Control cable	CF880	PVC	1					50
Control cable	CF881	PVC	1					54
Control cable	CF130US	PVC	1					58
Control cable	CF140US	PVC	1					62
Control cable	CF130-UL	PVC	1					66
Control cable	CF140-UL	PVC	1					70
Control cable	CF5	PVC		2				74
Control cable	CF6	PVC		2				78
Control cable	CFSOFT1	PVC		2				82
Control cable	CFSOFT2	PVC		2				84
Control cable	CF890	iguPUR			3			86
Control cable	CF891	iguPUR			3			90
Control cable	CF77-UL-D	PUR				4		94
Control cable	CF78-UL	PUR				4		98
Control cable	CF2	PUR				4		102
Control cable	CF9	TPE					5	106
Control cable	CF10	TPE					5	110
Control cable	CF9-UL	TPE					5	114
Control cable	CF10-UL	TPE					5	118
Control cable	CF98	TPE					5	122
Control cable	CF99	TPE					5	124
Data cables								
Data cable	CF8821	PVC	1					130
Data cable	CF240	PVC		2				132
Data cable	CF240-PUR	PUR				4		136
Data cable	CF211	PVC		2				140
Data cable	CF211-PUR	PUR				4		144
Data cable	CF11	TPE					5	148
Data cable	CF112	PUR				4		152
Data cable	CF12	TPE					5	156
Data cable	CF298	TPE					5	158
Data cable	CF299	TPE					5	160
Data cable	CFKoax	TPE					5	162
Bus cables								
Bus cable	CF888	PVC	1					174
Bus cable	CFBUS-PVC	PVC		2				178
Bus cable	CF898	iguPUR			3			182
Bus cable	CFBUS-PUR	PUR				4		186
Bus cable	CF14US	PUR				4		190
Bus cable	CFBUS	TPE					5	192
Bus cable	CFBUS-LB	TPE					5	198
Fibre Optic Cables								
Fibre Optic Cable	CFLK	PUR				4		208
Fibre Optic Cable	CFLG88	PVC	1					210
Fibre Optic Cable	CFLG-LB-PUR	PUR				4		212
Fibre Optic Cable	CFLG-LB	TPE					5	216
Fibre Optic Cable	CFLG-G	TPE					5	220
Measuring system cables								
Measuring system cable	CF884	PVC	1					230
Measuring system cable	CF211	PVC		2				234
Measuring system cable	CF894	iguPUR			3			240
Measuring system cable	CF111-D	PUR				4		244
Measuring system cable	CF113-D	PUR				4		250
Measuring system cable	CF11-D	TPE					5	256

Chemical resistance | **Selection chart**

Group	1	2	3	4	5
Inorganic chemicals					
Aqueous solutions, neutral					
Water	+	+	O	+	+
Common salt (10%)	+	+	O	+	+
Glauber's salt (10%)	+	+	O	+	+
Aqueous solutions, alkaline					
Soda (10%)	O	+	+	O	+
Aqueous solutions, acid					
Sodium bisulfate (10%)	O	+	+	O	+
Aqueous solutions, oxidising					
Hydrogen peroxide (10%)	+	+	O	+	+
Potassium permanganate (2%)	+	+	O	+	+
Inorganic acids					
Hydrochloric acid, concentrated	–	–	–	–	–
Hydrochloric acid (10%)	O	O	+	O	+
Sulfuric acid, concentrated	–	–	–	–	–
Sulfuric acid (10%)	O	O	+	O	+
Nitric acid, concentrated	–	–	–	–	–
Nitric acid (10%)	O	O	+	–	O
Inorganic caustic solutions					
Sodium hydroxide, concentrated	–	–	–	–	O
Sodium hydroxide (10%)	O	O	+	O	+
Caustic potash, concentrated	–	–	–	–	O
Caustic potash (10%)	O	O	+	O	+
Ammonia, concentrated	O	O	–	O	+
Ammonia (10%)	+	+	+	+	+
Organic chemicals / organic acids					
Acetic acid, concentrated (glacial acetic acid)	–	–	–	–	O
Acetic acid (10% in H_20)	O	+	+	O	+
Tartaric acid (10% in H_2O)	O	+	+	+	+
Citric acid (10% in H_2O)	O	+	+	+	+
Ketone					
Acetone	–	–	–	–	O
Methyl ethyl ketone (MEK)	–	–	–	–	O
Alcohols					
Ethyl alcohol (spirit)	–	O	+	O	+
Isopropyl alcohol	–	O	+	O	+
Diethylene glycol	O	O	+	+	+
Aromatic compounds					
Toluol	–	–	–	O	–
Xylol	–	–	–	O	–
Fuels					
Gasoline	–	O	O	+	+
Diesel fuel	–	O	O	+	+
Synthetic oils lubricating oil					
ASTM oil #2	O	+	+	+	+
Hydraulic oil					
Mineral oil base	–	O	+	+	+
Glycol base	O	O	+	+	+
Synthetic ester base	–	O	–	+	+
Vegetable oils					
Rapeseed oil	O	+	O	+	+
Olive oil	O	+	O	+	+
Soya bean oil	O	+	O	+	+
Cold cleaning agent					
Cold cleaning agent	–	O	+	+	O

\+ no or minimum negative influence
O medium reciprocal effect, short-term exposure permissible
– unstable, material partly destroyed

All information applies to room temperature

Chemical resistance | **Selection chart**

Group	chainflex® cable	Jacket material	1	2	3	4	5	Page
Servo cables								
Servo cable	CF887	PVC	1					268
Servo cable	CF210-UL	PVC		2				270
Servo cable	CF21-UL	PVC		2				274
Servo cable	CF897	iguPUR			3			278
Servo cable	CF270-UL-D	PUR				4		280
Servo cable	CF27-D	PUR				4		284
Servo cable	CF29-D	TPE					5	288
Hybrid servo cable	CF220-UL-H	PVC		2				290
Hybrid servo cable	CF280-UL-H	PUR				4		294
Motor cables								
Motor cable	CF885	PVC	1					306
Motor cable	CF886	PVC	1					308
Motor cable	CF210-UL	PVC		2				310
Motor cable	CF30	PVC		2				312
Motor cable	CF31	PVC		2				316
Motor cable	CF895	iguPUR			3			320
Motor cable	CF896	iguPUR			3			322
Motor cable	CF270-UL-D	PUR				4		324
Motor cable	CF27-D	PUR				4		328
Motor cable	CF34-UL-D	TPE					5	332
Motor cable	CF35-UL	TPE					5	336
Motor cable	CF37-D	TPE					5	340
Motor cable	CF38	TPE					5	342
Spindle cable/Single conductor	CF885	PVC	1					344
Spindle cable/Single conductor	CF885-PE	PVC	1					346
Spindle cable/Single conductor	CF886	PVC	1					348
Spindle cable/Single conductor	CF270-UL-D	PUR				4		350
Spindle cable/Single conductor	CF300-UL-D	TPE					5	352
Spindle cable/Single conductor	CFPE	TPE					5	354
Spindle cable/Single conductor	CF310-UL	TPE					5	356
Spindle cable/Single conductor	CF330-D	TPE					5	358
Spindle cable/Single conductor	CF340	TPE					5	360
Medium voltage cable	CFCRANE-PUR	TPE					5	362
Torsion cables								
Torsion cable	CF77-UL-D	PUR				4		372
Torsion cable	CFROBOT2	PUR				4		376
Torsion cable	CFROBOT3	PUR				4		378
Torsion cable	CFROBOT4	PUR				4		380
Torsion cable	CFROBOT5	TPE					5	384
Torsion cable	CFROBOT6	PUR				4		386
Torsion cable	CFROBOT7	PUR				4		388
Torsion cable	CFROBOT	TPE					5	392
Torsion cable	CFROBOT8	PUR				4		394
Torsion cable	CFROBOT8-PLUS	PUR				4		398
Torsion cable	CFROBOT9	PUR				4		402
Special cables								
Special cable	CFTHERMO	PUR				4		408
Special cable	CFFLAT	TPE					5	410
Special cable	CFSPECIAL-182	PUR				4		412
Special cable	CFSPECIAL-792	PUR				4		418

Chemical resistance | **Selection chart**

Group	1	2	3	4	5
Inorganic chemicals					
Aqueous solutions, neutral					
Water	+	+	O	+	+
Common salt (10%)	+	+	O	+	+
Glauber's salt (10%)	+	+	O	+	+
Aqueous solutions, alkaline					
Soda (10%)	O	+	+	O	+
Aqueous solutions, acid					
Sodium bisulfate (10%)	O	+	+	O	+
Aqueous solutions, oxidising					
Hydrogen peroxide (10%)	+	+	O	+	+
Potassium permanganate (2%)	+	+	O	+	+
Inorganic acids					
Hydrochloric acid, concentrated	–	–	–	–	–
Hydrochloric acid (10%)	O	O	+	O	+
Sulfuric acid, concentrated	–	–	–	–	–
Sulfuric acid (10%)	O	O	+	O	+
Nitric acid, concentrated	–	–	–	–	–
Nitric acid (10%)	O	O	+	–	O
Inorganic caustic solutions					
Sodium hydroxide, concentrated	–	–	–	–	O
Sodium hydroxide (10%)	O	O	+	O	+
Caustic potash, concentrated	–	–	–	–	O
Caustic potash (10%)	O	O	+	O	+
Ammonia, concentrated	O	O	–	O	+
Ammonia (10%)	+	+	+	+	+
Organic chemicals / organic acids					
Acetic acid, concentrated (glacial acetic acid)	–	–	–	–	O
Acetic acid (10% in H20)	O	+	+	O	+
tartaric acid (10% in H2O)	O	+	+	+	+
Citric acid (10% in H2O)	O	+	+	+	+
Ketone					
Acetone	–	–	–	–	O
Methyl ethyl ketone (MEK)	–	–	–	–	O
Alcohols					
Ethyl alcohol (spirit)	–	O	+	O	+
Isopropyl alcohol	–	O	+	O	+
Diethylene glycol	O	O	+	+	+
Aromatic compounds					
Toluol	–	–	–	O	–
Xylol	–	–	–	O	–
Fuels					
Gasoline	–	O	O	+	+
Diesel fuel	–	O	O	+	+
Synthetic oils lubricating oil					
ASTM oil #2	O	+	+	+	+
Hydraulic oil					
Mineral oil base	–	O	+	+	+
Glycol base	O	O	+	+	+
Synthetic ester base	–	O	–	+	+
Vegetable oils					
Rapeseed oil	O	+	O	+	+
Olive oil	O	+	O	+	+
Soya bean oil	O	+	O	+	+
Cold cleaning agent					
Cold cleaning agent	–	O	+	+	O

\+ no or minimum negative influence

O medium reciprocal effect, short-term exposure permissible

– unstable, material partly destroyed

All information applies to room temperature

Design parameters | **Cable and hose packages**

General rules for cables and hoses in E-Chains®

Rules for:
- **Maximum cable diameters**
- **Separation**
- **Bend radius**

Data and energy supply in all forms within an Energy Chain System®

The key advantage of an igus® Energy Chain System® is the safe accommodation of various forms of data cables and energy suppliers in one system. We recommend the optimal separation layout of the cables and hoses in the E-Chain®, but you, the customer, are still afforded the final choice. It is possible, for instance, to maintain minimum distances between bus and motor cables and mix pneumatics, electric and hydraulics in the same compartments.

In addition to the quality of the cables used, the arrangement of each Cable/hose within the E-Chain® and the space allowed, are important for the service life of the system. Various separation options enable the adaptation of the E-Chains® to the specific requirements of each respective application. Generalised rules such as "No more than 80% of the clear space of Energy Chains® is allowed to be used" no longer make sense given the complexity of present-day applications. In this chapter, we give you detailed recommendations. Due to the variety of the application parameters, we strongly recommend you take advantage of our free consultation services.Simply give us a list of your cable requirements (or merely the required electrical or other services) and you will receive our recommendation.

Hydraulics and electric cables are separated from one another in this example

Maximum cable and hose diameters

The maximum cable and/or hose diameter corresponds to the inner height of the selected E-Chain®/e-tube, with additional minimum clearance. This minimum clearance would be, for example, 10% for electrical round cables, 20% for hydraulic hoses. An E-Chain® is ideal if a minimum lateral gap to the next cable or hose has been factored in. Depending on the nature of the cables, the dynamics, and the expected service life, more clearance must be allowed. In specific cases, clearances may be altered further. You may talk to us about this.

Orderly cables with igus® interior separation

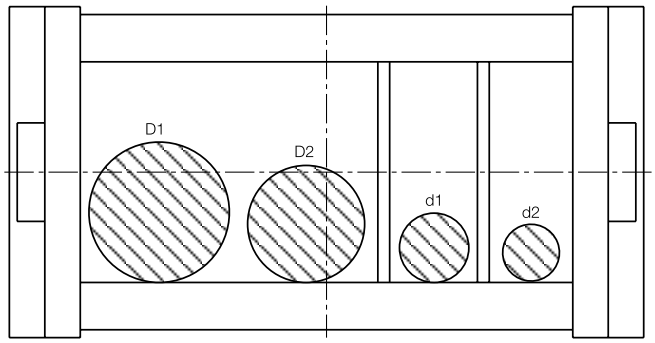
Electrical cables need at least 10% clearance space all around, hydraulic hoses need 20%

The maximum conduit diameter is specified for each series on its respective chapter

Design parameters | **Cable and hose packages**

Distribution in E-Chains®

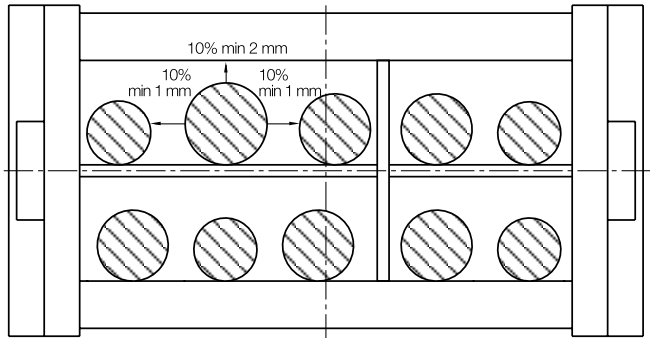
- Cables and hoses with very different diameters should be laid separately. The separation is achieved using modular separators.
- Cables and hoses must **under no circumstances** have the opportunity to tangle. Therefore, the clearance height of a compartment with several similar cables or hoses next to one another **must not amount to more than one and a half times the cable/hose diameter**.



D1 + D2 > 1.2 x hi **d1 + d2 ≤ 1.2 x hi**

Expressed in rules, this means:

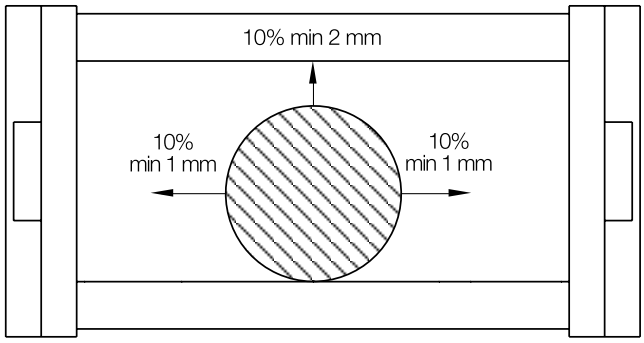
Rule 1:
if D1 + D2 > 1.2 x E-Chain® inner height, no separation between the two cables/ hoses is necessary. Two cables/ hoses should never be left unguided on top of one another or be allowed to become tangled.



d1 + d2 ≤ 1.2 x hi

Rule 2:
if d1 + d2 ≤ 1.2 x E-Chain® inner height, a vertical separator or a horizontal shelf must be used to reduce the inner height. Thereby preventing the entanglement of d1 and d2.

The reason for this rule is:
The cables and hoses must be laid so that they can move freely at all times and so that no tensile force is exerted at the radius of the E-Chains®.



Clearance space "all around" for round electrical cables

For high-speed applications and high cycles, cables or hoses must not be laid on top of each other without horizontal separation.
The standard values for this are:

Travel speed over **1.64 ft/s (0.5 m/s)** and cycles over **10,000 p.a.**

igus® interior separation offers a safe solution for this situation.

Clearance space in % for various cables

Cables	clearance space "all around"
Electrical round cables	**10%**
Electrical flat cables	**10%**
Pneumatics	**5-10%**
Hydraulics	**20%**
Media hoses	**15-20%**

Design parameters | **Cable and hose packages**

Further guidelines for distribution

- The cable weight should be symmetrically distributed along the width of the E-Chain®.
- Cables with different outer jacket materials must not be allowed to stick together. If necessary, they must be laid separately. All igus® chainflex® cables can be combined with each and all other brands of cables.
- The cables should always be fixed at the moving end. The fixed end should always involve strain relief. Exceptions are made only for certain hydraulic hoses with length compensation issues or other high pressure hoses. (i.e. to "hydraulic hoses").
- Generally, the faster and more frequently the E-Chain® operates, the more important the exact positioning of the cables and hoses inside the E-Chain® becomes. Due to the wide variety of the possibilities, we strongly recommend you take advantage of our free consultation services for your specific applications.

Bend radius R

- The bend radius of your E-Chain® depends on the thickest or stiffest cable or hose in your application.
- The bend radii of the E-Chains® should be adjusted to the recommendations of the cable or hose manufacturer. The selection of a larger radius than the minimum will positively affect service life.
- The specification of minimum bend radii for cables refers to use at normal temperatures. Other bend radii may be recommended like the ones seen in our guarantee charts within eatch chapter. Please ask your cable supplier for details.

The igus® construction kit of Energy Chain Systems® solves all the requirements for interior separation known today.

igus® chainflex® cables permit the smallest bend radius of 4 x d for one million strokes.

The igus® product range offers up to 12 different bend radii for each chain series from stock. Here series 50 in the Storebaelt bridge project.

We recommend complete E-ChainSystems® - where bend radii for all cables and hoses, interior separation and service life are optimally matched. Also ask for the igus® system guarantee. ▶ ReadyChain® **from page 792**

Design parameters | **Electrical round cables**

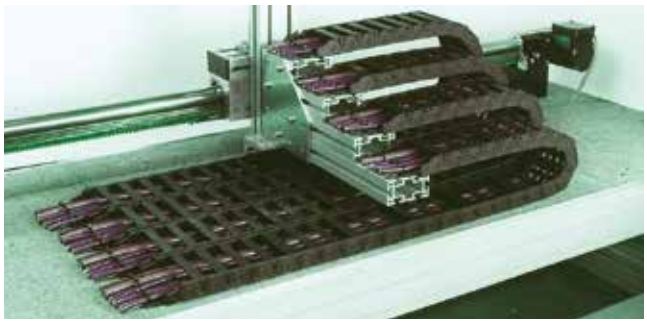
Electrical round cables

For electrical cables, the round cable is a safe, modular and cost-effective solution for E-Chain Systems®. We recommend the following criteria for selecting the proper round electrical cables:

Selection criteria:

- Small minimum bend radii and mounting heights
- Long service life at minimum bend radius
- Service life expectations for your application (short or long travel, hanging)
- Test data on service life from realistic tests
- Uncomplicated installation process - no hanging, laying out, etc, of cables
- Strain relief integrated directly into the mounting bracket
- Flexible shields for shielded cables
- Abrasion-resistant and non-adhesive outer jackets
- Large selection to avoid expensive custom designs

For bus cables and Fiber optic cables, special attention must be paid to how effective transmission rates and shielding remain after millions of cycles at the minimum bend radius.



Example at igus® experimental laboratory: constant development and testing of chainflex® electrical round cables

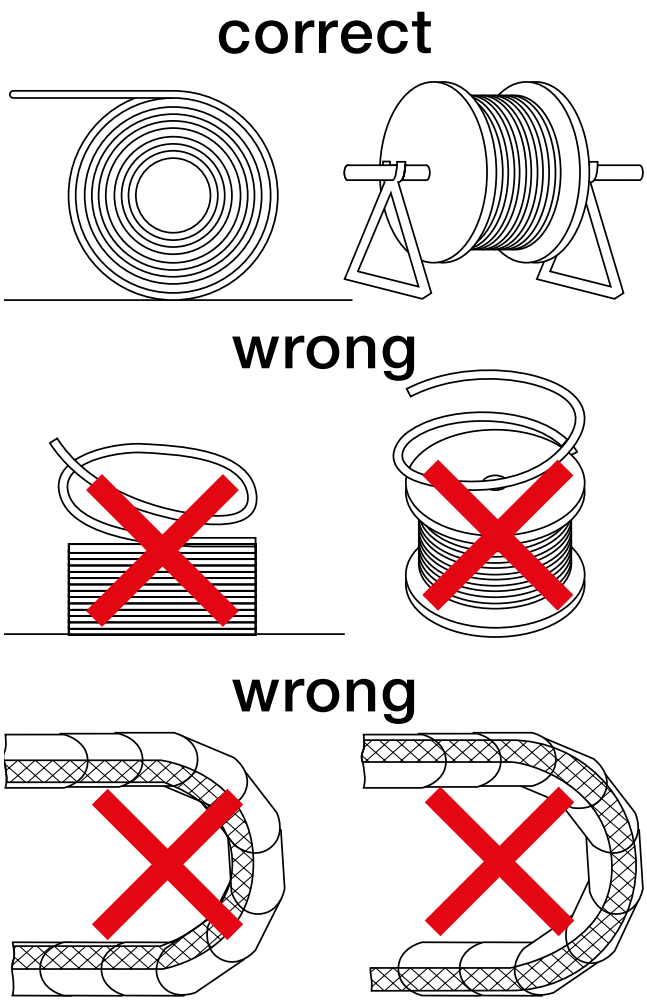
Design parameters | **Electrical round cables**

Installation and strain relief of round electrical cables

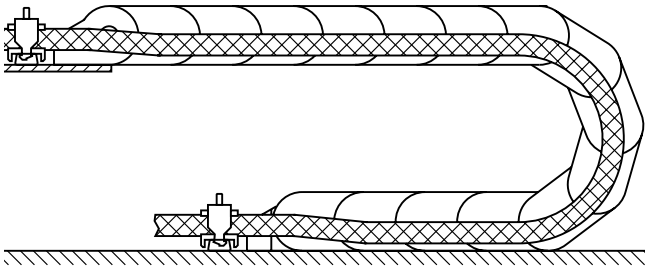
1. The cables must be laid straight, without twisting. Cables must not be uncoiled from the top of the spool. igus® chainflex® cables are immediately ready for placement directly into the E-Chain®. They need not be disconnected or laid out before installation.
2. The cables must be laid so that each individual cable can move freely from side to side.
3. The cables must be able to move freely along the radius. This must be double-checked if the upper run operates at the cable's maximum bend radius.
4. The division of the E-Chains® interior using igus® interior separators or shelves is necessary if several cables and/or hoses with varying diameters are laid out. It is important to prevent cables and hoses from tangling.
5. For cables and hoses with different jacket materials, it is important to prevent them from "sticking" to one another. If necessary, they should be separated. igus® chainflex® cables can be combined with all others.
6. Round electrical cables must be secured with strain relief at both ends. In exceptional cases, the cables may be fixed with strain relief at the moving end of the E-Chain® only. A gap of 10-30 x cable diameter between the end of the bend segment and the fixed point is recommended for most cables. chainflex® cables can, on the other hand, be secured directly to the mounting bracket with strain relief (this has been confirmed with testing).

We will be pleased to provide you with recommendations for complete E-ChainSystems:
„ReadyChain®: chain-cable harnessing".

▶ ReadyChain® **from page 792**



The cables must be able to move freely along the radius



chainflex® cables can be strain-relieved directly at the mounting bracket.

Corkscrewing: an effect of improper cable and hose placement in an E-Chain®

Design parameters | **Pneumatic hoses**

Pneumatic hoses

In principle, the same rules apply for pneumatic hoses as for round cables. In practice, it has been demonstrated that pneumatic hoses are less susceptible to wear. After consultation, they can be laid together more closely than the "10% all-around clearance" rule. A double-sided strain relief is required under these conditions. For pneumatic hoses made of rubber, we recommend strictly following the "10% clearance" rule because they tend to adhere to each other and to other cables and hoses.

Fully pre-assembled E-Chainsystem® with several pneumatic and hydraulic hoses

The igus® product range also offers thermo polymer pneumatic hoses called "chainflex® CFAir and CFCleanAir" ▶ **page 422**

At home in the world ...

The chainflex® approvals and their significance:
www.igus.eu/chainflex-certificates

igus 36-month chainflex cable guarantee and service life calculator based on 2 billion test cycles per year

Guarantee igus chainflex 36 up to 36 months guarantee

UL Marketing Claim Verification

Today, plant safety or availability can be the decisive reason to choose one machine over another.
As the complexity of the machines and number of electrical parts increases, the difficulty for designers to choose the best product also increases.
This is not helped by the fact that there is a lot of marketing information given, which is not norm based, and therefore difficult for the designer to verify the facts.
This is where the UL Marketing Claim Verification initiated by UL will help the designer.
This is because UL checks the marketing statements of the supplier for the technical data and accuracy.

The UL verified label now proves that the guarantee and quality statements for chainflex® cables and their durability, service life and functionality have been certified by UL. For companies that use these cables in their equipment, they offer more safety from purchasing parts for machine construction, customs clearance and shipping of the machines to America, right through to commissioning. Those who use chainflex® cables in energy chains can have confidence in terms of parameters such as temperature, type of movement, torsion, media influence or minimum bend radius.

The complex certification procedure (diagram 1) for the "igus® 36-month chainflex® cable guarantee and service life calculator based on 2 billion test cycles per year" claim, was carried out by auditors of the US institute at the igus® HQ in Cologne.

To do this, the processes and logic of service life determination were evaluated in a comprehensive audit programme in the 3,800 m^2 chainflex® test laboratory, which has over 800 parallel running tests and over 2 billion test cycles per year.

The following four areas were scrutinised:

Figure 1: The complex process to get the UL marketing certificate (source: igus®)

More details online:
verify.ul.com/verifications/368

More information:
www.igus.com/chainflex-at-home-in-the-world

UL Listed

Cables for applications that can be fully described in a standard are certified as "UL Listed". Example: A cable for a washing machine power supply can be clearly described for its application; therefore a normative description of the application of the cable and the associated test setup can be clearly defined. To certify that the cable is in accordance with "UL Listed" and then to manufacture, test and mark according to "UL Listed". It is not permissible to use a different kind of cable in such a clearly described application in the USA.

UL/CSA Recognized

The "UL/CSA Recognized" certification marks are issued for components of larger systems. In this case, only components that are not intended for a single, precisely defined installation or application are certified.
Cables for applications that cannot be described normatively and completely are then certified according to "UL/CSA Recognized" (AWM).

Example: Cables for use in energy chains are so diverse and complex that a normative description is impossible. This is where the " UL/CSA Recognized" certification is applicable. It allows cable developers a whole range of different combinable options with respect to insulation material, jacket material and design. From this cable manufacturers develop a combination that works, which means that it can be used for a specific customer application.

Be aware: "UL/CSA Recognized" describes a large, extremely varied range of applications. Here, it is the responsibility of the designer and manufacturer of such an "AWM cable" to work out and carry out appropriate additional tests to prove a specific application, e.g. in an energy chain.

UL

The institution responsible for approval in the USA is Underwriters Laboratories (UL). The Canadian Standards Association (CSA) is responsible for it in Canada. Certification guidelines and certification processes differ in their complexity, depending on the market and country. A so-called Memorandum of Understanding allows use in both countries, regardless of the place of certification. Both testing organisations distinguish between the so-called "UL/CSA Listed" and "UL/CSA Recognized" certification, both of which fulfil normative safety requirements that are verified by test procedures.

More details online:
iq.ul.com/

More information:
www.igus.com/chainflex-at-home-in-the-world

NFPA

The US **N**ational **F**ire **P**rotection **A**ssociation (NFPA), is a non-profit organisation that has been active in fire protection since 1896.
NFPA publishes numerous safety standards including electrical standards that are used in the USA today.
These include the "NFPA 79 - Electrical Standard for Industrial Machinery". The subject of the standard is primarily the correct application of electrical systems in industrial machinery and equipment used in the USA. With the help of the standard, designers can develop safe machines with the highest level of protection for operating personnel.
NFPA 79-2018 includes the topic "Special Cables and Conductors" relevant for chainflex cables in section 12.9.

More details online:
www.nfpa.org/

CLPA

The CC-Link Partner Association is an organisation based in Japan and represented in 11 regions of the world.
The purpose of CLPA is to spread and establish the industry network "CC-Link" standard worldwide.
In addition to the marketing of this standard, CC-Link products that are to be used for this standard are tested by this organisation and, if they are technically compliant with the corresponding certificates, are approved for use in CC-Link networks.

More details online:
www.cc-link.org/sch/c012List?userSeqNo=76&menuSeqNo=2

DNV-GL approval

The maritime economy is developing towards more automation and digitalisation: Whether vessel manufacture, shipping companies or the gas and oil industry - ships are becoming autonomous factories, shipping companies are becoming fully-fledged logistics providers, and refineries are becoming automated conveyor systems.
DNV-GL is responsible for certifications in the maritime environment, offshore facilities, gas and oil pipelines, and onshore applications such as wind, tidal or solar energy. The classification society was formed in 2012 through the merger of the Norwegian company Det Norske Veritas (DNV) and Germanischer Lloyd (GL).
The components used in maritime environments have to meet different requirements than those of classic factory automation on land.
This requires a separate approval for the operation of these components. The certification society checks compliance with international standards and guidelines, which are applied accordingly to these components. If existing regulations or standards do not describe the application sufficiently, additional testing measures are defined or developed.

If products have DNV GL approval, it simplifies and speeds up their use in the maritime sector, as it is not necessary to test individual components.

More details online:
www.dnvgl.com

More information:
www.igus.com/chainflex-at-home-in-the-world

EAC and CTP certificates

EAC (Eurasian Conformity) and CTP are testing standards that are binding for components to be exported to Russia. Among other things, CTP provides proof of compliance with fire protection guidelines for Russia, Kazakhstan and Belarus. The certifications were introduced after Russia's accession to the World Trade Organisation (WTO) in 2012. They replace the so-called GOST certifications.

The EAC certification is for export products and provides proof that the products conform to the technical requirements of the customs union of Russia, Belarus and Kazakhstan. Without this verification, imports into the customs union are prohibited.
The EAC follows the Russian machinery directive TR-753, which previously had to be taken into account when exporting to the Eurasian economic area.

Prior to certification, companies must submit an application to an accredited certification body in the EAWU (Eurasian Economic Union). The application includes:

- Detailed product description
- Product designation
- Customs tariff code
- Technical pass
- Security review
- Operating instructions
- Technical drawings
- Technical data sheet
- Test reports
- Already existing certificates: ISO, DIN, CE

The certificate/approval document for a product must generally be available in Russian and in the local language.

If products have EAC and CTP certification, this speeds up their release at customs and thus enables fast and uncomplicated import into the destination country of the customs union.

More details online:
www.eaeunion.org/?lang=en#info

More information:
www.igus.com/chainflex-at-home-in-the-world

REACH directive

The term REACH stands for a regulation called Registration, Evaluation, Authorisation and Restriction of Chemicals.

Its scope covers manufacturers or importers of more than one tonne of substances per year into the European Union .

The REACH directive is only partially valid for igus®: As a manufacturer of cables, the company is defined as a so-called "downstream user" with regard to the value-add chain. Nevertheless, the contents of the REACH directive and its rules for the production and processing of chemical substances are observed at igus®. For example, no chemicals are used in the production of chainflex® cables that are above the valid REACH limits. The entire range of chainflex® cables is free from materials such as sodium peroxometaborates, cadmium sulphides or also dihexyl phthalates.

More details online:
echa.europa.eu/de/regulations/reach/understanding-reach

RoHS-II / RoHS-III

More safety for people and the environment
The abbreviation RoHS stands for **R**estriction **o**f **H**azardous **S**ubstances and regulates the use of selected hazardous substances in electrical and electronic equipment, which includes cables. By complying with this directive, companies prove that problematic materials such as lead, mercury or phthalates - known as plasticisers - have been banned from electronic waste and also from working environments. One example is lead. It occurs, among other things, in the form of solder on circuit boards, which are installed in complex machine systems in a variety of ways.
Materials research in recent years has also produced new jacket materials which, among other things, do not contain hazardous plasticisers and thus function flexibly in dynamic applications. Until now, plasticisers have been used in industry mainly where plastics had to remain particularly pliable, soft and elastic in use.

igus® develops and tests special jacket materials for use in e-chains in its own laboratory, which are RoHS II /III compliant according to the respective requirements.

More details online:
ec.europa.eu/environment/waste/rohs_eee/legis_en.htm

CE mark

The CE marking makes it clear that the manufacturer of a product such as chainflex® cables complies with the applicable EU directives. The CE marking is not a seal of approval or quality mark and was created for trade in the European Economic Area.

- The CE certification basis has come to encompass more than 25 EU directives (issue 2020).
- The CE certificate is a kind of voluntary commitment.
- The CE mark on a machine and the corresponding signature confirms that this machine was planned, designed and built in accordance with the applicable standards.
- The CE marking is part of further regulations. These include the Machinery Directive, the Electromagnetic Compatibility (EMC) Directive, the Low Voltage Directive (often referred to as LVD), RoHS substance restrictions and protective equipment, etc.

CE conformity is based on a complex risk assessment.

Risk assessment - the iterative procedure consists of:

- Verification of the intended use of e.g. e-chain® and chainflex® cables
- Analysis of conceivable, foreseeable misuse
- Determination of relevant and valid standards for the production of chainflex® cables and e-chains®
- Determination of specific requirements and conditions for the use of chainflex® cables
- Research of the responsible "notified body", e.g. at the accreditation body DAkkS (Institute for the monitoring of all certification, testing and inspection bodies)
- (Laboratory) tests of chainflex® cables and e-chains®
- Data evaluation
- Preparation of technical documentation and translation into target languages
- Creation of the certificate/provision for download
- Attaching the CE mark

More details online:
c.europa.eu/growth/single-market/ce-marking_de

More information:
www.igus.com/chainflex-at-home-in-the-world

Information | **Approbation and approvals**

The following describes the typical Approvals and Standards that chainflex® cables carry. The table of contents and respective catalog page details the actual approval.

This is an Underwriters Laboratory designation that indicates compliance to the AWM (Appliance Wire Material) standard 758. This describes cables intended for internal and external wiring components. An AWM cable is useful when obtaining a UL listing on an overall product.

This mark is the same as except approved for use in Canada and the United States. In accordance with Canadian AWM Standard C22.2 No.210 and UL AWM Standard 758 respectively.

Cables that bear this mark are in compliance to a specific Article of the National Electrical Code. For example UL 1277 Tray Cable fulfills the requirements of Article 336 of the 2002 NEC. Listed products are intended for use within residential, commercial and industrial structures

This is the mark of the Canadian Standards Association. Many Chainflex types carry CSA AWM approvals. The Canadian AWM designates compliance to CSA Standard C22.2 No. 210. These products are intended for the internal and external wiring of electronic equipment. Typical markings on cable include the following. EX “CSA AWM I/II A/B 80°C 300V FT1” Optional markings for oil resistance and wet ratings may apply.

Class I: Internal
A - Where not subject to mechanical abuse
B - Where may be subject to mechanical abuse

Class II: External
A - Where not subject to mechanical abuse
B - Where may be subject to mechanical abuse

The cable must also pass a flame test typically as described below: FT1 - Vertical Flame Test CSA 22.2

No. 3: In general a Bunsen burner applies flame at base of 18” specimen. Cotton is placed below specimen. Flame is applied 5 times more for 15 seconds FT4 - Vertical Flame Test CSA 22.2 No. 3: In general a propane burner (70,000 BTU/HR) applies flame at one end of 8 foot cable lengths arranged in open steel trays.

Developed by VDW – Association of German Machine Tool Manufacturers. It describes a comprehensive total concept for the standardization and decentralization of the electrical and fluid-technical installation of machines and plants.

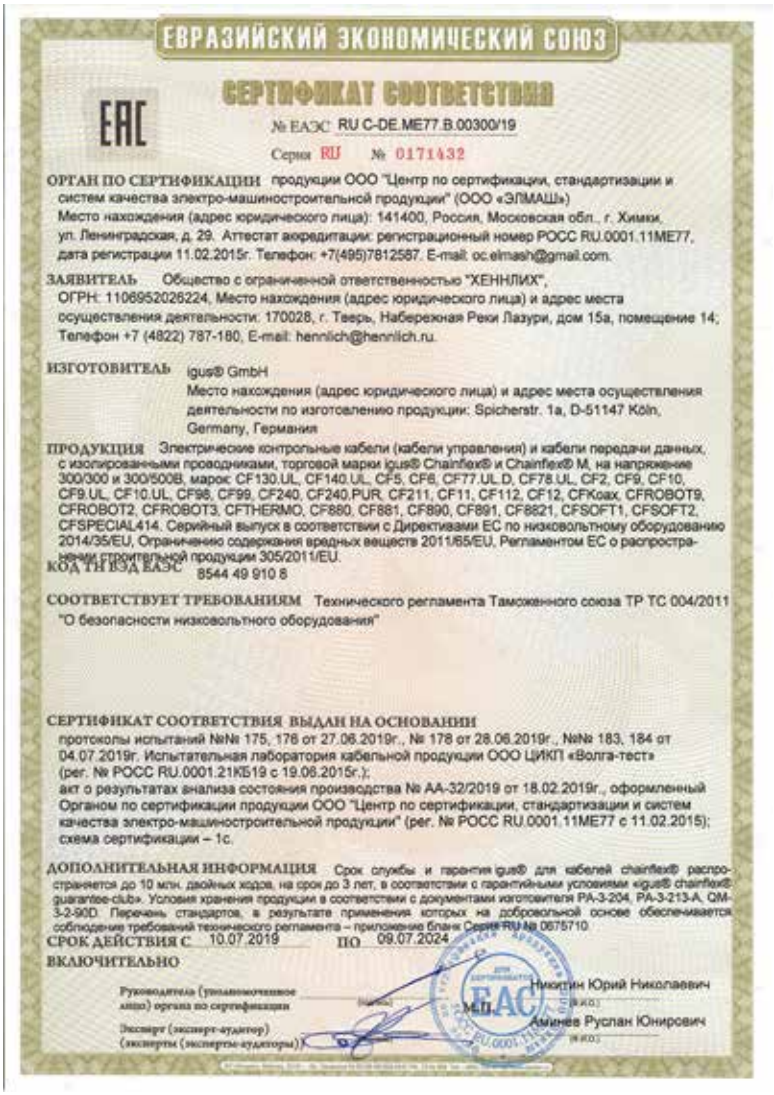
European Conformity – The CE mark on a cable designates that the product complies with relevant European health, safety and environmental protection legislations. 2014/35/EG

chainflex® cables now certified for the Russian market

igus® chainflex® cables are now certified for Russia, Belarus and Kazakhstan.
These certificates replace the outdated GOST certificates.

EAC

Certified according to the standards of the technical regulations of the customs union
Nr. RU C-DE.ME77.B.01218 (TR ZU)
Nr. RU C-DE.ME77.B.02324 (TR ZU)
Nr. RU C-DE.ME77.B.02806 (TR ZU)
Nr. RU C-DE.ME77.B.00295/19
Nr. RU C-DE.ME77.B.00300/19
Nr. RU C-DE.ME77.B.00302/19



ЕВРАЗИЙСКИЙ ЭКОНОМИЧЕСКИЙ СОЮЗ

EAC

СЕРТИФИКАТ СООТВЕТСТВИЯ

№ ЕАЭС RU C-DE.ME77.B.00300/19

Серия RU № 0171432

ОРГАН ПО СЕРТИФИКАЦИИ продукции ООО "Центр по сертификации, стандартизации и систем качества электро-машиностроительной продукции" (ООО «ЭПМАШ»)
Место нахождения (адрес юридического лица): 141400, Россия, Московская обл., г. Химки, ул. Ленинградская, д. 29. Аттестат аккредитации: регистрационный номер РОСС RU.0001.11ME77, дата регистрации 11.02.2015г. Телефон: +7(495)7812587. E-mail: oc.elmash@gmail.com.

ЗАЯВИТЕЛЬ Общество с ограниченной ответственностью "ХЕННЛИХ", ОГРН: 1106952026224, Место нахождения (адрес юридического лица) и адрес места осуществления деятельности: 170028, г. Тверь, Набережная Реки Лазури, дом 15а, помещение 14; Телефон +7 (4822) 787-180, E-mail: hennlich@hennlich.ru.

ИЗГОТОВИТЕЛЬ igus® GmbH
Место нахождения (адрес юридического лица) и адрес места осуществления деятельности по изготовлению продукции: Spicherstr. 1a, D-51147 Köln, Germany, Германия

ПРОДУКЦИЯ Электрические контрольные кабели (кабели управления) и кабели передачи данных, с изолированными проводниками, торговой марки igus® Chainflex® и Chainflex® M, на напряжение 300/300 и 300/500В, марок: CF130.UL, CF140.UL, CF5, CF6, CF77.UL.D, CF78.UL, CF2, CF9, CF10, CF9.UL, CF10.UL, CF98, CF99, CF240, CF240.PUR, CF211, CF11, CF112, CF12, CFKoax, CFROBOT9, CFROBOT2, CFROBOT3, CFTHERMO, CF880, CF881, CF890, CF891, CF8821, CFSOFT1, CFSOFT2, CFSPECIAL414. Серийный выпуск в соответствии с Директивами ЕС по низковольтному оборудованию 2014/35/EU, Ограничению содержания вредных веществ 2011/65/EU, Регламентом ЕС о распространении строительной продукции 305/2011/EU.

КОД ТН ВЭД ЕАЭС 8544 49 910 8

СООТВЕТСТВУЕТ ТРЕБОВАНИЯМ Технического регламента Таможенного союза ТР ТС 004/2011 "О безопасности низковольтного оборудования"

СЕРТИФИКАТ СООТВЕТСТВИЯ ВЫДАН НА ОСНОВАНИИ
протоколы испытаний №№ 175, 176 от 27.06.2019г., № 178 от 28.06.2019г., №№ 183, 184 от 04.07.2019г. Испытательная лаборатория кабельной продукции ООО ЦИКП «Волга-тест» (рег. № РОСС RU.0001.21КБ19 с 19.06.2015г.);
акт о результатах анализа состояния производства № АА-32/2019 от 18.02.2019г., оформленный Органом по сертификации продукции ООО "Центр по сертификации, стандартизации и систем качества электро-машиностроительной продукции" (рег. № РОСС RU.0001.11ME77 с 11.02.2015);
схема сертификации – 1с.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ Срок службы и гарантия igus® для кабелей chainflex® распространяется до 10 млн. двойных ходов, на срок до 3 лет, в соответствии с гарантийными условиями «igus® chainflex® guarantee-club». Условия хранения продукции в соответствии с документами изготовителя РА-3-204, РА-3-213-А, QM-3-2-90D. Перечень стандартов, в результате применения которых на добровольной основе обеспечивается соблюдение требований технического регламента – приложение бланк Серия RU № 0675710

СРОК ДЕЙСТВИЯ С 10.07.2019 ПО 09.07.2024 ВКЛЮЧИТЕЛЬНО

Руководитель (уполномоченное лицо) органа по сертификации — Никитин Юрий Николаевич

М.П. — Аминев Руслан Юнирович

Эксперт (эксперт-аудитор) (эксперты (эксперты-аудиторы))

All certificates can be found on ▶ www.igus.com/CTP-EAC

Information | **General**

The general conditions

The General Conditions of Sale of igus® shall apply. Excessive and short deliveries of ± 10 % for cables conform with contractual agreements. Deliveries can be made in part-lengths. Statutory VAT must be added to the prices. The General Conditions of Sale and Delivery of igus® GmbH, Cologne, can be found online under www.igus.eu.
The prices quoted in the catalogue or other media are subject to alteration. igus® can modify the prices at any time at their own discretion.

User information

Since our products are constantly being developed further in the interest of our customers, we reserve the right to make technical alterations at any time. With the issue of this catalogue, all previous publications lose their validity. Subject to printing errors.

Disclaimer

The terms "igus", "chainflex", "CFRIP", "readycable", "readychain", "e-chain", "e-chain systems", "e-ketten", "e-kettensysteme", "flizz", "iglidur", "drylin" are legally protected trademarks in the Federal Republic of Germany and in case also in foreign countries.

Outer jacket color according to RAL

chainflex® cable jacket colours are given with the similar RAL colour number; for example yellow-green, similar to RAL 6018. Slight differences can occur from the exact RAL colour, depending on the cable jacket material. However, this has no effect on the quality or functionality of the cable.

A RAL number is used to describe different shades of colour more consistently. For example, RAL 7040 is light gray and RAL 7016 is a dark gray. The RAL number describes the colour, but cannot guarantee the same shade in different applications.

RAL: German Institute for Quality Assurance and Certification EV. ▶ www.RAL.de

KTG

If cable drums are to be used, please visit KTG directly online.
▶ www.kabeltrommel.de

Product illustrations

The products illustrated are photos showing examples for whole series, i.e. the original cable can deviate from the cable shown.

Technical notes

The USB, FireWire and GigE cables listed on this page have been developed and manufactured for the mechanically demanding industrial application in e-chain systems®. High resistance against oil and lubricants are guaranteed, and also a high protection against electro-magnetic interference fields. This high mechanical service life was reached with the usage of high quality materials which even care for the electrical safeness.
In single cases communication errors can occur, if very different hardware and software is combined. We recommend tests with all components and the cables before starting serial production, to get the proove for a perfect running system.
Of course we support you with the details of these electrical tests.

The specifications in the catalogue referring to temperature range, bend radius and travel must be seen as limiting value specifications. If two limiting value specifications are combined, this can lead to a reduction of the cable's service life.

The term "oil resistant" refers to a few selected oil types which have been tested accordingly. This does not mean, however, that the products are automatically resistant to all the oils on the market.

Length printing: Respective printing of the metre length is already on many cables. These are not calibrated measurements, they are only intended as an orientation aid.
Just give us a call!

chainflex® CASE – ship'n store by igus®

Reduce costs in delivery, storage space & reordering

... with the new chainflex® CASE – ship'n store by igus®

The greatest potential is often in the details. The new chainflex® CASE – ship'n store by igus allows you to save at multiple levels:

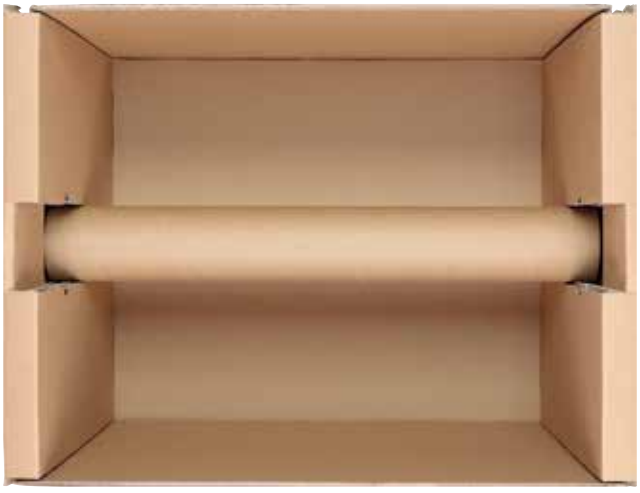
- In delivery by standard shipping
- In terms of storage costs through direct "unreeling" from the shipping carton without the cost of expensive storage systems
- In process costs through fast & mobile online ordering

Specifically, this chainflex storage logistics innovation consists of clever shipping packaging for cables sold by the metre, which greatly simplifies the cable handling process. The box can be sent by standard shipping, which reduces the shipping costs enormously.

The shipment can then be placed directly at the use or storage location without additional intermediate steps because the cables can be unreeled directly from the packaging. It is also possible to stack several chainflex cases, as the special construction of the chainflex shipping drum has been specially designed for modular stackability.

And finally, the QR code on the shipping label can be used to re-order the desired goods online via a mobile end device.

▶ www.igus.com/cf-case




igus
Igus GmbH Spicher Str. 1a 51147 Köln/Germany
chainflex
Artikel/Article:
CF880.15.03
Bezeichnung/Description:
chainflex PVC Steuer-Ltg.
3G1,5
Länge/Length:
100m
Einfach nachbestellen/Easy to reorder:

Online | Product finder und design

Find & compare cables

Quickcable

The chainflex® product finder simply shows which of our cables is best suited for your E-Chain® application:
Select the cable type , the connection and other desired product properties as well as the number of cores and the cross-section , the nominal voltage and type of the E-Chain® for your application. Select the bending radius, the maximum and minimum operating temperature ❶, torsion, maximum speed and acceleration, as well as the travel ❷. Select the bend radius, the maximum and minimum operating temperature ❸, torsion, maximum speed and acceleration, as well as the travel ❹.
The results are displayed at the bottom edge of the screen ❺.

▶ www.igus.com/quickcable

Calculate service life of cables

QuickLife

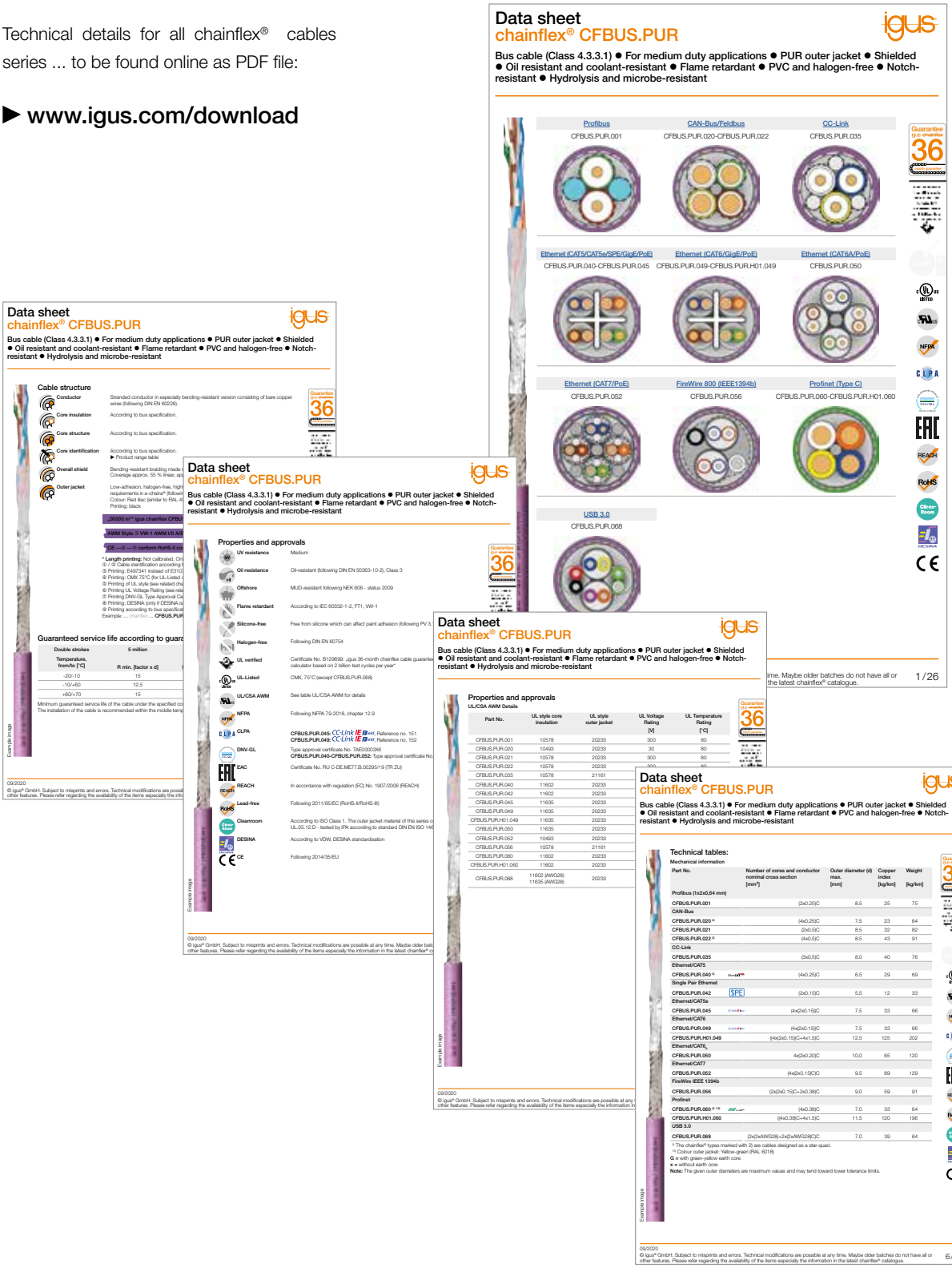
Calculate the service life of your required cable online with a few clicks. Enter the name of your system and select cable type, series and part number ❶. Enter the system information ❷ of your Energy Chain® and select whether you have an unsupported or gliding application.
By clicking on "Calculate" ❸ you will be shown the results ❹.

▶ www.igus.com/cf-lifetime

Data sheets online

Technical details for all chainflex® cables series ... to be found online as PDF file:

▶ www.igus.com/download



Information | **Catalogs and brochures**

Printed CATALOGS:

Catalog: E-Chains® and systems

The standard catalogue for e-chains® and e-chain systems®.

MAT0072320.16

Catalog: dry-tech® bearing technology

Catalogue about iglidur® bearings, igubal® spherical bearings, xiros® ball bearings and drylin® linear guide systems, lead screw technology and drive technology.

MAT0070571.16

Catalog: chainflex® cables

Worldwide No. 1 for cables in e-chains® - tested, tested, tested. More than 1,354 cables from stock. 36 months guarantee on every chainflex® cable ... up to 10 million double strokes guaranteed.

MAT0070582.16

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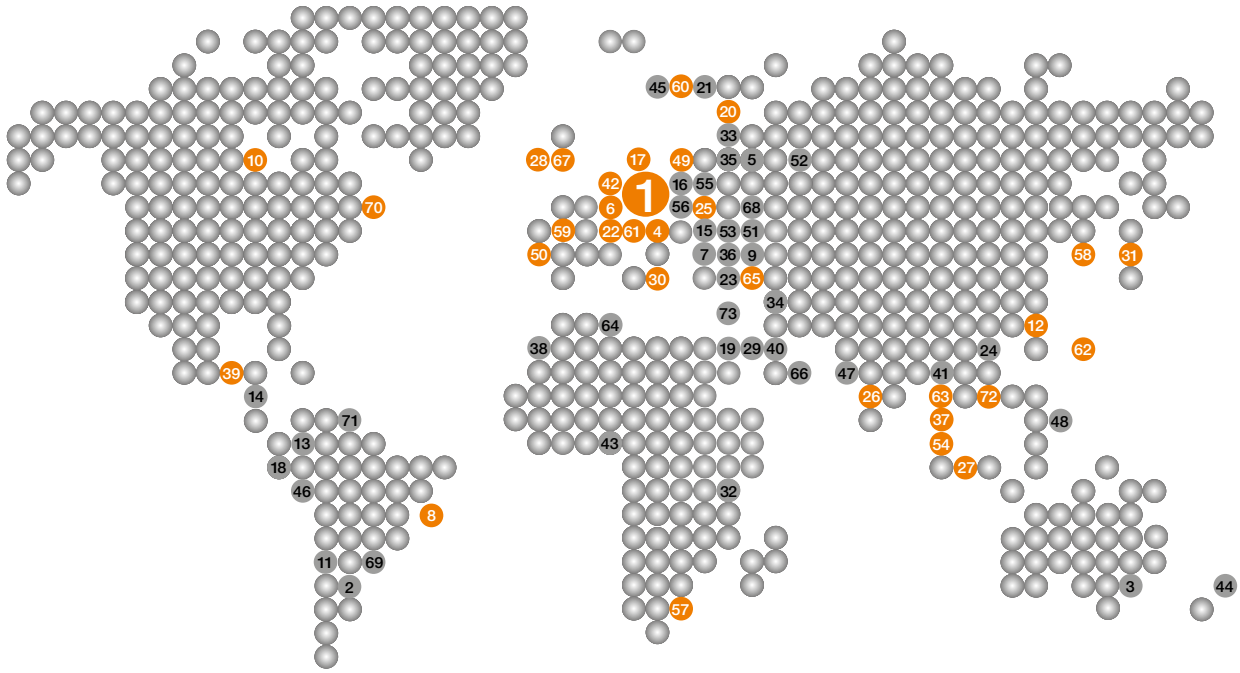

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