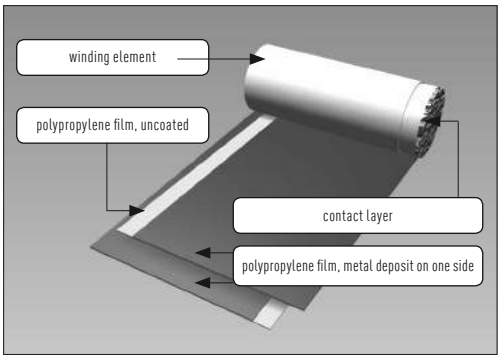
POWER CAPACITORS

INTERNAL CONSTRUCTION

Dielectric

MKP-/MKPg-type capacitors are based on a low-loss dielectric formed by pure polypropylene film. A thin mixture of zinc and aluminium is metallized directly on one side of the PP-film under vacuum. Our long term experience as well as on-going research and improvements in this technology ensure the excellent self-healing characteristics of the dielectric and a long operating life of our capacitors. The plastic film is wound into stable cylindrical windings on the most modern automated equipment. The ends of the capacitor windings are contacted by spraying with a metal contact layer, facilitating a high current load and ensuring a low-inductance connection between the terminals and windings.



pic.2

The link between PP-film and zinc contact layer is highly stressed during high surge or rms currents and therefore considered very critical for operating life and reliability of the capacitor. By cutting the film for selected types in a wavelike manner, our SINECUT™ technology increases the contact surface between film and zinc layer which substantially reduces this strain.

Impregnants

The use of impregnants and/or filling materials in capacitors is necessary in order to insulate the capacitor electrodes from oxygen, humidity, and other environmental interference. Without such insulation, the metal coating would corrode, an increasing number of partial discharges would occur, the capacitor would lose more and more of its capacitance, suffer increased dielectric losses and a reduced operating life. Therefore, an elaborate vacuum-drying procedure is initiated immediately after insertion of the capacitor elements into the aluminium case and dried insulation gas (MKPg), or biologically degradable plant oil (MKP(D), MKP-UHD), is introduced. Both protect the winding from environmental influence and provide an extended life-expectancy and stable capacitance.

MKPg 275 – Leakage Proof and Environmentally Friendly

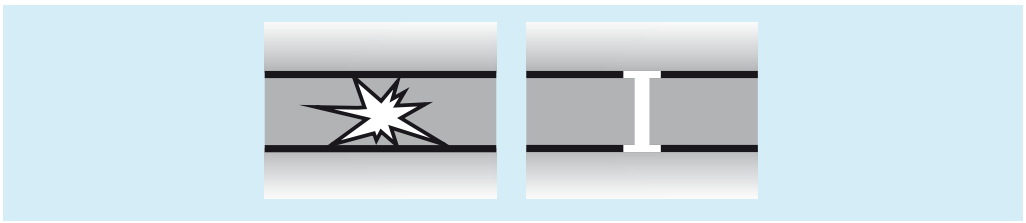
The gas in our MKPg-Capacitors is inert and entirely harmless to environment. When disposing of the capacitors, no liquids or toxic gasses need to be considered. Leakage of gas is extremely unlikely if the capacitors are handled and operated properly. It is possible to mount these capacitors in any desired position. However, should leakage occur, the leaking gas would escape into the atmosphere causing no undesirable effects to the adjacent equipment, e.g. damage, pollution, or staining. In the long run, such an unlikely event would result in a degradation of the capacitance; however, this process would take many months, during which the capacitor remains functional. By using gas, we are reducing the weight of a capacitor on average by 15% compared with resin or oil filled capacitors. This makes transportation and handling of the units easier. It also supports the concept of mounting the capacitors in almost any position.

SAFE OPERATION

Protection against Overvoltages and Short Circuits: Self-Healing Dielectric

All dielectric structures used in our power capacitors are "self-healing": In the event of a voltage breakdown the metal layers around the breakdown channel are evaporated by the temperature of the electric arc that forms between the electrodes. They are removed within a few microseconds and pushed apart by the pressure generated in the centre of the breakdown spot. An insulation area is formed which is reliably resistive and voltage proof for all operating requirements of the capacitor. The capacitor remains fully functional during and after the breakdown.

For voltages within the permitted testing and operating limits the capacitors are short-circuit- and overvoltage proof. They are also proof against external short circuits as far as the resulting surge discharges do not exceed the specified surge current limits.



Self-healing breakdown

pic.3

Protection Against Accidental Contact

All capacitors are checked by routine test (voltage test between shorted terminations and case: $U_{BG} \geq 2\ U_N + 2000$ V, at least 3000V) in accordance with IEC 60831. Accessible capacitors must be earthed at the bottom stud or with an additional earthing clamp.

The CAPAGRIP™ terminal blocks are rated IP20, i.e. they are protected against accidental finger contact with live parts. The discharge modules are designed in the same way (compare page 48). Unused contact cages of design M terminal blocks must be covered by a proper blank (available as standard accessory, see page 52).

CAPA***GRIP***™

Capacitors in design D are not provided with protection against accidental contact as standard. They are available with protective caps on request (see page 52).

Protection against Overload and Failure at the end of Service Life

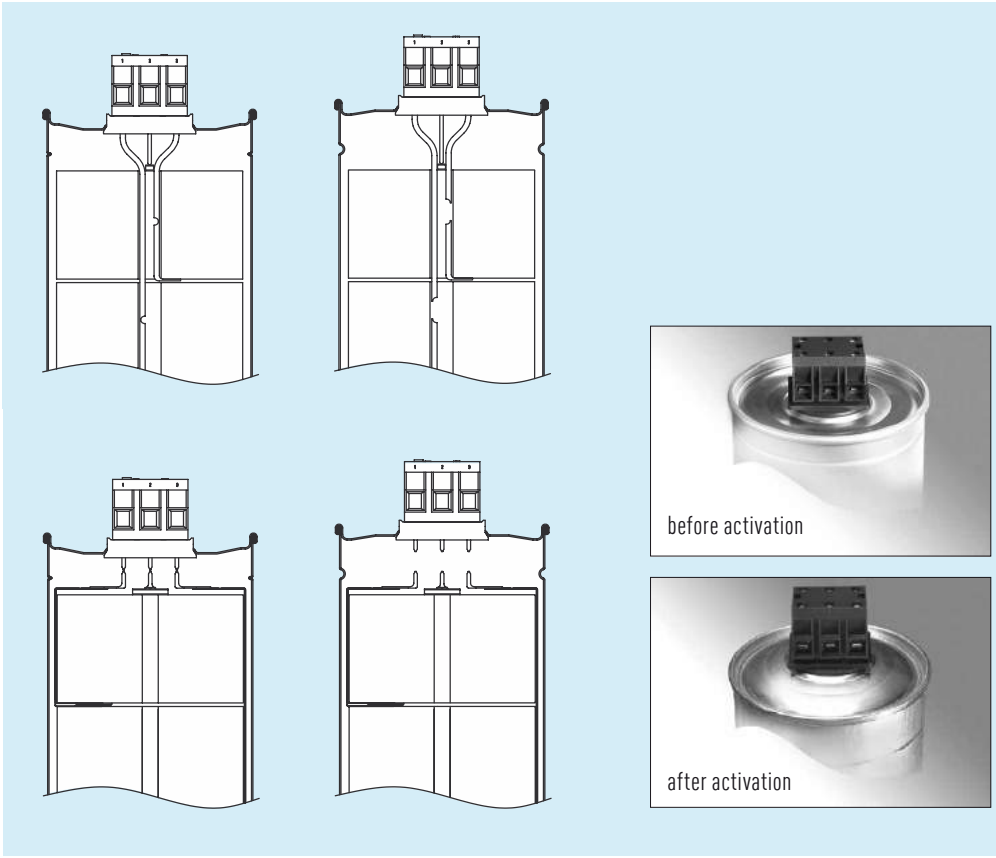
In the event of overvoltage, thermal overload or ageing at the end of the capacitor's useful service life, an increasing number of self-healing breakdowns may cause rising pressure inside the capacitor. To prevent it from bursting, the capacitor is fitted with an obligatory **«break action mechanism» (BAM™)**. This safety mechanism is based on an attenuated spot at one, two, or all of the connecting wires inside the capacitor.

All capacitors with diameters < 85 mm as well as some traditional models with large diameters are provided with BAM 1 mechanism. All new models with diameters ≥ 85 mm will be provided with BAM 2 mechanism.

With rising pressure the case begins to expand, mainly by opening the folded crimp and pushing the lid upwards. As a result, the prepared connecting wires are separated at the attenuated spot, and the current path is interrupted irreversibly. It has to be noted that this safety system can act properly only within the permitted limits of loads and overloads.

BAM 1

BAM 2



pic.4

Mind hazards of explosion and fire

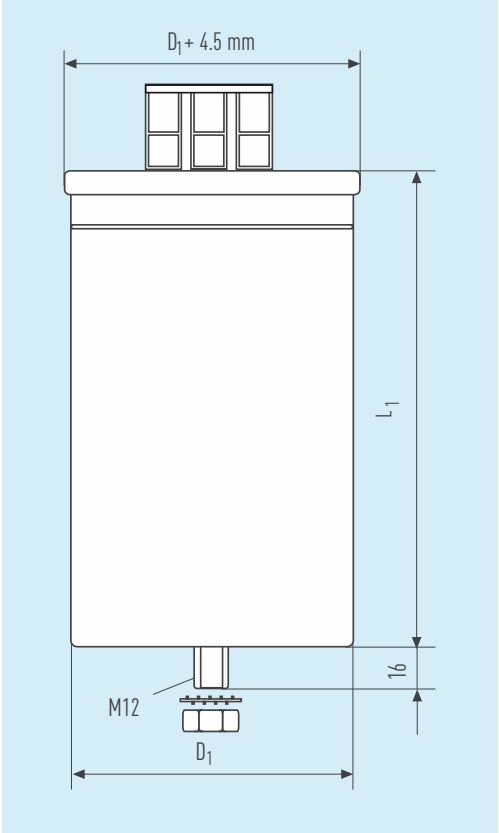
Capacitors consist mainly of polypropylene (up to 90 %), i.e. their energy content is relatively high. They may rupture and ignite as a result of internal faults or external overload (e.g. temperature, over-voltage, harmonic distortion). It must therefore be ensured, by appropriate measures, that they do not form any hazard to their environment in the event of failure or malfunction of the safety mechanism.

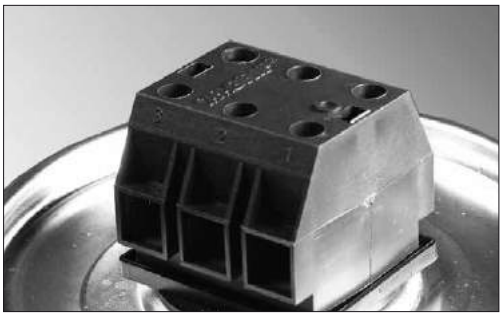
Fire Load: approx. 40 MJ/kg

Extinguish with: dry extinguisher (CO_2, foam), or other fire extinguishants suitable for this voltage level

DESIGN DRAWINGS

CAPAGRIP™ K, L, M AND CAPAGRIP II™: EASE OF ASSEMBLY WITH HIGH DEGREE OF PROTECTION





CAPAGRIP™

The CAPAGRIP™ terminals guarantee optimum sealing of the capacitors, and offer convenient connection of cables up to 50 mm². A special spring system guarantees reliable and durable operation of the clamp.
Whilst CAPAGRIP™ K and CAPAGRIP II™ ("L4") incorporate bleeding resistors, designs L and M permit the direct connection of discharge reactors and discharge resistor modules, as well as easy parallel connection of additional capacitors within the limits of the current capability of the respective terminal.
For single phase versions, the central screw has no contact.

Series	**MKPg 275, MKP 276, MKP-UHD**
Protection	IP20
Humidity class	C
Creepage distance	16 mm
Air clearance	16 mm

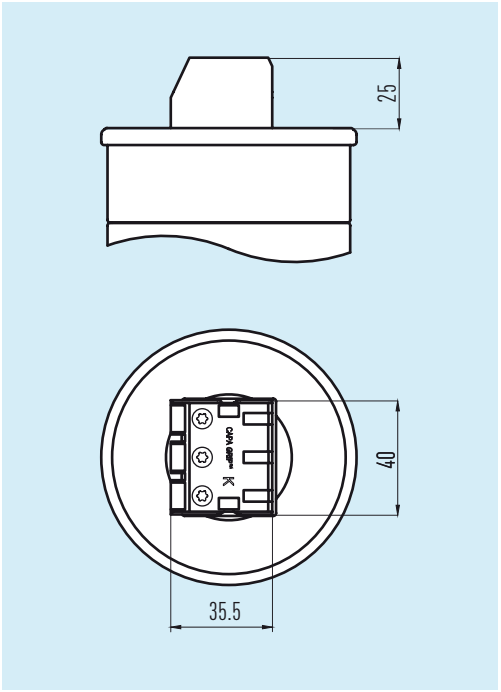
If flat over the entire width of the cage, the body inserted into the terminal must have a thickness of at least 1.2 mm in order to get gripped and fixed by the clamp cage. See chart 5 for minimum thickness of inserted conductor if round-shaped and/or NOT ranging over the entire width of the cage.
See also chart 9 on page 36 for more detailed instructions on connectors and cable sizes.

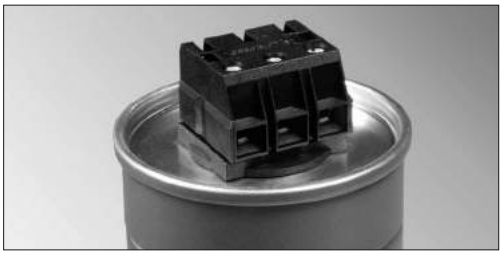
CAPA***GRIP***™	**Clamp width (mm)**	**minimum conductor height (if < 0.8 × clamp width)**
K	5	2
L, L4	7	2.5
M	10	2.5

chart 5

DESIGN DRAWINGS

CAPA*GRIP*™K





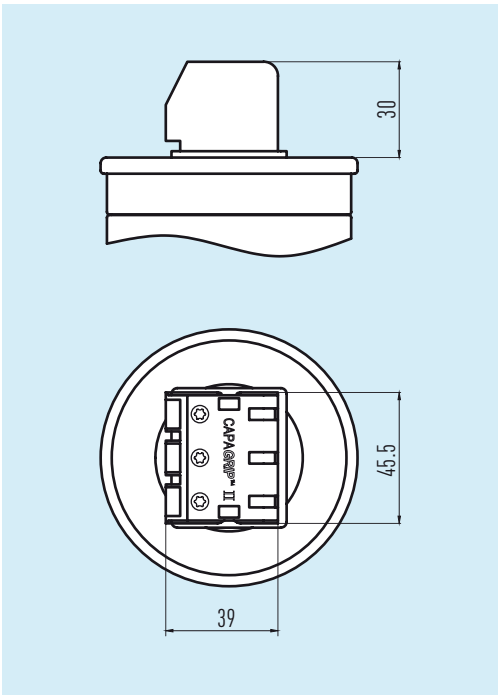
Available for diameters 60 ... 85 mm.

Case
extruded aluminium can with base mounting stud M12, hermetically sealed by aluminium lid (folded edge)

Terminal block
Steel clamp with T20 M4 screws in flame retardant plastic body (UL94:V0)
max. cable cross section: 1 × 10 mm² per phase
max. terminal rating: 39 A/phase

Internal resistors for discharge < 50 V within < 60 s

CAPA*GRIP*II™L4

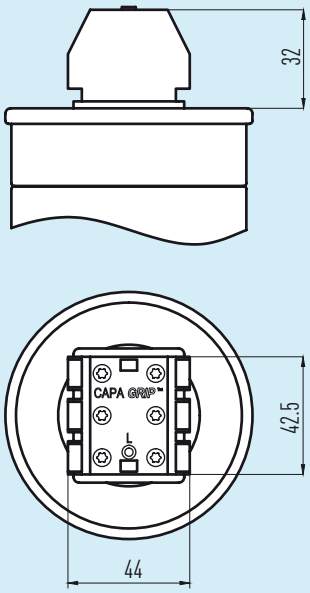


Available for diameters 85 ... 136 mm.

Case
extruded aluminium can with base mounting stud M12, hermetically sealed by aluminium lid (folded edge)

Terminal block
Steel clamp with T20 M5 screws in flame retardant plastic body (UL94:V0)
max.cable cross section: 1 × 25 mm² per phase
max. terminal rating: 56 A/phase

Internal resistors for discharge < 50 V within < 60 s



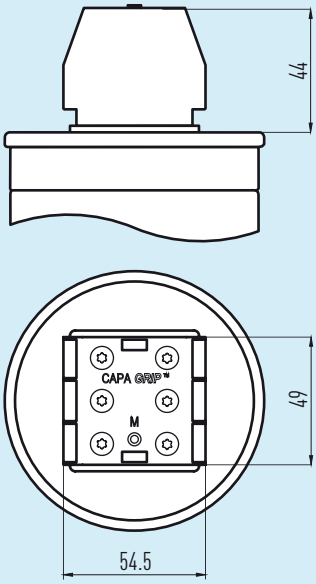
CAPA**GRIP**™ L

Available for diameters 85 ... 136 mm.

Case
extruded aluminium can with base mounting stud M12, hermetically sealed by aluminium lid (folded edge)

Terminal block
Steel clamp with T20 M5 screws in flame retardant plastic body (UL94:V0)
max. cable cross section: 2 × 25 mm² per phase
max. terminal rating: 56 A/phase

discharge resistors: available as separate item (see pgs. 47ff)



CAPA**GRIP**™ M

Available for diameters 95 ... 136 mm.

Case
extruded aluminium can with base mounting stud M12, hermetically sealed by aluminium lid (folded edge)

Terminal block
Steel clamp with T20 M6 screws in flame retardant plastic body (UL94:V0)
max. cable cross section: 2 × 50 mm² per phase
max. terminal rating: 104 A/phase

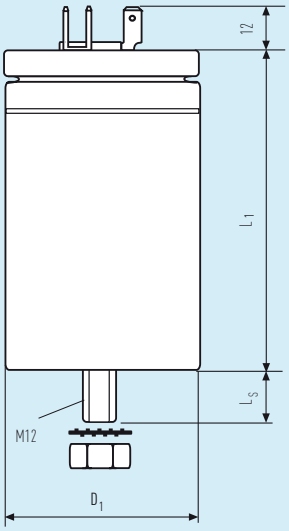
discharge resistors: available as separate item (see pgs. 47ff)

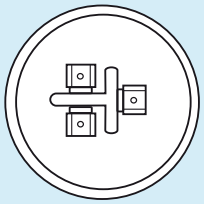
MKP(D): THE LOW-COST ALTERNATIVE

MKP(D)

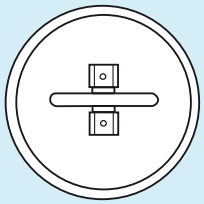
D1/D2

D3

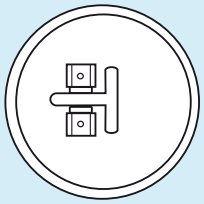




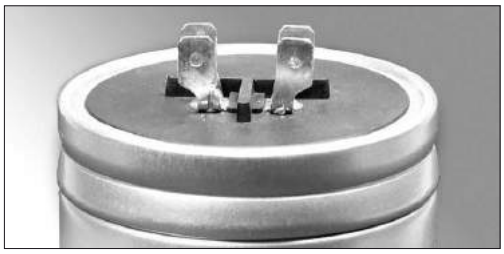
D3
3ph



D1
1ph
ø ≤ 60 mm



D2
1ph
ø = 65...75 mm



The low-cost alternative for single and three phase capacitors with a rated current of up to 16 A/phase and diameters of 40 to 75 mm. Also available with plastic protective cap and mounted discharge resistors.

Series	**MKP(D) 276**
Protection	IP00
Humidity class	F
Creepage distance	10 mm
Air clearance	8 mm

Available for diameters 40 ... 75 mm.

Case
Extruded aluminium can with base mounting stud (M12)
Hermetically sealed by plastic lid with rubber gasket

Terminals
Dual tab connectors, tinned steel 6.3 × 0.8 mm
max. terminal current: 21 A/phase using both terminal tabs

Discharge resistors available as separate item (see page 48)

DEFINITIONS AND SELECTION CRITERIA

Rated Voltage U_N
Root mean square of the max. permissible value of sinusoidal AC voltage in continuous operation. The rated voltage of the capacitors indicated in the data charts must not be exceeded even in cases of malfunction. Bear in mind that capacitors in detuned equipment are exposed to a higher voltage than that of the rated mains voltage; this is caused by the connection of detuning reactor and capacitor in series. Consequently, capacitors used with reactors must have a voltage rating higher than that of the regular mains voltage (compare U_C on page 57). Unless indicated otherwise, all voltages stated in this catalogue are rms values.

Maximum RMS Voltage U_{max}
Maximum rms voltage, which the capacitor can be exposed to permanently. This value also considers the maximum reactive power and the resulting power losses of the capacitor.

Test Voltage Between Terminals U_{BB}
Routine test of all capacitors conducted at room temperature, prior to delivery. A further test with 80 % of the test voltage stated in the data sheet may be carried out once at the user's location.

Voltage test between terminals and case U_{BG}
Routine test of all capacitors between short-circuited terminals and case, conducted at room temperature. May be repeated at the user's location.

Rated power Q_C
Reactive power resulting from the ratings of capacitance, frequency, and voltage: $Q_C = 2\pi f \cdot C \cdot U_N^2$

Maximum RMS Current Rating I_{max}
Maximum rms value of permissible current in continuous operation. The maximum permitted rms current for each particular capacitor is related either to construction features or to the current limits of the terminals. In accordance with IEC 60831 all ELECTRONICON capacitors are rated at least $1.3 \times I_N$ (with I_N being the nominal current of the capacitor at rated voltage and frequency), allowing for the current rise from permissible voltage and capacitance tolerances as well as harmonic distortion. As a rule, our values of maximum permitted continuous current are substantially higher. The exact value for each capacitor can be found in the individual data sheet. Higher rms values can be implemented by adjustments in construction and are available on request.

Continuous currents that exceed the I_{max} values specified in the data charts will lead to a build-up of heat in the capacitor and may cause reduced lifetime or premature failure. Permanent excess current may even result in malfunction of the capacitor's safety mechanisms, i.e. bursting or fire (see page 18).

Care must be taken not to exceed the maximum voltage and current ratings when installing capacitors in close-tuned or detuned equipment (see data sheets for maximum ratings). The thermal monitoring of reactors, or the use of overcurrent protection relays in the capacitor circuit is recommended to protect against overloads.

DEFINITIONS AND SELECTION CRITERIA

Current rating I_N

RMS value of the current at rated voltage and frequency, excluding harmonic distortion, switching transients, and capacitance tolerance.

It can be calculated by the formula $I = \frac{Q_C}{U_N} = 2\pi f \cdot C \cdot U_N$ and is not stated in the data charts.

Pulse current strength I_S

Depending on construction and voltage rating, the design of our capacitors permits short term inrush currents of 100...400 × I_N and – in accordance with IEC 60831 – up to 5000 switching operations per annum as standard. However, when switching capacitors in automatic capacitor banks without detuning reactors, higher loads are very often the case. This may generate negative effects on the operational life, especially with capacitors which are frequently connected and disconnected (e.g. primary stages in automatic capacitor banks). Moreover, even detuned capacitors may experience switching currents exceeding the permissible maximum current of the reactor and causing consequential damage to both capacitor and reactor.

We strongly recommend the use of special capacitor contactors with inrush limiting resistors, or other adequate devices for limitation of the peak inrush currents.

Temperature category

The average useful life of a capacitor depends very much on the ambient temperatures it is operated at. The permissible operating temperatures are defined by the temperature class stated on the label which contains the lower limit temperature (-40°C for design D, -50°C for all CAPAGRIP™ power capacitors) and a letter, which describes the values of the upper limit temperatures. Chart 6 is based on IEC 60831 and details the maximum permitted ambient temperatures for capacitors in each temperature category.

temperature category	ambient temperature limits		
	maximum	max. average 24 hrs	max. average 365 days
B	45°C	35°C	25°C
C	50°C	40°C	30°C
D	55°C	45°C	35°C
60	60°C	50°C	40°C
65	65°C	55°C	45°C
70	70°C	60°C	50°C

chart 6

Lifetime Statements

Even though all our lifetime statements are based on many years of empirical data, testing and field statistics, they will always remain just a general prognosis based on data of the past and accelerated laboratory tests which cannot reflect all aspects of modern operating conditions. The real "lifetime" of our capacitors depends on a multitude of influencing factors, such as ambient temperatures, operating voltages, frequency of overvoltages, frequency of switching, system faults a.o. The lifetime estimations given in our data sheets are therefore linked with specific operating conditions (voltage and temperature).

It has also to be noted that any lifetime statement considers a certain percentage of permitted failures within a given lot, reflecting the fact that any component has a FIT rate (failures in time). Under rated operating conditions, our capacitors can be expected to have a FIT rate of no more than 300 (corresponding to a maximum failure rate of 3 %) during their initial 100,000 hours of operation..

Please consult our sales teams if in doubt about the specific implications of your intended operating conditions on lifetime and reliability of our capacitors.

DATA CHARTS

General Technical Data

rated voltages		230 ... 800 V, 50 Hz
permitted overvoltages and test voltages		in accordance with IEC EN 60831-1/2 (see data charts for details)
tolerance of capacitance		– 5 ... + 10 %, ± 5 % on request
maximum permissible current		at least 1.3 I_N, see data charts for details
max. inrush current	MKPg 275, MKP(D) 276	300 x I_N
	MKP-UHD 280	400 x I_N
dissipation losses (capacitor)		approx. 0.25 ... 0.40 W/kvar
internal connection		delta
safety device		BAM™ (overpressure break action mechanism)
dielectric material		low-loss polypropylene, dry
impregnant (filling material)	MKPg 275	inert insulation gas (N_2)
	MKP(D) 276, MKP-UHD 280	resin, based on vegetable oil
mounting position	MKPg 275	any position
	MKP(D) 276, MKP-UHD 280	vertical position recommended
max. relative humidity		95 % (climatic class C; MKP(D) 276 only: climatic class F)
operating temperatures		see data charts for ambient temperature class
storage temperature		-50 ... +85°C
max. altitude abv.s.l.		4000 m a.s.l.
statistical life expectancy		100,000 ... 200,000 h depending on type range and operating temperatures (see charts for details)
applied standards		IEC EN 60831, VDE 0560-46/47 UL Standard No. 810, CSA C22.2 No. 190, GOST 1282-88, IS 13340/13341
approval marks	only ≥ 75 × 230	**all capacitors in this catalogue:** UL/C-UL recognized component, 10,000AFC internally protected **selected items:** CSA (C/US)

All capacitors listed in this catalogue comply with the relevant regulations and guidelines of the European Union: 2014/35/EU (Low-Voltage Directive).
This is proven by the technical documentation and compliance with the following standard: IEC/DIN EN 60831-1/2:2014

MKPg™
275.*** 3PH GAS-FILLED
400 ... 440 V 50Hz

for latest edition and updates
check www.powercapacitors.info

Three-phase power capacitors, dry self-healing dielectric, gas-filled (N_2)
For detuned and non-detuned PFC equipment in mains with standard operating conditions

U_N	$\Theta_{ambient}$	statistical life
400...415 V	-50/D	>130,000 h
440 V	-50/D	>100,000 h

Permitted overvoltages

8h/d	485 V	1min (200×)	575 V
30min/d	510 V	max. peak voltage	1350 V ac
5min (200×)	530 V		

CAPA***GRIP***™ K and II (L4) including discharge resistors. For L and M see resistor modules on pages 48f.

Q_C 440 V (kvar)	Q_C 415 V (kvar)	Q_C 400 V (kvar)	C_N (µF)	I_{max} (A)	$D_1 \times L_1$ (mm)	m (kg)	CAPA *GRIP*	order no.	packg.lot / box
5	–	–	3 × 28	3 × 12	60 × 164	0.4	K	275.525-402800	10 / FB8
6	5.4	5	3 × 33	3 × 16	65 × 164	0.5	K	275.535-403300	10 / FB8
8.4	7.5	–	3 × 46	3 × 20	75 × 164	0.7	K	275.545-404600	5 / FB8
9.3	8.3	7.5	3 × 51	3 × 19	65 × 230	0.8	K	275.536-405100	10 / FB9
10	–	8.3	3 × 57	3 × 25	65 × 245	1	K	275.538-405700	10 / FB12
11.3	10	–	3 × 62	3 × 23	65 × 245	1	K	275.538-406200	10 / FB12
12.5	–	10	3 × 68	3 × 27	75 × 230	1	K	275.546-406800	5 / FB9
14.1	12.5	–	3 × 77	3 × 28	75 × 230	1	K	275.546-407700	5 / FB9
15	13.3	12.5	3 × 82	3 × 31	75 × 245	1.1	K	275.548-408200	5 / FB12
16.8	15	–	3 × 92	3 × 33	85 × 230	1.3	K	275.556-409200	5 / FB9
18.2	–	15	3 × 100	3 × 36	85 × 245	1.5	K	275.558-410000	5 / FB12
20	–	16.6	3 × 110	3 × 39	85 × 245	1.5	K	275.558-411000	5 / FB12
22.4	20	–	3 × 123	3 × 39	85 × 280	1.5	K	275.559-412300	5 / FB10
25	–	20	3 × 137	3 × 47	85 × 280	1.5	L4	275.259-413700	5 / FB10
28.2	25	–	3 × 154	3 × 56	100 × 245	1.8	L4	275.278-415400	3 / FB12
30	–	25	3 × 166	3 × 56	95 × 280	2	L4	275.269-416600	3 / FB10
50	–	–	3 × 274	3 × 86	136 × 295	4.1	M	275.39B-527400	2 / FB11
–	50	–	3 × 308	3 × 90	136 × 295	4.1	M	275.39B-530800	2 / FB11
–	–	50	3 × 331	3 × 94	136 × 295	4.1	M	275.39B-533300	2 / FB11

Other sizes and ratings are available on request. Single phase capacitors are available on request in same dimensions and design.
Mind Mounting and Operating Instructions on pages 34ff!

MOUNTING INSTRUCTIONS

Safe operation of the capacitors can be expected only if all electrical and thermal specifications as stated on the label, in the data sheets or catalogues and the following instructions are strictly observed. ELECTRONICON does not accept responsibility for whatever damage may arise out of a non-observance.

Mounting Position
Oil-filled MKP(D) 276 and MKP UHD capacitors shall be installed upright with terminals facing upwards. Gas-filled MKPg 275 capacitors can be mounted in any position without restrictions, however, a position with terminals pointing downwards should be avoided.

Location/Cooling
The useful life of a capacitor may be reduced dramatically if exposed to excessive heat. Typically, an increase in the ambient temperature by 7°C will halve the expected life of the capacitor. The permitted temperature category of the capacitor is stated on the label. If extenuating circumstances give cause for doubt, special tests should be conducted by the user to ensure that the permitted maximum ambient temperature of the capacitor is not exceeded. It should be noted that the internal heat balance of large capacitors is only reached after a couple of hours.

To avoid overheating the capacitors must be allowed to cool unhindered and should be shielded from external heat sources. Do not place the capacitors directly above or next to heat sources such as detuning or tuning reactors, bus bars, etc. and make sure the connecting cables do not import additional heat via the terminals. We recommend forced ventilation for all applications with detuning reactors. Give at least 15 ... 20 mm clearance between the capacitors for natural convection or forced ventilation.

Mounting
All cylindrical capacitors are fitted with a "break-action" safety mechanism (BAM™, see page 18) which may cause the case to expand, especially at the crimp and at the lid.

- The folded edge of the lid must not be retained by clamps.
- A clearance of at least 35mm above the terminations shall be accommodated.
- Required clearances according to applicable voltage category must be maintained even after activation of the BAM™ and prolongation of the can.

The hermetic sealing of the capacitors is crucial for a long operating life and for the correct functioning of the beak action mechanism. Please pay special attention not to damage the following critical sealing points:

- the folded edge of the lid
- the connection between screw terminal and lid (designs K, L, L4, M)
- the rubber seal and the soldering at the base of the tab connectors (design D)

The folded edge and the connection terminals must not be hit with heavy or sharp objects or tools (e.g. hammer, screw driver).

Fixation
All cylindrical capacitors can be fixed sufficiently using the mounting stud at the base of the can. Make sure to insert the washer which is delivered along with the mounting nut.

mounting stud	Permitted max. torque
M8	5 Nm
M12	15 Nm

chart 7

Vibration stress according to DIN IEC 60068-2-6
Please consult us for details of permitted vibration stress in your application.
Note that capacitors fitted with the EL-Dr discharge reactor must not be exposed to any vibration stress at all.

Connection

Fuses and cross section of the leads should be sized for at least 1.5 times of the rated capacitor current (I_N). Please ensure that the permitted maximum rms current according to data chart (I_{max}) is not exceeded. Do not exceed the permitted nominal current values per contact as specified in chart 8 even when coupling capacitors in parallel.

The capacitors shall only be connected with flexible cables or elastic copper bands to ensure unrestricted functioning of the expansion mechanism (BAM™).
Stranded cables should be fitted with ferrules when connected to the CAPAGRIP terminals. See chart 8 for minimum cable size if used **without** ferrules. Make sure to use cables with fine or medium strands only.

The solder joints on the capacitor lids guarantee the hermetical sealing of the capacitors and must not be exposed to excessive heat. It is not recommended to solder cables to type D terminals. Instead, always use appropriate tab connectors (6.3 mm) for connection.
The CAPAGRIP™ terminals (design K, L, L4, M) and the tab connectors (design D) must not be bent, twisted or moved in any other way.

Selection of cables

Cables used for the connection of power capacitors must not contribute to the power losses of the capacitor. It may therefore be appropriate to select cable sizes in excess of the minimum permitted cross sections usually specified by cable manufacturers.

Chart 8 is based on DIN VDE 0100-430 and IEC 60439-1 and related to the operation of three or four bundled copper cables at an average ambient temperature of 40°C. Mind that national rules or the standards of your application may require different ratings.

Chart 8 outlines the minimum requirements towards the connection of capacitors. We recommend dimensioning the cables for at least 1.5 x I_N where possible, and using one grade larger cable ratings if expecting higher ambient temperatures and/or substantial content of harmonics.

max. nominal capacitor current (A/phase)	e.g. Q_c at 400V 50Hz (kvar)	recommended cable section (mm^2/phase)	max. recommended HRC fuse* (A)
6.0	2.5	1.5	25
12.3	5...7.5	2.5	32
16.2	8.3 ... 10	4	35
20.8	12.5...15	6	40
28.5	16.7...20	10	63
37.7	25	16	80
50.0	30...33.3	25	125
60.8	40	35	125
76.2	50	50 / 35**	160

* The recommended HRC fuses are rated for cable protection only.
** Cables shall not be bundled.

chart 8

Termination Torques
Do not exceed the permitted torque of the terminal screws (design K, L/L4, M) and the mounting studs. The test values specified by IEC 61068 must be guaranteed as a minimum value.
All CAPAGRIP™ terminals are equipped with Torx screws (T20). Use of improper screw-drivers may damage the screws and impair reliable fixation.

Terminal design	Minimum size of inserted flat conductor W x H (mm)	Cable size with ferrule or plug (mm^2)	Cable size if without ferrule (mm^2)	Max. nominal current (A)	Recommended torque (Nm)
D	n.a.	1.5 ... 6	n.a.	16/plug	n.a.
K	4 ... 4.8 x 1.2	2.5 ... 10	10	30	1.8 ... 2.5
L, L4	5.5 ... 6.8 x 1.2	10 ... 25	16 ... 25	43	2.5 ... 3.0
M	8 ... 9.8 x 1.2	16 ... 35	35 ... 50	80	4.0 ... 5.0

chart 9

Discharge
Standard IEC 60831 requires a safety discharge to ≤ 75 V within 3 minutes in order to protect maintenance personnel from accidental injury by residual voltage.

Capacitors must be discharged and short-circuited before working on the terminals.

In order to minimize the switching strain and to avoid high energizing currents by connection in phase opposition, capacitors shall be discharged to ≤10 % of the rated voltage prior to being re-connected if switched by mechanical devices (magnetic contactors). Note that in automatic capacitor banks, very often shorter discharge cycles may be required (e.g. < 50 V within 60 seconds).

Use rapid discharge reactors or switchable discharge resistors for very short discharge cycles (see chapter "Switching and Discharging Capacitors", pgs. 38ff).

Discharge Modules
For capacitors in **CAPAGRIP L/M**, separate discharge modules in finger-proof housing (IP20) are available for the discharge of single units or groups of paralleled capacitors. For **MKP(D)** capacitors, similar discharge sets are available (IP00). The correct size of the module to be applied can be taken from the selection matrix on pg. 48f.

The discharge resistors may become very hot (up to 200°C) during continuous operation!
For CAPAGRIP L/M only: Remove the lid of the discharge module if applying protective caps to the capacitors!

Capacitors in **CAPAGRIP K and CAPAGRIP II (L4)** are equipped with internal discharge resistors for a discharge within no more than 60 seconds from their highest rated voltage to less than 50 V.

Earthing
Capacitors with a metal case must be earthed at the mounting stud or by means of a separate metal strap or clamp.

Environment

All capacitors are made with lead-free solder tin and comply with the ROHS and REACH regulations. Our capacitors do not contain PCB, solvents, or any other toxic or banned materials. The impregnants and filling materials of MKP(D) and MKP-UHD contain vegetable oil or polyurethane mixtures. The gas-filled MKPg™ capacitors contain only neutral, ecologically sound insulation gasses. Further details on the filling materials can be provided on request.

The capacitors do not contain hazardous substances acc. to European Directives 2003/53/EC and Council Directive 76/769/EEC). They are not classified as **"dangerous goods"** according to transit rules. The capacitors do not have to be marked under the regulations for Hazardous Goods. They are rated WGK 0 (water risk **category 0 "no general threat to water"**).

No danger for health if applied properly. In case of skin contact with filling liquids, clean with water and soap.

Disposal

Capacitors are components of electrical devices. They are NOT equipment or devices by themselves, and not subject to the Waste Electrical and Electronic Equipment Directive (WEEE). We recommend disposing of the capacitors through professional recycling centers for electric/electronic waste.

The capacitors can be disposed of as follows:

- Disposal acc. to European waste catalogue (EWC) No. 16 02 16 ("Components removed from discarded equipment other than those mentioned in 16 02 15").
- Liquid filling materials which may have emerged from the capacitor shall be absorbed by proper granules and disposed of in accordance with EWC No. 08 04 10 ("waste adhesives and sealants other than those mentioned in 08 04 09").

Caution: When touching or disposing capacitors with activated break-action mechanism, please consider that even after days and weeks these capacitors may still be charged with high voltages!

Make also sure to consult your national rules and restrictions for waste and disposal.