Thermally Conductive Materials
Thermally Conductive Foils
Transistor Clips

Products 2003

Kunze

The Heatmanagement Company

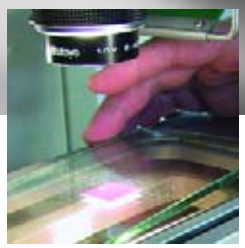
Kunze Heatmanagement shows competence, know-how ...

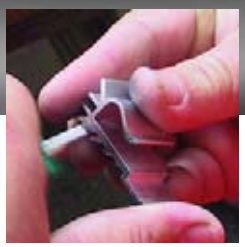
Our Philosophy

Founded in 1985 by Mr. Burkhard Kunze, Dipl.-Ing., Kunze Folien GmbH is located south of Munich, Germany, and is recognized as one of the leading providers of customized heat management solutions.

The key components of our company´s success are our focus on strong longterm partnerships with customers worldwide as well as the long standing expertise and dedication of our international employees.
They all form a strong teamwork with individual responsibilities. Our technical know-how combined with a permanent desire for innovation is all benefit for our customers.

In order to remain at the leading and driving edge of technology we maintain a permanent dialogue with customers´ R&D departments as well as with technological institutes. This enables us to stay one step ahead, giving our customers a high level, both of trust and satisfaction, making us to be a reliable and competent partner.





... and innovativeness
with strong quality commitment

Quality Commitment

All our processes are regularly submitted to evaluation and improvement. Accreditation according to **DIN EN ISO 9001:2000** is one confirmation of our ability to maintain a high quality level leading to optimizing processes and identifying and eliminating any defects.

We analyse your needs ...

Product Variety and Service

Our offer covers the full scope of heat management solutions, focussing on highly thermal conductive interface materials, heatsinks and semiconductor clips, especially in power electronics. We permanently analyse our customers´ needs and develop in partnership with them complete integrated heat management solutions.

Tailor made products are then produced in our own premises. We keep a stock of most of our articles so that we can meet our customers' needs in a short time.

… and develop individual and integrated solutions

Customers as Partners

The demand for both process reliability and flexibility has been constantly increasing. That is why it is very important to understand the complexity and the importance of each component in every application. As a "All-In-One-Supplier" familiar with each of these components we are able to find the best heat management solution, offering quality at a fair price. Working on a project from scratch to its fulfilment demands partnership and that is why our customers are more than that. They are our partners.

Our Target

As a leading international supplier of integrated heat management solutions, teamed with our technical know-how and through the high competence and longterm experiences of our employees, we strive for a strong partnership with our customers. Customer service in line with innovativeness, responsibility and an open company culture will remain the key pillars for joint organic growth together with our partners in the future.

Introduction

A semiconductor generates a significant amount of heat during operation which leads to an increase in the junction temperature. If appropriate measures are not taken to dissipate this heat, the performance of the components will be critically affected. In extreme cases, this can ultimately lead to the destruction of the components. In order to dissipate the heat generated during operation, power semiconductors are mounted on heat sinks. However, the surfaces of the semiconductors and the heat sinks are not generally flat and smooth and a good heat contact cannot be obtained without undertaking special measures such as grinding the contact surfaces. In many applications, the component must also be electrically insulated from the cooling surface. This requires an electrically insulating material having a low thermal resistance

Fundamentals

Heat dissipation from the source (semiconductor barrier layer) goes through many layers of different materials before the heat is finally transferred to the ambient environment through free or forced convection.

The heat flow H (per time unit of dissipated heat mass Q) through a layer in thermal equilibrium is given as:

$$H = \frac{dQ}{dt} = -kA \times \frac{dT}{dx}$$

A designates the contact area, dT/dx the temperature change over the thickness of the layer and k is the specific thermal conductivity of the material.

For a homogeneous material of uniform thickness and in thermal equilibrium, the formula simplifies to:

$$H = kA \times \frac{T2 - T1}{d}$$

where the temperature T2 is greater than T1 and d designates the thickness of the layer. The specific thermal conductivity is a material constant. Assuming the same geometry, the higher the value of k, the better the heat transfer. Some values of k are:

Aluminum (99%):	**220 W/mK**
Graphite:	**169 W/mK**
Steel:	**45 W/mK**
Air:	**0.0026 W/mK**

Analogous to the formula for electric current, the above equation can be written as:

$$H = \frac{\Delta T}{R_{th}} \qquad H \times R_{th} = \Delta T$$

where R_{th} is the heat resistance. Substituting the previous formula results in the following expression for R_{th}:

$$R_{th} = \frac{d}{k \times A}$$

R_{th} is generally given in °C/W.

As can be seen, the thermal resistance of a layer is dependent on the dimensions as well as on the thermal conductivity of the material. The thermal resistance decreases with an increase in the contact area or a higher thermal conductivity of the interface material and with a decrease in the layer thickness. It is therefore known as $R_{th\ material}$.

Another important impact on the heat transfer between two contact surfaces is the thermal contact resistance: $R_{th\ contact}$. Surface areas are never purely even and the bigger the surface is, the more ruggedness occur caused by concave, convex and other imperfections, hence the less contact there is. These imperfections or "micro pores" impede the heat flow, as the thermal path is then limited to the actual contact points between the two surface areas. The thermal contact resistance therefore depends on: the surface, the surface quality, the evenness, the flexibility of the interface material and the pressure applied.

The total resistance of heat flow between two surfaces is the sum of the material thermal resistance and the thermal contact resistance:

$$R_{th\ total} = R_{th\ material} + R_{th\ contact}$$

In practice, the contact area is pre-determined by the component outline. Likewise, the thickness of the material is kept within practical limits with respect to the dielectric strength of the insulating material as well as by the unevenness or burrs that must be smoothed out by the thermally conductive layer.

Materials

In power electronics, there is currently a plenty of thermally conductive insulating materials in use. These materials include elastomers with thermally conductive fillers, polyimide films coated with thermally conductive soft materials, ceramic insulators, mica insulators in combination with thermally conductive grease.

Elastomers

The time-consuming process of applying thermally conductive grease and the problems of soiled components with the grease ingredients led to the development of elastomer insulating materials. They are made of an elastomer binding agent, together with a thermally conductive filler.

When pressure is applied, the elastomer insulator adapts very well to the contact surfaces resulting in a low thermal contact resistance between the surface areas.

The most common elastomer binding agent is silicone. In addition to high tensile strength and good chemical stability, silicone has high temperature stability. The total thermal resistance can be optimally adjusted by regulating the application pressure. Because the degree of cross linking in silicone is very high, there is practically no danger that the silicone molecules will leak out over time and dirty the components.

Elastomer binding agents only have low thermal conductivity, but they can absorb large quantities of thermally conductive fillers. The thermal conductivity can be changed by mixing in ceramic powders. The least expensive ceramic filler is aluminum-oxide. Compared to mica and ceramic insulators, elastomer insulators filled with aluminum-oxide have medium thermal conductivity. This is adequate in most cases.

Another filler is boron nitride. It is finer grained and is not as thick as aluminum-oxide. This makes the rubber softer and more pliable so that boron nitride filled elastomer insulators adapt more easily to uneven surfaces, hence decreasing the thermal contact resistance. Boron-nitride is more expensive, but has a thermal conductivity that is distinctly higher than that of aluminum-oxide. These elastomer insulators filled with thermally conductive ceramic can be reinforced with fiberglass.

The thicker the fiber, the higher the material's tensile strength and the lower the thermal conductivity. The reinforced fiberglass also gives the insulator its mechanical loading capacity. Polyimide films are also used as a carrier.

The thermal conductivity of mica with thermally conductive grease lies somewhere between that of aluminum-oxide and boron-nitride filled elastomers. The thermal resistance of mica insulators coated with thermally conductive grease depends to a great degree on the care with which the grease is applied and on the thickness of the mica insulators.

The thermal resistance of elastomer insulators is not dependent on the assembly process and varies negligibly due to tight manufacturing tolerances. For the production, this means a guarantee of process reliability and reproduction capability.

Polyimide Films

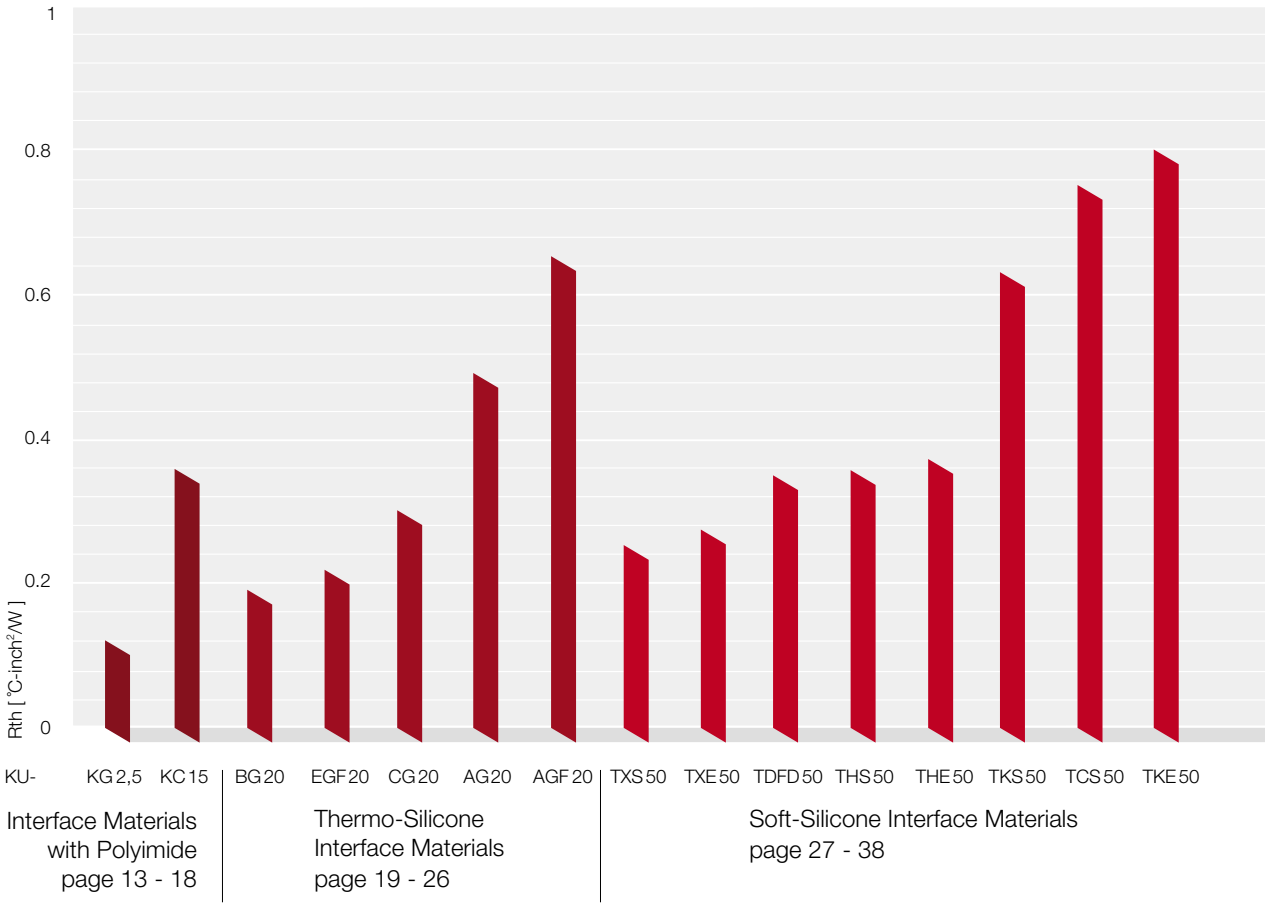
Polyimide films can also be used to insulate components. They have high tensile strength and are at the same time though and flexible, so that they are resistant to punctures and tearing. Polyimide films have relatively low thermal conductivity and are therefore usually very thin and coated. Coating with a good thermally conductive material such as thermally conductive silicone or polymers with phase change properties guaranties a good thermal contact.

Phase Change Materials

Phase change materials consist of a special thermally conductive compound that improves the heat flow by changing to a soft state and back to a solid state at pre-determined temperatures reached during the operation cycles of the component to be cooled. During the change to the soft state, the compound expands in volume thereby filling all interstitial voids and micro pores between the mounting surfaces. This eliminates all air pockets between the interfaces thereby allowing maximum heat transfer from the semiconductor to the cooling surface thus minimizing thermal contact as well as total thermal resistance. For mechanical stability and depending on the application, phase change materials can be applied either on electrically conductive metals like aluminum for instance or on electrically insulating substrates like polyimide films.

Thermal Resistance Overview

Electrically Insulating Interface Materials



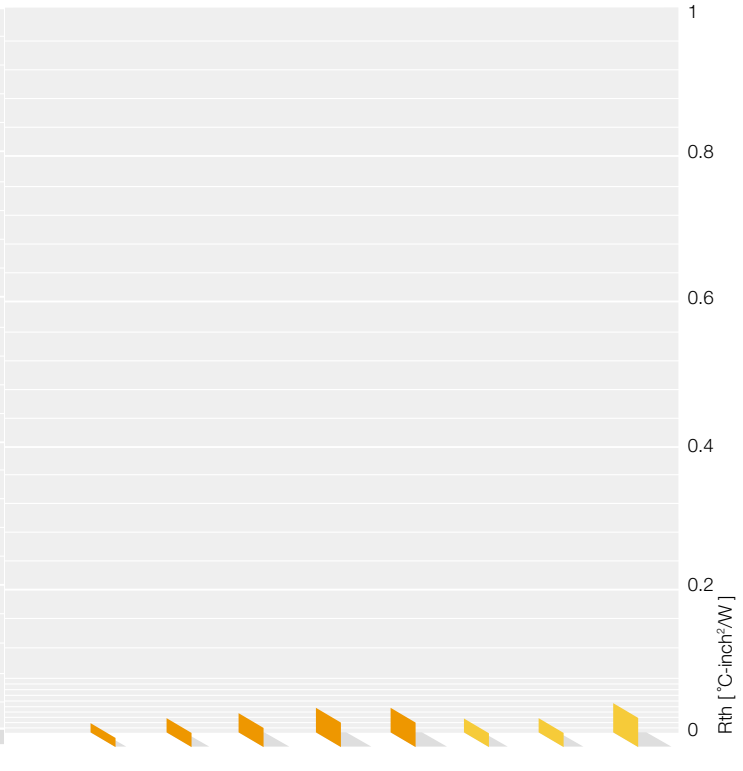
Ceramic Insulators

Ceramic insulators are used as insulators for semiconductor components. These are predominantly made of aluminum-oxide, beryllium-oxide, boron-nitride and aluminum-nitride. They are hard and are therefore usually used with thermally conductive grease to effect a good thermal contact. By mechanical handling of the surface (e.g. grinding), the heat transfer resistance can be considerably reduced. The thermal conductivity of a ceramic insulator is distinctly higher than that of mica. Therefore greater thicknesses of ceramic insulators can be used in order to achieve a high tensile strength. They are very brittle and expensive so their use is relatively costly. Moreover, beryllium-oxide requires careful processing to avoid mechanical damage as the inhalation of beryllium dust can lead to chronic pneumonia.

Mica Insulators

Mica insulators have long been used in a similar way. The dielectric strength of mica is excellent, however the thermal conductivity is not particularly high. Like the ceramic insulators, mica is very hard and therefore does not make very good contact with the component to be cooled. For this reason, mica has a high thermal resistance and is generally only used in combination with thermally conductive grease. When the contact surface is uneven or burred, the brittle mica insulators can easily break during mounting causing a short circuit. The use of thermally conductive grease requires a costly manufacturing process. The components must be cleaned and soldered before the grease is applied. With silicone-based greases, the danger arises that the silicone will leak out over time, thereby dirtying the electrical contact. This can lead to corrosion of the contacts and consequently to a loss of conductivity.

Electrically Non Insulating Interface Materials



Thermally Conductive Phase Change Interface Materials
page 47 - 56

Graphite Interface Materials
page 57 - 62

Conversion Table

Conversion Factors

	SI	Industry Unit	Physical Unit	British Unit
Thermal Conductivity	**W/mK** 1 1.163 4.1868 1.73070	**kcal/mh°C** 0.85985 1 360 1.48810	**cal/cm · s°C** 0.00239 0.00278 1 0.00413	**BTU/ft · h · F** 0.5778 0.672 241.9 1
Thermal Resistance	**°C/W** 1 0.85985 0.23885 3.41297	**°Ch/kcal** 1.163 1 0.27778 3.96825	**°Cs/cal** 4.1868 3.6 1 14.30615	**F · h/BTU** 0.293 0.252 0.0699 1

Thermally Conductive Interface Materials with Polyimide

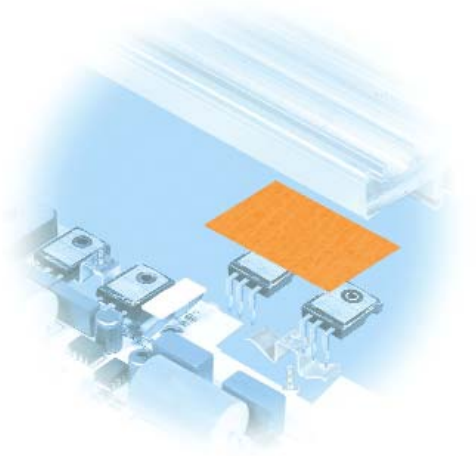
Polyimide films are ideal substrates to be coated with thermally conductive laminates due to their thinness, dielectric properties as insulators and their mechanical stability as well as their resistance to damage from chemicals and temperature.

Kunze thermally conductive foils based on a polyimide substrate are available with coating on both sides consisting of

1. KU-KG with CRAYOTHERM®, a silicone-free phase change thermally conductive polymer or
2. KU-KC with thermally conductive silicone

Due to the coatings, the application surfaces are optimally covered and air pockets are expelled from the micropores within the interface contact area, bringing the thermal contact resistance, thus the overall thermal resistance permanently to a minimum.

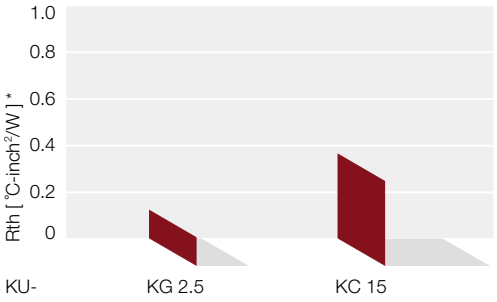
Due to their extraordinary mechanical stability, thermally conductive interface materials based on polyimide substrates are ideal for automated mounting processes.



Application Examples:

Thermal link and electric insulation of heat sources and heat sinks in
– Power electronics for the automotive industry
– Power supplies
– Frequency converters
– Electric Drives
– Telecommunication modules
– SMPS

Thermal Resistance Overview



* At a mounting pressure of approx. 700 kPa

Order free samples!

Polyimide with Phase Change Coating KU-KG

CRAYOTHERM®
is a registered trademark
of Kunze Folien GmbH

HEATPAD® KU-KG is an excellent thermally conductive foil, consisting of a thin polyimide film filled with thermally conductive ceramics, coated on both sides with our silicone-free, thermally conductive phase change compound CRAYOTHERM®. It shows extraordinary dielectric and mechanical properties combined with the excellent thermal properties of CRAYOTHERM®. CRAYOTHERM® undergoes a unique phase change once a temperature of approx. 60°C is reached, becoming soft. The compound expands in volume thereby actively filling all voids and micropores between the mounting surfaces, thus minimizing thermal contact resistance as well as the total thermal resistance. Once the first phase change has taken place and the material has expanded, the minimum thermal resistance remains in this condition through all temperature cycles, independent of the temperature.

Properties

- Minimum thermal resistance together with very high electrical insulation
- Silicone-free
- Active wet-out of the interfaces by volumetric expansion of CRAYOTHERM® by about 15-20 % without outflow
- Highly stable and flexible
- Guaranteed coating thicknesses
- Low starting torque required
- Clean and easy pre-mounting with high process reliability by adhesive or adhesive stripes
- Replaceable without surface treatment
- Cleaning with Isopropyl alcohol
- UL flammability rating: UL 94 VO

Product Availability

- All standard configurations see page 89
- Without adhesive or adhesive on one side (AV) or with adhesive stripes on the edges (S)
- In roll form according to customer specifications
- Stamped or cut according to customer specifications
- As sheets

KG 2.5	300 mm x 1000 mm
KG 3.8	452 mm x 1000 mm
KG 5; KG 7.5	584 mm x 1000 mm

Upon Request

- Other coating and substrate thicknesses

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Order free samples!

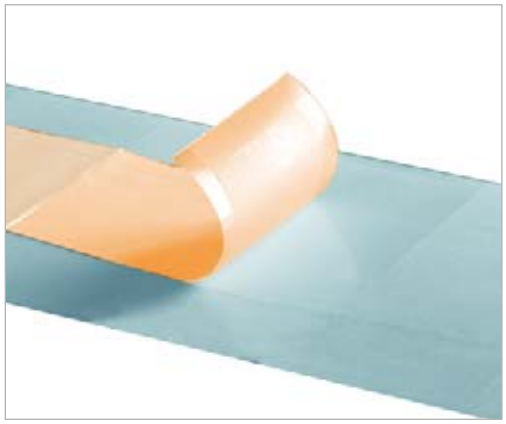
Technical Data

Part	KU-	KG 2.5	KG 3.8	KG 5	KG 7.5
General Properties					
Material	Construction	Phase Change - Polyimide - Phase Change			
Phase Change Material[1]		CRAYOTHERM®			
Colour		Light Orange			
Material Thickness With Coating	µm	25	38	51	76
Total Thickness	µm	50	63	76	101
Mechanical Properties					
Tensile Strength	MPa	124	124	124	124
Tear Strength	kN/m	300	300	300	300
Electrical Properties					
Breakdown Voltage[2]	V (AC)	4200	6000	7700	11000
Volume Resistivity	Ω m	1.0×10^{12}	1.0×10^{12}	1.0×10^{12}	1.0×10^{12}
Dielectric Constant (1 kHz)		4.5	4.5	4.5	4.5
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	0.45	0.45	0.45	0.45
Thermal Resistance[3,4](inch²)	°C/W	0.12	0.16	0.20	0.29
Phase Change Temperature CRAYOTHERM®	°C	60	60	60	60
Operating Temperature	°C	-60 to 150	-60 to 150	-60 to 150	-60 to 150
Storage Temperature	°C	max. 40	max. 40	max. 40	max. 40

[1] Coating thickness approx. 12.5 µm per side
[2] According to data for Kapton® of DuPont
[3] Measured with mounting pressure of approx. 550 kPa, test surface finish of Ra = 1.6 and 0.05 mm flatness over a 25 mm length
[4] Increase of thermal resistance through acrylic adhesive by about 0.05 °C/W

Ordering Example
KU 6-623 / KG 5
Part / material

Configurations and dimensions on page 89



CRAYOTHERM®
is a registered trademark
of Kunze Folien GmbH

HEATPAD® KU-KG/S
with adhesive stripes on the sides.

HEATPAD® KU-KG/S is a polyimide film, filled with ceramics, coated on both sides with CRAYOTHERM® and with 5mm wide acrylic adhesive stripes on the sides to help with the mounting. The excellent thermal conductivity of CRAYOTHERM® and the total thermal resistance are then maintained.

Product Availability
– Available only in roll form due to technical reasons

HEATPAD® KU-KG/AV
adhesive on one side.

HEATPAD® KU-KG/AV is a polyimide film, filled with ceramics, coated on one side with CRAYOTHERM® and acrylic adhesive on the other side to facilitate the mounting.

Product Availability
– As rolls or sheets

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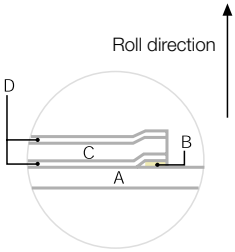
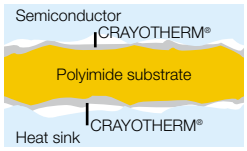
Construction of KU-KG/S



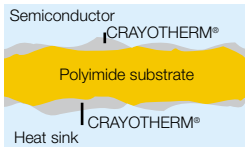
A Release liner
B Adhesive
C Polyimide
D Phase change thermal compound CRAYOTHERM®

Principle of Operation KU-KG and KU-KG/S

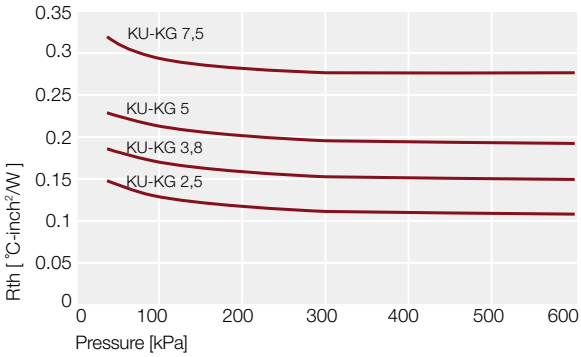
Before first operation, unheated



In operation, after first phase change



Thermal Resistance vs. Mounting Pressure



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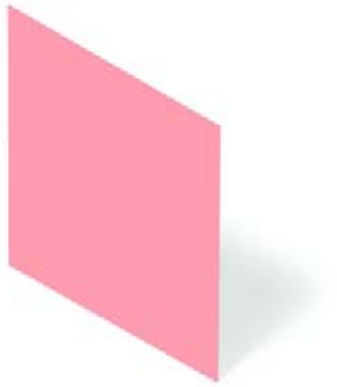
Ordering example
KU 6-623 / KG 5 / AV
Part / material /
adhesive on one side

Configurations and dimensions on page 89

Order free samples!

Polyimide with Silicone Coating KU-KC

HEATPAD® KU-KC is a very good thermally conductive foil with poliymide substrate, coated on both sides with a thermally conductive silicone film KU-C (same as KU-CG but without fiberglass reinforcement). It shows the extraordinary dielectric and mechanical properties of poliymide combined with the very good thermally properties of silicone. Due to its softness and with pressure applied, silicone then covers the contact surfaces, minimizing the thermal contact resistance, thus the total thermal resistance. In respect to mounting process reliability, this foil makes the breakable mica plus thermal grease combination obsolete.



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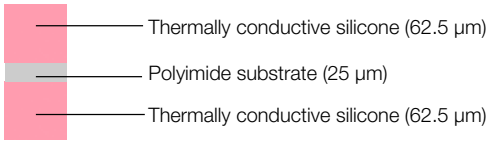
Properties

- Minimum thermal resistance together with very high electrical insulation
- Thermally conductive silicone coating on both sides
- Highly stable and flexible
- Guaranteed coating thicknesses
- Low starting torque required
- Clean and easy mounting with high process reliability
- Replaceable without surface treatment
- No thermal grease required
- UL flammability rating: UL 94 VO

Product Availability

- All standard configurations see page 89
- In roll form according to customer specifications, max. length 60 m
- Stamped according to customer specifications

Construction



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Technical Data

Part	KU-	KC 15
General Properties		
Material	Construction	Silicone - Polyimide - Silicone
Filler		Thermally Conductive Ceramic
Colour		Salmon
Substrate Thickness	µm	25
Material Thickness With Coating	µm	150
Mechanical Properties		
Tensile Strength	MPa	46
Tear Strength	kN/m	60
Hardness (Asker C)		90
Electrical Properties		
Breakdown Voltage (Voltage ramp)[1]	V (AC)	12500
Breakdown Voltage (Voltage steps)[2]	V (AC)	9500
Flame Rating		UL 94 VO
Thermal Properties		
Thermal Conductivity	W/mK	1.05
Thermal Resistance [3] (inch²)	°C/W	0.36
Operating Temperature	°C	-60 to 200

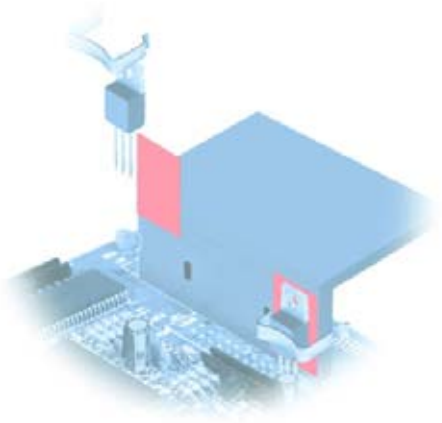
[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 700 kPa

Ordering example
KU 6-623 / KC 15
Part / material

Configurations and dimensions on page 89

Kunze HEATPAD® silicone foils KU-BG, KU-EGF, KU-CG, KU-AG, KU-AGF are the ideal and user-friendly substitution to the use of mica in combination with thermal grease for thermal conductivity and electrical insulation. The use of mica with thermal grease is a negative factor in today's always growing process reliability due to its lack of reproducibility. This problem is solved with the use of thermo-silicone foils. Furthermore they show higher temperature and chemical stability as well as high dielectric strength.

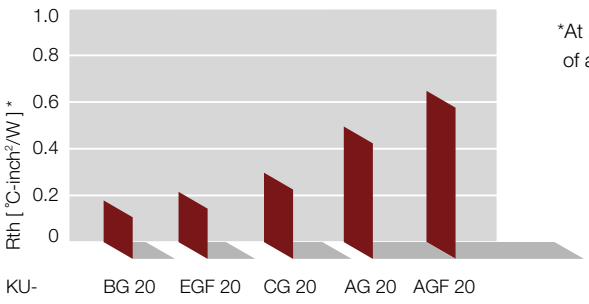
The thermal conductivity of the silicone is enhanced through the use of highly thermally conductive ceramics like aluminum-oxide, boron-nitride and aluminum-nitride for instance or through mixes in the polymer structure of the elastomer. Due to its softness and with pressure applied, silicone then covers the contact surfaces, expelling the air pockets, minimizing the thermal contact resistance, thus the total thermal resistance. The mechanical stability of the interface material is reinforced with fiberglass.



Application Examples

Thermal link and electric insulation of heat sources and heat sinks in
– Power modules
– Power supplies
– Electric drives
– Telecommunication modules
– Engine control
– Frequency converters
– UPS

Thermal Resistance Overview



*At a mounting pressure of approx.1.3 MPa

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HEATPAD® KU-BG is an extraordinary high thermally conductive silicone foil filled with boron-nitride, reinforced with fiber-glass. Its very soft surface complies with the contact surfaces so that the thermal resistance, thus the total thermal resistance is reduced to a minimum, fulfilling the highest technical requests expected from an interface material.

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

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Properties

– Extremely high thermal conductivity
– Minimum thermal resistance
– Fiberglass reinforced
– Very flexible
– Clean and easy mounting with high process reliability
– No thermal grease required
– UL flammability rating: UL 94 VO

Product Availability

– All standard configurations see page 89
– Tack-free or tacky on one side (AV)
– Stamped and cut according to customer specifications
– In sheet form:

BG 20	320 mm x 440 mm
BG 30	320 mm x 440 mm
BG 45	320 mm x 440 mm
BG 20/AV	200 mm x 260 mm
BG 30/AV	200 mm x 260 mm
BG 45/AV	200 mm x 260 mm

Order free samples!

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 1.3 MPa
[4] Increase of thermal resistance through tackiness by about 0.1 °C/W

Dry, tacky silicone resin on stainless steel:
Bond strength:
200 - 300 g/cm²
Tackiness:
150 - 550 g / 25mm width

Ordering example
KU 6-624 / BG 20 / AV
Part / material / tacky on one side

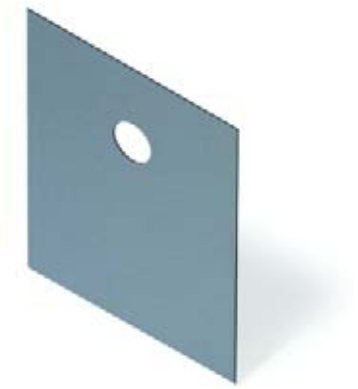
Configurations and dimensions on page 89

Technical Data

Part	KU-	BG 20	BG 30	BG 45	BG 80
General Properties					
Material		Fiberglass Reinforced Silicone			
Filler		Thermally Conductive Ceramic (Boron Nitride)			
Colour		White			
Thickness	mm	0.2 $^{+0.05}_{-0.05}$	0.3 $^{+0.1}_{-0}$	0.45 $^{+0.05}_{-0.05}$	0.8 $^{+0.1}_{-0}$
Mechanical Properties					
Tensile Strength	MPa	51.0	50.0	49.0	14.0
Tear Strength	kN/m	197	223	209	54
Hardness (Asker C)		90	90	90	90
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	7000	12000	16000	21000
Breakdown Voltage (Voltage steps)[2]	V (AC)	2000	5000	7000	12000
Volume Resistivity	Ω m	8.0×10^{12}	10.0×10^{12}	9.0×10^{12}	11.0×10^{12}
Dielectric Constant (1 kHz)		3.0	3.1	2.9	2.9
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	5.0	5.0	5.0	5.0
Thermal Resistance [3,4] (inch²)	°C/W	0.19	0.25	0.35	0.63
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200	-60 to 200

Thermo-Silicone KU-EGF

HEATPAD® KU-EGF is a silicone foil filled with highly thermally conductive ceramics and reinforced with fiberglass. By its implementation an extremely low total thermal resistance can be achieved which is why it is used in applications with critical temperatures.



Properties

– Very high thermal conductivity
– Extremely low thermal resistance
– Fiberglass reinforced
– Very flexible
– Clean and easy mounting with high process reliability
– No thermal grease required
– UL flammability rating: UL 94 VO

Product Availability

– All standard configurations see page 89
– Tack-free or tacky on one side (AV)
– In roll form according to customer specifications, max. length 50 m
– Stamped and cut according to customer specifications
– In sheet form:

EGF 20	330 mm x 1000 mm
EGF 30	330 mm x 1000 mm
EGF 45	330 mm x 1000 mm
EGF 20/AV	320 mm x 1000 mm
EGF 30/AV	320 mm x 1000 mm
EGF 45/AV	320 mm x 1000 mm

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	EGF 20	EGF 30	EGF 45
General Properties				
Material		Fiberglass Reinforced Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Blue Grey		
Thickness	mm	0.2 $^{+0.05}_{-0.05}$	0.3 $^{+0.1}_{-0}$	0.45 $^{+0.05}_{-0.05}$
Mechanical Properties				
Tensile Strength	MPa	18.0	17.0	15.0
Tear Strength	kN/m	70	50	55
Hardness (Asker C)		85	85	85
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	4000	7000	8000
Breakdown Voltage (Voltage steps)[2]	V (AC)	2000	5000	6000
Volume Resistivity	Ω m	25.0 x 10^{12}	22.0 x 10^{12}	19.0 x 10^{12}
Dielectric Constant (1 kHz)		6.5	6.5	6.5
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	4.5	4.5	4.5
Thermal Resistance [3,4] (inch²)	°C/W	0.22	0.30	0.44
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 1.3 MPa
[4] Increase of thermal resistance through tackiness by about 0.1 °C/W

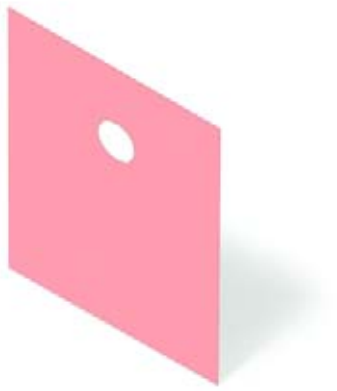
Dry, tacky silicone resin on stainless steel:
Bond strength:
200 - 300 g/cm²
Tackiness:
150 - 550 g / 25mm width

Ordering example
KU 6-624 / EGF 20 / AV
Part / material /
tacky on one side

Configurations and dimensions on page 89

Order free samples!

HEATPAD® KU-CG is a fiberglass reinforced silicone foil filled with thermally conductive ceramics, hence its high thermal conductivity. By its implementation a very low total thermal resistance can be achieved. Its performances and flexibility make it the ideal interface material for most applications.



State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

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Properties

- High thermal conductivity
- Very low thermal resistance
- Fiberglass reinforced
- Very flexible
- Clean and easy mounting with high process reliability
- No thermal grease required
- UL flammability rating: UL 94 VO

Product Availability

- All standard configurations see page 89
- Tack-free or tacky on one side (AV)
- In roll form (except KU-CG 80) according to customer specifications, max. length 50 m
- Stamped and cut according to customer specifications
- In sheet form:

CG 20	320 mm x 1000 mm
CG 30	320 mm x 1000 mm
CG 45	320 mm x 1000 mm
CG 80	320 mm x 1000 mm
Tacky on one side (AV)	320 mm x 1000 mm

Order free samples!

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 1.3 MPa
[4] Increase of thermal resistance through tackiness by about 0.1 °C/W

Dry, tacky silicone resin on stainless steel:
Bond strength:
200 - 300 g/cm²
Tackiness:
150 - 550 g / 25 mm width

Ordering example
KU 6-623 / CG 20 / AV
Part / material / tacky on one side

Configurations and dimensions on page 89

Technical Data

Part	KU-	CG 20	CG 30	CG 45	CG 80
General Properties					
Material		Fiberglass Reinforced Silicone			
Filler		Thermally Conductive Ceramic			
Colour		Salmon			
Thickness	mm	0,2 $^{+0.05}_{-0.05}$	0.3 $^{+0.1}_{-0}$	0.45 $^{+0.05}_{-0.05}$	0.8 $^{+0.1}_{-0}$
Mechanical Properties					
Tensile Strength	MPa	25.9	24.1	20.4	9.3
Tear Strength	kN/m	70	69	68	24
Hardness (Asker C)		90	90	90	90
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	5000	7000	10000	19000
Breakdown Voltage (Voltage steps)[2]	V (AC)	2000	3000	5000	10000
Volume Resistivity	Ω m	1.8×10^{12}	1.8×10^{12}	1.2×10^{12}	1.0×10^{12}
Dielectric Constant (1 kHz)		3.8	4.2	4.3	4.3
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	1.5	1.5	1.5	1.5
Thermal Resistance [3,4] (inch²)	°C/W	0.30	0.45	0.65	1.05
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200	-60 to 200

Thermo-Silicone KU-AG

HEATPAD® KU-AG is a fiberglass reinforced silicone foil filled with thermally conductive ceramics with a good thermal conductivity. Its very high dielectric strength makes it ideal for applications with a need for special electrical insulation.

Properties

- Good thermal conductivity
- Low thermal resistance
- Very high dielectric strength
- Fiberglass reinforced
- Very flexible
- Clean and easy mounting with high process reliability
- No thermal grease required
- UL flammability rating: UL 94 VO

Product Availability

- All standard configurations see page 89
- Tack-free or tacky on one side (AV)
- In roll form according to customer specifications, max. length 50 m
- Stamped and cut according to customer specifications
- In sheet form:

AG 20	320 mm x 1000 mm
AG 30	320 mm x 1000 mm
AG 45	320 mm x 1000 mm
Tacky on one side (AV)	320 mm x 1000 mm

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Order free samples!

Technical Data

Part	KU-	AG 20	AG 30	AG 45
General Properties				
Material		Fiberglass Reinforced Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Dark Grey		
Thickness	mm	0.2 $^{+0.05}_{-0.05}$	0.3 $^{+0.1}_{-0}$	0.45 $^{+0.05}_{-0.05}$
Mechanical Properties				
Tensile Strength	MPa	30.0	20.0	18.0
Tear Strength	kN/m	150	90	80
Hardness (Asker C)		70	70	70
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	9000	12000	15000
Breakdown Voltage (Voltage ramp)[2]	V (AC)	5000	7000	9000
Volume Resistivity	Ω m	20.0 x 10^{12}	20.0 x 10^{12}	20.0 x 10^{12}
Dielectric Constant (1 kHz)		3.0	3.3	3.8
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	1.2	1.2	1.2
Thermal Resistance [3,4] (inch²)	°C/W	0.49	0.69	0.95
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 1.3 MPa
[4] Increase of thermal resistance through tackiness by about 0.1 °C/W

Dry, tacky silicone resin on stainless steel:
Bond strength:
200 - 300 g/cm²
Tackiness:
150 - 550 g / 25mm width

Ordering example
KU 6-624 / AG 20 / AV
Part / material /
tacky on one side

Configurations and dimensions on page 89

Thermo-Silicone KU-AGF

HEATPAD® KU-AGF is a fiberglass reinforced silicone foil filled with thermally conductive ceramics with a good thermal conductivity. It shows the best price-quality ratio. After this interface material is implemented the total thermal resistance is greatly reduced.

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Properties

– Good thermal performance
– Fiberglass reinforced
– Very flexible
– Clean and easy mounting with high process reliability
– No thermal grease required
– UL flammability rating: UL 94 VO

Product Availability

– Standard configurations see page 89
– Adhesive-free or with adhesive on one side (AV)
– In roll form according to customer specifications, max. length 50 m
– Stamped and cut according to customer specifications
– In sheet form:

AGF 20	300 mm x 1000 mm
AGF 30	300 mm x 1000 mm
AGF 45	300 mm x 1000 mm
Adhesive on one side (AV)	300 mm x 1000 mm

Order free samples!

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	AGF 20	AGF 30	AGF 45
General Properties				
Material		Fiberglass Reinforced Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Grey		
Thickness	mm	0.23	0.30	0.45
Tensile Strength	MPa	33.0	32.0	30.0
Tear Strength	kN/m	60	60	60
Hardness (Shore A)		78	78	78
Electrical Properties				
Breakdown Voltage	V (AC)	3000	4000	6000
Volume Resistivity	Ω m	2.6×10^{13}	2.6×10^{13}	2.6×10^{13}
Dielectric Constant (10 kHz)		4.98	4.98	4.98
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	1.3	1.3	1.3
Thermal Resistance [1] (inch²)	°C/W	0.65	0.80	1.15
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

[1] Measured with mounting pressure of approx. 1.3 MPa

Ordering example
KU 6-624 / AGF 20 / AV
Part / material / adhesive on one side

Configurations and dimensions on page 89

Thermally Conductive Soft-Silicone Interface Materials

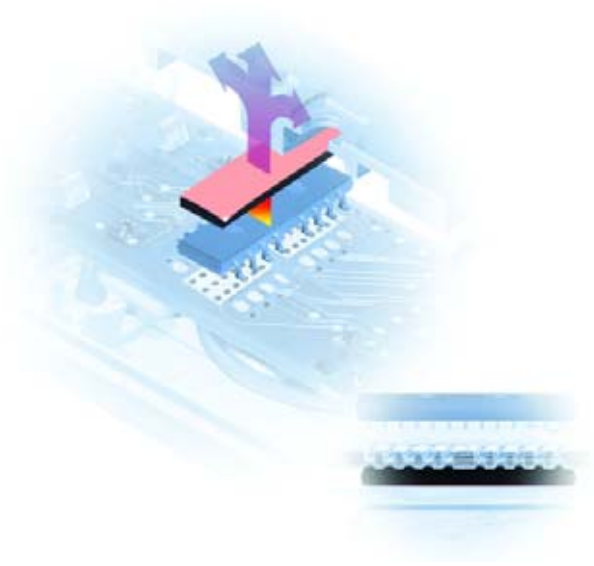
Kunze HEATPAD® soft-silicone foils KU-TXE, KU-TXS, KU-THE, KU-THS, KU-TKE, KU-TKS, KU-TDFD, KU-TCS are soft and highly thermally conductive silicone interface materials filled with thermally conductive ceramics. They are used for applications in which the heat has to be conducted on a longer distance from the source to the heat sink or the chassis because of the components' height difference or of different tolerances and unevenness for instance. In such cases, the advantages of silicone as basic material such as temperature and chemical resistance and high dielectric strength come in handy.

The high compressibility of these materials allows heat sources and heat sinks, both with extensive unevenness, stack up and tolerance differences to be optimally thermally linked. Chassis and housings can then be used as heat sinks, saving space within the application itself. Through the flexibility of the silicone material excellent compliance to the sides of the electronic components is reached, enlarging the contact surface areas and therefore improving the thermal contact. The pressure to be applied is very low, preventing the components, the board and the cabinet to be damaged. The high elasticity also helps the attenuation of mechanical vibrations and shock absorption within the application. Due to their mechanical and thermal properties, soft-silicone interface materials are the ideal thermal solution for applications with electronic components on SMD boards.

HEATPAD® soft-silicone foils are available with or without laminations based on HEATPAD® KU-C and KU-E silicone films (non-fiberglass reinforced version of KU-CG and KU-EGF), with the exception of KU-TDFD and KU-TCS. These laminations increase the mechanical stability and together with the one-side tackiness, are ideal for automated mounting processes.

Tackiness:

- KU-TXE, KU-THE, KU-TKE with silicone laminate: naturally tacky on one side
- KU-TXS, KU-THS, KU-TKS, KU-TCS without laminate: naturally tacky on both sides
- KU-TDFD without laminate: naturally tacky on one or on both sides

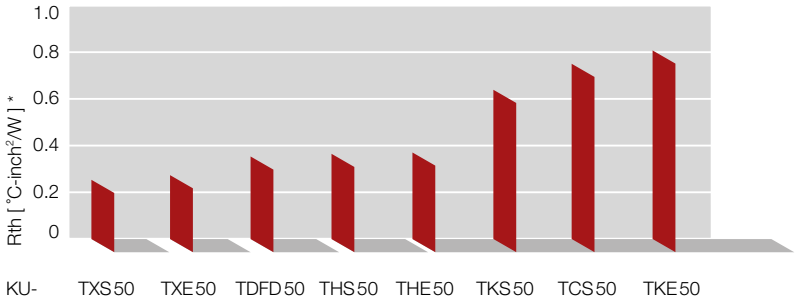


Application Examples

Thermal link and electric insulation of heat sources and heat sinks to bridge larger air gaps at

– SMD- power modules
– Engine control and cooling units
– Vias and heat sinks or housings
– Electrolytic capacitors
– Thermosensors
– High power diodes
– Heatpipes
– CD-ROM and DVD-ROM housings
– Battery chargers
– UPS
– SMPS

Thermal Resistance Overview



*At a mounting pressure of approx. 30 kPa

Order free samples!

Thermally Conductive Soft-Silicone Interface Materials KU-TXE

HEATPAD® KU-TXE is a soft-silicone interface material, filled with thermally conductive ceramics with very high thermal conductivity, dielectric strength and elasticity. KU-TXE meets the highest thermal flow requirements The total thermal resistance is therefore minimized. KU-TXE is laminated with KU-E material on one side (non-fiberglass reinforced version of KU-EGF) which insures a good mechanical stability and is naturally tacky on the other side.

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

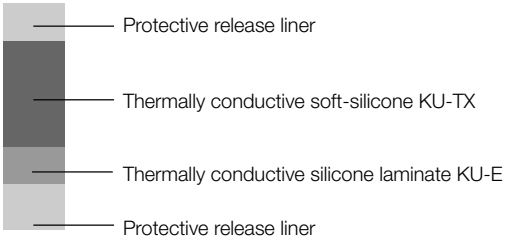
Properties

– Very high thermal conductivity
– Very high dielectric strength
– Very soft and flexible
– Naturally tacky on one side
– Clean and easy mounting with high process reliability
– KU-E laminate reinforced
– UL flammability rating: UL 94 VO

Product Availability

– Stamped and cut according to customer specifications
– In sheet form 300 x 400 mm

Construction



Upon request

– In-between thicknesses
– In roll form according to customer specifications for KU-TXE 50 and KU-TXE 100

Order free samples!

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	TXE 50	TXE 100	TXE 200	TXE 300
General Properties					
Material		Soft-Silicone with KU-E- Laminate Reinforcement			
Filler		Thermally Conductive Ceramic			
Colour (Soft-Silicone/Laminate)		Grey / Light Grey			
Thickness	mm	0.5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	0.80	0.50	0.46	0.44
Hardness (Asker C)		25	25	25	25
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	11000	21000	>21000	>21000
Breakdown Voltage (Voltage steps)[2]	V (AC)	8000	20000	>20000	>20000
Volume Resistivity	Ω m	2.3×10^{10}	5.1×10^{10}	1.2×10^{10}	1.1×10^{10}
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	5.0	5.0	5.0	5.0
Thermal Resistance [3] (inch²)	°C/W	0.27	0.48	0.90	1.32
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-TXE 50 / 30 x 50 mm
Material / dimensions

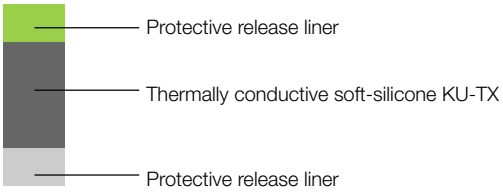
Thermally Conductive Soft-Silicone Interface Materials KU-TXS

HEATPAD® KU-TXS is a soft-silicone interface material, filled with thermally conductive ceramics with very high thermal conductivity, dielectric strength and elasticity. KU-TXS meets the highest thermal flow requirements. The total thermal resistance is therefore minimized. KU-TXS is naturally tacky on both sides.

Properties

– Very high thermal conductivity
– Very high dielectric strength
– Very soft and flexible
– Naturally tacky on both sides
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Construction



Product Availability

– Stamped and cut according to customer specifications
– In sheet form 300 x 400 mm

Upon request

– In-between thicknesses

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

Technical Data

Part	KU-	TXS 50	TXS 100	TXS 200	TXS 300
General Properties					
Material		Soft-Silicone			
Filler		Thermally Conductive Ceramic			
Colour		Grey			
Thickness	mm	0.5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	0.35	0.35	0.35	0.35
Hardness (Asker C)		25	25	25	25
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	8000	>15000	>15000	>15000
Breakdown Voltage (Voltage steps)[2]	V (AC)	6000	>15000	>15000	>15000
Volume Resistivity	Ω m	1.0×10^{10}	1.0×10^{10}	1.0×10^{10}	1.0×10^{10}
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	5.6	5.6	5.6	5.6
Thermal Resistance [3] (inch²)	°C/W	0.25	0.40	0.80	1.20
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-TXS 50 / 30 x 50 mm
Material / dimensions

Order free samples!

Thermally Conductive Soft-Silicone Interface Materials KU-THE

HEATPAD® KU-THE is a soft-silicone interface material, filled with thermally conductive ceramics with high thermal conductivity, dielectric strength and elasticity. KU-THE greatly reduces the total thermal resistance. KU-THE is laminated with KU-E on one side (non-fiberglass reinforced version of KU-EGF) which insures a good mechanical stability and is naturally tacky on the other side.

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

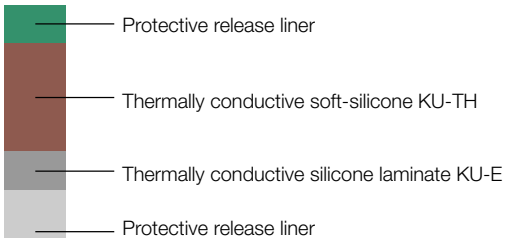
Properties

– High thermal conductivity
– High dielectric strength
– Very soft and flexible
– Naturally tacky on one side
– Clean and easy mounting with high process reliability
– KU-E laminate reinforced
– UL flammability rating: UL 94 VO

Product Availability

– Stamped and cut according to customer specifications
– In sheet form 300 x 400 mm

Construction



Upon request

– In-between thicknesses
– In roll form according to customer specifications for KU-THE 50 and KU-THE 100

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Technical Data

Part	KU-	THE 50	THE 100	THE 200	THE 300
General Properties					
Material		Soft-Silicone with KU-E- Laminate Reinforcement			
Filler		Thermally Conductive Ceramic			
Colour (Soft-Silicone/Laminate)		Brown / Light Grey			
Thickness	mm	0.5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	0.55	0.40	0.30	0.29
Hardness (Asker C)		30	30	30	30
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	6000	12000	17000	>17000
Breakdown Voltage (Voltage steps)[2]	V (AC)	3000	8000	15000	>15000
Volume Resistivity	Ω m	0.80×10^{11}	0.58×10^{11}	0.42×10^{11}	0.38×10^{11}
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	2.5	2.5	2.5	2.5
Thermal Resistance [3] (inch²)	°C/W	0.37	0.66	0.93	1.30
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-THE 50 / 30 x 50 mm
Material / dimensions

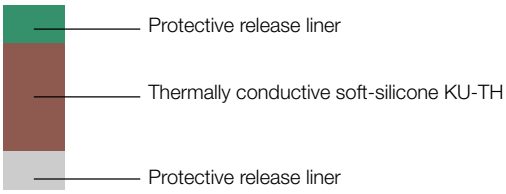
Thermally Conductive Soft-Silicone Interface Materials KU-THS

HEATPAD® KU-THS is a soft-silicone interface material, filled with thermally conductive ceramics with high thermal conductivity, dielectric strength and elasticity. KU-THS greatly reduces the total thermal resistance. KU-THS is naturally tacky on both sides.

Properties

– High thermal conductivity
– High dielectric strength
– Very soft and flexible
– Naturally tacky on both sides
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Construction



Product Availability

– Stamped and cut according to customer specifications
– In sheet form 300 x 400 mm

Upon request

– In-between thicknesses

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Order free samples!

Technical Data

Part	KU-	THS 50	THS 100	THS 200	THS 300
General Properties					
Material		Soft-Silicone			
Filler		Thermally Conductive Ceramic			
Colour		Brown			
Thickness	mm	0,5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	0.28	0.28	0.28	0.28
Hardness (Asker C)		30	30	30	30
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	4000	11000	>15000	>15000
Breakdown Voltage (Voltage steps)[2]	V (AC)	2000	8000	>15000	>15000
Volume Resistivity	Ω m	0.35 x 10^{11}	0.35 x 10^{11}	0.35 x 10^{11}	0.35 x 10^{11}
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	2.5	2.5	2.5	2.5
Thermal Resistance [3] (inch²)	°C/W	0.35	0.63	0.88	1.25
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

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[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-THS 50 / 30 x 50 mm
Material / dimensions

Thermally Conductive Soft-Silicone Interface Materials KU-TKE

HEATPAD® KU-TKE is a soft-silicone interface material, filled with thermally conductive ceramics with a good thermal conductivity, elasticity and a very high dielectric strength. KU-TKE considerably reduces the total thermal resistance. It is characterized by high quality and performance at a competitive price to cover a wide range of applications. KU-TKE is laminated with KU-C on one side (non-fiberglass reinforced version of KU-CG), which insures a good mechanical stability and is naturally tacky on the other side.

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

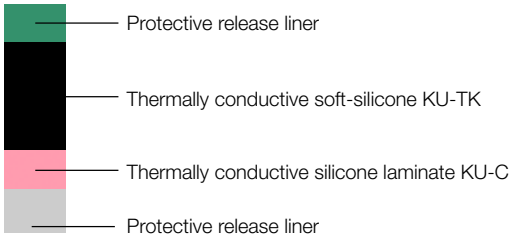
Properties

- Good thermal conductivity
- Very high dielectric strength
- Very soft and flexible
- Naturally tacky on one side
- Clean and easy mounting with high process reliability
- KU-C laminate reinforced
- UL flammability rating: UL 94 VO

Product Availability

- Stamped and cut according to customer specifications
- In sheet form 300 x 400 mm

Construction



Upon request

- In-between thicknesses
- In roll form according to customer specifications for KU-TKE 50 and KU-TKE 100

Order free samples!

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	TKE 50	TKE 100	TKE 200	TKE 300
General Properties					
Material		Soft-Silicone with KU-C- Laminate Reinforcement			
Filler		Thermally Conductive Ceramic			
Colour (Soft-Silicone / Laminate)		Black / Salmon			
Thickness	mm	0.5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	1.13	0.65	0.41	0.36
Hardness (Asker C)		24	24	24	24
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	11000	>20000	>20000	>20000
Breakdown Voltage (Voltage steps)[2]	V (AC)	8000	15000	>20000	>20000
Volume Resistivity	Ω m	2.2×10^{11}	1.6×10^{11}	1.0×10^{11}	0.4×10^{11}
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	1.1	1.1	1.1	1.1
Thermal Resistance [3] (inch²)	°C/W	0.80	1.25	2.04	2.90
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-TKE 50 / 30 x 50 mm
Material / dimensions

Thermally Conductive Soft-Silicone Interface Materials KU-TKS

HEATPAD® KU-TKS is a soft-silicone interface material, filled with thermally conductive ceramics with a good thermal conductivity, elasticity and a very high dielectric strength. KU-TKS considerably reduces the total thermal resistance. It is characterized by high quality and performance at a competitive price to cover a wide range of applications. KU-TKS is naturally tacky on both sides.

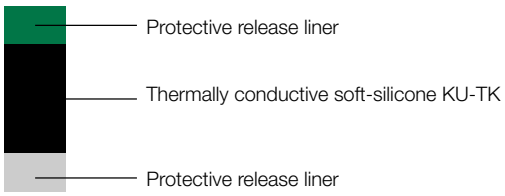
Properties

– Good thermal conductivity
– Very high dielectric strength
– Very soft and flexible
– Naturally tacky on both sides
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Product Availability

– Stamped and cut according to customer specifications
– In sheet form 300 x 400 mm

Construction



Upon request

– In-between thicknesses

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

Order free samples!

Technical Data

Part	KU-	TKS 50	TKS 100	TKS 200	TKS 300
General Properties					
Material		Soft-Silicone			
Filler		Thermally Conductive Ceramic			
Colour		Black			
Thickness	mm	0.5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	0.26	0.26	0.26	0.26
Hardness (Asker C)		17	17	17	17
Electrical Properties					
Breakdown Voltage (Voltage ramp)[1]	V (AC)	10000	>20000	>20000	>20000
Breakdown Voltage (Voltage steps)[2]	V (AC)	7000	15000	>20000	>20000
Volume Resistivity	Ω m	4.0 x 10^9	4.0 x 10^9	4.0 x 10^9	4.0 x 10^9
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	1.1	1.1	1.1	1.1
Thermal Resistance [3] (inch²)	°C/W	0.63	1.19	1.90	2.60
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

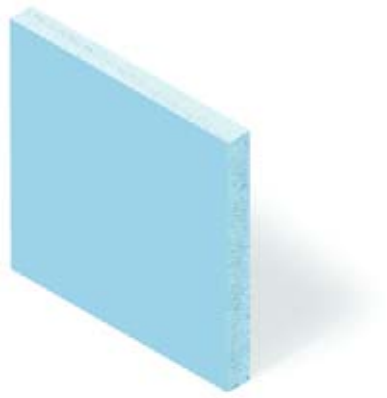
We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-TKS 50 / 30 x 50 mm
Material / dimensions

Thermally Conductive Soft-Silicone Interface Materials KU-TDFD

HEATPAD® KU-TDFD is a ultra soft-silicone interface material, filled with thermally conductive ceramics with a high thermal conductivity, dielectric strength and an extremely high conformability to the interfaces. KU-TDFD highly reduces the total thermal resistance. It shows an outstanding combination of mechanical and thermal properties as well as quality at a competitive price to cover a wide range of applications. KU-TDFD is available with one or both sides naturally tacky .

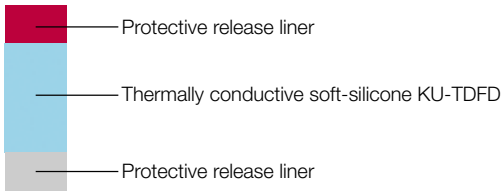


State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

Properties

– High thermal conductivity
– High dielectric strength
– Ultra soft, highly conformable, flexible
– Very good mechanical damping properties
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Construction



Product Availability

– Naturally tacky on one side (AV) or on both sides
– Stamped and cut according to customer specifications
– In sheet form:

TDFD 50	480 mm x 460 mm
TDFD 100	480 mm x 460 mm
TDFD 150	480 mm x 460 mm
TDFD 200	460 mm x 460 mm
TDFD 300	450 mm x 460 mm

Upon request

– In roll form according to customer specifications for KU-TDFD 50 and KU-TDFD 100 with tackiness on one side

Order free samples!

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	TDFD 50	TDFD 100	TDFD 200	TDFD 300
General Properties					
Material		Soft-Silicone			
Filler		Thermally Conductive Ceramic			
Colour		Light Blue			
Thickness	mm	0.5	1.0	2.0	3.0
Mechanical Properties					
Tensile Strength	MPa	0.15	0.15	0.15	0.15
Hardness (Asker C)		25	25	25	25
Electrical Properties					
Breakdown Voltage	V (AC)	5000	10000	20000	30000
Volume Resistivity	Ω m	1.0×10^{11}	1.0×10^{11}	1.0×10^{11}	1.0×10^{11}
Dielectric Constant (1 kHz)		5.2	5.2	5.2	5.2
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties					
Thermal Conductivity	W/mK	2.5	2.5	2.5	2.5
Thermal Resistance [1] (inch²)	°C/W	0.28	0.49	0.89	1.2
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180

[1] Measured with mounting pressure of approx. 100 kPa

Ordering example
KU-TDFD 50 / 30 x 50 mm
Material / dimensions

Thermally Conductive Soft-Silicone Interface Materials KU-TCS

HEATPAD® KU-TCS is a soft-silicone interface material, filled with thermally conductive ceramics with a good thermal conductivity and a very high dielectric strength. KU-TCS considerably reduces the total thermal resistance. The material is naturally tacky on both sides and available in numerous thicknesses, therefore covering a wide range of applications.

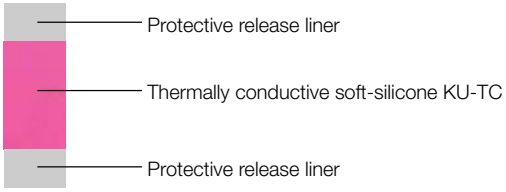
Properties

– Good thermal conductivity
– Very high dielectric strength
– Naturally tacky on both sides
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 V1

Product Availability

– Stamped and cut according to customer specifications
– In sheet form 300 x 400 mm

Construction



Upon request

– KU-TCS in greater thicknesses
– In-between thicknesses

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

Technical Data

Part	KU-	TCS 50	TCS 100	TCS 200	TCS 300	TCS 400	TCS 500
General Properties							
Material		Soft-Silicone					
Filler		Thermally Conductive Ceramic					
Colour		Salmon					
Thickness	mm	0.5	1.0	2.0	3.0	4.0	5.0
Mechanical Properties							
Tensile Strength	MPa	0.35	0.35	0.35	0.35	0.35	0.35
Hardness (Asker C)		25	25	25	25	25	25
Electrical Properties							
Breakdown Voltage (Voltage ramp)[1]	V (AC)	11000	22000	>40000	>40000	>40000	>40000
Breakdown Voltage (Voltage steps)[2]	V (AC)	9000	18000	>30000	>30000	>30000	>30000
Volume Resistivity	Ω m	1.4×10^{12}	1.4×10^{12}	1.4×10^{12}	1.4×10^{12}	1.4×10^{12}	1.4×10^{12}
Flame Rating		UL 94 V1	UL 94 V1	UL 94 V1	UL 94 V1	UL 94 V1	UL 94 V1
Thermal Properties							
Thermal Conductivity	W/mK	1.40	1.40	1.40	1.40	1.40	1.40
Thermal Resistance [3] (inch²)	°C/W	0.75	1.20	1.75	2.46	2.92	3.35
Operating Temperature	°C	-60 to 180	-60 to 180	-60 to 180	-60 to 180	-60 to 180	-60 to 180

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[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown
[3] Measured with mounting pressure of approx. 30 kPa

Ordering example
KU-TCS 50 / 30 x 50 mm
Part / Dimensions

Order free samples!

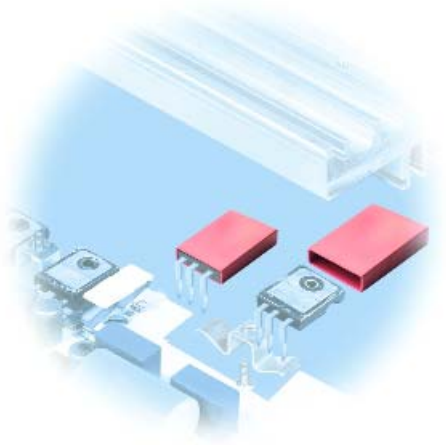
For Your Notes


OPTIC IN
STEREO
FUNCTION
VOLUME
POWER

Thermo-silicone caps of the S, C and A series and thermo-silicone tubes of the S, and A series are made of silicone filled with highly thermally conductive ceramics. The electric insulation around the components insures an optimum protection (depending on the thickness) against electrical breakdown while at the same time reducing the total thermal resistance to the heat-sinking device (heat sink or chassis).

Thermo-silicone caps exist in different sizes to fit the usual standards TO 220, TO 3P and TO 247. Thermo-silicone tubes are available with different diameters.

Thermo-silicone caps and thermo-silicone tubes are ideally used with Kunze POWER-CLIPS®.

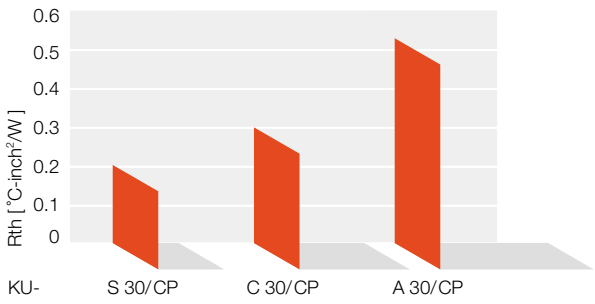


Application Examples

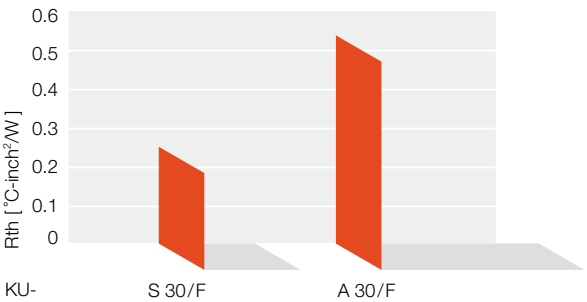
Thermal link and electric insulation of heat sources and heat sinks in:

- Power modules
- Power supplies
- Electric drives
- Telecommunication modules
- Engine control
- Frequency converters
- UPS

Thermal Resistance Overview – Caps

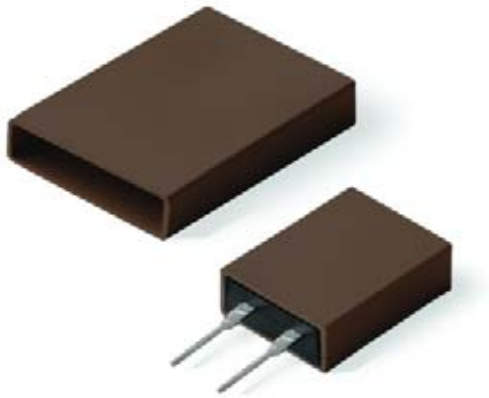


Thermal Resistance Overview – Tubes



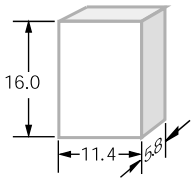
Order free samples!

Kunze thermo-silicone caps of the S type are made of silicone filled with very highly thermally conductive ceramics. The total thermal resistance is minimized due to the flexibility of the material and its fitting to the contact surface. Thermo-silicone caps of the S type are used in applications with the highest technical requirements thanks to their very high thermal conductivity and very low thermal resistance. Ideal with the use of Kunze POWERCLIPS®.

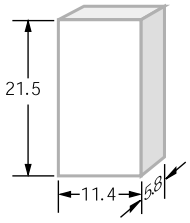


Properties

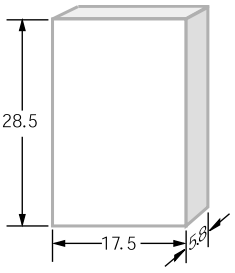
– Very high thermal conductivity
– Minimum thermal resistance
– Reliable all-around insulation
– Very flexible
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO



Part-No.
KU 7-723/16/Sxx/CP
TO 220



Part-No.
KU 7-723/Sxx/CP
TO 220



Part-No.
KU 7-724/Sxx/CP
TO-3P / TO 247

Order free samples!

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

Technical Data

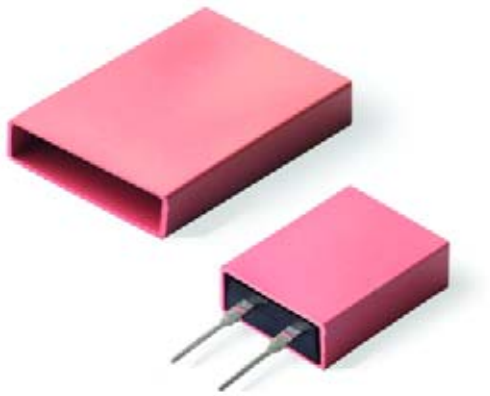
Type	KU-	S 30	S 45	S 80
General Properties				
Material		Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Brown		
Thickness	mm	0.3 $^{+0.15}_{-0}$	0.45 $^{+0.1}_{-0.05}$	0.8 $^{+0.15}_{-0}$
Mechanical Properties				
Tensile Strength	MPa	3.0	3.0	3.0
Tear Strength	kN/m	6.0	6.0	6.0
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	6000	9000	14000
Breakdown Voltage (Voltage steps)[2]	V (AC)	4000	7000	12000
Volume Resistivity	Ω m	3.5 x 10^{13}	3.5 x 10^{13}	3.5 x 10^{13}
Dielectric Constant (1 kHz)		6.3	6.3	6.3
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	2.0	2.0	2.0
Thermal Resistance (inch²)	°C/W	0.2	0.26	0.48
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown

Ordering example
KU 7-723 / S 30 / CP
Part / type / cap

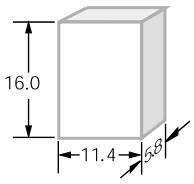
Thermo-Silicone Caps Series C

Kunze thermo-silicone caps of the C type are made of silicone filled with highly thermally conductive ceramics. Their very good thermal properties as well as their high dielectric strengths makes them the perfect material to be used in most applications. Ideal with the use of Kunze POWERCLIPS®.

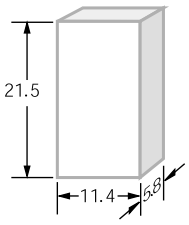


Properties

- High thermal conductivity
- Very low thermal resistance
- Reliable all-around insulation
- High dielectric strength
- Very flexible
- Clean and easy mounting with high process reliability
- UL flammability rating: UL 94 VO



Part-No.
KU 7-723/16/Cxx/CP
TO 220



Part-No.
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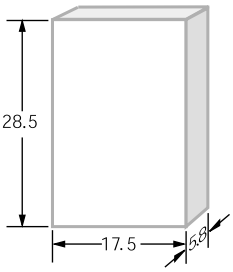
TO 220



Part-No.
KU 7-724/Cxx/CP
TO-3P / TO 247

Technical Data

Type	KU-	C 30	C 45	C 80
General Properties				
Material		Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Salmon		
Thickness	mm	0.3 $^{+0.15}_{-0}$	0.45 $^{+0.1}_{-0.05}$	0.8 $^{+0.15}_{-0}$
Mechanical Properties				
Tensile Strength	MPa	3.2	3.2	3.2
Tear Strength	kN/m	10.0	10.0	10.0
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	10000	12000	18000
Breakdown Voltage (Voltage steps)[2]	V (AC)	8000	10000	14000
Volume Resistivity	Ω m	3.2 x 10^{12}	3.2 x 10^{12}	3.2 x 10^{12}
Dielectric Constant (1 kHz)		6.0	6.0	6.0
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	1.5	1.5	1.5
Thermal Resistance (inch²)	°C/W	0.30	0.42	0.70
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown

Ordering example
KU 7-724 / C 45 / CP
Part / type / cap

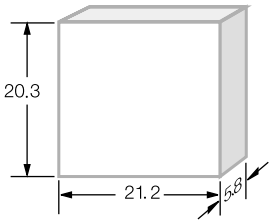
Order free samples!

Thermo-Silicone Caps Series A

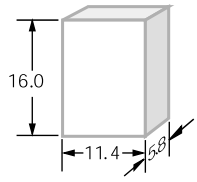
Kunze thermo-silicone caps of the A type are made of silicone filled with thermally conductive ceramics. After the cap is installed a low total thermal resistance can be achieved. Thermo-silicone caps of the A type are used in applications with high requirements for electrical insulation thanks to their very high dielectric strengths. Ideal with the use of Kunze POWERCLIPS®.

Properties

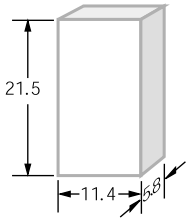
– Good thermal conductivity
– Low thermal resistance
– Reliable all-around insulation
– Very high dielectric strength
– Very flexible
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO



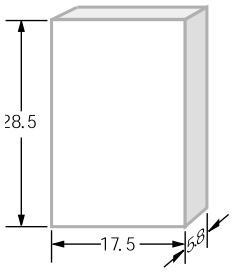
Part-No.
KU 7-700/Axx/CP



Part-No.
KU 7-723/16/Axx/CP
TO-220



Part-No.
KU 7-723/Axx/CP
TO-220



Part-No.
KU 7-724/Axx/CP
TO-3P / TO 247

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

Technical Data

Type	KU-	A 30	A 45	A 80
General Properties				
Material		Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Grey		
Thickness	mm	0.3 $^{+0.15}_{-0}$	0.45 $^{+0.1}_{-0.05}$	0.8 $^{+0.15}_{-0}$
Mechanical Properties				
Tensile Strength	MPa	5.7	5.7	5.7
Tear Strength	kN/m	8.0	8.0	8.0
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	12000	15000	20000
Breakdown Voltage (Voltage steps)[2]	V (AC)	7000	9000	13000
Volume Resistivity	Ω m	1.0 x 10^{12}	1.0 x 10^{12}	1.0 x 10^{12}
Dielectric Constant (1 kHz)		4.8	4.8	4.8
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	1.1	1.1	1.1
Thermal Resistance (inch²)	°C/W	0.53	0.74	1.14
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown

Ordering example
KU 7-723 / A 45 / CP
Part / type / cap

Order free samples!

Thermo-Silicone Tubes Series S

Kunze thermo-silicone tubes of the S type are made of silicone filled with very highly thermally conductive ceramics. An extremely low total thermal resistance is achieved due to the flexibility of the material and its fitting to the contact surface. Thermo-silicone tubes of the S type are used in applications with the highest technical requirements thanks to their very high dielectric strength and their high thermal conductivity. Ideal with the use of Kunze POWERCLIPS®.

Properties

– Very high thermal conductivity
– Extremely low thermal resistance
– Reliable all-around insulation
– Very high dielectric strength
– Very flexible
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Available Tube Diameters

Ø 7.0 ± 1 mm
Ø 9.5 ± 1 mm
Ø 10.7 ± 1 mm
Ø 13.5 ± 1 mm

Available Forms

– By meter
– In lengths cut according to customer specifications

Upon request

– Tubes with other diameters

Technical Data

Typ	KU-	S 30	S 45	S 80
General Properties				
Material			Silicone	
Filler			Thermally Conductive Ceramic	
Colour			Brown	
Thickness	mm	0.3 $^{+0.10}_{-0}$	0.45 $^{+0.05}_{-0.05}$	0.8 $^{+0.10}_{-0}$
Mechanical Properties				
Tensile Strength	MPa	4.0	4.0	4.0
Tear Strength	kN/m	11.8	11.8	11.8
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	12000	16000	23000
Breakdown Voltage (Voltage steps)[2]	V (AC)	10000	13000	17000
Volume Resistivity	Ω m	3.5 x 10^{13}	3.5 x 10^{13}	3.5 x 10^{13}
Dielectric Constant (1 kHz)		6.2	6.2	6.2
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	2.0	2.0	2.0
Thermal Resistance (inch²)	°C/W	0.25	0.36	0.57
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown

Ordering example
KU-S 30 / 107 / 30 / F
Type / diameter / length / tube form

Order free samples!

Thermo-Silicone Tubes Series A

Kunze thermo-silicone tubes of the A type are made of silicone with thermally conductive ceramics. After installation a low total thermal resistance can be reached. Thermo-silicone tubes of the A type are used in applications with high requirements for electrical insulation thanks to their very high dielectric strengths. Ideal with the use of Kunze POWERCLIPS®.

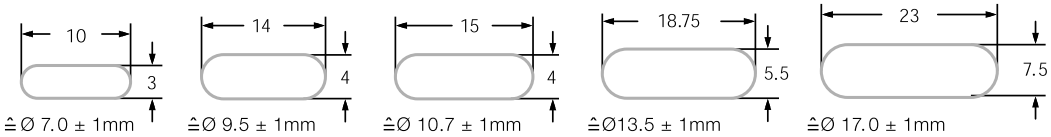
Properties

– Good thermal conductivity
– Low thermal resistance
– Reliable all-around insulation
– Very high dielectric strength
– Very flexible
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Upon request

– Tubes with other diameters

Available Tube Diameters



All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

Technical Data

Typ	KU-	A 30	A 45	A 80
General Properties				
Material		Silicone		
Filler		Thermally Conductive Ceramic		
Colour		Grey		
Thickness	mm	0.3 $^{+0.10}_{-0}$	0.45 $^{+0.05}_{-0.05}$	0.8 $^{+0.10}_{-0}$
Mechanical Properties				
Tensile Strength	MPa	5.7	5.7	5.7
Tear Strength	kN/m	8.0	8.0	8.0
Electrical Properties				
Breakdown Voltage (Voltage ramp)[1]	V (AC)	12000	15000	20000
Breakdown Voltage (Voltage steps)[2]	V (AC)	7000	9000	13000
Volume Resistivity	Ω m	1.0 x 10^{12}	1.0 x 10^{12}	1.0 x 10^{12}
Dielectric Constant (1 kHz)		4.8	4.8	4.8
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity	W/mK	1.1	1.1	1.1
Thermal Resistance (inch²)	°C/W	0.53	0.74	1.14
Operating Temperature	°C	-60 to 200	-60 to 200	-60 to 200

[1] Voltage ramp of 1000 V/s
[2] Step by step voltage increments until dielectric breakdown

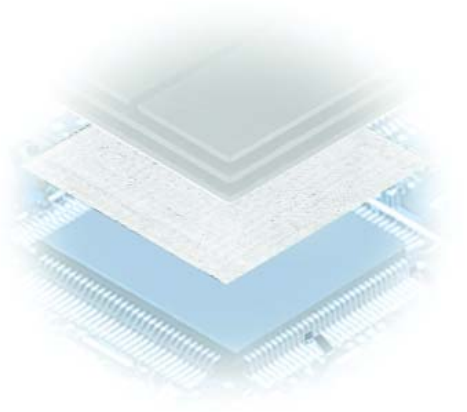
Ordering example
KU-A 30 / 107 / 30 / F
Type / diameter / length / tube form

Order free samples!

Thermally Conductive Phase Change Interface Materials

Kunze phase change interface materials KU-ALF, KU-ALC, KU-CRFI, KU-CRF, KU-CR as well as KU-PCO und KU-PCI all conduct a change phase from a solid state to a soft state from a certain temperature, the so-called phase-change-temperature. Because phase change materials expand after having passed the phase-change-temperature, they fill all air voids and expel the air pockets from the contact surfaces' micro-pores, wetting out the whole surfaces. Through pressure and expansion of the material, the layer becomes very thin resulting in a minimum thermal contact resistance. Both the thermal contact andtotal thermal resistances remain for ever very low, at all temperature cycles, even when the temperature drops under the phase-change-temperature point.

Kunze phase change interface materials show no electrical insulation properties. They are made either of pure phase change material or used in combination with highly thermally conductive metals.

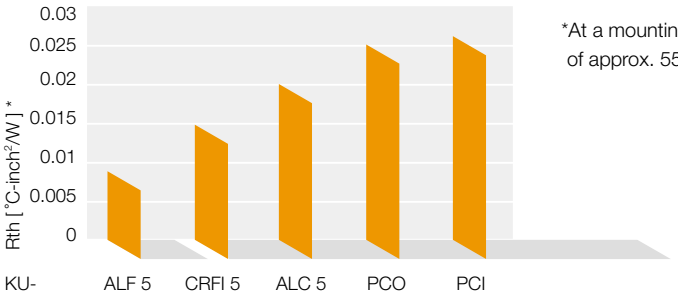


Application Examples

Thermal link of heat sources and heat sinks in

- Active heat sources and heat sinks replacing thermal grease
- Electrically insulated multichip modules
- Microprocessors, ASICs
- Power modules in power supplies
- UPS
- CPU modules
- Diodes
- RF components

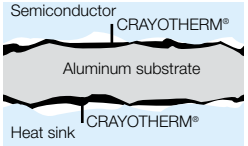
Thermal Resistance Overview



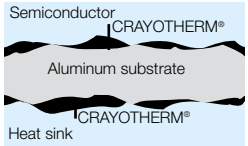
*At a mounting pressure of approx. 550 kPa

Principle of Operation (e.g. KU-ALF, KU-ALF/S)

Before first operation, unheated



In operation, after first phase change



Order free samples!

Aluminum with Phase Change Coating KU-ALC, KU-ALF

HEATPAD® KU-ALC und KU-ALF are both very thin aluminum foils, coated on both sides with the silicone-free, thermally conductive polymer CRAYOTHERM®. This coating changes its state at about 60°C for KU-ALC and 51°C for KU-ALF and becomes soft. CRAYOTHERM® expands in volume by about 15% to 20% once past the phase-change-temperature and complete wet-out of the contact surfaces takes place without outflow. After the first phase change has taken place and the material has expanded, it irreversibly remains in that condition through all following temperature cycles. Thus a minimum thermal resistance and therefore a minimum total thermal resistance is permanently assured. The fact that CRAYOTHERM® is mixed with highly thermally conductive graphite in the KU-ALF version enhances this thermal result even more.

KU-ALC/S and KU-ALF/S offer narrow acrylic adhesive stripes on the sides, making the mounting easier also with respect to process reliability, without impairing neither the extreme good thermal flow effected by CRAYOTHERM® nor the total thermal resistance.

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State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

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Properties

- Minimum thermal resistance through active wet-out of the interfaces by volumetric expansion of CRAYOTHERM® by about 15-20 % without outflow
- Silicone-free
- Guaranteed coating thicknesses
- Low starting torque required
- Clean and easy pre-mounting with high process reliability by adhesive stripes (ALC/S, ALF/S)
- Mechanically stable through aluminum substrate
- Replaceable without surface treatment
- Cleaning with Isopropyl alcohol

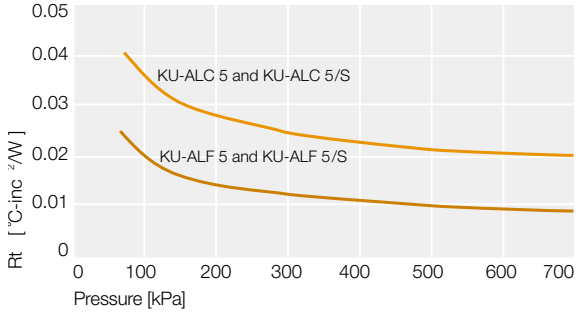
Product Availability

- All standard configurations
- Without adhesive or with adhesive stripes on the edges (S)
- In roll form according to customer specifications
- Stamped or cut according to customer specifications

Upon Request

- Other coating and substrate thicknesses

Thermal Resistance vs. Mounting Pressure



Technical Data

Part	KU-	ALC 5 and ALC 5/S	ALF 5 and ALF 5/S
General Properties			
Material	Construction	Phase Change - Aluminum - Phase Change	
Phase Change Material[1]		CRAYOTHERM®	CRAYOTHERM® / Carbon
Colour		Light Grey	Black
Material Thickness With Coating	µm	51	51
Total Thickness	µm	76	76
Thermal Properties			
Thermal Conductivity (Aluminum Substrate)	W/mK	220	220
Thermal Resistance [2] (inch²)	°C/W	0.021	0.009
Phase Change Temperature CRAYOTHERM®	°C	60	51
Operating Temperature	°C	-60 to 150	-60 to 150
Storage Temperature	°C	max. 40	max. 40

[1] Coating thickness approx. 12.5 µm per side
[2] Measured with mounting pressure of approx. 550 kPa, test surface finish of Ra = 1.6 and 0.05 mm flatness over a 25 mm length

Ordering example
KU-ALC 5 / 30 x 50 mm
Part / Dimensions

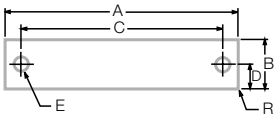
Order free samples!

Aluminum with Phase Change Coating KU-ALC, KU-ALF

Schottky, SCR, Darlington Module

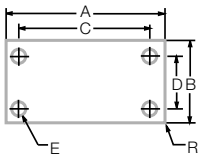
Further standard configurations upon request

Part No.	A	B	C	D	E
KU-ALC 5/244-102	62.0	25.9	52.0	13.0	4.4
KU-ALC 5/354-154	90.0	39.1	76.0	19.5	5.5
KU-ALC 5/364-081	92.5	20.3	80.0	10.2	6.8
KU-ALC 5/370-134	94.0	34.0	80.0	17.0	6.8
KU-ALC 5/425-134	108.0	34.0	93.0	17.0	6.8
KU-ALC 5/480-150	122.0	38.1	110.0	19.0	5.5



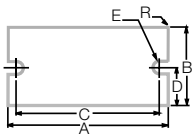
SCR, Darlington Module

Part No.	A	B	C	D	E
KU-ALC 5/366-197	93.0	50.0	80.0	38.1	6.0
KU-ALC 5/370-339	94.0	86.1	80.0	73.9	5.6
KU-ALC 5/374-244	95.0	62.0	80.0	48.0	6.0
KU-ALC 5/386-252	98.0	64.0	63.0	52.1	6.0
KU-ALC 5/402-358	102.1	91.0	80.0	73.9	6.0
KU-ALC 5/425-244	108.0	62.0	93.0	48.0	6.4
KU-ALC 5/445-354	113.0	90.0	93.0	70.1	6.4
KU-ALC 5/449-449	114.0	114.0	93.0	93.0	6.4
KU-ALC 5/550-370	139.7	94.0	80.0	80.0	8.3
KU-ALC 5/630-302	160.0	76.7	80.0	62.7	6.8
KU-ALC 5/750-370	190.5	94.0	80.0	80.0	6.8



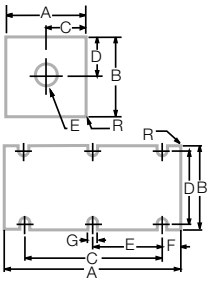
Relays

Part No.	A	B	C	D	E
KU-ALC 5/220-064	55.9	16.3	48.3	8.1	4.0
KU-ALC 5/225-175	57.2	44.5	47.5	22.3	4.4
KU-ALC 5/250-125	63.5	31.8	48.3	16.0	5.2
KU-ALC 5/276-106	70.1	27.0	60.0	13.5	5.6
KU-ALC 5/315-114	80.0	29.0	68.0	14.5	6.4
KU-ALC 5/315-157	80.0	39.9	66.0	20.1	6.4
KU-ALC 5/346-154	87.9	39.1	76.0	20.0	5.2



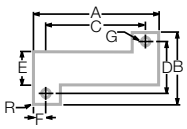
Rectifier bridges

Part No.	A	B	C	D	E	F	G
KU-ALC 5/100-100	25.4	25.4	12.7	12.7	4.8	-	-
KU-ALC 5/112-112	28.5	28.5	14.2	14.2	5.2	-	-
KU-ALC 5/125-125	31.8	31.8	15.9	15.9	3.6	-	-
KU-ALC 5/206-206	52.3	52.3	26.2	26.2	9.5	-	-
KU-ALC 5/241-229	58.2	61.2	33.0	53.3	16.5	12.6	3.8
KU-ALC 5/456-236	115.8	60.0	91.5	53.3	45.7	12.2	4.1
KU-ALC 5/460-230	116.8	58.5	101.6	43.2	47.0	-	7.6



Resistances

Part No.	A	B	C	D	E	F	G
KU-ALC 5/075-080	19.0	20.3	14.3	15.9	10.8	2.4	2.4
KU-ALC 5/106-108	27.0	27.4	18.3	19.8	14.0	4.4	3.2
KU-ALC 5/197-114	50.0	29.0	39.6	21.3	16.0	5.1	3.2
KU-ALC 5/350-281	88.9	71.4	69.9	57.1	46.0	9.7	4.8



All dimensions in mm
Tolerances: ± 0.15
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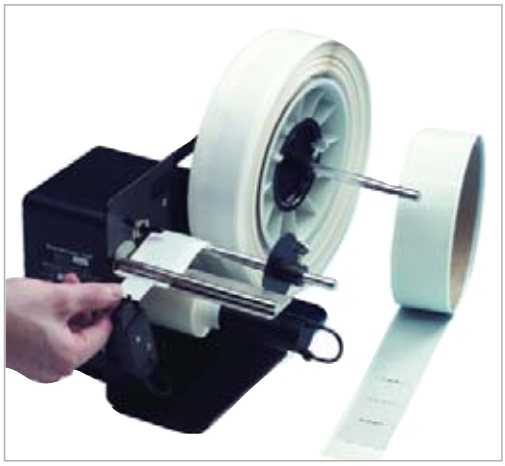
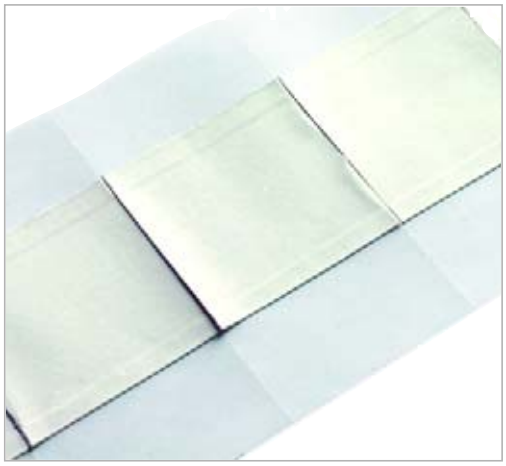
Order free samples!

Aluminum with Phase Change Coating KU-ALC/S, KU-ALF/S

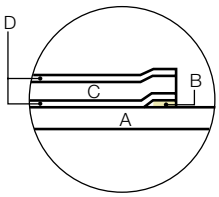


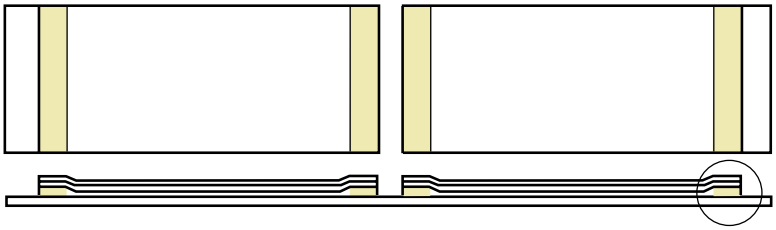


Construction of KU-ALC/S, KU-ALF/S

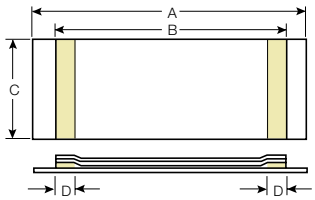
Roll direction

A Release liner
B Adhesive
C Aluminum
D Phase change thermal compound CRAYOTHERM®

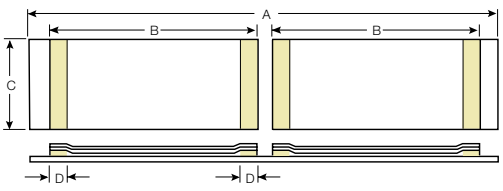




Types and dimensions



A	B	C	D	Part No. ALC5/S	Part No. ALF5/S
50.80	25.40	17.78	3.18	KU-ALC5/S/100-070	KU-ALF5/S/100-070
50.80	25.40	25.40	3.18	KU-ALC5/S/100-100	KU-ALF5/S/100-100
50.80	31.80	31.80	3.18	KU-ALC5/S/125-125	KU-ALF5/S/125-125
50.80	36.83	31.80	3.18	KU-ALC5/S/145-125	KU-ALF5/S/145-125
50.80	44.45	31.80	3.18	KU-ALC5/S/175-125	KU-ALF5/S/175-125
50.80	44.45	35.81	3.18	KU-ALC5/S/175-141	KU-ALF5/S/175-141



A	B	C	D	Part No. ALC/S	Part No. ALF/S
76.20	25.40	17.78	3.18	KU-ALC5/S/100-07B	KU-ALF5/S/100-07B
76.20	25.40	25.40	3.18	KU-ALC5/S/100-10B	KU-ALF5/S/100-10B
76.20	31.80	31.80	3.18	KU-ALC5/S/125-12B	KU-ALF5/S/125-12B
76.20	36.83	31.80	3.18	KU-ALC5/S/145-12B	KU-ALF5/S/145-12B
76.20	44.45	31.80	3.18	KU-ALC5/S/175-12B	KU-ALF5/S/175-12B
76.20	44.45	35.81	3.18	KU-ALC5/S/175-14B	KU-ALF5/S/175-14B

All dimensions in mm

Ordering example
KU-ALF 5 / S / 100-700
Material / adhesive stripes / part number

Order free samples!

Phase Change Foils KU-CRFI

HEATPAD® KU-CRFI is a homogeneous foil made out of pure silicone-free thermally conductive polymer CRAYOTHERM®. This coating changes its state at about 51°C and becomes soft. CRAYOTHERM® expands in volume by about 15% to 20% once passed the phase-change-temperature and complete wet-out of the contact surfaces takes place without outflow. After the first phase change has taken place and the material has expanded, it irreversibly remains for ever in this condition through all following temperature cycles. A minimum thermal resistance and therefore a minimum total thermal resistance is permanently assured. This material replaces normal thermal grease used to reduce the thermal contact resistance in applications where no electrical insulation is needed. It is of ideal use for applications with rough contact surfaces (concave, convex or in wave form) such as it is the case with base plates of power modules.

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Properties

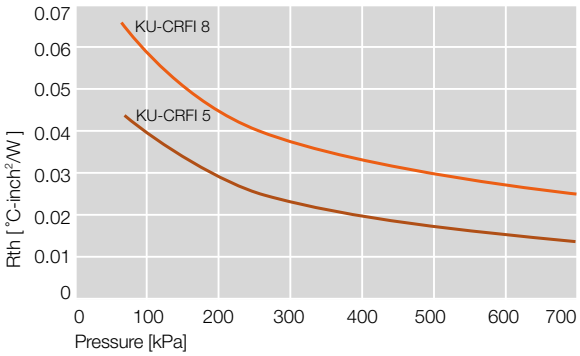
- Minimum thermal resistance through active wet-out of the interfaces by volumetric expansion of CRAYOTHERM® by about 15-20 % without outflow
- Silicone-free
- Guaranteed thicknesses
- Low starting torque required
- Clean and easy mounting with high process reliability
- Replaceable without surface treatment
- Cleaning with Isopropyl alcohol

Product Availability

- All standard configurations
- In roll form according to customer specifications
- Stamped or cut according to customer specifications

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

Thermal Resistance vs. Mounting Pressure



We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	CRFI 5	CRFI 8
General Properties			
Material		CRAYOTHERM®	
Colour		Black	
Thickness	µm	53	81
Thermal Properties			
Thermal Conductivity	W/mK	3.0	3.0
Thermal Resistance [1] (inch²)	°C/W	0.015	0.028
Phase Change Temperature CRAYOTHERM®	°C	51	51
Operating Temperature	°C	-60 to 150	-60 to 150
Storage Temperature	°C	max. 40	max. 40

[1] Measured with mounting pressure of approx. 550 kPa, test surface finish of Ra = 1.6 and 0.05 mm flatness over a 25 mm length

Ordering example
KU-CRFI 5 / 30 x 50 mm
Material / dimensions

Order free samples!

Phase Change Compound CRAYOTHERM® KU-CR, KU-CRF

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CRAYOTHERM® KU-CR and KU-CRF are silicone-free and exceptionally thermally conductive polymer compounds in a bloc form, which assure a simple, clean and quick use. The disadvantages of grease are thus eliminated. The materials change their aggregate from a solid state into a soft one once their phase-change-temperature of approx. 60°C for KU-CR and approx. 51°C for KU-CRF is reached. CRAYOTHERM® expands in volume by about 15% to 20% once passed the phase-change-temperature and complete wet-out of the contact surfaces takes place without outflow. After the first phase change has taken place and the material has expanded, it irreversibly remains for ever in this condition, through all temperature cycles. A minimum thermal resistance and therefore a minimum total thermal resistance is permanently assured. The fact that CRAYOTHERM® is mixed with highly thermally conductive graphite in the KU-CRF version enhances this result even more. It is of ideal use for applications with rough contact surfaces (concave, convex or in wave form) such as it is the case with base plates of power modules.

Properties

– Minimum thermal resistance through active wet-out of the interfaces by volumetric expansion of CRAYOTHERM® by about 15-20 % without outflow
– Solid, dry to the touch
– Silicone-free thermally conductive compound
– No hardening or run out
– Easy to use hand-held block applicator
– Replaceable without surface treatment
– Cleaning with Isopropyl alcohol

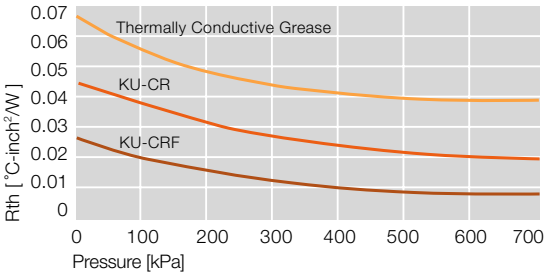
Product Availability

– In stick form

Dimensions

Part	Stick length	Width	Depth	Total Length
KU-CR-MINI	52 mm	10 mm	10 mm	127 mm
KU-CRF-MINI	52 mm	10 mm	10 mm	127 mm
KU-CR-125	46 mm	33 mm	13 mm	103 mm
KU-CRF-125	46 mm	33 mm	13 mm	103 mm

Thermal Resistance of CRAYOTHERM® and Thermally Conductive Grease vs. Mounting Pressure



We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

[1] Measured with mounting pressure of approx. 550 kPa, test surface finish of Ra = 1.6 and 0.05 mm flatness over a 25 mm length and a thickness of about 12.5 µm

Ordering example
KU-CR Mini
Part

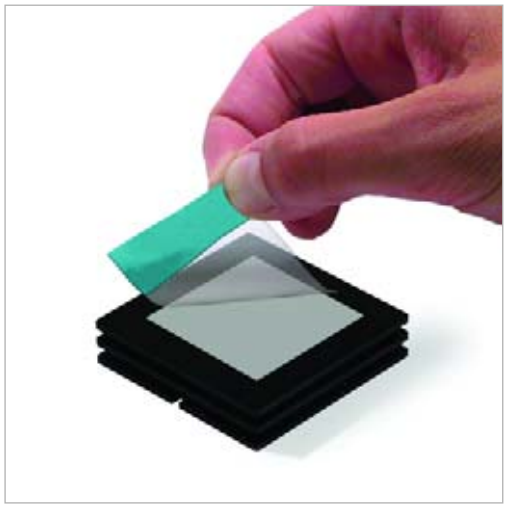
Technical Data

Typ	KU-	CR	CRF
General Properties			
Material		CRAYOTHERM®	CRAYOTHERM®/Carbon
Colour		White	Black
Thermal Properties			
Thermal Conductivity	W/mK	0.47	3.0
Thermal Resistance [1] (inch²)	°C/W	0.020	0.008
Phase Change Temperature CRAYOTHERM®	°C	60	51
Operating Temperature		-60 to 150	-60 to 150
Storage Temperature	°C	max. 40	max. 40

Order free samples!

Phase Change Silicone Foils KU-PCO, KU-PCI

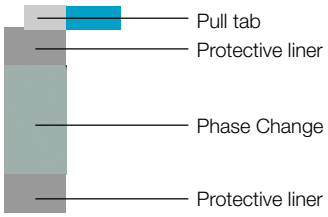
HEATPAD® KU-PCO and KU-PCI are interface materials made of a silicone phase change substance. They are mostly used to minimize the thermal contact resistance on CPUs and power modules, for which no special electrical insulation is necessary. The optimum thermal contact resistance is obtained after the first phase-change-temperature of about 48°C has been reached and it remains for ever in this condition, through all following temperature cycles. The material is easy to install and it peels off easily without leaving any residues.



Properties

– Minimum thermal resistance
– No hardening or run out
– Guaranteed thicknesses
– Low starting torque required
– Clean and easy mounting with high process reliability
– Naturally tacky on both sides
– No outflow
– Residue-free removal
– UL flammability rating: UL 94 VO
– KU-PCI: electrically insulating depending on the thickness

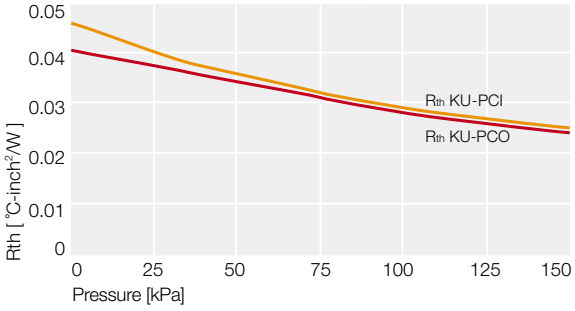
Construction



Product Availability

– On a polyester release carrier with quick snap tab liner on roll:
– 35 x 35 mm or
– According to customer specifications

Thermal Resistance vs. Mounting Pressure



Technical Data

Typ	KU-	PCO	PCI
General Properties			
Material		Phase Change	Phase Change[1]
Colour		Grey	White
Thickness	µm	60	100
Electrical Properties			
Flame Rating		UL 94 VO	UL 94 VO
Thermal Properties			
Thermal Conductivity	W/mK	5.1	3.3
Thermal Resistance [2] (inch²)	°C/W	0.025	0.026
Phase Change Temperature	°C	48	48
Operating Temperature	°C	-60 to 200	-60 to 200

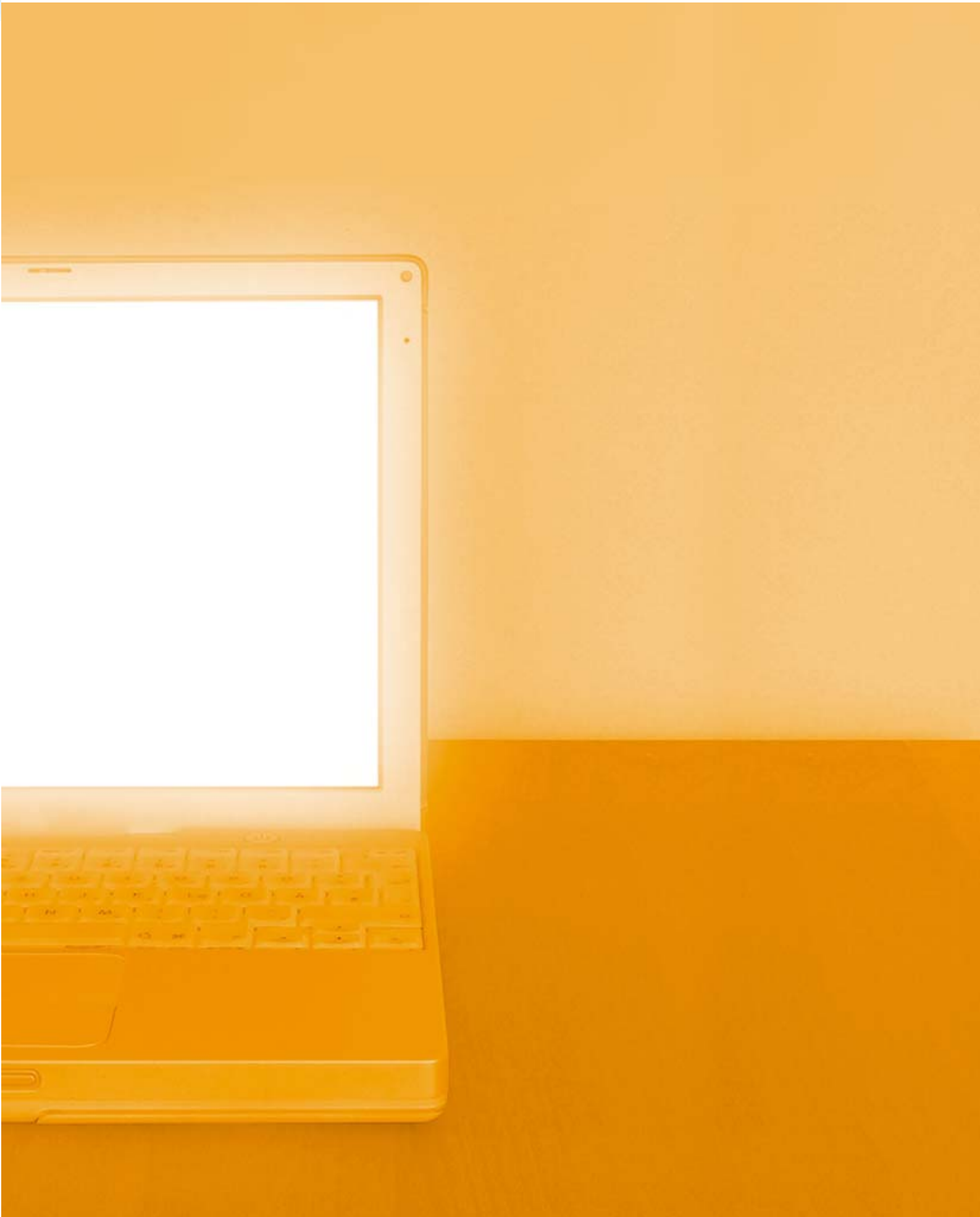
We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

[1] KU-PCI has a dielectric strength of approx. 8.5 kV/mm
[2] Measured with a mounting pressure of approx. 150 kPa

Ordering example
KU-PCO / 35 x 35 mm
Part / Dimensions

Order free samples!

For Your Notes

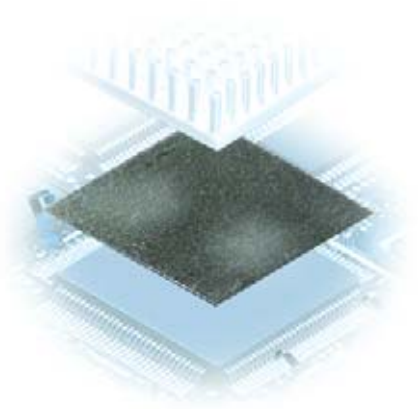


Kunze graphite interface materials KU-CB 2000, KU-CB 1200 and KU-CB 700 are made out of pure graphite and are not electrically insulating. They combine high thermal conductivity with a very low thermal contact resistance. The graphite structure shows an anisotropic behaviour of the thermal conductivity in the X-Y direction (in-plane direction) and Z direction (through direction). These interface materials are ideally used to spread heat from hot spots as caused by high performance microprocessors. Due to their natural softness, they fit perfectly to the contact surfaces without applying much pressure, expelling air pockets, greatly reducing the thermal contact resistance, hence the total thermal resistance.

Graphite interface materials replace effectively thermal grease. They are ideally used in applications in which phase-change-temperatures cannot be reached and therefore phase change materials cannot be applied.

Through its natural heat resistance property, graphite material can also be used for applications with extreme high temperatures far above 200°C.

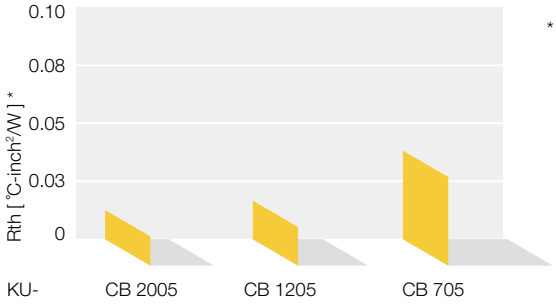
Due to their electrical properties, Kunze graphite foils can also be used as EMI shielding up to the GHz range with very good attenuation.



Application Examples

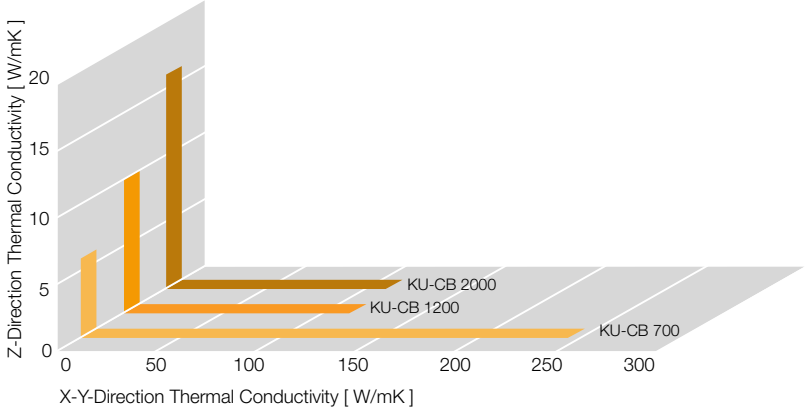
Thermal link of heat sources and heat sinks in
- CPU modules and microprocessors
- DC/DC converters
- Power modules
- Power units in automotive applications
- Active components in notebooks
- Telecommunication modules

Thermal Resistance Overview



* At a mounting pressure of approx. 700 kPa

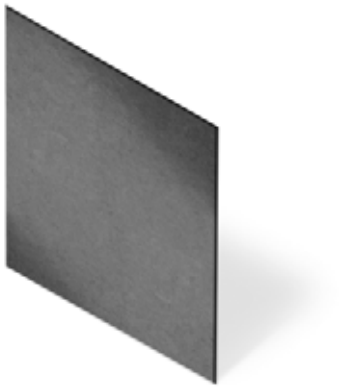
Comparison of thermal conductivities



Order free samples!

Graphite Interface Material KU-CB 2000

HEATPAD® KU-CB 2000 is a graphite interface material with a polymer additive. It has a very high thermal conductivity along length and width (X-Y-direction) and a very good thermal conductivity through the thickness (Z-direction). Due to its natural softness and the polymer additive, KU-CB 2000 fits perfectly to the contact surfaces already with a low pressure, minimizing the thermal contact resistance. The total thermal resistance is comparable to that obtained by use of a phase change material.



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Properties

- Anisotropic thermal conductivity: Very high thermal conductivity along length and width (X-Y-direction), very good thermal conductivity through the thickness (Z-direction)
- Very low thermal resistance
- Silicone-free
- Very soft and flexible
- High temperature resistance
- No hardening, no outgasing
- Guaranteed thicknesses
- Low starting torque required
- Clean and easy mounting with high process reliability

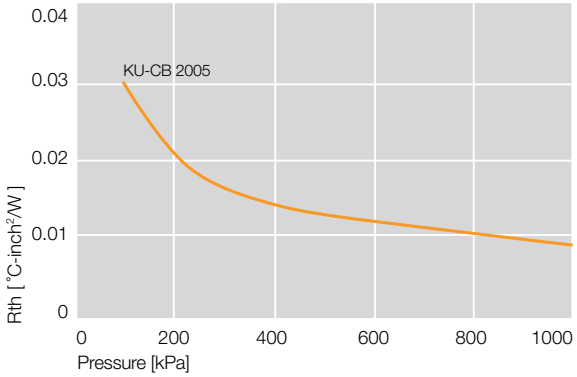
Available Thicknesses

KU-CB 2003	75 µm
KU-CB 2005	125 µm
KU-CB 2010	250 µm

Product Availability

- All standard IGBT and microprocessor configurations
- In roll form according to customer specifications
- Stamped and cut according to customer specifications
- With edge sealing
- Adhesive on one side, the adhesive is electrically and thermally conductive (AV)

Thermal Resistance vs. Mounting Pressure



Technical Data

Part	KU-	CB 2005
General Properties		
Material		Graphite and Polymer
Colour		Dark Grey
Thickness	µm	125
Purity of Material (Graphite)	%	ca.70
Mechanical Properties		
Tensile Strength	MPa	1.4
Electrical Properties		
Volume Resistivity in X-Y-direction (In-Plane)	Ω m	1.0×10^{-5}
Volume resitstivity in Z-direction (Through-Plane)	Ω m	$>1.0 \times 10^{-4}$
Thermal Properties		
Thermal Conductivity in X-Y-direction (In-Plane)	W/mK	120
Thermal Conductivity in Z-direction (Through-Plane)	W/m	16
Thermal Resistance [1,2] (inch²)	°C/W	0.011
Operating Temperature	°C	-40 to 150

Order free samples!

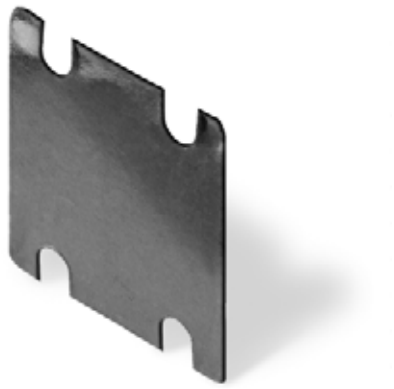
We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

[1] Measured with mounting pressure of approx. 700 kPa
[2] Increase of thermal resistance through adhesion by about 0.02 °C/W

Ordering example
KU-CB 2005/AV/30x40 mm
Material / adhesive / dimensions

Graphite Interface Material KU-CB 1200

HEATPAD® KU-CB 1200 are pure graphite interface materials with a very high thermal conductivity along length and width (X-Y-direction) and a high thermal conductivity through the thickness (Z-direction).



Properties

- Anisotropic thermal conductivity: very high thermal conductivity along length and width (X-Y-direction), high thermal conductivity through the thickness (Z-direction)
- Silicone-free
- Soft and flexible
- Very high temperature resistance
- No hardening, no outgasing
- Guaranteed thicknesses
- Low starting torque required
- Clean and easy mounting with high process reliability

Product Availability

- All standard IGBT and microprocessor configurations
- In roll form according to customer specifications
- Stamped and cut according to customer specifications
- With edge sealing
- Adhesive on one side, the adhesive is electrically and thermally conductive (AV)

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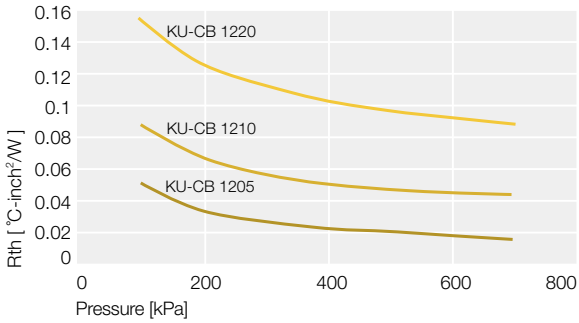
Thermal Resistance vs. Mounting Pressure



Technical Data

Part	KU-	CB 1205	CB 1210	CB 1220
General Properties				
Material			Graphite	
Colour			Dark Grey	
Thickness	µm	125	250	500
Purity of Material (Graphite)	%	98	98	98
Mechanical Properties				
Tensile Strength	MPa	1.8	3.1	3.1
Electrical Properties				
Volume Resistivity in X-Y-direction (In-Plane)	Ω m	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Volume Resistivity in Z-direction (Through-Plane)	Ω m	$>1.0 \times 10^{-4}$	$>1.0 \times 10^{-4}$	$>1.0 \times 10^{-4}$
Thermal Properties				
Thermal Conductivity in X-Y-direction (In-Plane)	W/mK	120	120	120
Thermal Conductivity in Z-direction (Through-Plane)	W/mK	10	10	10
Thermal Resistance [1,2] (inch²)	°C/W	0.016	0.042	0.088
Operating Temperature	°C	-40 to 400	-40 to 400	-40 to 400

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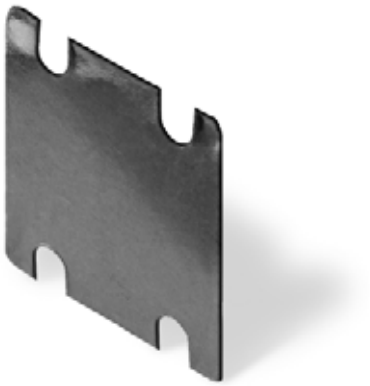
[1] Measured with mounting pressure of approx. 700 kPa
[2] Increase of thermal resistance through adhesion by about 0.02 °C/W

Ordering example
KU-CB 1205 / AV / 20 x 30 mm
Material / adhesive / dimensions

Order free samples!

Graphite Interface Material KU-CB 700

HEATPAD® KU-CB 700 are pure graphite interface materials with an extraordinary high thermal conductivity along length and width (X-Y-direction) and a good thermal conductivity through the thickness (Z-direction). Due to their extremely high thermal conductivity in the X-Y direction, they are ideally used in applications to prevent hot spots.



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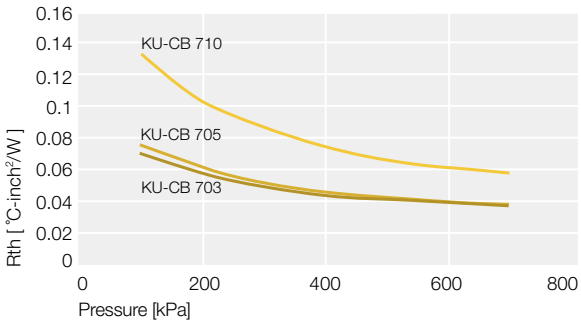
Properties

- Anisotropic thermal conductivity: extremely high thermal conductivity along length and width (X-Y-direction), good thermal conductivity through the thickness (Z-direction)
- Silicone-free
- Soft and flexible
- Very high temperature resistance
- No hardening, no outgasing
- Guaranteed thicknesses
- Low starting torque required
- Clean and easy mounting with high process reliability
- UL flammability rating: UL 94 VO

Product Availability

- All standard IGBT and microprocessor configurations
- In roll form according to customer specifications
- Stamped and cut according to customer specifications
- With edge sealing
- Adhesive on one side, the adhesive is electri cally and thermally conductive (AV)

Thermal Resistance vs. Mounting Pressure



We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	CB 703	CB 705	CB 710
General Properties				
Material			Graphite	
Colour			Dark Grey	
Thickness	µm	75	125	250
Purity of Material (Graphite)	%	98	98	98
Mechanical Properties				
Tensile Strength	MPa	4.0	4.7	4.7
Electrical Properties				
Volume Resistivity in X-Y-direction (In-Plane)	Ω m	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
Volume Resistivity in Z-direction (Through-Plane)	Ω m	$>1.0 \times 10^{-4}$	$>1.0 \times 10^{-4}$	$>1.0 \times 10^{-4}$
Flame Rating		UL 94 VO	UL 94 VO	UL 94 VO
Thermal Properties				
Thermal Conductivity in X-Y-direction (In-Plane)	W/mK	240	240	240
Thermal Conductivity in Z-direction (Through-Plane)	W/mK	6	6	6
Thermal Resistance [1,2] (inch²)	°C/W	0.038	0.039	0.058
Operating Temperature	°C	-40 to 400	-40 to 400	-40 to 400

[1] Measured with mounting pressure of approx. 700 kPa

[2] Increase of thermal resistance through adhesion by about 0.02 °C/W

Ordering example
KU-CB 705/AV / 20 x 30 mm
Material / adhesive / dimensions

Order free samples!

Thermally Conductive EMI Shielding Materials

Thermally Conductive EMI Shielding Materials

High frequency switch modes in electronics require EMI suppression of electromagnetic interferences over a broad frequency range. These interferences appear e.g. through undesired and technically inevitable harmonics or at high frequency SMPS power supplies as well as at high performance electronic components in fast high-speed computers.

KU-EC and KU-K/CU/K shielding materials meet the high damping requirements of these interferences either through conduction of these occurring electromagnetic irradiations with KU-EC/A and KU-EC/BM and KU-K/CU/K, or through absorption with KU-EC/E. Since all Kunze shielding materials are thermally conductive as well, the total thermal resistance that can be reached is very low and a dangerous overheating of the components can be prevented.

Application Examples

Suppression of electromagnetic interferences in
– SMPS
– Between PCBs and housings
– Between LSI and heat sinks
– Transformers
– Flat cables
– PCBs
– Telecommunication modules
– Operational amplifiers

EMI Conducting Interface Material KU-EC/A

KU-EC/A are silicone materials filled with silver causing a very high electric conductivity and therefore effecting a very high conductive shielding of electromagnetic interferences over a broad frequency range. The good coverage of the contact surfaces through the highly thermally conductive silicone strongly reduces the total thermal resistance. Thus at the same time components can be protected from dangerous overheating.

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

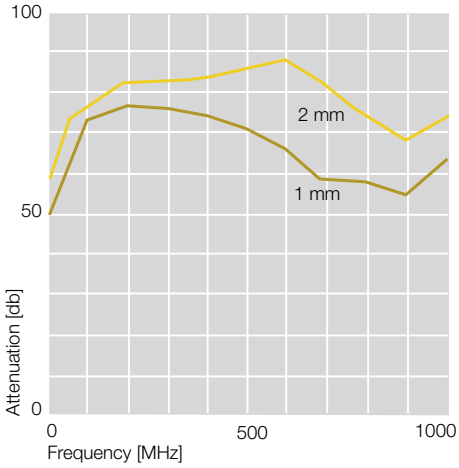
Properties

– Very high electrical conductivity
– Very high attenuation over a broad frequency range
– High thermal conductivity
– Very flexible
– Clean and easy mounting with high process reliability

Product Availability

– All standard configurations according to customer specifications
– In sheet form: 200 mm x 200 mm

Attenuation vs. Frequency



Order free samples!

We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Technical Data

Part	KU-	EC/A
General Properties		
Material		Silicone
Filler		Silver
Colour		Yellow Brown
Thickness	mm	0.3 0.6 1.0 1.5 2.0 3.0
Mechanical Properties		
Tensile Strength	MPa	1.5
Tear Strength	kN/m	7.8
Hardness (Asker C)		70
Electrical Properties		
Volume Resistivity	Ω m	0.00005
Thermal Properties		
Thermal Conductivity	W/mK	1.0
Operating Temperature	°C	-60 to 120

Ordering example
KU-EC 30 / A / 20 x 20 mm
Material thickness / type / dimensions

EMI Conducting Interface Material KU-EC/BM

KU-EC/BM are silicone materials filled with graphite causing a high electric conductivity and therefore effecting a high conductive shielding of electromagnetic interferences over a broad frequency range. The good coverage of the contact surfaces through the thermally conductive silicone considerably reduces the total thermal resistance. Thus at the same time components can be protected from dangerous overheating.

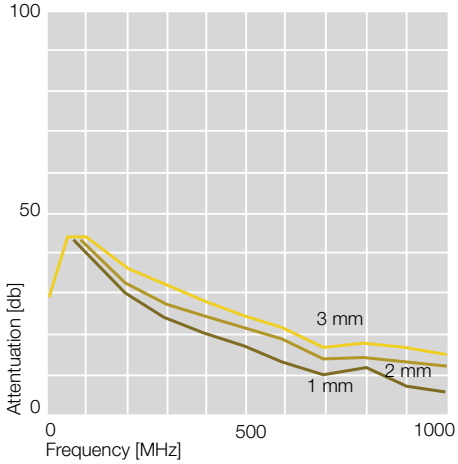
Properties

– High electrical conductivity
– High attenuation over a broad frequency range
– Good thermal conductivity
– Very flexible
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

Product Availability

– All standard configurations according to customer specifications
– In sheet form: 300 mm x 300 mm

Attenuation vs. Frequency



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Order free samples!

Technical Data

Part	KU-	EC/BM							
General Properties									
Material		Silicone							
Filler		Carbon							
Colour		Black							
Thickness	mm	0.2	0.4	0.6	0.8	1.0	1.5	2.0	3.0
Mechanical Properties									
Tensile Strength	MPa	5.9							
Tear Strength	kN/m	11.8							
Hardness (Asker C)		70							
Electrical Properties									
Volume Resistivity	Ω m	0.03							
Flame Rating		UL 94 VO							
Thermal Properties									
Thermal Conductivity	W/mK	0.65							
Operating Temperature	°C	-60 to 180							

Ordering example
KU-EC 20 / BM / 30 x 50 mm
Material thickness / type / dimensions

EMI Absorbing Interface Material KU-EC/E

KU-EC/E absorbs high frequency interferences such as RFI. It is a flexible material based on polymer silicone and filled with soft magnetic alloy powder. During the absorption a change is made from the electromagnetic interferences over a broad frequency into heat. The radiation reflection is then minimized. The good coverage of the contact surface through the extremely thermally conductive silicone reduces the total thermal resistance to a minimum. Thus at the same time components can be protected from dangerous overheating.

Order free samples!

State of the art machinery allows us to produce and deliver customer specific forms with the shortest possible lead time

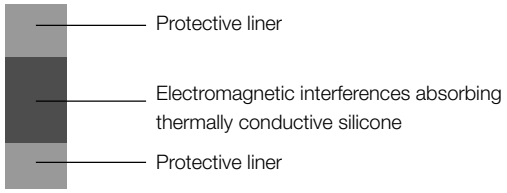
Properties

– Very high magnetic permeability and absorption over a broad frequency range
– Minimum thermal resistance
– Very flexible
– Clean and easy mounting with high process reliability
– UL flammability rating: UL 94 VO

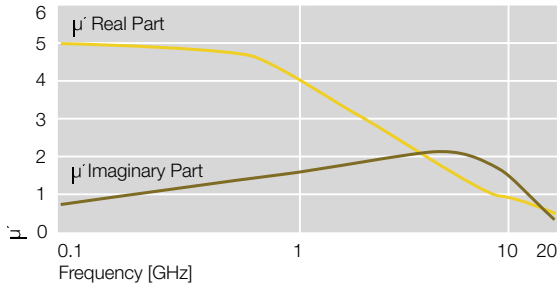
Product Availability

– All standard configurations according to customer specifications
– Adhesive on one side
– In sheet form: 300 mm x 400 mm

Construction



Magnetic Permeability



We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

[1] Measured with mounting pressure of approx. 30 kPa

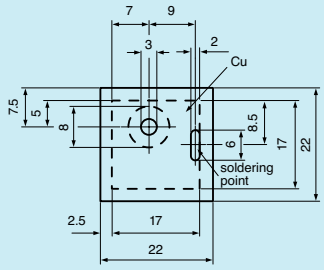
Ordering example
KU-EC 30 / E / 30 x 50 mm
Material thickness / type / dimensions

Technical Data

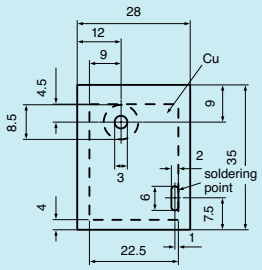
Part		KU-	EC/E
General Properties			
Material			Silicone
Colour			Grey
Thickness		mm	0.3 0.5 1.0 2.0
Mechanical Properties			
Hardness (Asker C)			61
Electrical Properties			
Magnetic Permeability (1 GHz)	Real Part		4.1
	Imaginary Part		1.4
Flame Rating			UL 94 VO
Thermal Properties			
Thermal Conductivity		W/mK	3.5
Thermal Resistance [1] (inch²)		°C/W	0.21 0.27 0.48 0.90
Operating Temperature		°C	-60 to 180

EMI Conducting Interface KU-K/CU/K

HEATPAD® KU-K/CU/K is a very thin copper foil, electrically insulated by thin polyimide coatings on both sides. The copper foil has a soldering contact point that can be grounded thus conducting electromagnetic interferences away. The thinness and the good thermal conductivity of the material contribute to a low total thermal resistance. By this the components can be prevented at the same time from dangerous overheating and electromagnetic interferences. KU-K/CU/K is mostly used in high frequency SMPS as a really good thermally conductive electric insulation with very good shielding properties.



Part-No. **KU 6-623**/TO-220



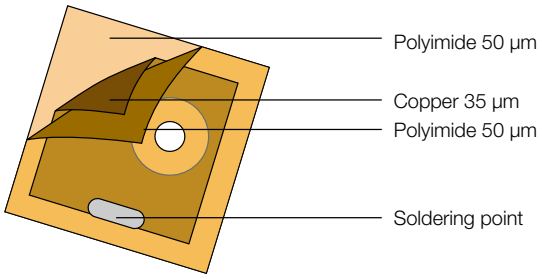
Part-No. **KU 6-624**/TO-247/248

Properties
– Very high shielding
– Good thermal conductivity
– Very flexible
– Clean and easy mounting with high process reliability

Product Availability
– Standard semiconductor types TO 220 and TO 247/248
– Also without hole for clip mounting

Upon Request
– Special shapes according to customer specifications

Construction of KU-K/CU/K



Technical Data

Part	KU-	K/CU/K
General Properties		
Material Construction (sealed)		Polyimide - Copper - Polyimide
Thickness Copper Substrate	µm	35
Total Thickness	µm	140
Mechanical Properties		
Tensile Strength	N/m²	124
Electrical Properties		
Breakdown Voltage	V(AC)	4000
Spezific Volume Resistivity	Ωm	1.2×10^{12}
Dielectric Constant		4.5
Thermal Properties		
Thermal Conductivity	W/mK	0.5
Thermal Resistance (inch²)	°C/W	0.5
Operating Temperature	°C	-60 to 200

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice
all parts have a tinned soldering point

Ordering example
KU 6-623 / K/CU/K
Part / material

Order free samples!

Ceramic Insulators KU-BEO, KU-ALN, KU-ALO

The ceramic plates made out of beryllium-oxide/ aluminum-nitride and aluminum-oxide have an extremely high thermal conductivity and mechanical stability. They meet the highest requirements to operating temperatures.

Mechanical finishing, such as lapping, can significantly improve surface smoothness. This produces a much better thermal resistance and therefore noticeably better heat transfer.

Beryllium-oxide powder is poisonous. The ceramic insulators are harmless in the delivered form, but should not be mechanically reworked in any way.

Properties

– Extremely high thermal conductivity
– High dielectric strength
– Very high temperature resistance
– Very stable

Product Availability

– Standard semiconductor types TO 3, TO 220 and TO 247 / TO 248
– Configurations according to customer specifications

Upon Request

– Ceramic insulators with greater thicknesses

Order free samples!

Technical Data

Ceramic material	KU-	BEO	ALN	ALO
General Properties				
Material		Beryllium-Oxide	Aluminum-Nitride	Aluminum-Oxide
Colour		White	Light Grey	White
Purity of Material	%	99.5%		96.0%
Mechanical Properties				
Flexural Strength	N/mm^2	245	350	380
Compressive Strength	kN/mm^2	-	2.1	3.0
Roughness, unfinished	µm	5	~ 0.6	0.9 - ~ 1.3
Smoothness	mm	-	0.025	0.15
Electrical Properties				
Volume Resistivity	Ωm	1.0×10^{13}	1.0×10^{10}	1.0×10^{12}
Dielectric Constant (1kHz)		6.4	8.6	9.6
Dieelectric Strength	kV/mm	10.6	25	10
Thermal Properties				
Thermal Conductivity	W/mK	300	150	25
Operating Temperature	°C	– 65 to 850	– 65 to 850	– 65 to 850

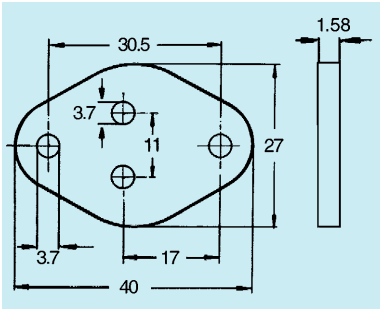
We disclaim all liability for the correctness of the information contained herein We reserve the right to make technical changes without notice

Ordering example
KU 6-623 / ALO
Part / material

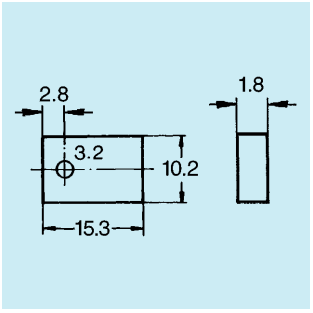
Ceramic Insulator Configurations and Dimensions

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

KU-BEO

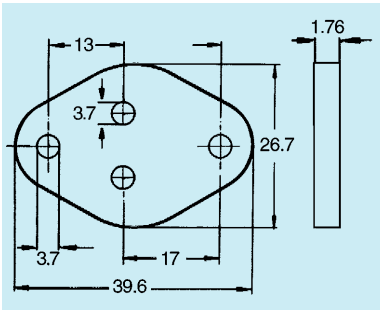


Part No. **KU 6-619**
TO-3

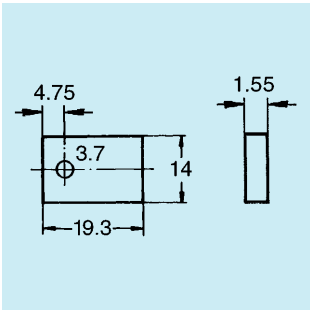


Part No. **KU 6-623**
TO-220

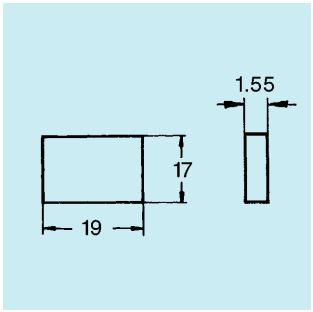
KU-ALN



Part No. **KU 6-619**
TO-3

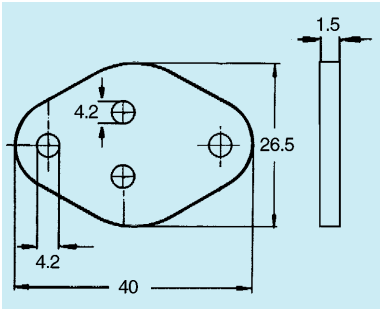


Part No. **KU 6-623**
TO-220

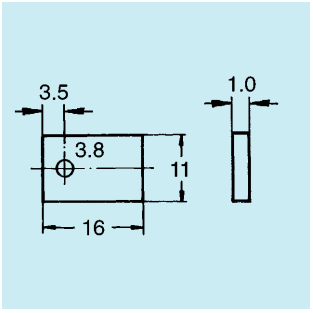


Part No. **KU 6-628/0**

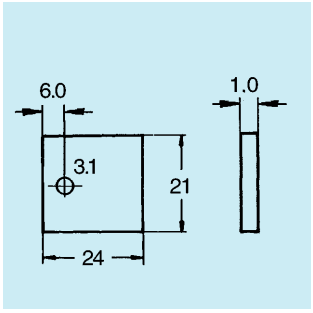
KU-ALO



Part No. **KU 6-619**
TO-619



Part No. **KU 6-623**
TO-220



Part No. **KU 6-624**
TO-3P

Order free samples!

Mica Insulators KU-GL

Properties
– High dielectric strength
– Very stable
– Non-flammable, flame proof

Product Availability
– All standard semiconductor types (see page 89)
– Configurations according to customer specifications

Ordering example
KU 6-623 / GL
Part / material

Technical Data

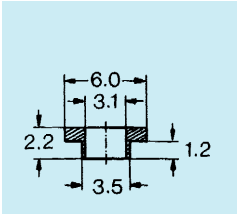
Material	KU-	GL
General Properties		
Material		Mica
Thickness	mm	0.05 - 0. 07
Mechanical Properties		
Tensile Strength	MPa	27
Hardness (Shore A)		80 - 150
Electrical Properties		
Volume Resistivity (1 MHz)	Ωm	1.0×10^{11} - 1.0×10^{15}
Dielectric Constant		3.5
Dielectric Strength	kV/mm	20
Thermal Properties		
Thermal Conductivity	W/mK	0.4
Thermal Resistance (inch²)	°C/W	0.5
Operating Temperature	°C	up to +200

Insulating Bushings (up to 200°C)

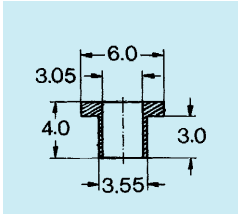
Material
– High heat resistant plastic SR
– This material has
high temperature resistance up
to approx. 200°C
excellent shape retention

Upon Request
– Bushings in other dimensions

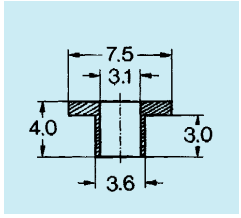
Configurations and Dimensions



Part No. **KU 6-650**/SR



Part No. **KU 6-651**/SR



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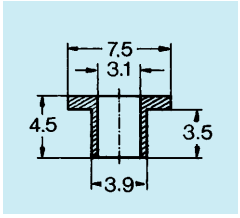

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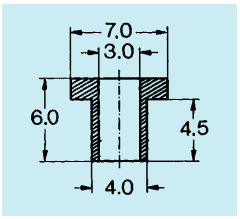
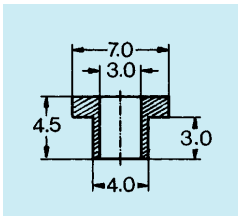
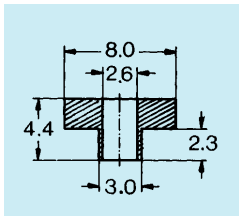


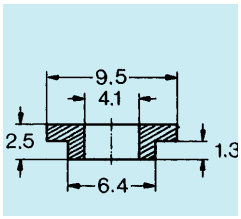
Part No. **KU 6-655**/SR



Part No. **KU 6-656**/SR



Part No. **KU 6-657**/SR



Part No. **KU 6-658**/SR

Technical Data

Insulating bushings		Up to approx. 200°C
General Properties		
Colour		Grey
Mechanical Properties		
Density	g/cm³	1.4
Tensile Strength	N/mm²	80
Modulus in Tension	N/mm²	2400
Impact Resistance as per DIN 53453	KJ/m²	Without Breakage
Electrical Properties		
Volume Resistivity	Ωm	1.0×10^{15}
Dielectric strength	kV/mm	40

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

Ordering example
KU 6-654 / SR
Part / material

Order free samples!

Insulating Bushings (up to 140°C)

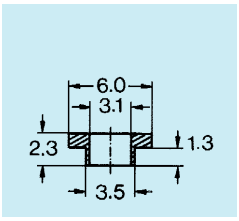
Material

– Polyamide GV
– This material has high shape retention due to the addition of heat stabilisers for continuous-use high temperature resistance up to approx. 140°C fiberglass fillers and polymerisation products

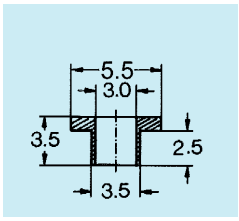
Upon Request

– Bushings in other dimensions

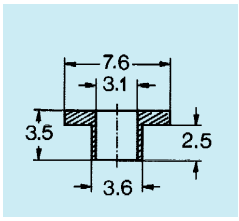
Configurations and Dimensions



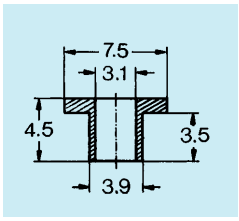
Part No. **KU 6-650**/PA



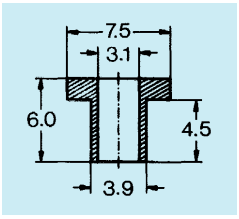
Part No. **KU 6-651**/PA



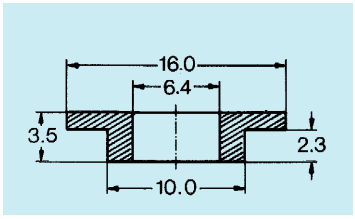
Part No. **KU 6-652**/PA



Part No. **KU 6-654**/PA



Part No. **KU 6-655**/PA



Part No. **KU 6-665**/PA

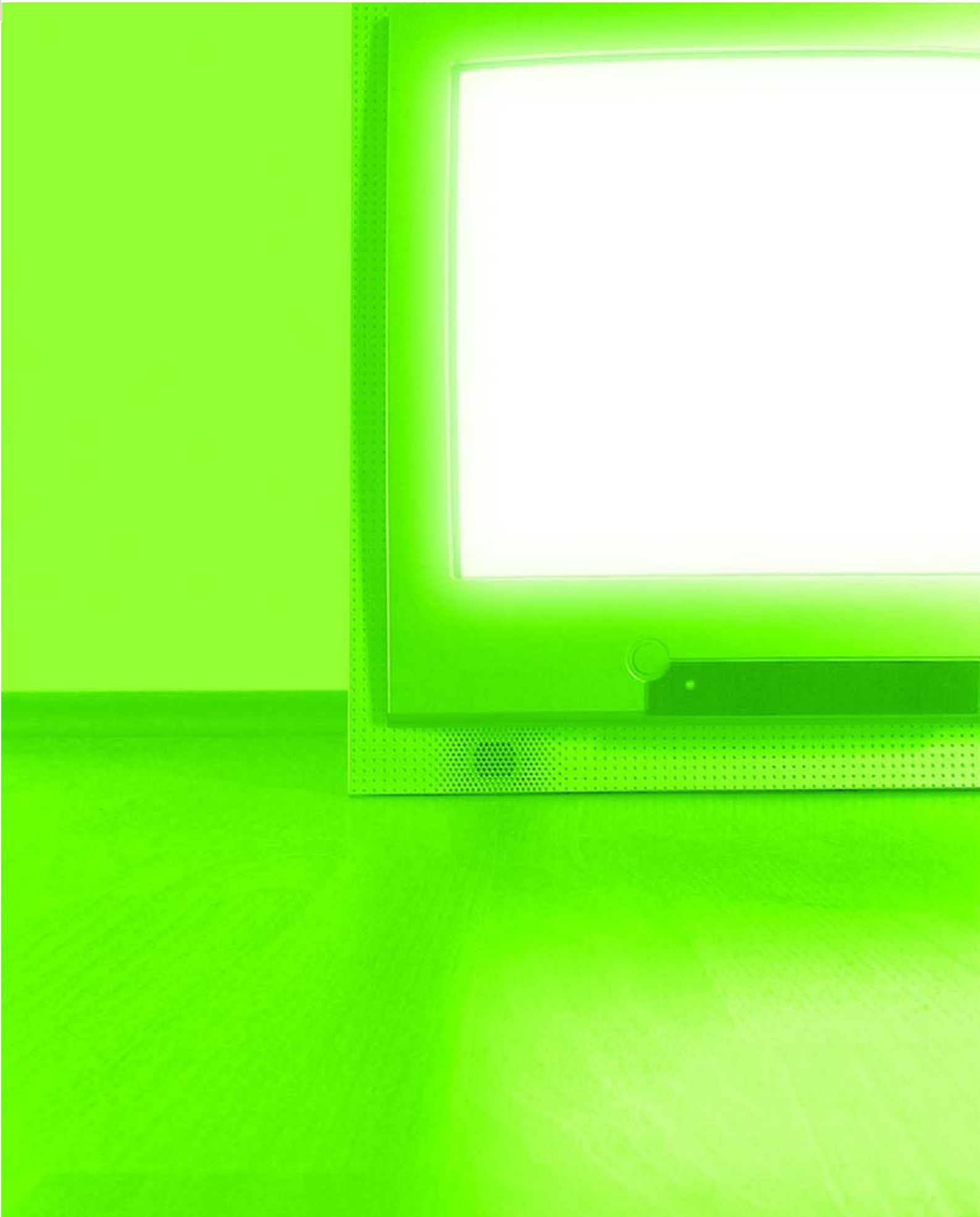
Technical Data

Insulating bushings			Up to approx. 140°C
General Properties			
Colour			Black
Proportion of Fberglass Reinforcement		%	25
Mechanical Properties			
Density		g/cm³	1.3
Tensile Strength		N/mm²	110
Modulus in Tension		N/mm²	6000
Impact Resistance	bei +23 °C	KJ/m²	30
	bei -40 °C	KJ/m²	25
Electrical Properties			
Volume Resistivity		Ωm	1.0 x 10^{10}
Dielectric Strength		kV/mm	40

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

Ordering example
KU 6-665 / PA
Part / material

Order free samples!



Kunze POWERCLIPS®,
as ideal parts for integrated
heatmanagement solutions:

Optimum interaction of transistor clips,
interface materials, heat sinks through
well-suited clip design

Perfect application design
by clamping force vs. distance graphs

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of POWERCLIPS®, upon request

100% corrosion-free
through stainless steel CrNi 1.4310

All clips available with insulation

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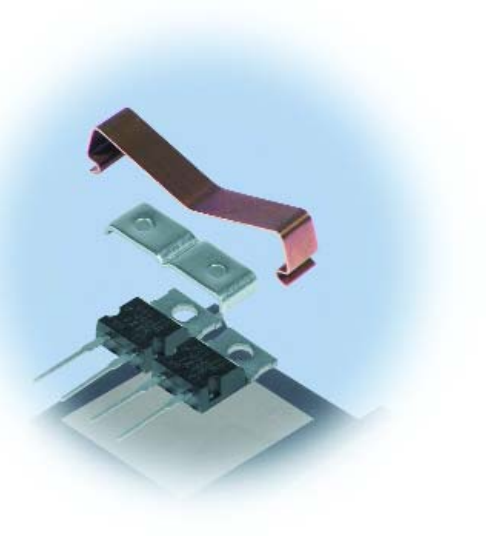
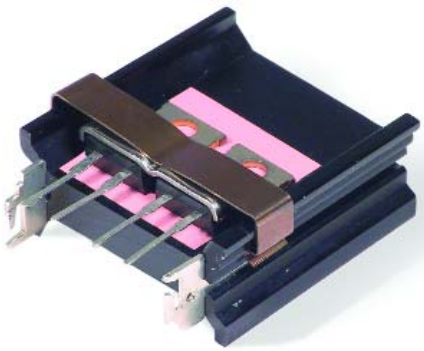
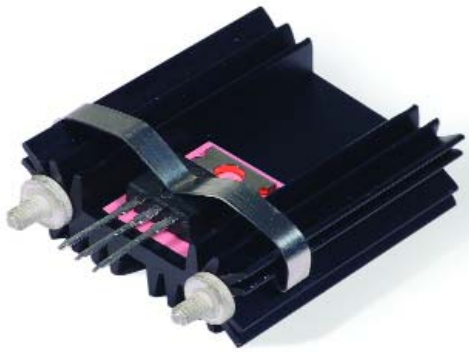






Technical Data

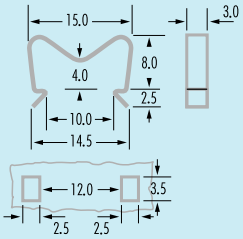
Type		POWERCLIPS®
General Properties		
Material		Through Stainless Steel CrNi 1.4310
Mechanical Properties		
Tensile Strength	N/mm²	1300-1500
Elongation	%	>40
Young Modulus	kN/mm²	190

All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice

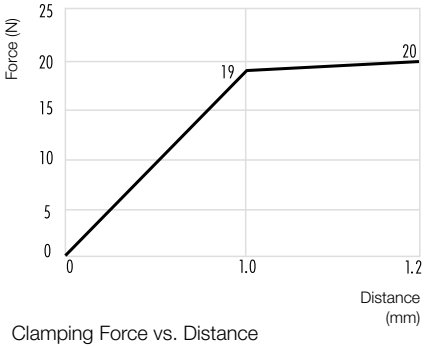
All mechanical properties at room temperature

Order free samples!

Part No. **KU 3-381**
TO-220

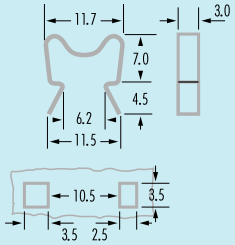


mat. 0.3 mm, for sheet metal thickness
1.5-2.0 mm

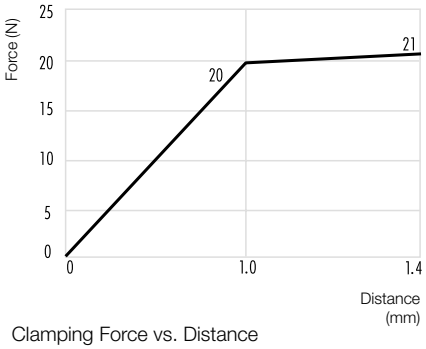


Clamping Force vs. Distance

Part No. **KU 3-383**
TO-126

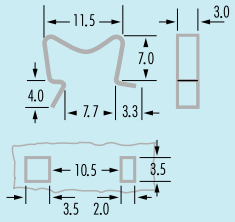


mat. 0.3 mm, for sheet metal thickness
2.0 mm

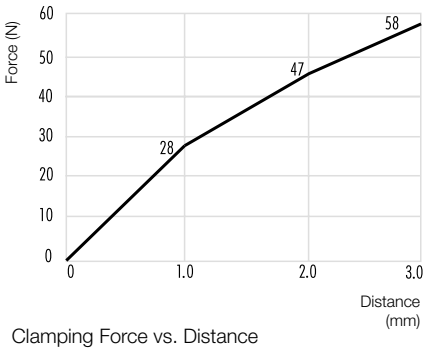


Clamping Force vs. Distance

Part No. **KU 3-384**
TO-126

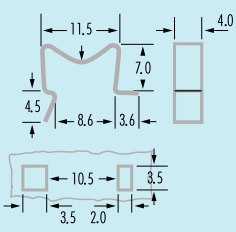


mat. 0.3 mm, for sheet metal thickness
2.0 mm

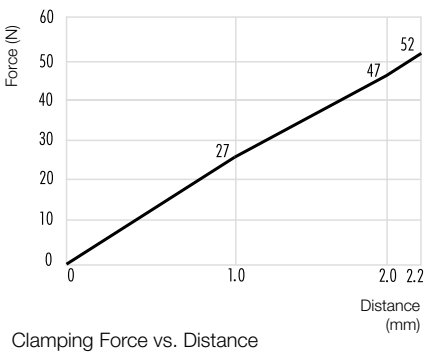


Clamping Force vs. Distance

Part No. **KU 3-385**
TO-126



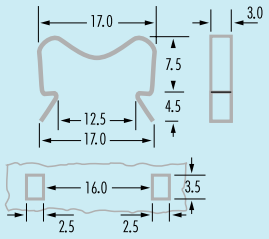
mat. 0.3 mm, for sheet metal thickness
2.0 mm



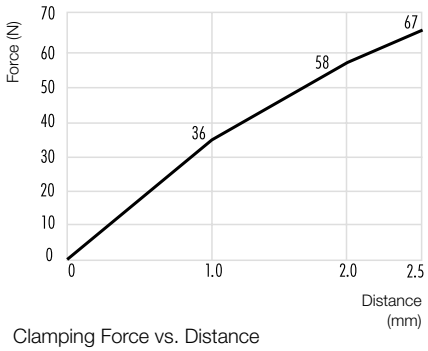
Clamping Force vs. Distance

Order free samples!

Part No. **KU 3-386**
TO-220

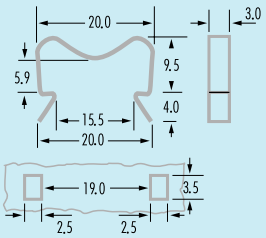


mat. 0.3 mm, for sheet metal thickness
1.5-2.0 mm



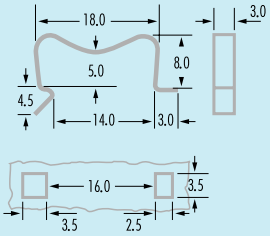
Clamping Force vs. Distance

Part No. **KU 3-386/20**
TO-220

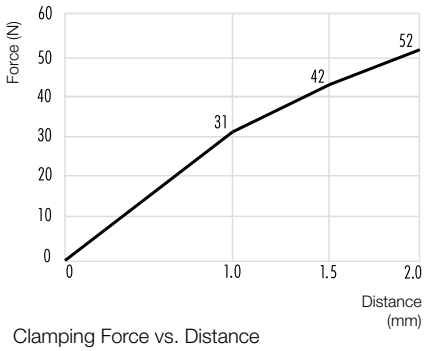


mat. 0.3 mm, for sheet metal thickness
2.0-3.0 mm

Part No. **KU 3-387**
TO-220

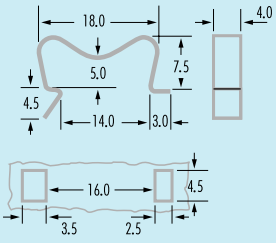


mat. 0.3 mm, for sheet metal thickness
1.5-2.0 mm

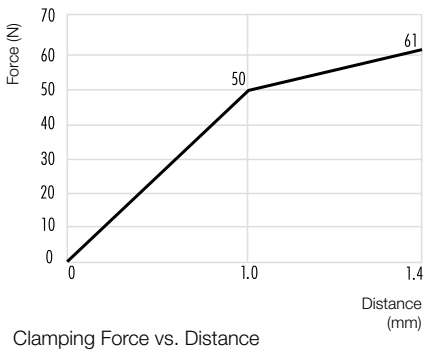


Clamping Force vs. Distance

Part No. **KU 3-388**
TO-220



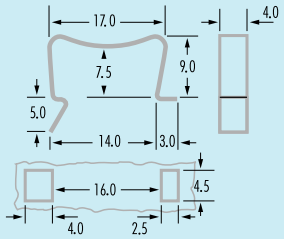
mat. 0.4 mm, for sheet metal thickness
1.5-2.0 mm



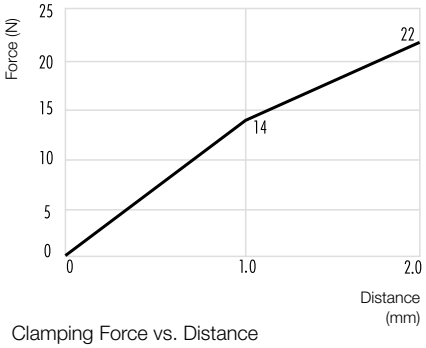
Clamping Force vs. Distance

Order free samples!

Part No. **KU 3-389**
TO-220

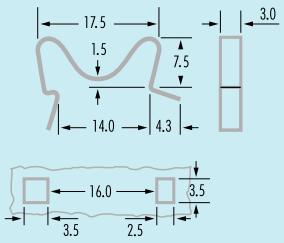


mat. 0.3 mm, for sheet metal thickness 4.0 mm

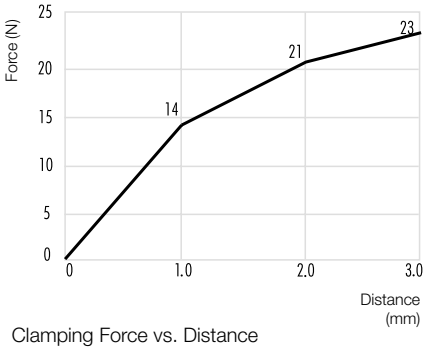


Clamping Force vs. Distance

Part No. **KU 3-390**
TO-126

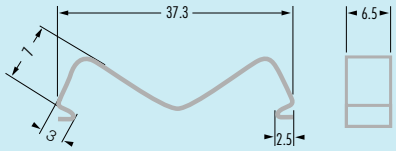


mat. 0.3 mm, for sheet metal thickness 1.0-2.0 mm



Clamping Force vs. Distance

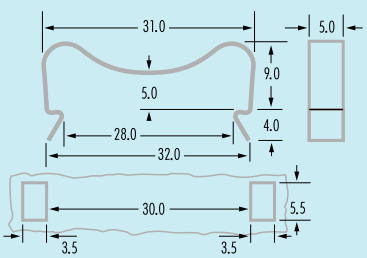
Part No. **KU 3-391**
TO-126



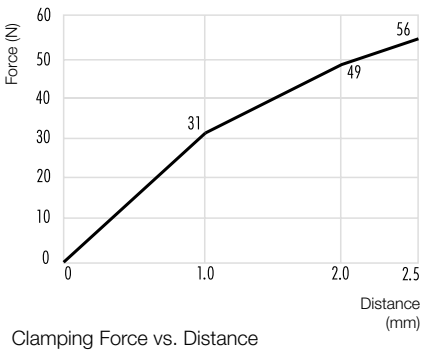
mat. 0.3 mm, for Heat sink KU1-070

Application Example
Components on page 87

Part No. **KU 3-392**
TO-3P · TO-247/248



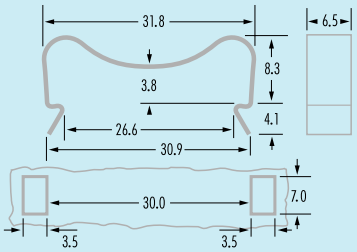
mat. 0.5 mm, for sheet metal thickness 2.0 mm



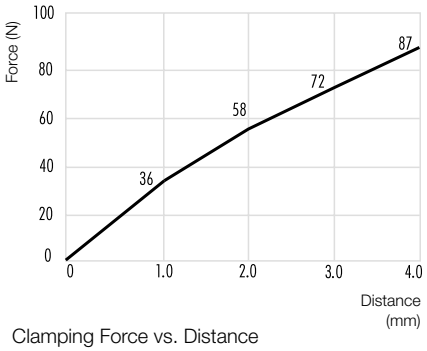
Clamping Force vs. Distance

Order free samples!

Part No. **KU 3-393**
Rectifier bridges

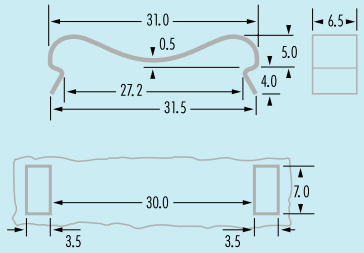


mat. 0.5 mm, for sheet metal thickness
1.5 mm

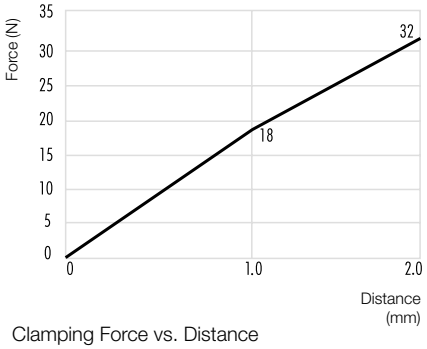


Clamping Force vs. Distance

Part No. **KU 3-394**
Multiwatt

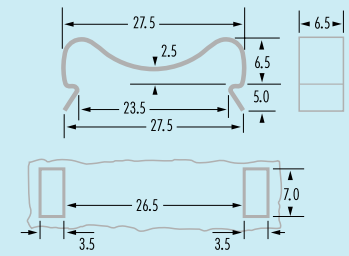


mat. 0.3 mm, for sheet metal thickness
1.5-2.0 mm

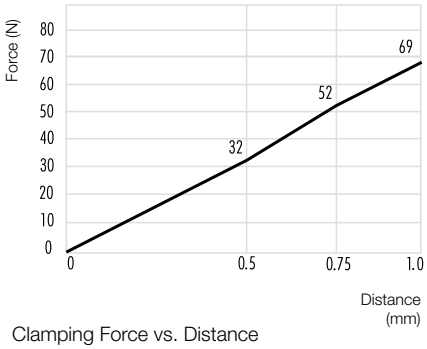


Clamping Force vs. Distance

Part No. **KU 3-395**

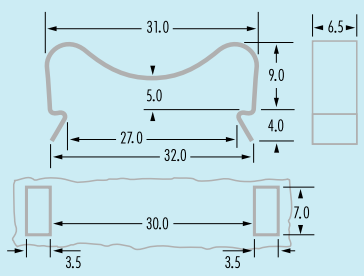


mat. 0.4 mm, for sheet metal thickness
1.0-2.0 mm

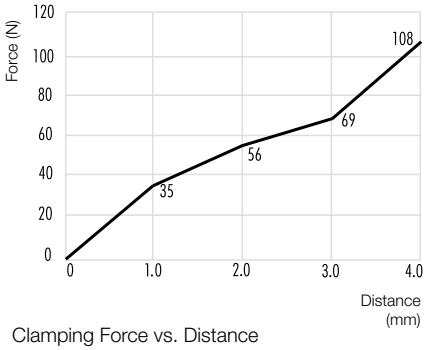


Clamping Force vs. Distance

Part No. **KU 3-396**
TO-3P · TO-247/248



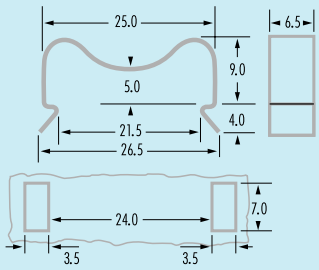
mat. 0.5 mm, for sheet metal thickness
2.0 mm



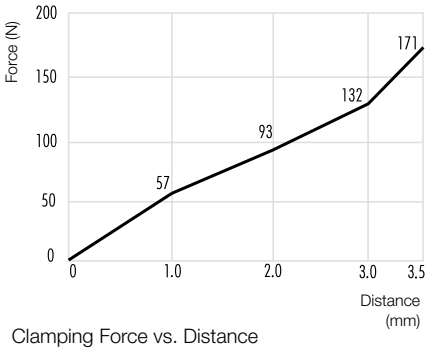
Clamping Force vs. Distance

Order free samples!

Part No. **KU 3-396/24**
TO-3P

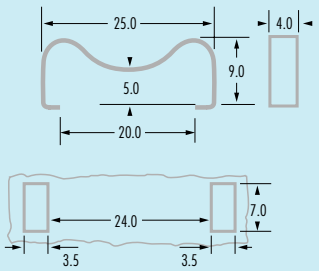


mat. 0.5 mm, for sheet metal thickness
2.0 mm



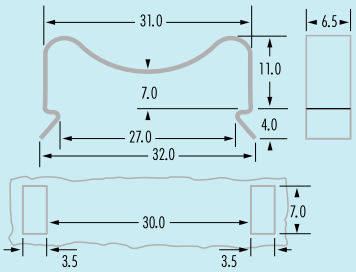
Clamping Force vs. Distance

Part No. **KU 3-396/24/4**
TO-3P

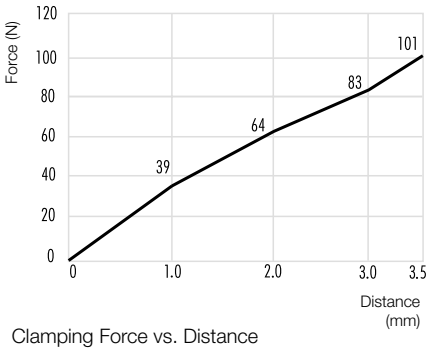


mat. 0.5 mm, for sheet metal thickness
2.0 mm

Part No. **KU 3-397**
TO-3P · TO-247/248

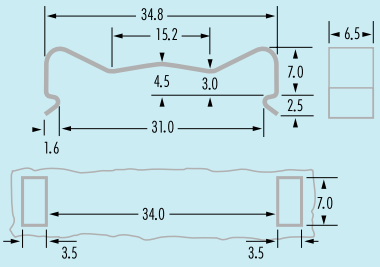


mat. 0.5 mm, for sheet metal thickness
4.0 mm

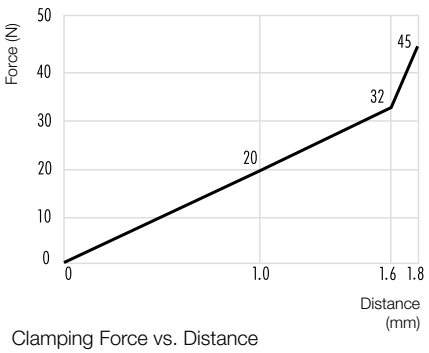


Clamping Force vs. Distance

Part No. **KU 3-398**
2 x TO-220



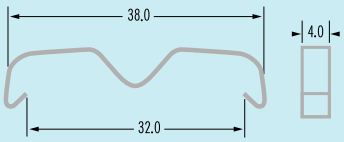
mat. 0.4 mm, sheet metal thickness
1.0-1.5 mm



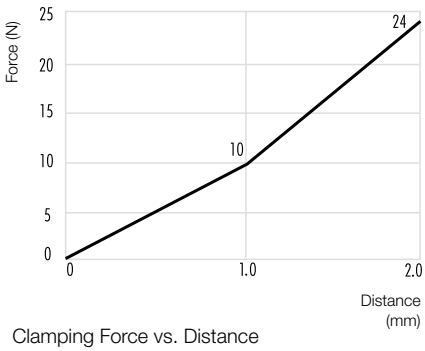
Clamping Force vs. Distance

Order free samples!

Part No. **KU 3-399**
TO-220 / TO-3P



mat. 0.4 mm

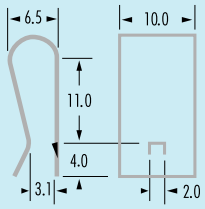


Clamping Force vs. Distance

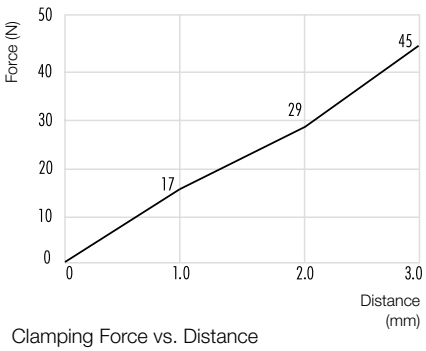
Application Examples for KU 3-399 with Heat Sink KU 1-072

Order free samples!

Part No. **KU 4-440/3.1**
TO-220 / TO-3P

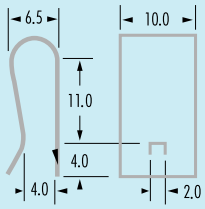


mat. 0.5 mm
spring steel, hardened and tempered

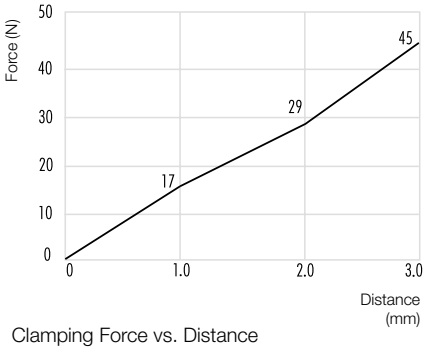


Clamping Force vs. Distance

Part No. **KU 4-440/4.0**
TO-220 / TO-3P

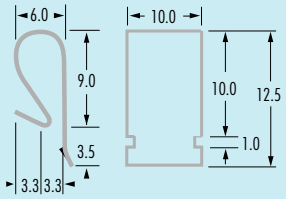


mat. 0.5 mm
spring steel, hardened and tempered



Clamping Force vs. Distance

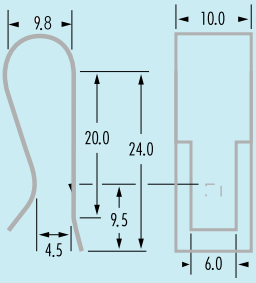
Part No. **KU 4-441**
TO-220 / TO-3P



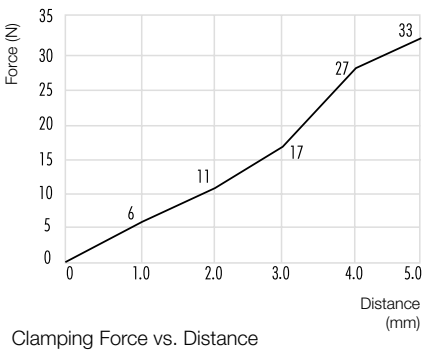
mat. 0.5 mm

Application Example

Part No. **KU 4-443**
TO-220 / TO-3P



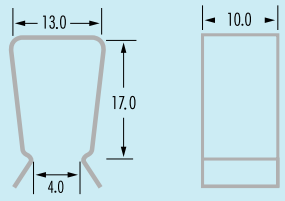
mat. 0.6 mm
spring steel, hardened and tempered



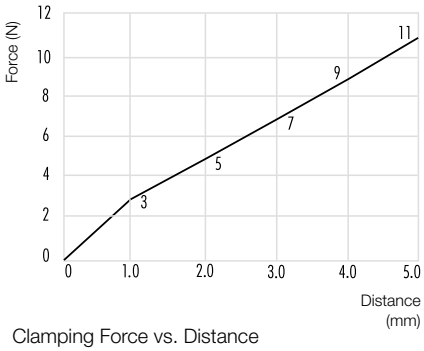
Clamping Force vs. Distance

Order free samples!

Part No. **KU 4-445**
TO-220 / TO-3P

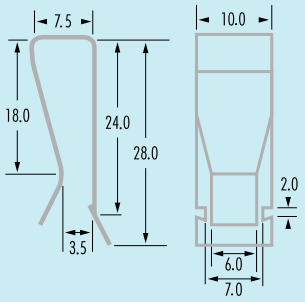


mat. 0.5 mm

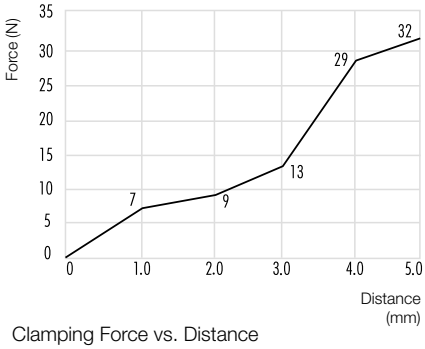


Clamping Force vs. Distance

Part No. **KU 4-450**
TO-220 / TO-3P

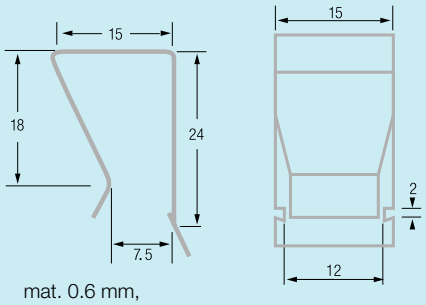


mat. 0.6 mm
spring steel, hardened and tempered



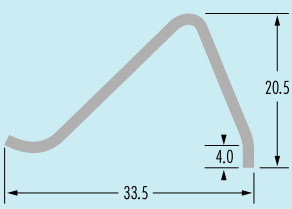
Clamping Force vs. Distance

Part No. **KU 4-460**
TO-220 / TO-3P



mat. 0.6 mm,
Alternatively made of stainless steel 1.4130
or spring steel, hardened and tempered

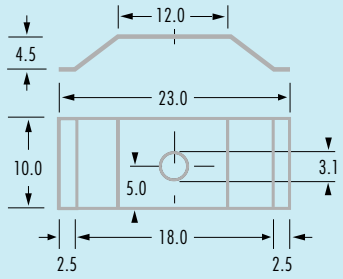
Part No. **KU 4-490**
TO-220 / TO-3P



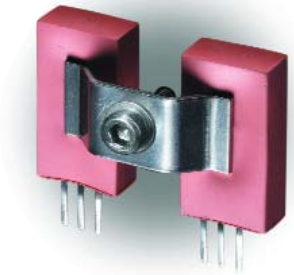
Wire elbows can be produced
in all variations to customer specifications
without tooling costs

Order free samples!

Part No. **KU 4-430**

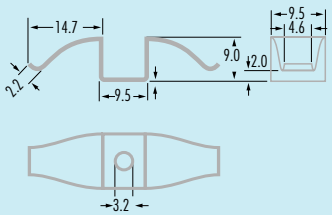


mat. 0.8 mm

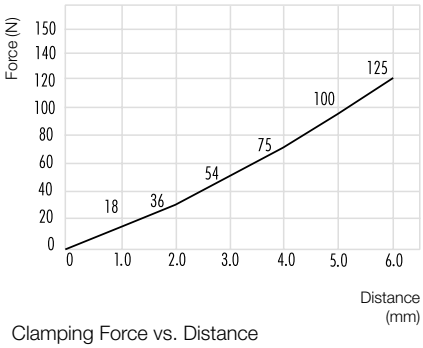


Mounting Example

Part No. **KU 4-495**
Gull Wing Clip

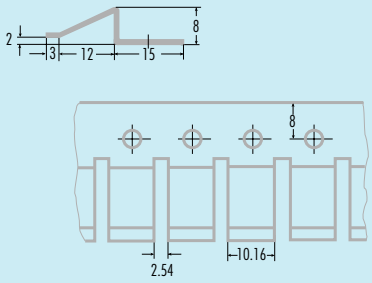


mat. 0.6 mm

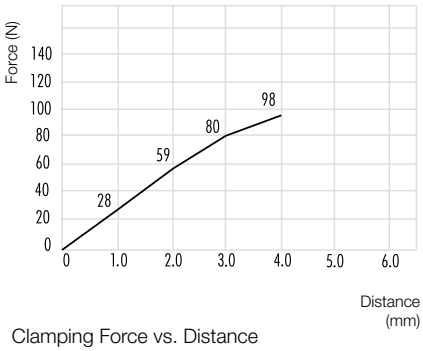


Clamping Force vs. Distance

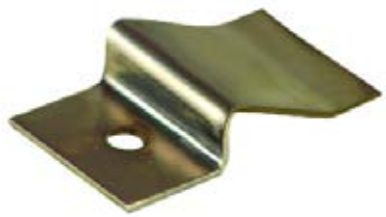
Multiple Transistor Clip
Part No. **KU 4-498/X**
TO-220
(X= Number of fingers)



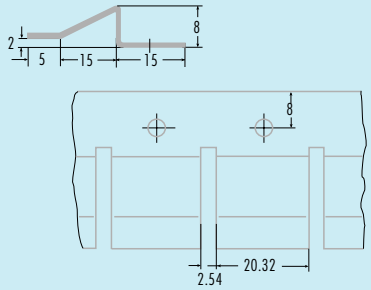
mat. 0.8 mm, Holes 4.0 mm ø



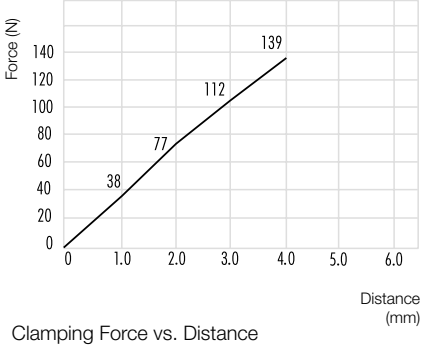
Clamping Force vs. Distance



Multiple Transistor Clip
Part No. **KU 4-499/X**
TO-247 / TO-264
(X= Number of fingers)

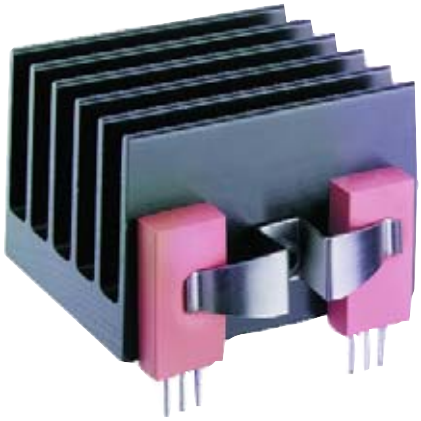


mat. 0.8 mm, Holes 4.0 mm ø

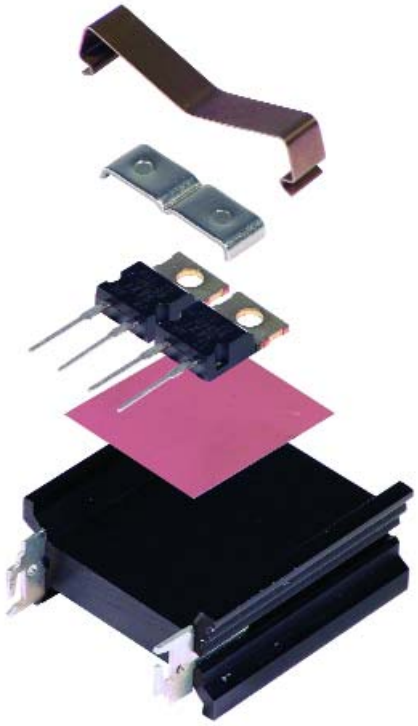


Clamping Force vs. Distance

Order free samples!

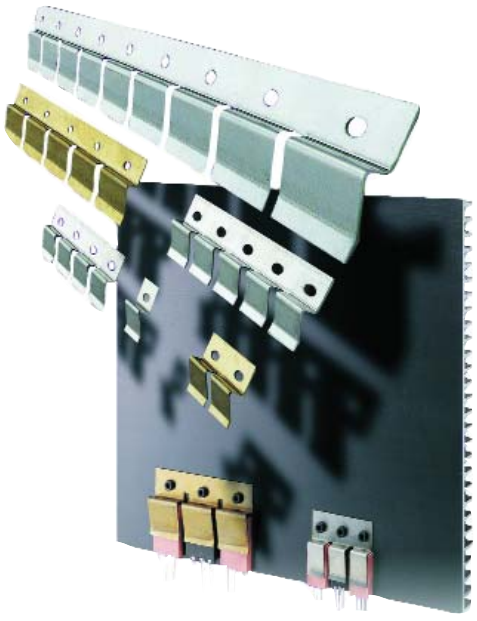


Application Example for Gull Wing Clips



Mounting Example
Heat Sink: KU 1-070
POWERCLIP®: KU 3-391
Centering Element: KU 2-ZUB O1-567
Mounting Element: KU 2-ZUB 38-1

For further information on heat sinks and mounting device please order our Kunze Heat Sink Catalogue or visit our Heatmanagement Homepage: www@heatmanagement.com

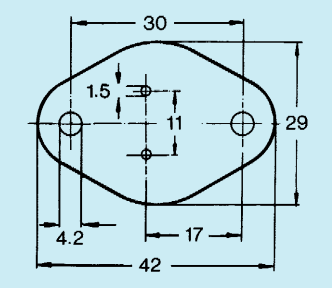


Application Example
for Multiple Transistor Clips

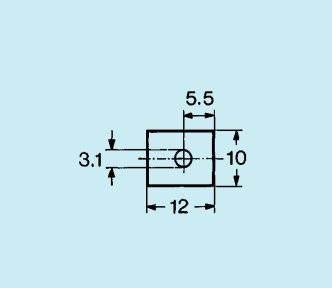
The number of clips on a multiple transistor clip can be specified without incurring additional tooling costs

Order free samples!

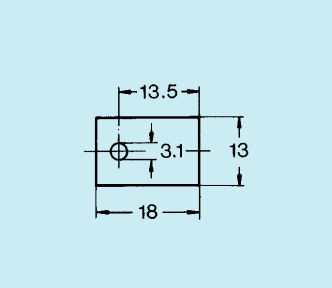
For Your Notes



Part No **KU 6-619**
TO-3

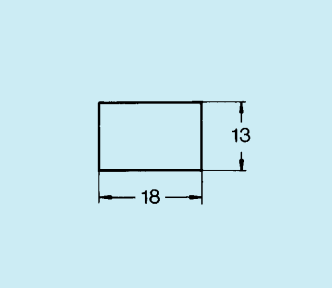


Part No **KU 6-620**
TO-126 · SOT-32

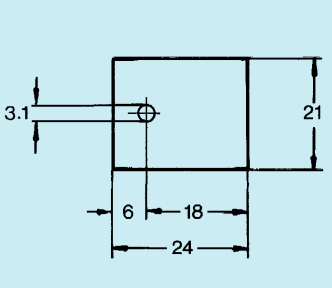


Part No **KU 6-623**
TO-220

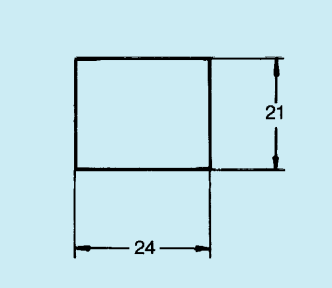
All dimensions in mm
We disclaim all liability for the correctness of the information contained herein
We reserve the right to make technical changes without notice



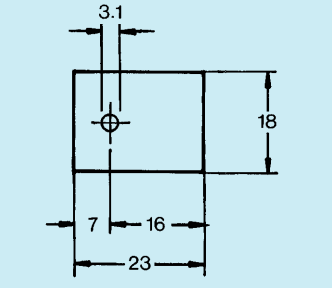
Part No. **KU 6-623/0**
TO-220



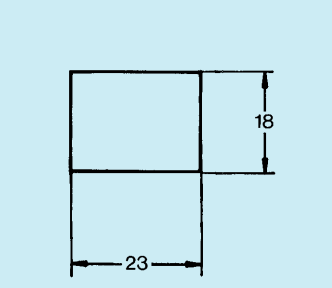
Part No. **KU 6-624**
TO-3P · TO-218/247/248
MT100



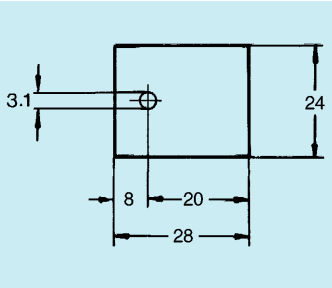
Part No. **KU 6-624/0**
TO-3P · TO-218/247/248
MT100



Part No. **KU 6-630**
TO-220



Part No. **KU 6-628/0**
TO-220



Part No. **KU 6-630**
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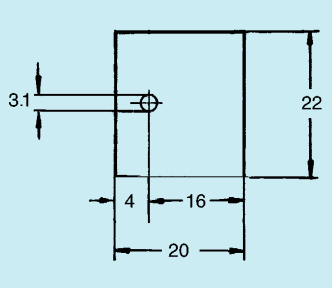

Part No. **KU 6-631**
Multiwatt

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General Terms and Conditions of Sale

§ 1 Definitions - Scope of Application

(1) The following terms and conditions of sale and delivery shall apply exclusively for the legal relations between the customer and us. We do not recognize any conflicting or differing terms and conditions of the customer unless we expressly approved the applicability thereof in writing. The following terms and conditions shall also apply in the event of performing delivery to the customer without any reservation while being aware of the conflicting or differing terms and conditions of the customer.
(2) Any arrangements or collateral agreements variant from these terms and conditions shall only be valid, if we confirm them in writing.
(3) In any case, we reserve the right to improve designs, forms and technical aspects as required to comply with the latest state of the art before shipping ordered products.

§ 2 Offers – Offer Documents

(1) Our offers are subject to alteration.
(2) In the event any order qualifies as an offer pursuant to § 145 of the German Civil Code, we may accept such order within three weeks.
(3) We hereby reserve copyright and the rights of ownership on drawings, calculations and any other documents. This shall also apply to any written documents designated "confidential". The customer shall require our expressed consent before forwarding such documents to third parties.
(4) A contract for delivery shall first be effected by way of written order confirmation from us, though upon delivery at the latest. The sending of a confirmation per remote data transfer shall satisfy the requirement for the written form. In the event we can prove that a statement was sent per fax or remote data transfer by presenting a dispatch report, it shall be assumed that the customer received such statement.

§ 3 Prices – Terms and Conditions of Payment

(1) Only those prices are valid that are confirmed by us in writing. These prices are exworks, plus the valueadded tax required by law, (plus postage, packaging, freight, insurance, etc.)
(2) We reserve the right to change the agreedupon prices by an appropriate amount if after the contract conclusion any cost reduction or increase arise, particularly because of increases in wage, material costs…. These changes in costs can be disclosed upon customer's request.
(3) Our invoices must be paid either within 10 days with a 2% discount, or within 30 days in full.
(4) Payments shall be made by way of bank remittance, check or cash. Other ways of payment require a special agreement. The receipt of payment by us shall be decisive with regard to the timeliness thereof.
(5) The legitimate rules relevant to the effects of payment defaults are valid.
(6) The customer may only set off claims with undisputed counterclaims recognized by us or recognized by a nonappealable judgment. The customer shall only be authorized to exercise a retention right in the event his counterclaim is based on the same contractual relation.
(7) In the event, after the conclusion of the contract, we become aware of circumstances, which challenge the creditworthiness of the customer or in the event of a substantial risk of its claim to payment due to dwilling assets of the customer, or in the event the customer falls into arrears over the payment of a purchase price, we may request advance payment or collateral within a reasonable period and refuse performance until its request is fulfilled. In the event the customer refuses to render an advance payment or provide collateral or in the event the period determined has lapsed without result, we shall be entitled to withdraw from contract in whole or in part and demand damage compensation due to nonperformance.

§ 4 Deliveries – Delivery Period

(1) The observation of agreedupon delivery and performance dates shall require that all technical matters have been clarified and payments or any other obligations of the customer have been fulfilled in due time. In the event technical matters have not been clarified and the customer has not fulfilled its obligations, the period shall be adequately extended. The objection of the nonfulfilled contract is reserved.
(2) The delivery period shall be extended by the duration of the hindrance in the event of force majeure, strike, inability to perform not caused by someone's negligence as well as any adverse weather conditions.
(3) Partial deliveries shall be permissible provided no disadvantages for us arise thereby. We also reserve the right to increase and reduce deliveries by up to 10%.
(4) In the event the customer falls into arrears in accepting delivery, violates any other cooperation duties or delivery is delayed because of any other reasons induced by the customer, we shall be entitled to give preference to other thirdparty orders and reasonably extend the delivery period. The distress of an accidental sinking or deterioration of the ordered item passes to the customer at that time he falls into arrears in accepting delivery or violates any other cooperation duties. Irrespective of any further claims, we shall be entitled to demand that any damages it incurs in this regard, including any additional expenses be compensated. In particular, we can charge each month, irrespective of any other rights, a storage charge of 0.5%, not exceeding 5% of the purchasing price of the delayed item.
(5) In the event condition (4) is valid, the danger of an accidental sinking or deterioration of the ordered item passes to the customer at that time he falls into arrears in accepting delivery or violates any other cooperation's duties.
(6) By issue of release orders we shall be entitled to set a monthlong additional respite for acceptance, after an expiration time of 12 months ex order confirmation, implicating an invoice of the not accepted ordered item or service as well as storage charges and reserve costs respectively till acceptance.
(7) We shall be liable according to the provisions of the law, in so far as the delay in delivery is attributable to a breach of contract resulting from either gross negligence or intent on our behalf; we shall be accountable in all cases where our representatives or vicarious agents are responsible. In the event of a grossly negligent breach of contract, our liability to pay damages shall be limited to the foreseeable loss as may typically be expected. This regulation does not imply a change in the burden of proof to the customer's disadvantage.
(8) We shall also be liable according to the provisions of the law, in so far as the delay in delivery is attributable to a culpable breach of an essential contractual obligation. In this case, the liability to pay damages shall be limited to the foreseeable loss as may typically be expected.
(9) In so far as, according to these provisions, we are responsible for a delay in delivery, our liability shall be limited to compensation amounting to 0.5% of the delivery value for each week that we are in default, but shall not, however, exceed 5% of that part of the delivery value, which is not usable according to the delay.
(10) At our request, the customer agrees to state within an appropriate period of time whether he wishes to withdraw from the agreement as a result of the delay in delivery or whether he wishes to have delivery carried out.
(11) Other rights and claims to which the customer may be entitled in the event of delayed delivery shall be excluded herewith.

§ 5 Shipping – Transfer of Risk

(1) Unless specified otherwise in the order confirmation, delivery ex works shall be agreed upon. Kind and way of dispatch are undertaken by our estimation. Shipping shall take place at the risk and expense of the customer. This shall also apply to return shipments.
(2) Any transport or other disposable packaging shall not be taken back.
(3) Small and stamped parts are delivered as bulk goods. Individual or special packaging is only provided on the basis of a corresponding agreement.
(4) The delivery can be insured by a transportation insurance. The emerging costs are born by the customer.

§ 6 Rights and liability resulting from defects

(1) Customary deviations with deliveries from different production runs shall not be considered as defects. The same applies to generally reasonable deviations in the products delivered from samples. Technical data, specifications and performance designations in offers, agreements, exhibits, booklets and documentaries etc., merely characterise the consistency of products and do not represent a warranty, unless, they are specially designated as such.
(2) Notice of defects must be issued in writing immediately, however, no later than within a period of 8 days. In the case of obvious defects, this time limit shall commence upon delivery. In the case of hidden defected, this limit shall commence upon discovery of the defect. Should the customer refrain from issuing said notice, the delivery shall be considered to have been accepted.
(3) In so far the defect concerns the object of sale, we shall have the option to either remedy the defect or deliver a new, faultless object. In the case of remedial action, we agree to bear all necessary costs for the remedial action including, in particular, the cost of carriage, transport, labor and materials, provided that these costs do not increase as a result of the object of sale being delivered to a place other than the agreed place of performance. The subsequent fulfilment of performance can be rejected by us, if it just incorporates unreasonable and disproportional exalted costs.
(4) Should subsequent performance prove unsuccessful, the customer shall – irrespective of any claims for damages – be entitled to either withdraw from the contract (Rescissions of the agreement) or demand an abatement (Reduction of the payment).
(5) Defect claims shall not arise in the case of insignificant deviations from the agreed condition or quantity of the goods, in the event of negligible impairment of the usability, in the event of natural wear and tear or damages arising subsequent to the transfer of risk as a result of incorrect or careless treatment, excessive strain, inappropriate equipment, inappropriate application, improper use, incorrect installation or as a result of specific external influences which are not provided for in the agreement. A deviation in the delivery amount of up to 10 % shall be considered negligible. Similarly, defect claims shall not exist for these or any consequential damage if the customer or third parties improperly undertake modifications.
(6) In any case, we shall make the form of subsequent performance (remedial action or replacement delivery) dependent on whether or not part of the agreed payment proportionate to the scope and extent of the defect has already been paid.
(7) The customer shall undertake to render assistance in fault finding and removal and shall furnish us with comprehensive information and advice. Furthermore, he shall give us opportunity to investigate the event of loss.
(8) We shall be liable according to the provisions of the law, in so far as the customer asserts claims for damages resulting from intent or gross negligence, including intent or gross negligence on the part of our representatives or vicarious agents. Provided that we are not accused of a wilful breach of contract, the liability to pay damages shall be limited to the foreseeable loss as may typically be expected.

(9) We shall be liable according to the provisions of the law, in so far as we culpably breach an essential contractual obligation. In this case, the liability to pay damages shall be limited to the foreseeable loss as may typically be expected.
(10) In so far as the customer is entitled to payment of damages in lieu of the service, our liability to pay damages shall be limited to the foreseeable loss as may typically be expected.
(11) Liability due to culpable loss of life, physical injury or damage to health shall remain unaffected hereby. The same shall apply to the statutory liability according to the product liability laws.
(12) The aforementioned regulations do not imply a change in the burden of proof to the customer's disadvantage.
(13) The statutory period of limitations for defect claims shall be 12 months. This shall not apply if the law pursuant to § 479 Section 1 of the German Civil Code (BGB) provides for longer time limits in cases of loss of life, physical injury or damage to health, in the event of a wilful or grossly negligent breach of obligations and in the event of fraudulent concealment of a defect. The statutory regulations regarding the commencement of the statute of limitations, estoppel and reinception of the time limits shall remain unaffected hereby.
(14) Recourse claims of the customer against us, under §478 BGB (Recourse of the entrepreneur), shall only be valid insofar, that the customer has not met any agreements with his acceptor, which exceed the legal defect claims. For the complexity of our compensation liability shall be applied the abovementioned rules and regulations.

§ 7 Deficiencies – Property Rights

(1) The customer hereby agrees to immediately inform us of any thirdparty right claims with regard to the delivered products and to leave the legal defence to us at our own expense.
(2) We shall be entitled to perform any necessary alterations at our own expense also with regard to delivered and purchased goods due to thirdproperty right claims.
(3) Claims of the customer shall be excluded, in so far as he is responsible for infringing an industrial property right. Furthermore, claims of the customer shall also be excluded to the extent that the infringement of industrial property right arises as a result of specific guidelines issued by the customer as a result of a form of use which we could not possibly foresee or as a result of the delivered products being modified by the customer or if they are used in conjunction with products which were not supplied by us.

§ 8 Joint and several liability

(1) Liability for damages beyond the scope provided for in §§ 6 and 7 shall be excluded herewith regardless of the legal nature of the claim asserted. This shall apply in particular to all claims for damages resulting from any fault upon conclusion of this agreement, due to other breaches of obligations or due to claims in tort for payment of property damage pursuant to § 823 German Civil Code (BGB).
(2) In so far as our liability for damages is excluded or limited, this shall also apply to the personal liability for damages of our salaried workers, employees, assistants, representatives and vicarious agents.

§ 9 Special Models – Tool Costs

(1) When specially produced merchandise is delivered, we will charge for the costs incurred for making the required tools.
(2) The tools shall remain our property. However, the customer can demand that such tools only be used for orders submitted by him. Furthermore, all copyrights and performance protection rights of the tools are reserved to us.
(3) In the event of a custommade product showing defects, the customer shall only be entitled to subsequent performance. Should the customer demand subsequent performance, we shall be entitled to choose whether we perform remedial action or produce a new product. Should the subsequent performance prove unsuccessful the customer shall – irrespective of any claims for damages – be entitled to either withdraw from the contract (Rescissions of the agreement) or demand an abatement (Reduction of the payment). For the rest, defects and our liability shall be governed by the provisions of §§ 7 to 9 analogously.

§ 10 Retention of Title

(1) We hereby reserve the right of title of the delivery items until all payments from the business relation with the customer have been received.
(2) In the event the customer acts in breach of contract, in particular, in the event of delayed payment, we shall be entitled after an agreed timeframe to take back the delivery items and the customer shall be obligated to surrender the delivery items. The taking back of the delivery items is considered as a withdrawal of the contract. After taking back the delivery items, we are authorized for further utilization. Emerging proceeds of utilization are added up to the obligation of the customerless appropriate utilization costs.
(3) The customer may neither pledge nor assign the article of sale to third parties by way of security. In the event of the goods being pledged, confiscated or given other forms of third party intervention, the customer shall notify us of this immediately and furnish us with all information and documentation deemed necessary to protect our interests. Enforcement officers or third parties must designate our property. In so far as the third party is not able to reimburse to us the legal and extrajudicial costs of court action pursuant to § 771 Code of Civil Procedure (ZPO), the customer shall be liable for all losses incurred by us.
(4) The customer shall be entitled to resell the delivery items within the ordinary course of business; the customer hereby assigns us all claims incurred by the customer from the resale in the amount of the purchase price agreed upon by us and the customer (including valueadded tax) in advance regardless of whether the delivery items are sold without being fabricated or after being fabricated. The customer shall be empowered to collect such claims after the claims have been assigned. The authorization from us to collect the claims itself shall remain un-affected thereby. We, however, hereby, agree not to collect the claims as long as the customer properly fulfils its payment obligations and is not in arrears in payment. In the event this is, however, not the case, we demand that the customer disclose the assigned claims and their debtors, provide all information necessary for collection, surrender the related documents and inform the debtors (third parties) of the assignment.
(5) The goods shall always be processed or transformed by the customer on our behalf. In the event the delivery items are processed with other objects not belonging to us, we shall acquire the joint title to the new item in proportion of the value of the delivery items to the other fabricated objects at the time of the fabrication.
(6) In the event the delivery items are mixed with other objects not belonging to us to the extent that they cannot be separated from one another, we shall acquire the joint title to the new items in proportion of the value of the delivered items to the other mixed objects. The customer shall keep in safe custody the joint title for us.
(7) The customer shall also assign to us all claims necessary to secure our claims against him that may arise against a third party as a result of the connection between the article of sale and a property.
(8) We hereby agree to release the securities to which it is entitled upon the request of the customer to the extent such securities do not exceed the value of the claims to be secured by us by more than 10%, provided such have not yet been satisfied. We shall be responsible for selecting the securities to be released.

§ 11 Secrecy, data protection and data security

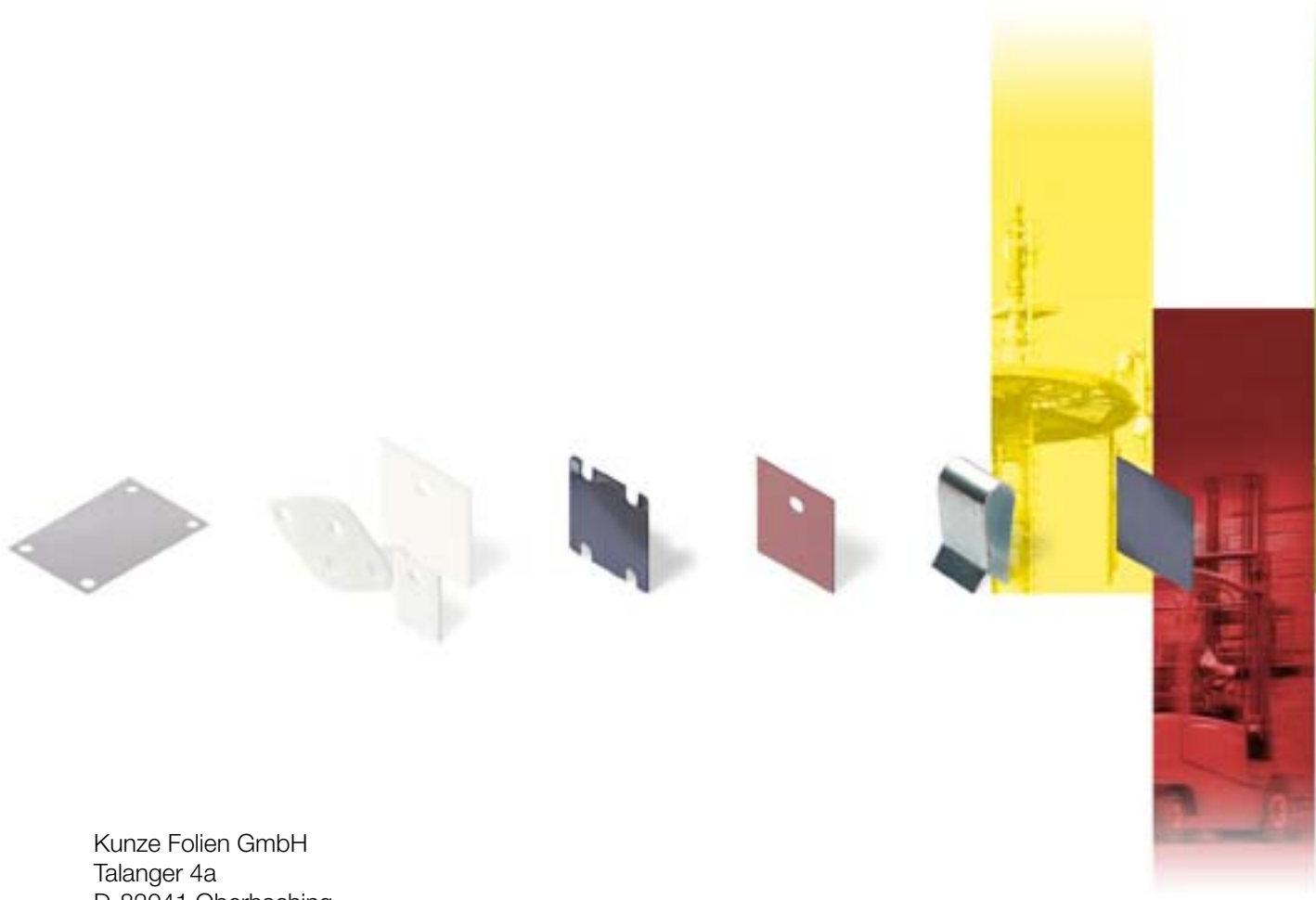
(1) The contracting parties agree to treat all information, which may be considered to be confidential or by its very nature is customarily deemed to be confidential, and which was acquired during the course of the contractual relationship orally, in writing or otherwise, either directly or indirectly, in the strictest confidence for the entire duration of the contractual relationship and for a period of two years subsequent to its termination. Furthermore, both parties agree to use such information exclusively within the scope of services under this agreement and, pending the authorization of the other party, to neither pass on such information to third parties or otherwise make it available to third parties and to make all such provisions as may be necessary to prevent and exclude any third parties from gaining access thereto. In particular, the customer shall treat all information relating to methods or technical process used by us in the strictest confidence.
(2) Exceptions to the obligation of secrecy. Only such information will be excluded from the obligation of secrecy which
– upon becoming known was already evident, i.e. was freely accessible to third parties,
– upon becoming known was legally made accessible to one of contracting parties by a third party not bound by an obligation of secrecy,
– at the request of a public authority or another entitles third party, must be conveyed by law,
– must as a matter of necessity be conveyed to the legal advisers or tax consultants of the respective party for consultancy purposes.
(3) Both parties shall impose a corresponding obligation of secrecy on all employees or third parties employed in rendering the services under this agreement.
(4) Within the scope of our contractual services, we agree to comply with all statutory data protection regulations. Moreover, we undertake to commit out employees to adhere to all statutory data protection regulations and swear these persons to secrecy. Furthermore, we shall coordinate all sensitive activities in terms if data protection and secrecy with the customer's data protection officer.

§ 12 Place of Performance – Place of Jurisdiction

(1) In the event the customer is a merchant, place of jurisdiction shall be the court competent for our registered seat. We shall, however, be entitled to file an action at the general place of jurisdiction of the customer.
(2) Exclusively German law shall apply. The applicability of the UN-Law on Sales shall be excluded thereby.
(3) Unless expressly agreed upon otherwise the registered seat of us shall be place of performance.

§ 13 Miscellaneous

(1) If any of the provisions of the agreement should be or become invalid, then this shall not affect the validity of the remaining provisions. In place of the invalid provision, another provision shall then be regarded as having been agreed upon that most closely approximates the business objective pursued by the invalid provision.
(2) All changes and additions to this agreement must be in writing.



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