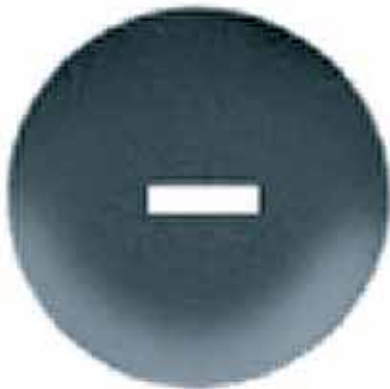


Designing with igus[®]

Calculation tools, diagrams,
and application examples



e-chain system® Design

Table of Contents

Introduction

Designing with igus®	page 1.4
Application examples.....	page 1.5
igus® terminology	page 1.7
Calculation of e-chain® lengths	page 1.8
Camber	page 1.8
System Analysis Worksheet	page 1.9

Applications

Unsupported applications

Short travels	page 1.11
Noise-optimized	page 1.14

Unsupported short travel load charts

e-chains® with fill weights up to 1.01 lbs/ft (1.5 kg/m).....	page 1.15
e-chains® with fill weights up to 6.05 lbs/ft (9.0 kg/m).....	page 1.17
e-chains® with fill weights up to 60.48 lbs/ft (90.0 kg/m).....	page 1.19

Gliding - long travel	page 1.21
Vertical hanging	page 1.25
Vertical standing.....	page 1.27
Zig-zag / liftband	page 1.28
Side-mounted	page 1.29
Rotary motion.....	page 1.31

Filling and Strain Relief

Filling

Cable and hose packages, General Rules	page 1.35
Cable and hose packages, Distribution Rules.....	page 1.36
Strain relief elements - Chainfix.....	page 1.39

Technical Data

igus® Material Data.....	page 1.41
igumid Material	page 1.42
ESD & ATEX	page 1.43
Cleanroom and ESD.....	page 1.45
Dirty Environment.....	page 1.46
Material Data / igumid Colors.....	page 1.47
Chemical Resistance.....	page 1.48
Standards and Certificates	page 1.49

igus® readychain®

readychain® - Ready-to-install pre-assembled e-chain Systems®	page 1.50
readycable - Cable assemblies	page 1.59

igus® Assembly Service

Assembly service - save time and money	page 1.61
--	-----------

e-chain system® Design

Designing with igus®

Introduction

An all-in-one energy supply system - **the-chain**

There are many options to supply your equipment and systems with energy and data. But there is hardly a solution as universal and durable as the e-chain system®. Whether you have a circular motion, a suspended or upright application, a long travel distance, high loads or large cables and hoses - igus® plastic e-chains® will help you solve nearly any type of energy supply problem, quickly, safely and with ease. Whether you wish to reliably guide many large hoses for any type of media, sensitive fiber optic signals over long distances, disruption-free data in torsional movements, or only air at high accelerations, igus® can supply you with the matching energy supply system in addition to the optimally matched chainflex® cables. By tapping into the extensive igus® construction kit, you will find the solution to match your needs and application: from the individual components to the completed installation at your facility. We have developed an online tool to help you find these resources with greater ease ► www.igus.com/the-chain. Should you have trouble finding exactly the product you need, our engineers are always at your disposal to help you design **the-chain**.

On the following pages, we offer important guidelines which are to be taken into consideration when designing safe e-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

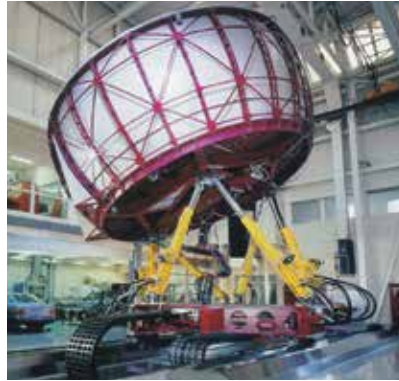
Our calculations and analyses are based on the result of ongoing practical tests in our Technical Center and our experience with gliding applications. The focal points of our tests are push-pull forces, friction values and abrasion under widely varying conditions and speeds, as well as factors such as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



E-Chain System® Design Application Examples



Long travels 1,447 ft. (441 m) with igus® rol e-chain® long travel applications



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



Multi-axis E-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

E-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



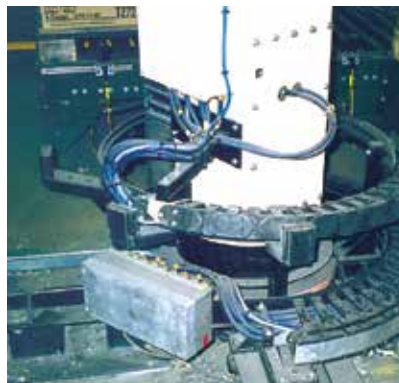
Rotary movement System E4



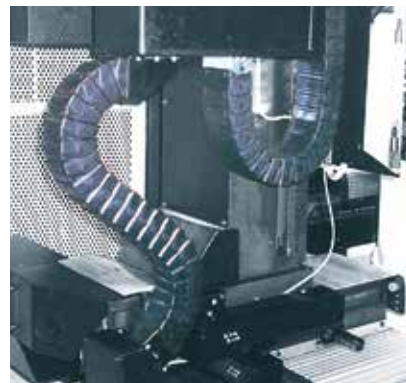
e-chains® side by side as individual or "multiband" j21 Series Zipper



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



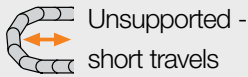
Spiral and rotary movement twisterchain®



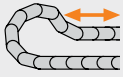
Combined movement Series triflex®

e-chain system® Design igus Terminology and Formulas

Application-Icons



Unsupported -
short travels



Gliding -
long travels



Vertical
hanging



Vertical
standing



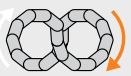
Zig-zag



Side-mounted



Rotary
motion



Continuously
revolving



Horizontal
and vertical



Nested



Side by
side



Combined
motions

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/s ²)
AR	= Outer radius, e-chain®	(in.)
Ba	= Outer e-chain® width	(in.)
Bi	= Inner e-chain® width	(in.)
B_{Ra}	= Guide trough outer width	(in.)
B_{Ri}	= Guide trough inner width	(in.)
D	= Over length e-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 e-chain® height	(in.)
H_F	= Required clearance height	(in.)
hi	= Inner e-chain® height	(in.)
H_{Ra}	= Outer trough height	(in.)
H_{Ri}	= Inner trough height	(in.)
IR	= Inner radius, e-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	= e-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

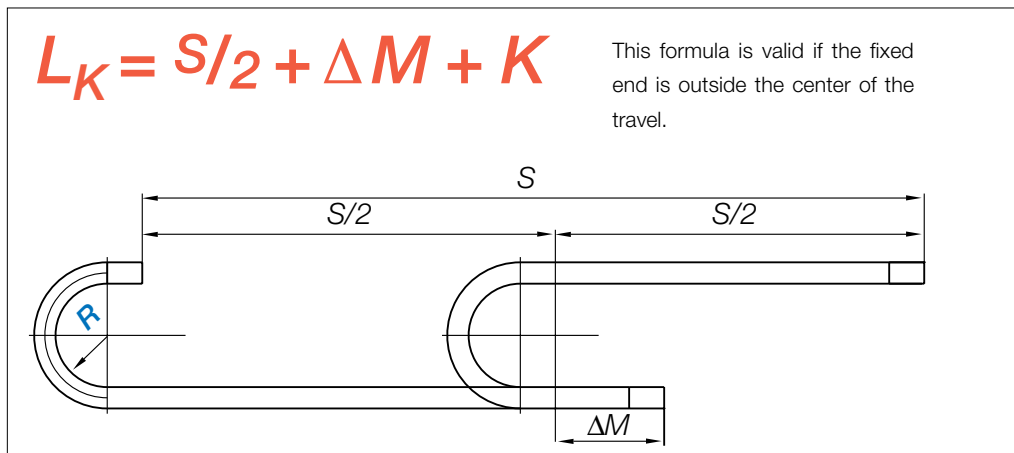
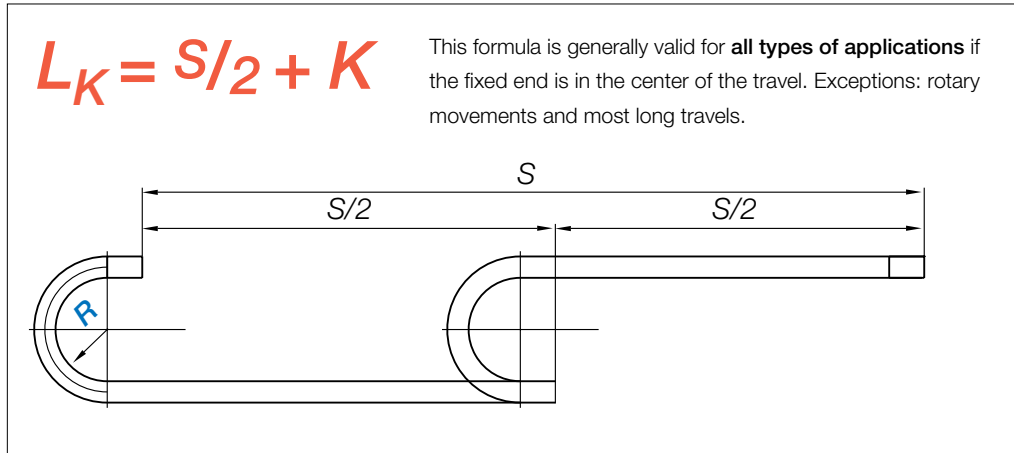
e-chain® Design

Calculation of e-chain® Lengths

Camber

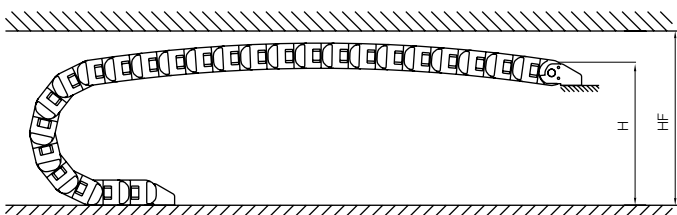
Calculation of e-chain® lengths

If the fixed end of the e-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 e-chain®, cables and hoses.



Camber

"Camber" is the curve of the upper run along its unsupported length. **All igus® e-chains are manufactured with camber, special "no camber" (NC) e-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 e-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 e-chains® without camber for restricted space applications; however, these "no camber" chains do not have the same load-bearing capacity. Please consult igus®.



Principle of camber for igus® e-chains® H_F = required installation height



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

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



"No camber" - Special "NC" e-chains® with no camber are also available. Please consult igus®

H = Nominal clearance height
 H_F = Required clearance height

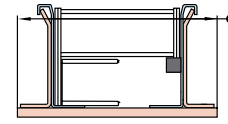
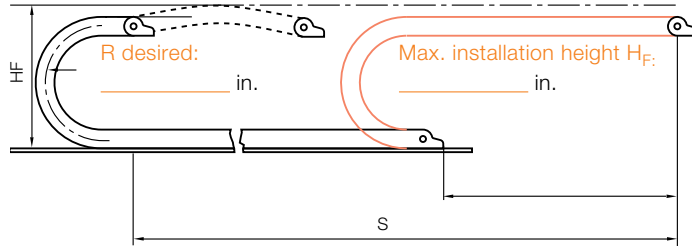
Necessary clearance height depends on the camber of the e-chain®. Find values for necessary clearance height " H_F " on each product page.

e-chain system® Design System Analysis Worksheet

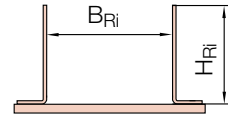
Please supply us with as much application data as possible. Items highlighted in red must be filled out for analysis. You will receive a complete analysis with cable/hose layout proposal and quote by the end of the next business day. Please contact us if you have any questions.

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.): _____

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: _____

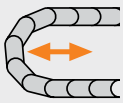
Cables/Hoses

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

Further individual components desired:

- | | | | |
|--|--------------------------|-------------------------|--------------------------|
| e-chains® / e-tubes | <input type="checkbox"/> | e-chain® | <input type="checkbox"/> |
| chainflex® cables/special conduits | <input type="checkbox"/> | e-tube | <input type="checkbox"/> |
| Guide troughs | <input type="checkbox"/> | To be opened: | |
| Strain relief | <input type="checkbox"/> | On both sides | <input type="checkbox"/> |
| Harnessing | <input type="checkbox"/> | Along the outer radius | <input type="checkbox"/> |
| On-site assembly | <input type="checkbox"/> | Along the inner radius | <input type="checkbox"/> |
| Other: _____ | | Special requests: _____ | |
| Please copy, fill in and fax. Thank you. | | igus® System guarantee? | <input type="checkbox"/> |

e-chain system® Design
Use this page for your drawings

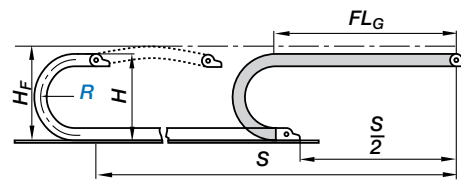


e-chain system® Design

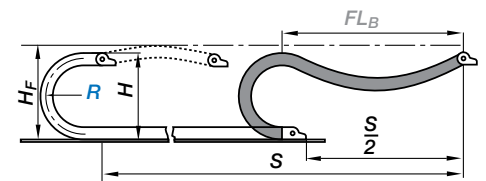
Unsupported, Short Travel Applications



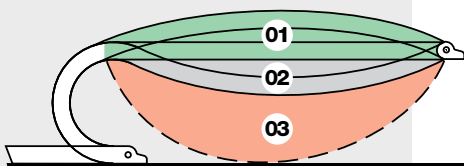
The FL_G type of installation always generates the longest service life and can be operated with the maximum values for speed and acceleration.



FL_G unsupported straight length



FL_B unsupported length with sag



- 01) Unsupported with straight upper run FL_G

Unsupported applications

If the upper run of the e-chain® operates without touching the lower run over the entire travel, it is called and “unsupported” application. The distance between the moving end and the beginning of the radius curve of the e-chain® is called the “unsupported length”. The unsupported application is the most common. igus® e-chains® are very well suited for high dynamics and long service life. The maximum unsupported length is dependent upon the fill weight and the type of e-chain® or e-tube. As a result, we differentiate among three types of unsupported length:

01) Unsupported with “straight” upper run FL_G

The FL_G e-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 e-chain® runs quietly and is not exposed to any additional vibration.

02) Unsupported with permitted sag FL_B

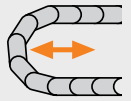
The FL_B e-chain® applies when the sag amounts to more than .39”-1.97” (10-50 mm), depending on the chain size, and less than a defined maximum sag. This maximum sag is dependent on the type of chain. The FL_B application is technically permissible in many cases. It becomes problematic if the acceleration 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 e-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 e-chain®/tube should be replaced at that time.

e-chain system® Design

Unsupported, Short Travel Applications



For every igus e-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 e-chain® for your fill weight and travel distance
- Identifying the maximum load for the selected e-chain®

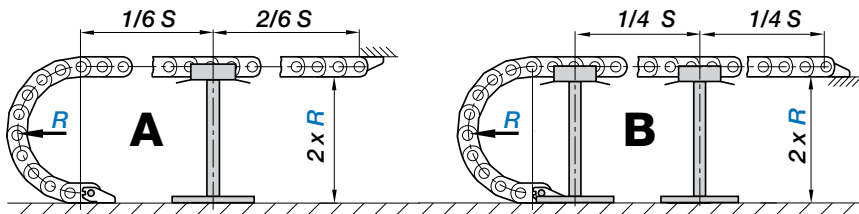


Example of unsupported with FL_B sag

What to do if the unsupported length is insufficient:

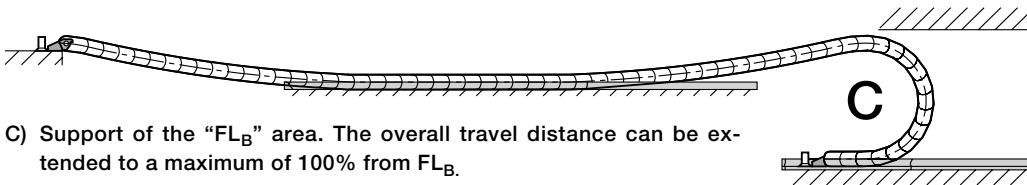
If your application, fill weight and travel fall outside the “unsupported length” parameters of the desired e-chain®, you have the following options:

- Select a more stable igus® e-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 e-chains® inside one another (please consult igus® regarding these options)
- Design the travel distance as a “gliding application” (see page 1.x).

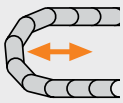


Support of the “FL_G” area.

- A) The overall “straight, unsupported travel can be increased along the upper run by a maximum of 50% of the FL_G and
- B) along the lower run by a maximum of 100%.



- C) Support of the “FL_B” area. The overall travel distance can be extended to a maximum of 100% from FL_B.



e-chain system® Design

Unsupported, Short Travel Applications

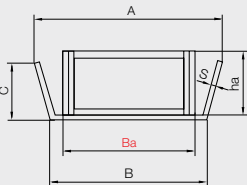


We recommend pivoting mounting brackets as standard. We also recommend locking mounting brackets as standard if high speeds > 65.6 ft/s (20 m/s) or accelerations > 65.6 ft/s² (20 m/s²)

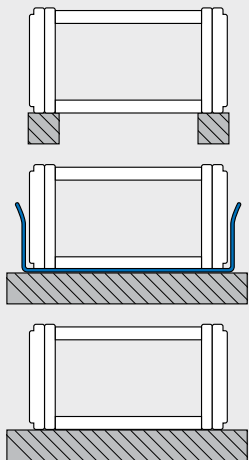


Standard values of maximum speed and acceleration

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/s ² (m/s ²)	656 (200)	19.69 (6)
a peak ft/s ² (m/s ²)	2572 (784)	–



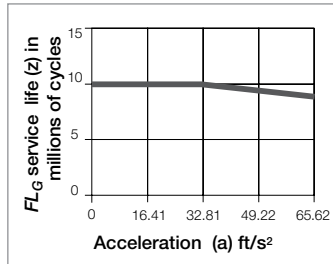
- Ba = chain outer width
- A = B + .39" (10)
- B = ba + .20" (5)
- C = ha/.08" (2)
- S = .06" - .12" (1.5 - 3)



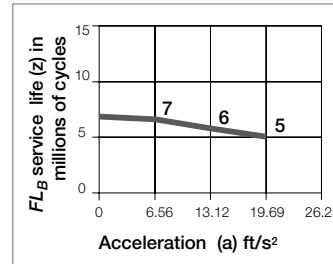
Different surfaces and guide troughs are possible

Speed and acceleration, service life

For unsupported applications, the acceleration (a) is the critical parameter. High acceleration can cause the e-chain® to vibrate and reduce its service life. This is a particular danger if the e-chain® already has a sag greater than the FL_G value. Maximum values for acceleration speed and service life are achieved only with e-chains® incorporating the FL_G (unsupported, straight) design. FL_G designed igus e-chain systems® can sustain very high loads. To date, a peak acceleration of 2,572 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 e-chains® and e-tubes. It is crucial to determine whether the application will be designed as unsupported, straight FL_G or unsupported, with sag FL_B.



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



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

Load-bearing surfaces

Unsupported e-chains® normally require some type of surface on which the lower portion of the chain runs. As the drawings on the left 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 e-chain® path.

Mounting Brackets

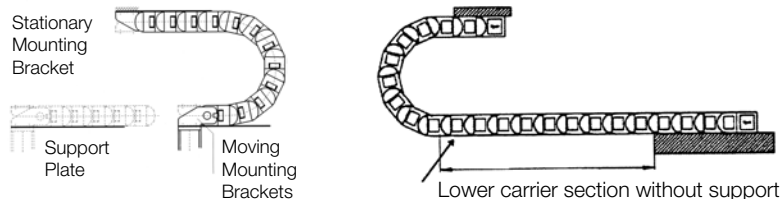
We recommend pivoting mounting brackets as standard for unsupported applications. Pivoting mounting brackets compensate for the camber, can be installed more easily and decrease the load on the first e-chain® link in operation. **Exception:** If the acceleration is greater than 65.6 ft/s² (20 m/s²) or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

Horizontal Inverted

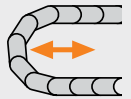
e-chains® without support along the lower run have restricted use. An e-chain® is said to be "horizontal inverted" when the stationary end is positioned on the top and the moving end is positioned on the bottom. Care must be taken to assure the maximum unsupported inverted span (FL_U) is not exceeded. A support plate behind the moving end bracket may be necessary to prevent cantilevered loading and potential wear or breakage. If the lower run of the e-chain® cannot be supported over the whole length of travel, please contact igus® with your application information and we will be happy to specify a chain for you.



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



e-chain system® Design Unsupported, Noise-Optimized



Unsupported, noise optimized

The igus® program offers you optimal noise-reduction e-chains®. The table below briefly illustrates the differences in noise levels among various e-chains®. In addition to the e-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 e-chain system® for your application.

System T3 ≤ 33 dB(A)

Optimal smoothness of motion was the prime development goal, as well as making it an economic solution. The igus® T3 e-chain® is very flexible and runs -due to the special geometry- very smooth. A measurement indicates a value of ≤ 33 dB(A) at 1 m/s and with an unsupported length with series **T3.29.050.038.0**, and all this with a sound pressure level generated by external noise.

System E3 ≤ 38 dB(A)

Long-term tests in the igus® acoustic laboratory showed reductions of 19-20 db(A) compared with standard e-chains®, measured at a speed of 1.8 m/s and an acceleration of 3 m/s². Figure determined in the igus® laboratory in accordance with DIN 45635, taking into consideration background noises, for the series **E3.22.060.044.0**.

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.

System E4 ≤ 46 dB(A)

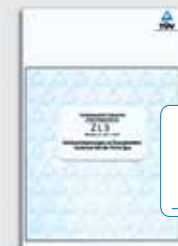
A measurement by the Rhineland Technical Inspection Authority (TÜV Rheinland) for **System E4/101, Series 220-100-200-0** indicates a value of 46 dB(A) at 4.92 ft/s (1.5 m/s) with an unsupported length.

igus® Series	System	Average of the corrected sound pressure levels	Test method (unsupported)
E61-29	E6-1	= 32 dB(A)	3.28 ft/sec (1.0 m/s)
T3-29	T3	= 33 dB(A)	3.28 ft/sec (1.0 m/s)
E3-22	E3	= 38 dB(A)	5.91 ft/sec (1.8 m/s)
E6-52	E6	= 46 dB(A)	6.56 ft/sec (2.0 m/s)
ES4-42	E4-1	= 46 dB(A)	3.28 ft/sec (1.0 m/s)
E4-42	E4-1	= 50 dB(A)	3.28 ft/sec (1.0 m/s)
255	E2 Medium	= 53 dB(A)	4.92 ft/sec (1.5 m/s)
Competitors Product		Average sound levels	Test method (unsupported)
Chain 1 Third party product		= 77 dB(A)	6.56 ft/sec (2.0 m/s)
Chain 2 Third party product		= 68 dB(A)	6.56 ft/sec (2.0 m/s)
Chain 3 Third party product		= 73 dB(A)	6.56 ft/sec (2.0 m/s)

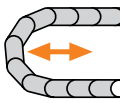
Source: TÜV Rheinland, except series E3-22 - source: igus® laboratory



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



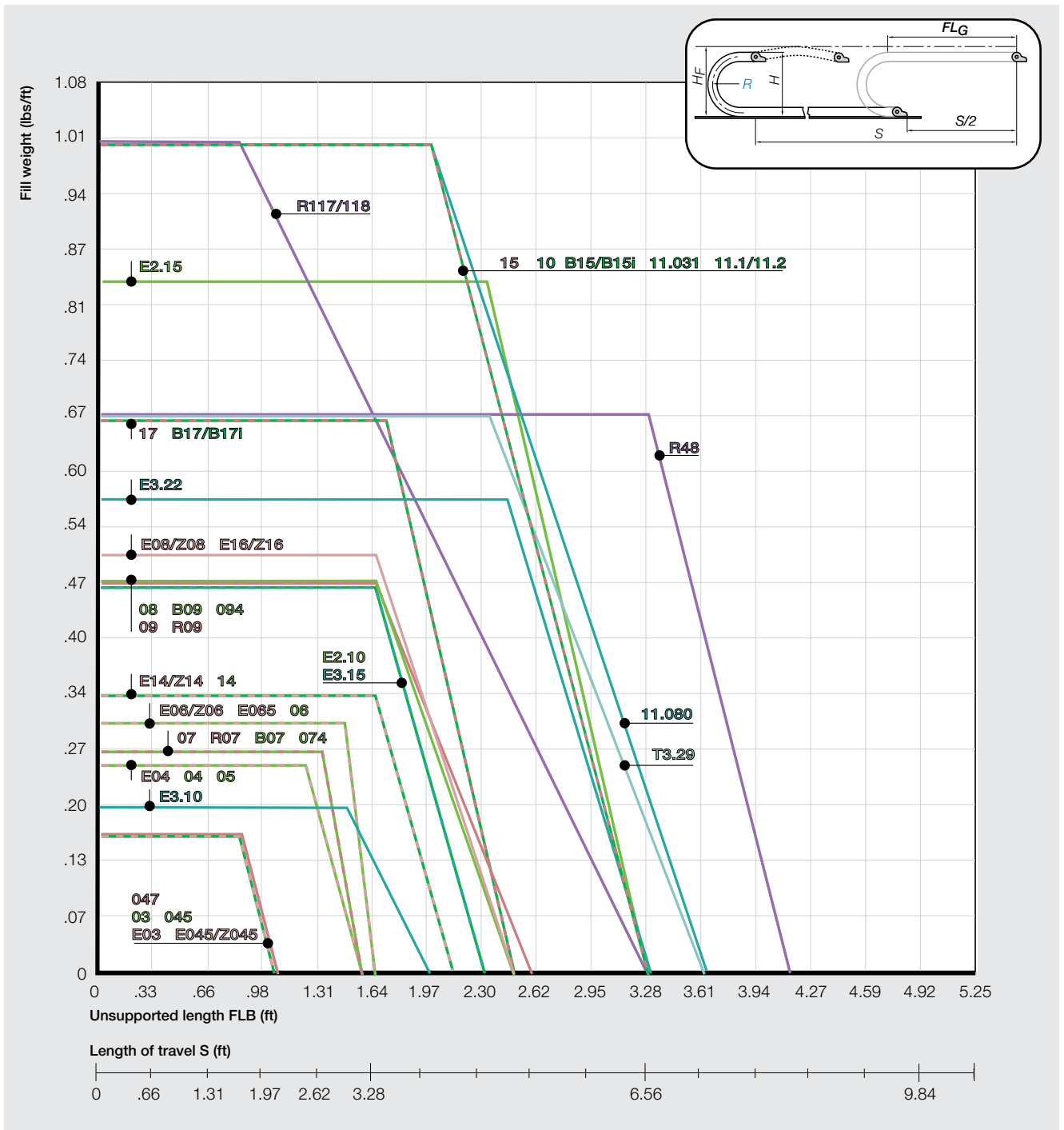
We have received an official certificate from the Rhineland Technical Inspection Authority (TÜV Rhineland Berlin Brandenburg). A copy is available upon request.



e-chain system® Design

Unsupported, Straight FL_G

Fill weights up to 1.01 lbs/ft (1.5 kg/m)



i Important information

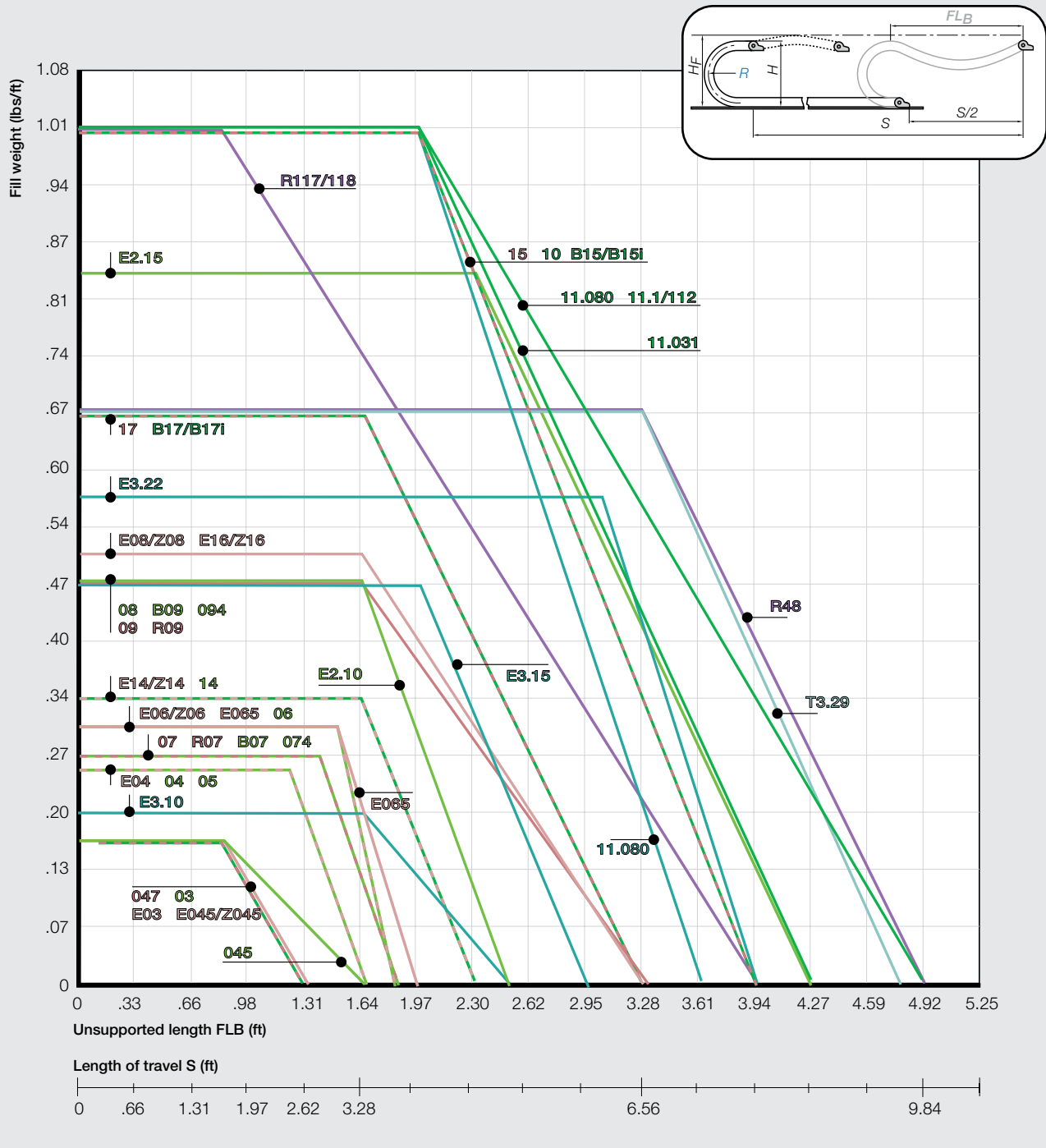
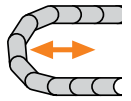
- Fill weight - Weight of all cables and hoses, including contents (for media hoses) within the e-chain®, typically given (lbs/ft)
- FL_G - unsupported e-chain® with straight upper run
- FL_B - unsupported e-chain® with permitted sag
- To the right of the FL_B graph of the diagram, the application is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

These values are essential for:

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

e-chain system® Design
Unsupported, Sag FL_B
Fill weights up to 1.01 lbs/ft (1.5 kg/m)



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

e-chain® length: $L_K = S/2 + K$

S = Length of travel

R = Bending radius

H = Nominal clearance height

H_F = Required clearance height

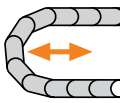
$K = \pi \cdot R +$ "safety buffer" Add-on for bending radius

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

Diagram Series

E1	chapter	E2R100	chapter	E3	chapter
E-Zchain®	chapter	E2R	chapter	E6-1	chapter
zipper	chapter	R2-1	chapter	E6	chapter
E2 micro	chapter	RX	chapter	e-skin®	chapter
E2 mini	chapter	E4-1L	chapter	TH3	chapter
E2-1 micro	chapter	E4-1	chapter		
E2-1	chapter	E4/light	chapter		
E2/000	chapter	T3	chapter		

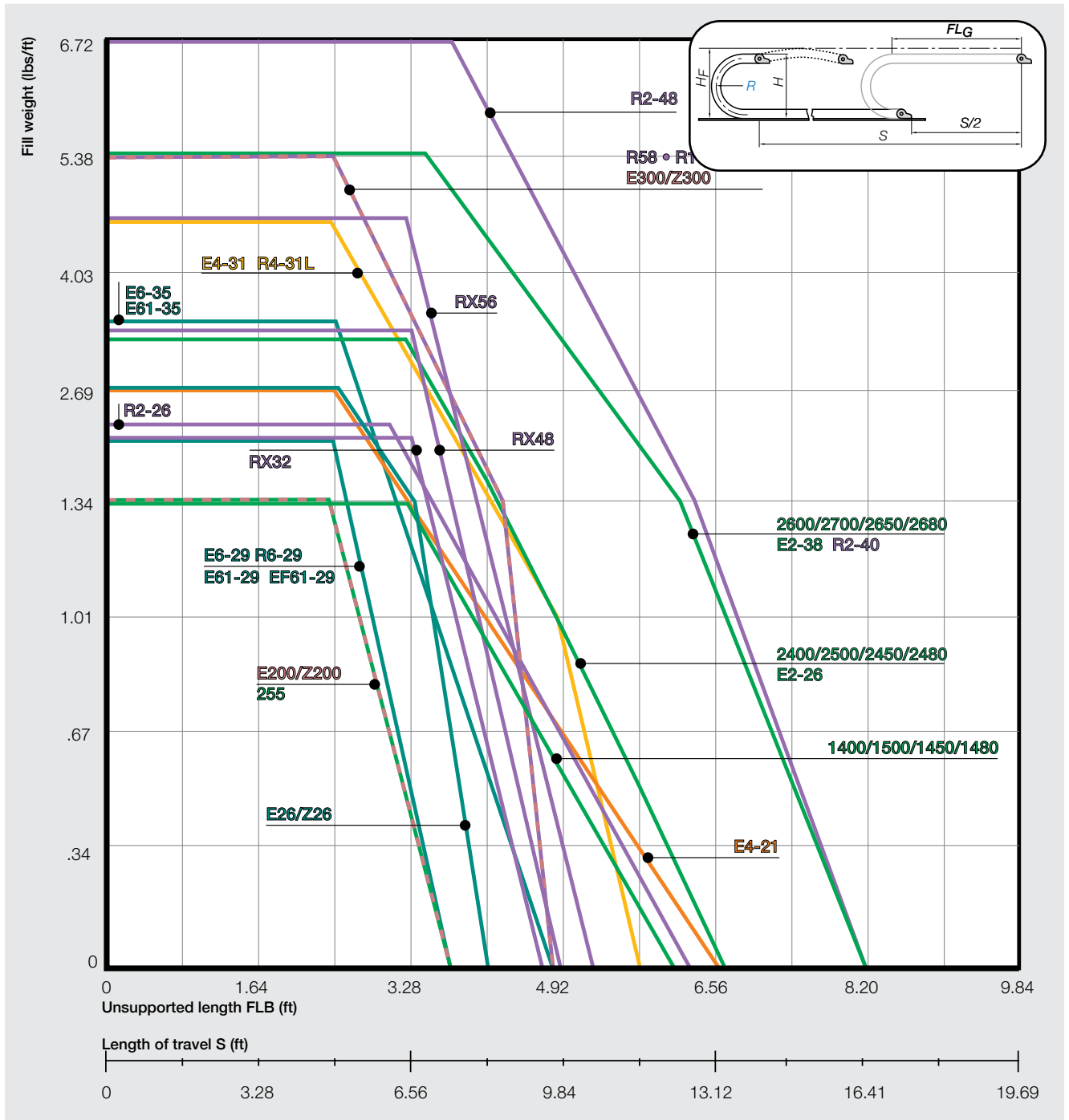
You will find the diagrams for each series listed individually in the catalog



e-chain system® Design

Unsupported, Straight FL_G

Fill weights up to 6.05 lbs/ft (9.0 kg/m)



Important information

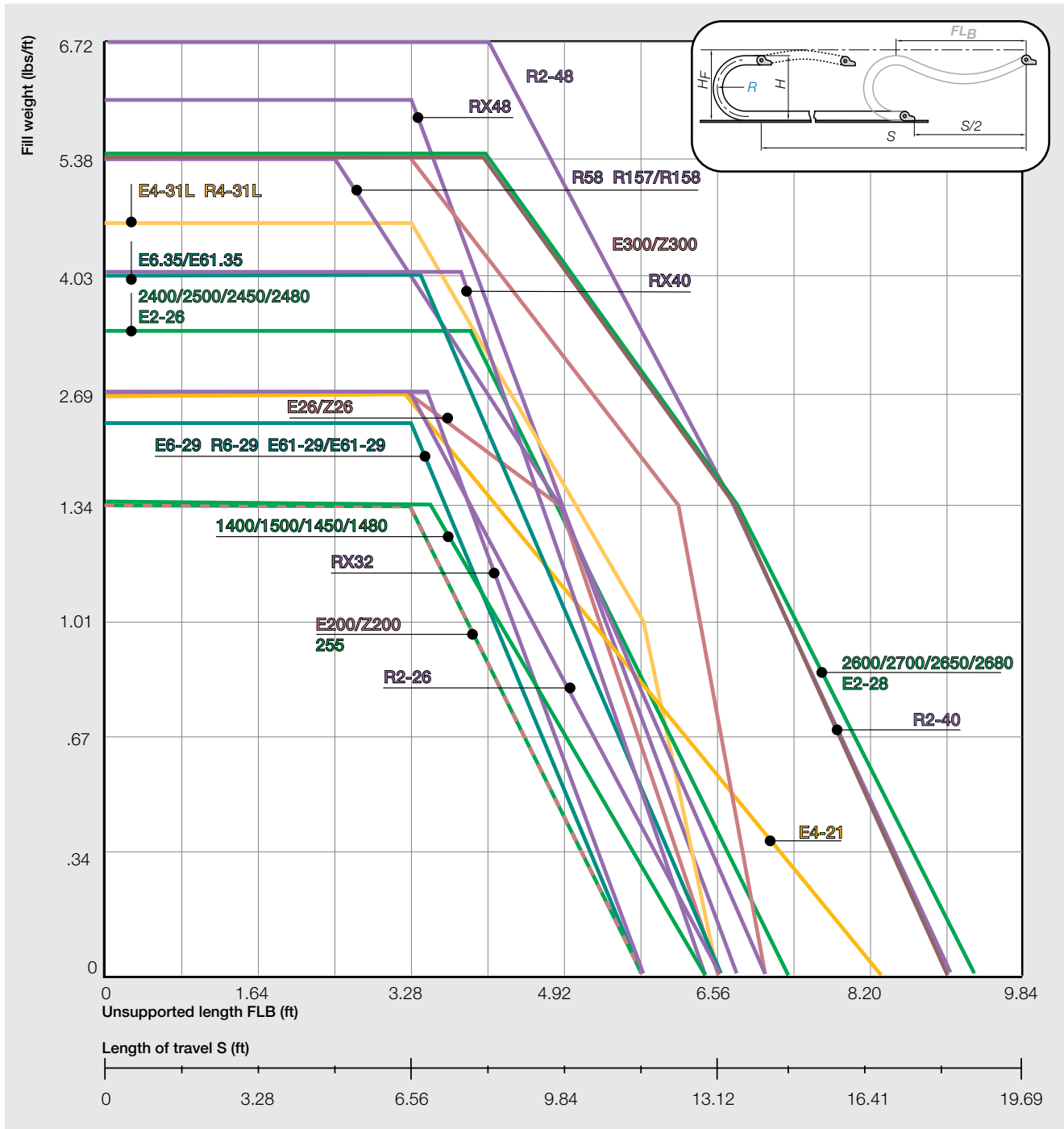
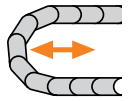
- Fill weight - Weight of all cables and hoses, including contents (for media hoses) within the e-chain®, typically given (lbs/ft)
- FL_G - unsupported e-chain® with straight upper run
- FL_B - unsupported e-chain® with permitted sag
- To the right of the FL_B graph of the diagram, the application is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

These values are essential for:

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

e-chain system® Design
 Unsupported, Sag FL_B
 Fill weights up to 6.05 lbs/ft (9.0 kg/m)



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

e-chain® length: $L_K = S/2 + K$

S = Length of travel

R = Bending radius

H = Nominal clearance height

H_F = Required clearance height

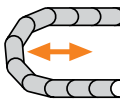
$K = \pi \cdot R +$ "safety buffer" Add-on for bending radius

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

Diagram Series

E1	chapter	E2R100	chapter	E3	chapter
E-Zchain®	chapter	E2R	chapter	E6-1	chapter
zipper	chapter	R2-1	chapter	E6	chapter
E2 micro	chapter	RX	chapter	e-skin®	chapter
E2 mini	chapter	E4-1L	chapter	TH3	chapter
E2-1 micro	chapter	E4-1	chapter		
E2-1	chapter	E4/light	chapter		
E2/000	chapter	T3	chapter		

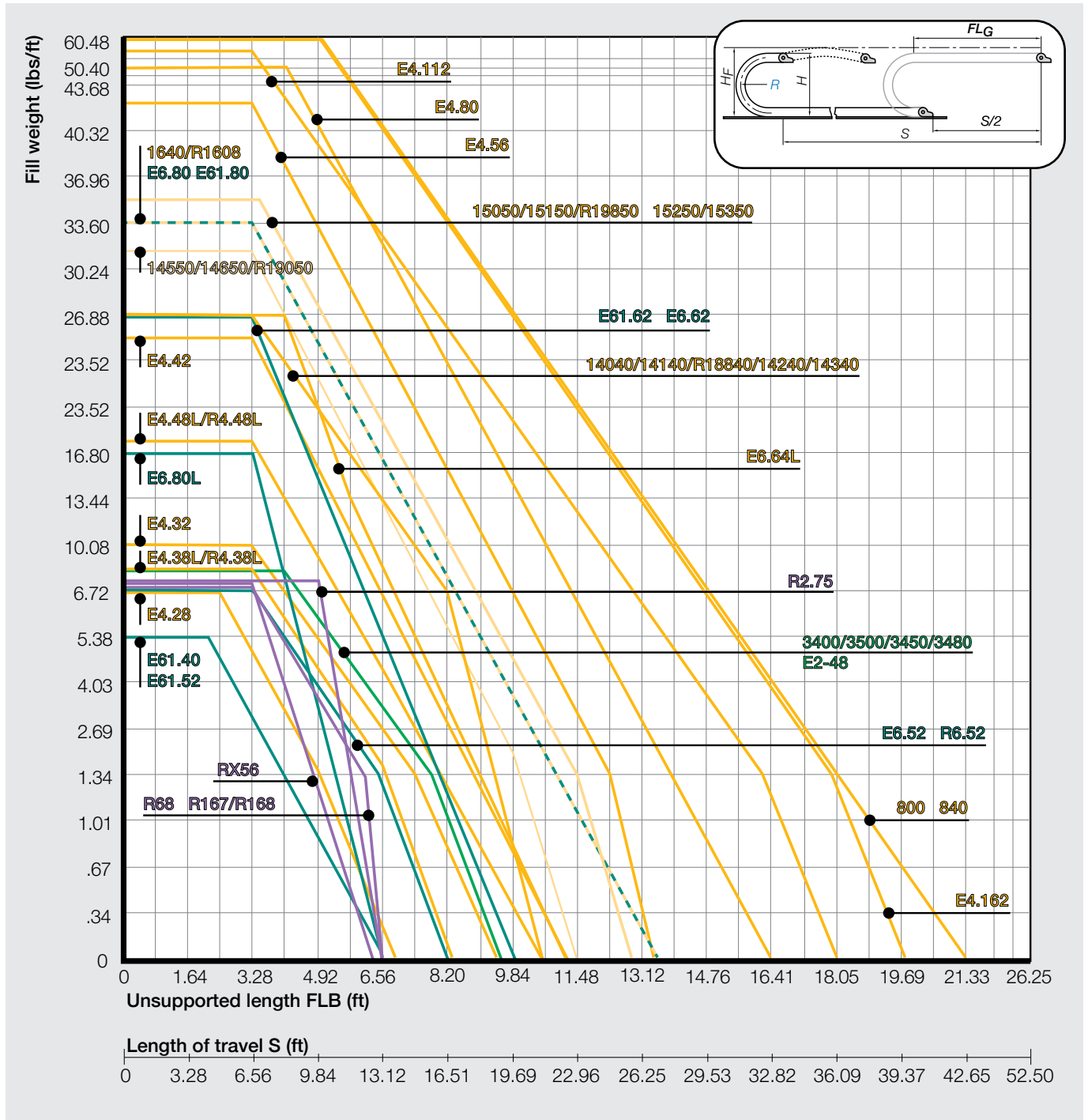
You will find the diagrams for each series listed individually in the catalog



e-chain system® Design

Unsupported, Straight FL_G

Fill weights up to 60.48 lbs/ft (90.0 kg/m)



Important information

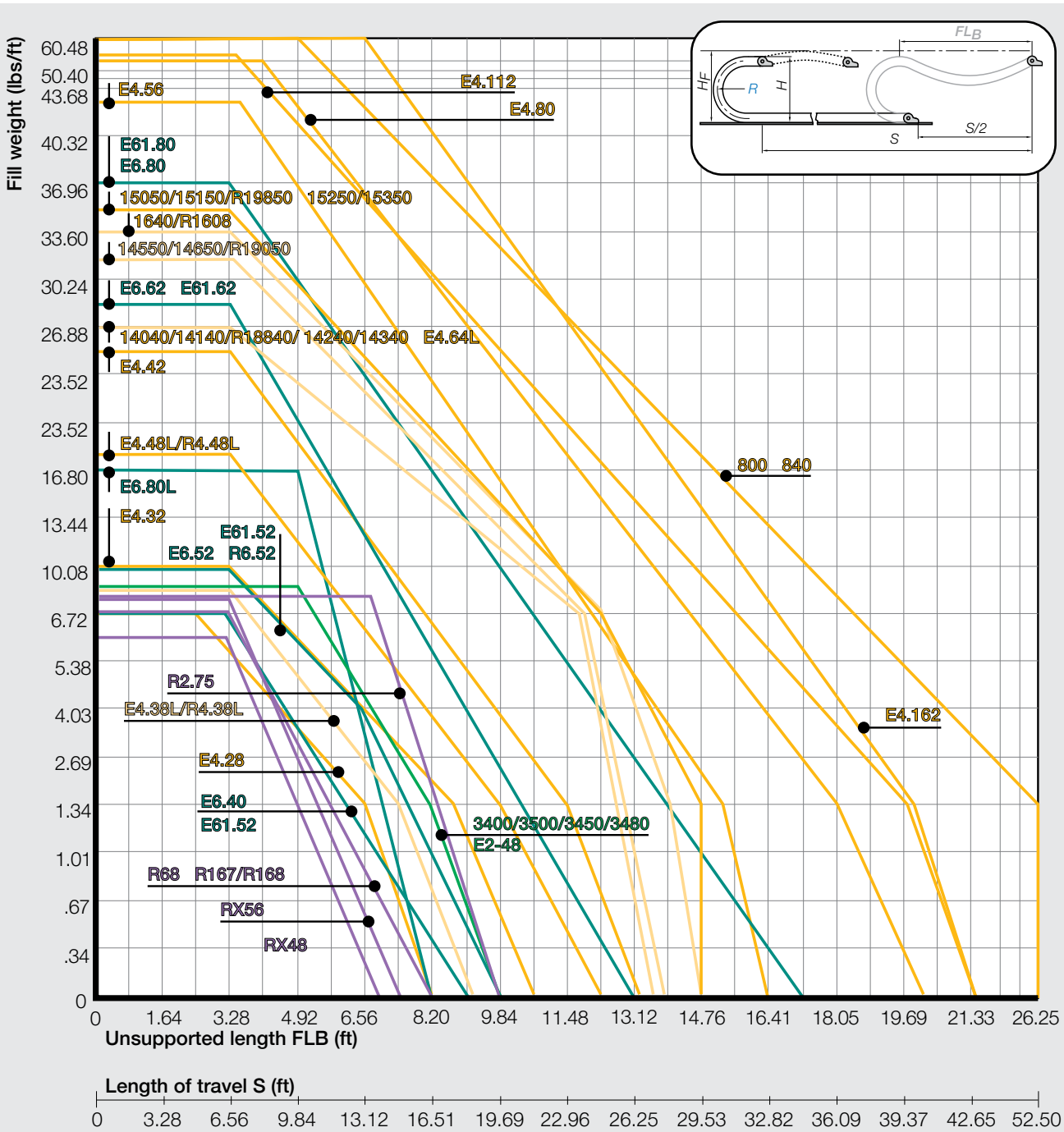
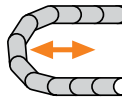
- Fill weight - Weight of all cables and hoses, including contents (for media hoses) within the e-chain®, typically given (lbs/ft)
- FL_G - unsupported e-chain® with straight upper run
- FL_B - unsupported e-chain® with permitted sag
- To the right of the FL_B graph of the diagram, the application is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

These values are essential for:

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

e-chain system® Design
Unsupported, Sag FL_B
Fill weights up to 60.48 lbs/ft (90.0 kg/m)



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

e-chain® length: $L_K = S/2 + K$

S = Length of travel

R = Bending radius

H = Nominal clearance height

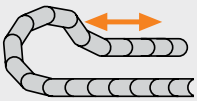
H_F = Required clearance height

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

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

Diagram Series

E1	chapter	E2R100	chapter	E3	chapter
E-Zchain®	chapter	E2R	chapter	E6-1	chapter
zipper	chapter	R2-1	chapter	E6	chapter
E2 micro	chapter	RX	chapter	e-skin®	chapter
E2 mini	chapter	E4-1L	chapter	TH3	chapter
E2-1 micro	chapter	E4-1	chapter		
E2-1	chapter	E4/light	chapter		
E2/000	chapter	T3	chapter		



e-chain system® Design Gliding, Long Travel Applications



Recommended ratio of e-chain® inner width B_i and bending radii R (on long travels)

The minimum inner widths of an e-chain® on long travels depends on the bending radii of the e-chain®.

igus® specifies: $B_{i_{min.}} = R/4$

Please contact igus® if you have large bending radii on long travel lengths.



Example of lowered mounting height

Gliding applications principle

For long travels, the upper run of the igus® e-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 e-chain® length is calculated as follows: $L_K = S/2 + K_2$. Depending on the technical data and the selected e-chain®, the mounting point of the moving end of the e-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.

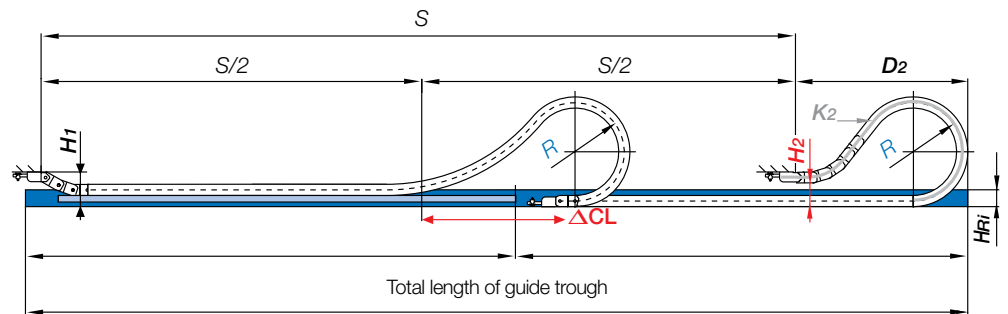
For center mounted applications, e-chain® length:

$$L_K = S/2 + K$$

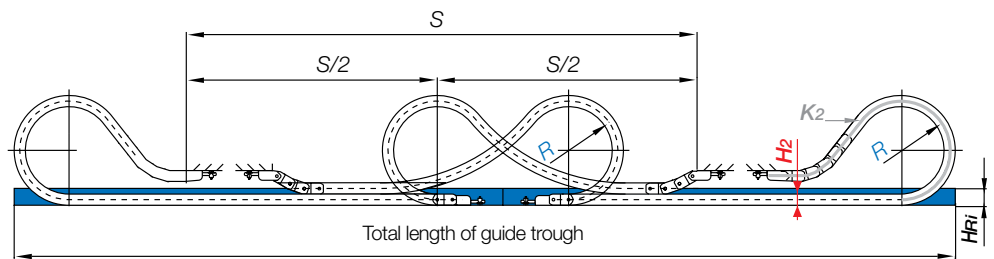
- S = Length of travel
- $S/2$ = half Length of travel
- R = Bending radius
- H_{Ri} = Trough inner height
- H_F = Required clearance height
- K_2 = Add-on if the mounting bracket location is set lower (specified by igus®)
- D_2 = Over length for long travels gliding
- H_2 = Installation height with lowered mounting



Long travel with E4 rol e-chain®, guided in a igus® steel guide trough



The function of an e-chain system® for gliding applications (schematically)
The fixed end of the e-chain® is located in the center of the travel distance



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

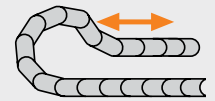


Advantages lowered moving end:

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

e-chain system® Design

Gliding, Long Travel Applications



Advantages for long travel applications with igus® e-chains®

- 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® e-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



E4 e-chain® with extension links for many cables and large hoses on a long travel application



Gliding applications = pivoting mounting brackets

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) | ● Type and number of cables and hoses |
| ● Travel speed (ft/min) or (ft/s) | ● Required bending radius (in.) or (mm) |
| ● Acceleration (ft/s ²) | ● Cycle frequency (n/day or n/hour) |
| ● Fill weight (lbs/ft) | ● Technical environment. |
| ● Maximum cable/hose outer diameter (in.) or (mm) | |

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



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

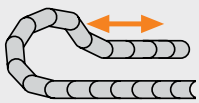
Trends in long travel applications

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 e-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 e-chains®. We have recently extended this technology to large e-chains® and currently offer travels up to 328 ft (100 m).
- Long travels with very small e-chains, for example, the igus “flizz” offers the guidance of a single bus cable inside a small e-chain with high acceleration on long travel applications.



Longest igus® travel of 2,018 ft (615 m) with rol-e-chain and chainflex® cables



e-chain system® Design Gliding, Long Travel Applications



If the fixed point is in the center of the travel, use half of the guide trough with glide bars and the other half of the guide trough without glide bars

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

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



Ba = e-chain® outer width

Bi = e-chain® inner width

ha = e-chain® outer height

H_{Ri} = inner trough height

B_{Ri} = inner trough width

(depending on Ba)

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

$$B_{Ri} = Ba + 4$$

(Aluminum SuperTrough)

$$B_{Ri} = Ba + 5$$

(Steel guide trough)



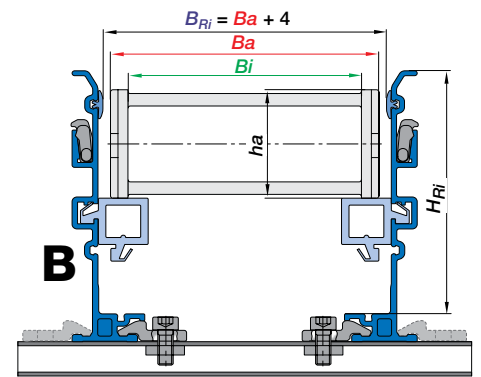
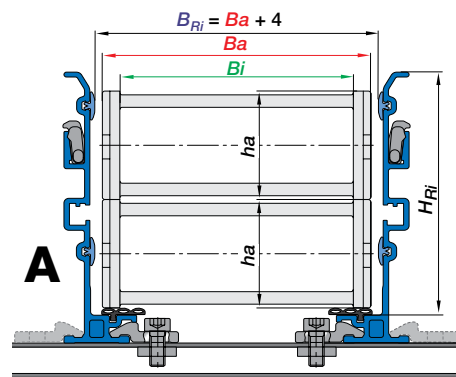
Guide troughs

Guide troughs are used for long travels. They allow igus® e-chains® and e-tubes to continue smooth low-friction operation in these long travel situations. 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 .16 (4 mm) for Aluminum SuperTrough and plus .20" (5 mm) for Steel Guide Trough. 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 e-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

These points must be observed when using assembly-friendly igus® guide troughs



A) Aluminium SuperTrough without glide bars - upper run glides on the lower run

B) Aluminium SuperTrough with glide bars.

We recommend the use of igus® polymer glide bars. They are optimally matched to the e-chain® material and achieve the lowest values for friction, noise and wear.

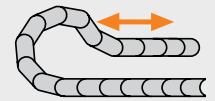
Glide friction values for igus e-chains® made of igamid G and various glide bars:

igamid 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

e-chain system® Design

Gliding, Long Travel Applications



Travel speeds and accelerations

Travel speeds up to 19.7 ft/s (6 m/s) in continuous operation are possible and in use on current applications. In special cases, up to (10 m/s) are possible after consultation with igus®. For example, E4 Series e-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® e-chains® prove to be very durable.



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)

Service Life

We offer service life calculations for your application based on our extensive gliding application experience. As developers of plastic bearings, we possess vast material behavior knowledge which we apply to the development of e-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 15 years with almost no maintenance. (Please consult igus® for references and calculations for your project.) The maintenance-free aspects of igus® e-chain systems® over long periods and under harsh operating conditions is often the deciding factor in choosing igus. Our system guarantee (depends on the application) provides additional peace of mind.

Technical environment

Long travel applications using igus e-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.

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 calculate your application based on these factors, we will perform a practical test for you in our laboratory. Please consult igus®.

Technical data - gliding applications

Travel max	1,969 - 2,625 ft (600-800m)	
Travel speed max	32.8 ft/s (10 m/s)	
Travel acceleration max	164 ft/s² (50 m/s²)	depending on application, please consult igus®
Fill weight max	47.04 lbs/ft (70 kg/m)	depending on application, please consult igus®

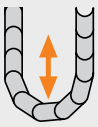


Corrosion-free guide troughs are available in the material:

- Normally galvanized
- Stainless steel
- Seawater resistant
- Aluminum



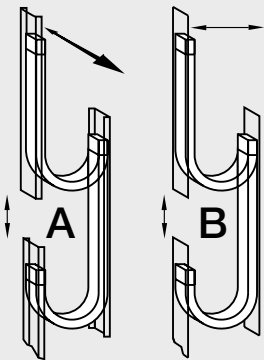
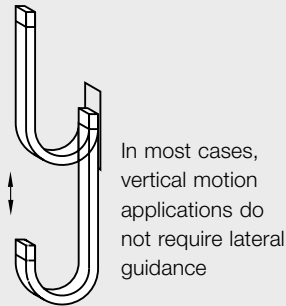
Long travel “off the reel.” Up to 328 ft (100 m) travel pre-assembled and ready to install



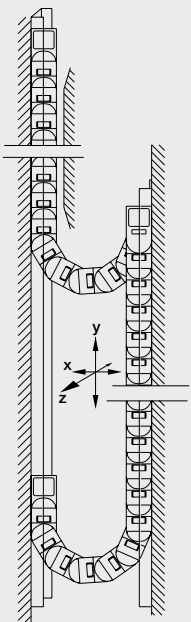
e-chain system® Design Vertical, Hanging Applications



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



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



Principle of a hanging igus® e-chain® with lateral guidance, lateral accelerations in both directions are contained



Vertical, hanging applications

In accordance with the principle of hanging applications, heights of over 328 ft (100 m) are possible with igus® e-chains®. e-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 and/or hoses lay in the e-chain® and how they are secured at the end points: all cables and hoses must bear their own weight when hung. The e-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 e-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.**



Hanging assembly with one-sided U profile

Vertical motion without lateral acceleration

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

Vertical motion with lateral acceleration

In most cases where lateral acceleration occurs, lateral guidance of the e-chain® must be provided. The diagram shows an example of such guidance. Partial guidance is also an option, however, it must at least cover the area in which the e-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 e-chain® helps to stabilize the chain further.

e-chain system® Design Vertical, Hanging Applications guidelok Slimline P

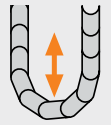
No camber version with igus® special NC e-chains®

A normal igus® e-chain® with camber is suitable for hanging use if enough space is available. Camber contributes to the quiet operation of the e-chain®, required by the slightly bulbous appearance a little more space. If there is not enough room, a “no camber” e-chain® must be installed. This is frequently the case with storage and retrieval systems in narrow aisles. igus® offers numerous NC versions without camber. With igus® E4-1 it is easy to create a NC-version. Simply rotate the e-chain® outer link 180°. (NCST - No Camber Standard)

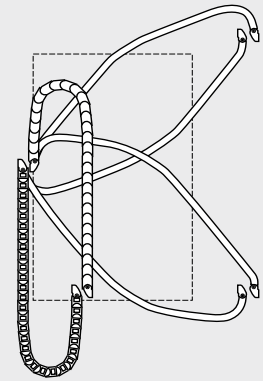
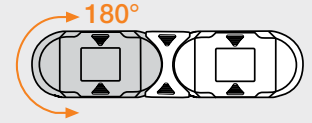
Order example: **E4-32-10-175-0-NCST** (No Camber)



The E4-1 system is one of igus® best solutions for hanging applications



With E4-1 it's easy to create a NC-version. Simply rotate the e-chain® outer link



Hanging and standing igus® e-chain systems® can reach different points

Technical data - vertical, hanging

Travel height max.	328 ft (100 m)	
v max.	65.6 ft/s (20 m/s)	dependent on height and strength of the e-chain®
a max.	164 ft/s ² (50 m/s ²)	dependent on height and strength of the e-chain®

Special solution guidelok slimline P - safe and fast vertical guidance

- Up to 23 ft/s (7 m/s) and 32.8 ft/s² (10 m/s²)
- Up to 80% less trough required, saving costs and weight
- For hanging systems up to 164 ft. (50 m)
- No swinging of the e-chain®, high reliability due to the locking mechanism and guiding rails
- Faster and easier installation
- Reduced noise
- Easy access for servicing
- Energy and data and all kinds of media are safely guided

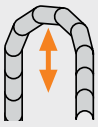


More information ► Chapter 9



igus® guidelok slimline P vertical guidance in a high-bay warehouse

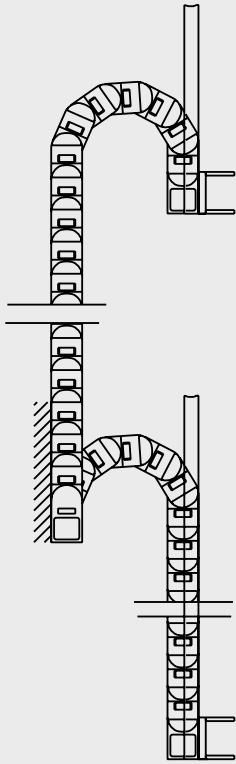




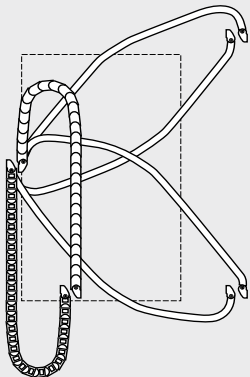
e-chain system® Design Vertical Standing Applications



We recommend locking mounting brackets for standing applications



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.



Hanging and standing igus® e-chain systems® can reach different points



Locking KMA mounting brackets can be directly attached flush to the machine



Standing application with support of the first chain links; R68 e-tube

Vertical standing applications

Standing applications are standard on many machines and plants. Cables will be guided safely in vertical strokes.

Mounting brackets

The mounting brackets must be attached so that the e-chain® cannot bow out.

The igus® program offers locking or one-sided locking mounting brackets for almost all types of e-chains®. 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 separation elements. Cables must be strain relieved at both ends

Lateral acceleration

If lateral acceleration occurs, the e-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 entire distance must often be supported. Due to the wide variety of combinations involving weights, stroke heights, e-chain® types and bending radii, we strongly recommend you consult igus® for design assistance.

Combined movements

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



For higher e-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.

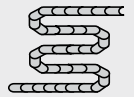
With lateral acceleration, the e-chain® must be supported and, depending on the direction of this acceleration, be guided along the side.

Technical data - vertical, standing

Max. stroke height		
- without support	≈ 13 ft (4 m)	
- with support of the first e-chain® links	≈ 19.7 ft (6 m)	
- with full support	≈ 65.6 ft (20 m)	
v max	65.6 ft/s (20 m/s)	dependent on stroke height and weight
a max	164 ft/s ² (50 m/s ²)	dependent on stroke height and weight

e-chain system® Design

Zig-Zag - liftband



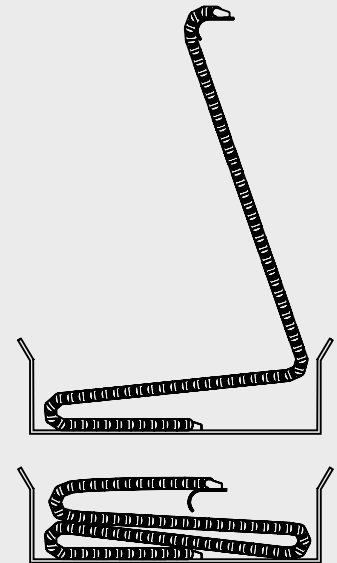
Decommissioning of a nuclear power station. Zig-zag application with igus® e-chains®

Zig-zag design

The modular design of igus® e-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 difficulties. The photo above shows an e-chain® in a zig-zag configuration produced by incorporating reverse bend radii or **RBR**. The unextended e-chain® is stored in a basket. When the platform is raised, the e-chain® unfolds, generating little to no noise. This construction is possible with E4-1 System as well as many other e-chain® systems. Please consult igus® for these kinds of applications.



We recommend pivoting mounting brackets for zig-zag applications



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

Technical data - zig-zag

Travel max.	131 ft (40 m)	
v max.	1.31 ft/s (0.4 m/s)	depending on application, please consult igus®
a max.	3.28 ft/s ² (1.0 m/s ²)	depending on application, please consult igus®

Special solution

liftband -

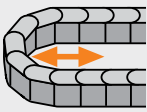
vertical guidance with limited space

Modular, silent, space saving - vertical guidance for energy, data and media. High vertical applications that have plenty of space horizontally but allow only for little system height can be implemented with the liftband.

- Available in 2 sizes
- Alternative to Zig-Zag solution
- Lighter and smaller installation space
- Vertical applications implemented with ease
- Maximum expansion length: 42.7 ft. (13m)



More information ► Chapter 9



We recommend locking mounting brackets for side-mounted applications



Side-mounted e-chains® - are strongly recommended if the installation height is restricted.



E4 e-chains® assembled in an unsupported manner on the traveling column machine. The Y and Z axes have a travel of 314.9" (8,000 mm) and 68.9" (1,750 mm) at a speed of 82 ft/min (25 m/min).

e-chain system® Design Side Mounted Applications



e-chain®, side-mounted, supported
System E4

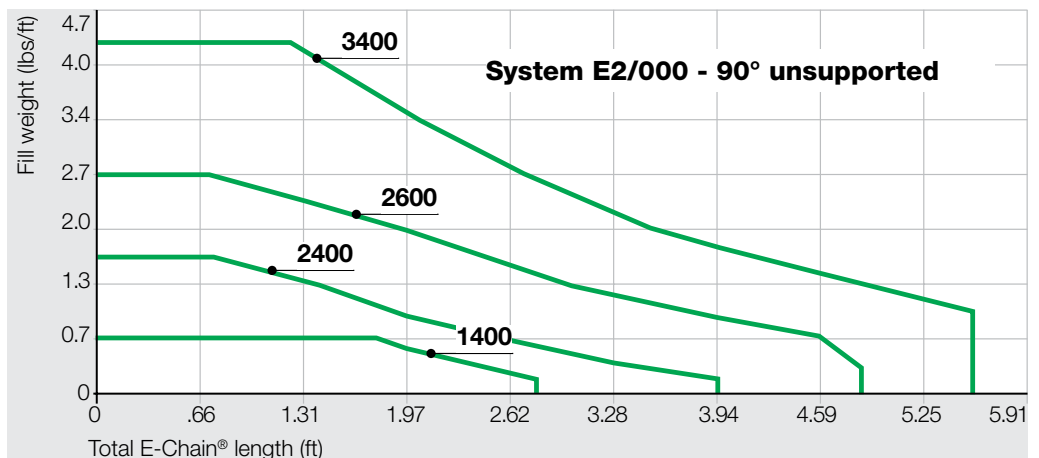
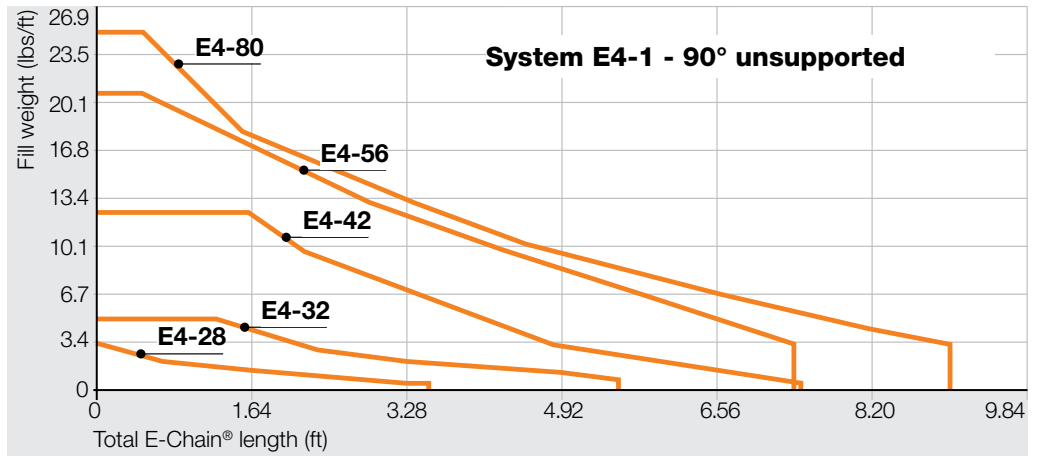
Short travels with or without support

igus® e-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 e-chain®
- Bending radius
- Parallel placement

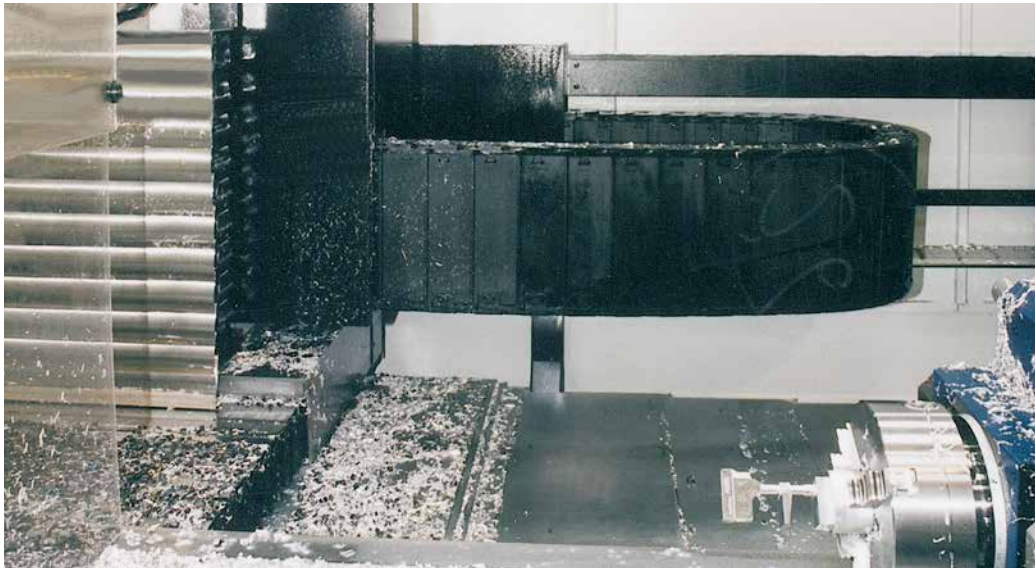
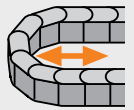
The greater the fill weight of the e-chain®, the shorter the available unsupported length. When placed on its side, the chain width, in effect, becomes the height. As this "height" increases, the e-chain system® becomes proportionally more stable. Small bending radii provide greater stability. If further 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 e-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.

Example load diagrams for e-chains® side-mounted at 90°



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

e-chain system® Design Side Mounted Applications



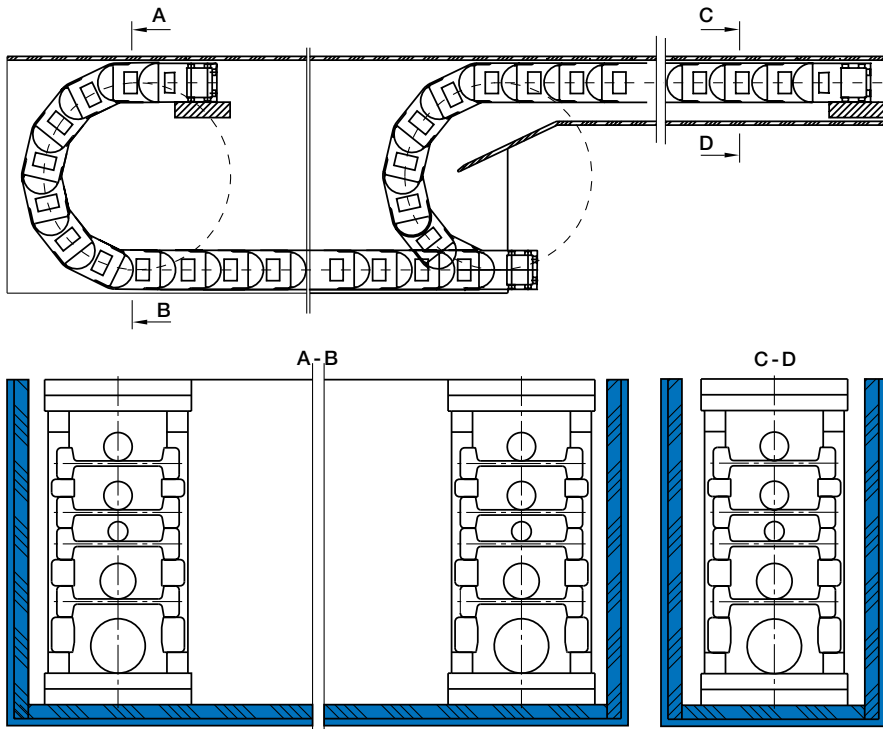
System E4 e-tube in direct chip area E4/light

Long travel, gliding

Side-mounted e-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® e-chains®.

Cables and hoses

Cables and hoses must be guided so that the e-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



igus® - Series E4 with partial support



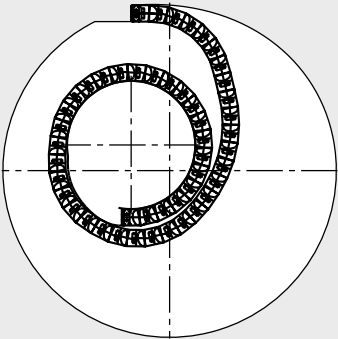
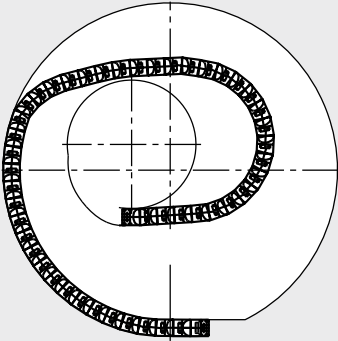
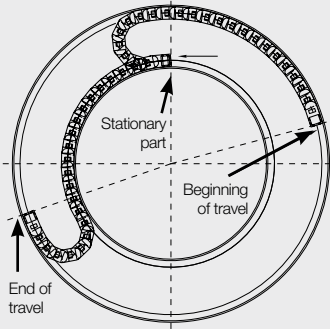
Unsupported - System E4



e-chain system® Design Rotary Motion - RBR - Applications



We recommend pivoting mounting brackets for most applications with rotary motions



Standard E2/000 e-chain®
angle of rotation 225°



RBR-rotary movement with igus® System E4, installed on a crane



Rotary motion with a standard igus® e-chain®



Circular motion of 180° with standard e-chain® on a crane turret drive

Rotary motion with an “RBR”

RBR is “reverse bending radius” and means that the e-chain® can bend in two directions. Each igus® e-chain® can incorporate **RBR** designs, with the exception of several radii, for the e-tubes R117 to R9850 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 e-chain®. For example: Part No. E4-32-15-100/425-0, describes a Series E4-32 e-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. Below is an example of rotary motion using an **RBR** e-chain®. Please consult igus for your particular application.

Rotary movements require less installation height. The e-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 radius, circular radii and e-chain® widths are variable with this product line.

Rotary motion with standard e-chains®

The photo to the left shows an application which was achieved using “standard” e-chains® (standard, in this case, means that the e-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® e-chains®, e-tubes and chainflex® cables are appropriate for this situation.

Technical data - rotary motion RBR

Max. angle of rotation	540°	more upon request
v max	6.56 ft/s (2.0 m/s)	more upon request, depending on the application
a max	65.6 ft/s ² (20 m/s ²)	more upon request, depending on the application

e-chain system® Design

Rotary Motion - RBR - Applications



System E2 medium with 360° RBR rotary motion on a robot

Product range for rotary motions with RBR

e-chains® with **RBR** are available as standard from stock for the complete Triflex® range. In addition, we supply a number of e-chains® which are molded with **RBR**. For all other types, **RBR** requires modification. We will be more than willing to offer you this option.

The e-chain® Series appearing in the table are **RBR** versions available from stock. Almost all igus® e-chains® can be delivered as a **RBR** version. Please contact us for a special inquiry.

- chainflex® cables with TPE outer jacket are specially suited for e-chains® with **RBR** option
- Please use for e-chains® with **RBR** option a strain relief only for the moving end

Table of RBR e-chains® available from stock

Part Number	Series	Part Number	Series
03-05-10/70	E2 micro	10-4-038/600	E2 mini
03-10-010/070-0	E2 micro	10-4-048/048	E2 mini
05-16-018/018	E2 micro	10-4-048/400	E2 mini
06-20-018/018	E2 micro	10-4-075/220	E2 mini
06-20-038/350	E2 micro	B15i-050-100/460	E2 mini
06-30-018/018	E2 micro	1400-050-075/075-0	E2/000
06-64-018/018	E2 micro	1400-068-038/038-0	E2/000
10-1-028/028	E2 mini	1500-038-075/450-0	E2/000
10-1-038/600	E2 mini	2400-09-055/250	E2/000
10-1-048/048	E2 mini	2700-15-150/090	E2/000
10-1-075/220	E2 mini	250-05-060/060	E2 medium
10-2-028/028	E2 mini	250-07-060/060	E2 medium
10-2-038/600	E2 mini	E/Z14-1-038/038	E-Z Chain®
10-2-048/048	E2 mini	E/Z14-2-038/038	E-Z Chain®
10-2-075/220	E2 mini	E/Z14-3-038/038	E-Z Chain®
10-3-028/028	E2 mini	E/Z14-3-075/075	E-Z Chain®
10-3-038/600	E2 mini	E/Z14-4-038/038	E-Z Chain®
10-3-048/048	E2 mini	TE14-50-028/028	SnapChain
10-3-075/220	E2 mini	TE26-120-063/063	SnapChain
10-4-028/028	E2 mini		



Many igus® e-chains® are available with **RBR** -reverse bending radius. Please see the 'Product Range' for relevant series.



Vertical rotary motion of an E2 e-chain®



The e-chain® series appearing in the table at the left are **RBR** versions available from stock. Almost all other igus® e-chains® can be special ordered as **RBR**. Please contact us for any special inquiry.



e-chain system® Design Rotary Motion - RBR - Guide Troughs



Rotary motion with **RBR**, diameter 236.2" (6,000 mm), with **RBR** the inner ring rotates



Guide troughs for rotary applications

igus® guide troughs - standard modular system RM

For rotary motions up to 540° igus® offers a modular system of guiding trough systems. Those systems are divided into an inner and an outer ring. Since one ring is moving together with the e-chain® there is no relative movement between e-chain® and trough, so the wear is reduced to an absolute minimum. Depending on the application they are made from galvanized steel or stainless steel.

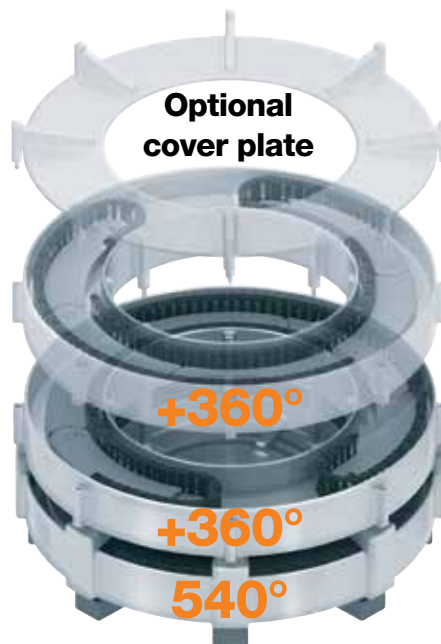


Typical application areas:
offshore, stacker/reclaimer, bucket-wheel excavators, rotary cranes, other rotating applications

Realize 900° and more with igus® Multi Rotation Modules (MRM)

igus® Multi Rotation Modules help to realize rotating movements up to 900° and more. Thanks to stackable add-on modules the angle of rotation can be extended "virtually" indefinitely. The Multi Rotation Modules are also ideally suited for rotary motions with high fill weights and limited space.

- Several individual systems are stacked on each other and form a complete system
- The maximum rotation of the individual levels can easily be added, thereby enabling rotary motions up to 900 degrees and more
- Compact design enables the operation even in tight spaces, and can be extended as needed
- High fill weights possible
- e-chains® can be assembled easily
- Peripheral speeds up to 3.28 ft/s (1 m/s)
- One layer for rotation movements up to 540°, two layers for up to 900°, higher rotation angle possible with more layers



Functional principle

- As the defined rotation angle of the lower layer is reached, the next upper module is carried along automatically due to an integrated connection system
- The construction minimizes potential interference. The Multi-Rotation Module-System is ideal for rotary applications, heavy loads and for harsh environments
- Unlike other systems using sliding contacts, the e-chain® can also guide hoses for air, gas or fluids, as well as bus and fiber optic cables

e-chain system® Design

twisterchain® - twisterband - e-spool



Circular and spiral movements up to 540° - twisterchain®

- Higher loads and smoother running
- igus® 2nd generation of twisterchain® circular e-chains® significantly improved smoothness, stability and strength
- The twisterchain® has a modular construction for width, height and radius
- Stronger with intermediate link - more fill weight possible
- 25% less weight than existing twisterchain®
- Rotary speeds up to 3.28 ft/s (1 m/s) and more, rotary/spiral movements up to 540°
- Highly dynamic and smoother running (with the guide trough Type 01)

More information ► see Chapter 8



Rotary movements in small spaces - twisterband

- Compact
- Cost effective
- Low wear and low maintenance in a confined space
- Energy (in the process), data and media are kept secure
- Rotary movements up to 7000° (Installation position, vertical: up to 3000°, horizontal: 7000° and more possible)
- Rotary speeds up to 360°/s possible
- Minimum installation space, fits closely around the rotary axis
- Can be reliably used in various installation positions (horizontal or vertical)
- Compact, modular and lightweight

More information ► see Chapter 8



Special solutions for multi-axis motion

The cable reeling drum without a slip ring - igus® e-spool

- Route many different cables in very narrow spaces
- Different media and diameters possible in one drum
- No tensile load of the cables
- Energy supply in all possible directions (horizontal, vertical, diagonal)
- Space-saving, no "e-chain® junction" - e-chain® rolled into the home position, access paths remain free
- Cable diameters up to .67" (17 mm)
- Cables can be retrospectively added or changed
- Alternative to zig-zag solutions
- Maximum deployment and retract speed: 3.28 ft/s (1 m/s)

More information ► see Chapter 8



e-spool standard and HD - flexible use



e-spool compact - space saving, spring-driven



e-spool for manual operation - cost-effective



e-spool power - motor-driven for long extension lengths



igus® e-spool and zig-zag solutions in a theatre. Space-saving and maintenance-free: guide all kind of energy, data and media safely, in all directions

More Information ► www.igus.com



e-chain system® Design Cable and Hose Packages General Rules

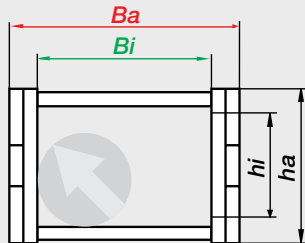


Rules for:

- Maximum conduit diameters
- Shelving
- Bend radius



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



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



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

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 e-chain®/e-tube, with additional minimum clearance. This minimum clearance would be, for example, 10% for electrical round cables, 20% for hydraulic hoses. An e-chain® is ideal if a minimum lateral gap to the next cable or hose has been factored in. Depending on the nature of the cables, the dynamics, and the expected service life, more clearance must be allowed. In specific cases, clearances may be altered further. Please consult igus®.



Neatly laid cables with igus® interior separation

General rules for cables and hoses in e-chains®

The key advantage of an igus® e-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 e-chains® to the

e-chain® Interior separation

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 e-chain system® solves all known requirements for interior separation

e-chain[®] Design Cable and Hose Packages Distribution Rules



Reasons for distribution rules

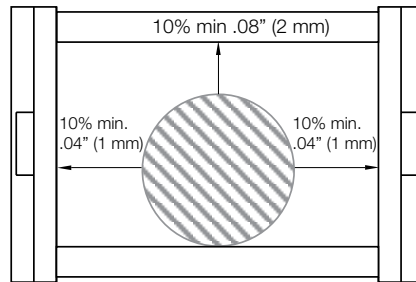
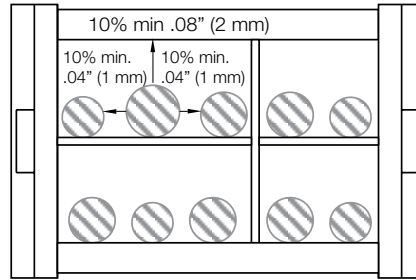
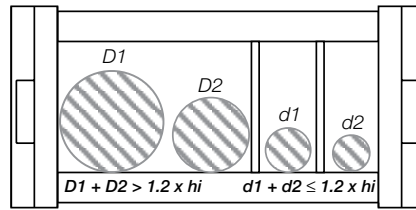
The cables and hoses must be laid so that they can move freely at all times and so that no tensile force is exerted at the radius of the e-chains[®]. For high-speed applications and high cycles, cables or hoses must not be laid on top of each other without horizontal separation. The standard values for 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 e-chain[®]. Cables and hoses with different outer jacket materials must not be allowed to “stick” together. If necessary, they must be laid separately. All igus[®] chainflex[®] cables can be combined with each other and all other brands of cable or hose. The cables and hoses should always be fixed at the moving end. The fixed end should always involve strain relief. Exceptions are made only for certain hydraulic hoses with length compensation issues or other high pressure hoses. Generally, the faster and more frequently the e-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.

Bend radius *R*

The bend radius of our e-chain[®] depends on the thickest or stiffest cable or hose in your application. The bend radii of the e-chains[®] should be adjusted to the recommendations of the cable or hose manufacturer. The selection of a larger radius than the minimum will positively affect service life. The specification of minimum bend radii for cables and hoses refers to use at normal temperatures; other bend radii may be recommended. Please ask your cable or hose supplier for details. We recommend complete e-chain systems[®] - where bend radii for all cables and hoses, interior separation and service life are optimally matched. igus[®] chainflex[®] cables permit a small bend radius of 4 x d for one million strokes



Clearance space “all-around” for round electrical cables



e-chain[®] with extension links supports a smaller e-chain[®] with electric cables

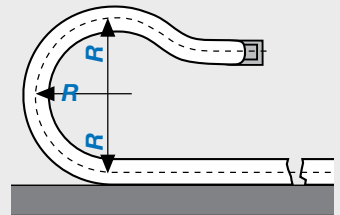
i Distribution Rules

$D1 + D2 > 1.2 \times hi$
Rule 1: If $D1 + D2 > 1.2 \times hi$ 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.

$D1 + D2 \leq 1.2 \times hi$
Rule 2: If $d1 + d2 \leq 1.2 \times hi$ 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 $d2$.

Clearance space in %

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



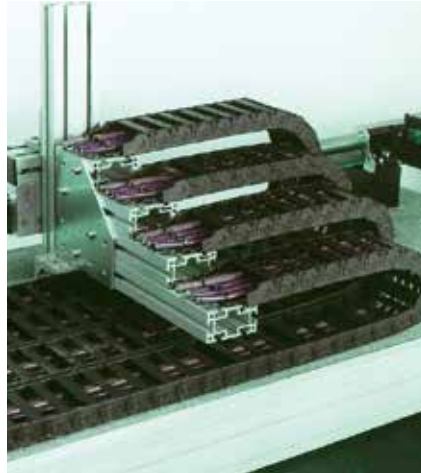
Pinciple sketch - bending radius *R*



e-chain system® Design Cable and Hose Packages Distribution Rules



Corkscrewing: an effect of improper cable and hose placement in an e-chain®



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

Round Electrical Cables

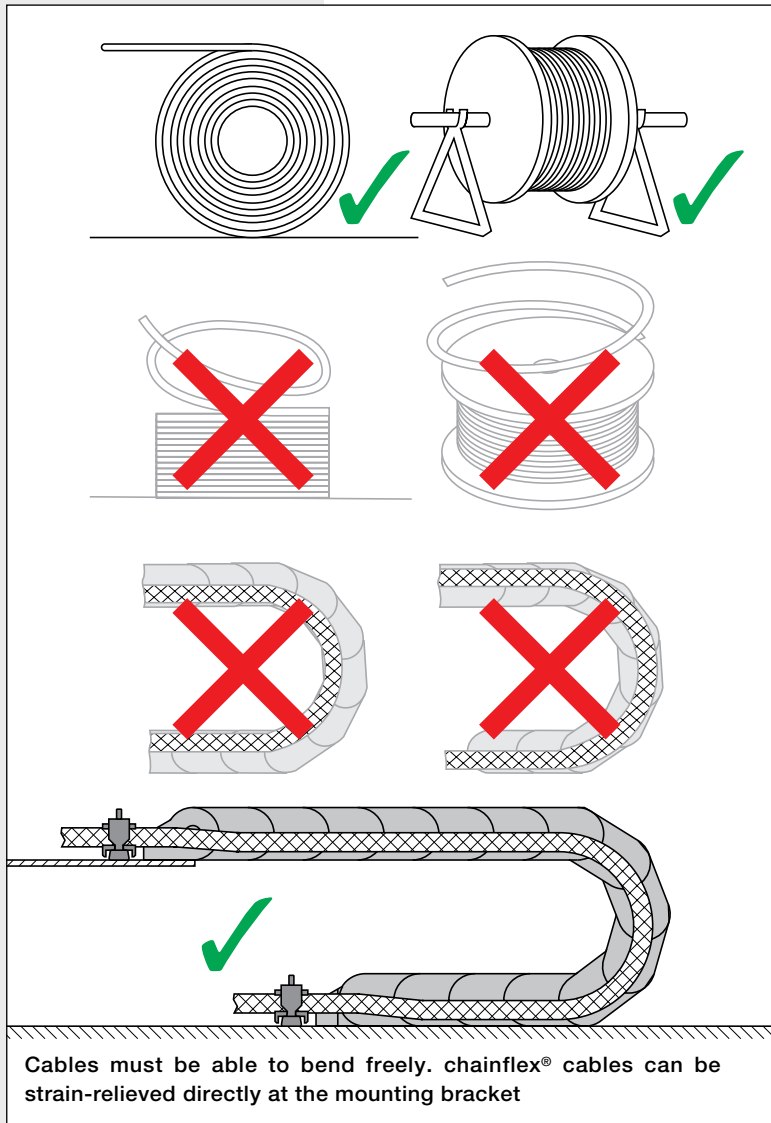
For electrical cables, the round cable is a safe, modular and cost-effective solution for e-chain systems®. We recommend the following criteria for selecting the proper round electrical cables:

- 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 e-chain®. They need not be disconnected or laid out before installation.
2. The cables must be laid so that each individual cable can move freely from side to side.
3. The cables must be able to move freely along the radius. This must be double-checked if the upper run operates at the cable's maximum 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 e-chain® only. A gap of 10-30 x cable diameter between the end of the bending segment and the fixed point is recommended for most cables. chainflex® cables can, on the other hand, be secured directly to the mounting bracket with strain relief (this has been confirmed with testing).



We will be pleased to provide you with recommendations for complete e-chain systems® - where bending radii for all cables and hoses, interior separation and service life are optimally matched

e-chain system® Design Cable and Hose Packages Distribution Rules



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.

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 e-chain®. Strain relief should be attached at both ends. Flat cables are only conditionally recommended for use in e-chains®.

Hydraulic hoses

When designing hydraulic hoses in e-chains®, special attention should be paid to the expansion of the hoses when pressurized. Sufficient room must be left in the e-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 e-chain®). The gliding ability and abrasion-resistant surface of the hoses are also important. All crossbars and shelves in the igus e-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.

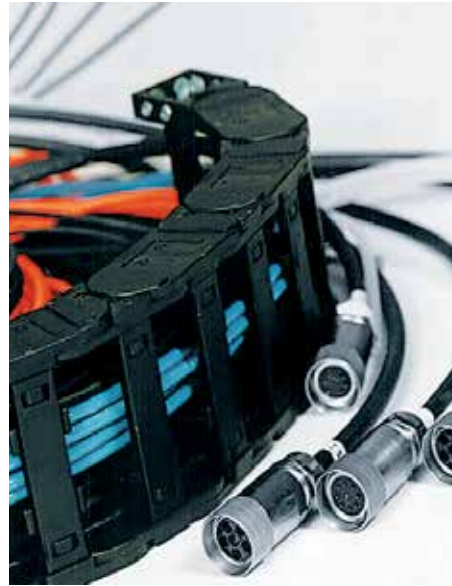
As lateral movements of the hydraulic hoses within the chain can lead to increased abrasion of the hose material, they should be secured in position with vertical separators, but not forced. Special “locking” separators, which grip the opening crossbars of the chain, as well as the use of “spacers,” 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® e-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.



Fully pre-assembled e-chain system® with several pneumatic and hydraulic hoses



● Pneumatic hoses

The igus® program also offers polymer pneumatic hoses called chainflex® Air

● Flat cables

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

● Hydraulic hoses

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



The new roller crossbars for the E4.1 system significantly reduce jacket abrasion of very stiff cables and hoses with rolling contact surfaces equipped with tribo-optimized bearings. Available upon request



e-chain system® Design Strain Relief Elements Chainfix

i

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

i

For more information on all igus® strain relief elements, [► Chapter 10](#)



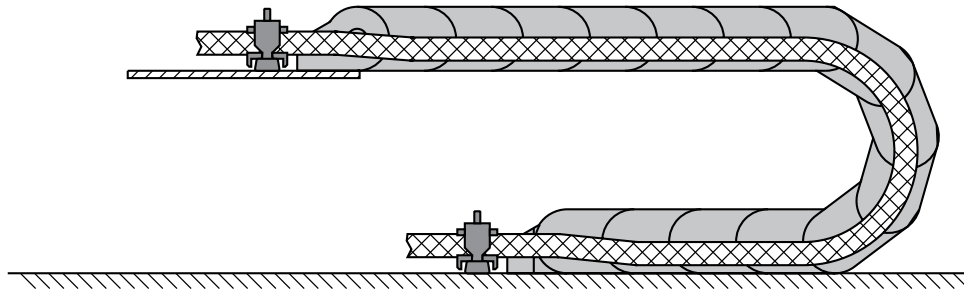
Strain relief in KMA mounting bracket with profile rail.

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 tie wraps and tie wrap plates. In ideal cases, the cables should be secured at both ends of the e-chain® with strain relief (in a few instances, strain relief at the moving end of the e-chain® is sufficient - please consult igus® for these cases).

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

Tests on our premises and in field applications have shown strain relief located at the last bending point of the e-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 e-chains® (More details on this in the individual chapters).



Ideal installation of cables in e-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

e-chain system® Design

Strain Relief Elements

Chainfix



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-chain systems®
- 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.

4 options available:

- Tiewrap plates with clip-on connection for the profile rail
- Integrated strain relief for E2 tubes - series R
- Tiewrap plates for fixed crossbars
- Tiewrap plates for opening crossbars

CFU Honeycomb strain relief

- Up to 80% faster strain relief for different cables in one slot
- Simply insert cables and hoses into the honeycomb and close
- Easy to make changes - add or remove cables/hoses
- Simplified parts
- Can be used in gliding applications

Strain relief separator

- Can be integrated in mounting bracket
- Can be positioned as required
- Easy installation
- Cost-effective
- For most series from stock

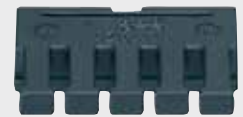
Strain relief element outside of the e-chain® cross section

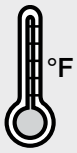
- Easy strain relief for cables, even in enclosed tubes
- Stepped strain relief - good access when retrofitting several cables with strain reliefs
- Matching for e-chains® and e-tubes
- Easy retrofit assembly possible
- Simple installation into top-hat rails and profile rail on KMA mounting brackets

Chainfix nugget - for profile rail

Option 1: universal cable fixation, for diameter with $\varnothing .79"$ (20 mm) and $\varnothing 1.18"$ (30 mm)

- The smart helper for electricians in the machine building industry
- Accessory for all KMA with integrated profile rail
- Easy to assemble, without any screws and tools
- Adjustable to every e-chain® filling
- Very small space requirement
- Easy strain relief with pre-attached cable strap





e-chain system® Design

Technical Data

Material Data



igus® materials

- igumid G
- igumid NB
- igumid ESD
- igumid TE
- igumid GE
- igumid DT

Find technical data about igus® materials, temperatures and chemical resistance
 ►see page 1.47



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



Technical environment:

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

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

Each year, igus® engineers develop more than one hundred new plastic compounds and test igus® products in more than 15,000 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 better assess 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 e-chains® or e-tubes and guide troughs.

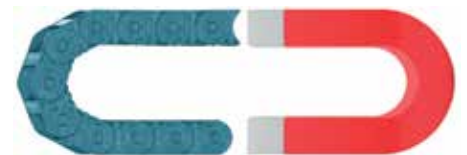
Technical environment

The igumid G material, from which igus® e-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®.

Magnetically detectable plastic e-chains® - For the food and tobacco industry

- The material igumid DT is detected to the tiniest fragment all common metal detection systems and can therefore be selected automatically
- Particles as small as .04" (1.0 mm) can be recognized for fragments passing at speeds of 65.6 ft/min (20 m/min)

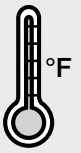
More information ► www.igus.com



e-chain system® Design

Technical Data

Material igumid



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 Ilc.
- 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 (UL94-V2 or UL94-V0).

All e-chains® (except for the E-Z Chains and Series 14 Chains) are made from igumid G.

Flammability of igumid NB

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

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

Please consult igus regarding material availability "V0."

Temperature resistance

igumid G is very suitable for outdoor applications. In our experience, the mechanical properties of the chain are not impaired. igumid G is also UV-resistant. igus® e-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.

Resistance to radiation

igus® offers several solutions for high radiation areas. igumid G is very resistant to high-energy radiation. Under gamma radiation, in the range of 8×10^4 rd, the mechanical properties of igumid G change very little. Please consult igus®



Reflecting telescope at 2,200m. Robust under high wind speeds, snow, ice and increased UV radiation



Series 4040R rol e-chain® on a coal unloading system - travel 623 ft. (190 m), speed 1.64 ft/s (0.5 m/s), fill weight 5.41 lbs/ft. (8.05 kg/m)



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



igumid G:
UL 94 HB (Standard)

igumid NB:
UL 94 V2 (Standard)
UL 94 V0 (upon request)



igumid G:

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



e-chain system® Design

Technical Data

ESD & ATEX



- **ESD** - avoidance of static charges in the field of manufacturing processes of electronic components or assemblies
- **ATEX** - prevention of explosive static charge in hazardous environment



100% of the produced ESD e-chains® are checked for their continuous conductivity from one end to the other

Measurements of the electrical surface leakage resistance for igus® e-chains® with the special material igumid GC were made already in 1992 by the igus® GmbH together with the PTB (Physikalisch-Technische-Bundesanstalt) in Braunschweig, supplemented by additional certifications in 1998 and 1999 according to DIN 53482 and the guidelines for static electricity "ZH1/200" of the Federation of Trade Associations. In the course of further innovation, the material igumid ESD was certified by the PTB (Physikalisch-Technische-Bundesanstalt) in May 2002. The material igumid ESD combines in its properties the requirements of the ESD as well as ATEX criteria. In some mechanical requirements, the igumid ESD surpasses even the standard material igumid and has been tested with over 10 million cycles in the igus® technology center.



Product range of ESD e-chains® from stock

Zipper	in.	Bi	(mm)
07	.39 - 1.97		(10 - 50)
09	.63 - 1.97		(16 - 50)
E2/000			
1500	.59 - 3.15		(15 - 80)
2500	.98 - 4.92		(25 - 125)
2700	1.97 - 4.92		(50 - 125)
E4-1			
E4.21	1.18 - 2.76		(30 - 70)
E4.28	1.57 - 4.92		(40 - 125)
E4.32	1.97 - 7.87		(50 - 200)
E4.42	1.97 - 7.87		(50 - 200)
E4.56	2.95 - 11.81		(75 - 300)
E4.80	2.95 - 11.81		(75 - 300)
Triflex® R TRC	in.	Ba	(mm)
TRC.40	1.69		(43)
TRC.60	2.56		(65)
TRC.70	3.19		(81)

Your benefits with ESD products

- ESD material tested with over 10 million cycles for the highest requirements
- Snap-open e-chains® with mounting brackets and interior separation in ESD and ATEX design available from stock
- Standardized product - igumid ESD with PTB certificate
- Proven over years of use in explosion-proof areas

Conductivity of igus® products from igumid ESD

In contrast to applied conductive surface coatings or potentially volatile incorporated anti-static agents, the additives used in the igumid ESD products from igus® grant long-term, maintenance-free conductivity to e-chains®. However, a conductive e-chains® alone is not enough to ensure sufficient conductivity. Instead, all individual components, as well as the entire e-chain®, must exhibit continuous conductivity. igumid ESD e-chains® are slate grey in color* to distinguish as conductive materials. All products in this catalog are optimized in this regard, and their continuous conductivity is tested, measured and documented prior to delivery. Only igus® e-chains® that have passed these tests are marked with the tested seal, and delivered to igus® customers.

*Exception: igus® Zipper e-chains® Series 07/09





More information on igus[®] ESD e-chains[®] - classification II 2 GD

● **General safety information:** these additional operating Instructions apply to the explosion-protected versions of our e-chains[®] of Type ESD in color grey (similar to RAL 7015). They supplement the Installation Instructions for the standard e-chains[®] and the catalog information. The information in these instructions relates only to data impacting on explosion protection. The technical information in the Installation Instructions for the standard e-chains[®] and the category information still apply unchanged unless these Instructions explicitly exclude or replace the relevant information. Required documentation and other documents are filed with the following institute pursuant to the ATEX Directive:

Physikalisch-Technische Bundesanstalt (PTB) Braunschweig and Berlin
 Bundesallee 100 • 38116 Braunschweig/Germany

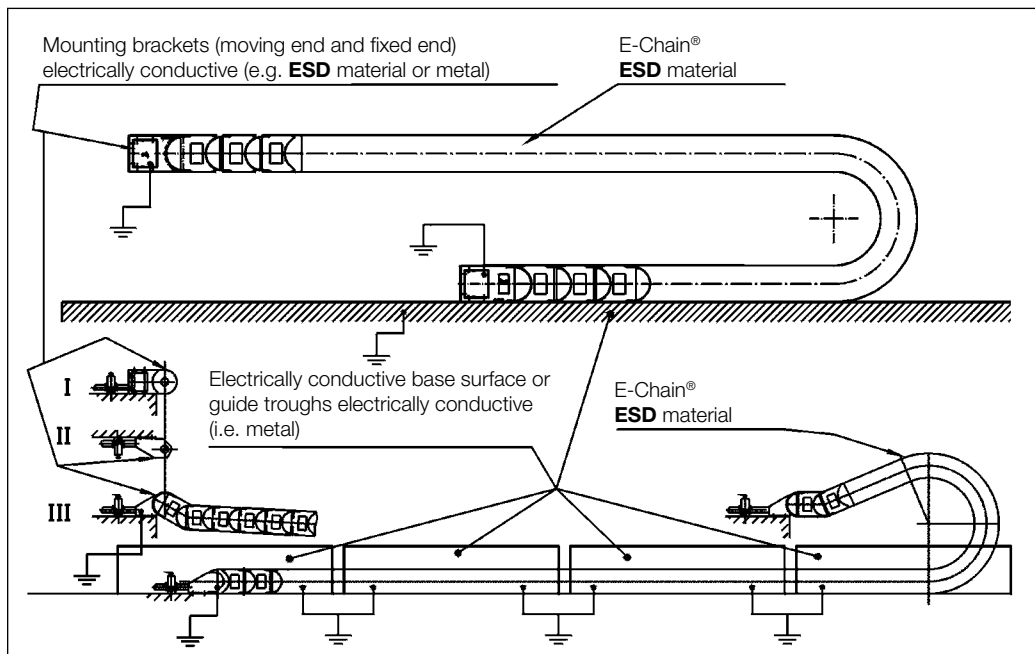
● **Assembly, removal and installation:** please follow the information in the installation instructions for the standard e-chains[®] and the catalog information on assembly, removal and installation for trouble-free operation. igus[®] ESD e-chains[®] must be grounded with appropriate measures in accordance with drawing number 18392.2 in order to discharge any electrostatic charges occurring.

Assembly, installation, commissioning and maintenance may be performed only by personnel trained in explosion protection!

Please also note the corresponding national safety regulations and the relevant national regulations in respect of explosion protection during installation and operation.

● **Commissioning:** before commissioning the system, check that the system has been installed correctly in accordance with the Installation Instructions for the standard e-chains[®] and the catalog information. Correct grounding must be checked in particular in the case of ESD e-chains[®].

● **Maintenance:** igus[®] e-chains[®] are maintenance-free. Correct grounding of the e-chains[®] must be inspected at regular intervals. (*in case of large projects a customized maintenance plans can become an issue and will be created if necessary)



Connection of an e-chain[®] in accordance with ATEX Directive 94/9/EC



igumid G - II 3 GD

igus[®] e-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.

igumid ESD - II 2 GD

igus[®] e-chains[®] made of igumid ESD correspond according to the German federal office of Physics and Technology (PTB) to classification Ex II 2 GD according ATEX-RL 94/9/EG



igus[®] igumid ESD with PTB certificate

We have received an official certificate from the German National Standards Laboratory (PTB) on material igumid ESD and we are able to provide you with a copy on request.

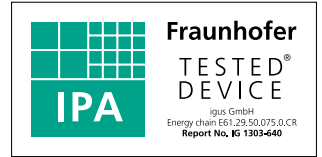
e-chain system® Design

Technical Data

Cleanroom and ESD

Cleanroom qualification of igus® e-chains®

In many applications where cumbersome special solutions are used, a simple standard e-chain® can be used instead. A comprehensive test program was devised and performed for both gliding use and unsupported use. For many applications, the e-chains® in special materials are practically abrasion-free. Detailed test results are available upon request. IPA tests confirm that standard igus® e-chains® meet cleanroom requirements. "Tested and certified as very good!" e-chains® for cleanroom applications in the test stand cleanroom environment demand very high wear-resistance of moving parts. e-chain®, for example, must be very wear resistant, in order to meet the normal requirements for such a sensitive environment.



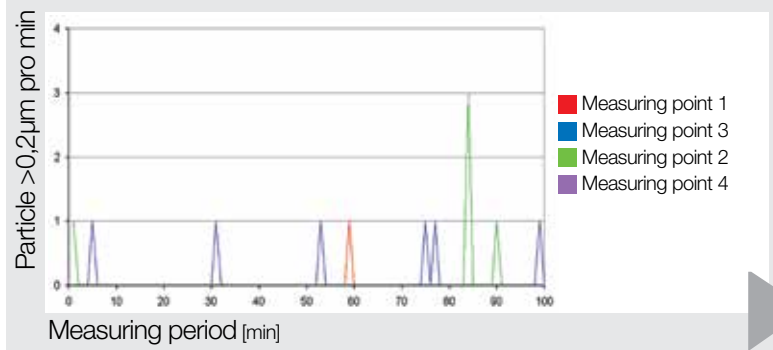
IPA Fraunhofer Institute has tested the following igus® series according to DIN EN ISO 14644-1

Result according to DIN EN ISO 14644-1	Equivalent to US Federal Standard 209E	Classification Series	Report No.	Speed ft/s (m/s)
ISO Class 1	No comparable classification	E3-15-040-075-0	IG0704-400	1.64 / 3.28 / 6.56 (0.5 / 1.0 / 2.0)
ISO Class 1	No comparable classification	E61-29-050-075-0	IG1303-640-1	1.64 / 3.28 / 6.56 (0.5 / 1.0 / 2.0)
ISO Class 2	No comparable classification	E14-3-038-0	IG0308-295	3.28 (1.0)
ISO Class 2	No comparable classification	1500-050-038-0	IG1303-640-1	1.64 / 3.28 / 6.56 (0.5 / 1.0 / 2.0)
ISO Class 2	No comparable classification	T3-29-050-038-0	IG1303-640-1	1.64 / 3.28 / 6.56 (0.5 / 1.0 / 2.0)
ISO Class 3	ISO Class 1	E6-29-060-150-0	IG0704-400	1.64 / 6.56 (0.5 / 2.0)
ISO Class 3	ISO Class 1	2500-05-055-0	IG0308-295	6.56 (2.0)
ISO Class 5	ISO Class 3	E4-32-10-063-0	IG1303-640-1	1.64 / 3.28 / 6.56 (0.5 / 1.0 / 2.0)

Particle generation measurement



Result: particle generation
E14-3-038-0



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

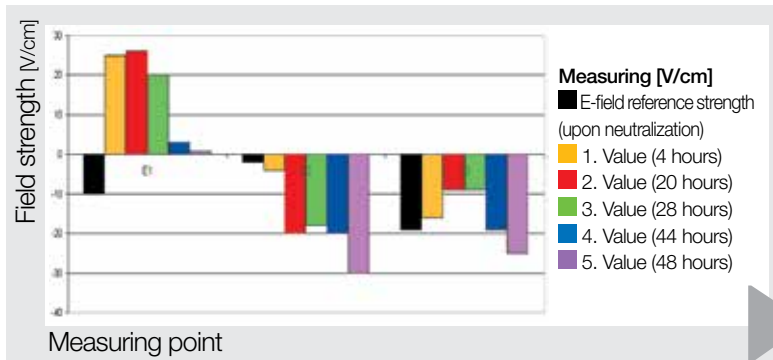


Absorption LEVEL 1 confirmed by IPA-Fraunhofer-Institut according to SEMI E78-0998 for the E6 standard material. Continuously constant conductance value as there are no pin-bore connection (no air gaps).

Field strength measurement



Result: field strength
E6-29-050-055-0



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

e-chain system® Design

Technical Data

Dirty Environments

Spatter, hot chips

Laboratory tests and numerous field applications over the past 20 years have proven that igus® e-chains® and fully enclosed e-tubes protect cables used in welding robots and machine tools. e-tubes made from the igus® igumid HT material are resistant against hot chips and flying debris up to 1,562°F (850°C), no chips stick. This opens up new possibilities for replacing more complex and expensive steel tubes. All standard E2 and E4 e-tubes are available made from igumid HT, upon request. Please note: igumid G in direct contact with large amounts of melted aluminum is not recommended.



igus® e-tubes in the chip area of machine tools

Dirt, dust, chips

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



Also hot asphalt is no problem for igus® e-tubes

Vacuum

igus® e-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 table on ► Page 1.48 shows an excerpt of the precise details concerning resistance to chemicals. Acid-resistant e-chains® are available upon request.

Coolant resistance

e-chains® and e-tubes have proven resistant to cooling agents. However, we are always willing to perform individual tests if you have particular problems or advanced developments.



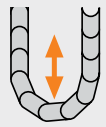
System E4 in an incinerating plant - safe also in abrasive dirt and dust



Compost sludge - numerous related references available upon request

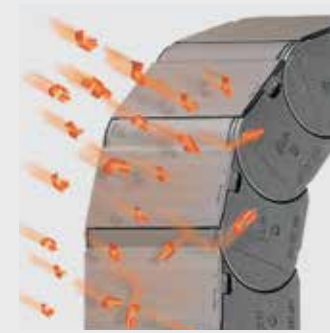
Chemical Resistance Table

► Page 1.48



igus® - experience with:

dust, dirt, mud, compost, wood, textile fibers, paper dust, abrasive paste, cooling agents, glass dust, glass splinters, coal dust, sand, corundum and much more.



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



igus® tests: e-chains® and chainflex® cables are tested for resistance against chemicals and oils in long-term tests

e-chain system® Design

Technical Data

Material Data igumid - Colors

Material data igumid

Material data table						
	Units of measure	igumid G	igumid NB	igumid ESD	igumid TE	igumid GE
Mechanical properties						
Yield stress (dry/wet)	MPa	190/130	78/40	*	*	*
Elongation at break (dry/wet)	%	004/006	20/210	*	*	*
Elasticity module (tensile test)	MPa	9000/7000	2900/1200	*	*	*
Limit of elasticity (bending)	MPa	7.800	3.000	9.500	1.290	7200
Bending strength	MPa	240	120	230	55	200
Hardness Shore D	-	79	79	83	72	80
General properties						
Density	g/m3	1,37	1,14	1,2	1,02	1,46
Absorption of humidity 23/50 RF	% by weight	1,4	3,4	1,9	0,8	0,7
Maximum water absorption	% by weight	5,6	7,6	7,3	1,6	4
Electical properties						
Specific transitional resistance	Ω*cm	>1011	>1011	<109	>1011	>1011
Surface resistance ROA	Ω	>1011	>1011	<109	>1011	>1011
Thermal properties						
Lower application temperature	°C / °F	-40°C / -40°F	-40°C / -40°F	-40°C / -40°F	-40°C / -40°F	-40°C / -40°F
Upper long-term application temp.	°C / °F	120°C / 248°F	80°C / 176°F	80°C / 176°F	70°C / 158°F	120°C / 248°F
Upper short-term application temp.	°C / °F	180°C / 356°F	170°C / 338°F	150°C / 302°F	140°C / 284°F	200°C / 392°F
Material certificates						
Fire resistance as per UL94	-	HB	V2	HB	HB	HB
Silicone-free	-	++	++	++	++	++
Halogen-free	-	++	++	++	++	x
2002/95/EG (RoHS)	-	++	++	++	++	++
2002/96/EG (WEEE)	-	++	++	++	++	-
Color						
according to RAL, approx.	-	■ ≈RAL9004	■ ≈RAL9004	■ ≈RAL7015	■ ≈RAL9004	■ ≈RAL9004

++ = yes x = no *Values upon request



Colors and special solutions

Product prices are always based on the color black. e-chains® in any color shown in the color selection chart are subject to a percentage based color surcharge. Any other colors that are not shown in the chart are individually calculated depending on the article and quantity, insofar as this is technically possible. As a rule, colored e-chains® are not available from stock. Delivery lead-time and surcharges for colored e-chains® are available upon request. As a rule, all specifications related to stability (for instance unsupported lengths) and material characteristics apply only to black e-chains®. The characteristics of colored e-chains® may differ. This also applies to all e-chains® from special materials, such as conducting e-chains® made from igumid ESD material or other special materials. For technical reasons HT and ESD materials cannot be supplied in other colors.

e-chain® color variations with RAL-numbers

Color	Availability	RAL #	Part No. Suffix	Color	Availability	RAL #	Part No. Suffix
■ Black	Standard, from stock	≈ RAL 9004	-0	■ Orange	special color	≈ RAL 2003	-2
■ Dusty grey	special color, e-tubes only	≈ RAL 7037	-31	■ Yellow	special color	≈ RAL 1018	-4
□ White	special color	≈ RAL 9003	-1	■ Light grey	special color	≈ RAL 7035	-14
■ Grey white	special color	≈ RAL 9002	-1S				

Black e-chains® available from stock! Delivery time for special colors: Please consult igus®.

e-chain system® Design

Technical Data

Chemical Resistance

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



The values specified are values determined by laboratory tests and are material-specific. All specifications apply to black e-chains®

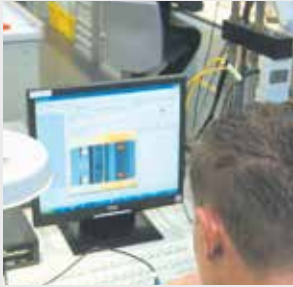
Resistance classes

++ = resistant
 + = conditionally resistant
 - = non-resistant

Sat. aq. sol. = saturated aqueous solution

e-chain system® Design Standards and Certificates

Examples for test certificates and approvals of igus® products



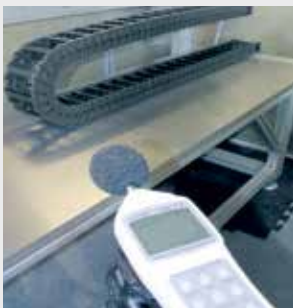
Quality inspection of every e-chain® production



Test location for ESD-e-chains®



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



Noise level tests in igus® own acoustic laboratory

ISO 9001:2015

igus® Inc. has been certified since May 2002

TÜV construction test

igus® e-chains® and e-tubes are construction-tested by TÜV Rheinland. igus® e-chains® were tested and passed by TÜV Rheinland in accordance with the valid machine guidelines. As a result, the user of igus® e-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

ESD/ATEX

igus® e-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® e-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

Many e-chains® are suitable for the use in cleanrooms according to DIN EN ISO 14644-1. Confirmed by the IPA Fraunhofer Institute.

UL, CSA, CEI, CE, VDE

All igumid-materials for e-chains® and e-tubes have got the UL-material approval. The material igumid NB has the fire protection class approval IIIb according to the test VDE 0304 Part 3/5.70, the approval V2 according UL94 and the construction material class B2 according DIN 4102.

Interbus, CC-Link and DESINA

chainflex®- cables are produced according to a variety of international standards. **Interbus certification:** for Interbus certification of certain CF11 bus cables. **CC-Link:** CC Link is a Fieldbus established by Mitsubishi Electric Automation. igus® chainflex® CFBUS.035 is

Clearly quieter

igus® e-chain systems® are clearly quieter. In the acoustic laboratory of the TÜV and the igus® GmbH different e-chains® were compared. The igus® System E3, E6 and E4/00 (Series E4/101) are measurably (and clearly) quieter than other products

igumid

The material igumid is free from toxins, according 2011/65/EU (RoHS2).

iF Design Award

32 iF Design Awards since 1987

