

## DSM Engineering Plastics - Property Data

# Akulon® K225-KS

PA6

Flame Retardant (Halogen free), Heat Stabilized

Properties	Typical Data	Unit	Test Method
<b>MECHANICAL PROPERTIES</b> dry / cond			
Tensile modulus	3800 / 1400	MPa	ISO 527-1/-2
Yield stress	80 / 40	MPa	ISO 527-1/-2
Yield strain	3 / 22	%	ISO 527-1/-2
Nominal strain at break	8 / >50	%	ISO 527-1/-2
Charpy impact strength (+23°C)	60 / -	kJ/m <sup>2</sup>	ISO 179/1eU
Charpy impact strength (-30°C)	55 / -	kJ/m <sup>2</sup>	ISO 179/1eU
Charpy notched impact strength (+23°C)	8 / 10	kJ/m <sup>2</sup>	ISO 179/1eA
Charpy notched impact strength (-30°C)	6 / 6	kJ/m <sup>2</sup>	ISO 179/1eA
<b>THERMAL PROPERTIES</b> dry / cond			
Melting temperature (10°C/min)	220 / *	°C	ISO 11357-1/-3
Temp. of deflection under load (1.80 MPa)	90 / *	°C	ISO 75-1/-2
Temp. of deflection under load (0.45 MPa)	200 / *	°C	ISO 75-1/-2
Coeff. of linear therm. expansion (parallel)	0.9 / *	E-4/°C	ISO 11359-1/-2
Coeff. of linear therm. expansion (normal)	1.4 / *	E-4/°C	ISO 11359-1/-2
Burning Behav. at 1.6 mm nom. thickn.	V-0 / *	class	IEC 60695-11-10
Thickness tested	1.5 / *	mm	IEC 60695-11-10
Burning Behav. at thickness h	V-0 / *	class	IEC 60695-11-10
Thickness tested	0.38 / *	mm	IEC 60695-11-10
<b>ELECTRICAL PROPERTIES</b> dry / cond			
Relative permittivity (100Hz)	3.3 / 8	-	IEC 60250
Relative permittivity (1 MHz)	3.2 / 3.6	-	IEC 60250
Dissipation factor (100 Hz)	90 / 1250	E-4	IEC 60250
Dissipation factor (1 MHz)	200 / 800	E-4	IEC 60250
Volume resistivity	1E13 / 1E11	Ohm*m	IEC 60093
Surface resistivity	* / 1E14	Ohm	IEC 60093
Electric strength	30 / 25	kV/mm	IEC 60243-1
Comparative tracking index	600 / 600	-	IEC 60112
<b>OTHER PROPERTIES</b> dry / cond			
Water absorption	9 / *	%	Sim. to ISO 62
Humidity absorption	2.5 / *	%	Sim. to ISO 62
Density	1170 / -	kg/m <sup>3</sup>	ISO 1183

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## Akulon in electrical and electronic applications

Polyamides are used in electrical or electronic applications:  
 low voltage switch gears;  
 connectors, bobbins and electromotor parts.

Below the main emphasis will be directed towards low voltage switchgears and towards connectors. Information on the other applications can be obtained at our sales engineers or application development engineers.

### Low voltage switchgear

The segment of 'Low Voltage Switchgear' can be sub-segmented into the following categories of applications (which are covered by the different IEC standards, quoted between brackets):

- miniature circuit breakers; domestic (IEC 898) or industrial (IEC 947)
- residual current devices (IEC 1008/1009)
- fuses (IEC 269)
- switches and relays (IEC 947-3)
- contactors (IEC 947-4)
- cabinets (IEC 439-5).

The main trends in these sub-segments are:

- thermo set replacement
- shift from halogen containing flame retardant systems towards halogen free and phosphorous free systems
- the integration of functions, miniaturization and designs with thinner wall thickness
- and the application of laser marking instead of printing.



Fuses, Akulon K223-KMV6, K222-KGMV14.



Residual Current Device (RCD), Akulon K223-KMV6, K222-KGV4.

These trends lead to more stringent requirements with respect to the thermoplastics used, especially due to trends in design, Comparative Tracking Index (CTI) requirements shift to 'CTI  $\geq$  400 V' and Relative Temperature Index (RTI) requirements towards 'RTI electrical  $\geq$  130 °C' and 'RTI mechanical  $\geq$  120 °C'. All this preferably realized in a halogen free and phosphorous free system. Other requirements are:

#### Minimum general requirements:

- Glow Wire Flammability Index of 960 °C
- Ball Pressure >125 °C
- specific combinations of Flammability, Hot Wire Ignition and High Current Arc Ignition (according to IEC 947-1; see Table 3).

#### Customer specific requirements:

- short term and long term temperature resistance
- stiffness combined with good elongation at break
- specific CTI-value dependent on the actual creep age distance realized in the application
- specific values for other, specific electrical properties (electric strength, resistivity,...)
- limited, controllable warp age level
- colour consistency (base colour) and colour stability (as well in processing as in use: both after a specific temperature/time exposure).

This set of requirements explains why PA6 (and specifically Akulon) is the preferred material for these applications:

Table 3. Specific combinations of Flammability, Hot Wire Ignition and High-Current Arc Ignition.

Property	Standard	Unit	A	B	C	D	E
Flammability	IEC 707	Class	FV 0	FV 1	FV 2	FH 1	FH 3
Flammability	UL 94	Class	V-0	V-1	V-2	HB	HB
HWI	IEC 695-2-2	Sec	> 7	> 15	> 30	> 30	> 30
HAI	IEC 947-1	Arcs	> 15	> 30	> 30	> 60	> 120

#### Miniature Circuit Breaker

Enclosures: Akulon K223-KMV6, K222-KGMV14, K222-KGV4, K222-KMV5 and K223-KMV6.

Other parts: Akulon K222-KGV4.

its melting point of 220 °C is sufficient to withstand the short-term temperature rises. Its stiffness is the same as that of PA66 up to 190 °C); with its high RTI values it can easily meet the long-term temperature requirements. Typically continuous temperatures seldom exceed 70-90 °C. There is however a trend to higher continuous temperature exposures); it is available in halogen free and phosphorous free flame retardant versions, which also comply with the CTI  $\geq$  400 V requirement; it is tough and easy process able.

Especially the halogen free and phosphorous free flame retardant requirement in combination with a CTI  $\geq$  400 V is difficult to be met by PBT or PA66. Other deficiencies of these materials are: too much warp age sensitivity, less stiffness and strength at elevated temperatures, less impact resistance in the case of PBT and more difficult process ability and limited electrical properties in the case of phosphorous based flame retardant PA66. Despite its moisture absorption, PA6 still easily manages to meet the various specifications with respect to dimensional stability and electrical requirements.

**Circuit breakers.** Circuit breakers protect wiring systems from over-current situations and protect equipment from short circuits. Ball pressure temperature and glow wire flammability index are important requirements for domestic applications (as laid down in IEC 898). Glow wire flammability index and comparative tracking index are requirements for industrial applications, as described in IEC 947-2. The devices have to exhibit high impact resistance (polyamide is preferred above polyester) and must pass cyclic thermal and mechanical endurance tests. Akulon PA6, in the standard colours such as electro-grey RAL7035 and black, is used as well for the enclosures as well for various internal parts.

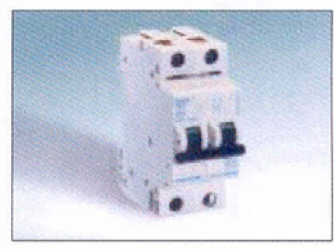
**Contactors.** Contactors connect and interrupt electrical power. In general they are subject to higher currents than switches. They can be controlled remotely, or by an integrated switch, as for example in motor starters. The main material related requirements are described in IEC 947-4 and include a glow wire flammability index of 960 °C. Also the comparative tracking index is important here, because it is strongly related to the level of design freedom of these contactors.

**Table 4. The Akulon PA6 portfolio for the low voltage switchgear segment consists of:**

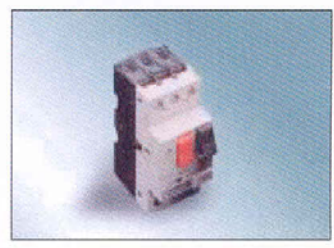
<b>K225-KS</b>	halogen free, unreinforced, UL94 V-0
<b>K222-KGV4</b>	halogen free, 20% glass fibre reinforced, GWFI 960 °C
<b>K222-KGMV14</b>	halogen free, 5% glass fibre reinforced, 20 % mineral reinforced, GWFI 960 °C
<b>K-FKGS6</b>	halogen containing, 30 % glass fibre reinforced, UL94 V-0
<b>K222-KMV5</b>	halogen free, 25% mineral reinforced, GWFI 960 °C
<b>K223-KMV6</b>	halogen containing, 30 % mineral reinforced, GWFI 960 °C

*(note: halogen free versions of the latter two are under development)*

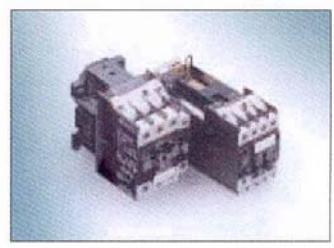
**Contactors**  
Akulon K225-KS, K222-KGV4.



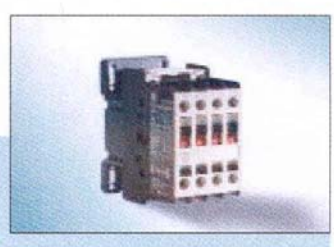
**Miniature Circuit Breaker (MCB), Akulon K222-KGV4.**

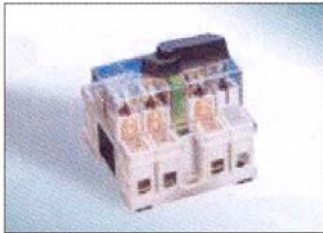


**Motorstarter, PA66 GF V-0.**



**Contactors, Akulon K223-HMS6.**





Switch, Akulon K223-KMV6.

**Switches and relays for industrial applications.** Switches connect or interrupt electrical power. There exists a wide range of switches, like rotary switches and push buttons. Their requirements are described in IEC 947-3. The main material-related requirement is again glow wire flammability index. The CTI plays an important role in designing these devices. This because of its relation to environmental pollution requirements. If a compact design is needed, materials should have a CTI-value as high as possible (preferably > 600 V). In many cases additionally dimensional stability is required, while thermal requirements are often not as high compared with MCB's or RCD's.

**Connector applications**

- The segment of connectors can be sub-segmented into:
- automotive connectors
  - PCB-connectors
  - industrial connectors (CEE)
  - terminal blocks
  - wire-to-wire-connectors
  - and various other type of connectors.

Below a special emphasis is given to the sub-segments of "industrial connectors" and "terminal blocks". Information on the other sub-segments can be obtained via our sales engineers or application development engineers.



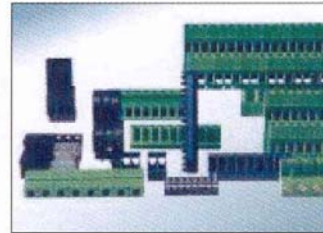
CEE Connectors, Akulon F223-D.

**Industrial connectors (CEE).** The CEE-connectors (CEE = International Commission on Rules for Approval of Electrical Equipment) are found in industrial environments as devices for supplying and coupling of electrical power. Important requirements for this market are laid down by the industry standard EN 60309-1. It states that connector materials supporting current carrying parts must:

- exhibit resistance to chemicals and a ball pressure of at least 125 °C
- impact resistance also at -25 °C
- UL94 V-2 and resistance to ageing up to 100 °C.

- Other, more or less customer specific requirements, are:
- high stiffness to prevent creep age and possible bad connections
  - high ductility because of film hinges and dovetailing interconnections
  - and good flow ability because of thin sections.

This set of requirements explains why PA6 (and especially Akulon) is preferred above PBT (which has a too low impact resistance, a limited flow ability and only UL94 HB in unreinforced version) and PA66 (which is too expensive). The main Akulon grades used are F223-D (unreinforced PA, V-2), K224-G0 (PA6, 50% GF) and K223-KMV6 (PA6, 30% mineral reinforced, V-2). Some are available in company specific colours as well as in signal (cadmium free) colours.



Terminal blocks, Akulon S225-KS.

**Terminal blocks.** Terminal blocks are either modular or one-piece (multi-contact). They connect individual wires by means of a screw or spring contact. They are primarily found in industrial switch cabinets and on printed circuit boards (PCB's) to provide the wire-to-board connection. Important requirements, as described in EN 60998 and EN 60947, are:

- high levels of CTI, HWI and HAI
  - and in addition, resistance to soldering heat at 260 °C (pin-through-hole, wave soldering technique). A trend is observed towards surface-mount-technology. This implies: the necessity of the application of a high temperature restant material as Stanyl (PA46).
- Other requirements are:
- halogen and phosphorous free flame retardancy (UL94 V-0 at 0.4 mm) in combination with a CTI level > 600 V
  - a high flowability, because of thin sections down to 0.2 mm
  - a low corrosivity in injection moulding
  - a high stiffness to prevent creep age and possible bad connections
  - and a high ductility because of film hinges and dovetailing interconnections.

In the case of PCB terminal blocks are also required:

- a low warp age level (necessary for a good fit to the PCB)
- and high levels of stiffness and strength, combined with low creep levels (necessary for sufficient high levels of pin retention).

The main Akulon grade used here is S225-KS (unreinforced PA66, halogen free, UL94 V-0).