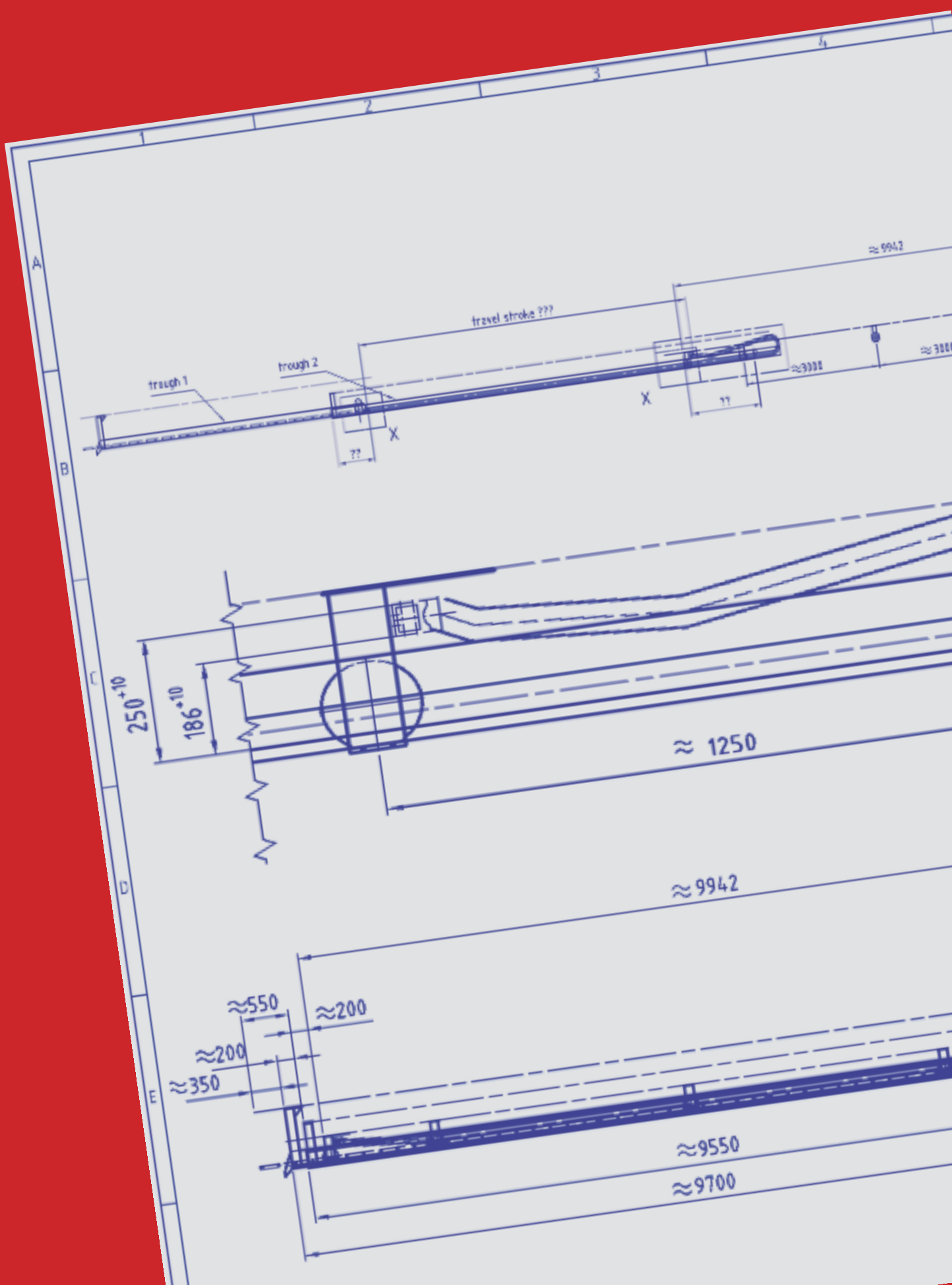
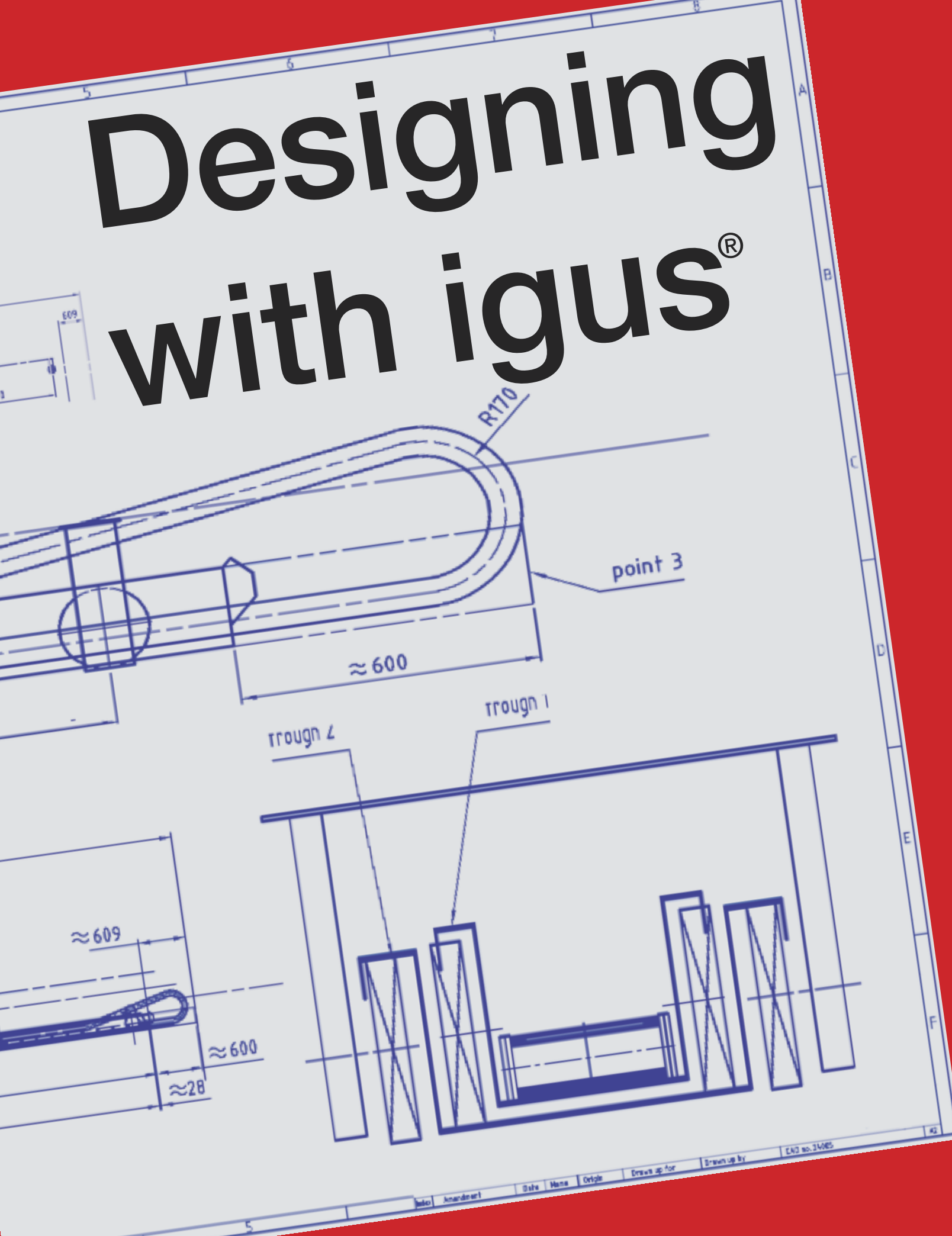

trough 1
trough 2
travel stroke ???
??
X
??
X
≈9942
250+10
186+10
≈ 1250
≈9942
≈550
≈200
≈200
≈350
≈9550
≈9700

Designing with igus®



Energy Chain System® Design
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Energy Chain System® Design
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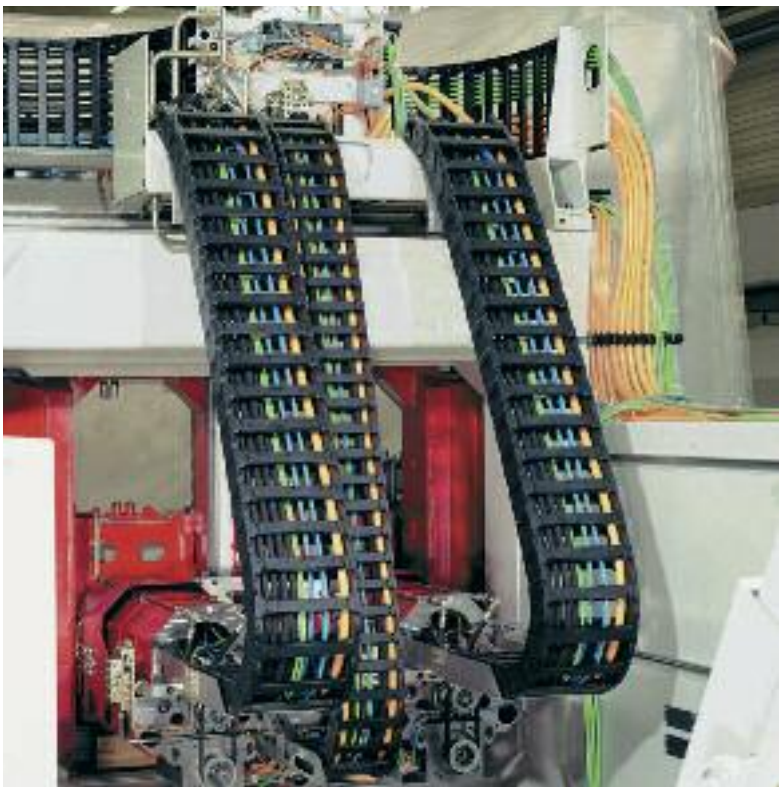
Introduction

About igus® Energy Chain Systems®



igus® Energy Chain Systems® guide and protect moving cables and hoses on automated equipment. They can be used in a wide variety of applications and possess the following capabilities:

- **Use with various types of motion and travels**
- **Guidance of sensitive bus and data cables, as well as fiber optic cables, using the same techniques as with electric, gas, air and liquid hose guidance**
- **Long service life under very high loads and demanding requirements**
- **Smooth operation in a full range of environments and climates**

On the following pages, we offer important guidelines which are to be taken into consideration when designing safe Energy Chain Systems®. All specifications are based on test results from the igus® laboratory and our field experience since 1971.
In addition, we strongly encourage you to take advantage of our free design service. Simply fill in the “igus® system design” fax sheet on page 1.5 of this catalog, log onto the igus web site at http://www.igus.com and e-mail us your technical specifications, or call us at 1-800-521-2747.

We will provide a comprehensive quote by the end of the next business day.

Laboratory tests and practical experience

Our calculations and analyses are based on the result of ongoing practical tests in our Technical Center and our experience with gliding applications. The focal points of our tests are push-pull forces, friction values and abrasion under widely varying conditions and speeds, as well as factors such as dirt, weathering or impact and bumps. We test all system components such as cables, hoses, strain relief and other accessories, in addition to the Energy Chains® or Energy Tubes and Guide Troughs.

The igus® test laboratory for Energy Chains® and Chainflex® cables

Energy Chain System® Design Application Examples

Long travels 1,447 ft. (441 m) with igus® RoI E-Chain ® long travel applications

High fill weights 40.3 lbs/ft (60 kg/m) with System E4. fill weights/load diagrams

Multi-axis Energy Chains® E-Z Triflex® on a production line, combined movements

ReadyChain® under water. System E4 and Chainflex® CF9, ReadyChain®

ReadyChain® with combined motions on tooling machines

Series E6-52 high speed 49.2 ft/s (15 m/s) low noise operation, optimized noise level

Crash test unit: 72.2 ft/s (22 m/s) speed and 2,572 ft/s² (784 m/s²) acceleration, travel speed

Complex movements with igus® Triflex®R, combined movements

Cleanroom and Triflex® R technical environment

Extension links for E2 and E4 for large conduits, cable and hoses

Zig-zag movements, 118 ft. (36 m) height with E4/4

igus® System E6 - High acceleration and ESD safety, ESD & ATEX

Energy Chain System® Design
Application Examples

Unsupported application System E4, up to 164 ft/s (50 m/s) speed

Unsupported, side-mounted
E4 Series R188

Unsupported nested application
System E4

Gliding application System E4,
up to 1641 ft (500 m) realized

Gliding, side-mounted
Series E4/4

Gliding application
System E4

Vertical, standing Series E4/light,
up to 19.69 ft (6 m) possible

Rotary movement
System E4

Energy Chains® side by side as
individual or “multiband”
Series “Zipper”

Vertical, hanging Series E4 up
to 131 ft (40 m) possible

Spiral and rotary movement
TwisterChain®

Combined movement
Series Triflex®

Energy Chain System® Design
igus Terminology and Formulas

Application-Icons


Unsupported - short travels


Gliding - long travels


Vertical hanging


Vertical standing


Side-mounted


Rotary motion


Horizontal and vertical


Nested


Side by side

Throughout this catalog you will find the following terms and formulas:

Short cut		Description	
α	=	The rotation angle of the rotating machine element	(°)
ΔM	=	Deviation of the center point	(in.)
a	=	Acceleration	(ft/s²)
AR	=	Outer radius, Energy Chain®	(in.)
Ba	=	Outer Energy Chain® width	(in.)
Bi	=	Inner Energy Chain® width	(in.)
B_{Ra}	=	Guide trough outer width	(in.)
B_{Ri}	=	Guide trough inner width	(in.)
D	=	Over length Energy Chain® radius in final position	(in.)
D_2	=	Over length for long travels gliding	(in.)
FL_B	=	Unsupported length with sag	(ft)
FL_G	=	Unsupported straight length	(ft)
FL_U	=	Unsupported lower run	(ft)
FZ_{max}	=	Maximum additional load	(lbs/ft)
H	=	Nominal clearance height	(in.)
ha	=	Outer Energy Chain® height	(in.)
H_F	=	Required clearance height	(in.)
hi	=	Inner Energy Chain® height	(in.)
H_{Ra}	=	Outer trough height	(in.)
H_{Ri}	=	Inner trough height	(in.)
IR	=	Inner radius, Energy Chain®	(in.)
K	=	Add-on for bending radius (K is taken from the data tables of the individual igus® Series)	(in.)
K_2	=	Further add-on if the mounting bracket location is set lower (for long travels)	(in.)
L_K	=	Energy Chain® length	(in.)
n	=	Number of links	(1)
n_{Mon}	=	Number of installation sets (left/right)	(1)
n_{Ri}	=	Number of trough-sets (left/right)	(1)
R	=	Bending radius	(in.)
RBR	=	"Reverse bending radius“	(in.)
S	=	Length of travel	(in.)
$S/_2$	=	Half length of travel	(in.)
T	=	Pitch	(in.)
v	=	Speed (travel)	(ft/s)
X_1	=	Inner machine-construction space (TwisterChain®)	(in.)
X_2	=	Outer radius chain, including clearance (TwisterChain®)	(in.)

Formula		Description
$2 \times FL_B$	=	Calculation of maximum travel length, unsupported with sag
$2 \times FL_G$	=	Calculation of maximum travel length, unsupported straight
$B_{RI} \geq Ba + .20\ (5mm)$	=	Calculation of the minimum guide trough width
$H_{RI} \geq 2 \times ha$	=	Calculation of the minimum guide trough height
$K = \pi \times R$	=	Add-on for bending radius
$L_K = S/_2 + \Delta M + K$	=	Calculation of chain lengths for all types of applications, fixed end is outside the center of travel, except rotary movements and most long travels
$L_K = S/_2 + K$	=	Calculation of chain lengths for all types of applications, fixed end in the center of travel, except rotary movements and most long travels
$L_K = S/_2 + K_2$	=	Calculation of chain lengths for long travel gliding applications fixed end in the center of travel

Energy Chain System® Design
Calculation of Energy Chain® Lengths
Camber

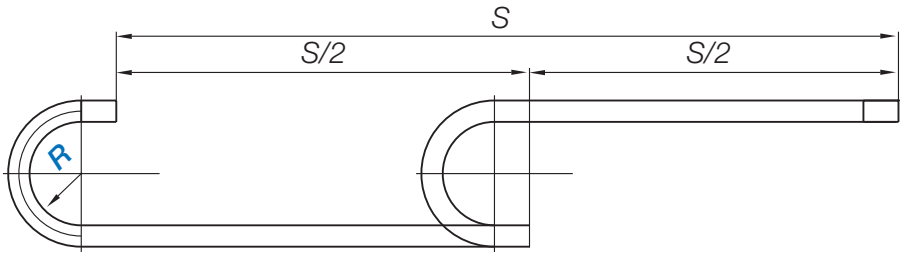
Calculation of Energy Chain® lengths

If the fixed end of the Energy Chain® is located in the center of the travel, the chain length "L_K" is calculated by using half the length of travel and adding the value "K" for the curve length. (You can obtain the value "K" from the tables in the catalog.) Placing the fixed end in the **center** of the travel is the most **cost-effective solution** because it requires the shortest Energy Chain®, cables and hoses.

The fixed end in the center of the travel is the most favorable solution

$$L_K = S/2 + K$$

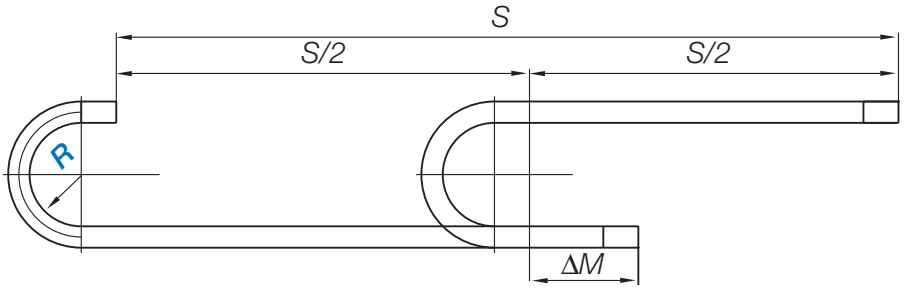
This formula is generally valid for **all types of applications** if the fixed end is in the center of the travel. Exceptions: rotary movements and most long travels.



L_K = Energy Chain® length
S = Length of travel
R = Bending radius
ΔM = Deviation from the center point
K = $\pi \bullet R$ + "safety buffer"
Add-on for bending radius (K is taken from the data tables of the individual igus® series

$$L_K = S/2 + \Delta M + K$$

This formula is valid if the fixed end is outside the center of the travel.

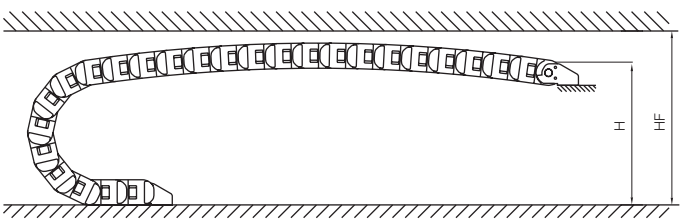


Camber

"Camber" is the curve of the upper run along its unsupported length. **All igus® Energy Chains are manufactured with camber, special "no camber" (NC) Energy Chains® are available upon request.** The camber allows for longer unsupported lengths and increases service life and operating safety. In the **Installation Dimensions** section of each respective Energy Chain® description, you will find the measurement H_F, which specifies the **necessary clearance height**, taking the camber into account. The camber allows for longer unsupported lengths and increases service life and operating safety. Upon request, we can deliver Energy Chains® without camber for restricted space applications; however, these "no camber" chains do not have the same load-bearing capacity. Please consult igus®.

H = Nominal clearance height
H_F = Required clearance height

Necessary clearance height- depends on the camber of the Energy Chain®. Find values for necessary clearance height *"H_F"* on each product page.



Principle of camber for igus® Energy Chains® H_F = required installation height

igus®

Energy Chain System® Design System Analysis Worksheet

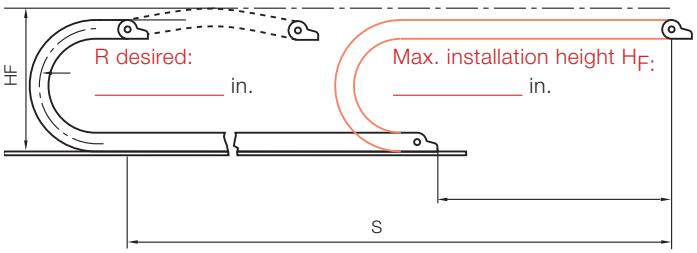
igus® Energy Chain System®
Telephone 1-800-521-2747
Fax 1-401-438-7270
Internet: http://www.igus.com
email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

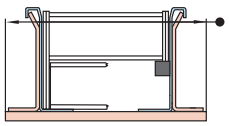
Date:	Telephone: 1-800-521-2747 Fax: 1-401-438-7270
From:	To: **igus®, inc.** P.O. Box 14349 East Providence, RI 02914

Please supply us with as much application data as possible. Items highlighted in red must be filled out for analysis. You will receive a complete analysis with cable/hose layout proposal and quote by the end of the next business day. Please contact us if you have any questions.

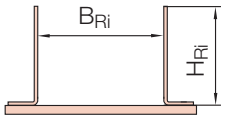
Installation space

Travel: _____ in. Fixed end: center of the travel ☐ yes or_____ inches from the center





Max. width permitted (if applicable):
_____ in.



Guide trough?
☐ yes; if yes, which:
Dimensions:
B_{Ri} _____ in.
Dimensions:
H_{Ri} _____ in.

Assembly point (floor, wall, console, etc.): _____in.

Span (Standard = 6.5 ft.):_____in.

Dynamics

Speed:_____ (f/s) Acceleration: _____ (f/s²)

Cycles/Day: _____ Days/Year: _____ Outer diameter: _____

Environment

Temperature (°F): _____ Humidity (%): _____ Dust, dirt, chips: _____

Special parameters: _____

Cables/Hoses

Number	Manufacturer/Type, No.	Conductor/AWG	Outer Dia.	Weight lbs/ft.	Bending radius

Further individual components desired:

Energy Chains® / Energy Tubes ☐
Chainflex® cables/special conduits ☐
Guide troughs ☐
Strain relief ☐
Harnessing ☐
On-site assembly ☐
Other: _____

Please copy, fill in and fax. Thank you.

Energy Chain® ☐
Energy Tube ☐
To be opened:
On both sides ☐
Along the outer radius ☐
Along the inner radius ☐
Special requests: _____
igus® System guarantee? ☐

igus® Energy Chain System®

Telephone 1-800-521-2747
Fax 1-401-438-7270

Internet: http://www.igus.com
email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

Energy Chain System® Design
Unsupported, Short Travel Applications

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Internet: http://www.igus.com
email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

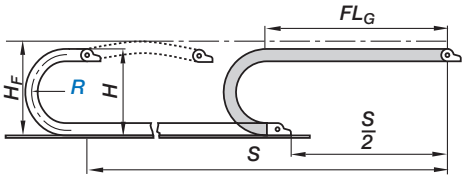
Unsupported

If the upper run of the Energy Chain® operates without touching the lower run over the entire travel, it is called an "unsupported" application.

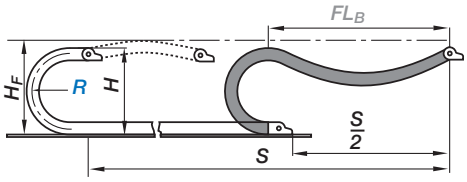
Unsupported length

The distance between the carrier and the beginning of the radius curve of the Energy Chain® is called the "unsupported length." It is always dependent upon the type of chain and the fill weight.

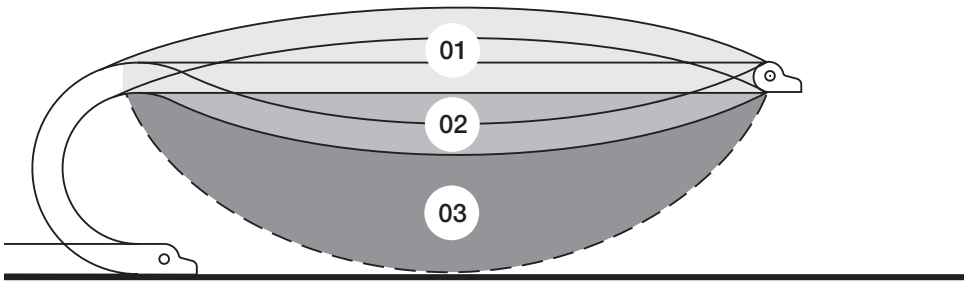
The "FL_G" type of installation always generates the longest service life and can be operated with the maximum values for speed and acceleration.



FL_G unsupported straight length



FL_B unsupported length with sag



01) Unsupported with "straight" upper run (FL_G)

The "FL_G" Energy Chain® applies when the upper run either has camber, is straight, or has a maximum of .39"-1.97" (10-50 mm) sag, depending on the size of the chain. The "FL_G" type of installation is always preferred. The Energy Chain® runs quietly and is not exposed to any additional vibration.

02) Unsupported with permitted sag (FL_B)

The "FL_B" Energy Chain® applies when the sag amounts to more than .39"-1.97" (10-50 mm), depending on the chain size, and less than a defined maximum sag. This maximum sag is dependent on the type of chain. The "FL_B" application is technically permissible in many cases. It becomes problematic if the acceleration and the travel frequency are high.

03) "Critical Sag"

If the sag is greater than permissible for "FL_B", then we refer to it as "critical sag." An installation with critical sag must be avoided or reserved for extreme circumstances. An Energy Chain® should never be installed with critical sag. There are applications which, after a very long period of use, reach the stage of "critical sag." The Energy Chain®/Tube should be replaced at that time.
Please contact us if your application reaches critical sag.

The following important factors should be considered to select the correct Energy Chain®:

- Unsupported length
- Speed
- Acceleration
- Service life
- Load bearing areas
- Noise level
- Technical environment

Example of unsupported with FL_B sag

Unsupported Length

For every igus Energy Chain®/Tube, you will find the values for "FL_G" and "FL_B" in two locations: On the following pages in this chapter as an overview and within every individual series' chapter. These values are essential for:

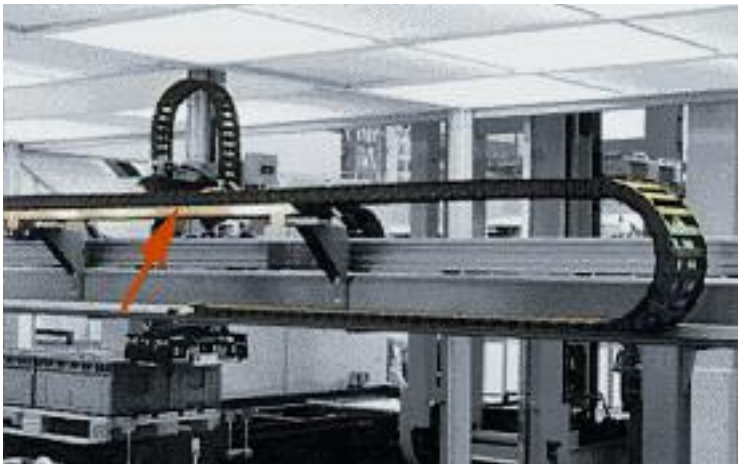
- Finding a suitable Energy Chain® for your fill weight and travel distance
- Identifying the maximum load for the selected Energy Chain®

Graphs of unsupported lengths on ➤ Pages 1.15 to 1.18

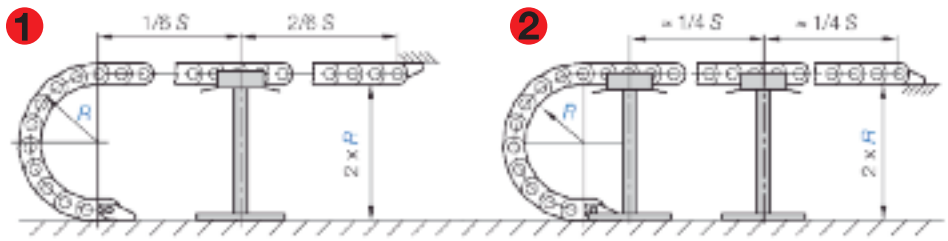
What to do if the unsupported length is insufficient:

If your application, fill weight and travel fall outside the "unsupported length" parameters of the desired Energy Chain®, you have the following options:

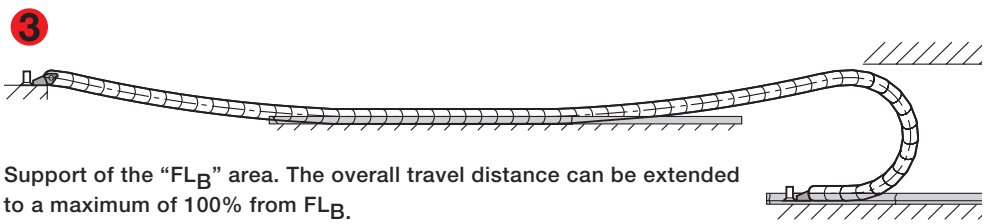
- Select a more stable igus® Energy Chain®
- Support the chain in the unsupported area (this possibility has restrictions for acceleration, speed and noise as a consequence; three fundamental examples are detailed below; please consult igus if you are considering this possibility we will gladly provide you with a detailed proposal)
- Use a "multiband" chain or "nest" two Energy Chains® inside one another
  (please consult igus regarding these options)
- Design the travel distance as a "gliding application" (see page 1.19).



Series 28 with support of the "FL_B" area



Support of the "FL_G" area. The overall "straight, unsupported travel can be increased along the upper run by a maximum of 50% of the FL_G and along the lower run by a maximum of 100%.

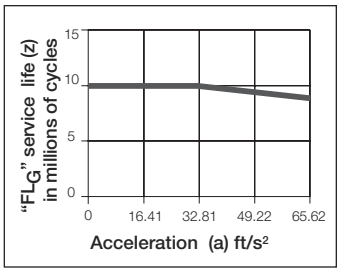


Support of the "FL_B" area. The overall travel distance can be extended to a maximum of 100% from FL_B.

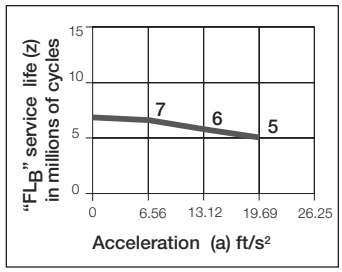
Energy Chain System® Design
Unsupported, Short Travel Applications

Max ft/s (m/s) Unsupported	FL_G	FL_B
v max ft/s (m/s)	65.6 (20)	9.84 (3)
v peak ft/s (m/s)	164 (50)	–
a max ft/s² (m/s²)	656 (200)	19.69 (6)
a peak ft/s² (m/s²)	2572 (784)	–

Standard values of maximum speed (v) and acceleration for unsupported lengths



Standard values on service life for "FL_G" dependent on acceleration



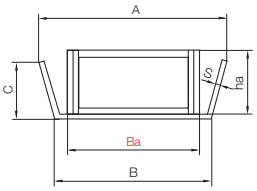
Standard values of service life for "FL_B" dependent on acceleration

Speed and acceleration, service life

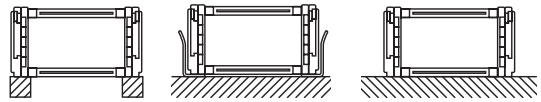
For unsupported applications, the acceleration (a), is the critical parameter. High acceleration can cause the Energy Chain® to vibrate and reduce its service life. This is a particular danger if the Energy Chain® already has a sag greater than the FL_G value. Maximum values for acceleration speed and service life are achieved only with Energy Chains® incorporating the FL_G (unsupported, straight) design. FL_G designed igus Energy Chain Systems® can sustain very high loads. To date, a peak acceleration of 2572 ft/s² (784 m/s²) has been achieved during continuous use. Through ongoing testing in the igus® laboratory and from practical experience, standard values for service life have been formulated (see graphs). Our tests confirm that these standard values apply to all igus Energy Chains® and Energy Tubes. It is crucial to determine whether the application will be designed as unsupported, straight (FL_G) or unsupported, with sag (FL_B).

Load-bearing surfaces

Unsupported Energy Chains® normally require some type of surface on which the lower portion of the chain runs. As the drawings on the right demonstrate, a wide range of configurations are available. Many material options are feasible: Metals, polymers, stone, wood, concrete, glass, etc. **We also have solutions to minimize the noise generated by the carrier's lower portion. Please consult igus®.** When selecting the running surface, be sure dirt and debris cannot collect in the Energy Chain® path.



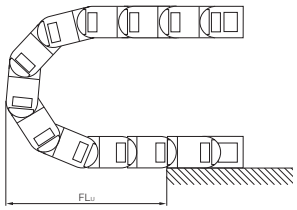
Ba = chain outer width
A = B + .39" (10)
B = ba + .20" (5)
C = ha/.08" (2)
S = .06" - .12" (1.5 - 3)



Different surfaces and guide troughs are possible

Unsupported lower run

Energy Chains® without support along the lower run have restricted use. The FL_U value must be determined in a test by igus®. The maximum permissible amount of the projection depends on the fill weight, the selected Energy Chain®, the dynamics, and other factors. The various combinations of these parameters can produce very different results. **If the lower run of the Energy Chain® cannot be supported over the whole travel, please consult igus®.**



System E4 partially unsupported - please consult igus regarding this type of configuration.

Mounting Brackets

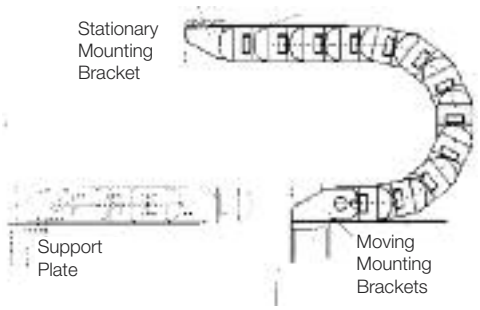
We receommend **pivoting mounting brackets** as standard for unsupported applications. Pivoting mounting brackets compensate for the camber, can be installed more easily and decrease the load on the first Energy Chain® link in operation. **Exception:** If the acceleration is greater than 65.6 ft/s² (20 m/s²) or if the height is limited to the H_F measurement, locking mounting brackets keep the Energy Chain under the H_F measurement.

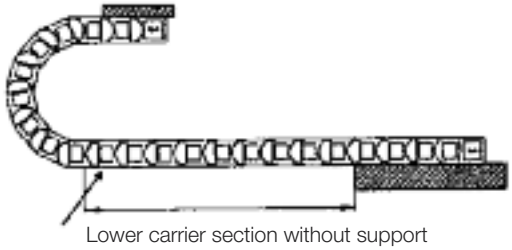
igus® Energy Chain System®
Telephone 1-800-521-2747
Fax 1-401-438-7270
Internet: http://www.igus.com
email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

Horizontal Inverted

An Energy Chain System® is said to be horizontal “inverted” when the stationary end (fixed) is positioned on the top and the moving end is positioned on the bottom. Care must be taken to assure the maximum unsupported inverted span (FLu) is not exceeded. A support plate behind the moving end bracket may be necessary to prevent cantilevered loading and potential wear or breakage. Please contact igus® with your application information. We will be happy to spec a chain in for you.

Guidelines for unsupported lengths, lower section has no support.





Lower carrier section without support

Unsupported, noise optimized

The igus® program offers you optimal noise-reduction Energy Chain®. In addition to the Energy Chain®, the running surface, the dynamics and the cable and hose package all play a role in overall noise generation. Have our specialists design the quietest Energy Chain System® for your application.

System E4 ≤ 46 dB(A)

A measurement by the Rhineland Technical Inspection Authority (TÜV Rheinland) for **System E4/101, Series 221-10-200-0** indicates a value of 46 dB(A) at 4.92 ft/s (1.5 m/s) with an unsupported length.

System E6 ≤ 46 dB(A)

A measurement conducted by the Rhineland Technical Inspection Authority (TÜV Rheinland) in May 2002 indicates a value of ≤ 46 dB(A) at 6.56 ft/s (2 m/s) and with an unsupported length of 4.92 ft (1.5 m) with **Series E6-52-10-100-0**, and all this with at least 10 dB(A) sound pressure level generated by external noise. The System E6 runs very smooth due to the short link pitch.

A reduction of 3 dB(A) sounds like a 50% reduction in the noise level to the human ear.

Selected noise tests
External noise corrected measurement values

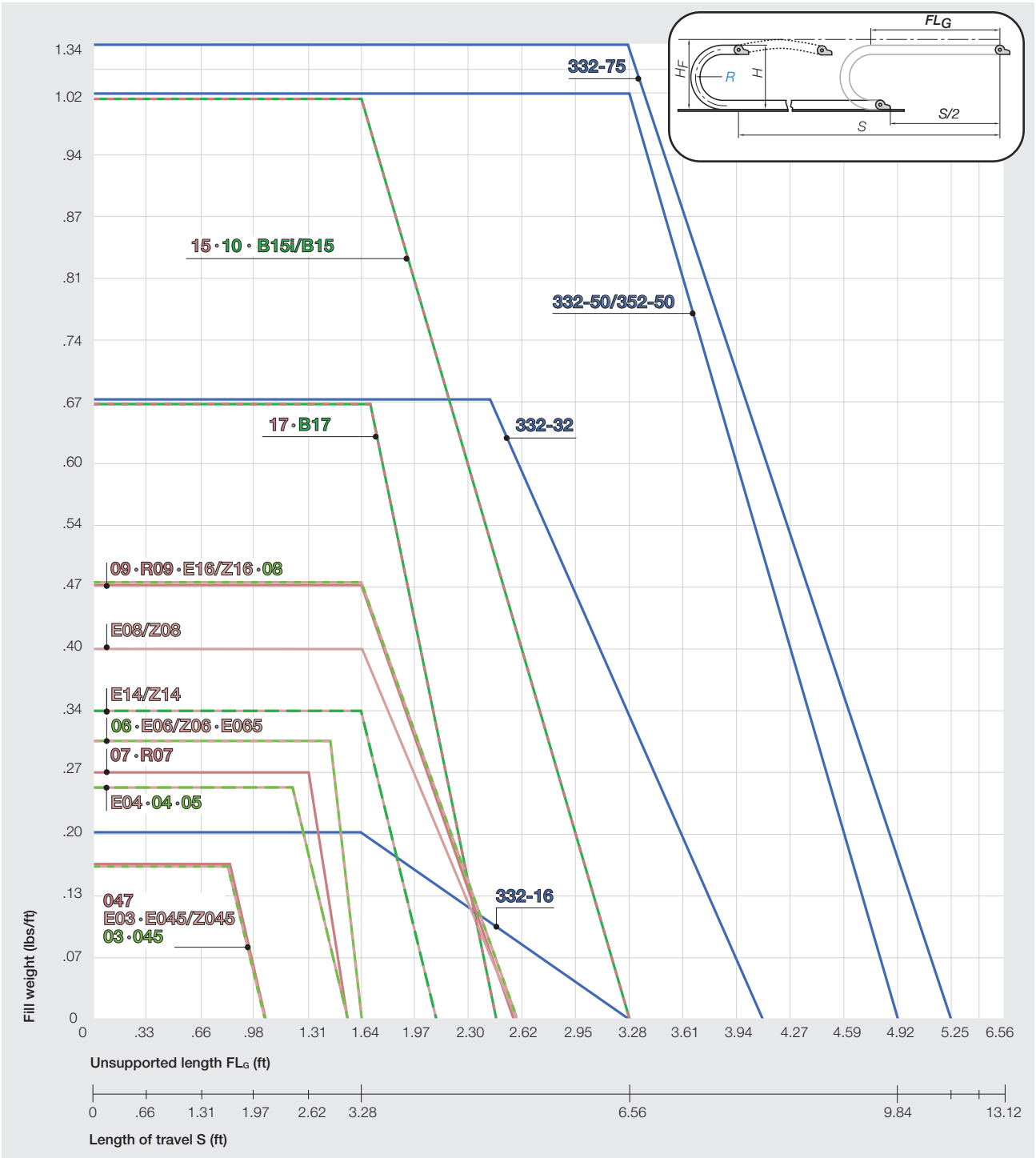
igus® Series	System	Average sound levels	Test method (unsupported)
E6-52	E6	=46 dB(A)	6.56 ft/sec
221	E4/101	=46 dB(A)	4.92 ft/sec
255	E2 Medium	=53 dB(A)	4.92 ft/sec
280	E4/100	=64 dB(A)	6.56 ft/sec

igus® Series	System	Average sound levels	Test method (unsupported)
381	E4/101	=66 dB(A)	9.84 ft/sec

Competitors Product	Average sound levels	Test method (unsupported)
Chain 1	=77 dB(A)	6.56 ft/sec
Chain 2	=68 dB(A)	6.56 ft/sec
Chain 3	=73 dB(A)	6.56 ft/sec

We have received an official comment from the Rhineland Technical Inspection Authority (TÜV Rheinland Berlin Brandenburg). A copy is availabole upon request.

Energy Chain System® Design
Unsupported, Straight FL_G Short Travel Applications
Load diagram for small to medium Energy Chains®



Important information

- Fill weight - Weight of all cables and hoses, including contents (for media hoses) within the Energy Chain®, typically given (lbs/ft)
- FL_G - unsupported Energy Chain® with straight upper run
- FL_B - unsupported Energy Chain® with permitted sag
- To the right of the FL_B graph of the diagram, the application is shown in "critical sag", which must be avoided!

These values are essential for:

- Finding a suitable Energy Chain® for your fill weight and travel distance
- Identifying the max. load for the selected Energy Chain®.

If you cannot meet your application demands using these parameters, keep in mind these specifications are conservative maximum values. In individual cases, they can be exceeded by up to 30%. Special solutions are also possible. Please consult igus®, we will be happy to assist you with your application.

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Fax 1-401-438-7270
Internet: http://www.igus.com
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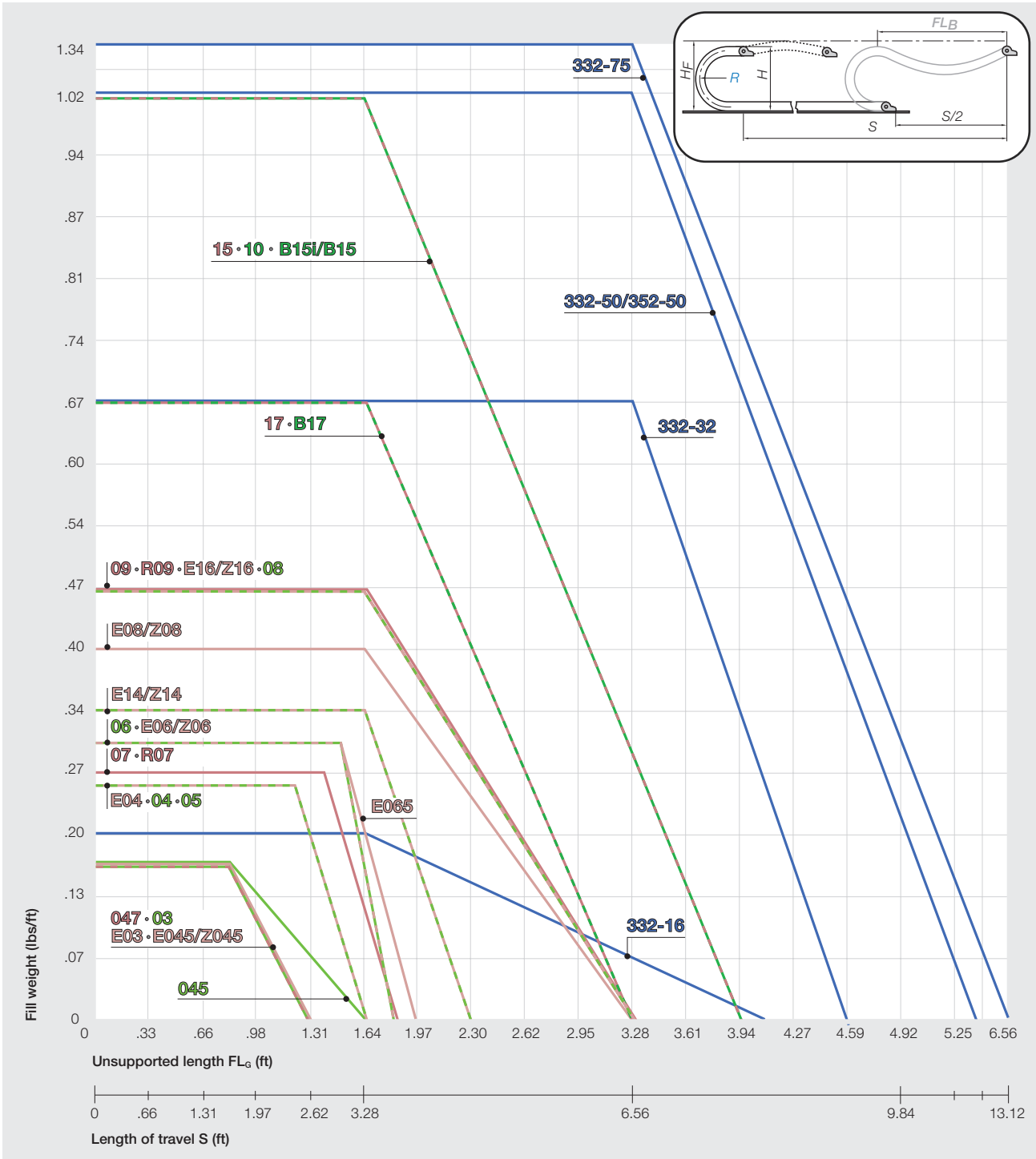
QuickSpec: http://www.igus.com/quickspec

Energy Chain System® Design
Unsupported, Sag FL_B Short Travel Applications
Load diagram for small to medium Energy Chains®



The maximum travel - 2 x FL_G or FL_B

If the fixed end is in the center, then:

Energy Chain® length: $L_K = S/2 + K$

S = Length of travel

R = Bending radius

H = Nominal clearance height

H_F = Required clearance height

K = $\pi \bullet R$ + "safety buffer" Add-on for bending radius

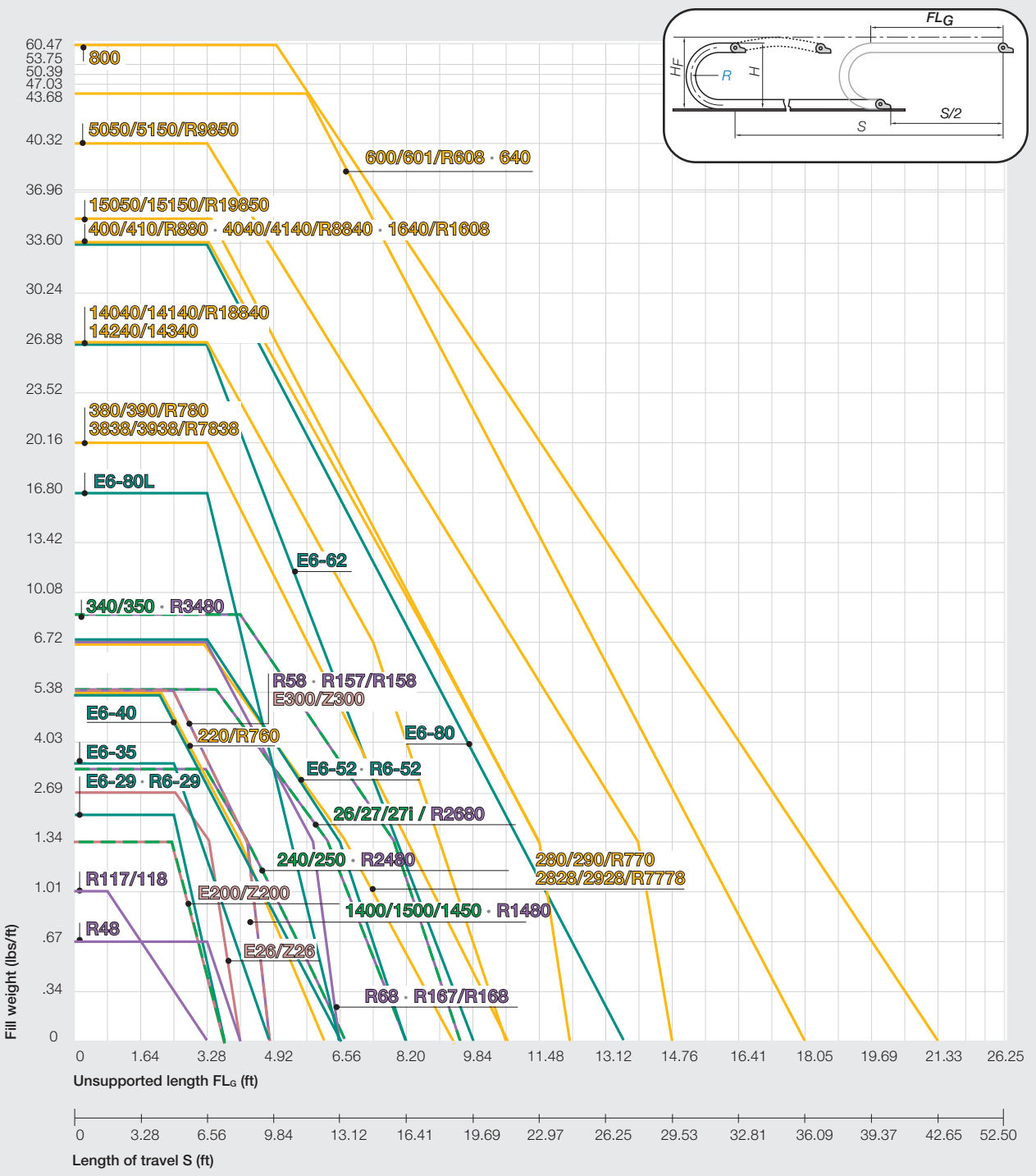
(*K* is taken from the data tables of the individual igus® series)

Diagram Series

You will find both diagrams for each series listed individually in the catalog!

E-Z Chain®	chapter 2
Zipper	chapter 3
E2 micro	chapter 4
E2 mini	chapter 4
Triflex®	chapter 8

Energy Chain System® Design
Unsupported, Straight FL_G Short Travel Applications
Load diagram for large Energy Chains®



Important information

- Fill weight - Weight of all cables and hoses, including contents (for media hoses) within the Energy Chain®, typically given (lbs/ft)
- FL_G - unsupported Energy Chain® with straight upper run
- FL_B - unsupported Energy Chain® with permitted sag
- To the right of the FL_B graph of the diagram, the application is shown in "critical sag", which must be avoided!

These values are essential for:

- Finding a suitable Energy Chain® for your fill weight and travel distance
- Identifying the max. load for the selected Energy Chain®.

If you cannot meet your application demands using these parameters, keep in mind these specifications are conservative maximum values. In individual cases, they can be exceeded by up to 30%. Special solutions are also possible. Please consult igus®, we will be happy to assist you with your application.

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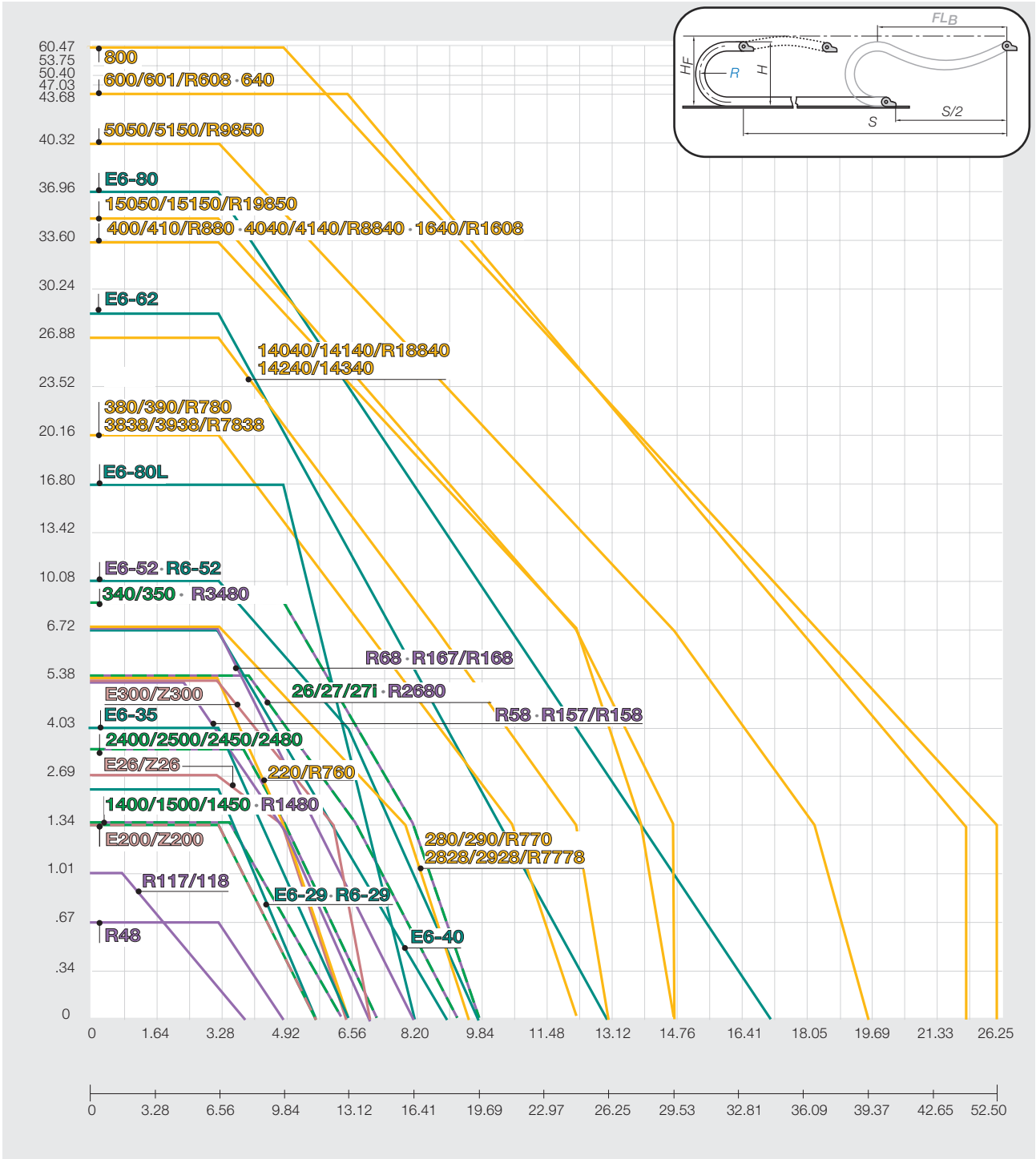
Energy Chain System® Design
Unsupported, Sag FL_B Short Travel Applications
Load diagram for large Energy Chains®



The maximum travel -always amounts to **2 x 2 x FL_G or FL_B** if the fixed end is in the center of the travel. In this case, the following applies:

Energy Chain® length: $L_K = S/2 + K$

S = Length of travel

R = Bending radius

H = Nominal clearance height

H_F = Required clearance height

K = $\pi \bullet R$ + "safety buffer" Add-on for bending radius

(*K* is taken from the data tables of the individual igus® series

Diagram Series

You will find both diagrams for each series listed individually in the catalog!

E-Z Chain®	chapter 2
E2/000	chapter 4
E2 Tubes	chapter 5
E4	chapter 6
E6	chapter 7

PDF: www.igus.com/e-chain-pdfs
Specs/CAD/RFQ: www.igus.com/e-chains
RoHS info: www.igus.com/RoHS

Energy Chain System® Design
Gliding, Long Travel Applications

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Gliding application -
If the upper run of the Energy Chain® rests on the lower run, it is a gliding application

Preferred igus® Energy Chains® for gliding, long travels

- Rol-E-Chain®
- System E4
- E2/000

Gliding applications principle

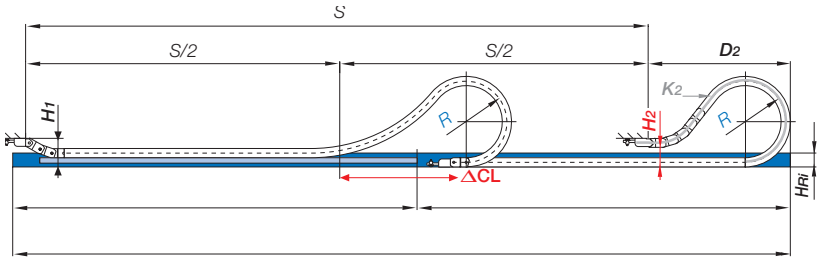
For long travels, the upper run of the igus® Energy Chains® rests on the lower run. The upper run glides partially on the lower run and partially at the same height on a glide bar.

The illustrations shown below depict the gliding application principle. For lateral guidance, a guide trough is necessary. If the stationary mounting bracket and the fixed end of the cables and hoses can be placed in the center, the Energy Chain® length is calculated as follows:

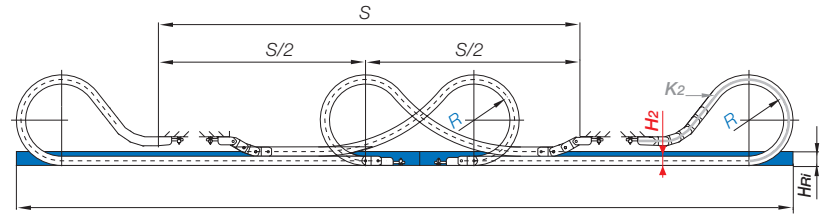
$$L_k = S/2 + K_2$$

Depending on the technical data and the selected Energy Chain®, the mounting point of the moving end of the Energy Chain® must be lowered on some units.

Lowered mounting height: In our system analysis for long travels, we give exact details for your specific application.



The function of an Energy Chain System® for gliding applications (schematically)
The fixed end of the Energy Chain® is located in the center of the travel distance



For a configuration involving two opposed Energy Chains®, the travel is measured as shown and selected when these factors apply: ● Restricted space ● High loads

For center mounted applications, Energy Chain® length:

$$L_k = S/2 + K$$

S = Length of travel
R = Bending radius
H_{Ri} = Trough inner height
H_F = Required clearance height
K_2 = Add-on if the mounting bracket location is set lower (specified by igus®)
D_2 = Over length for long travels gliding
H_2 = Installation height with lowered mounting

● Guide trough
● Glide bar

Advantages for long travel applications with igus® Energy Chains®

Example of lowered mounting height

- Travels over 1312 ft (400 m)
- Gliding speeds up to 16.4 ft/s (5 m/s) (more in individual cases)
- Service life of 10 years and more with igus® Energy Chain Systems®

Further advantages of the design are:

- Many different types of cables and hoses can operate side by side in the same system (i.e. electrical, data, fiber optic cables with hydraulic and pneumatic hoses)
- Space-saving installation
- Quiet operation
- High accelerations
- Durable in wind, weather, dirt, and chemicals
- Simple assembly of the modular system on the spot
- Rapid assembly and replacement of cables and hoses

Recommended ratio of Energy Chain® inner width *Bi* and bending radii *R* (on long travels)
The minimum inner widths of an Energy Chain® on long travels depends on the bending radii of the Energy Chain®.
igus® specifies: $Bi_{min.} = R/4$
Please contact igus® if you have large bending radii on long travel lengths.

Advantages lowered moving end:

- Space saving
- Longer travels possible
- Higher service life due to less wear

Trends in long travel applications

New developments are currently being tested:

- Travels up to 2,625 ft (800 m). We break through the 1,312 ft (400 m) barrier by means of special components. Please ask us for more specific information.
- Long travel systems “off the reel.” Complete made-to-spec Energy Chain Systems® - with cables, connectors, strain relief - are delivered on the reel and “rolled off” into the pre-assembled guide troughs. Travel distances up to 328 ft (100 m) are delivered this way today, with longer travels possible.
- Long travel **without** guide troughs. Our AUTO-GLIDE system consists of self-guiding Energy Chains®. We have recently extended this technology to large Energy Chains® and currently offer travels up to 328 ft (100 m).
- Long travels with very small Energy Chains, for example, the igus “Flizz” offers the guidance of a single bus cable inside a small Energy Chain with high acceleration on long travel applications.

Longest igus® travel of 2,018 ft (615 m) with Rol-E-Chain and Chainflex® cables

Design assistance, free of charge

We recommend that igus® calculate every gliding application for you. We will always offer the most cost-effective solution, taking the technical requirements and operating safety into consideration. The system solution designed by us is also automatically given an igus® system guarantee.

To be able to advise you accurately, we require the following specifications:

- Travel in (ft) or (m)
- Travel speed (ft/min) or (ft/s)
- Acceleration (ft/s²)
- Fill weight (lbs/ft)
- Maximum cable/hose outer diameter (in.) or (mm)
- Type and number of cables and hoses
- Required bending radius (in.) or (mm)
- Cycle frequency (n/day or n/hour)
- Technical environment.

Please call us and within hours you will receive a detailed system proposal!

Long travel "off the reel." Up to 328 ft (100 m) travel pre-assembled and ready to install

Mobile camera, live images, Olympic Games in Atlanta S = 328 ft (100 m) V = 32.8 ft (10 m/s) in push-pull operation

Robotics: quiet running, high acceleration; up to 10,000 cycles per day

Conveyor belt in quarry. Travel distance of 587 ft (179 m), travel speed 220 ft/min. (67 m/min.) and fill weight 5.38 lbs/ft (8 kg/m)

Energy Chain System® Design
Gliding, Long Travel Applications

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Guide troughs are used for for long travels, travels from 16.4 to 32.8 ft (5 to 10 m) and greater, depending on the chain type. They enable igus® Energy Chains® and Energy Tubes to deliver smooth, low-friction operation in long-travel situations. Various guide trough systems are available.

➤**Guide Troughs, Section 9**

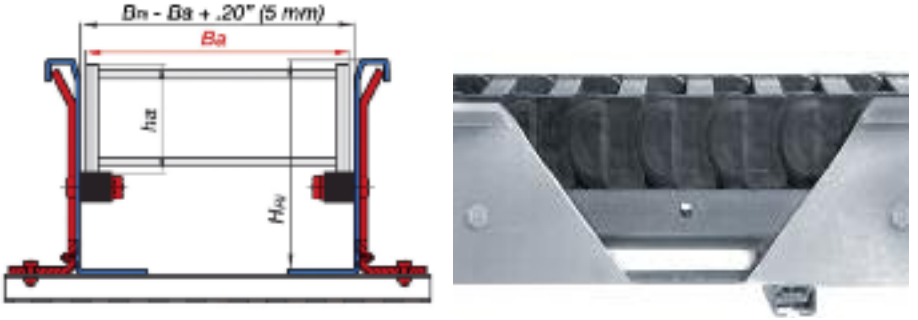
Guide troughs

A guide trough is an important element in long travel applications. Diagrams are shown below. The height of the trough must be at least twice the total chain link height. The sides must provide a chamfered opening. The trough inner width is the same as the chain outer width, plus .20" (5 mm). When the upper run cannot glide on the lower run, glide bars must be installed along the sides of the trough. igus® recommends the use of polymer glide bars. They are optimally matched to the chain material and achieve the lowest values for friction, noise and wear. Guide troughs with and without glide bars can be obtained for almost all igus Energy Chains®.

Important: When assembling the trough parts, the following points must be given particular attention:

- Properly align all trough parts upon installation
- All screw heads should be flush with the trough
- Smooth leveled transition between the end of the chain and the glide bars
- Solid connection with the glide surface

If the fixed point is in the center of the travel, use half of the guide trough with glide bars...

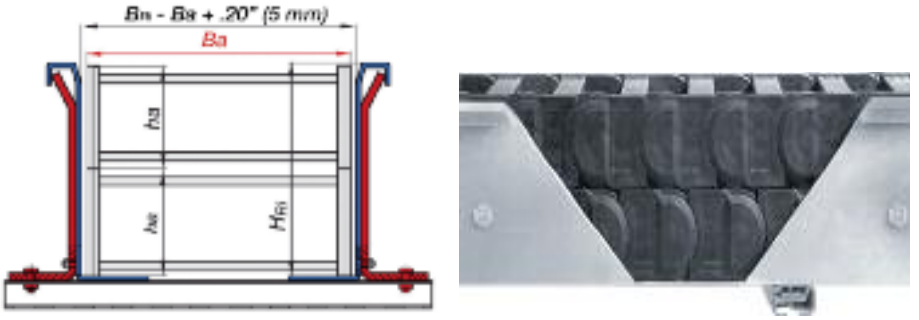


Above: Guide troughs with glide bars. igus® recommends the use of polymer glide bars made of UHMW. They are optimally matched to the Energy Chain® material and achieve the lowest values for friction, noise and wear.

... and the other half of the guide trough without glide bars

$H_{Ri} \geq 2 \times h_a$

$B_{Ri} \geq Ba + .20"$ (5 mm)



Above: Guide troughs without glide bars - upper run glides on the lower run.

Ba	= Energy Chain® outer width
ha	= Energy Chain® outer height
H_{Ri}	= Inner trough height
B_{Ri}	= Inner trough width

= guide trough
= assembly elements
= glide bars

Glide friction values for igus Energy Chains® made of igumid G and various glide bars:

igumid G	igus® Polymer Glide Bar	Galvanized Sheet Steel	Anodized Aluminum	Stainless Steel
Friction value (dynamic)	0.19	0.45	0.54	0.48

Source: igus® Laboratory

Energy Chain System® Design
Gliding, Long Travel Applications

Travel speeds and accelerations

Travel speeds up to 16.4 ft/s (5 m/s) in continuous operation are possible and in use on current applications. In special cases, even higher speeds are possible. For example, igus® E4/100 and E4/4 Energy Chains® achieve speeds of 72 ft/s (22 m/s) and accelerations of 2,572 ft/s² (784 m/s²) in crash test units. (Only a few thousand cycles per year are required in this situation.) Acceleration plays a large role in the calculation. Differentiations must be made between normal operational acceleration and a sudden jolt of acceleration such as unexpected stops or so-called "E-stops." Even in these situations, igus® Energy Chains® prove to be very durable.

Corrosion-free guide troughs are available in the material:

- Normally galvanized
- Stainless steel
- Seawater resistant aluminum

Service Life

We offer service life calculations for your application based on our extensive gliding application experience. As developers of polymer plain bearings, we possess vast material behavior knowledge which we apply to the development of Energy Chains® as well. Units with 656 ft (200 m) travels have been in operation for 8 years with minimum maintenance. Units up to 197 ft (60 m) travels have been in operation for 12 years with almost no maintenance. (Please consult igus® for references and calculations for your project.) The maintenance-free aspects of igus® Energy Chain Systems® over long periods and under rough operating conditions is often the deciding factor in choosing igus. Our system guarantee provides additional peace of mind.

Automated storage/retrieval system with System E2 and Chainflex® cables - travels up to 262 ft (80 m) and speed of 14.8 ft/s (4.5 m/s)

Special properties - Long travel applications

Energy Chains® that are **nested** can be used in gliding applications. This type of installation is most often used when there is a width restriction. Guide troughs with special wall heights are necessary.

Energy Chains® **running side by side,** or in a "multiband" design can also be used in gliding applications. Higher fill weights often require special guide troughs which can be delivered either from stock or on short notice.

We have also developed standard parts for unconventional solutions involving **large hoses** in gliding applications.

Technical environment

Long travel applications using igus Energy Chains® run in water, in dirt, in the tropics, in explosion risk areas (with special design features) and many other conditions. Guide troughs can be supplied in corrosion-free materials. You will find more details in the **Technical Environment** section of this chapter.

Nested, gliding Energy Chains®

"Multiband"Energy Chain®

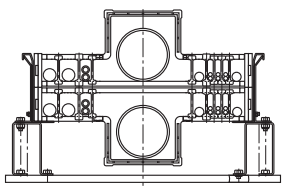
Calculation

Comprehensive tests place us in the position of knowing our products precisely. Important factors in these tests are:

• Push-pull forces under both ambient and extreme temperatures • Humidity and dirt • Friction values of the polymers, alone and against various glide surfaces • Behavior of electrical cables under push-pull conditions • Behavior of hydraulic and media hoses under push-pull conditions • Service life, and noise generation.

If we cannot in fact calculate your application based on these factors, we will perform a practical test for you in our laboratory. Please consult igus®.

E4 in a pre-cast concrete plant with dust and concrete sediment



Large hose elements

General data, long travels

Travel max	1,312 ft (400 m) / 2,625 ft (800m)
Travel speed max	16.4 ft/s (5 m/s)
Travel acceleration max	dependent on calculation, can be 164 ft/s² (50 m/s²) and more
Fill weight max	dependent on calculation, can be 47 lbs/ft (70 kg/m) and more

Energy Chain System® Design
Vertical, Hanging Applications

igus® Energy Chain System®
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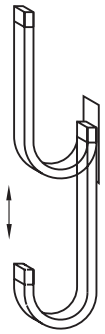
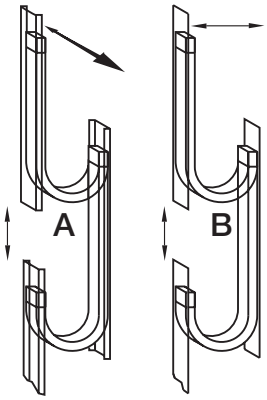
Internet: http://www.igus.com
email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

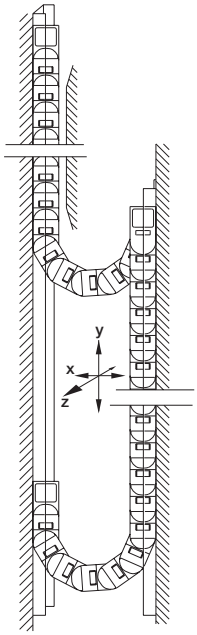
We recommend **locking mounting brackets** for hanging applications. In restricted spaces, other solutions are possible with consultation.



In most cases, vertical motion applications do not require lateral guidance



If lateral acceleration will occur in two directions, guidance is necessary



Vertical, hanging applications

In accordance with the principle of hanging applications, heights more than 328 ft (100 m) are possible with igus® Energy Chains®. Energy Chains® with interior separation allow many different types of cables/hoses to operate together in the same system without becoming entangled.

Cables and hoses

Two important factors in vertical hanging applications are how the cables/hoses lay in the chain and how they are secured at the end points:

- All cables and hoses must bear their own weight when hung. The Energy Chain® should house and protect the cables and should not absorb any further tensile forces.
- **igus® interior separation elements** should be used for distinct division of all cables and hoses.
- **The cables and hoses must be secured carefully to both end points of the Energy Chain®.**

The strain relief must be designed so that the opposite run cannot catch. Safe strain relief and clear separation of the cables/hoses are the basic prerequisites for hanging installations. Cables and hoses must be able to move freely and bear their own weight.

Camber

A normal igus Energy Chain® with camber is suitable for hanging use if enough space is available. If there is not enough room, a “no camber” Energy Chain® must be installed. This is frequently the case with storage and retrieval systems in narrow aisles.
Order example: 27-07-100-0-**NC** (No Camber)

Vertical motion without lateral acceleration

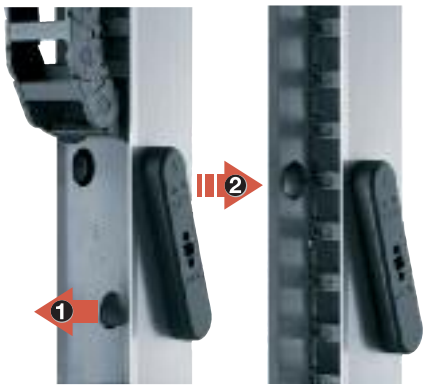
If the application involves vertical motion without lateral acceleration, the Energy Chain® can be installed without lateral support. If the space restrictions are severe, an igus Energy Chain® with no camber must be specified.

Vertical motion with lateral acceleration

In most cases where lateral acceleration occurs, lateral guidance of the Energy Chain® must be provided. The diagram to the right shows an example of such guidance. Partial guidance is also an option, however, it must at least cover the area in which the Energy Chain® may sway. Lateral acceleration can occur in two directions. Lateral guidance must be installed accordingly. **If you have a choice, the layout in Figure A is preferred.** Additional guidance along the side of the carrier helps to stabilize the chain further.

Guidelok vertical - no sideways swinging of the Energy Chain®

The problem: Suspended Energy Chains® swing out due to transverse acceleration -
The solution: igus® "Guidelok" system. Energy Chain® stays on track even with acute transverse acceleration! When the chain moves over the control button ❶ the fixing button ❷ is moved, the lower run of the Energy Chain® is held in place, preventing it swinging out. For elevators, racking units, material handling equipment. igus® Guidelok offers a simple, cost-effective and safe system solution for vertical applications with lateral motion. Please call us if you re interested in this product! .

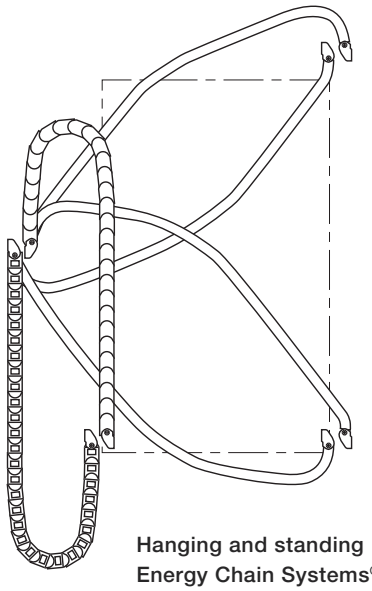


Typical applications

- Automated storage/retrieval systems
- Lifts
- Revolving storage systems
- Diagonal lifts
- All vertical applications

➤ **Chapter 9**

Energy Chain System® Design
Vertical, Hanging Applications
Zig-Zag Applications



Hanging and standing Energy Chain Systems® can reach to very different points

Hanging assembly with one-sided U profile

Due to the wide variety of combinations involving stroke height, cable/hose packages, dynamic values, and application environments, we strongly recommend you make use of our consulting services. Simply call, E-mail or fax us.

Preferred Series for vertical, hanging design

- E4/00
- E4/4
- E2/000
- E2 Energy Tubes

“Zig-zag” design

The modular design of igus® Energy Chains® facilitates this space-saving and unconventional solution. For modern platform technology, such as performance stages, a variety of cables/hoses which adjust the stage height must be accommodated. Lack of space almost invariably presents particular difficulties. The photo below shows an Energy Chain® in a “zig-zag” configuration produced by incorporating reverse bend radii or “RBR”. The unextended Energy Chain® is stored in a “basket” underneath the stage. If the stage is raised, the Energy Chain® unfolds, generating little to no noise. This construction is possible with System E4 and E4/4 Energy Chains® as well as many other types. Please consult igus® for these kinds of applications.

Preferred Series for "Zig-Zag" design

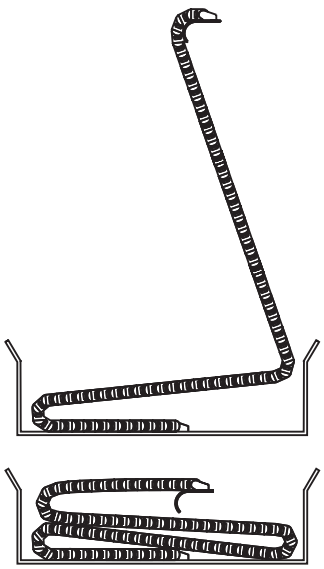
- E4/4

Technical data: vertical, hanging

Travel Height Max: 328 ft (100 m)

v max:	65.6 ft/s (20 m/s) dependent on height and stability of the Energy Chain®
a max:	164 ft/s (50 m/s²) dependent on height and stability of the Energy Chain®

With System E4 and E4/4 Energy Chains®, zig-zag solutions can be realized quickly and cost-effectively with standard parts



Space-saving solution - stroke heights of over 65.6 ft. (20 m) are possible

PDF: www.igus.com/e-chain-pdfs
Specs/CAD/RFQ: www.igus.com/e-chains
RoHS info: www.igus.com/RoHS

Energy Chain System® Design
Vertical Standing Applications

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email: sales@igus.com
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Cables must be able to move freely and carry their own weight,

Side-mounted Energy Chains® - are strongly recommended if the installation height is restricted.

Standing application with support of the first chain links; R68 Energy Tube

Locking KMA mounting brackets can be directly attached flush to the machine; igus® Series 4040

Mounting brackets

The mounting brackets must be attached so that the Energy Chain® cannot bow out.
The igus® program offers locking or one-sided, locking mounting brackets for almost all types of carriers. Locking KMA mounting brackets are highly recommended because they can be attached flush to the machine.

Cables and hoses

Cables and hoses must be laid in the chain so that they can bend freely For precise guidance of the cables and hoses, we strongly recommend igus interior spacer modules Cables must be strain relieved at both ends

Preferred series for vertical standing design

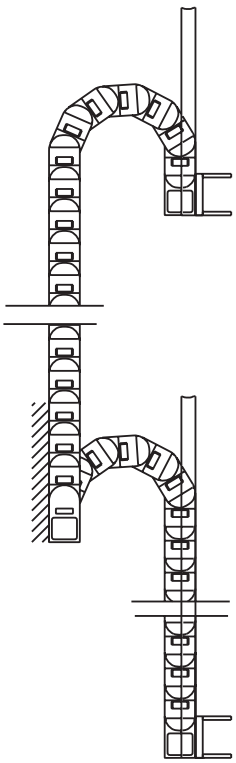
- E4/00
- E4/4
- E2/000
- E2 Energy Tubes

Technical data: vertical, standing applications

Maximum Travel	
- without support	≈ 13 ft (4 m)
- with support	≈ 19.7 ft (6 m)
of the first chain links	
- with full support	≈ 65.6 ft (20 m)
v max	65.6 ft/s (20 m/s) (dependent upon travel and weight)
a max	164 ft/s² (50 m/s²) (dependent upon travel and weight)

Lateral acceleration

If lateral acceleration occurs, the Energy Chain® should be supported along the outer radius. For higher chain heights, it is generally recommended that at least the first three links on the outer radius be supported. For maximum heights and weights, the whole distance must often be supported.
Due to the wide variety of combinations involving weights, stroke heights, chain types and bending radii, we strongly recommend you make use of our consulting services.



**Options for a standing application with support of the first chain links:
on the left, with U-shaped guidance; on the right, with the support of the first chain links**

For higher Energy Chain® stroke heights, it is generally recommended that at least the first three links along the outer radius be supported. For maximum heights and strokes, the whole chain must often be supported.

With lateral acceleration, the Energy Chain® must be supported and, depending on the direction of this acceleration, be guided along the side.

Combined movements

Combined vertical and horizontal movements are possible with igus Energy Chains® for a cost-saving solution.

Combined horizontal and vertical movements on a construction vehicle.

Energy Chain System® Design
Side Mounted Applications

igus® Energy Chain System®
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email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

Side-mounted Energy Chains® - are strongly recommended if the installation height is restricted.

System E4 Energy Tube in direct chip area E4/light

Standard values for unsupported lengths, side-mounted, upon request. The unsupported lengths can be extended by supporting the links next to the mounting brackets

Short travels with or without support

igus® Energy Chains® placed on their side can be used unsupported to a limited extent. The turned "unsupported length" in this case is dependent on the following factors:

- Fill weight
- Width of the Energy Chain®
- Bending radius
- Parallel placement

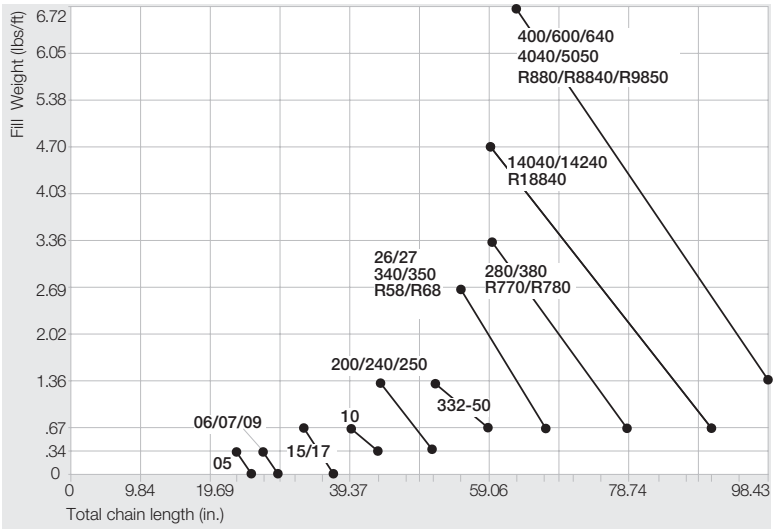
The greater the fill weight of the Energy Chain®, the shorter the available unsupported length. When placed on its side, the chain width, in effect, becomes the height. As this "height" increases, the Energy Chain System® becomes proportionally more stable. Small bending radii provide greater stability. If further movement in a second axis is added to the parallel motion of two chains, the unsupported length is impaired. For applications with low fill weight, the standard mounting brackets are adequate. If, however, the fill weight is high and the travels are long, the Energy Chain® must then be supported either in whole or in part. Due to the variety of application possibilities, we strongly recommend you make use of our consulting services.

igus® - Series E4/4 with partial support

Unsupported - System E4

Energy Chain®, side-mounted, supported System E4

Energy Chain System® Design
Side Mounted Applications



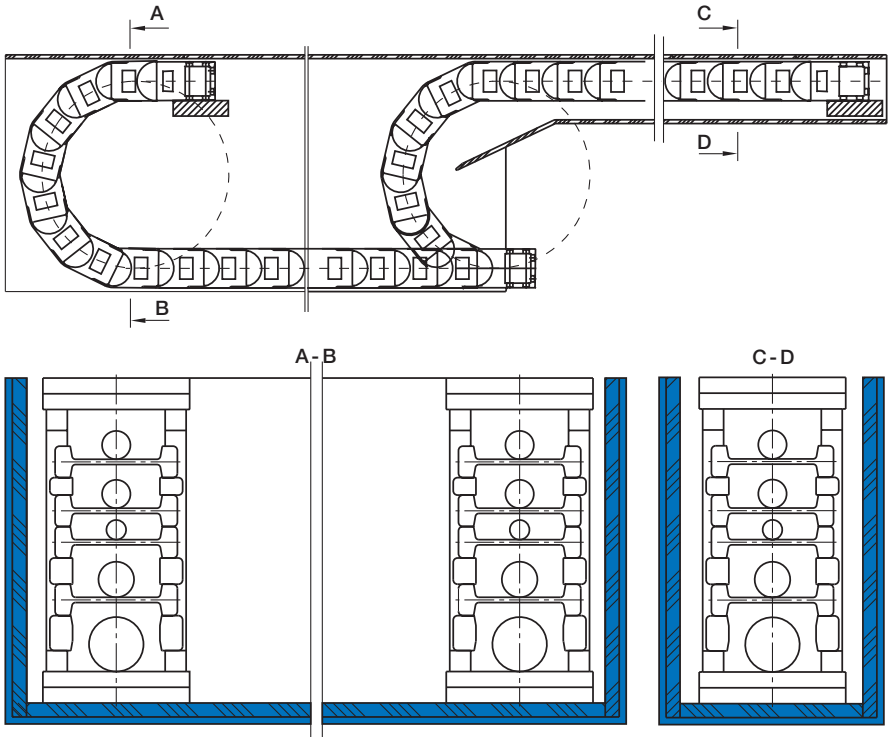
The unsupported lengths can be extended by supporting the links next to the mounting brackets. Please consult igus® for more details.

Long travel, gliding

Side-mounted Energy Chains® can travel over 328 ft (100 m) with adequate guidance. All chain types are designed to operate gliding on their side. The corresponding glide surface is usually an igus® polymer, stainless steel or galvanized steel, depending on how high the demands on the travel speed and service life are. Roller and ball bearings or additional gliding elements are not necessary for igus Energy Chains®. **The diagram below shows the principle of a guide trough for side-mounted applications**.

Cables and hoses

Cables and hoses must be guided so that the Energy Chain System® can move freely at all times. The igus® modular separation options offers numerous possibilities, such as separators and spacers, to keep these cables/hoses separated and bending freely for maximum service life. igus will gladly provide an application analysis, free of charge.



Principle of a guide trough for long travel, side-mounted

For a side-mounted gliding application, we recommend locking mounting brackets. The Energy Chain® is then pushed straight through the guidance

Cable and hose guidance with separators and spacers

Preferred series for side-mounted applications

- E4/00
- E4/4
- E2 Energy Tube

Energy Chain System® Design
Rotary Motion Applications

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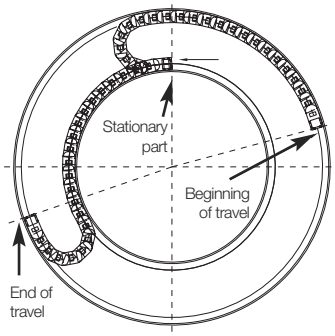
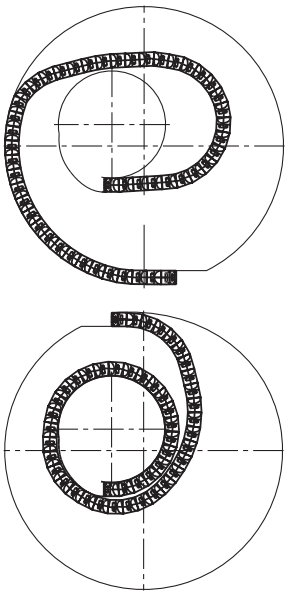
Options 2 and 3 for rotary movements require less installation height. The Energy Chains glide mostly on surfaces made of polymer, stainless steel or steel and are guided through channels into a rotary movement. (See “side mounted” for further design tips.)

Bending radii, circular radii and chain widths are variable with this product line.



Preferred series for rotary motion applications

- TwisterChain®
- All “RBR” Energy Chains®
- System E4
- System E2/000



Standard Energy Chain®
350-075-200-0,
angle of rotation 225°

Rotary motion with a “standard” Energy Chain®

"RBR"-rotary movement with Series 5050, installed on a crane

1. Rotary motion with TwisterChain®

The TwisterChain® product line offers the biggest selection for rotary movements. TwisterChain® solutions are particularly recommended for space-restricted applications such as articulated robots, revolving tables, etc. Further details can be found in the TwisterChain® chapter.

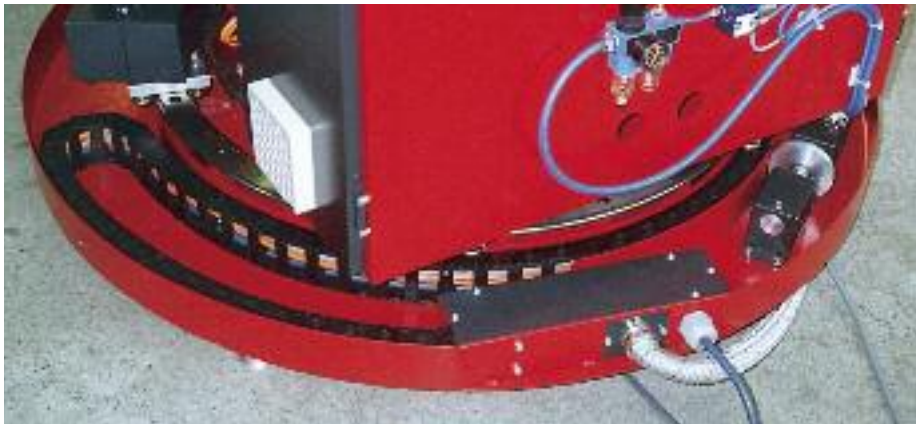
➤ **TwisterChain®, Chapter 8**

2. Rotary motion with standard Energy Chains®

The photo to the left shows an application which was achieved using “standard” Energy Chains® (standard, in this case, means that the Energy Chain® only bends in one direction). Such solutions are possible if a **great deal of space** is available and if the angles of rotation are limited to a maximum of 450°. All igus® Energy/Tubes and Chainflex® cables are appropriate for this situation.

3. Rotary motion with an “RBR” Energy Chain®

“RBR” is “reverse bending radius” and means that the Energy Chain® can bend in two directions. Each igus® Energy Chain® can incorporate RBR designs, with the exception of several radii, for the Energy Tubes R117 to R98 and for the Series 07, 09, 14, 15, and 17. The RBR does not necessarily need to be identical to the normal bending radius of an Energy Chain®. For example: Part No. 280-15-100/425-0, describes a Series 280 Chain with an inner width of 5.91 (150 mm), standard bending radius of 3.94 (100 mm) and RBR of 16.73 (425 mm). Most rotary motions can be achieved with the RBR option. **Angles of rotation up to 540°** have been achieved. To the left and below are examples of rotary motion using an RBR Energy Chain. Please consult igus for your particular application.



Series 250 with 360° RBR rotary motion on a robot

Energy Chain System® Design
Rotary Motion Applications

Guide troughs

Depending on the dynamics and load of the application, the guide troughs are made of steel or stainless steel. For applications with a high cycle frequency, we suggest coating the guide troughs with polymer. igus® Energy Chains® require no additional gliding elements for contact with the base or sidewalls. igus® offers complete systems including guide troughs, but we are pleased to offer support with drawings for your own construction.

Product range

Energy Chains® with “RBR” are available as standard from stock for the complete Triflex® range. In addition, we supply a number of Energy Chains® which are equipped as standard with “RBR”. For all other types, “RBR” means custom-made, and we will be more than willing to offer you this option

Guide troughs for rotary applications

Many igus® Energy Chains® are available with "RBR" -reverse bending radius. Please see the ‘Product Range’ for relevant series.

Example:

10-4-075/220

RBR
Radius
Width
Series

Rotary motion with RBR; diameter 236” (6000 mm); Series 50 with RBR; the inner ring rotates

Technical data rotary motion:
max. angle of rotation = 540°
(larger angles possible)
v max. = 32.8 ft/s (10 m/s)
a max. = 65.6 ft/s² (20 m/s²)

igus® Energy Chains® with RBR available from stock

Part Number	Series	Part Number	Series
05-16-018/018	E2 micro	10-4-038/600	E2 mini
06-20-018/018	E2 micro	10-4-048/048	E2 mini
06-30-018/018	E2 micro	10-4-048/400	E2 mini
06-64-018/018	E2 micro	10-4-075/220	E2 mini
10-1-028/028	E2 mini	240-05-060/060	E2 medium
10-1-038/600	E2 mini	240-07-060/060	E2 medium
10-1-048/048	E2 mini	250-05-060/060	E2 medium
10-1-075/220	E2 mini	250-07-060/060	E2 medium
10-2-028/028	E2 mini	27-07-075/300	E2 medium
10-2-038/600	E2 mini	27i-12-125/400-0	E2 medium
10-2-048/048	E2 mini	5050-00-150/150	E4/4
10-2-075/220	E2 mini	B15i-050-100/460	E2 mini
10-3-028/028	E2 mini	E/Z14-1-038/038	E-Z Chain®
10-3-038/600	E2 mini	E/Z14-2-038/038	E-Z Chain®
10-3-048/048	E2 mini	E/Z14-3-038/038	E-Z Chain®
10-3-075/220	E2 mini	E/Z14-3-075/075	E-Z Chain®
10-4-028/028	E2 mini	E/Z14-4-038/038	E-Z Chain®

The Energy Chain® series appearing in the table at the left are "RBR" versions available from stock. Almost all other igus® Energy Chains® can be special ordered as "RBR".
Please contact us for any special inquiry.

Energy Chain System® Design
Cable and Hose Packages

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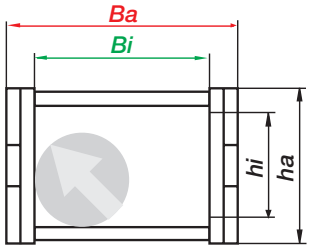
Rules for:
- Maximum cable/hoses diameters
- Shelving
- Bending radius

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



The maximum cable/hose diameter is specified for each series in its respective chapter

Neatly laid cables with igus® interior separation

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

General rules for cables and hoses in Energy Chains®

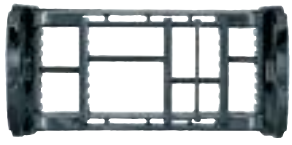
Supply of data and energy in all forms within an Energy Chain System®

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. 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.

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®.

Energy Chain® Distribution



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.**

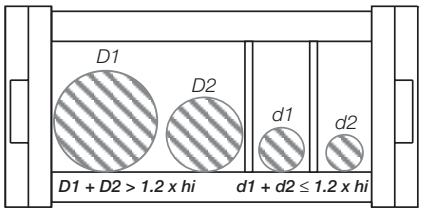
The igus® modular Energy Chain System® solves all known requirements for interior separation

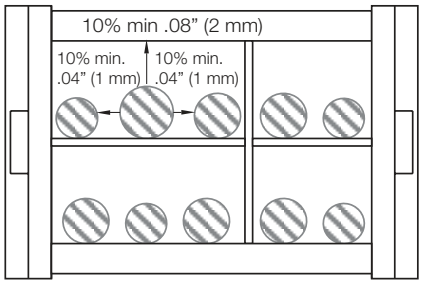
Reasons for distribution rules

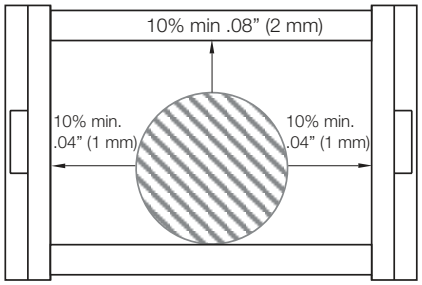
The cables and hoses must be laid so that they can move freely at all times and so that no tensile force is exerted at the radius of the Energy Chains®. For high-speed applications and high cycles, **cables or hoses must not be laid on top of each other without horizontal separation.** The standard values for this are: Travel speed over **1.64 ft/s (0.5 m/s)** and cycles over **10,000 per year.** igus® interior separation offers a safe solution for this situation.

Further guidelines for distribution

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 and the fixed end. 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.**







Clearance space "all-around" for round electrical cables

Distribution Rules

D1 + D2 > 1.2 x hi

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.

D1 + D2 ≤ 1.2 x hi

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.

All-around clearance space in % for various cables/hoses

- Electrical round cables: 10 %
- Electrical flat cables: 10 %
- Pneumatics: 5 - 10%
- Hydraulics: 20 %
- Media hoses: 15 - 20 %

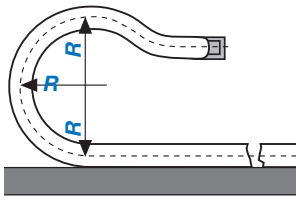
Bending radius R

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.

Some igus® Chainflex® cables permit a small bending radius of 5 x d for one million strokes

The igus® program offers up to 12 different bending radii from stock. Here, System E4 was used in the Storebaelt bridge project in Germany



Pinciple sketch bending radius "*R*"

Chainflex® cables - smallest bending radius of 5 x d

Energy Chain System® Design
Cable and Hose Packages

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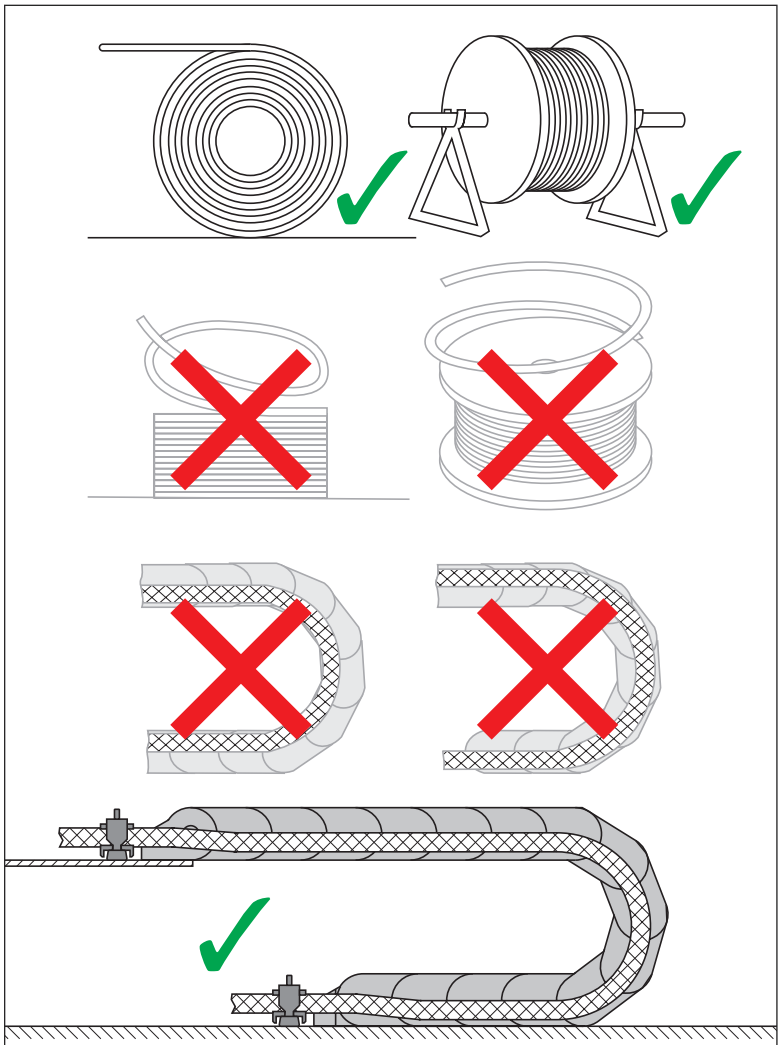
We will be pleased tp provide you with recommendations for complete Energy Chain Systems® - where bending radii for all cables and hoses, interior separation and service life are optimally matched

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

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



Cables must be able to bend freely.
Chainflex® cables can be strain-relieved directly at the mounting bracket

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:

- 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

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.

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).

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.

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

The igus® program also offers polymer pneumatic hoses called “Chainflex Air”.

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

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®.

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

Hydraulic hoses

When designing hydraulic hoses in Energy Chains®, special attention should be paid to the expansion of the hoses when pressurized. Sufficient room must be left in the Energy Chain® for this as well as the possible larger external diameter of the hoses under pressure. It is important for selected hoses to be sufficiently flexible (i.e. meet bending radius specified by the Energy Chain®). The gliding ability and abrasion-resistant surface of the hoses are also important. All crossbars and shelves in the igus Energy Chain® minimize abrasion of hoses through wide, rounded and smooth surfaces. Normally, hoses with textile braiding are more flexible than hoses made of steel wire, while maintaining smaller outer diameters and better fatigue strength under stress.

igus® Energy Chains® with hydraulic hoses in a tree-stripping machine

As lateral movements of the hydraulic hoses within the chain can lead to increased abrasion of the hose material, they should be secured in position with vertical separators, but not forced. Special “locking” separators, which grip the opening crossbars of the chain, as well as the use of “spacers,” prevent lateral shifting of the separators; they also ensure the hoses stay put in cases of strong vibration and impact on the chain. Details about these accessories can be found in the description of various chain types.

Strain Relief - Hydraulic hoses are most often stretched lengthwise during operation. This must be taken into account when applying strain relief. More hose length is factored in to allow the hose to “breathe,” or “floating” strain relief must be implemented. In some cases, strain relief on the moving end only can be tolerated.

Rollclip - In almost all cases, the broad, smooth and rounded surfaces of all igus® Energy Chains® and Tubes are sufficient to protect hydraulic hoses from abrasion. In extreme cases, the igus Rollclip can be installed. The hoses come in contact with a series of polymer cylinders which rotate. “Extreme” cases include particularly soft materials, particularly narrow bending radii or highly dynamic loads. Over 95% of all applications can be solved without Rollclips.

Hydraulic hoses need more space: 20% all-around clearance

igus® Rollclip, detachable

Energy Chain System® Design
Strain Relief Elements

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Ideally, the cables/hoses should have strain relief at both ends of the Energy Chain®. At the very least, they must have strain relief at the moving end of the Energy Chain®.

For more information on all igus® strain relief elements,
➤ Chapter 10

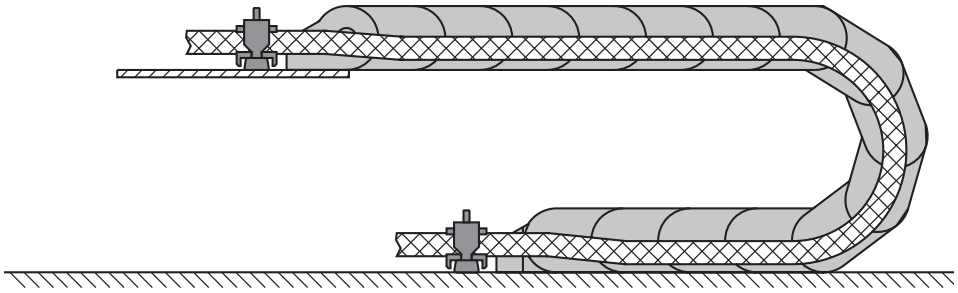
Strain relief in KMA mounting bracket with profile rail.

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).

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 individual chapters).



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)!

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

Features of chainfix clamp

- Optimal igus® Chainfix housing with reduced height
- Long service life for dynamic applications thanks to improved clamping elements
- Integration with KMA mounting brackets - saves both time and space during installation and available for complete systems with cables and strain relief
- Improved housing foot clamp for easy fit into the profile rail
- Black housing and setscrews for attractive appearance
- Setscrews, tightened with Allen wrench, for easy installation
- Mark of the installation direction
- Now with better fixation due to optimized design

Tiewrap plates as individual parts

- Strain relief accessory for igus® E-ChainSystems®
- Attachment to mounting brackets
- Integration into the profile rail of KMA (polymer/metal mounting brackets)

Tiewrap plates with clip-on connection for the profile rail

The plates **3050-ZC** and **3075-ZC** can be clipped directly into the profile rail without bolts or any extra hardware. Clip-on tiewrap plates can be released and repositioned with just a screwdriver used as a lever.

Chainfix clip - modular snap-on strain relief device

Chainfix clip is a series of clamps and bottom parts made of plastic for cable diameters ranging from .16 to .94 inches (4 to 24 mm). Chainfix Clip is available for C profiles, also suitable for assembly in the KMA mounting brackets and clip-on strain relief for cross bars.

Characteristic features:

- Quick assembly without any tools
- 2 and 3 layers on top of one another possible
- Each layer can be detached and changed later on
- High tensile forces in case of single-layer installation, decreasing with the number of layers

Strain relief separator

- Can be integrated in mounting bracket
- Can be positioned as required
- Easy installation
- Cost-effective
- For series E6-29, 26/27/27i (other series upon request)

Energy Chain System® Design
igumid Material

Telephone 1-800-521-2747
Fax 1-401-438-7270

Internet: http://www.igus.com
email: sales@igus.com
QuickSpec: http://www.igus.com/quickspec

Technical environment:

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

Resistance to radiation

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

igumid G:
UL 94 HB

igumid NB:
UL 94 V2
UL 94 V0

igumid G:

- UV-resistant
- Temperature range from:
  -40°F (-40°C) to
  +248°F (+120°C)

Technical environment and igumid G

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

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

Flammability of igumid G

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

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

Flammability of igumid NB

All E-Z Chains and Series 14 Chains are made from the flame-retardant igumid NB material. These chains have the following flame-retardant classifications:

- UL 94 classification - V2
- VDE 0304 Parts 3-5.70 classification - IIb
- DIN 4102 flammability of materials - B2

Please consult igus regarding material availability "V0."

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

Temperature resistance

igumid G is very suitable for outdoor applications. In our experience, the mechanical properties of the chain are not impaired. igumid G is also UV-resistant. igus® Energy Chains® are used in applications as cold as -40°F (-40°C). Installation may be eventually compromised at temperatures below -13°F (-25°C). In such cases, we offer special solutions made from cold-elastic materials. +248°F (+120°C) continuous temperatures are possible, however, the mechanical values are reduced and the service life is impaired. Please consult igus® if you have specific temperature requirements.

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

ESD & ATEX

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

igumid ESD is RAL 7015 slate-gray.

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

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

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

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

Benefits:

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

Energy Chain System® Design
Cleanroom and ESD

igus® Energy Chain System®
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QuickSpec: http://www.igus.com/quickspec

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

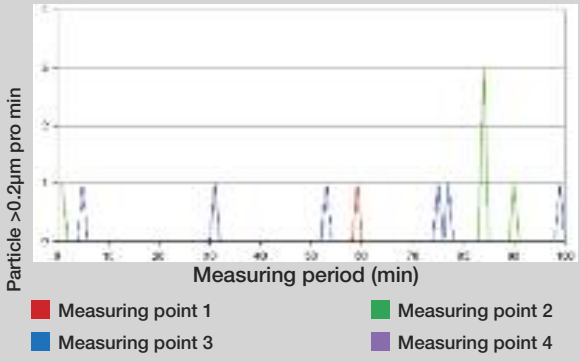
In many applications where cumbersome special solutions are used, a simple standard Energy Chain® can be used instead. A comprehensive test program was devised and performed for both gliding use and unsupported use. For many applications, the Energy Chains® in special materials are practically abrasion-free. Detailed test results are available upon request. IPA tests confirm that standard igus® Energy Chains® meet cleanroom requirements. "Tested and certified as very good!". Clean room applications demand very high wear-resistance of moving parts and Energy Chain® is able to meet this need, even in the extremely sensitive environment.

IPA Fraunhofer Institute has tested igus® Series E6 and E14 as follows:

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

Test setup: particle generation measurement

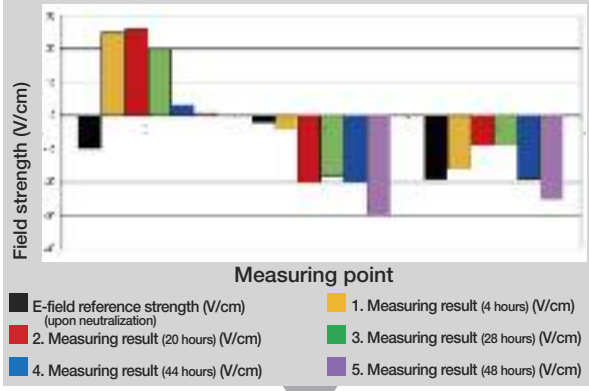
Measurement result: Particle generation E14-3-038-0



ISO Class 2
acc. to DIN EN ISO 14644-1
for E14-3-038-0

Test setup: field strength measurement

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



Level 1
ESD-compatibility acc. to SEMI E78-0998
for E14-3-038-0 and E6-29-050-055-0

Classification chart

Class per DIN EN ISO 14644-1	Equivalent to VDI 2083	Equivalent to US Fed.Std. 209E	Classification Series	Speed (m/s)
ISO class 1	no comparable classification	no comparable classification	E3-15-040-075-0	0.5 / 1.0 / 2.0
ISO class 1	no comparable classification	no comparable classification	E6-29-060-150-0-CR*	0.5 / 2.0
ISO class 2	no comparable classification	no comparable classification	E14-3-038-0	1.0
ISO class 3	class 1	class 1	E6-29-060-150-0	0.5 / 1.0 / 2.0
ISO class 4	class 2	class 10		
ISO class 5	class 3	class 100		
ISO class 6	class 4	class 1,000		
ISO class 7	class 5	class 10,000		
ISO class 8	class 6	class 100,000		

*special material "cleanroom"

Spatter, hot chips

Laboratory tests and numerous field applications over the past 20 years prove that igus®' Energy Chains® and fully enclosed Energy Tubes protect cables used in welding robots and machine tools. For extreme-temperature applications, igus® offers Energy Tubes made from its igumid HT material, which repels hot chips and flying debris reaching 1,562°F (850°C). All standard E2 and E4 Energy Tubes are available made from igumid HT, upon request.

Dirt, dust, chips

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

Vacuum

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

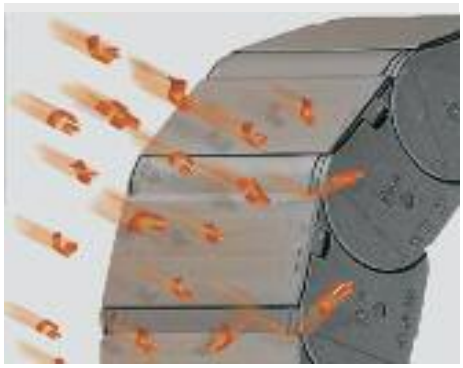
Chemical resistance

igumid G is resistant to fuel, lubricants, oils, fats, alcohol, ester, ketone, and aliphatic and aromatic hydrocarbons. Oxidants and acids are damaging. The **Material Data table on page 1.42** shows an excerpt of the precise details concerning resistance to chemicals. Acid-resistant Energy Chains® are available upon request.

Coolant resistance

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

Table on resistance to chemicals
➤ Page 1.42



Energy Tubes that repel hot chips, up to 1,562°F (850 °C) with the igus® "igumid HT" material.

igus® Energy Tubes in the chip area of machine tools

Also hot asphalt is no problem for igus® Energy Tubes, Series R48

Compost sludge - numerous related references available upon request

Tests with 1,562°F (850°C) hot chips

Particularly suitable Energy Chain® Series for dirt, dust, chips

- E4/4HD
- System E4
- E2 E-Tubes
- E2/000

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Energy Chain System® Design
Material Data

Plastics for longer life® - igus® know-how in plastic materials

Each year, igus® engineers develop more than one hundred new plastic compounds and test igus®-products in more than 5,000 experiments per year. That's how in recent years they have built an extensive database of the tribological properties of polymers. This database makes it possible for us to assess better most of the applications in advance and provide our customer with confidence during use. Our calculations and analyses are based on the result of ongoing practical tests in our Technical Center and our experience with gliding applications. The focal points of our tests are push-pull forces, friction values and abrasion under widely varying conditions and speeds, as well as factors such as dirt, weathering or impact and bumps. We test all system components such as cables, hoses, strain relief and other accessories, in addition to the Energy Chains® or Energy Tubes and Guide Troughs.

igumid material data table	Units of Measure	Values igumid G	Values igumid NB	Values igumid ESD	Values igumid TE
Yield stress	MPa	190/130	78/40	–	–
Elongation at break	%	004/006	20/210	–	–
Elasticity module (tensile test)	MPa	9000/7000	2900/1200	–	–
Impact strength +73°F (+23°C)	kJ/m²	55/65/55	not broken	–	–
Impact strength -40°F (-40°C)	kJ/m²	40	90	–	–
Ball indentation hardness H 961/30	MPa	230/160	150/60	–	–
Heat conductivity W/k * m	Ω/k * m	0.23	–	–	–
Dielectric constant	10^h Hz	3.9/6.2	–	–	–
Special transitional resistance	Ω*cm	$>10^{11}$	$>10^{11}$	$<10^9$	–
Impact strength density 0.6-0.8 mm	kV/mm	80	16-18	–	–
Surface resistance ROA	Ω	$>10^{11}$	$>10^{11}$	$<10^9$	–
Density	g/cm³	1.37	1.14	1.2	1.02
Absorption of humidity 23/50 RF	%	1.4	3.4	1.9	1.1
Coefficient of sliding friction	–	0.3	0.3	0.3	0.3
Fire resistance as per VDE	–	FH2	–	–	–
Fire resistance as per UL	–	HB	V-2	HB	HB
Color	–	≈ RAL 9004	≈ RAL 9004	≈ RAL 7015	≈ RAL 9004
Maximum water absorption	–	5.6	7.6	7.3	–
Limit of elasticity in bending	MPa	7.800	3.000	9.500	–
Bending strength	MPa	240	120	230	–
Hardness Shore D	–	79	79	83	–
Upper long-term application temp	–	248°F (120°C)	176°F (80°C)	176°F (80°C)	158°F (70°C)
Upper short-term application temp.	–	356°F (180°C)	338°F (170°C)	302°F (150°C)	284°F (140°C)
Lower application temp.	–	-40°F (-40°C)	-40°F (-40°C)	-40°F (-40°C)	-40°F (-40°C)

Energy Chain System® Design
Chemical Resistance*

Medium	Concentration Weight %	Material igumid G /NB
Acetone	100	+
Formic acid (aqueous)	2	O
Ammonia (aqueous)	10	+
Gasoline	100	+
Benzole	100	+
Bitumen	100	O
Boric acid (aqueous)	10	+
Butyric acid	100	O
Calcium chloride (aqueous)	Sat. aq. sol.	+
Chlorinated hydrocarbons		+
Chlorine water	Sat. aq. sol.	–
Chromic acid (aqueous)	1	O
Diesel oil	100	+
Iron II cyanide	30	O
Acetic acid	2	+
Color		+
Fats, cooking		+
Fluorinated hydrocarbons		+
Formaldehyde (aqueous)	30	O
Hydraulic oils		+
Caustic potash	10	+

Medium	Concentration Weight %	Material igumid G /NB
Potassium carbonate (aqueous)	60	+
Potassium sulphate (aqueous)	100	+
Methyl acetate	100	+
Milk		+
Mineral oil		+
Sodium carbonate (aqueous)	50	+
Oil, cooking		+
Oil, lubricating oil		+
Oleic acid	100	+
Paraffin oil		+
Perchlorethylene	100	+
Polyester resins (with styrene)		+
Propane gas		+
Mercury		+
Hydrochloric acid	pH2	O
Hydrochloric acid	2	–
Hydrochloric acid	10	–
Ink, printing ink		+
Vaseline		+
Tartaric acid		O
Zinc sulfate (aqueous)	10	+

Resistance classes

+	=	resistant
O	=	conditionally resistant
–	=	non-resistant
Sat. aq. sol.	=	saturated aqueous solution
Conc. aq. sol.	=	concentrated aqueous solution

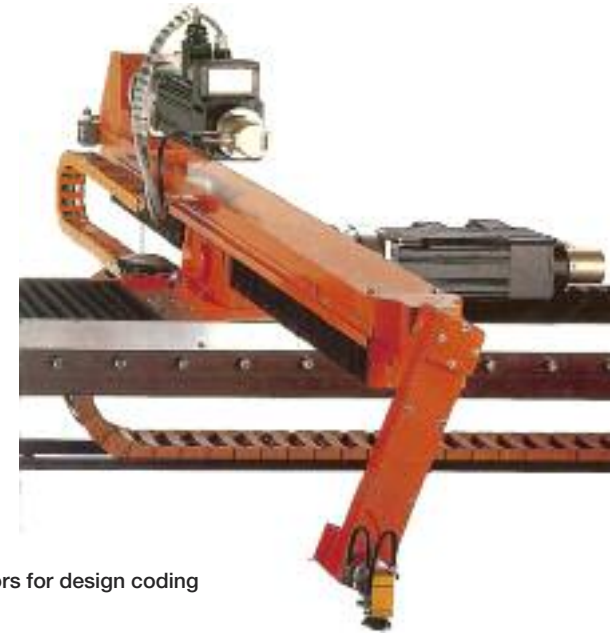
*The values specified are values determined by laboratory tests and are material-specific

Colors and special solutions

All Energy Chains® made from igumid G are available in the colors listed below. Additional colors are usually feasible. Colored Energy Chains® are not available from stock. Contact igus® for more information regarding colored Energy Chains®. Colored Energy Chains® may have altered characteristics. This also applies for all Energy Chains made from special materials (e.g. conductive Energy Chains® made from igumid ESD or other special materials).

"RAL" Numbers

			Part No. Suffix
	Black	≈ RAL 9004	-0
	White	≈ RAL 9003	-1
	Magenta	≈ RAL 4010	-13
	Yellow	≈ RAL 1018	-4
	Orange	≈ RAL 2003	-2
	Red	≈ RAL 3002	-6
	Blue	≈ RAL 5005	-8
	Green	≈ RAL 6011	-7
	Grey	≈ RAL 7023	-3 for Chains
	Silver-grey	≈ RAL 7037	-3 for Tubes
	Grey	≈ RAL 7038	-11
	Light grey	≈ RAL 7035	-14
	Slate-grey	≈ RAL 7015	only ESD-E-Chain®
	Yellow/black	–	-9



Colors for design coding

Energy Chain System® Design Standards and Cetificates

igus® Energy Chain System®
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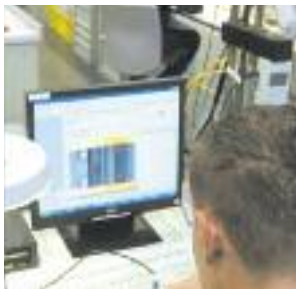
Examples for test certificates and approvals of igus®-products

Certified ISO 9001:2008

ISO 9001:2008

igus® has been certified since May 2002



Quality inspection of every E-Chain® production

TÜV construction test

igus® Energy Chains® and Energy Tubes are construction-tested by TÜV Rheinland. igus® Energy Chains® were tested and passed by TÜV Rheinland in accordance with the valid machine guidelines. As a result, the user of igus® Energy Chains® need not worry about meeting CE requirements through testing for this portion of the machinery.
The construction test 2PFG 1036 / 10/97 for protective equipment includes the following:

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

Test location for ESD-E-Chains®

ESD/ATEX

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

IPA Cleanroom

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

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

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

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

Noise level tests in igus® own acoustic laboratory

Clearly quieter

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

igumid

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

iF Design Award

13 iF Design-Awards since 1984

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