1. Environment

(1) Water, salt water, oil, and other electro conductive liquid adhered to the capacitors may cause capacitor failure. Capacitors wetted with liquid must never not be operated.
(2) Capacitors must never be stored or operated in corrosive atmospheres, particularly not where chlorides, sulfides, acids, alkalis, salts, organic solvents or similar substances are present.
(3) Capacitors must not be operated in ozone or where ultra violet radiation or radio active rays are irradiating.
(4) In dust and dirt-prone environments, regular checks and maintenance (particularly of the terminals and insulators) are absolutely necessary to prevent creation of creepage distances between live parts and / or the protective conductor / ground. Dust and dirt shall be cleaned with paper or towel wetted with ethanol, not detergent.
(5) Excessive vibration and/or shock may cause capacitor failure.

2. Mounting Location

2-1. Precaution

(1) Mechanically or electrically damaged, leaky or otherwise damaged capacitors may not be used or continue to be used.
(2) Do not place the capacitors directly above or nest to heat sources such as detuning or tuning reactors, bus bars, etc.
(3) Enough creepage distances and air clearance have to be kept when connecting capacitors, bus bars and housings.

2-2. Mounting

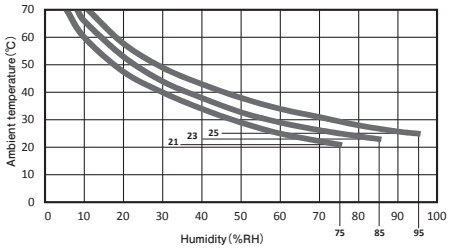
(1) Keep the torque described in catalog or data sheet. Toothed washer has to be used for fixing sutd bolt.
(2) Stud bolt

Series	Stud bolt	Torque
MLC/MLC2/MLCA	M12	7 ± 1Nm

(3) Three terminal type capacitors are equipped with Torx (T20). Use of improper screwdrivers may damage the screws and impair reliable fixation.
(4) Improper connection may cause local heat generation, and rupture and ignite. Don't apply excessive stress to terminals and stud bolt.
(5) The useful life of a capacitor may be reduced dramatically if exposed at excessive heat.
(6) The permitted max temperature of the capacitor must not be exceeded even under the most critical ambient circumstances.
(7) The inner temperature of capacitors must be verified not to exceed the maximum operating temperature specified in data sheet at the worst operating condition.
Capacitors with thermo sensor (PT100) are available depending of requests. Under force cooled condition, current over value specified in data sheet could be applied to capacitor. Please contact us when bus bars have high temperature and / or capacitors are placed with narrow space between them. They may cause increase in temperature of capacitors.
(8) It should be noted that the internal heat balance of large capacitors is only reached after a couple of hours when verifying inner temperature rise of capacitors.
(9) Capacitors with liquid or viscous filling shall be installed upright with terminals facing upwards. Capacitors with gas or solid resin filling can be mounted in any position without restriction.

3. Humidity

Capacitors may not be stored or operated outside the specified humidity ranges.



MLC/MLC2/MLCA series

max. relative humidity	: 75% annual means
	: 95% 30 days/year
condensation	: not permitted

4. Use condition

4-1. Ambient temperature / Current

(1) Capacitors must be operated according to the specification in catalog and / or data sheets.
(2) Overvoltage or thermal overload may cause rupture, ignition, and internal faults. When the highest temperature in capacitor is higher than 70℃, voltage derating has to be applied. For MLC and MLC2 series, permissible ripple current can be calculated from ambient temperature, operating voltage and information in data sheet or catalog.
Even if operating current is lower than permissible value, the current over permissible terminal current may cause excessive terminal heat generation.
(3) Ambient temperature is measured at point a point approximately 0.1m away from the capacitor housing and at two-third of the height from its base.
(4) It has to be noted that capacitors themselves generate heat.
(5) Permissible current decrease with the increase of ambient temperature. Therefore, It should be considered that capacitors must be selected by considering the operation at maximum ambient temperature.
(6) Frequency may affect electric load. Capacitors have to be selectedby considering the effect of frequency.
(7) It should be noted that resonance by inductance of external circuit may affect capacitor's performance.
(8) It should be noted that parallel connection may cause current unbalance because of the difference of circuit impedance.
(9) Harmonics current may cause excessive heat generation because of dielectric loss at low frequency, or skin effect at high frequency. When harmonics current includes frequencies under 50Hz and/or over 10kHz components, the inner temperature of capacitors must be verified.
We recommend to check the following characteristics before proceeding evaluation.
Please consult us for individual support if any of the following conditions apply.
a. Total current harmonic distortion based on the data computed exceed 200%
b. Ratio between total current power losses and total dielectric power losses exceed 150%
Capacitors with thermo sensor are not for endurance test, just for testing inner temperature rise. After the test, please scrap them.
The internal temperature should be measured after the inner temperature reachs saturation (approx. five hours).

4-2. Cooling

(1) Give at least 40mm for MLC / MLC2 / MLCA series or 20mm for the others of clearance between the capacitors for natural or forced ventilation for effective heat dissipation of capacitors.

4-3. Voltage / Other use condition

(1) Dielectric breakdown may cause severe internal fault such as short circuit, ignition and rupture.
Capacitors must be operated inside the specified range specified in catalog and/or data sheets.
For overvoltage within short period may not shorten service life time of capacitors.
(2) Capacitors must be operated under rated voltage. Surge voltage specified in data sheet is just for capacitor evaluation, and does not guarantee the continuous operation of capacitors.
(3) Inrush current may cause internal faults.
(4) Film capacitors have finite service life.
(5) DC capacitors must not be operated under AC condition. When ripple voltage over 20% of rated voltage is applied to DC capacitors, it may cause capacitor failure. In this case, please contact us.

5. Vibration / Shock

(1) Vibration and shock mainly affect fixing materials and terminals. It is important to measure the degree of vibration and shock at mounting location.
(2) The capacitors comply with test standard (IEC60068-2-6) as follows.

series	capacitor weight	test duration	frequency range	max. acceleration	max. displacement amplitude
MLC、MLC2、MLCA MKCP4、MKCP4T、MKCA	< 3kg	10 cycles per each axes	10 to 55Hz	50m/s^2	±0.35mm
	3kg ≤	information available on request			

6. Safety of self-healing type film capacitors

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. 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.
Surge voltages and surge currents within rated values induced by switching or faults of the system or any part of it are also permitted.

7. Mind hazards of explosion and fire

(1) Capacitors consist mainly of polypropylene, 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, overvoltage, harmonic distortion).
(2) 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 device.

8. Discharge

In any event, the poles of the capacitors must be discharged with 1kOhm or larger resistance before being touched.
Note that capacitors with nominal voltages above 750Vac or 2,000Vdc in particular may regenerate new voltage at their terminals after having been short-circuited just for short periods. This condition will be avoided by storing them permanently short circuited.

9. Earthing

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

10. Environmental Compatibility

(1) Our capacitors do not contain PCB, solvents or any other toxic or banned materials.
(2) Our capacitors comply with RoHS directive.

11. Storage

☆ Storage environment
- Ambient temperature : −40℃ to +35℃
- Humidity : max. RH75%
- Others : indoor without direct sunlight, without condensation

☆ Storage limitation
- 3 years without any verifications (2 years for lead-wire terminals)

If the storage time exceeds the above term, please confirm before usage that electric characteristics are within specifications, capacitor case is not covered with stains, and terminals are not covered with oxide layer.

12. Fumigation treatment

Fumigation treatment may be performed during transportation for insect proofing.
Halide such as methyl bromide may cause corrosion inside capacitors, and lead to failure.
Insecticide also may cause capacitor failure.

13. Disposal

(1) We recommend disposing of the capacitors through professional recycling centers for electric / electronic waste.
(2) After incineration of capacitors, matal parts such as terminal, aluminum case, lid and internal wirings will be remained.
(3) Please consider that disposed capacitors should not put on the market.

14. Others

(1) In case of fire, dried powder, carbon dioxide or foam fire extinguishing agent has to be used.
(2) Please comply with transportation and exporting regulation in each nation.
(3) Capacitors usually have design life of approx. 15 to 20 years under proper operating condition. In order to maintain the reliability of equipment, it is recommend to replace the capacitors after ten years operation.

15. Important notice before use

Hitachi AIC does not accept responsibility for whatever damage may arise out of a non-observance, or caused by capacitors without agreement on detail of use condition, evaluation condition etc.

Service life of plastic film capacitor for power eloctromics

16. Formula for estimating service life (MLC, MLC2, MLCA)

(1) Estimating from the core temperature of the capacitor and applied voltage Formula for calculating the service life of our capacitors in mid-to-high voltage applications (filters).

$$L = L_0 \times 2^{\frac{T_0 - T}{A}} \times \left(\frac{V_0}{V} \right)^N$$

Where,

To : Maximum core temperature setting when subjected to the maximum allowable ripple load at the maximum operating temperature

Lo : Standard service life when core temperature is T_0 and base voltage is (V_0)

L : Estimated service life when core temperature is T and applied voltage is (V)

A, N : Acceleration coefficients (contact us for details)

(2) Estimating core temperature of a capacitor from load ripple current

We recommend that you estimate service life by measuring the core temperature of the capacitor with a thermocouple. We can manufacture samples with inserted thermocouples according to customer requests.

If for some reason it is impossible to measure the core temperature, you can estimate the service life by making a rough estimate of the core temperature of the capacitor from the load ripple current. As shown below, assuming the rise in temperature and the square of load current to be nearly proportionate, obtain the core temperature of the capacitor that occurs when the capacitor is loaded with a ripple current.

$$T = T_a + I^2 \cdot ESR \cdot R_{th}$$

Where,

T : Core temperature of the capacitor when ripple current I is loaded (℃)

Ta : Ambient temperature (℃)

I : Ripple current (Arms)

ESR : Equivalent series resistance of capacitor (Ω)

Rth : Thermal resistance (K/W)

※ Ripple current (I) is limited by maximum current (Imax) specified for each capacitor.

Glossary

Rated capacitance C_N

Capacitance value rated at 20℃ / rated frequency.

Rated Voltage U_N

The maximum or peak voltage of either polarity of a reversing or nonreversing type wave form for which the capacitor has been designed and rated (unlike other standards for AC capacitors, the rated voltage is not the rms value).

Non repetitive peak (surge) voltage U_S

Voltages beyond the rated voltage induced by switching or faults of the system or any part of it. Maximum count 1000 times with a duration of not more than 50 ms each.

rms voltage U_{rms}

Root mean square of the max. permissible value of sinusoidal AC voltage in continuous operation.

Ripple voltage U_r

The peak-to-peak alternating component of the unidirectional voltage.

Voltage test between terminals U_{TT}

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_{TC}

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

Maximum current I_{max}

Maximum rms value of permissible current in continuous operation. The values given in the data sheets are related to either the specified maximum power dissipation or the current limits of the connection terminals.

Peak current $\hat{I}$

Maximum permitted repetitive current amplitude during continuous operation.

Non-repetitive peak current (surge) I_S

Maximum current that may occur non-repetitively and briefly in the event of a fault.
Maximum count 1000 times with a duration of not more than 50 ms each.

Equivalent series resistance R_S

Equivalent resistance representing the sum of all Ohmic resistances occurring inside the capacitor. Essential for calculation of the current dependent losses.

Self-inductance L_e

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

Resonant frequency f_{res}

The capacitance and self-inductance of any capacitor form a series resonant circuit.
Above the resonant frequency, the inductive part of this LC-circuit prevails.
The capacitor would then behave as an inductor.

Dielectric dissipation factor $\tan\delta_0$

Constant dissipation factor of the dielectric material for all capacitors in their rated frequency.

Thermal resistance R_{th}

The thermal resistance indicates by how many degrees the capacitor temperature at the hotspot rises in relation to the dissipation losses.

Maximum power dissipation P_{max}

Maximum permitted power dissipation for the capacitor's operation at a certain ambient temperature.

Ambient temperature θ_U

Temperature of the surrounding air, measured 10 cm away and at 2/3 of the case height of the capacitor.

Lower category temperature θ_{min}

Lowest permissible ambient temperature at which a capacitor may be used.

Upper category temperature θ_{max}

Highest permissible capacitor temperature during operation, i.e. temperature at the hottest point of the case.

Hotspot temperature $\theta_{HOTSPOT}$

Temperature at the hottest spot inside the capacitor.

Rated energy contents E_N

Energy stored in the capacitor when charged at rated voltage.

Clearance in air L

The shortest distance between conducting parts of the terminals or between terminals and case.

Creepage distance K

The shortest distance along an insulated surface between conducting parts of the terminals or between terminals and case.