Designing with igus®
Calculation tools, diagrams, applications
the-chain - moving energy made easy - an all-in-one energy supply system

There are many ways to supply your equipment and systems with energy and data. But there is no solution as universal and durable as the e-chain system®. Whether you have a circular movement, a hanging or standing application, a long travel distance or high loads - igus® plastic e-chains® will help you solve nearly any type of energy supply problem, quickly, safely and with ease. By using the extensive igus® construction kit, you will find the solution to match your needs and application: from individual components to a complete installation at your facility. We have developed an online tool to help you find what you need with greater ease ▶ www.igus.eu/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.

The igus® lab and field experience

Our calculations and analyses are based on the result of ongoing practical tests in our technical centre and our experience with moving 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. 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.
**igus® terms**  |  **Alphabetical order**

**Abbreviations and description**

- \( \alpha \) = Angle of rotation  
- \( \Delta M \) = Deviation of the centre point  
- \( a \) = Acceleration  
- \( AR \) = Outer radius, e-chain® (twisterchain)  
- \( Ba \) = Outer e-chain® width  
- \( Bi \) = Inner e-chain® width  
- \( B_{na} \) = Guide trough outer width  
- \( B_{ni} \) = Guide inner trough width  
- \( D \) = Over-length e-chain® radius in final position  
- \( D_1 \) = Over-length for long travel gliding  
- \( FL_2 \) = Unsupported length with sag  
- \( FL_2' \) = Unsupported straight length  
- \( FL_3 \) = Unsupported lower run  
- \( FZ_{max} \) = Maximum fill weight  
- \( H \) = Nominal clearance height  
- \( H_{i} \) = Clearance height with lowered moving end  
- \( ha \) = Outer e-chain® height  
- \( H_{f} \) = Required clearance height  
- \( hi \) = Inner e-chain® height  
- \( H_{io} \) = Outer trough height  
- \( H_{fo} \) = Inner trough height  
- \( IR \) = Inner radius, e-chain® (twisterchain)  
- \( K \) = Add-on for bend radius (K is taken from the data tables of the individual series)  
- \( K_{a} \) = Add-on for bend radius (K is taken from the data tables of the individual series)  
- \( L_{K} \) = e-chain® length  
- \( n \) = Number of links  
- \( n_{max} \) = Number of installation sets (left/right)  
- \( n_{nl} \) = Number of trough sets (left/right)  
- \( R \) = Bend radius  
- \( RBR \) = Reverse Bend Radius  
- \( S \) = Length of travel  
- \( S_{2} \) = Half length of travel  
- \( T \) = e-chain® link pitch  
- \( v \) = Travel speed  
- \( X_{i} \) = Inner machine limit (twisterchain)  
- \( X_{o} \) = Outer radius e-chain®, including clearance (twisterchain)  
- \( \Delta CL \) = Offset fixed end

**Calculation | e-chain® length and camber**

**Calculation of the e-chain® length**

If the fixed end of the e-chain® is located in the centre of the travel, the e-chain® length \( L_K \) is calculated by using half the length of travel and adding the value \( K \) for the bend radius. You can obtain the value \( K \) from the tables in the catalogue. Placing the fixed end in the centre of the travel is the most cost-effective solution because it requires the shortest e-chain®, cables and hoses.

\[
L_K = S/2 + K
\]

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

\[
L_K = S/2 + \Delta M + K
\]

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

The fixed end in the centre of the travel is the most cost-effective solution.

\[
K = \pi R + (2 \times T)
\]

\[
L_{K} = e-chain® length
\]

\[
S = Length of travel
\]

\[
S_{2} = Half length of travel
\]

\[
R = Bend radius
\]

\[
\Delta M = Deviation of the centre point
\]

\[
K = Add-on for bend radius
\]

\[
T = e-chain® link pitch
\]

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

**Camber**

The largest possible unsupported length is influenced by the design, material and camber. Camber is the curve of the upper run along its unsupported length. All igus® e-chains® are manufactured with camber. 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 e-chains® do not have the same load-bearing capacity. Please consult igus®.

\[
H_f = Required clearance height
\]

\[
H = Nominal clearance height
\]

\[
H_{f} = Required clearance height
\]

The necessary clearance height depends on the camber of the e-chain®. Find values for the necessary clearance height \( H_f \) on each product page.

**igus® formulae**

- \( SFL_{L2} = 2 \times FL_{L2} \)  
  Calculation of maximum travel length, unsupported with sag
- \( SFL_{L3} = 2 \times FL_{L3} \)  
  Calculation of maximum travel length, unsupported straight
- \( B_{na} = Ba + 4 \)  
  Minimum guide trough width
- \( H_{na} \geq 2 \times ha \)  
  Minimum guide trough height for gliding applications
- \( K = \pi R + (2 \times T) \)  
  Add-on for bend radius
- \( L_{e} = S/2 + \Delta M + K \)  
  e-chain® length, fixed end is outside the centre of the travel (\( FL_{L2}, FL_{L3} \) and \( \Delta M \))
- \( L_{e} = S/2 + K \)  
  e-chain® length, for all types of applications, fixed end in the centre of travel, except circular movements and most long travels
- \( L_{e} = S/2 + K_{2} \) [m]  
  e-chain® length for long travels, fixed end in the centre of travel
Unsupported | Short travels

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

Example for unsupported straight FLa

Unsupported applications

If the upper run of the e-chain® operates without touching the lower run over the entire travel, it is called an unsupported application. The distance between 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 depends on the fill weight and the type of e-chain® or e-tube. As a result, we differentiate among three types of unsupported length:

1. Unsupported with straight upper run FLa
   The e-chain® is unsupported FLa when the upper run still has camber, is straight or has a maximum sag of 1/2 of the e-chain® link height. Installing the e-chain® in FLa is always recommended. The e-chain® runs smoothly without additional vibration.

2. Unsupported with permitted sag FLb
   The e-chain® is unsupported FLb when the sag is more than 1/2 e-chain® link height and less than the smallest available radius of this e-chain® series. In most applications the e-chain® can be used unsupported FLb without any problems. There are restrictions concerning the maximum speed and acceleration.

3. Critical sag
   When the sag of the e-chain® is higher than allowed for FLb, it is in critical sag. Using an e-chain® in critical sag should be avoided or solved with special solutions. An e-chain® should never be installed with critical sag. Applications may reach critical sag after long service times. The e-chain® or e-tube should be replaced in these cases. Please contact us!

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 stronger igus® e-chain®
- Support the e-chain® in the unsupported area. This option means restrictions for acceleration, speed and noise as a consequence - three fundamental examples are detailed to below - please consult igus® if you are considering this possibility - we will gladly provide you with a detailed proposal
- Use a multiband e-chain® or nest two igus® e-chains® inside one another. (Please consult igus®)
- Design the travel distance as a gliding application

More information > www.igus.eu

Unsupported | Short travels

Example of unsupported with sag, FLa

Support of the FLa area. A) The overall straight, unsupported travel can be increased here by a maximum of 50% of the FLa and in case of option B) by a maximum of 100%

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

For every igus® e-chain® or e-tube, you will find the values for FLa and FLb in two locations: on the following pages in this chapter as an overview and within every individual series' chapter. They are essential for:

- Finding a suitable e-chain® for your fill weight and travel distance
- Identifying the maximum load for the selected e-chain®
Unsupported | Short travels

Speed, acceleration and service life

For unsupported applications, the acceleration (a) is the more critical parameter than the speed (v). High acceleration can cause the e-chain® to vibrate and reduce its service life. This is a particular issue if the e-chain® already has a sag greater than the FLp value. Max. values for acceleration (a), speed (v) and service life are achieved only with e-chains® incorporating the FLp design. igus® e-chain systems® can sustain very high loads. To date, a peak acceleration of 784m/s² has been achieved during continuous use. The guideline values that result from continuous experiments in the igus® laboratory and countless practical applications can be obtained from the two diagrams for your design. 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 FLp or unsupported, with sag FLp.

Contact surfaces

Unsupported igus® e-chains® normally require some type of surface on which the lower portion of the e-chain® runs. A wide range of configurations is available, as the drawings on the right demonstrate. Many material options are feasible: metals, polymers, stone, wood, concrete, glass, etc. We also have solutions to minimise the noise generated by the e-chain® lower portion. Please consult igus®. When selecting the running surface, please ensure that 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. Exceptions: If the acceleration is greater than 20m/s² or if the height is limited to the H₀ measurement. In such cases, locking mounting brackets keep the e-chain® under the H₀ measurement.

Unsupported lower run

e-chains® without support along the lower run have restricted use. The value FLp usually must be determined in a test by igus®. The maximum permissible amount of the projection depends on the fill weight, the selected e-chain®, the dynamics, and other factors. The combination of fill weight, e-chain® type and FLp is always different. If the lower run of the e-chain® cannot be supported over the whole travel, please consult igus®.

Unsupported | Noise-optimised

Minimise noise levels with igus® e-chain systems®

The igus® product range includes e-chains® optimised for low noise. The table below briefly illustrates the differences in noise level among various e-chains®. In addition to the e-chain®, the running surface, the dynamics and the cable and hose package play a role in overall noise generation. Have our specialists design the quietest e-chain system® for your application, for example.

System T3 ≤ 33dB(A)

Optimal smoothness of motion was the prime development goal for the t-shaped band e-chain® T3. The igus® T3 e-chain® is very flexible and runs - due to the special geometry- very smoothly. A measurement indicates a value of 33dB(A) at 1m/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 ≤ 38dB(A)

Long-term tests in the igus® acoustic laboratory showed reductions of 19-20dB(A) compared with standard e-chains®, measured at a speed of 1.8m/s and an acceleration of 3m/s². Figure determined in the igus® laboratory in accordance with DIN 45635, taking into consideration background noise, for the series E3.22, 060.044.0.

System E6.1 ≤ 32dB(A) / System E6 ≤ 46dB(A)

A measurement conducted by the Rhineland Technical Inspection Authority (TÜV Rheinland) in May 2002 indicates a value of ≤ 46dB(A) at 2m/s and with an unsupported length of 1.5m with series E6.52, 10.100.0, and this with at least 10dB(A) sound pressure level generated by external noise. A value of 32dB(A) was measured during the igus® internal test 4479 for the series E6.1, 070.055.0. The quiet operation is due to a very small pitch and a brake in the stop-dog system. The so-called "polygon effect" is virtually non-existent during the rolling of the E6/E6.1 e-chains®.

System E4 ≤ 46dB(A)

A measurement by the Rhineland Technical Inspection Authority (TÜV Rheinland) for system E4/101, series 221,10.200.0 indicates a value of 46dB(A) at 1.5m/s with an unsupported length. Due to the special rubber pads (shown in red) of the system E4, the noise will be largely damped. The standard version of the E4.1 and E4 systems are already very reduced in noise due to their special designed stop-dog.

Selected noise tests - external noise corrected measurement values

e-chain® Sound pressure levels

<table>
<thead>
<tr>
<th>Test method</th>
<th>e-chain®</th>
<th>System</th>
<th>Average of the corrected sound pressure levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain 1 third-party product</td>
<td>E2 medium</td>
<td>255</td>
<td>≤ 77 dB(A)</td>
</tr>
<tr>
<td>Chain 2 third-party product</td>
<td>E4.1</td>
<td>443</td>
<td>1.0m/s</td>
</tr>
<tr>
<td>Chain 3 third-party product</td>
<td>E6</td>
<td>442</td>
<td>2.0m/s</td>
</tr>
</tbody>
</table>

Source: TÜV Rheinland, except series E3.22 and T3.29 - source: igus® laboratory
Quick overview | Fill weights up to 4kg/m
Unsupported length vs. fill weight vs. inner height

Preselection for the following series

- E1
- easy chain®
- zipper
- E2 micro
- E2 mini
- E2.1 micro
- E2.1
- E2/000
- E2 R100
- E2 R
- R2.1
- RX
- E4.1L
- E4.1
- E4/light
- T3
- E3
- E6.1
- E6
- e-skin®
- TH3

Note: This matrix is just a preselection. Exact values can be found in the chapters of the chosen series and on the next pages.

Exact values can be found ► in the chapters of the chosen series
Unsupported straight \( FL_G \) | Fill weights up to 1.5kg/m

Load diagram for unsupported use

Important information
- Fill weight - weight of all cables and hoses, including contents (for media hoses) within the e-chain®, typically given [kg/m]
- \( FL_G \) - unsupported e-chain® with straight upper run
- \( FL_B \) - unsupported e-chain® with permitted sag
- To the right of the \( FL_G \) graph of the diagram, the application is shown in critical sag. This must be avoided!

These values are essential for finding a suitable e-chain® for your fill weight and travel distance, and 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®.

The maximum travel
- The maximum travel always amounts to \( 2 \times FL_G \) or \( FL_B \)
- If the fixed end is in the centre of the travel. In this case, the following applies e-chain® length: \( L_C = \frac{H_N}{2} + K \)

\[ S = \text{Length of travel} \]
\[ R = \text{Bend radius} \]
\[ H_N = \text{Nominal clearance height} \]
\[ H_C = \text{Required clearance height} \]
\[ K = \pi \times R + (2 \times T) \text{ Add-on for bend radius} \]

Diagram series legend on the right
- E1 | Page 174
- RX | Page 502
- easychain® | Page 198
- E4.1L | Page 524
- zipper | Page 226
- E4.1 | Page 566
- E2 micro | Page 260
- E4/light | Page 660
- E2 mini | Page 290
- T3 | Page 722
- E2.1 micro | Page 320
- E3 | Page 732
- E2.1 | Page 334
- E6.1 | Page 750
- E2/000 | Page 360
- E6 | Page 788
- E2R100 | Page 428
- e-chain® | Page 834
- E2R | Page 454
- TH3 | Page 850
- Add-on for bend radius 15
- R2.1 | Page 478

You will find the diagrams for each series listed individually in the catalogue.
Unsupported straight $F_{L_g}$ | Fill weights up to 9.0kg/m

Unsupported with sag $F_{L_b}$ | Fill weights up to 9.0kg/m

Important information
- Fill weight - weight of all cables and hoses, including contents (for media hoses) within the e-chain®, typically given [kg/m]
- $F_{L_g}$ - unsupported e-chain® with straight upper run
- $F_{L_b}$ - unsupported e-chain® with permitted sag
- To the right of the $F_{L_g}$ graph of the diagram, the application is shown in critical sag. **This must be avoided!**

These values are essential for finding a suitable e-chain® for your fill weight and travel distance, and 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®.

The maximum travel
The maximum travel always amounts to $2 \times F_{L_g}$ or $F_{L_b}$ if the fixed end is in the centre of the travel. In this case, the following applies e-chain® length: $L_s = \frac{S}{2} + K$

S = Length of travel
R = Bend radius
H = Nominal clearance height
$H_y$ = Required clearance height
$K = \pi \times R + (2 \times T)$ Add-on for bend radius

Diagram series legend on the right

Find the values for $F_{L_g}$ and $F_{L_b}$ also in every individual series chapter!
Unsupported straight \( FL_g \) | Fill weights up to 90kg/m

Load diagram for unsupported use

Unsupported with sag \( FL_b \) | Fill weights up to 90kg/m

Load diagram for unsupported use

Important information

- Fill weight - weight of all cables and hoses, including contents (for media hoses) within the e-chain®, typically given [kg/m]
- \( FL_g \) - unsupported e-chain® with straight upper run
- \( FL_b \) - unsupported e-chain® with permitted sag
- To the right of the \( FL_g \) graph of the diagram, the application is shown in critical sag. **This must be avoided!**

These values are essential for finding a suitable e-chain® for your fill weight and travel distance, and 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®.

The maximum travel

The maximum travel always amounts to \( 2 \times FL_g \) or \( FL_b \).

If the fixed end is in the centre of the travel. In this case, the following applies e-chain® length: \( L_x = \frac{S}{2} + K \)

\[ S = \text{Length of travel} \]
\[ R = \text{Bend radius} \]
\[ H = \text{Nominal clearance height} \]
\[ H_0 = \text{Required clearance height} \]
\[ K = \pi \times R \times (2 \times T) \] Add-on for bend radius

Diagram series legend on the right

- E1 Page 174
- RX Page 502
- easychain® Page 198
- E4.1L Page 524
- zipper Page 226
- E4.1 Page 566
- E2 micro Page 260
- E4/5 Page 660
- E2 mini Page 290
- T3 Page 722
- E2.1 micro Page 320
- E3 Page 732
- E2.1 Page 334
- E6.1 Page 750
- E2R Page 360
- E6 Page 788
- E2R000 Page 428
- e-skin® Page 834
- E2R Page 454
- TH3 Page 850
- RX48 Page 742
- RX56 Page 478

Find the values for \( FL_g \) and \( FL_b \) also in every individual series chapter!
Recommended ratio of inner width $B_i$ to bend radius $R$
The minimum inner width of an e-chain® on long travels depends on its bend radius. For particularly large bend radii on long travels, please consult igus®.

Igus® specifies:

$$L_{K_{\text{max}}} = \frac{s}{2} + K_2$$

- $L_{K_{\text{max}}}$ = e-chain® length
- $S$ = Length of travel
- $s/2$ = Half length of travel
- $R$ = Bend radius

ACL = Offset fixed end

$H_0$ = Trough inner height

$H_2$ = Lowered mounting height

$D_2$ = Over-length for long travel gliding

$K_2$ = Add-on with lowered moving end

Long travel with an energy-efficient rol e-chain® - saving drive power

Example of lowered moving end

**Gliding application 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 diagram below shows this. 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 centre, the e-chain® length is calculated as follows: $L_{K_{\text{max}}} = \frac{s}{2} + K_2$.

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 moving end).

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

- Travels over 800m
- 6m/s speed (up to 10m/s possible after consultation with igus®)
- Fill weights up to 70kg/m
- 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, fibre 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

**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.

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

- Travel [m]
- Travel speed [m/min] or [m/s]
- Acceleration [m/s²]
- Fill weight [kg/m]
- Maximum cable/hose outer diameter [mm]
- Type and number of cables and hoses
- Required bend radius [mm]
- Cycle frequency (n/day or n/hour)
- Technical environment

We recommend pivoting mounting brackets for gliding applications.

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

Longest igus® travel of 615m with rol e-chain® and chainflex® cables

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

More information ➤ www.igus.eu

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3D CAD, configurators, service life calculation and more ➤ www.igus.eu

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Long travels with igus® guide troughs

Guide troughs allow igus® e-chains® and e-tubes to continue smooth, low-friction operation in long travel applications. Principle sketches are shown on this page. The height of the trough must be at least twice that of the e-chain® height. The sides must provide a chamfered opening. The trough inner width is the same as the e-chain® outer width, plus 4mm on igus® aluminium SuperTroughs. Along the side of the trough, where the upper run cannot glide on the lower run, glide bars must be installed. We recommend the use of polymer glide bars from igus®. They are optimally matched to the e-chain® material and achieve the lowest values for friction, noise and wear. Guide troughs with and without glide bars can be obtained from stock 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 during installation
- All screw heads should be flush with the trough
- Smooth level transition between the end of the e-chain® and the glide bars
- Solid connection with the glide surface. These points must be observed when using igus® guide troughs.

Friction values for e-chains® made of igumid G and various glide bars

<table>
<thead>
<tr>
<th>igus®</th>
<th>igus® polymer</th>
<th>Galvanised steel sheet</th>
<th>Anodised aluminium</th>
<th>AISI 303 stainless steel (material 1.4301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>glide bar</td>
<td>Coefficient of friction dynamic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>igumid G</td>
<td>0.19</td>
<td>0.45</td>
<td>0.54</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Service life

We offer service life calculations for your application based on our extensive gliding application experience. As developers of polymer plain bearings, we possess vast material behaviour knowledge which we apply to the development of e-chains® as well. Units with 200m travels have been in operation for 8 years with minimum maintenance. Units up to 600m 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 operational 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 explosive environments (with special design features) and many other conditions. You will find more details in the Technical Environment section of this chapter. Guide troughs can be supplied in corrosion-free materials.

Calculation

Comprehensive tests place us in the position of knowing our products capabilities. 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
- Behaviour of electrical cables under push/pull conditions
- Behaviour 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 can carry out a test for you in our laboratory. Please consult igus®.

Technical data - gliding applications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel max.</td>
<td>600 m - 800 m</td>
</tr>
<tr>
<td>Speed (v) max.</td>
<td>10 m/s</td>
</tr>
<tr>
<td>Acceleration (a) max.</td>
<td>50 m/s²</td>
</tr>
<tr>
<td>Fill weight max.</td>
<td>70 kg/m</td>
</tr>
</tbody>
</table>

Corrosion-free igus® guide troughs are available in the material:

- Galvanised steel
- AISI 316Ti/AISI 316L stainless steel material 1.4571/1.4404 upon request
- Seawater resistant aluminium
Vertical hanging | Application

**Vertical, hanging applications**
For hanging applications, heights of over 100m are possible with igus® e-chains®. Particularly in the area of material flow technology, the igus® e-chain® enables a bundled supply of a wide variety of cable types. The use of an e-chain® ensures that individual cables are not entangled in parts of shelves or protruding pallets.

**Cables and hoses**
Two important factors in vertical hanging applications are how the cables and hoses lay in the e-chain® and how they are secured at the end points: all cables and hoses must be hung so that they bear their own weight. The e-chain® fulfills the function of orderly conduit bundling only 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 and hoses are the basic prerequisites for hanging installations.

**Vertical motion with lateral acceleration**
If the application has a purely vertical movement without lateral acceleration, a lateral support is not necessary. If lateral acceleration occurs, lateral guidance of the e-chain® must be provided in most cases. The diagram shows the principle 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. The lateral guidance must be installed accordingly. If you have a choice, the layout in figure A is preferred. The lateral acceleration then acts transversely to the e-chain®, where it is more stable. When using a guide, an e-chain® with camber should be selected. This ensures that the chain is pressed into the trough.

**Technical data - vertical hanging**

<table>
<thead>
<tr>
<th>Stroke height max.</th>
<th>100 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>v(\text{max.})</td>
<td>20 m/s</td>
</tr>
<tr>
<td>a(\text{max.})</td>
<td>50 m/s²</td>
</tr>
</tbody>
</table>

**Special solution for vertical motion:**
**guidelok slimline P - safe and fast vertical guidance**
- Up to 7m/s and 10m/s²
- Up to 80% less trough required, saving costs and weight
- For hanging systems up to 50m
- 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
- Low weight due to plastic construction
- Energy, data and fluids supply without interruption in one system

More information ➤ From page 1034

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

**Guidelok slimline P vertical guidance in a high-bay warehouse, high reliability**

More information ➤ www.igus.eu

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Vertical standing | Application

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 outwards. The igus® product range 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 e-chain® so that they can bend freely and bear their own weight. 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, in most cases, be supported along the outer radius. For higher e-chain® heights, it is generally recommended that at least the first three links on the outer radius be supported. For maximum heights and weights, the whole distance must often be supported. Due to the wide variety of combinations involving fill weights, stroke heights, e-chain® types and bend radii, we strongly recommend you make use of our consulting services.

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

Technical data - vertical standing applications
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. stroke height - without support</td>
<td>≥ 4 m</td>
</tr>
<tr>
<td>Max. stroke height - with support of the first e-chain® links</td>
<td>≥ 6 m</td>
</tr>
<tr>
<td>Max. stroke height - with full support</td>
<td>≥ 20 m</td>
</tr>
<tr>
<td>v max (depending on stroke height and fill weight)</td>
<td>20 m/s</td>
</tr>
<tr>
<td>a max (depending on stroke height and fill weight)</td>
<td>50 m/s²</td>
</tr>
</tbody>
</table>

Zig-zag | liftband | Application

Zig-zag application: de-commissioning of a nuclear power station. About 14 m high steel containers are milled into small swarf for disposal.

Zig-zag design
The modular design of igus® e-chains® facilitates this space-saving and unconventional solution. For modern platform technology, such as theatre stages, a variety of cables and hoses which adjust the stage height must be accommodated. Lack of space almost invariably presents difficulties. The picture shows an e-chain® in a zig-zag configuration. The unstretched e-chain® is stored in a basket. If the platform is raised, the e-chain® unfolds, generating little or no noise. This construction is possible with the E4.1 system as well as many other types. Please consult igus® for these kinds of applications.

Technical data - zig-zag
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. travel</td>
<td>40 m</td>
</tr>
<tr>
<td>v max.</td>
<td>0.4 m/s</td>
</tr>
<tr>
<td>a max.</td>
<td>1.0 m/s²</td>
</tr>
</tbody>
</table>

Special solution for vertical motion: liftband - guide up to a height of 13m with limited installation space
- For high vertical applications that have plenty of space horizontally but little height space
- Modular, silent, space-saving; vertical guidance for energy, data and media
- Max. extension length: 13 m
- Available in 2 sizes
- Alternative to zig-zag solution, but lighter and smaller installation space
- Vertical applications implemented with ease

More information ➤ From page 1028
Unsupported - side-mounted

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:

- Time
- Fill weight
- Width of the e-chain®
- Bend radius
- Parallel placement

The greater the fill weight of the e-chain®, the shorter the available unsupported length. When placed on its side, the e-chain® width, in effect, becomes the height. As this height increases, the e-chain system® becomes proportionally more stable. If further movement in a second axis is added to the parallel motion of two e-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°

**System E4.1 - side-mounted unsupported**

![Graph showing load diagrams for System E4.1](image)

**System E2/000 - side-mounted unsupported**

![Graph showing load diagrams for System E2/000](image)

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

Side-mounted | Application

The lying e-chain®, one side of the igus® e-chain® is supported

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

More information ➤ www.igus.eu

Side-mounted | Application

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

Long travel, gliding

Side-mounted e-chains® can travel over 100m with adequate guidance. All e-chain® types are designed to operate gliding on their side. The corresponding glide surface is usually an igus® polymer, stainless steel (1.4301 material) 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 vertical separators and spacers. igus® will gladly provide an application analysis, free of charge.

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

More information ➤ www.igus.eu
Circular movement with **RBR**

**RBR** (Reverse Bend Radius) means that the e-chain® can bend in two directions. Most igus® e-chains® can be used in **RBR** designs, with the exception of some bend 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 bend radius \( R \) of an e-chain®. For example, Part No. E4.32.15 100/425.0, describes series E4.32 e-chain® with an inner width of 150mm, standard bend radius of \( R = 100 \text{mm} \) and **RBR** of 425 mm. Most circular movements can be achieved with an **RBR** option. Angles of rotation up to 540° have been achieved. Please consult igus® for your particular application.

Circular movements require less installation height. The e-chains® glide mostly on surfaces made of polymer, stainless steel (1.4301 material) or steel and are guided through channels in the circular movement. See side mounted for further design tips. Bend radius, circular radius and e-chain® width are variable with this product line.

Circular movement with standard e-chains®

The photo to the left shows an application which was achieved using standard e-chains®. Such solutions are possible if 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.

Circular movement on a robot

System E2 medium with 360° **RBR** circular movement on a robot

**Product range for circular movement 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 have **RBR** as standard. For all other types, **RBR** is made to order, and we will be more than willing to offer you this option, igus® e-chains® with **RBR**, available as standard ► triflex® R, easy triflex® and triflex®. The e-chain® series appearing in the table are **RBR** versions available from stock. Almost all igus® e-chains® can be delivered as an **RBR** version. Please contact us for any enquiry.

- **e-chain®** cables with TPE outer jacket are especially suitable for e-chains® with **RBR** option
- Strain relief only for the moving end

**Table of RBR e-chains® available from stock**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Series</th>
<th>Part No.</th>
<th>Series</th>
<th>Part No.</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>03.05.10/70</td>
<td>E2 micro</td>
<td>10.2.048/048</td>
<td>E2 mini</td>
<td>1500.038.075/450.0</td>
<td>E2/000</td>
</tr>
<tr>
<td>03.10.01/070.0</td>
<td>E2 micro</td>
<td>10.2.075/220</td>
<td>E2 mini</td>
<td>2400.06.05/250</td>
<td>E2/000</td>
</tr>
<tr>
<td>05.16.02/016</td>
<td>E2 mini</td>
<td>10.3.028/028</td>
<td>E2 mini</td>
<td>250.05.06/060</td>
<td>E2 medium</td>
</tr>
<tr>
<td>06.20.02/018</td>
<td>E2 mini</td>
<td>10.3.038/600</td>
<td>E2 mini</td>
<td>250.07.06/060</td>
<td>E2 medium</td>
</tr>
<tr>
<td>06.20.03/030</td>
<td>E2 mini</td>
<td>10.3.048/048</td>
<td>E2 mini</td>
<td>2700.15.150/900</td>
<td>E2/000</td>
</tr>
<tr>
<td>06.30.04/018</td>
<td>E2 mini</td>
<td>10.3.075/220</td>
<td>E2 mini</td>
<td>250.05.06/060</td>
<td>E2 medium</td>
</tr>
<tr>
<td>06.64.01/018</td>
<td>E2 mini</td>
<td>10.4.028/028</td>
<td>E2 mini</td>
<td>2800.15.150/900</td>
<td>E2/000</td>
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<tr>
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<td>10.4.048/048</td>
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<td>E/Z14.1.038/038 easy chain®</td>
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</tr>
<tr>
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<td>10.4.038/600</td>
<td>E2 mini</td>
<td>E/Z14.2.038/038 easy chain®</td>
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<tr>
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<td>10.4.048/048</td>
<td>E2 mini</td>
<td>E/Z14.3.038/038 easy chain®</td>
<td></td>
</tr>
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<td>10.4.048/400</td>
<td>E2 mini</td>
<td>E/Z14.3.075/075 easy chain®</td>
<td></td>
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<td>E2 mini</td>
<td>10.4.075/220</td>
<td>E2 mini</td>
<td>E/Z14.4.038/038 easy chain®</td>
<td></td>
</tr>
<tr>
<td>10.2.028/028</td>
<td>E2 mini</td>
<td>1400.05.075/075</td>
<td>E2/000</td>
<td>TE14.50.028/028 snapchain</td>
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</tr>
<tr>
<td>10.2.038/600</td>
<td>E2 mini</td>
<td>1400.06.038/038</td>
<td>E2/000</td>
<td>TE26.120.063/063 snapchain</td>
<td></td>
</tr>
</tbody>
</table>

**Available from stock. Ready to ship in 24 - 48hrs.*

* The delivery times indicated correspond to the average time until the ordered goods are dispatched.

More information ► www.igus.eu/rbr-configurator
Circular movement | RBR | Guide troughs

igus® guide troughs - standard modular system RM

Depending on the dynamics and load of the application, the guides are made of steel or stainless steel (material: 1.4301). For applications with high duty cycle, we provide a plastic sliding liner in the guide troughs. The igus® e-chains® do not require any additional sliding pads either for contact with the substrate or with the side walls. We would be happy to offer complete systems with guide troughs, and also support you with drawings for your own construction.

igus® Multi Rotation Module (MRM) allows circular movements up to 900° and more

With the Multi Rotation Module (MRM) you can implement larger angles of rotation of 900° and more. Thanks to stackable add-on modules the angle of rotation can be extended virtually indefinitely. One layer for rotations up to 540°, two layers for 900°, larger angles of rotation are possible with more layers. The rotation and add-on modules are ideally suited for rotary movements with high fill weights and limited space.

- Several individual systems are stacked on each other and thus are combined to a complete system
- The maximum rotation of the individual levels can easily be added, thereby enabling rotary movements up to 900° and more
- Compact design enables the operation even in tight spaces, extendable
- High fill weights possible
- e-chains® can be freely assembled
- Peripheral speeds up to 1m/s

Functional principle

- Is the defined rotation angle of the lower layer reached, the next upper module is carried along automatically due to an integrated connection system. The entire system only needs a mechanical force transfer
- Construction minimises 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 fibre optic cables
- Even for tough environmental conditions.

More information ▶ From page 1006

Circular movement with RBR, diameter 6000mm, the inner ring rotates

Typical application areas: off shore, stacker/reclaimer, bucket-wheel excavators, rotary cranes, reclaimer, bucket-wheel areas: offshore, stacker/bucket-wheel excitation, tools or telescopes in space, e.g., in machine tools or telescopes

igus® MRM modules: Rotate heavy filling in a small space, e.g., in machine tools or telescopes

Twisterchain | Twisterband | e-spool

Strong, quiet and up to 540° - circular and spiral movements - twisterchain

- Tough, quiet and high dynamics, suitable for high fill weights
- Rotary speeds up to 1m/s and more
- e-chains® for circular and spiral movements up to 360° from stock (up to 540° upon request)
- Modular interior separation
- Smooth, cable-friendly interior
- Openable from both sides - crossbars removable along the inner and outer radius
- Available with guide trough for smooth operation
- Successfully tested for over 1 million cycles in the igus® laboratory

More information ▶ From page 966

Rotary movements in small spaces - twisterband

- Rotary movements up to 7000° (“Installation position, vertical: up to 3,000°; horizontal: 7,000° and more possible”) • Rotary speeds up to 180°/s possible • Snap open with hinge or with “easy” design • HD version with very stable pin and hook connection for an even longer service life as well as for temperatures from 0°C to -80°C • Compact, modular and lightweight • Bands can be lengthened and shortened as required • Minimum installation space, fits closely around the rotary axis • Can be reliably used in various installation positions (horizontal or vertical) • Cost-effective and easy to fill

More information ▶ From page 988

Special solutions for multi-axis motion

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

- More versatile and flexible to use than cable reeling drums
- Different media (power, data and fluids) can be routed together in one system
- Energy supply in all directions (horizontal, vertical, diagonal) • Travels must be kept free • Very well suited for theatre and stage technology • No tensile load on the cables • Cables can be retrospectively added or changed • Alternative to zig-zag solutions
- Max. deployment and retract speed: 1m/s
- Large standard product range and special projects available

More information ▶ From page 1006

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.eu/MRM

igus® system RM - guide troughs for circular movement applications with RBR

Cover plate, optional

igus® MRM modules: Rotate heavy filling in a small space, e.g., in machine tools or telescopes

More information ▶ www.igus.eu/MRM

igus® MRM modules: Rotate heavy filling in a small space, e.g., in machine tools or telescopes

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3D CAD, configurators, service life calculation and more ▶ www.igus.eu

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Distribution rules | Cables and hoses

General rules for igus® 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 and hoses in the e-chain®, but you, the customer, are still afforded the final choice. It is possible, for instance, to maintain minimum distances between bus and motor cables and mix pneumatics, electric and hydraulics in the same compartments. It is possible to mix pneumatics, electric and hydraulics in the same compartments. In addition to the quality of the cables used, the arrangement of each conduit within the e-chain® and the space allowed, are important for the service life of the system. Various separation options enable the adaptation of the e-chains® to the specific requirements of each respective application. 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.

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.

Orderly cables with igus® interior separation

Further guidelines for distribution
The cable or hose weight should be symmetrically distributed across 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 series can be combined. The cables should always have strain relief at the fixed and at the moving end. Exceptions are made only for certain hydraulic hoses with length compensation issues or other high pressure hoses (i.e. hydraulic hoses). Generally, the faster and more frequently the e-chain® operates, the more important the exact positioning of the cables and hoses inside the e-chain® becomes. Due to the wide variety of the possibilities, we strongly recommend you take advantage of our free consultation services for your specific applications. igus® tip: interior separation configurator | www.igus.eu/quickchain100

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 0.5m/s and cycles over 10,000p.a, an igus® interior separation offers a safe solution for this situation.

Further guidelines for distribution
The cable or hose weight should be symmetrically distributed across 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 series can be combined. The cables should always have strain relief at the fixed and at the moving end. Exceptions are made only for certain hydraulic hoses with length compensation issues or other high pressure hoses (i.e. hydraulic hoses). Generally, the faster and more frequently the e-chain® operates, the more important the exact positioning of the cables and hoses inside the e-chain® becomes. Due to the wide variety of the possibilities, we strongly recommend you take advantage of our free consultation services for your specific applications. igus® tip: interior separation configurator | www.igus.eu/quickchain100

Distribution rules

| Cables and hoses
<table>
<thead>
<tr>
<th>Distribution rule</th>
<th>Cable type</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 1 mm</td>
<td>Electrical round cables</td>
</tr>
<tr>
<td>≥ 1 mm</td>
<td>Electrical flat cables</td>
</tr>
<tr>
<td>≥ 1 mm</td>
<td>Pneumatic hoses</td>
</tr>
<tr>
<td>≥ 1 mm</td>
<td>Hydraulic hoses</td>
</tr>
<tr>
<td>≥ 1 mm</td>
<td>Media hoses</td>
</tr>
</tbody>
</table>

Optional separators
An E4 extender chain with vacuum hose also guides an E2 e-chain® here

igus® interior separation configurator | www.igus.eu/quickchain100

Bend radius $R$
The bend radius of our e-chain systems® depend on the largest or stiffest cable or hose in your application. The bend radii of the e-chain® 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. We recommend complete e-chain system® - where bend radii for all cables and hoses, interior separation and service life are correctly matched. igus® chainflex® cables permit the smallest bend radius of $5 \times d$ for one million strokes.
Distribution rules | Cables and hoses

Round electrical cables
For electrical cables, the round cable is a safe, simple and cost-effective solution for e-chain systems®. We recommend the following criteria for selecting the proper round electrical cables:
- Small minimum bend radius and mounting heights
- Long service life at minimum bend radius
- Service life expectations for your application (short or long travel, hanging)
- Test data on service life from realistic tests
- Uncomplicated installation process - no hanging, laying out, etc. of cables
- Strain relief integrated directly into the mounting bracket
- Flexible shields for shielded cables
- Abrasion-resistant and non-adhesive outer jackets
- Large selection to avoid expensive custom designs. For bus cables and fibre optic cable, special attention must be paid to how effective transmission rates and shielding remain after millions of cycles at the minimum bend 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 bend radius.
4) The division of the e-chains® interior using igus® interior separators or shelves is necessary if several cables and/or hoses with varying diameters are laid out. It is important to prevent cables and hoses from tangling.
5) Cables and hoses with different jacket materials must not be allowed to stick together. If necessary, they should be separated. igus® chainflex® cables can be combined with all others.
6) Round electrical cables must be secured with strain relief at both ends. In exceptional cases, the cables may be fixed with strain relief at the moving end of the e-chain® only. A gap of 10-30 x cable diameter between the end of the bend segment and the fixed point is recommended for most cables. chainflex® cables can, on the other hand, be secured directly to the mounting bracket with strain relief (this has been confirmed with testing).

We will be pleased to provide you with recommendations for complete e-chain systems®: bend radii of all cables and hoses, interior separation and service life are then optimised.

Distribution rules | Cables and hoses

Pneumatic hoses
In principle, the same rules for round cables apply to pneumatic hoses. 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" rule. A double-sided strain relief is required under these conditions. For pneumatic hoses made of rubber, we recommend strictly following the "10% clearance" rule because they tend to adhere to each other and to other cables and hoses.

Flat cables
Flat cables must be able to move freely at the bend 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 into e-chains®, special attention should be paid to the expansion of the hoses when pressurised. Sufficient room must be left in the e-chain® (20% clearance). It is important for selected hoses to be sufficiently flexible (i.e. meet bend radius specified by the e-chain®). The gliding ability and abrasion-resistant surface of the hoses are also important. The igus® interior separation minimises 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 reverse-travel stresses. As lateral movements of the hydraulic hoses within the e-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 e-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 e-chain®.

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, one-sided strain relief on the moving end can be tolerated.

Rollclip
In almost all cases, the broad, smooth and rounded surfaces of all igus® e-chains® 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 small bend radii or highly dynamic loads. Over 95% of all applications can be solved without Rollclips.
Ideally, the cables/hoses should be strain relieved at both ends of the e-chain®. At the very least, they must be strain relieved at the moving end of the e-chain®.

Strain relief for electrical cables
Strain relief can consist of standard elements or can be custom-made. For most applications, our standard programme of C-profiles with mounting brackets and space-saving chainfix clamps can be used. We also offer simple strain relief solutions using tiewrap plates and cable tiewraps. 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 between 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 bend 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. Strain relief options, i.e. chainfix clamp or space-saving tiewrap plate, are offered by igus® for almost all e-chains®.

Strain relief separators - separator with integrated strain relief strain relief teeth
● Can be integrated in mounting bracket ● Strain relief separator can be positioned as required ● Double strain relief possible ● Easy to assemble without any screws ● Cost-effective ● For most series from stock

Stepped strain relief element outside of the e-chain® cross section
● Easy strain relief for cables, even in enclosed e-tubes ● Stepped strain relief - good access ● For e-chains® and e-tubes ● Easy retrofit assembly possible ● Simple installation into top-hat rails and C-profile on KMA mounting brackets

chainfix clip - modular snap-on strain relief device
chainfix clip is a series of clamps and bottom parts made of plastic for cable diameters ranging from 4mm to 24mm. chainfix clips are available for C-profiles, also suitable for assembly in the KMA mounting brackets and clip-on strain relief for cross bars. Characteristics: ● Quick installation without any tools ● 2 and 3 layers on top of one another possible ● Each layer can be detached and changed later on ● High tensile forces in case of single-layer installation, decreasing with the number of layers

Strain relief separators - separator with integrated strain relief strain relief teeth
● Can be integrated in mounting bracket ● Strain relief separator can be positioned as required ● Double strain relief possible ● Easy to assemble without any screws ● Cost-effective ● For most series from stock

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chainfix nugget - for C-profile and top hat rail
Option 1: universal cable fixation, for diameter with Ø 20mm and Ø 30mm
Option 2: fastening through clipping onto standard top-hat (DIN) rail
● The smart helper for electricians in the machine building industry ● Accessory for all KMA with integrated C-profile ● Easy to assemble, without any screws and tools ● Adjustable to every e-chain® filling ● Very small space requirement ● Easy strain relief due to fixation with pre-harnessed cable tiewrap

chainfix nugget - for C-profile and top hat rail
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Tiewrap plates as individual parts
The tiewrap plate is integrated on the end of the mounting bracket, and cables and hoses can be fixed with cable tiewrap. ● Quick and easy to assemble (clip on). The tiewrap plate is also captivated by the fixation of the mounting brackets ● Longer service life for cables ● Space-saving design ● Assembly in the C-profile of the KMA (plastic/metal mounting brackets) possible

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

4 options available: ● Tiewrap plates with clip-on connection for the C-profile ● Integrated strain relief for E2 e-tubes - series R ● Tiewrap plates for fixed crossbars ● Tiewrap plates for opening crossbars

Features of chainfix clamps
● 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 are available for complete systems with cables and strain relief ● Improved housing foot clamp for easy fit into C-profile ● Black housing and setscrews for aesthetic appearance ● Setscrews, tightened with Allen wrench, for easy installation ● Mark of the installation direction

chainfix | Strain relief elements

More information ► www.igus.eu
igus® material data | Technical environment

Chemical resistance

Find technical data about igus® materials: temperatures and chemical resistance

From page 142

For the food and tobacco industry

igumid G

igumid NB

igumid ESD

igumid TE

igumid GE

igumid DT

igumid ESD

igumid NB

igumid G

igus® materials:

Chemicals

Cleanroom

Dirt, dust

Hot swarf

Explosive environments

Cold, heat

Weathering

Radiation

Fire resistance

Technical environment:

Fire resistance

Radiation

Weathering

Cold, heat

Explosive environments

Vacuum

Hot swarf

Dirt, dust

Cleanroom

Chemicals

magnetically detectable plastic e-chains®

For the food and tobacco industry

igumid DT - automatic detection by all common metal detection systems

Particles as small as 1.0mm can be recognised for fragments passing at speeds of 20m/min

more information: www.igus.eu/detectable-chain

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 behaviour 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.

3D CAD, configurators, service life calculation and more: www.igus.eu

igus® material data | Technical environment

flammability of igumid G

The flame retardant characteristics of igumid G can be described using various classifications. Most of igus® e-chains® are made from igumid G, i.e. the popular E4.1 and E2/000 e-chain systems®. Classifications:

Test procedure VDE 0034 parts 3/5.70

Tested according to UL94 “Standard tests for Flammability of Plastic Materials for Arts in Devices and Appliances” classification 94 HB for 3.2 and 1.6mm thickness of the body.

Tested according to DIN 4102 “Fire Behaviour 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).

flammability of igumid NB

All easy e-chains® and series 14, F17 e-chains® are made from the flame retardant igumid NB material. These e-chains® have the following flame retardant classifications:

UL94-HB (Standard)

VDE 0034 part 3/5.70 classification - IIb

DIN 4102 flammability of materials - B2

Please consult igus® for material availability of V3

Weathering and temperature resistance

Igumid G is very suitable for outdoor applications. In our experience, the mechanical properties of the e-chains® are not impaired. igus® e-chains® are used in applications as cold as -40°C (40°F). Installation may be eventually compromised at temperatures below -25°C (-13°F). In such cases, we offer special solutions made from cold plastic materials: +120°C (248°F) continuous temperatures are possible with igumid G, short-term up to +180°C (357°F). However, the mechanical values are reduced and the service life is impaired.

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 x 10^8 rd, the mechanical properties of igumid G change very little.

magnetically detectable plastic e-chains®

For the food and tobacco industry

igumid DT - automatic detection by all common metal detection systems

Particles as small as 1.0mm can be recognised for fragments passing at speeds of 20m/min

More information: www.igus.eu/detectable-chain

igumid NB:

UL94-HB (Standard)

igumid G:

UL94-V2 (Standard)

UL94-V0 (upon request)

igumid G:

UV-resistant!

Temperature range from -40°C (40°F) up to +120°C (248°F)

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

rol e-chain® on a coal unloading system with fire protection regulations - travel 190m, fill weight 8kg/m, v = 0.5m/s

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

Flammability class igumid G:

UL94-HB (Standard)

igumid NB:

UL94-V2 (Standard)

UL94-V0 (upon request)

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Live broadcast from the Winter Olympics in Lillehammer, 75m travel at -25°C (-13°F)
ESD e-chains® | Technical environment

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

Measurements of the electrical surface leakage resistance for igus® ESD e-chains® with the special material igumid GC were made already in 1992 by 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. To discharge build up of electrostatic energy, igus® recommends the igumid ESD material for the production of sensitive electrical components and for applications in hazardous environments (ATEX). igumid ESD surpasses even the standard material igumid and has been tested for over 10 million cycles in igus® technology.

Your benefits with ESD products

- ESD material tested with over 10 million cycles for the toughest requirements
- Openable e-chains® with mounting brackets and interior separation in ESD and ATEX design available from stock
- Standardised product - igumid ESD
- Proven over years of use in explosion-proof areas
- Short delivery times 7:00am to 8:00pm - ordering and delivery service

Conductivity of igus® products from igumid ESD

In contrast to temporary conductive surface coatings or volatile incorporated antistatic agents, the additives used grant a long lasting and maintenance-free conductivity. An e-chain® is not deemed conductive if the individual components exhibit conductivity, but the whole e-chain® from one end to the other must offer continuous conductivity. All products in this catalogue are optimised in this regard and the continuous conductivity is measured and documented prior to delivery by a 100% test. Only e-chain® that have passed this test are provided with the test seal and delivered. Colour* of igumid ESD products: similar to RAL7015, slate-grey to ensure distinguishability from standard materials.

(*Exception: cover zipper and triflex® R - here black in colour)

More information on igus® ESD e-chains®

1. General safety information:
These additional operating instructions apply to our ESD e-chains® in colour grey (similar to RAL 7015). They supplement the installation instructions for the standard e-chains® and the catalogue information. The information in these instructions relates only to data impacting on ESD areas. 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.

2. Assembly, removal and installation
Please follow the information in the installation instructions for the standard e-chains® and the catalogue 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 in order to discharge any electrostatic charges occurring.
Assembly, installation, commissioning and maintenance may be performed only by personnel properly 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.

3. 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 catalogue information. Correct grounding must be checked in particular in the case of ESD e-chains®.

4. 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 customised maintenance plans can become an issue and will be created if necessary)

Mounting brackets (moving end and fixed end)
Electrically conductive e-chain® material
3D CAD, configurators, service life calculation and more ➤ www.igus.eu
Safe and clean with igus® e-chains®

Cleanroom qualification of igus® e-chains®

By using a special material, the already low abrasion of the e-chain® can be reduced even further. In many applications where cumbersome special solutions are required, a simple standard e-chain® can be used instead. For many applications, the e-chains® in special materials are virtually abrasion-free. IPA tests confirm that standard igus® e-chains® meet cleanroom requirements, "tested and certified as very good". e-chains® for cleanroom applications demand very high wear resistance of moving parts, e-chains®, for example, must be very wear-resistant, in order to meet the normal requirements for such a sensitive environment.

Class per DIN EN 14644-1 Equivalent to US Fed. Std. 209E Classification series Report number Speed

ISO Class 1 no comparable classification E61.29.50.075.0 IG 1303-640-1 0.5 / 1.0 / 2.0
ISO Class 1 no comparable classification E3.15.040.075.0 IG 0704-400 0.5 / 1.0 / 2.0
ISO Class 1 no comparable classification E6.29.060.150.0,CR* IG 0704-400 0.5 / 1.0 / 2.0
ISO Class 1 no comparable classification e-skin® IG 1504-755 0.5 / 1.0 / 2.0
ISO Class 2 no comparable classification 1500.050.038.0 IG 1303-640-1 0.5 / 1.0 / 2.0
ISO Class 2 no comparable classification E4.32.10.063.0,CR* IG 1303-640-1 0.5 / 1.0 / 2.0
ISO Class 2 no comparable classification T3.29.050.038.0 IG 1303-640-1 0.5 / 1.0 / 2.0
ISO Class 2 no comparable classification E14.3.038.0 IG 0308-295 1.0
ISO Class 3 Class 1 2500.05.055.0 IG 0308-295 2.0
ISO Class 3 Class 1 E6.29.060.150.0 IG 0704-400 0.5 / 1.0 / 2.0
ISO Class 5 Class 100 E4.32.10.063.0 IG 1303-640-1 0.5 / 1.0 / 2.0

*Special material cleanroom

Cleanroom and ESD | Technical environment

Safe and clean with igus® e-chains®

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 ► Page 143 shows an excerpt of the resistance to chemicals. Acid-resistant e-chains® are available upon request.

Coolant resistance

e-chains® and e-tubes have proven resistance to cooling agents. However, we are always willing to perform individual tests if you have particular problems or advanced developments. Table on resistance to chemicals ► Page 143

Spatter, hot swarf

Laboratory tests and numerous field applications have proved that igus® e-chains® and e-tubes reliably protect cables in welding robots and machine tools since 20 years. e-tubes made from the igus® igumid HT material are resistant to hot swarf up to +850°C (1,562°F), no swarf sticks. This opens new possibilities for replacing more complex and expensive steel tubes. All E2 and E4 e-tubes from the standard product range are available in igumid HT material upon request. igumid G in direct contact with large amounts of melted aluminium is not recommended.

Dirt, dust, swarf

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

Vacuum

Igus® e-chains® made of igumid G can be used in vacuum applications. Very little outgassing occurs.

Dirt, dust, swarf

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### Material data igumid | Colours

#### Material data table

<table>
<thead>
<tr>
<th></th>
<th>Units of measurement</th>
<th>igumid G</th>
<th>igumid NB</th>
<th>igumid ESD</th>
<th>igumid TE</th>
<th>igumid GE</th>
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</thead>
<tbody>
<tr>
<td><strong>Mechanical properties</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Yield stress (dry/wet)</td>
<td>MPa</td>
<td>190/130</td>
<td>78/40</td>
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<tr>
<td>Elongation at break (dry/wet)</td>
<td>%</td>
<td>004/006</td>
<td>22/210</td>
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<td>Fracture modulus (tensile test)</td>
<td>MPa</td>
<td>9,000/7,000</td>
<td>2,900/1,200</td>
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<td>1</td>
<td>1</td>
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<td>Limit of elasticity (bending)</td>
<td>MPa</td>
<td>7,800</td>
<td>8,000</td>
<td>9,500</td>
<td>1,260</td>
<td>7,200</td>
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<td>Flexural strength</td>
<td>MPa</td>
<td>240</td>
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<td>Shore-D-Hardness</td>
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<td>79</td>
<td>79</td>
<td>83</td>
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<td>80</td>
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<tr>
<td><strong>General properties</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Density</td>
<td>g/cm³</td>
<td>1.37</td>
<td>1.14</td>
<td>1.2</td>
<td>1.02</td>
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<td>Moisture absorption 23/50 r.h.</td>
<td>% by weight</td>
<td>1.4</td>
<td>3.4</td>
<td>1.9</td>
<td>0.8</td>
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<td>Maximum water absorption</td>
<td>% by weight</td>
<td>5.8</td>
<td>7.6</td>
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<td><strong>Electrical properties</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Specific transitional resistance</td>
<td>Ω/cm</td>
<td>&gt;10¹⁰</td>
<td>&gt;10¹⁰</td>
<td>&lt;10¹⁴</td>
<td>&gt;10¹⁰</td>
<td>&gt;10¹⁰</td>
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<tr>
<td>Surface resistance ROA</td>
<td>Ω</td>
<td>&gt;10¹⁰</td>
<td>&gt;10¹⁰</td>
<td>&lt;10¹⁴</td>
<td>&gt;10¹⁰</td>
<td>&gt;10¹⁰</td>
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<tr>
<td><strong>Thermal properties</strong></td>
<td></td>
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<tr>
<td>Lower operating temperature</td>
<td>°C / °F</td>
<td>-40°C / -40°F</td>
<td>-40°C / -40°F</td>
<td>-40°C / -40°F</td>
<td>-40°C / -40°F</td>
<td>-40°C / -40°F</td>
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<tr>
<td>Upper long-term application temp.</td>
<td>°C / °F</td>
<td>120°C / 248°F</td>
<td>80°C / 176°F</td>
<td>80°C / 176°F</td>
<td>70°C / 158°F</td>
<td>120°C / 248°F</td>
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<tr>
<td>Upper short-term application temp.</td>
<td>°C / °F</td>
<td>180°C / 356°F</td>
<td>170°C / 338°F</td>
<td>150°C / 302°F</td>
<td>140°C / 284°F</td>
<td>200°C / 392°F</td>
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<td><strong>Material certificates</strong></td>
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</tr>
<tr>
<td>Fire resistance as per UL94</td>
<td>–</td>
<td>HB</td>
<td>V2</td>
<td>HB</td>
<td>HB</td>
<td>HB</td>
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<tr>
<td>Silicone-free</td>
<td>–</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Halogen-free</td>
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<tr>
<td>2002/55/EG (RoHS)</td>
<td>–</td>
<td>++</td>
<td>++</td>
<td>++</td>
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<td>++</td>
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<tr>
<td>2002/95/EG (WEEE)</td>
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<td>++</td>
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<tr>
<td><strong>Colour</strong></td>
<td>according to RAL, approx.</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

#### Colours and special solutions

Product prices are always based on the colour black. e-chains® in any colour shown in the colour selection chart are subject to a percentage-based colour surcharge. Any other colours 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, coloured e-chains® are not available from stock. Delivery time and surcharges for coloured 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 coloured 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 colours. For more information, please visit our website: [www.igus.eu](http://www.igus.eu).

#### e-chain® colour variations with RAL-numbers

- **Black**: Standard, from stock - RAL 9004
- **Silver-grey**: Special colour - RAL 7001
- **White**: Special colour - RAL 9003
- **Grey-white**: Special colour - RAL 7002
- **Orange**: Special colour - RAL 2003
- **Yellow**: Special colour - RAL 1016
- **Light grey**: Special colour - RAL 7035

**Black e-chains® available from stock!** Delivery time* for special colours: from 5 business days.

*The delivery times indicated correspond to the average time until the ordered goods are dispatched.

### Chemical resistance | Technical environment

#### Chemical resistance of igumid

<table>
<thead>
<tr>
<th>Medium</th>
<th>Concentration % weight</th>
<th>igumid G / NB</th>
<th>igumid TE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>2</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Acetone</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Ammonia (aqueous)</td>
<td>10</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Benzene</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Bitumen</td>
<td>100</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Boric acid (aqueous)</td>
<td>10</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>100</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Calcium chloride (aqueous)</td>
<td>Sat. aq. sol.</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Caustic potash</td>
<td>10</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Chlorinated hydrocarbons</td>
<td>++</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Chlorine water</td>
<td>Sat. aq. sol.</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Chromic acid (aqueous)</td>
<td>1</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Colour</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Diesel oil</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Fats, cooking fat</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Fluorinated hydrocarbons</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Formaldehyde (aqueous)</td>
<td>30</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Formic acid (aqueous)</td>
<td>2</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Gasoline</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Hydraulic oils</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>pH₃</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>2</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>10</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Ink, printing ink</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Mercury</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Methyl acetate</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Milk</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Oil, cooking</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Oil, lubricating oil</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Paraflin oil</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Perchloroethylene</td>
<td>100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Polyester resins (with styrene)</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Potassium carbonate (aqueous)</td>
<td>60</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Potassium sulphate (aqueous)</td>
<td>100</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Propane gas</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Sodium carbonate (aqueous)</td>
<td>50</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Tartaric acid</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Vaseline</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Zinc sulphate (aqueous)</td>
<td>10</td>
<td>++</td>
<td>–</td>
</tr>
</tbody>
</table>

++ = Resistant
+ = Conditionally resistant
– = Non-resistant
Sat. aq. sol. = Saturated aqueous solution

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

igus® is certified in accordance with DIN EN ISO 9001:2015 and IATF 16949:2016 in the field of energy supply systems, cables and harnessing, as well as plastic plain bearings.

ESD
According to a statement by TÜV Rheinland 557/ Ex 12561309.00 /17, igus® energy chains do not fall under the scope of application of Directive 2014/34/EU. The material properties of igumid ESD combine the requirements according to ESD. igus® therefore recommends igumid ESD for use in the relevant ATEX zone.

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

Interbus, CC-Link, DESINA and NFPA
chainflex® cables are produced according to a lot 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 CC Link certified.
DESINA: many chainflex® cables are Desina-compliant.
NFPA: with the CF130.US and CF140.US, igus® offers the MTW (Machine Tool Wire) cable which meets the requirements of NFPA 79.

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 (see also noise-optimised e-chains® page 107).

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

if Design Award
Since 1987 - 38 if Design Awards www.igus.eu/if

More information www.igus.eu
**readychain® | Ready-to-install harnessed e-chain systems®**

Assembled energy supply systems, connectors and cables from igus®. Everything from one source, directly from the manufacturer, delivered quickly to your machine.

**readychains® - increase your capacity and cash flow quickly with igus®**

- Reduce overhead costs
- Reduce your throughput times from days to hours
- Respond flexibly to order variations
- Utilise igus® manufacturing capacities and our know-how in cable assembly

**Reduce the number of suppliers and orders by 75% with igus®**

- One order, one invoice, one delivery
- A partner for minimal machine downtimes
- All readychain® components are subject to an extensive quality control and function testing

**Customer-specific production**

From one off to mass production

**readychain® | You decide, igus® delivers**

Industrially harnessed energy chain modules direct from the manufacturer...

You decide the quantity, the travel and the degree of harnessing...

**Benefits:**

**readychain® basic**

1. ONE supplier - combine suppliers
2. Reduce assembly time
3. Reduce failures

Reduction of assembly time
Reduction of logistics cost
Procurement optimisation

Further information, videos, configurators and product finders [www.igus.eu/RCbasic](http://www.igus.eu/RCbasic)

**Benefits:**

**readychain® standard**

4. No electrical termination needed
5. 100% digitally tested
6. No cable surplus

Reduction of assembly time
Reduction of logistics cost
Procurement optimisation

Further information, videos, configurators and product finders [www.igus.eu/RCstandard](http://www.igus.eu/RCstandard)

**Benefits:**

**readychain® standard+**

7. Reduce interfaces
8. Optimise points of connection / interfaces
9. Ready-to-install multi-axis system

Reduction of assembly time
Reduction of logistics cost
Procurement optimisation

Further information, videos, configurators and product finders [www.igus.eu/RCstandard+](http://www.igus.eu/RCstandard+)

**Benefits:**

**readychain® premium**

10. Optimise your transport / assembly
11. One single assembly
12. One Part No. / Product group
13. Plug & Play

Reduction of assembly time
Reduction of logistics cost
Procurement optimisation

Further information, videos, configurators and product finders [www.igus.eu/RCpremium](http://www.igus.eu/RCpremium)

Reducing the number of suppliers and orders by 75% with igus®

- One order, one invoice, one delivery
- A partner for minimal machine downtimes
- All readychain® components are subject to an extensive quality control and function testing

**www.readychain.eu**

3D CAD, configurators, service life calculation and more [www.readychain.eu](http://www.readychain.eu)
Everything from one source

The readychain® system includes pre-assembled, customised e-chain systems®. The "Plug & Play" solutions are configured, manufactured and delivered according to individual customer specifications. The use of the mounting rack can yield benefits even at low quantities.

Flexible components

The telescopic supports and braces of the readychain® rack allow flexible adaptation to the installation needs on site. Changes in serial production can be undertaken easily. By using modular parts, additional components can also be easily attached to the rack.

Sustainable use

The components of the readychain® rack are galvanised and thus designed for a long life. Each rack can be constructed within a few hours. The individual elements can be reused at any time removing the need to dispose of custom made parts, such as conventional welded transport racks.

Precise fitting "Plug & Play"

All interfaces and attachments are designed in such a way that the installation of the e-chain® can be managed quickly and easily. The complete package includes the matching plugs and connectors, plates, sensor actuator boxes, linear bearings, links to the central lubrication, etc., all reducing the installation time considerably.

Up to 1,600 readychain® systems per week, over 4,700m² floor space, "chain-cable-guarantee" since 1989. 3 shifts, 24 project engineers, 359 employees just for assembly
readychain® Connectors, cables and accessories

igus® connectors

Round connector connector kit
Square plug connector kit
Tools and accessories

igus® readycable®

4,400 drive cables in accordance with 24 manufacturer standards, from stock
Catalogue standards: Video/vision/bus technology
Catalogue standards: network/ethernet/FOC/Field bus
Catalogue standards: CF/INI initiator cables up to 4 x d

igus® hoses and attachments

Configured online with hose cable configurator

readychain® Configured, fitted, with system guarantee

1. System acceptance
2. Project phase
3. Initial acceptance of prototype
4. igus® installation

readychain® service

- We visit you
- Define interfaces
- Logistics planning
- Cycle integration
- Time schedule

readychain® service

- Component selection
- Interface optimisations
- Documentation
- Integrated project management
- Cost optimisation

readychain® Skype service*

- Initial acceptance from your workplace
- Build your prototype with an igus® project engineer, live in your meeting
- Your requests for changes explained with a model or visit us for production acceptance

*Only available in Germany

readychain® installation

- System installation by igus® specialists
- igus® supervision service for your own installation
- Transparent, fixed price

3D CAD, configurators, service life calculation and more www.readychain.eu

More information www.readychain.eu

150

www.readychain.eu

151
Capacity for 600,000 assembled cables a year, more than 18,000 test programmes, 1,800 test adapters

Process reliability, crimp force monitored, automated, time-optimised

Computer-based high-voltage testing and inspection of all assembled cables

Modern machinery - automatic stripper-crimper

Special cable assemblies to your specifications

Worldwide system guarantee

In our warehouse the material waits for your order and not your order for the materials!

100,000 e-chain® components

5 million meter of cables on stock

5,000 connector components

Hundreds of meters of guide troughs

2,750m² test lab - more than 15,000 tests every year

Quickly within reach

Numerous strain relief solutions

More than 8,000 cables per week

Just-in-time supply

Global Warranty

Global warranty for

igus® GmbH    Spicher Str. 1a    51147 Köln

Phone + 49-22 03-96 49-800

Fax + 49-22 03-96 49-222

Internet igus.de

E-Mail info@igus.de

Certificate

Guarantee

36 month guarantee

Certificate

Guarantee

36 month guarantee

We hereby confirm the following warranty for the igus® e-chainsystem® application described on the back page of this certificate:

For a period of 24 months upon delivery, we will ship replacement parts for any igus® components that fail due to wear and tear, free of charge (shipping ex works). This does not include failure due to mechanical impact and damage due to incorrect assembly. Shipping of replacement parts does not prolong the warranty period.

We reserve the right of inspecting the installed e-chainsystem®, prior to its first operation.

Other agreements:_____________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

Warranty confirmed

Date

igus® GmbH

Stamp and signature

Global Warranty

Global warranty for

igus® GmbH
ready cable® | From 24hrs ... for 24 manufacturers

No. 1 in moving, harnessed cables for e-chains®

The most cost-effective cable for your drive
igus® offers 7 price levels with the same electrical properties for ready cable® harnessed drive cables to your requirements:
- From ± 180° torsion to small movements
- From the smallest to the largest bend radius
- For outdoor or indoor applications
- Seven different outer jacket materials
- Chainflex® measuring system and servo cables

Find the right drive cable and calculate the savings potential ► www.igus.eu/readycable-finder

Example:
- B&R CF887, PVC, 15xd
- ELAU CF210, PVC oil-resistant, 10xd
- Fanuc CF21, PVC oil-resistant, 7.5xd
- LinMot CF897, iguPUR, 15xd
- NUM CF270, PUR, 10xd
- Rexroth CF27, PUR, 7.5xd
- SEW CF400BOT7, PUR, ±180°

60,000 test programmes
- High-voltage tests
- Digital continuity test
- 1,800 test adapters
- Custom tests

More information ► www.igus.eu/test

"QuickPin" - connector-cable configurator integrated directly in EPLAN P8
► www.igus.eu/quickpin

Predictable reliability ... tested!
- 36-month igus® guarantee on every cable**
- More than 2,0 billion test strokes per year
- 1.4 million electric measurements per year
- Security for machine builders
- Clear statements on durability and service life
- Unique in the market (as of 04/2016)

More information ► www.igus.eu/chainflex-guarantee

**Predictable reliability for full 36 months, or up to 10 million double strokes (5 million double strokes for the very cost-effective chainflex® M cables), whichever comes first. For the guarantee to be valid, the cables must be operated within the parameters for each cable series shown in the selection tables.
Save time and money - installation and maintenance of your e-chain system®

New installation
- Installation of a tailored e-chain system® on-site at your facility or your new plant
- Documentation and planning of the project at your construction site
- Configuration of the system interfaces and consulting by igus® engineering
- Fast and error-free installation on your machine
- Everything from a single source - including customised system guarantee

Conversion / Modernisation / Retrofit
- Modernisation and implementation concept for the conversion of existing energy supply systems to e-chain systems®
- To expand the capability
- Reduction of costs and energy consumption
- Increased service life
- Increased plant reliability and availability

Inspection
- Assessment of the technical condition of the your energy supply system
- Determination of the repair and maintenance requirements
- Reporting of deficiencies, risks and optimisation proposals
- Documentation of the plant condition in the inspection report

Maintenance
- Preventive maintenance of more complex e-chain systems® - proactively recognise and address any damage or issues, therefore extending the service life of your system.
- Adjustments on e-chain®, cables and strain reliefs
- Measurement, assessment, and documentation in the maintenance handbook

Repair / Service
- Prompt, flexible, and professional exchange and service on e-chain systems® and their components
Installation service | Quick, error-free, calculable prices

Installation service | Everything from a single source

From a single source - components, service, and reliability

Your reliable plant
"Improving technology and reducing costs"

System guarantee up to 36 months
(depending on application)

Supervisor service
New installation
Installation support

igus® installation service

Inspection and maintenance
Repair service and maintenance
Modernisation and retrofit

igus® energy chains
igus® chainflex® cables
igus® harnessed system

Tested: igus® lab, Cologne

Development and production: igus® GmbH, Cologne

Fast, professional installation by specialised installation staff:
- saves installation time and cost,
- increases the service life,
- prevents failures

Fast with approved partners in your area - keeps travel and response times short and saves installation costs

Predictable installation time for your system at your premises -
- helps you schedule and contributes to high plant availability

System guarantee up to 36 months
(depending on application)

Ranging from the initial assessment to the final system configuration, the delivery, and the on-site installation of the system in your plant. You can focus on your core business.