## EVOX RIFA PRODUCT QUALITY

The quality of Evox Rifa's products and services is based on a continuous strive towards excellency throughout the whole organization. Skilled and motivated personnel, technical know-how and modern equipment combined with extensive quality assurance make Evox Rifa the supplier of components of the highest quality.

The up-to date quality tools like Statistical Process Control (SPC) in various forms, Failure Mode and Effect Analysis (FMEA), Accelerated Reliability Testing and Zero Defect Acceptance concept in final testing are the corner stones of the every day quality work. Cross-functional teams are routinely used in Problem Solving (8D method) with effective Failure Analysis support.

As a visible evidence of our quality, all the manufacturing units world wide are certified according to EN ISO 9001 or 9002. In addition to that, the factories have the automotive industries' QS 9000 certifications. In Europe our manufacturing is also CECC approved with several qualified product families. Our world famous EMI capacitors carry all the important safety approval marks for world wide applications.
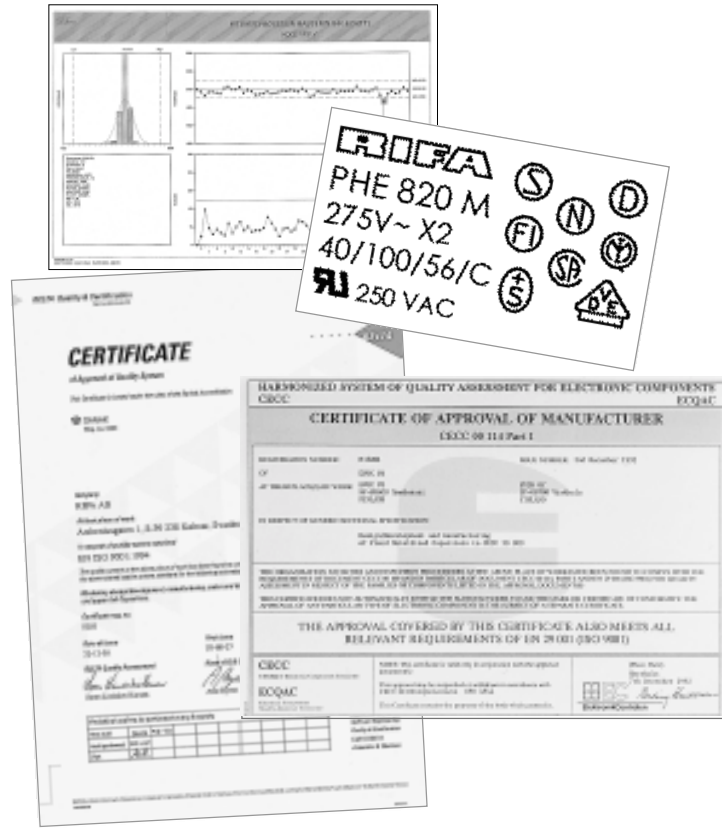
CUSTOMER IN FOCUS

The only real measure of our total quality performance is the acceptance of our customers.

Evox Rifa's quality work has always been focused on the customer. We have actively made quality agreements with ambitious goal settings with World-Class Companies – small and large.

This active quality cooperation has been most fruitful to Evox Rifa by bringing in most modern quality tools, but especially by providing us with reliable feed back on the performance quality of our products and services.

The cooperation has not only lead to continuous improvement of the quality of our products, but sometimes also helped our customers to spot some weaknesses in their designs. A visible sign of these close links between Evox Rifa and various customers is the numerous approvals and the performance awards addressed to Evox Rifa.

EVOX RIFA

IN-HOUSE RESEARCH AND DEVELOPMENT FOR TOMORROW'S NEEDS

Evox Rifa has over fifty years accumulated experience in developing a wide range of world-class capacitor products. Our leading position in the market with a wide product range is based on our deep knowledge of the materials and ways in which they can be used in capacitor designs to provide the best possible solutions.

Evox Rifa invests substantial human and financial resources in finding new highly reliable and cost effective solutions for today's and tomorrow's needs. Our R&D department can simulate most operational conditions and apply our products to the envisaged working environment, giving to the customer optimized capacitors for a particular specification.

The simulation capabilities substantially shorten the design cycle of capacitors. To assist in shortening the design cycle of our customers, we have brought our R&D department to our customers by providing them with a CAD software, which allows them to select the most suitable capacitors for their application (Figure 1). For easy calculation of signal stresses, there is also a fast Fourier transform software available. In this software complicated signal forms can easily be simulated and analysed (Figures 2 and 3).
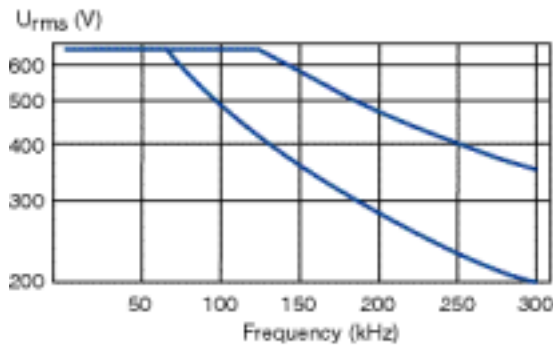

Fig. 2. Signal s (t)

Fig. 1. From CAD software, showing max U_{rms} vs. frequency for two different capacitors
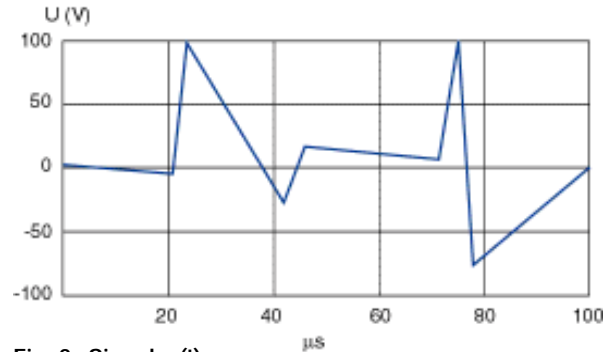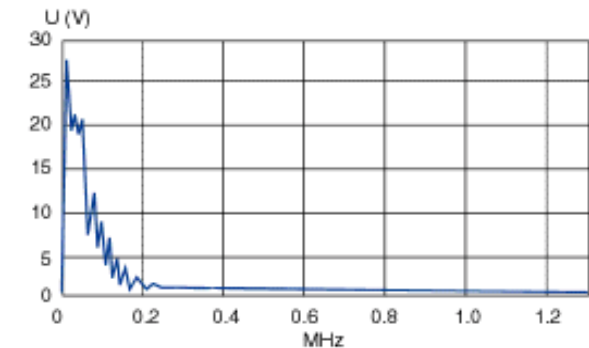

Fig. 3. Frequency spectrum

PRODUCT SPECIFICATION

All descriptions, drawings and other particulars (including dimensions, materials and performance data) given by Evox Rifa are as accurate as possible but, being given for general information, are not binding on Evox Rifa unless specifically agreed in writing. All dimensions and materials are, unless otherwise stated, subject to reasonable variations resulting from the raw material available or arising in the ordinary course of manufacture. Any performance data are based upon Evox Rifa's experience and are such as Evox Rifa normally expects to achieve.

WARRANTY, PRODUCT LIABILITY

Evox Rifa warrants that the goods manufactured by Evox Rifa are free from defects in design, material and workmanship.

Evox Rifa's liability under this warranty shall be limited to replacement or repair free of charge, at one of Evox Rifa's factories selected by Evox Rifa, provided that notification of such failure or defect is given to Evox Rifa immediately upon the same becoming apparent and that on Evox Rifa's request and instruction the goods are promptly returned to Evox Rifa carriage paid by buyer.

In case the goods thus returned as defective, prove to be without fault or defect, Evox Rifa is entitled to charge buyer 10% of the value of the returned goods.

If the goods supplied or part thereof are not manufactured by or branded Evox Rifa, Evox Rifa will only extend to the buyer the benefit of the warranty granted by the manufacturer of the goods.

Evox Rifa's liability is further limited to a period of 12 months from the date of shipment to buyer.

Evox Rifa shall not be liable for any defect which is due to accident, fair wear and tear, negligent use, tampering, improper handling, improper use, improper operation or improper storage or any other default on the part of any person other than Evox Rifa.

Evox Rifa shall have no other liabilities in case of defective goods than those stated above shall under no circumstances be liable for any consequential loss or damage arising from the use of goods sold by Evox Rifa. Liability under paragraph 823 BGB is expressly excluded.

The above limitations of Evox Rifa's liability for defective goods shall apply also with regard to product liability, and Evox Rifa shall have no responsibility for injury to persons or for damage to goods or property of any kind.

In case of product liability claims from third parties against Evox Rifa, not falling within Evox Rifa's liability in accordance with the above, buyer shall hold Evox Rifa harmless.

TERMS AND DEFINITIONS

Rated capacitance (C_R)
The rated capacitance of a capacitor is the value which is indicated upon it. The capacitance is measured at 1 kHz and +23°C.

Rated voltage (U_R)
The rated voltage is the maximum direct voltage or the maximum RMS alternating voltage which may be applied continuously to the terminals of the capacitor at any temperature within the rated temperature range.

Rated temperature
The rated temperature is the maximum ambient temperature at which the rated voltage can be continuously applied.

Climatic category
The climatic category states the category temperature range and the humidity class. For example 40/085/56 stands for –40°C to +85°C; 56 states that the steady state humidity test should take 56 days.

Tangent of the loss angle (Dissipation factor, tan𝛿)
The tangent of the loss angle is the power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage of specified frequency. The tangent of loss angle is given in percent (Eg 0.01 tan𝛿=1%).
The dissipation factor is of interest especially when the capacitor is operated on AC. The dielectric loss causes heating of the capacitor which under unfavourable circumstances may lead to a destructive breakdown. This will not happen if the capacitor is used within specified limits. The ability to withstand short duration thermal and voltage overload is greater for small capacitors than for large ones.

Insulation resistance
The values given in the catalogue indicate the insulation resistance after one minute of electrification at +23°C with the following voltages: 100 VDC for capacitors rated at 100 to 500 VDC and 500 VDC for capacitors rated at 500 VDC. Insulation resistance is temperature dependent and is approximately halved for each 7 °C of temperature rise. Multilayer construction provides insulation resistance higher than that of single-layer types.

Pulse operation
Capacitors loaded with pulses with fast rise or fall times (high dU/dt) will be exposed to high current pulses. In order not to overload the internal connections the current must be limited. The current limits for a specific type are dependent upon:
• Amplitude and form of the pulse
• Rated voltage of the capacitor
• Capacitance
• Geometrical configuration of the winding

$$dU/dt = U_R/(R \times C)$$

U_R = Rated voltage
R = Discharge resistor
C = Rated capacitance

At repeated pulse operation, self-heating, ambient temperature and cooling set the load limit.
Pulse current limits are commonly expressed in the form of maximum permitted dU/dt in volts per microsecond. The figures stated in the type specifications refer to an unlimited number of pulses charging or discharging from rated voltage U_R.

Passive flammability
The ability of a capacitor to burn with a flame as a consequence of the application of an external source of heat.

Resonance frequency
The resonance frequency of a capacitor is reached when

$$\omega L = 1/\omega C$$

ω = 2πf (f = frequency)
L = inductance caused by the winding
      and the length of the leads
C = the capacitance at f.

Dielectric absorption (DA)
Dielectric absorption describes the dielectric material's properties to "remember" the applied voltage. One method to define DA is:
The capacitor is to be charged for one hour at rated voltage DC (U_R) then discharged through a resistor of 5 ohms for 10 seconds. The discharge resistor must then be disconnected and the recovery voltage U_r measured 15 minutes after disconnection. The dielectric absorption is defined by:
$$DA = (U_r/U_R) \times 100\%$$

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PROPERTIES OF DIELECTRICS

**POLYESTER
(Polyethylene Terephthalate, PET)
Metallized and Film/foil**
High dielectric constant and high dielectric strength provides good volumetric efficiency for metallized polyester film capacitors. Metallized polyester film has excellent self-healing properties.
Typical applications: Bypassing, coupling, filtering.

**POLYESTER
(Polyethylene Naphthalate, PEN)
Metallized**
High temperature Polyester. Relatively high dielectric constant and dielectric strength, and availability of thin films, provide good volymeric efficiency for metallized construction. High melting point allowes SMD constructions and service in high ambient temperatures. General purpose capacitor.

**POLYPROPYLENE (PP)
Metallized and Film/foil**
Very low losses, low dielectric absorption, high dielectric strength, very high insulation resistance, and negative temperature coefficient.
Typical applications: Stable oscillators and filters. Sample & hold circuits, pulse handling circuits, AC applications and mains filtering.

**POLYCARBONATE (PC)
Metallized and Film/foil**
Very low temperature dependency, wide operating temperature range, good long term stability, and low losses. Typical applications: Timers and filters. Applications in high ambient temperatures.

**POLYPHENYLENE SULPHIDE (PPS)
Metallized**
Low losses, wide operating temperature range, low temperature coefficient, good stability.
Typical applications: Timers and filters. Automotive and other applications in high ambient temperatures. Available in SMD constructions.

**PAPER
Metallized**
High dielectric constant. Excellent self-healing properties and transient handling capability. High ionisation level due to impregnated dielectric material. Outstanding reliability in mains connected and other low frequency applications.

NUMERICAL COMPARISON OF FILM MATERIALS

Material (Trade names)	Abbreviation	Min. film thickness (µm)	Dielectric constant at 1 kHz, +23°C	Operating temperature (°C)	Temperature coefficient (ppm/°C)	Dissipation factor at 1 kHz, +23°C	Insulation time constant (s) at +23°C	Dielectric absorption %
Polyester (Mylar, Lumirror, Hostaphan, Diafoil)	PET	0.9	3.3	–55 ... +100 (... +125)	+400 (±200)	0.5%	25 000	0.5
Polyethylene Naphthalate	PEN	1.4	3.0	–55 ... +125 (... +150)	+200 (±150)	0.4%	25 000	1.2
Polycarbonate (Makrofol)	PC	2.0	2.8	–55 ... +125	0 (±100) nonlinear	0.15%	25 000	0.06
Polypropylene (Torayfan, Trespaphan)	PP	3.5	2.2	–55 ... +105	–200 (–100, +50) almost linear	0.03%	100 000	0.01
Polyphenylene sulfide (Torelina)	PPS	1.2	3.0	–55 ... +125 (... +150)	0 (–50) up to +100 °C	0.06%	25 000	0.05
Paper Impregnated	P	7.0	5.5	–40 ... +115	+1200 (±200)	0.8%	15 000	

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PROPERTIES OF DIELECTRICS

tanδ %, 1 kHz
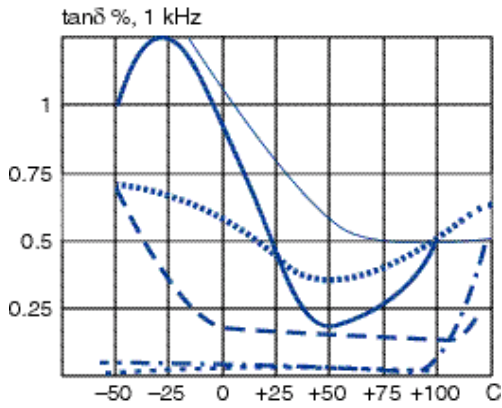
Dissipation factor vs. temperature

ΔC/C%, 1kHz
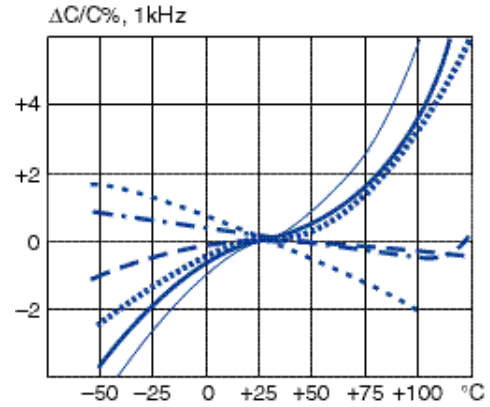
Capacitance vs. temperature

tanδ %, 23 C
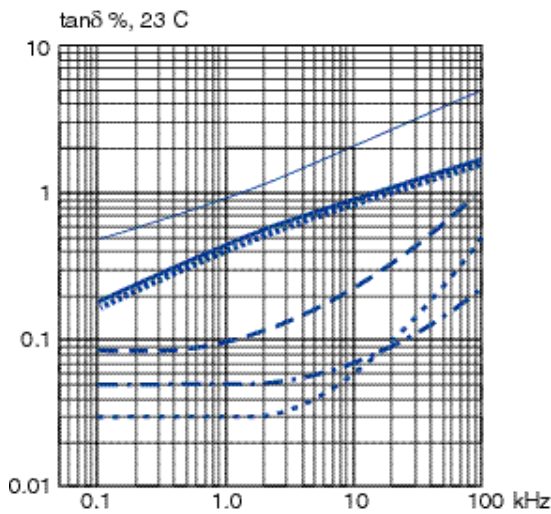
Dissipation factor vs. frequency

C/C%, 23 C
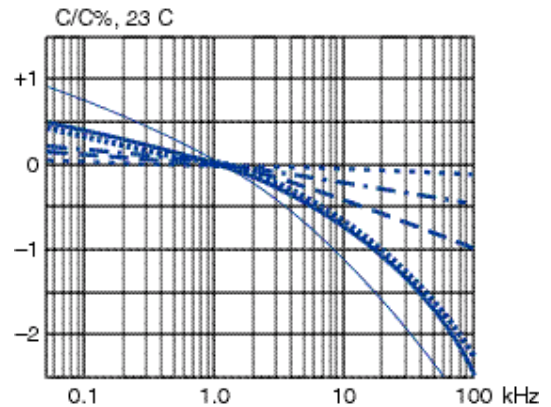
Capacitance vs. frequency

M • µF
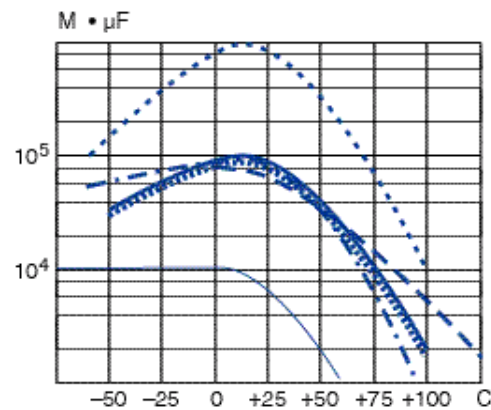
Insulation resistance vs. temperature

——————— Polyester PET

···················· Polyethylene
Naphthalate PEN

– – – – – Polycarbonate PC

–·–·–·– Polyphenylene sulfide PPS

········· Polypropylene PP

——— Paper

PROPERTIES OF DIELECTRICS
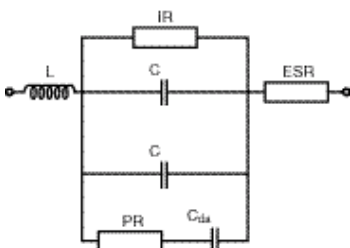
C   = nominal value of the capacitor
L   = inductance (leads, metallization, winding)
ESR = equivalent series resistance (leads, metallization, metal spraying)
IR   = insulation resistance (properties of the dielectric material)

ΔC = variable capacitance (temperature, DC voltage, frequency (changes)
PR = dielectric polarization resistance
C_{da} = dielectric absorption

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RELIABILITY

The reliability of a capacitor is mainly a function of:
• The construction; dielectric material and its thickness
• The manufacturing process
• The application; electrical stress and temperature

The failure rate, λ, vs. voltage and temperature for the most common dielectric materials is shown in the diagrams below. U_R = rated voltage.
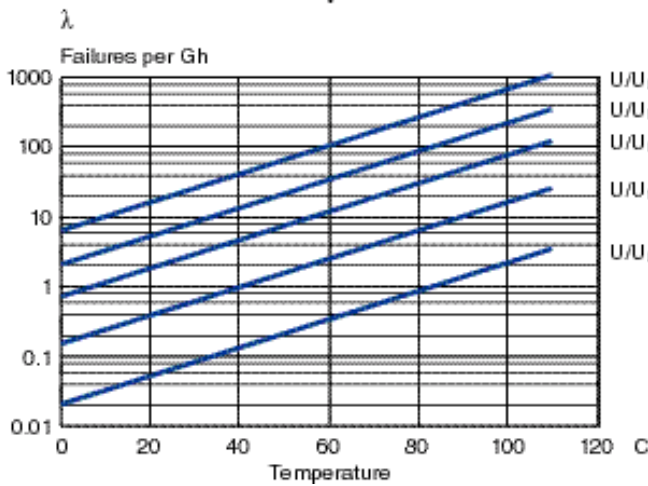
The operating life (L) can be calculated as:
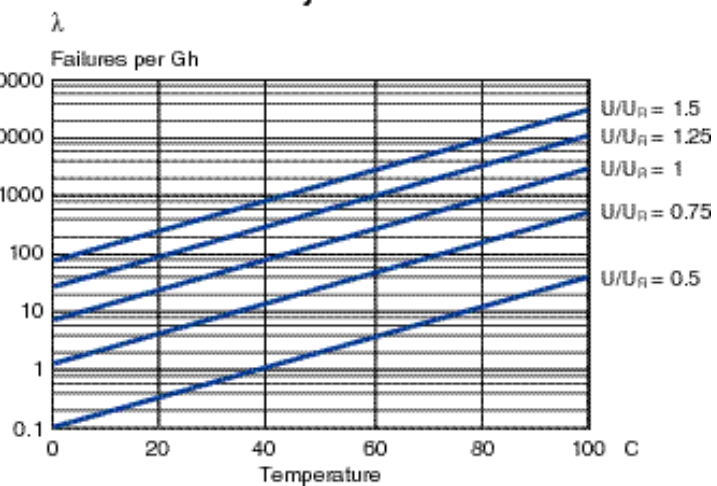
$$L = \frac{1}{\lambda} \times \ln \frac{1}{1 - F}$$

where F is the expected probability of failures.

Example: If λ = 20 x 10^{-9} it takes 6 years to have
F = 0.001 (0.1% failures)
and 300 years to have
F = 0.05 (5% failures)
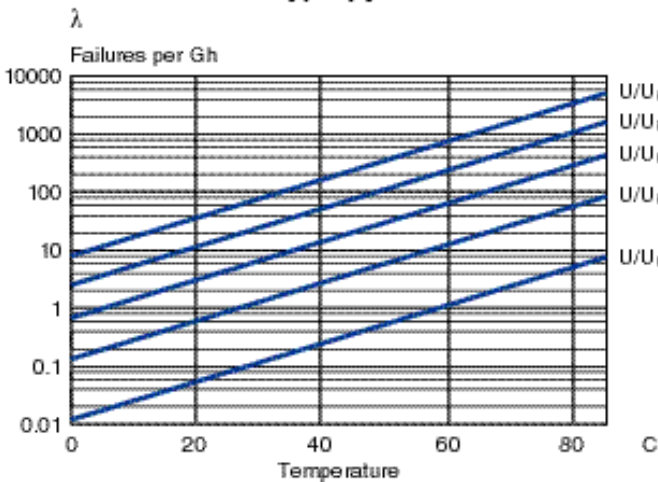
MTBF (mean time between failures) = 1 / λ

Failure rates vs. temperature and voltage
Paper

Failure rates vs. temperature and voltage
Polyester

Failure rates vs. temperature and voltage
Polypropylene

Failure rates vs. temperature and voltage
Polyphenylene sulfide

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