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Design Rules for Cables and Hoses in Energy Chains®

Supply of data and energy 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/hoses in the carrier, 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 chain and the space allowed, are important for the service life of the system. Various separation options enable the adaptation of the Energy Chains® to the specific requirements of each respective application. General rules of thumb, such as "maximum 80% of the cross section of an Energy Chain should be used" **are no longer viable** with today's application complexities. 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 by the end of the next business day.

Neatly laid cables with igus® interior separation

Maximum cable and hose diameters

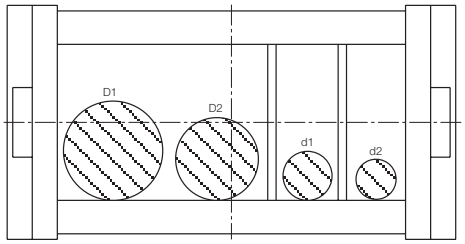
The maximum cable and/or hose diameter corresponds to the inner height of the selected Energy Chain®/Tube, with additional minimum clearance. This minimum clearance would be, for example, 10% for electrical round cables, 20% for hydraulic hoses. An Energy Chain® is ideal if a minimum lateral gap to the 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. Please consult igus®.

Clearance space in % for various cables/hoses

Cables and Hoses	"All-Around" Clearance
Electrical round cables	**10 %**
Electrical flat cables	**10 %**
Pneumatics	**5 -10%**
Hydraulics	**20 %**
Media hoses	**15 - 20 %**

Distribution within the Energy Chain®:

- 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.**

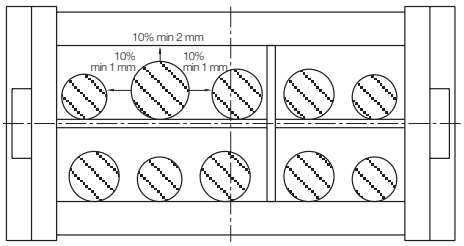


D1 + D2 > 1.2 x hi **d1 + d2 ≤ 1.2 x hi**

Distribution Rules:

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

Rule 2:
If d1 + d2 ≤ 1.2 x 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.

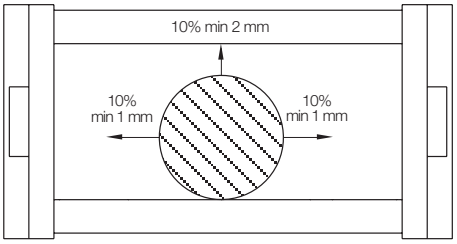


d1 + d2 ≤ 1.2 x hi

The reason for these rules is as follows:
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 Energy Chains®.

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 "all around" space for round electrical cables

Design Rules for Distribution of Cables/Hoses:

The cable or hose weight should be symmetrically distributed along the width of the chain

- Cables and hoses 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 other and all other brands of cable or hose
- The cables and hoses 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. hydraulic hoses)
- Generally, the faster and more frequently the Energy Chain® operates, the more important the exact positioning of the cables and hoses inside the chain. Due to the wide variety of the possibilities, we strongly recommend you take advantage of our free consultation services for your specific applications

The igus® modular Energy Chain System® solves all known requirements for interior separation

Bending radius R

- The bending radius of our Energy Chain® depends on the “thickest” or “stiffest” cable or hose in your application
- The bending radii of the Energy 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 bending radii for cables and hoses refers to use at normal temperatures; other bending radii may be recommended. Please ask your cable or hose supplier for details

We recommend complete Energy Chain Systems® where bending radii for all cables and hoses, interior separation and service life are optimally matched. Please ask for the igus® System Guarantee.

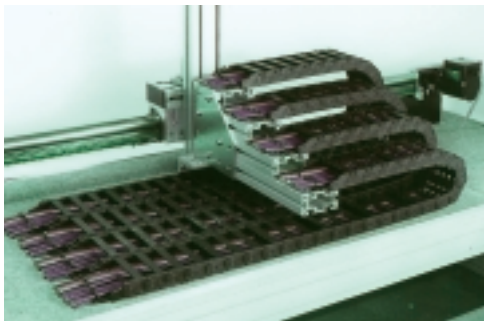
igus Chainflex® cables permit the smallest bending radius of 5 x d for one million strokes

Round electrical cables

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

Selection Criteria:

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



Example from igus® test laboratory: continuous development and testing of Chainflex® round electrical cables

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

igus® test laboratory

We are continuously developing and testing electrical cables in Energy Chains® and Tubes. As a result, we offer detailed reports on the service life of a cable or hose for your application. This concerns both Chainflex® cables and other brands which are important in our consultation for a safe Energy Chain System®. Statements we make including those regarding strain relief, EMC, transmission characteristics, etc. are backed by our own tests. We are always happy to provide a system analysis and quote. Provide us with your electrical performance requirements and you will receive an analysis from us within a matter of hours.

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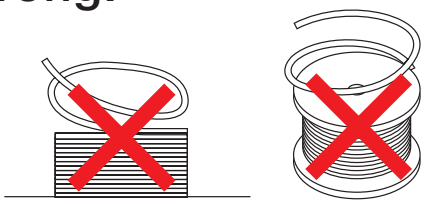
Design: Cable and Hose Packages, Round Electrical Cables

Guidelines for the installation and strain relief of round electrical cables

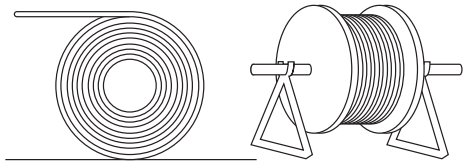
1. The cables must be laid straight, without twisting. Cables must not be uncoiled from the top of the spool. igus® Chainflex® cables are immediately ready for placement directly into the Energy Chain®. They need not be disconnected or laid out before installation.
2. The cables must be laid so that 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 bending radius.
4. The division of the carrier's interior using shelves or igus® interior separators 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 Energy Chain® only. A gap of 10-30 x cable diameter between the end of the bending 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 are happy to offer a pre-assembled Energy Chain System®: the igus® "Triple Guarantee" of chain and cable, pre-assembled and fully harnessed.

Wrong!

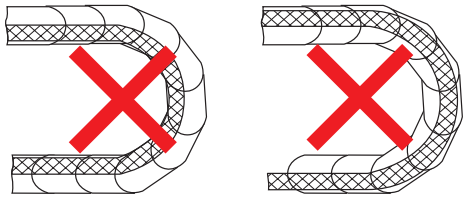


Correct!



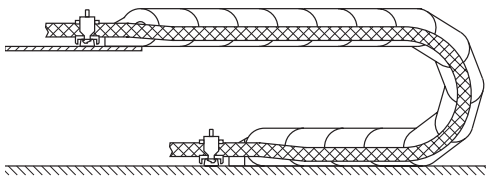
Corkscrewing: an effect of improper cable and hose placement in an Energy Chain®

Wrong!



Cables must be able to bend freely

Correct!



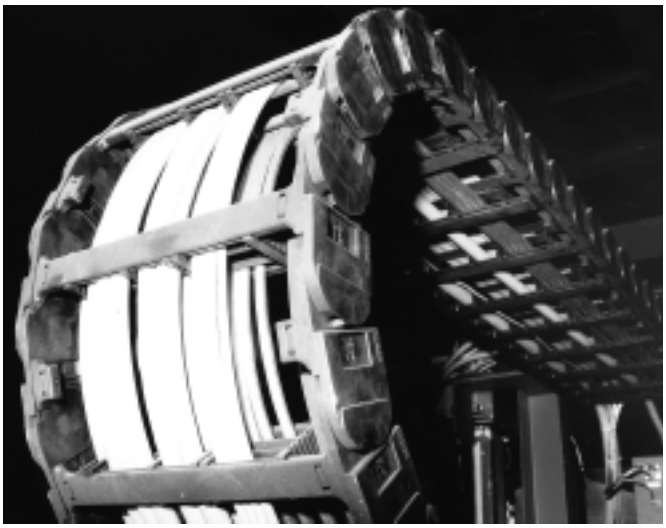
Chainflex® cables can be strain-relieved directly at the mounting bracket

Design: Cable and Hose Packages, Flat Cables and Pneumatic Hoses

Flat cables

Flat cables must be able to move freely along the bending radius. Two flat cables next to one another should be kept apart with separators. If two flat cables are laid on top of one another, we strongly recommend the use of horizontal igus® shelving. Flat and round cables should be laid separately in the Energy Chain®. Strain relief should be attached at both ends. Flat cables are only conditionally recommended for use in Energy Chains®.

Outer jackets made of rubber must be specified particularly carefully, because of potentially high static friction.



Flat cables and pneumatic hoses installed in an Energy Chain® with full interior separation of all cables.

Fully pre-assembled Energy Chain® System® with several pneumatic hoses next to and above each other

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% clearance all-around” 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/hoses.

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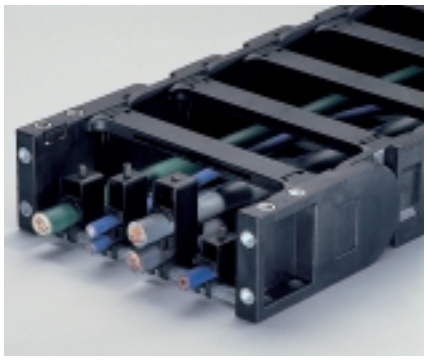
Design: Strain Relief

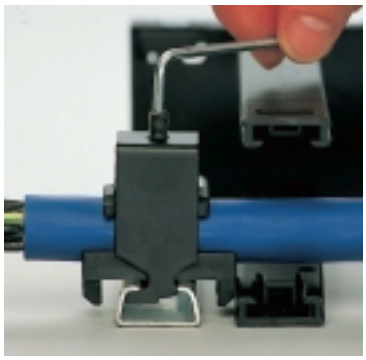
We recommend strain relief on both ends.

Strain relief for electrical cables

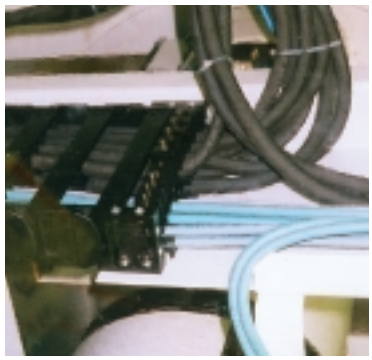
Strain relief can consist of standard elements or can be custom-made. For most applications, our standard program of profile rails in mounting brackets and space-saving “Chainfix®” clamps can be used. We also offer simple strain relief solutions using cable tiewraps and tiewrap plates. In ideal cases, the cables should be secured at both ends of the Energy Chain® with strain relief (in a few instances, strain relief at the moving end of the Energy Chain® is sufficient - please consult igus® for these cases).



Strain relief in KMA mounting bracket with profile rail



The Chainfix clamp



igus® Chainfix strain relief with KMA brackets; used here for cables and hoses

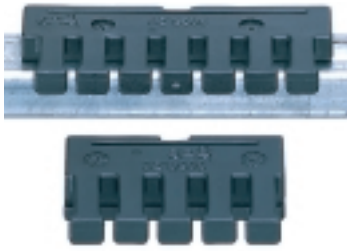
Minimum gap of the strain relief and the beginning of the bending radius

Tests on our premises and in field applications have shown strain relief located at the last bending point of the Energy Chain® has no influence over the durability of igus® Chainflex® cables. It is possible, therefore, to integrate the strain relief with the mounting bracket. This space-saving option for strain relief is offered by igus® for almost all Energy Chains® (More details on this in the relevant chapters).

Another integrated strain relief option is the igus® tiewrap plate. The mounting bracket includes comb-like plates to which cables and hoses can be secured with the help of cable tiewraps.

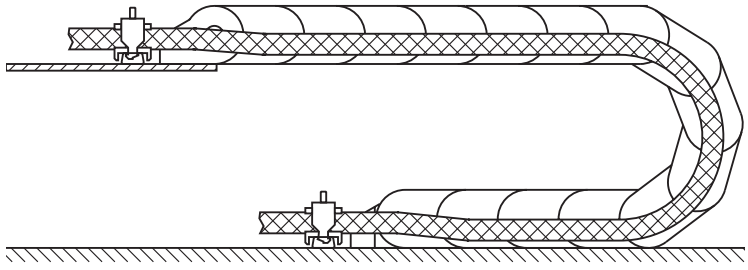
The decisive features and advantages of these elements are:

- Time saving installation: strain relief is already in place when mounting brackets are bolted in
- Longer service life for cables and hoses - when the strain relief system is implemented the cables and hoses last longer
- Space-saving design - strain relief at the mounting bracket almost always leaves room



Detachable tiewrap plate for the profile rail

Simple strain relief with cable tiewraps attached to igus® tiewrap plates and integrated into the mounting bracket



Ideal installation of cables in Energy Chains®. Chainflex® cables can be directly strain-relieved in the mounting bracket (minimum gap to the last curved chain link is not necessary)!

Design: A Guide to Regulatory Approval Codes for Chainflex®

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 above except approved for use in Canada and the United States.

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 designats 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.

Association of German Electrical Engineers - The recognized association for German standards is the German Electrotechnical Commission of DIN & VDE (DKE).

All Chainflex® cables manufactured after January 1, 2006 are RoHS Compliant according to 2002/95/EC directives.

igus® Energy Chain Systems®

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Chainflex® AWG Charts

AWG - American Wire Gauge Chart - Solid Wire

This chart is intended for reference only. Contact igus® for conductor information for Chainflex® cables

AWG	Diameter		Cross-Sectional Area		DCR @ 20°C - Ohms/mft max		Wgt	Break Strength
	Inches	MM	CMA	Sq. MM	Bare or Silver Plated Cu.	Tinned Cu	Lbs/Mft	(lbs) max
46	.00155	0.039370	2.391	0.0012	4932	5294	0.01451	.15491
44	.00195	0.049530	3.801	0.0019	3030	3253	0.01830	.19534
42	.00246	0.062484	6.044	0.0031	1862	1999	0.02308	.24632
40	.0031	0.078740	9.61	0.0049	1152	1236.6	.0291	.3106
39	.0035	0.088900	12.3	0.0062	897.1	963.0	.0371	.3917
38	.0040	0.101600	16.0	0.0081	681.9	732.0	.0484	.4939
37	.0045	0.114300	20.3	0.0103	535.7	575.1	.0613	.6228
36	.0050	0.127000	25.0	0.0127	431.9	463.6	.0757	.7854
35	.0056	0.142240	31.4	0.0159	342.8	368.0	.0949	.9904
34	.0063	0.160020	39.7	0.0201	269.8	289.6	.120	1.249
33	.0071	0.180340	50.4	0.0255	211.7	227.3	.153	1.575
32	.0080	0.203200	64.0	0.0324	166.2	178.4	.194	1.986
31	.0089	0.226060	79.2	0.0401	133.9	143.7	.240	2.504
30	.0100	0.254000	100	0.0506	105.8	113.6	.3042	3.157
29	.0113	0.287020	128	0.0647	82.9	88.0	.387	3.981
28	.0126	0.320040	159	0.0804	66.7	70.8	.481	5.020
27	.0142	0.360680	202	0.1021	52.5	55.8	.610	6.331
26	.0159	0.403860	253	0.1280	41.9	44.5	.765	7.983
25	.0179	0.454660	320	0.1623	33.0	35.0	.970	10.07
24	.0201	0.510540	404	0.2046	26.2	27.2	1.22	12.69
23	.0226	0.574040	511	0.2587	20.7	21.5	1.55	15.41
22	.0253	0.642620	640	0.3242	16.5	17.2	1.94	19.43
21	.0285	0.723900	812	0.4114	13.0	13.5	2.46	24.50
20	.0320	0.812800	1020	0.5186	10.3	10.7	3.10	30.89
19	.0359	0.911860	1290	0.6527	8.21	8.54	3.90	38.95
18	.0403	1.023620	1620	0.8225	6.52	6.78	4.92	49.12
17	.0453	1.150620	2050	1.0393	5.16	5.37	6.21	61.93
16	.0508	1.290320	2580	1.3070	4.10	4.26	7.81	78.10
15	.0571	1.450340	3260	1.6512	3.25	3.38	9.87	98.48
14	.0641	1.628140	4110	2.0809	2.58	2.68	12.4	124.2
13	.0720	1.828800	5180	2.6254	2.04	2.12	15.7	156.6
12	.0808	2.052320	6530	3.3064	1.62	1.68	19.8	197.5
11	.0907	2.303780	8230	4.1663	1.29	1.34	24.9	249.0
10	.1019	2.588260	10380	5.2588	1.02	1.06	31.4	314.0
9	.1144	2.905760	13090	6.6281	.809	.833	39.6	380.5
8	.1285	3.263900	16510	8.3626	.641	.660	50.0	479.8
7	.1443	3.665220	20820	10.5456	.508	.523	63.0	605.0
6	.1620	4.114800	26240	13.2913	.403	.415	79.4	762.9
5	.1819	4.620260	33090	16.7572	.320	.329	100	961.9
4	.2043	5.189220	41740	21.1385	.254	.261	126	1213
3	.2294	5.826760	52620	26.6516	.201	.206	159	1530
2	.2593	6.586220	66360	34.0520	.157	.161	201	1929
1	.2893	7.348220	83690	42.3871	.126	.129	253	2432
1/0	.3249	8.252460	105600	53.4609	.100	.102	319	2984
2/0	.3648	9.265920	133100	67.3980	.0795	.0814	403	3763
3/0	.4096	10.40384	167800	84.9683	.0631	.0646	508	4745
4/0	.4600	11.68400	211600	107.1649	.0500	.0512	641	5983

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AWG - American Wire Gauge Chart - Stranded Conductors

This chart is intended for reference only. Contact igus® for conductor information for Chainflex® cables

AWG	Stranding	Diameter		Cross-Sectional Area		WGT/MFT	DCR @ 20°C - Ohms/mft max	
		Inches	MM	CMA	Sq. MM		Silver or Bare Cu	Tinned Cu
36	7/44	.006	0.1524	28.00	.0133	.085	446	479.0
34	7/42	.0075	0.1905	43.75	.0217	.132	274	294.0
32	7/40	.009	0.2286	67.27	.0343	.203	169.5	182.0
32	19/44	.008	0.2032	76.00	.0361	.230	165.9	178.1
30	7/38	.012	0.3048	112.00	.0567	.339	100.3	107.7
30	19/42	.013	0.3302	118.75	.0589	.359	101.9	109.4
28	7/36	.015	0.3810	175.00	.0889	.55	63.55	68.22
28	19/40	.016	0.4064	182.59	.0931	.59	63.06	67.69
27	7/35	.017	0.4318	219.52	.1113	.632	50.44	54.15
27	65/44	.018	0.4572	260.00	.1235	.70	49.41	53.05
26	7/34	.019	0.4826	277.83	.1407	.87	39.70	42.61
26	10/36	.020	0.5080	250.00	.1270	.77	44.92	48.21
26	19/38	.020	0.5080	304.00	.1539	.93	37.33	40.07
24	7/32	.024	0.6096	448.00	.2268	1.38	24.46	26.25
24	10/34	.023	0.5842	396.90	.2010	1.22	28.06	30.12
24	19/36	.025	0.6350	475.00	.2413	1.47	23.64	25.38
24	41/40	.024	0.6096	384.40	.2009	1.25	29.78	31.97
22	7/30	.030	0.7620	700.00	.3542	2.19	15.57	16.72
22	19/34	.032	0.8128	754.11	.3819	2.32	14.77	15.85
22	26/36	.029	0.7366	650.00	.3302	1.97	17.44	18.72
20	7/28	.038	0.9652	1111.00	.5628	3.49	9.81	10.42
20	10/30	.036	0.9144	1000.00	.5060	3.14	11.00	11.81
20	19/32	.038	0.9652	1216.00	.6156	3.75	9.10	9.765
20	26/34	.040	1.0160	1031.94	.5226	3.21	10.90	11.70
20	41/36	.038	0.9652	1025.00	.5207	3.17	11.17	11.99
18	7/26	.046	1.1684	1769.60	.8960	5.04	6.165	6.550
18	16/30	.046	1.1684	1600.00	.8096	5.00	6.877	7.384
18	19/30	.048	1.2192	1900.00	.9614	5.90	5.791	6.218
18	41/34	.046	1.1684	1627.29	.8241	5.06	6.975	7.487
18	65/36	.048	1.2192	1625.00	.8255	5.00	7.043	7.560
16	7/24	.060	1.5240	2828.00	1.4322	8.56	3.855	4.002
16	19/29	.054	1.3716	2426.30	1.2293	7.50	4.538	4.817
16	26/30	.058	1.4732	2600.00	1.3156	8.06	4.273	4.588
16	65/34	.059	1.4986	2579.85	1.3065	8.03	4.400	4.723
16	105/36	.059	1.4986	2625.00	1.3335	8.09	4.360	4.680
14	7/22	.073	1.8542	4480.00	2.2694	12.76	2.428	2.531
14	19/27	.068	1.7272	3830.40	1.9399	12.50	2.874	3.054
14	41/30	.070	1.7780	4100.00	2.0746	12.88	2.735	2.937
14	105/34	.086	2.1844	4167.50	2.1105	13.00	2.724	2.924
12	7/20	.096	2.4384	7168.00	3.6302	21.69	1.516	1.574
12	19/25	.090	2.2860	6087.60	3.0837	19.70	1.806	1.916
12	65/30	.102	2.5908	6500.00	3.2890	20.76	1.725	1.853
12	165/34	.095	2.4130	6548.90	3.3165	19.82	1.750	1.878
10	37/26	.110	2.7940	9353.60	4.7360	29.00	1.189	1.263
10	49/27	.116	2.9464	9878.40	5.0029	29.89	1.136	1.207
10	105/30	.120	3.0480	10530.00	5.3130	33.10	1.068	1.147
8	49/25	.147	3.7338	15699.60	7.9527	47.53	.714	.757
8	133/29	.166	4.2164	16984.10	8.6051	52.87	.661	.701
8	655/36	.147	3.7338	16625.00	8.3185	51.30	.706	.757
6	133/27	.206	5.2324	26812.80	13.5793	81.14	.418	.445
6	266/30	.210	5.3340	25900.00	13.4596	86.01	.426	.457
6	1050/36	.184	4.6736	26250.00	13.3350	79.47	.440	.472
4	7x19/25	.257	6.5278	42613.00	21.5859	133.00	.263	.279
4	259/27	.232	5.8928	52214.40	26.4439	158.02	.217	.231
4	1666/36	.232	5.8928	41650.00	21.1582	126.10	.277	.298
2	133/23	.292	7.4168	67936.40	34.4071	205.62	.164	.171
2	259/26	.292	7.4168	65475.20	33.1520	198.14	.173	.184
2	665/30	.235	5.9690	66500.00	33.1430	201.16	.170	.183
2	2646/36	.292	7.4168	66150.00	33.6042	200.28	.175	.187
1	19/.0664	.328	8.3312	82983.60	42.4700	251.20	.134	.137
1	19x44/30	.377	9.5758	81700.00	43.3016	267.79	.135	.171
1	2109/34	.328	8.3312	83706.20	42.3909	253.29	.137	.147
1/0	133/21	.368	9.3472	108035.90	54.7162	327.05	.104	.108
1/0	259/24	.368	9.3472	104636.00	52.9914	316.76	.108	.112
2/0	133/20	.414	10.5156	136192.00	68.9738	412.17	.0821	.0853
2/0	259/23	.414	10.5156	132297.20	67.0033	400.41	.0855	.0888
2/0	1330/30	.406	10.3124	133300.00	67.2980	430.00	.0851	.0914
3/0	259/22	.464	11.7856	163195.00	83.9678	501.70	.0682	.0711
3/0	427/24	.464	11.7856	172508.00	87.3642	522.20	.0657	.0682
4/0	259/21	.597	15.1638	210385.70	106.5526	638.88	.0537	.0558
4/0	427/23	.598	15.1892	218111.60	110.4649	660.01	.0519	.0539
4/0	2107/30	.608	15.4432	211468.00	106.6142	653.00	.0537	.0577

igus® Energy Chain Systems®

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European Cable Stranding

According to VDE 0295 and IEC 60228

Cross Section mm²	DIN VDE 0295 class 5/IEC 60228 No. of Wires	DIN VDE 0295 class 5/IEC 60228 Max. wire-ø mm/mil	DIN VDE 0295 class 6/IEC 60228 No. of Wires	DIN VDE 0295 class 6/IEC 60228 Max. wire-ø mm/mil	According to DIN VDE 0812 No. of Wires	According to DIN VDE 0812 Max. wire-ø mm/mil
0.14					18	x 0.10/3.94
0.25					14	x 0.15/5.91
0.34					7	x 0.25/9.84
0.50	15/17	x 0.21/8.27	28/31	x 0.16/6.30	15/17	x 0.20/7.87
0.75	23	x 0.21/8.27	42	x 0.16/6.30	23	x 0.20/7.87
1.00	30	x 0.21/8.27	56	x 0.16/6.30	30	x 0.20/7.87
1.50	27-29	x 0.26/10.24	84	x 0.16/6.30	27-29	x 0.25/9.84
2.50	46	x 0.26/10.24	140	x 0.16/6.30	46	x 0.25/9.84
4.00	52	x 0.31/12.20	224	x 0.16/6.30		
6.00	78	x 0.31/12.20	192	x 0.21/8.27		
10.00	77	x 0.41/16.14	320	x 0.21/8.27		
16.00	119	x 0.41/16.14	512	x 0.21/8.27		
25.00	196	x 0.41/16.14	512	x 0.21/8.27		
35.00	280	x 0.41/16.14	798	x 0.21/8.27		
50.00	400	x 0.41/16.14	1102	x 0.21/8.27		
70.00	554	x 0.41/16.14	703	x 0.31/12.20		
95.00	484	x 0.51/20.08				
120.00	589	x 0.51/20.08				
150.00	740	x 0.51/20.08				
185.00	902	x 0.51/20.08				
240.00	1220	x 0.51/20.08				
300.00	1525	x 0.51/20.08				

Comparison
European/American Cable Stranding

mm²	AWG/MCM	mm²	AWG/MCM	mm²	AWG/MCM	mm²	AWG/MCM	mm²	AWG/MCM	mm²	AWG/MCM
0.08	= 28	0.50	= 20	2.50	= 14	16.00	= 6	70.00	= 2/0	185.00	= 350
0.14	= 26	0.75	= 18	4.00	= 12	25.00	= 4	95.00	= 3/0	240.00	= 450
0.25	= 24	1.00	= 17	6.00	= 10	35.00	= 2	120.00	= 4/0	300.00	= 550
0.34	= 22	1.50	= 16	10.00	= 8	50.00	= 1	150.00	= 300		

Load-Carrying Capacity of Chainflex® Cables

The values from Table 1 have been taken from DIN VDE 0298, Part 4. The values are simplified and are only approximates. In borderline cases, the DIN VDE specifications must be strictly followed. Selection of the cross-section only takes place with regard to the load in undistrubed operation, i.e. when used correctly with permissible operating temperature in the line.

We recommend that each user obtain and comply with a copy of the regulations valid for the individual area of application (e.g. measures for protection in the case of indirect contact in accordance with DIN VDE 0100, Part 410, overcurrent protective devices in accordance with DIN VDE 0100, Part 430 or power failure in accordance with DIN VDE 0100, Part 520), as it is not possible to print all regulations and overviews in this catalog. as a result of the standardization which has taken place, different load capacity values may be permissible for the same line under certain circumstances. The load during undisturbed operation is crucial when selecting relevant cross-sections (or AWG) - for example, use at permitted operating temperature in respect to the maximum permitted temperature on the conductor. The load-carrying capacity according to Table 1on this page refers to the conductors carrying the operating current. This is usually 2 loaded lines for 2 or 3 wire lines and 3 loaded lines for 4 or 5 wire lines. For multi-wire lines in electrical wiring conduits or Energy Chains®, this must be observed during the design process.

The ambient temperature is the temperature of the atmospheric air = 86°F (30° C) if the line in question is not loaded. If the air temperature is increased by leakage of heat from the lines, the conversion factors listed in Table 2 on this page should be applied. For example, heat radiation from the sun must be taken into consideration.

The possible methods of laying cables in Energy Chains® lead to such a broad range of load profiles that no universal conversion factors can be given if multiple cables or conductors are involved. Table 3 lists conversion factors for multi-conductor cables, depending on the individual application.

Table 1:
Cables for stationary use and use in Energy Chains®/Tubes

Insulating Material		PVC	TPE
Number of Conductors Installation		2 or 3	2 or 3
Cross-Section mm² mm	AWG	Amperes	Amperes
0.5	20	7	–
0.75	18	12	14
1	17	15	17
1.5	16	18	21
2.5	14	26	30
4	12	34	41
6	10	44	53
10	8	61	74
16	6	82	99
25	4	108	131
35	2	135	162
50	1	168	202
70	2/0	207	250
95	3/0	250	301
120	4/0	292	352
150	300		404
185	350		461

Table 2:
Conversion factors for change in ambient temperature

	Conversion Factor	
°C	PVC	TPE
10	1.22	1.18
15	1.17	1.14
20	1.12	1.10
25	1.06	1.05
30	1.00	1.00
35	0.94	0.95
40	0.87	0.89
45	0.79	0.84
50	0.71	0.77
55	0.61	0.71
60	0.50	0.63
65	–	0.55
70	–	0.45

Table 3:
Conversion factors for multi-conductor cables with cable cross-sections up to 16 mm²

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

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Chainflex® Cables: Electrical Characteristics

The tables below show the electrotechnical data and measured values of the tested cables. The values are intended as guideline values only.

Cable Type / Characteristics	Conductor AWG Size															
CF130	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft				7.9	5.9	4.1	2.4									
Capacitance pF/ft - (cond. to cond.)				36.6	38.1	38.1	38.1									
Inductance µH/ft- (cond. to cond.)				0.204	0.204	0.204	0.204									
Characteristic impedance at 800Hz in Ω				275.0	225.0	200.0	150.0									
Capacitance pF/ft - (1 cond. to all others)				54.9	57.9	57.9	57.9									
CF140	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft				7.9	5.9	4.1										
Capacitance pF/ft - (cond. to cond.)				36.6	38.1	38.1										
Inductance µH/ft- (cond. to cond.)				0.204	0.204	0.204										
Characteristic impedance at 800Hz in Ω				275.0	225.0	200.0										
Capacitance pF/ft - (1 cond. to all others)				54.9	57.9	57.9										
CF130US	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft				7.9	5.9	4.1	2.4	1.8	1.0							
Capacitance pF/ft - (cond. to cond.)																
Inductance µH/ft- (cond. to cond.)																
Characteristic impedance at 800Hz in Ω																
Capacitance pF/ft - (1 cond. to all others)																
CF140US	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft				7.9	5.9	4.1	2.4	1.8	1.0							
Capacitance pF/ft - (cond. to cond.)																
Inductance µH/ft- (cond. to cond.)																
Characteristic impedance at 800Hz in Ω																
Capacitance pF/ft - (1 cond. to all others)																
CF170	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft				7.9	5.9	4.1	2.4									
Capacitance pF/ft - (cond. to cond.)				36.6	38.1	38.1	38.1									
Inductance µH/ft- (cond. to cond.)				0.204	0.204	0.204	0.204									
Characteristic impedance at 800Hz in Ω				275.0	225.0	200.0	150.0									
Capacitance pF/ft - (1 cond. to all others)				54.9	57.9	57.9	57.9									
CF5	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft			11.9	7.9	5.9	4.1	2.4									
Capacitance pF/ft - (cond. to cond.)			30.5	36.6	38.1	38.1	38.1									
Inductance µH/ft- (cond. to cond.)			0.204	0.204	0.204	0.204	0.204									
Characteristic impedance at 800Hz in Ω			375.0	275.0	225.0	200.0	150.0									
Capacitance pF/ft - (1 cond. to all others)			51.8	54.9	57.9	57.9	57.9									
CF6	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft		24.4	11.9	7.9	5.9	4.1										
Capacitance pF/ft - (cond. to cond.)		30.5	35.1	36.6	39.6	45.7										
Inductance µH/ft- (cond. to cond.)		0.204	0.204	0.204	0.204	0.204										
Characteristic impedance at 800Hz in Ω		550.0	350.0	275.0	225.0	175.0										
Capacitance pF/ft - (1 cond. to all others)		50.3	57.9	61.0	67.1	76.2										
CF7/7-D	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft			11.9	7.9	5.9	4.1	2.4									
Capacitance pF/ft - (cond. to cond.)			30.5	36.6	38.1	38.1	38.1									
Inductance µH/ft- (cond. to cond.)			0.204	0.204	0.204	0.204	0.204									
Characteristic impedance at 800Hz in Ω			350.0	275.0	225.0	200.0	150.0									
Capacitance pF/ft - (1 cond. to all others)			57.9	54.9	57.9	57.9	76.2									
CF8	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft			11.9	7.9	5.9	4.1										
Capacitance pF/ft - (cond. to cond.)			35.1	36.6	39.6	45.7										
Inductance µH/ft- (cond. to cond.)			0.204	0.204	0.204	0.204										
Characteristic impedance at 800Hz in Ω			350.0	275.0	225.0	175.0										
Capacitance pF/ft - (1 cond. to all others)			57.9	61.0	67.1	76.2										

Chainflex® Cables: Electrotechnical Data

Cable Type / Characteristics	Conductor AWG Size															
CF2	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft	42.7	24.4	11.9	7.9	5.9	4.1										
Capacitance pF/ft - (cond. to cond.)	27.4	24.4	33.5	36.6	39.6	45.7										
Inductance µH/ft- (cond. to cond.)	0.204	0.204	0.204	0.204	0.204	0.204										
Characteristic impedance at 800Hz in Ω	750.0	550.0	350.0	275.0	225.0	175.0										
Capacitance pF/ft - (1 cond. to all others)	44.2	50.3	56.4	59.4	64.0	76.2										
CF9	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft				7.9	5.9	4.1	2.4									
Capacitance pF/ft - (cond. to cond.)				30.5	33.5	33.5	36.6									
Inductance µH/ft- (cond. to cond.)				0.189	0.189	0.189	0.189									
Characteristic impedance at 800Hz in Ω				300.0	250.0	200.0	150.0									
Capacitance pF/ft - (1 cond. to all others)				51.8	51.8	51.8	57.9									
CF10	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft	42.7	24.4														
Capacitance pF/ft - (cond. to cond.)	27.4	30.5														
Inductance µH/ft- (cond. to cond.)	0.192	0.192														
Characteristic impedance at 800Hz in Ω	750.0	525.0														
Capacitance pF/ft - (1 cond. to all others)	42.7	48.8														
CF240	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft		24.4														
Capacitance pF/ft - (cond. to cond.)		36.6														
Inductance µH/ft- (cond. to cond.)		0.189														
Characteristic impedance at 800Hz in Ω		490.0														
Capacitance pF/ft - (1 cond. to all others)		58.5														
CF211	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft		24.4	12.0													
Capacitance pF/ft - (cond. to cond.)		33.5	43.6													
Inductance µH/ft- (cond. to cond.)		0.183	0.162													
Characteristic impedance at 800Hz in Ω		530.0	330.0													
Capacitance pF/ft - (1 cond. to all others)			19.8													
CF11/11-D	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft		24.4		7.9												
Capacitance pF/ft - (cond. to cond.)		39.6		36.6												
Inductance µH/ft- (cond. to cond.)		0.190		0.204												
Characteristic impedance at 800Hz in Ω		480.0		275.0												
Characteristic impedance at 100 Mhz in Ω		70.0		75.0												
CF11-LC	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft			11.9													
Capacitance pF/ft - (cond. to cond.)			10.7													
Inductance µH/ft- (cond. to cond.)			0.207													
Characteristic impedance at 800Hz in Ω			650.0													
Characteristic impedance at 100 Mhz in Ω			120.0													
CF12	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft		24.4	11.9													
Capacitance pF/ft - (cond. to cond.)		54.9	61.0													
Inductance µH/ft- (cond. to cond.)		0.189	0.158													
Characteristic impedance at 800Hz in Ω		420.0	280.0													
Characteristic impedance at 100 Mhz in Ω		60.0	50.0													
CF14 CAT 5	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft		27.1														
Capacitance pF/ft - (cond. to cond.)		16.5														
Inductance µH/ft- (cond. to cond.)		0.189														
Characteristic impedance at 100 Mhz in Ω		108.0														

Chainflex® Cables: Electrotechnical Data

Cable Type / Characteristics	Conductor AWG Size															
CF21 Power Conductor	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft						4.1	2.7	1.5	1.0	0.70	0.52	0.30				
Capacitance pF/ft - (cond. to cond.)							51.8		51.8	45.7						
Inductance µH/ft- (cond. to cond.)							0.213		0.213	0.213						
Characteristic impedance at 800Hz in Ω							130.0		90.0	80.0						
Capacitance pF/ft - (1 cond. to all others)							134.1		88.4	79.2						
CF21 Signal Pair	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft					5.9	4.1										
Capacitance pF/ft - (cond. to cond.)						76.2										
Inductance µH/ft- (cond. to cond.)						0.168										
Characteristic impedance at 800Hz						135.0										
Capacitance pF/ft - (1 cond. to all others)						134.1										
CF27 Power Conductor	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft						4.1	2.7	1.5	1.0	0.70	0.52	0.30	0.17			
Capacitance pF/ft - (cond. to cond.)																
Inductance µH/ft- (cond. to cond.)						0.256										
Characteristic impedance at 800Hz in Ω						190.0										
Capacitance pF/ft - (1 cond. to all others)						97.5										
CF27 Signal Pair	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft					5.9	4.1										
Capacitance pF/ft - (cond. to cond.)																
Inductance µH/ft- (cond. to cond.)					0.232											
Characteristic impedance at 800Hz in Ω					196.0											
Capacitance pF/ft - (1 cond. to all others)					107.3											
CF30	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft						4.1	2.7	1.5	1.0	0.72	0.52	0.30	0.174	0.143		
Capacitance pF/ft - (cond. to cond.)								30.5	29.0	32.0	24.4	24.4	47.2			
Inductance µH/ft- (cond. to cond.)								0.213	0.213	0.213	0.213	0.213	0.213			
Characteristic impedance at 800Hz in Ω								140.0	120.0	100.0	100.0	100.0	70.0			
Capacitance pF/ft - (1 cond. to all others)								45.7	45.7	48.8	36.6	36.6	79.2			
CF31	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft						4.1	2.7	1.5	1.0	0.72	0.52	0.30	0.174	0.143	0.088	
Capacitance pF/ft - (cond. to cond.)								51.8	51.8	42.7	51.8	48.8	47.2			
Inductance µH/ft- (cond. to cond.)								0.213	0.213	0.213	0.213	0.213	0.213			
Characteristic impedance at 800Hz in Ω								110.0	90.0	80.0	70.0	70.0	70.0			
Capacitance pF/ft - (1 cond. to all others)								82.3	85.3	73.2	85.3	82.3	79.2			
CF34	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft						4.1	2.7	1.5	1.0	0.7	0.52	0.30		0.148	0.088	0.063
Capacitance pF/ft - (cond. to cond.)																
Inductance µH/ft- (cond. to cond.)																
Characteristic impedance at 800Hz in Ω																
Capacitance pF/ft - (1 cond. to all others)																
CF35	26	24	20	18	17	16	14	12	10	8	6	4	2	1	2/0	3/0
Resistance Ohms/Mft						4.1	2.7	1.5	1.0	0.7	0.52					
Capacitance pF/ft - (cond. to cond.)																
Inductance µH/ft- (cond. to cond.)																
Characteristic impedance at 800Hz in Ω																
Capacitance pF/ft - (1 cond. to all others)																

CF300	8	6	4	2	1	2/0	3/0	4/0	300MCM	350MCM
Resistance Ohms/Mft	0.582	0.369	0.238	0.169	0.118	0.083	0.063	0.049	0.039	0.032
CF310	8	6	4	2	1	2/0	3/0	4/0	300MCM	350MCM
Resistance Ohms/Mft	0.582	0.369	0.238	0.169	0.118	0.083	0.063	0.049	0.039	0.032

Chainflex® Cables: Electromagnetic Compatibility

The “Electromagnetic Compatability” of Chainflex® Cables

The subject of "electromagnetic compatibility (EMC)" is increasing in importance. This is due in part, to the increase in electro-magnetic interference fields, both in the environment created by modern telecommunications and the power systems used by local governments.

However, data transmission requirements are becoming more stringent. The signals are increasingly susceptible to interference and ambient electromagnetic interference is diversifying.

The coupling between cables which, as is frequently the case with Energy Chains®, are routed parallel over a certain distance may be specific problematic.

A power cable exposed to interference acts as the generator of an electromagnetic interference field which, in turn, acts on another cable (normally a signal cable) and causes conducted interference

We therefore introduced glass and polymer fiber optic cables a few years ago, which are capable of withstanding the mechanical stresses of use in Energy Chains®.

Chainflex cables using conventional copper conductors were tested for their electromagnetic compatibility in an extensive, application-oriented testing program.

For example, an asynchronous motor was connected via an unshielded power cable (Chainflex® CF30) to a frequency converter. This frequency converter with pulse width modulation generates new spectral components not present to date either in the primary power system or in the secondary power system.

Chainflex® cables for digital signal transmission in an Energy Chain® were guided parallel to this power cable. The **Chainflex® CF 12 cable (the no interference cables)**, designed taking EMC aspects into account, is particularly efficient. This cable features twisted pair conductors with individual copper shielding, along with an overall ferrous shield. This ensures effective interference suppression over a wide frequency range.

Both capacitive and inductive coupling were tested. Under the test conditions selected, we were able to determine that, even if power and signal cables contact each other over a long distance, it is possible to achieve errorless data transmission if a shielded Chainflex® cable is used and this shield is grounded at both ends.

Tests were also carried out in accordance with applicable EMC compatibility standards. These standards are the basis for determining the operational performance of electrical equipment repeatedly exposed to electrical interference. These standards were not introduced solely for cables. Specifically, tests were carried out using a "burst generator," where rapid, transient interference is generated in pulse runs, mainly simulating switching operations. Such transient phenomena are produced, for example, by interrupting inductive loads or with relay contact bounce. As with other tests, shielded Chainflex® cables proved to be highly efficient.

Color Code Information

DIN47100 Numbering/Color Code System

(without repetition of the color after the 44th conductor, unlike DIN)*

The first color indicates the basic color of the conductor insulation and the second color indicates the color of the printed rings. If three colors are specified, the second and third colors are printed in the basic color.

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

* Exception: 4-conductor cables are stranded in the color sequence white, yellow, brown, green.

Color Code Table for CF211 Position Feedback Cables

New Part No.	Old Part No.	Number of Conductors and Nominal Cross Section (mm²)	Single Conductor	Color of Conductor
CF211-001	CF211-01-03-02-04-05-02	(3 x (2 x 0.14) C+	(3 x (2 x 0.14) C	yellow/green, black/brown, red/orange
		(4 x 0.14) + (2 x 0.5)) C	4 x 0.14	gray, blue, white-yellow, white-black
			2 x 0.5	brown-red, brown-blue
CF211-002	CF211-01-03-02-05-02	(3 x (2 x 0.14) C+	3 x (2 x 0.14) C	green/yellow, black/brown, red/orange
		(2 x 0.5C)) C	2 x 0.5 C	black, red
CF211-006	CF211-01-10-02-04-05-02	(3 x (2 x 0.14) C+	3 x (2 x 0.14) C	green/yellow, black/brown, red/orange
		(2 x 0.5 + 2 x 0.14)+	4 x 0.14	gray, blue, white-yellow, white-black,
		(4 x 0.23 + 2 x 0.14)) C	4 x 0.23	brown-yellow, brown-gray, green-black, green-red
			2 x 0.5	brown-red, brown-blue
CF211-010	CF211-02-04-02-10-02	(4 x (2 x 0.25) + 2 x 1.0) C	4 x (2 x 0.35)	brown/green, blue/violet, gray/pink, red/black
			2 x 1.0	white, brown
CF211-011	CF211-03-04-02-05-04	(4 x (2 x 0.34) + 4 x 0.5) C	4 x (2 x 0.34)	black/brown, red/orange, yellow/green, blue/violet
			4 x 0.5	blue-white, black-red, red-white, yellow-white
CF211-014	CF211-02-04-02-C-05-02	(4 x (2 x 0.25) C +	4 x (2 x 0.25) C	white/brown, yellow/green, gray/pink, blue/red
		1 x 2 x 0.5) C	2 x 0.5	black (Numeral printing 1-2)
CF211-016	CF211-02-C-03-02	(3 x (2 x 0.25) C) C	3 x (2 x 0.25) C	white/brown, yellow/green, gray/pink
CF211-017	CF211-01-04-02-10-04-01-04	(4 x (2 x 0.14) +	(4 x 0.14) C	blue-black, red-black, yellow-black, green-black
		4 x 1.0 + (4 x 0.14) C) C	4 x (2 x 0.14)	red/black, green/brown, yellow/violet, pink/gray
			4 x 1.0	white-green, brown-green, blue, white
CF211-018	CF211-02-02-02-05-02	(2 x (2 x 0.25) + 2 x 0.5) C	2 x (2 x 0.25)	red/black, gray/pink
			2 x 0.5	white, brown
CF211-019	CF211-02-02-03-02-03-10-02-D	(3 x 0.25) +	3 x (2 x 0.25) C	brown/green, pink/gray, red/black
		3 x (2 x 0.25) C + 2 x 1.0) C	3 x 0.25	blue, yellow, violet
			2 x 1.0	white, brown

Color Code Table for CF11-D

New Part No.	Old Part No.	Number of Conductors and Nominal Cross Section (mm²)	Single Conductor	Color of Conductor
CF11-001-D	CF11-01-03-02-04-05-02-D	(3 x (2 x 0.14) C+	(3 x (2 x 0.14) C	yellow/green, black/brown, red/orange
		(4 x 0.14) + (2 x 0.5)) C	4 x 0.14	gray, blue, white-yellow, white-black
			2 x 0.5	brown-red, brown-blue
CF11-002-D	CF11-01-03-02-05-02-D	(3 x (2 x 0.14) C+	3 x (2 x 0.14) C	green/yellow, black/brown, red/orange
		(2 x 0.5C)) C	2 x 0.5 C	black, red
CF11-003-D	CF11-01-10-02-04-05-02-D	(3 x (2 x 0.14) + 2 x 1.0) C	3 x (2 x 0.14)	white/brown, yellow/green, gray/pink
			2 x 1.0	blue, red
CF11-004-D	CF11-01-04-02-01-04-05-04-D	(4 x (2 x 0.14) +	4 x (2 x 0.14)	brown/green, violet/yellow, gray/pink, rred/black
		(4 x 0.14) C + 4 x 0.5) C	(4 x 0.14) C	yellow-black, red-black, green-black, blue-black
			4 x 0.5	brown-green, white-green, blue, white
CF11-005-D	CF11-01-04-02-05-04-D	(4 x (2 x 0.14) + 4 x 0.5) C	4 x (2 x 0.14)	white/brown, yellow/green, gray/pink, blue/red
			4 x 0.5	black, violet, gray-pink, red-blue
CF11-006-D	CF11-01-10-02-04-05-02-D	(3 x (2 x 0.14) C +	3 x (2 x 0.14) C	green/yellow, black/brown, red/orange
		(2 x 0.5 + 2 x 0.14) +	4 x 0.14	gray, blue, white-yellow, white-black
		(4 x 0.23 + 2 x 0.14)) C	4 x 0.23	brown-yellow, brown-gray, green-black, green-red
			2 x 0.5	brown-red, brown-blue
CF11-007-D	CF11-03-02-02-D	(2 x (2 x 0.34)) C	4 x 0.34	white, brown, green, yellow
CF11-008-D	CF11-02-03-02-D	(3 x (2 x 0.25)) C	3 x (2 x 0.25)	white/brown, yellow/green, gray/pink
CF11-009-D	CF11-02-04-02-05-02-D	(4 x (2 x 0.25) + 2 x 0.5) C	4 x (2 x 0.25)	brown/green, blue/violet, gray/pink, red/black
			2 x 0.5	white, brown
CF11-010-D	CF11-02-04-02-10-02-D	(4 x (2 x 0.25) + 2 x 1.0) C	4 x (2 x 0.25)	brown/green, blue/violet, gray/pink, red/black
		3 x (2 x 0.25) C + 2 x 1.0) C	2 x 1.0	white, brown
CF11-011-D	CF11-03-04-02-05-04-D	(4 x (2 x 0.34) + 4 x 0.5) C	4 x (2 x 0.34)	black/brown, red/orange, yellow/green, blue/violet
			4 x 0.5	blue-white, black-red, red-white, yellow-white
CF11-012-D	CF11-01-06-03-04-02-05-02-D	(3 x (2 x 0.14) C	3 x (2 x 0.14) C	green/yellow, white/gray, blue/red
		(2 x 0.5 + 6 x 0.14) +	(3 x 0.14) C	red, green, brown
		(1 x (3 x 0.14) C) C	6 x 0.14	blue, gray, gray, yellow, pink, violet
			2 x 0.5	brown-red, brown-blue
CF11-013-D	CF11-01-03-02-C-05-02-D	(3 x (2 x 0.14) C + 2 x 0.5) C	3 x (2 x 0.14) C	white/brown, yellow/green, gray/pink
			2 x 0.5	red, blue
CF11-015-D		(4 x (2 x 0.14) + 4 x 0.5) C	4 x (2 x 0.14)	brown/green, violet/yellow, gray/pink, red/black
			4 x 0.5	blue, white, brown-green, white-green
CF11-017-D	CF11-01-04-02-10-04-01-04-D	(4 x (2 x 0.14) +	(4 x 0.14) C	blue-black, red-black, yellow-black, green-black
		4 x 1.0 + (4 x 0.14) C) C	4 x (2 x 0.14)	red/black, green/brown, yellow/violet, pink/gray
			4 x 1.0	white-green, brown-green, blue, white
CF11-018-D	CF11-02-02-02-05-02-D	(2 x (2 x 0.25) + 2 x 0.5) C	2 x (2 x 0.25)	red/black, gray/pink
			2 x 0.5	white, brown
CF11-019-D	CF11-02-02-03-02-03-10-02-D	(3 x 0.25) +	3 x (2 x 0.25) C	brown/green, pink/gray, red/black
		3 x (2 x 0.25) C + 2 x 1.0) C	3 x 0.25	blue, yellow, violet
			2 x 1.0	white, brown
CF11-021-D		(6 x 0.5 + 5 x 2 x 0.25) C	(3 x 0.5)	black (numeral printing 1-3)
			(3 x 0.5)	red (numeral printing 1-3)
			(5 x 2 x 0.25)	yellow/white, gray/white, black/orange, white/brown, black/gray
CF11-022-D		(5 x 0.5 + 1 x 2 x 0.25) C	(5 x 0.5)	blue, green, yellow, gray, pink
			(2 x 0.25)	white, brown
CF11-025-D		(3 x (2 x 0.14) C	3 x (2 x 0.14)	green/yellow, blue/red, gray/pink
			(2 x 0.5)	white, brown

Color Code Table for CFBUS Cables

New Part No.	Characteristic Wave Impedance in Ω approx.	Number of Conductors and Nominal Cross Section (mm^2)	Color of Conductor
PROFIBUS			
CFBUS-001	150	(2 x 0.5)) C	red, green
CFBUS-002	150	4 x 1.5+	black with white numbers
		(2 x 0.25) C	red, green
CFBUS-003	150	3 x 0.75+	black, blue, green-yellow
		(2 x 0.25) C	red, green
INTERBUS			
CFBUS-010	100	(3 x 2 x 0.25) C	white, brown, green, yellow, gray, pink
CFBUS-011	100	(3 x 1.0 +	red, blue, green-yellow
		3 x 2 x 0.25) C	white, brown, green, yellow, gray, pink
FIELD BUS (CAN)			
CFBUS-020	120	(2 x 2 x 0.25) C	white, brown, green, yellow (star-quad stranding)
CFBUS-021	120	(1 x 2 x 0.5) C	white/brown
CFBUS-022	120	(2 x 2 x 0.5) C	white, brown, green, yellow (star-quad stranding)
DEVICENET			
CFBUS-030	120	(1 x 2 x AWG 24) +	white, blue
		(1 x 2 x AWG 22) C	red, black
CFBUS-031	120	(1 x 2 x AWG 18) +	white, blue
		(1 x 2 x AWG 15) C	red, black
ETHERNET/CAT5			
CFBUS-040	100	(2 x 2 x 0.25) C	white, green, brown, yellow (star-quad stranding)
CFBUS-041	100	(4 x 2 x 0.25) C	white, brown, green, yellow, gray, pink, blue, red
CFBUS-042	100	(5 x 2 x 0.25) C	white, brown, green, yellow, gray, pink, blue, red, black, violet
CFBUS-044	100	(4 x 2 x 0.15) C	white, brown, green, yellow, gray, pink, blue, red
ETHERNET/CAT5			
CFBUS-050	100	(4 x (2 x 0.14) C) C	white, blue, white, orange, white, green, white, brown

Chainflex® Cables: Chemical Resistance

Cable Type	CF130, CF140	CF5, CF6, CF21, CF30, CF31, CF240 CF211, CF130US, CF140US	CF2, CF7, CF8, CF27 CF170, CF14US	CF9, CF10, CF11, CF12, CF14 CFBUS, CF98, CF34, CF35, CFPE CFKoax1, CF300, CF310
Inorganic chemicals				
Aqueous solutions, neutral				
Water	+	+	+	+
Sodium chloride (10%)	+	+	+	+
Glauber salt (10%)	+	+	+	+
Aqueous solutions, alkaline				
Soda (10%)	O	+	O	+
Aqueous solution, acidic				
Sodium bisulfate(10%)	O	+	O	+
Aqueous solutions, oxidizing				
Hydrogen peroxide (10%)	+	+	+	+
Potassium permanganate (2%)	+	+	+	+
Inorganic acids				
Concentrated hydrochloric acid	–	–	–	–
Hydrochloric acid (10%)	O	O	O	+
Concentrated sulfuric acid	–	–	–	–
Sulfuric acid (10%)	O	O	O	+
Concentrated nitric acid	–	–	–	–
Nitric acid (10%)	O	O	O	+
Inorganic bases				
Concentrated sodium hydroxide solution	–	–	–	O
Sodium hydroxide solution (10%)	O	O	O	+
Concentrated potassium hydroxide solution	–	–	–	O
Potassium hydroxide solution (10%)	O	O	O	+
Concentrated ammonia	O	O	O	+
Ammonia (10%)	+	+	+	+
Organic chemicals				
Organic acids				
Concentrated acetic acid (glacial acetic acid)	–	–	–	O
Acetic acid (10% in H20)	O	+	O	+
Tartaric acid (10% in H20)	O	+	+	+
Citric acid (10% in H20)	O	+	+	+
Ketones				
Acetone	–	–	–	O
Methyl ethyl ketone (MEK)	–	–	–	O
Alcohols				
Ethanol (spirits)	–	O	O	+
Isopropanol	–	O	O	+
Diethylene glycol	O	O	+	+
Aromatic hydrocarbons				
Toluene	–	–	O	–
Xylene	–	–	O	–
Fuels				
Benzine	–	O	+	+
Diesel fuel	–	O	+	+
Synthetic oils Lubricants				
ASTM Oil #2	O	+	+	+
Hydraulic oil				
Mineral oil base	–	O	+	+
Glycol base	O	O	+	+
Synthetic ester base	–	O	+	+
Vegetable oils				
Rape-seed oil	O	+	+	+
Olive oil	O	+	+	+
Soybean oil	O	+	+	+
Cold cleaning agent				
Cold cleaning agent	–	O	+	O

+ = no/few negative effects
0 = average interaction, short-term exposure permissible
- = unstable, partial destruction of material
All information applies to room temperature