Power Electronics Capacitor

一、电力电子电容器的标准体系

电力电子电容器的主要标准是由中国国家标准委员会发布的 GB/Tl7702 和 GB/Tl2747.1、GB/T12747.2 (分别等同于由 IEC33 技术委员会(电力电容器)制定 IEC61071, IEC60831-1、IEC60831-2) ,作为补充，我司也引用了 GB/T25121 (等同于 IEC61 881 -1)、GB/T21563(等同于 IEC61373)和 AEC-Q200 等标准,以满足铁路、汽车等特定场合的应用要求。

我司主要在上述标准的基础上制定了各个型号电力电子电容器的企业标准，以供内部引用,另外，电力电子电容器的部分标准术语也参考了其它电容器标准中的定义,不再一一列出 。

以上，构成了电力电子电容器的标准体系

电力电子电容器的标准体系,举例如下:

一、The standard electronics system of capacitors for power

The main standards are GB/T17702 and GB/T12747.1&GB/T GB/T12747.2, published by China Notional standardizing committee.These standards are equal toIEC61071, IEC60831-1&IEC60831-2, prepared by IEC technical committee 33: Power capacitors.

As supplementary,KWOKTRAN also refers to GB/T 25121(IEC6188l-1 idt), GB/T21563 (IEC61373 idt) and AEC-200 and so on,for railway or automobile applications.

According to the basic requirements of above standards, KWOKTRAN made detailed standards of various types of capacitors for internal use.

In additional, some terminologies are also reference to other capacitor standards, which will be not listed below.

The standard system of lamp capacitors is made up of all above standards.

Following, please find the corresponding specification lists for power electronics capacitors.

标准号(No.)	标准(**Standards**)
GB/T17702 (IEC61071)	电力电子电容器 Capacitors for power electronics
GB/T12747.1 (IEC60831-1)	标称电压 1 KV 及以下交流电力系统用自愈式并联电容器 第 1 部分:总则一性能、试验和定额一安全要求一安装和运行导则 Shunt power capacitors of the self- healing type for a.c. systems having a rated voltage up to and
GB/T12747.2 (IEC60831-2)	标称电压 1KV 及以下交流电力系统用自愈式并联电容器 第 2 部分:老化试验、自愈性试验和破坏试验 Shunt power capacitors of the self- healing type for a.c. systems having a rated voltage up to and Part1: Ageing test, self- healing test and destruction test
GB/T25121 (IEG61881-1)	轨道交通机车车辆设备电力电子电容器 Railway applications- Rolling stock equipment- Capacitors for power electronics
GB/T21563	轨道交通 机车车辆设备 冲击和振动试验
GB/T2693 (IEC60384-1)	电子设备用固定电容器 第 1 部分:总规范 Fixed capacitors for use in electronic equipment- Part1: Generic specification
AEC-Q200	STRESS TEST QUALIFICATION FOR PASSIVE COMPONENTS
GB/T4798.1 (IEC60721-3-1)	电工电子产品应用环境条件 第 1 部分 贮存 Classification of environmental conditions- Part3 Classification of groups of environmental parameters and their severities- Section 1 Storage
GB/T4798.2 (IEC60721-3-2)	电工电子产品应用环境条件 第 2 部分 运输 Classification of environmental conditions- Classification of groups of environmental parameters and their severities- Section2 Transportation
GB/T4798.3 (IEC60721-3-3)	电子产品应用环境条件 第 3 部分 有气候防护场所固定使用 Classification of environmental conditions- Part3 Classification of groups of environmental parameters and their severities- Section3 Stationary use at weather protected locations.
	详细规范: Detail specification for each type.

二、一些常见的标准术语

2.1、额定容量 C_N

电容器在 20C/50~1 20Hz 下的设计电容量。

2.2、额定电压 U_R

设计电容器时所采用的非反复型波形的任一极性的可连续运行的最高运行峰值电压。基值应大于直流工作电压与纹波电压峰值之和。

2.3、有效值电压 Urms

电容器在连续运行过程中允许出现的最大正弦交流电压的均方根值。

2.4、纹波电压 Ur

单向电压的峰到峰的交流分量。

纹波电压的方均根值应低于额定电压的 10%。

2.5、非周期冲击电压 U_S

由切换或系统中任何别的扰动所导致的峰值电压，此电压只允许出现有限的次数，且每次持读时间应比基本周期短。

-最大持续时间：50 毫秒/脉冲

-最大出现次数：1000 (负载)

2.6 绝缘电压 U_i

电容器时规定的电容器端子对外壳或对地交流电压的方均根值。若未作说明，此绝缘电压等于额定电压除以 $\sqrt{2}$ 。

2.7 最大电流 I_{max}

连续运行时的最大电流的方均根值。

2.8、最大峰值电流 Î

在连续运行中允许重复出现的最大峰值电流。

其数值：

Î=C x(dV/dt)

其中 C 为电容量, dV/dt 表示电压爬升速率，即在运行中允许重复出现的最大电压爬升速率，常用来代替Î使用 。

二. Terminologies

2.1. Rated capacitance C_N

Nominal value of the capacitance at 20℃ and measuring frequency range of 50 to 120 Hz.

2.2. Rated voltage U_R

Maximum operating peak voltage of either polarity but of a non reversing type wave form,for which the capacitor has been designed, for continuous operation.

2.3 rms voltage Urms

Root mean square of max. Permissible value of sinusoidal a.c. voltage in continuous operation.

2.4.Ripple voltage Ur

Peak- to- peak alternating component of the unidirectional voltage. The maximum allowed rms ripple voltage has to be lower than 10% of the rated voltage.

2.5.Non-recurrent surge voltage Us

Peak voltage induced by a switching or any other disturbance of the system which is allowed for a limited number of times and for durations shorter than the basic period.

Maximum duration: 50 ms/pulse

Maximum number of occurrences: 1000 (during load)

2.6.Insulation voltage U_i

Rms value of a.c. voltage designed for the insulation between terminals of the capacitor to case or earth.The insulation voltage is equal to the rated voltage of the capacitor, divided $\sqrt{2}$

by ,unless otherwise specified.

2.7.Maximum current I_{max}

Maximum rms current for continuous operation

2.8.Maximum peak current Î

Maximum permitted repetitive peak current that can occur during continuous operation. The value is following:

Î=Cx(dV/dt)

Where C is capacitance and dV/dt indicates rate of voltage rise, which means maximum permitted repetitive rate of voltage rise of operational voltage, usually using instead of Î.

2.9、最大冲击电流 $\hat{I}_S$

由切换或系统中任何别的扰动所导致的允许出现的峰值电流，此电流只允许出现有限的次数，且每次持续时间应比基本周期短。

2.9 Maximum surge current $\hat{I}_S$

Peak non-repetitive current induced by switching or any other disturbance of the system which is allowed for a limited number of times, for durations shorted than basic period.

2.10、串联电阻 R_s

在规定的运行条件下,电容器导体部分的电阻。串联电阻随温度升高而增大，其电阻温度系数约为0.004/℃, 近似公式为:

$R_s(T2)=[1+0.004x(T2-T1)]xR_s(T1)$

2.10. Series resistance Rs

Effective ohmic resistance of the conductors of a capacitor under specified operating conditions. It depends on temperature and the approximate TCR is 0.004/℃. The approximate formula is following:

$R_s(T2)=[1+0.004x(T2-T1)]xR_s(T1)$

2.11、等效串联电阻 ESR

一个有效电阻，当它和所探讨的电容器有相等电容值的理想电容器串联时，在规定的运行条件下，该电阻的损耗功率将等于该电容器中耗散的有功功率。

2.11. Equivalent series resistance ESR

Effective resistance which, if connected in series with an ideal capacitor of capacitance value equal to that of the capacitor in question, would have a power loss equal to active power dissipated in that capacitor under specified operating conditions.

2.12 介质损耗因素 $tg\delta_d$

电容器的介质材料在额定频率下的损耗常数。 的典型介质损耗因素为 2 xl 0-4。

2.12 Dielectric dissipation factor $tg\delta_d$

Constant dissipation factor of the dielectric material for all capacitors at their rated frequency The typical loss factor of polypropylene film is $2x10^{-4}$.

2.13 电容器的损耗因素 tg δ

在规定频率的正弦波电压作用下，电容器的损耗功率

2.13 Loss factor of the capacitor tgδ

The dissipation factor is ratio between reactive power of the impedance of the capacitor and effective power when capacitor is submitted to a sinusoidal voltage of specified frequency, it is that ratio between the equivalent series resistance and the capacitive reactance of a capacitor

2.14 介质损耗功率 P_d

电容器的电介质由于扱化或电导引起的损耗,其值为：

$Pd=\hat{U}^2 x \pi xf_oxCxtg\delta_d$

直流电容器: $\hat{U}$=Ur/2

交流电容器: $\hat{U}=\sqrt{2}$ Urms

GTO 吸收电容器: $\hat{U}=U_{NDC}/2$

fo: 施加在电容器上电压的基本频率

C: 电容量

2.14 Dielectric power loss P_d

Loss power induced by dielectric polarization or dielectric conductance. The value is following:

$Pd=\hat{U}^2 x \pi xf_oxCxtg\delta_d$

Where, for DC capacitors: $\hat{U}$=Ur/2

For AC capacitors: $\hat{U}=\sqrt{2}$Urms

for GT〇 snubber capacitors: $\hat{U}=U_{NDC}/2$

fo: fundamental frequency

C: capacitance

2.15 焦耳损耗功率 P_j

当电容器通过有效电流时，由于串联电阻 R_S 发热而引起的损耗，其值为：

$P_j= I^2_{rms} x R_s$

2.15 Joule power loss P_j

Loss power induced by series resistance of the capacitor under rms current. The value is following:

$P_j= I^2_{rms} x R_s$

2.16 电容器的损耗功率 P_t

电容器所消耗的有功功率,由介质损耗与焦耳损耗组成，即 $P_t=P_d + P_j= I^2_{rms} \times ESR$

2.16 Capacitor losses P_t

Active power dissipated in the capacitor, consists of dielectric loss and joule loss, i.e. $P_t=P_d + P_j= I^2_{rms} \times ESR$

2.17 最大损耗功率 P_{max}

在最高运行温度下电容器可承载的最大损耗功率。

2.17 Maximum power loss P_{max}

Maximum power loss at which the capacitor may be operated at the maximum case temperature.

2.18 自感 L_s

电容器由于自身结构或组成的原因所表现出来的电感。

2.18 Self-inductance L_s

Represents the sum of all inductive elements which are-for mechanical and construction reosons-contained in any capacitor.

2.19、谐振频率 f_r

电容器的阻抗成为最小时的最低频率。 其值为: $f_r= 1 /(2\pi \times \sqrt{L_S \times C_N})$

2.19. Resonance frequency f_r

Lowest frequency at which the impedance of the capacitor becomes minimum. The value is following:

$f_r= 1 /(2\pi \times \sqrt{L_S \times C_N})$

2.20 额定频率 f_N

设计电容器时所规定的频率。

2.20 Rated frequency f_N

Specified frequency for which the capacitor has been designed.

2.21、运行温度 θ_{case}

在电容器达到热平衡状态时的外壳最热点处的温度。

2.21.Operating temperature θ_{case}

Temperature of the hottest point on the case of the operating capacitor in thermal equilibrium.

2.22、最高运行温度 θ_{max}

电容器可以运行的最高外壳温度。

2.22.Maximum operating temperature θ_{max}

Highest temperature of the case at which the capacitor may be operated.

2.23、最低运行温度 θ_{min}

电容器可以运行的最低电介质温度。

2.23. Lowest operating temperature θ_{min}

Lowest temperature of the dielectric at which the capacitor may be energized.

2.24、冷却空气温度 θ_{amb}

在稳定状态条件下，在电容器组最热区域的两单元之间中途所测得的空气温度。

如果仅涉及一单元。 则指在离电容器外壳 10cm 且距其基底 2/3 高度处所测得的空气温度 。

2.24.Cooling-air temperature θ_{amb}

Temperature of the air measured at the hottest position of the capacitor, under steady-state conditions, midway between two units. If only one unit is involved, it is the temperature of surrounding air, measured 10cm away and at2/3 of the case height of the capacitor under steady-state conditions.

2.25、外壳温升$\triangle\theta_{case}$

外壳最热点温度和冷却空气温度之差。

2.25.Contained temperature rise$\triangle\theta_{case}$

Difference between the temperature of the hottest point of the container and the temperature of the cooling air.

2.26、热阻 R_{th}

热阻表征的是电容器的发热功率每上升 1 瓦,电容器内最热点的温度在环境温度θ_{amb}的基础上升高的度数。

R_{th}由内部热点到外壳的热阻R_{thhc}与外壳到环境的热阻 R_{thca} 两部分组成。

2.26.Thermal resistance R_{th}

The thermal resistance indicates by how many degrees the capacitor temperature at the hotspot rises aboveθ_{amb} per watt of the heat dissipation losse.

R_{th} consists of R_{thhc}(thermal resistance from internal hotspot to case) and R_{thca}(thermal resistance from case to ambient).

2.27、热点温度 θ_{hs}

电容器内部最热点处的温度。 其值为:

$\theta_{hs}=\theta_{amb} + P_t \times R_{th}$ 或者

$\theta_{hs}=\theta_{case} + P_t \times R_{thhc}$

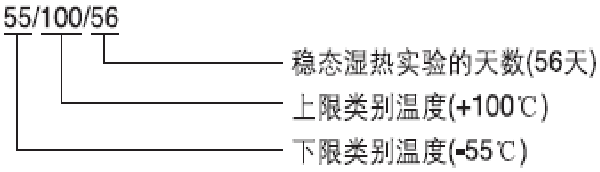
2.27. Hotspot temperature

Temperature at the hottest spot inside the capacitor The value is following:$\theta_{hs}=\theta_{amb} + P_t \times R_{th}$ or

$\theta_{hs}=\theta_{case} + P_t \times R_{thhc}$

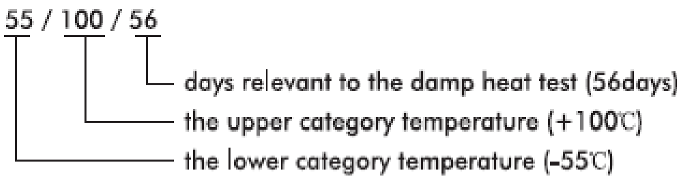
2.28、气候类别

电容器所属的气候类别用斜线分隔的三个数来表示（IEC 60068-1：如：55/100/56)



2.28.Climatic category

The climatic category which the capacitor belongs to express in three numbers separated by slashes,(IEC60068-1:example 55/100/56)



2.29、容量温度系数（a）

电容器在规定的温度范围内容量随温度变化率。通常以20℃时电容量为参考,用百万分之一每摄氏度（10^{-6}/℃）表示（10^{-6}/℃=1ppm/℃)

$$a_i = \frac{C_i - C_o}{C_o(T_i - T_o)}$$

C_i: 电容器在温度T_i时容量

C_o: 电容器在T_o(20 ± 2)℃时的容量

2.29.Temperature coefficient of capacitance(a)

The change rate of capacitance with temperature measured over a specified range of temperature. It is normally expressed in parts per million per Celsius degree (10^{-6}/℃)and referred to 20℃.

$$a_i = \frac{C_i - C_o}{C_o(T_i - T_o)}$$

C_i: Capacitance at temperature T_i.

C_o: Capacitance at temperature T_o(20 ± 2)℃.

2.30、绝缘电阻（I.R.)/时间常数（t)

绝缘电阻为电容器充电一分钟后所加的直流电压和流经电容器漏电流的比值，单位为 MΩ。时间常数为绝缘电阻和电容量的乘积，通常以秒表示，公式如下：

t[s]=I.R.[MΩ] x C[μF]

一般情况下，绝缘电阻用于描述小容量电容器的绝缘特性，时间常数用于描述大容量（如：C_R>0.33μF)电容器的绝缘特性。另外，对于 l 分钟内无法充满电的更大容量的产品，常选 5 分钟、1 0 分钟,甚至更长时间作为充电时间 ,或者由供需双方协商决定。

2.10.Insulation resistance(I.R.)/Time constant(t)

The insulation resistance is the ratio between an applied D.C.voltage and the resulting leakage current after a minute of charge. It is expressed in MΩ. The time constant is expressed in seconds with the following formula:

t[s]=I.R.[MΩ] x C[μF]

In general,Insulation resistance is used for describing smaller capacitance capacitors' insulation character, Time constant for describing larger ones'(example:CR>0.33μF)。

In addition, if the capacitor with larger capacitance couldn't fully charge in one minute, we maychoose5min, 10min, even longer time as charging time, or it is to be determined by both purchaser and manufacturer.

2.31、自愈性（仅对金属化膜电容器）

金属化膜的金属层是通过真空蒸发的方法将金属沉积在薄膜上，厚度只有几十个纳米，当介质上存在弱点，杂质时，局部电击穿就可发生，电击穿处的电弧放电所产生的能量足以使电击穿点邻近处的金属镀层蒸发，使击穿点与周围极板隔开，电容器电气性能即可恢复正常。

2.31.Self-healing(Only for metallized film capacitor)

The metal coatings of the metallized film, which are vacuum-deposited directly onto the metallized, have a thickness of only dozens of nanometers. At weak points or impurities in the dielectric, a dielectric breakdown won energy released by the arc discharge in the breakdown channel is sufficient to totally evaporate the thin metal coating in the vicinity of the channel. The insulated region thus resulting around the former faulty area will cause the capacitor to regain its full operation ability.

2.32、失效率 λ

表示元件在单位时间内发生失效的概率，数值上等于单位时间内失效的元件数与元件总数的比值。其单位为 FIT(也写成 Fit 或 fit) , 1FIT=1/(l0^9 小时)。
举例:1 0 000 只元件在给定条件下工作 1 0 000 小时出现了 10 只失效,则 λ =l0/(l0 000x10 000) =l00 FIT。

2.32. Failure rate λ

It indicates the failure probability of components in unit time and the value is the number of failure components in unit time compared to the total number of components. The unit of λ is FIT(also expressed as Fit or fit) and1 FIT=1/(l0^9 hrs).
For example, 10 000 pcs of components work at given conditions for 10 000 hrs and 10 pcs of components failed, so λ =10/(10 000x 10 000) =100 FIT.

三、电容器的预期寿命

电容器的预期寿命与电容器的运行电压及热点温度有关。对于应用在不同场合的电容器，它们的设计寿命是不同的。一般而言,应用在直流 1 虑応波电路中电容器,在额定电压及热点温度为 70℃的应用条件下，它们的预期寿命可达到 l 00 000 小时。

电容器的预期寿命是一个基于实践经验和理论计算的统计学数值。以下图片是电容器的预期寿命与运行电压及热点温度之间的特性曲线，仅仅作为理论参考。对于工作条件与额定条件有差别的情况，可以联系我们的技术部门。

三 Expected lifetime of the capacitor

The expected lifetime of the capacitor depends on the applied voltage and the hot spot temperature during operation. For capacitors applied in different situation, the designed average service lifes are different. Generally speaking, capacitors used in DC-Link circuits will have a expected lifetime of probablel00 000 hrs at rated voltage and 70℃ hot spot temperc1ture. Expected lifetime is a statistical value calculated on the basis of experience and on theoretical evaluations. The following diagrams show the correlation between expected life, operating voltage and hot spot temperature. The diagrams should be considered only as a theoretical reference. Please consult our technical department in case of working condition different from the rated ones.