

5 Quality

In order to meet the high technical demands of a free world market, the EPCOS Ceramic Components Division has established a sophisticated quality assurance system. This is based on the standards QS-9000/VDA 6.1, ISO 9001 and CECC as well as on customer requirements. Certification to QS-9000/VDA 6.1 was obtained in October 1997, certification to ISO 9001 in September 1991.

5.1 Quality assurance procedure

SIOV varistors are tested and released by the quality department on the basis of the following criteria: compliance with type specifications, process capability of production equipment as well as accuracy of measuring and test methods and equipment. To ensure a constantly high quality level, the following tests are carried out:

5.1.1 Incoming goods inspection

The properties of the parts and materials required for production are defined in close cooperation with qualified suppliers. Quality is ensured by quality assurance measures at the supplier as well as by quality assurance agreements (QSV) and defined inspection procedures for incoming goods.

5.1.2 Process control

A variety of measures is implemented – wherever possible at the source – in order to achieve the objective of eliminating defects as efficiently as possible. Already at the preliminary stage, FMEA (Failure Mode and Effects Analysis) is applied: *potential* errors are given a risk priority number corresponding to their significance and the probability of their occurrence and detection. If the risk priority number is high, remedial measures are introduced right from the start. During production, the processes are monitored using SPC (Statistical Process Control) methods: on-the-spot action is taken immediately if a process starts to deviate from the desired results. All important manufacturing processes are continuously monitored, parallel to the production process.

5.1.3 Product assurance

Each manufacturing stage is followed by a “quality control gate”, i. e. the product is only released for the next stage after passing a corresponding test. The test results are constantly monitored and evaluated and are then used to assess the quality of the manufacturing process itself. The flow charts (table 5 and table 6) assign the major quality measures to the different production steps.

5.1.4 Final inspection

The electrical characteristics, dimensions and material quality of SIOV varistors are checked in a final inspection in accordance with the required specifications.

5.2 AOQ

For SIOV varistors an AOQ (average outgoing quality) figure of < 10 dpm (defectives per million) is given. This value refers to inoperatives defined as follows:

Inoperatives of varistors are:

- Short circuit or open circuit
- Component, case, terminals or encapsulation broken
- Incorrect marking
- Mixing of different types

Other defects are:

- Electrical defects (maximum ratings are exceeded)
- Mechanical defects, e.g. incorrect dimensions, damaged housings, illegible marking, twisted leads

Quality

Table 5 Production process and quality assurance for monolithic varistors

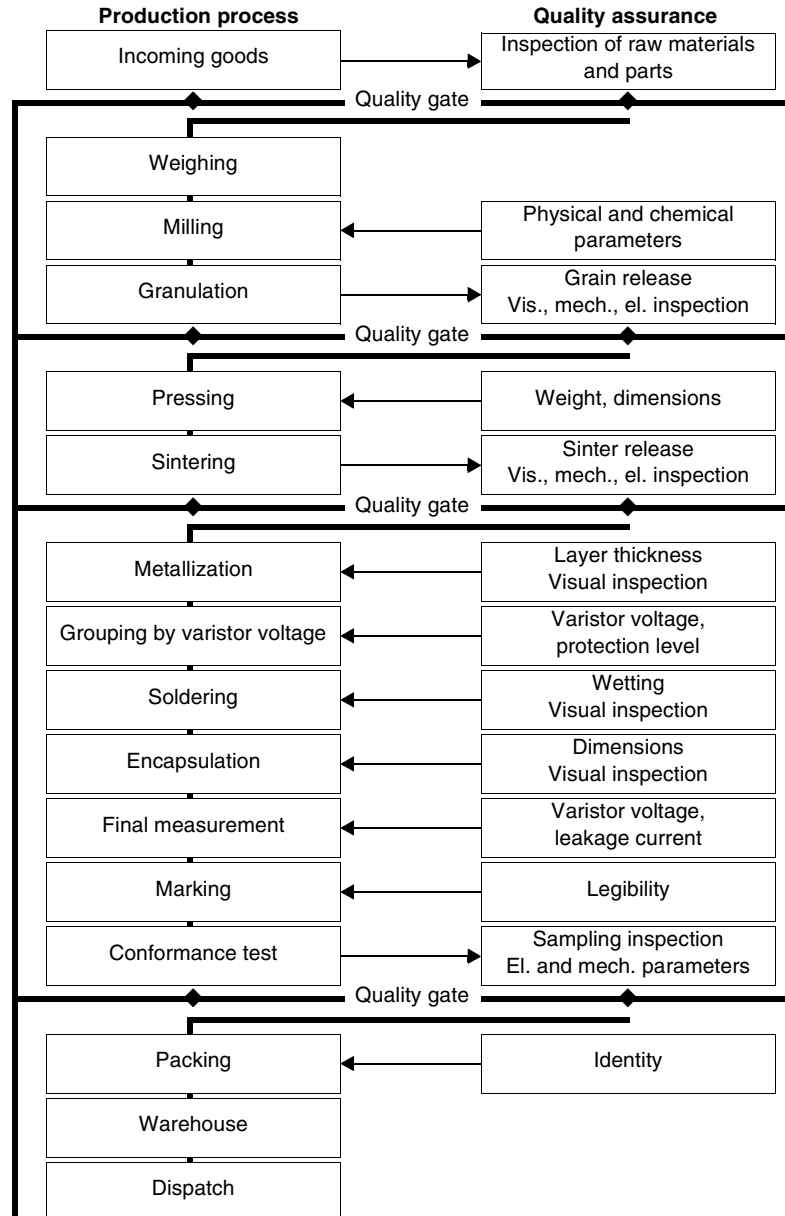
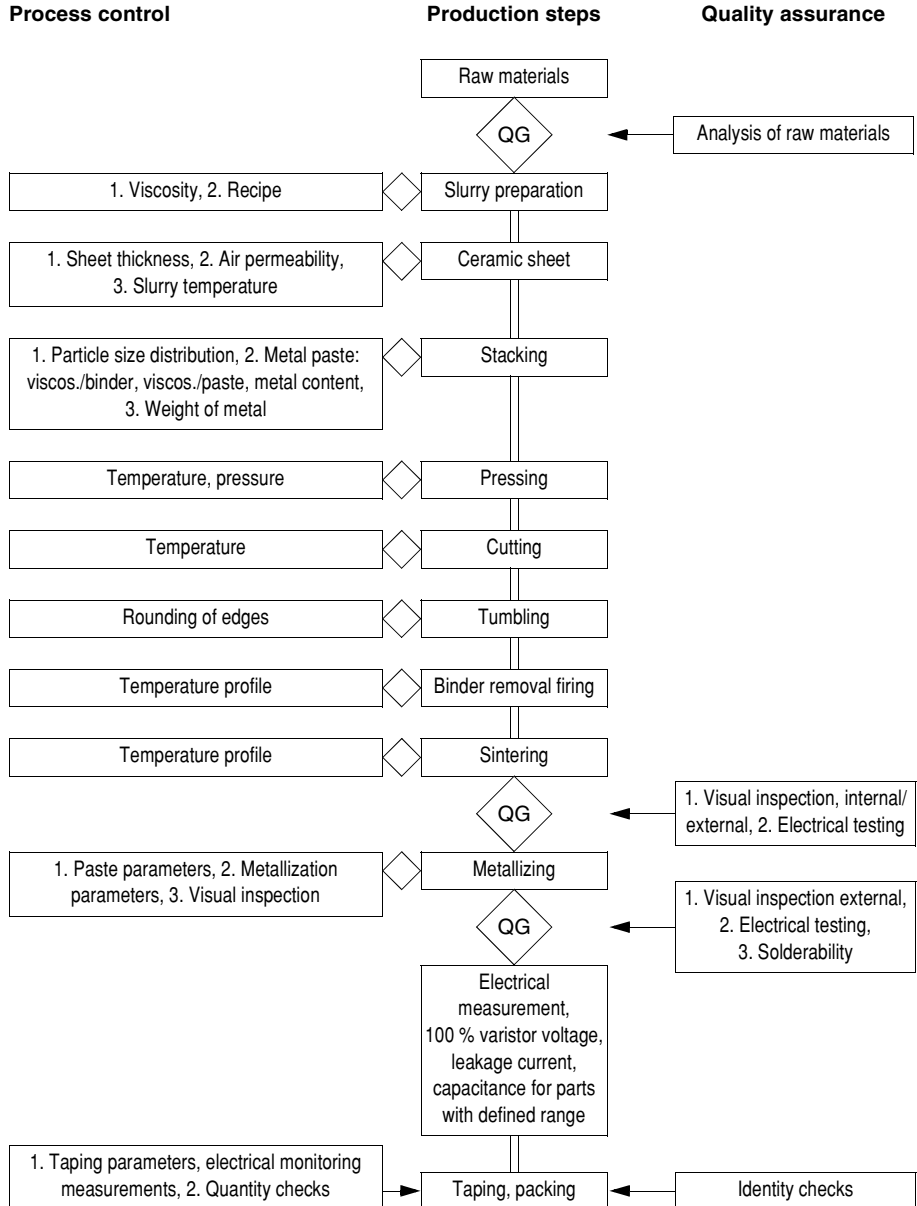


Table 6 Production process and quality assurance for multilayer varistors



5.3 Reliability

5.3.1 Lifetime

The mean life (ML) of SIOV varistors as a function of

- voltage class (i.e. ceramic material)
- ambient temperature
- applied voltage ratio (AVR)

can be derived from figure 55.

There is marked difference between “low-voltage ceramics” ($\leq K40$) and “high-voltage ceramics” ($\geq K50$).

AVR is defined as the ratio between intended operating voltage and maximum permissible operating voltage.

$$AVR = \frac{V^*}{V_{max}} \quad (\text{equ. 22})$$

Reaching the maximum average power dissipation is defined as the end of useful life. But the varistor is still functional.

The increase in leakage current is, to a good approximation

$$i_L = A + k\sqrt{t} \quad (\text{equ. 23})$$

- i_L = leakage current at constant voltage
- A = factor, dependent on temperature, AVR, geometry, encapsulating material
- k = slope coefficient of leakage current over \sqrt{t}

Investigations at different temperatures and AVRs show that the logarithm of lifetime is in a linear relation to reciprocal ambient temperature. The slope of this curve is virtually constant for zinc oxide. It can be attributed to activation energy.

The theoretical background of these relations is known as the Arrhenius model. Figure 55 shows evaluation for SIOV varistors.

EPCOS lifetime tests extend over a period of several 10^4 hours. The higher lifetime figures are determined by extrapolation on the Arrhenius model.

5.3.2 Failure rate

The failure rate λ is the reciprocal of mean life in hours, the unit being fit (failures in time) = $10^{-9}/h$.

$$\lambda[\text{fit}] = \frac{10^9}{ML[h]} \quad (\text{equ. 24})$$

Accordingly, the fit rate can also be derived from the Arrhenius model.

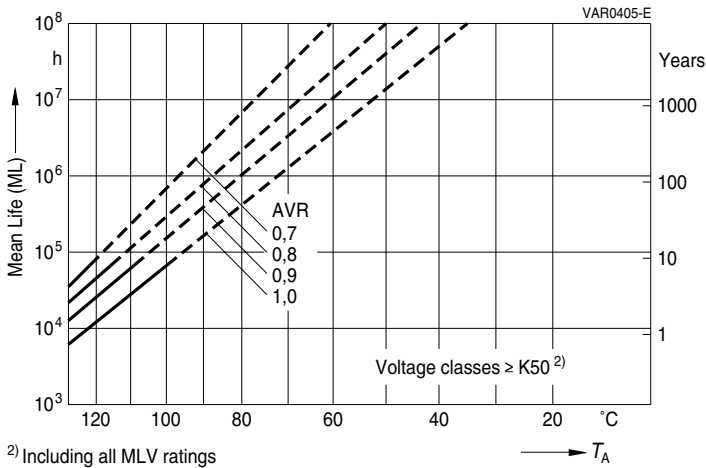
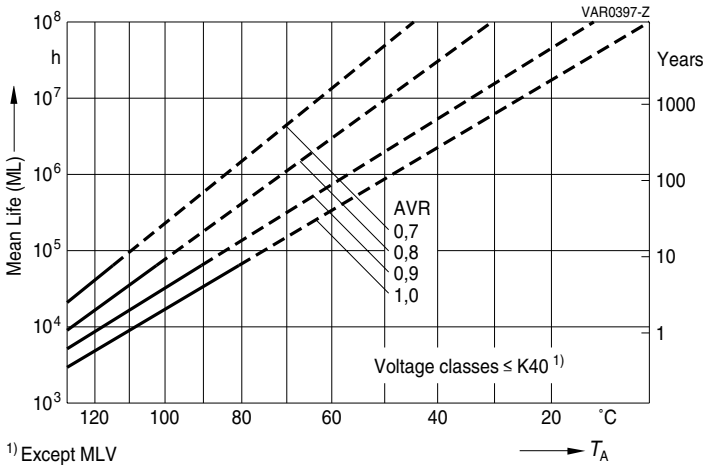


Figure 55 Mean life on Arrhenius model
Applied voltage ratio (AVR) referred to maximum permissible operating voltage

Failure rate figures refer to the average production status and are therefore to be understood as mean values (statistical expectations) for a large number of delivery lots of identical varistors. These figures are based on application experience and on data obtained from preceding tests under normal conditions, or – for purposes of accelerated aging – more severe conditions.

5.4 Tests

5.4.1 Standard disk varistors

Tests of SIOV disk varistors are made according to IEC 60068 and the harmonized system of quality assessment CECC 42 000.

Table 7

Characteristics	Test Methods	Specifications
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_V (1 mA _{DC} @ 0,2–2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 μs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT ¹⁾ : After having continuously applied the maximum allowable voltage at UTC ± 2 °C for 1000 hours, the specimen shall be stored at room temperature and normal humidity for 1 to 2 hours. Thereafter, the change of V_V shall be measured.	$I \Delta V/V$ (1 mA) $I \leq 10 \%$
Surge current derating, 8/20 μs	CECC 42 000, test C 2.1 100 surge currents (8/20 μs), unipolar, interval 30 s, amplitude corresponding to derating curve for 20 μs	$I \Delta V/V$ (1 mA) $I \leq 10 \%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 2 ms	$I \Delta V/V$ (1 mA) $I \leq 10 \%$ (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 metal-sphere method: 2500 V _{RMS} , 10 s The varistor is placed in a container holding 1,6 ± 0,2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

1) UCT = Upper Category Temperature; LCT = Lower Category Temperature

Table 7 (continued)

Characteristics	Test Methods	Specifications												
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT ¹⁾ , 16 h b) damp heat, 1st cycle: 55 °C/25 °C, 93 % r.H., 24 h c) cold, LCT ¹⁾ , 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93 % r.H., 24 h/cycle Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 hours. Thereafter, the change of V_v shall be measured.	$I \Delta V/V (1 \text{ mA}) \leq 10 \%$ $R_{is}^{2)} \geq 1 \text{ M}\Omega$												
Fast temperature cycling	IEC 60068-2-14, test Na, UCT/LCT ¹⁾ dwell time 30 min, 5 cycles: The temperature cycle shown below shall be repeated 5 times. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 hours. The change of V_v and mechanical damage shall be examined. <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Step</th> <th>Temperature (°C)</th> <th>Period (min.)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>LCT ± 3</td> <td>30 ± 3</td> </tr> <tr> <td>2</td> <td>transition time</td> <td>< 10 s</td> </tr> <tr> <td>3</td> <td>UCT ± 2</td> <td>30 ± 3</td> </tr> </tbody> </table>	Step	Temperature (°C)	Period (min.)	1	LCT ± 3	30 ± 3	2	transition time	< 10 s	3	UCT ± 2	30 ± 3	$I \Delta V/V (1 \text{ mA}) \leq 5 \%$ No visible damage
Step	Temperature (°C)	Period (min.)												
1	LCT ± 3	30 ± 3												
2	transition time	< 10 s												
3	UCT ± 2	30 ± 3												
Damp heat, steady state	IEC 60068-2-3 56 days, 40 °C, 93 % r.H.: The specimen shall be subjected to 40 ± 2 °C, 90 to 95 % r.H. for 56 days, then stored at room temperature and normal humidity for 1 to 2 hours. Thereafter, the change of V_v shall be measured.	$I \Delta V/V (1 \text{ mA}) \leq 10 \%$ $R_{is}^{2)} \geq 1 \text{ M}\Omega$												

1) UCT = Upper Category Temperature; LCT = Lower Category Temperature

 2) R_{is} : Insulation resistance to CECC 42 000, test 4.8

Table 7 (continued)

Characteristics	Test Methods	Specifications								
Solderability	IEC 60068-2-20 test Ta, method 1, 235 °C, 5 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 235 °C for 5 seconds, the terminals shall be visually examined.	Solderable upon delivery and after 6 months storage: The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 times to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.								
Resistance to soldering heat	IEC 60068-2-20 test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ± 5 °C to a point 2,0 to 2,5 mm from the body of the unit, be held there for 10 ± 1 s and then be stored at room temperature and normal humidity for 1 to 2 hours. The change of V_v and mechanical damage shall be examined.	$I \Delta V/V (1 \text{ mA}) I \leq 5 \%$ No visible damage								
Tensile strength	IEC 60068-2-21, test Ua1 tensile force for wire diameter <table data-bbox="412 1114 636 1219" style="margin-left: 40px;"> <tr><td>0,5 mm</td><td>5 N</td></tr> <tr><td>0,6 mm</td><td>10 N</td></tr> <tr><td>0,8 mm</td><td>10 N</td></tr> <tr><td>1,0 mm</td><td>20 N</td></tr> </table> After gradually applying the force specified and keeping the unit fixed for 10 seconds, the terminals shall be visually examined for any damage.	0,5 mm	5 N	0,6 mm	10 N	0,8 mm	10 N	1,0 mm	20 N	$I \Delta V/V (1 \text{ mA}) I \leq 5 \%$ No break of solder joint, no wire break
0,5 mm	5 N									
0,6 mm	10 N									
0,8 mm	10 N									
1,0 mm	20 N									

Table 7 (continued)

Characteristics	Test Methods	Specifications
Vibration	IEC 60068-2-6, test Fc frequency range 10 ... 55 Hz amplitude: 0,75 mm or 98 m/s ² duration: 6 h (3 × 2 h) pulse: sine wave After repeatedly applying a single harmonic vibration according to the table, the unit shall be visually examined.	$I \Delta V/V (1 \text{ mA}) \leq 5 \%$ No visible damage
Bump	IEC 60068-2-29, test Eb pulse duration: 6 ms max. acceleration: 400 m/s ² number of bumps: 4000 pulse: half sine	$I \Delta V/V (1 \text{ mA}) \leq 5 \%$ No visible damage

Figures 56 through 59 are examples of test results showing mean values and distribution.

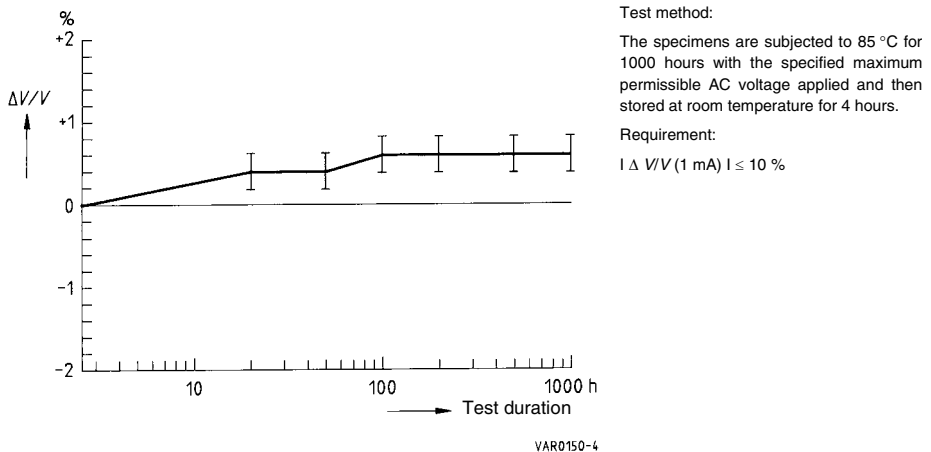
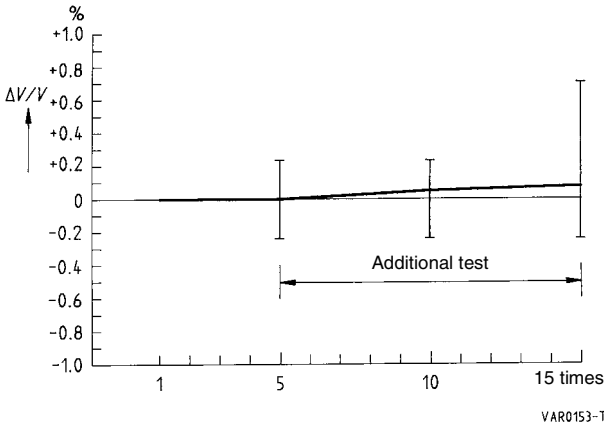


Figure 56 Testing of maximum AC operating voltage on SIOV-S10K130, 13 specimens



Test method:

The temperature cycles below are repeated five times, followed by measurement of the voltage change and examination for mechanical damage.

Additional test:

Another ten cycles.

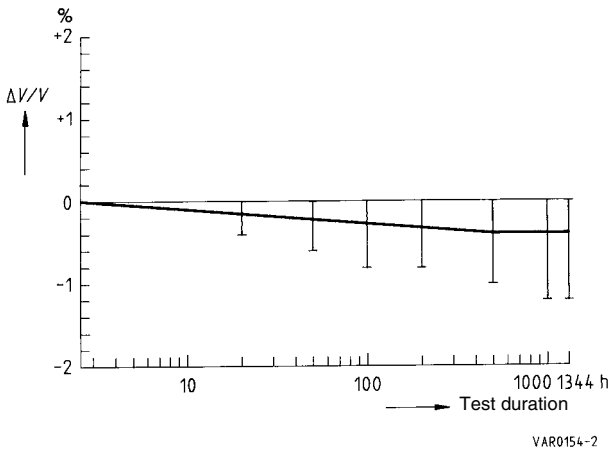
Step	Temp. °C	Time min.
1	-40	30
2	+85	30

Requirement:

$I \Delta V/V (1 \text{ mA}) \leq 5 \%$

No visible damage

Figure 57 Temperature cycling test (5 cycles + 10 additional cycles) on SIOV-S10K275, 13 specimens



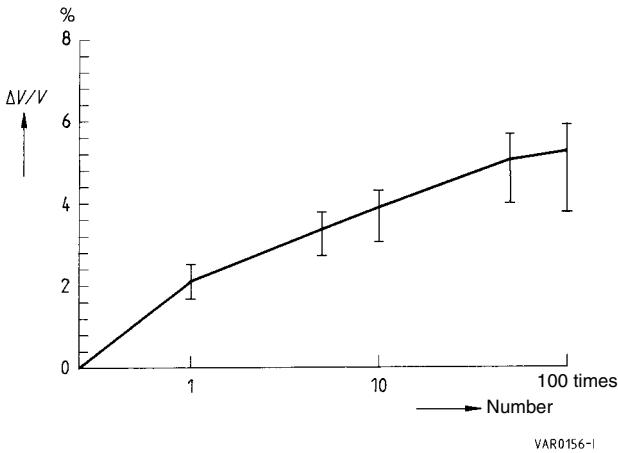
Test method:

The specimens are subjected to 40 °C and 93 % relative humidity for 56 days and then stored at room temperature for 2 hours.

Requirement:

$I \Delta V/V (1 \text{ mA}) \leq 10 \%$

Figure 58 Steady-state damp heat test on SIOV-S07K50, 8 specimens



Test method:

The specified surge current is applied 100 times at intervals of 30 s at 25 °C.

Surge current (8/20 μs): 500 A

Requirement:

$I \Delta V/V (1 \text{ mA}) \leq 10 \%$

Figure 59 Surge current derating test (8/20 μs) on SIOV-S14K150, 13 specimens

5.4.2 Tests of multilayer varistors (MLV)

Table 8

Characteristics	Test Methods	Specifications
Surge current derating, 8/20 μs	Surge current (8/20 μs), unipolar, n = 1, amplitude corresponding to derating curve for 20 μs	$I \Delta V/V (1 \text{ mA}) \leq 10 \%$ (measured in direction of surge current) No visible damage
ESD contact discharge	IEC 61000-4-2 Test voltage: 8 kV Type of discharge: direct contact discharge Number of test pulses: 20 × Polarity: +/- Discharge network: 150 pF, 330 Ω Preconditioning: IR reflow soldering on test PCB	$I \Delta V_V/V (1 \text{ mA}) \leq 15 \%$ (see also figure 60)
ESD air discharge	IEC 61000-4-2 Test voltage: 15 kV Type of discharge: air discharge Number of test pulses: 20 × Polarity: +/- Discharge network: 150 pF, 330 Ω Preconditioning: IR reflow soldering on test PCB	$I \Delta V_V/V (1 \text{ mA}) \leq 15 \%$

Table 8 (Fortsetzung)

Characteristics	Test Methods	Specifications
High-temperature life test	Temperature: max. operating temperature $\pm 2\text{ }^{\circ}\text{C}$ Duration: 1000 (+48/-0) hrs Applied voltage: VDC max Preconditioning: IR reflow soldering on test PCB Recovery: 1 hour of recovery under the standard condition after the removal from test chamber	$I \Delta V_V/V (1\text{ mA}) I \leq 10\%$
Fast temperature cycling (thermal shock)	IEC 60068-2-14, test Na Temperature cycling: minimum/ maximum operating temperature Dwell time: 15 min. Number of cycles: 50 Recovery: 1 hour of recovery under the standard condition after the removal from test chamber	$I \Delta V_V/V (1\text{ mA}) I \leq 10\%$ No mechanical damage
Damp heat, steady state	IEC 60068-2-3 Temperature: 40 $^{\circ}\text{C}$ Humidity: 93 % r.H. Duration: 56 days Preconditioning: IR reflow soldering on test PCB Recovery: 1 hour of recovery under the standard condition after the removal from test chamber	$I \Delta V_V/V (1\text{ mA}) I \leq 10\%$
Bump	IEC 60068-2-29, test Eb Pulse duration: 6 ms Max. acceleration: 400 m/s^2 Number of bumps: 4000 Pulse: half sine	$I \Delta V_V/V (1\text{ mA}) I \leq 10\%$ No visible damage

Figure 60 demonstrates the stability of SIOV-MLV against multiple ESD pulses

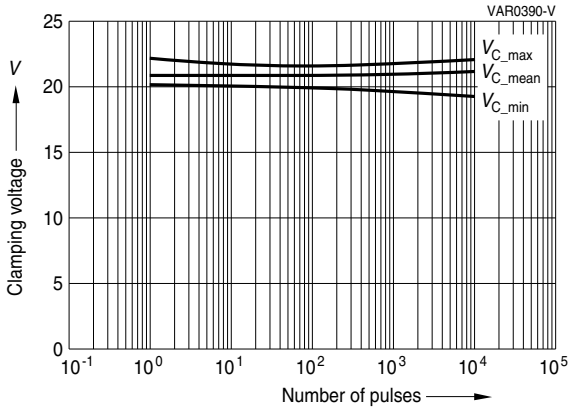


Figure 60 SIOV-MLV, typical stability of clamping voltage against multiple ESD pulses (8 kV, contact discharge, mean value and distribution), taking the CN0603M7G as an example, 25 specimens

5.5 Rejects and traceability


5.5.1 Identification and traceability

The packing of all varistors has a barcode label with details of type, ordering code, quantity, manufacturing date and lot number (figure 61). This information is required in order to process complaints quickly and efficiently.


Due to our systematic, unambiguous identification system, each component *and* inspection report can be allocated to a specific production lot. If we know the lot number, we can retrace the component back through the entire production process, right back to purchasing.

EPCOS TYPE METALOXIDEVARISTOR
US-TARIFF 85334


[1P] PROD ID: B72 ...





[1T] LOT NO: [10D] D/C:



[30P] PRODUCT NO: [Q] QTY:



MADE IN AUSTRIA

[1P] Ordering code
[1T] Lot number
[10D] Date code (yywwd)
[30P] Product number
[Q] Quantity

VAR0398-H

Figure 61 Package barcode label for varistors (made in Austria)

5.5.2 Corrective and preventive measures

Quality issues are handled by interdisciplinary Q teams using the 8D (8 disciplines) method. This method is also applied for handling customer complaints. The focus is on eliminating quality problems from the very start. If a problem has occurred nevertheless, the target is quick response and effective elimination.

In order to enable us to respond quickly and efficiently to any complaints and claims, the following information is of great assistance:

- A description of the fault
- How and when was the fault noticed?
- Logistic information (date code, delivery document, lot no)
- Operating conditions
- Service life up to the time the fault occurred

Technical related complaints are replied by using 8-D-Report regulations. In the case of transportation damage, please describe the damage as accurately as possible and, if possible, identify the damage so that it can be distinguished from any subsequent damage which might be incurred when the goods are returned. When doing so, also check the original packaging and describe any damage to the packaging. To prevent additional damage, use the original packaging when returning the goods.

5.5.3 Supplementary information

SIOV varistors may only be used in line with the corresponding specifications, mounting instructions and state of the art. If there is any issue you are not sure about, do not hesitate to consult our specialists, who will be pleased to give you support. Non-observance of limit specifications, operating conditions or processing instructions may lead to circuit malfunction (and further consequences) or at least to increased failure rates.

The specification of quality data – which always refer to a fairly large number of components – does not constitute a guarantee of characteristics or properties in the legal sense. However, agreement on these specifications does not mean that the customer may not claim for replacement of individual defective varistors within the terms of delivery. EPCOS cannot, however, assume any further liability beyond the replacement of defective components. This applies in particular to any further consequences of component failure.

5.6 Approvals

SIOV varistors have received the following certifications:

Underwriters Laboratories, Inc.

UL 1449 Transient voltage surge suppressors: File E97877

SMD types SIOV-CU

Disk types SIOV-S and SIOV-Q

Block types SIOV-B

Strap types SIOV-LS

UL1414 Across-the-line components: File E63802

Type series S05/S07/S10/S14/S20, voltage classes K130 ... K300; for S20 up to K680

Type series LS40K130 ... K750

Canadian Standards Association

Class 2221 01 Accessories and Parts for Electronic Products

Metal oxide varistors, for use as across-the-line transient protectors: Master contract No. 175282

SMD types SIOV-CU, voltage classes \geq K130

Disk types SIOV-S, voltage classes \geq K115, and SIOV-Q

Block types SIOV-B, voltage classes \geq K130

Strap types SIOV-LS

Schweizerischer Elektrotechnischer Verein SEV

(Swiss Electrotechnical Association)

Protection class 1

Degree of protection IP 00

Test requirement CECC 42 200

Test report no. 90.1 02484.02 (approved No. 96,5 51641,01)

Disk types SIOV-S

Block types SIOV-B (except B80)

CECC approval of manufacturer in accordance with EN 100114-1

(includes the requirements of EN ISO 9001)

Qualification approval according to CECC 42201-004

Disk types SIOV-S and SIOV-Q

VDE marks license

Certification in accordance with CECC 42 000, CECC 42 200, CECC 42 201-004

Disk types SIOV-S and SIOV-Q

5.7 Environmental protection, hazardous materials

5.7.1 Environmental protection

EPCOS is responsible for protection of the environment in the development, fabrication and use of its products for the intended purpose. EPCOS is very thorough in fulfilling the resulting obligations. Over and above the legal prescriptions, our guiding principle is the corporation's responsibility towards man and environment.

Responsibility for safety in working with materials that have a potential environmental impact rests with the manager in charge. This involves, in the first place, instructing and informing the staff concerned. A specially trained environmental protection supervisor watches over adherence to regulations, reports on the introduction of processes within an environmental context and on decisions relating to investment (e.g. he ensures that all environmentally associated requirements like filters and sumps have been considered). Advising and informing staff have the highest priority; only in this way all protective measures are known and observed.

All chemicals employed in development and fabrication are examined for environmental compatibility or harmful effects before their use on the basis of safety specifications according to EU-directives.

Dust and vapor generated during fabrication are filtered for disposal. The emission figures of the filters are constantly examined; considerable efforts are undertaken to ensure that these figures are well below the legally prescribed limits. The same applies to the water used in the plant; this water is cleansed using a special waste-water treatment process. Water consumption has been reduced substantially in recent years through the use of cooling water circuits and water recycling.

Waste produced in the fabrication of components is sorted and collected on the spot and recycled by state-of-the-art methods.

The packaging materials used for our components can be fully recycled.

Varistors can be disposed of without any special provisions together with domestic-type commercial refuse on adequately designed dumps or tips. However, the respective national and local regulations must be observed.

5.7.2 Hazardous materials

The materials used in SIOV varistors comply with the limiting conditions of the EU directives on hazardous materials and contain no ozone-layer-damaging compounds as listed in groups I to VI of the Montreal Protocol on substances that deplete the ozone layer.

The varistors listed in this data book specifically **do not contain** any of the following hazardous substances:

- Aliphatic chlorinated hydrocarbons
- Arsenic compounds
- Asbestos
- Azo dyes containing carcinogenic amine compounds
- Lead carbonate and lead sulphate
- Chlorated and bromated dioxines and furanes
- CFHC and halocarbon substances
- Formaldehyde
- Pentachlorophenol (PCP) and salts of PCP
- Polychlorinated biphenyls and terphenyls
- Mercury
- Creosote
- Ugilec and DBBT (PCB substitutes)
- Organic tin compounds

EPCOS is certified in accordance with ISO 14001.

5.8 Export restrictions

SIOV varistors are **not subject to** export restrictions of any kind.

Herausgegeben von EPCOS AG

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This brochure replaces the previous edition.

For questions on technology, prices and delivery please contact the Sales Offices of EPCOS AG or the international Representatives.

Due to technical requirements components may contain dangerous substances. For information on the type in question please also contact one of our Sales Offices.