Memory Products
Handling Precautions and Requests

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KIOXIA

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Handling Precautions and Requests

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Appendix

Chapter 1. Usage Notes for Memory Products

Even though we make continuous efforts to improve the quality and reliability of our products, devices can malfunction or fail.

When using our memory products (hereinafter called “Product”), customers are requested to consider at their responsibility the safety design of their hardware, software, and systems to prevent loss of human life, bodily injury or damage to property due to the malfunction or failure of a Product.

Before starting design for or using a Product, customers must read and comply with the latest information about the Product (this document, specifications, data sheets, application notes, and technical references for the Product) and the product instruction manuals and operation manuals for the application in which the Product will be used.

When using any technical content, including product data, diagrams, tables and information including program code, algorithms, and sample application circuits described in the above documents, for a product, the customer must thoroughly evaluate their own product independently as well as the system as a whole and determine the applicability of the information in relation to the customer’s responsibilities.

Chapter 2. Safety Precautions

This section lists important precautions that users of semiconductor products should observe in order to avoid injury to the user or anyone else and damage to property, and to ensure safe and correct use of our products. Please be sure that you understand the meanings of the labels and graphic symbols described below before you move on to the detailed descriptions of the precautions, and comply with the precautions stated.

[Explanation of Labels]

⚠ **DANGER**	⚠ **WARNING**	⚠ **CAUTION**	***NOTICE***
Indicates a hazardous situation, which, if not avoided, will result in death or serious injury[1].	Indicates a hazardous situation, which, if not avoided, could result in death or serious injury[1].	Indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury[2].	Indicates a practice that may cause property damage[3] and other problems, but not personal injury.

1. Serious injury includes blindness, wounds, burns (low and high temperature), electric shock, fractures, and poisoning, etc. with long-lasting effects or that require hospitalization and/or long-term hospital visits for treatment.
2. Minor or moderate injury includes wounds, burns, electric shock, etc. not requiring hospitalization and/or long-term hospital visits for treatment.
3. Property damage means damage to customer or third party machines and equipment.

[Explanation of Graphic Symbols]

🛇 **Prohibited**	❗ **Instructions**
Indicates prohibited actions.	Indicates actions that must be undertaken for safety purposes.

Chapter 2. Safety Precautions

2-1. General Precautions Regarding Devices

⚠CAUTION	
🛇 **Prohibited**	The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings. Exceeding the rating(s) may cause device breakdown, damage or deterioration, resulting in injury by explosion or combustion.
🛇 **Prohibited**	Do not insert any device in the wrong orientation or incorrectly. Make sure that the positive and negative terminals of power supplies are connected properly. Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause device breakdown, damage or deterioration, resulting in injury by explosion or combustion. In addition, do not use any device that was inserted in the wrong orientation or incorrectly and to which current was applied even just one time.
🛇 **Prohibited**	Do not touch a device or its heat sink while the device is on or immediately after it has been turned off. Devices become hot. Coming into contact with a device may result in a burn.
🛇 **Prohibited**	Do not touch the leading edges of a device. Some devices have edges. Coming into contact with a sharp edge may result in a puncture wound.
❗ **Instructions**	Check that there is no electrical leakage before grounding any measuring equipment or soldering irons. Electrical leakage may cause electric shock or the device you are testing or soldering to electrically break down.
❗ **Instructions**	In an evaluation, inspection or test, be sure to connect the test equipment's electrodes or probes to the pins of the device before turning the power on. When you have finished, discharge any electrical charge remaining in the device. Failure to do so may cause electric shock, resulting in injury.

Chapter 3. General Usage Considerations

This chapter provides general information to correctly understand memory devices our memory products in order to ensure the safety, quality and reliability of the devices.

3-1. From Incoming to Shipment

3-1-1. Electrostatic Discharge (ESD)

The devices are very sensitive to electrostatic discharge (ESD).

High voltages generated by ESD can damage the devices. In particular, MOS type devices can be damaged by as little as 10 to 20 volts. Humans can feel an ESD of 2 to 3 kilovolts, which indicates that a trace amount of voltage can damage a device. To prevent ESD damage, ESD controls are required.

Handle the devices in an ESD-protected environment by personnel wearing ESD-protective smocks or garments, ESD-protective footwear and wrist straps. Use ESD-protective materials for packing, filler and carriers that have direct contact with the devices.

Perform routine control and maintenance for air ionizer and/or static neutralizer to make sure that they are functioning properly.

Follow the instructions below for the devices with ESD* caution labels.

*: ElectroStatic Discharge

3-1-1-1. ESD Control at Work Areas

(1) A lower relative humidity is a static-prone environment by friction. The devices absorb the moisture in the work areas after a sealed moisture-barrier bag is opened. Control the relative humidity in the work areas within a range from 40 to 70%RH.

(2) Ground all the equipment, jigs and tools installed in the work areas.

(3) Use grounded ESD-protective flooring or floor mats in the work areas. Resistance to ground shall be 1 x 109 ohms or less

(4) Use grounded ESD-protective worksurface or mats. Resistance to ground shall be 7.5 x 105 to 1 x 109 ohms. Do not use metallic worksurface. Metallic materials are of low resistance, which can induce rapid discharge if a charged device touches such metallic materials.

(5) Perform the following ESD controls for automated equipment and tooling if used.

  (a) If vacuum pick-up tools are used, use ESD-protective material tip.

  (b) Avoid friction of the equipment or tooling on the device surface to the extent possible. If mechanical structure of the equipment/tooling cannot avoid touch, minimize the area of the device plane to touch the equipment/tooling or use low-resistance materials with low coefficient of friction as well as ionizers to neutralize static charges.

  (c) Use dissipative materials for the areas that can touch leads or terminals of the devices.

  (d) Avoid touch of the devices with charged objects such as clothing or human bodies.

  (e) Use low-resistance materials for the surface of carrier tapes that touches the devices.

  (f) Avoid touch of jigs and tools used in the workstations with the devices.

(g) At workstations in which operations causing packaged devices to be statically charged are performed, use air ionizers to neutralize static charges in the atmosphere.

(6) Use grounded ESD-protective work chairs that use such as ESD-protective cover and casters. Resistance to ground shall be 1 x 1010 ohms or less.

(7) Place ESD-protective mats on storage shelf surfaces and ground the mat surface. Resistance to ground shall be 7.5 x 105 to 1 x 109 ohms.

(8) Use static-shielding bags, carriers and containers to store and transport the devices.

(9) Use carts with conductive wheels grounded and with conductive materials at the surface that touches carriers or containers in which devices are placed.

(10) The ESD-protected area (EPA) must have a common ESD ground wire that meets the requirements for protective ground for power transmission and trunk lines. Ground each equipment to the ground wire individually.

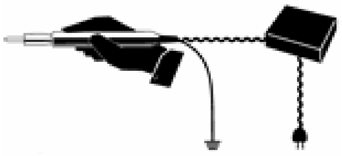
(11) Protect surfaces of displays in the EPA from static electricity. Avoid or minimize turning on or off computer in the EPA during operating the devices.

(12) Periodically measure electric potentials of the devices, equipment, apparatus, systems, fixtures and tools in the EPA to make sure that they are not statically charged.

3-1-1-2. ESD Control During Handling and Operations

(1) Personnel must wear ESD-protective smocks or garments as well as ESD-protective footwear (shoes, toe straps or heal straps).

(2) Personnel must wear wrist straps grounded via a resistor. Resistance to ground (when worn) shall be 7.5 x 105 to 3.5 x 107 ohms



(3) Soldering irons must be grounded from the iron tip and must be low-voltage type (6 to 24 volts).

(4) Tweezers, if used, that may touch leads or terminals of the devices must be ESD-protective. Do not use metallic tweezers. Metallic materials are of low resistance, which can induce rapid discharge if a charged device touches such metallic materials. Vacuum tweezers, if used, must have ESD-protective suction pads at the tip and be grounded, used and maintained per manufacturer’s instructions.

(5) The devices and/or carriers in which the devices are stored must not be placed or stored near sources generating high fields such as above field emission displays.

(6) Printed circuit boards (PCBs) populated with the devices must not be stacked in order to avoid physical contacts between populated PCBs. Stacking populated PCBs can be charged and discharged by friction. Populated PCBs must be stored in ESD-protective storage racks or shelves with clearance between populated PCBs.

(7) Clipboards or similar items used in the EPA should be made of ESD-protective materials.

(8) Personnel should wear ESD-protective gloves or finger cots while touching the devices.

(9) Protective covers and equipment guarding near the devices must be made of materials with resistance of 1 x 109 ohms or less.

(10) If personnel cannot wear wrist straps during operations that may touch the devices, use ionizers.

(11)Tape and reel (T&R) uses static-prone carrier tapes. While the devices packed in T&R are handled, use ionizers to prevent the carrier tapes from being charged.

3-1-2. Transportation

(1) Handle outer cardboard boxes with care. Do not drop or throw the boxes. Doing so can damage the Product in the boxes on physical impact.

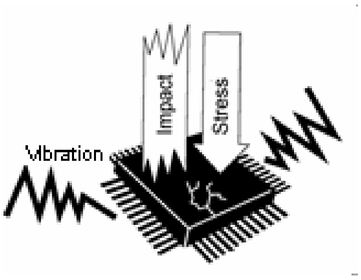
(2) Handle inner cardboard boxes with extra care. Dropping the boxes can cause the devices in the boxes to protrude through the trays and deform the leads or terminals of the devices.

(3) Keep the cardboard boxes dry.

(4) Minimize any mechanical vibrations or shocks to cardboard boxes, especially those containing wafer-level products, during transportation.

3-1-3. Vibration, Impact and Stress

Handle the packed devices as well as unpacked devices with care. Do not drop or throw the packed or unpacked devices. Doing so can damage the devices on physical impact. Minimize any mechanical vibrations or shocks on the packed or unpacked devices.



Vibrations, impacts or stresses to the devices mounted on a printed circuit board (PCB) or solder joints/ interconnects can cause solder joint failure or damage integrated circuit (IC) elements in the devices. This must be carefully considered in PCB level and system level designs.

Strong vibrations, impacts or stresses can cause package cracks or IC chip cracks in packaged devices. Stresses to an IC chip in a packaged device can change resistance in the IC chip due to the piezoresistance effect and change characteristics of IC elements.

Reports show that prolonged stresses to the devices can deform or break constituents of an IC chip or cause IC elements failures although momentary stresses are not to that extent. Vibrations, impacts and stresses must be carefully considered in PCB level and system level designs.

3-2. Storage

3-2-1. Dry Packing

Devices packed in a moisture-barrier bag (MBB) must be handled with due care in accordance with the KIOXIA’s handling guideline specified for the applicable packing type. Failure to do so may cause the quality and reliability of the devices to deteriorate. This section provides general handling precautions for the MBB .

3-2-1-1. General Handling Precautions for Dry Packing

(1) Keep the MBB away from direct sunlight and environment that could wet the MBB.

(2) Follow the description on the caution label on the packing box for handling during transportation and storage.

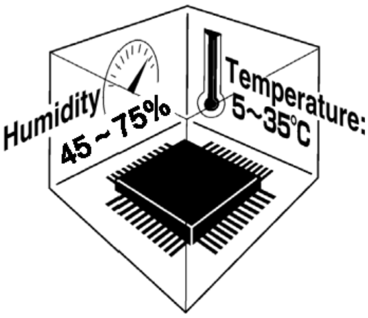
(3) Follow the description in subsection 3-1-2. “Transportation” for handling during transportation.

(4) Do not toss or drop the MBB. Doing so may cause the MBB to tear and result in a loss in airtightness.

(5) Keep the MBB in storage away from poisonous gases (especially corrosive gases) and dusty environments.

(6) Do not impose direct loads on the MBB in storage or do not allow the MBB under direct load.

(7) Store the MBB at the storage environmental, temperature and relative humidity conditions specified in the applicable individual delivery specification. If not specified, ask our sales representatives.



(8) If the shelf life of the sealed MBB is exceeded, or if the 30% spot of the humidity indicator card (HIC) is pink when the MBB is opened even within the shelf life, bake the devices as stated in Table 3-2-1. The floor life (i.e. the allowable time from opening the MBB to the solder process without baking), if the devices removed from the MBB have been stored at a temperature range from 5°C to 30°C and a relative humidity of 60%RH or less, is printed on the MBB. If the floor life is exceeded, or if the devices removed from the MBB have been stored in a high humidity environment or an environment where condensation can occur, bake the devices before the solder process.

(9) Protect the devices from ESD damage during baking process.

(10) The HIC detects an approximate value of the ambient relative humidity at a normal temperature of 25°C. Figure 3-2-1 shows an example of a 1 spot HIC.

Figure 3-2-1 shows a 1-point indicator.

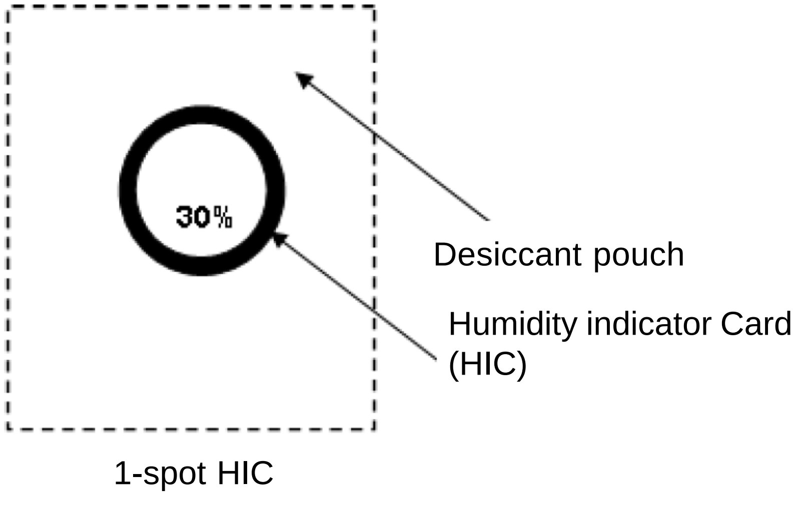


Figure 3-2-1. An example of a HIC

Table 3-2-1. Bake-resistant carrier types and baking conditions for memory devices

Carrier Type	Bake-resistant carrier types and baking conditions
Tray	The MBB is not heat-resistant. Do not bake the devices in the MBB. Observe the following. (1) If trays are heat-resistant (i.e. trays marked with “heatproof” or a high temperature), (i) Remove the trays from the MBB, and (ii) Bake the devices in the original trays in accordance with the instructions printed on the MBB. (2) If trays are not heat-resistant (trays not marked with “heatproof” or a high temperature), (i) Remove the trays from the MBB, (ii) Remove the devices from the original trays to another heat-resistant ESD-protective trays, and (iii) Bake the devices in the heat-resistant ESD-protective trays in accordance with the instructions printed on the MBB.
Tape and reel (T&R)	The MBB is not heat-resistant. Do not bake the devices in the MBB. The reel, the embossed tapes and the cover tapes are not heat-resistant. Do not bake the devices in the tape and reel. Observe the following. (i) Remove the tape and reel from the MBB. (ii) Remove the devices from the tape and reel to another heat-resistant ESD-protective carrier. (iii) Bake the devices in the heat-resistant ESD-protective carrier in accordance with the instructions printed on the MBB.

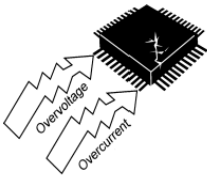
3-3. Design

To achieve the reliability required by an electronic device or system, it is important not only to use the device in accordance with the specified absolute maximum ratings and operating ranges, but also to consider the environment in which the equipment will be used, including factors such as the ambient temperature, humidity, vibration, impact, stress, transient noise and current surges, as well as mounting conditions which affect device reliability. This section describes general design precautions. Be sure to refer to the respective technical datasheets of each product when performing design.

3-3-1. Absolute Maximum Ratings

⚠CAUTION	
⊘ **Prohibited**	The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings. Exceeding the rating(s) may cause device breakdown, damage or deterioration, resulting in injury by explosion or combustion.

If the voltage or current on any pin exceeds the absolute maximum rating, the overvoltage or overcurrent causes the device's internal circuitry to deteriorate. In extreme cases, heat generated in internal circuitry can fuse wiring or cause the device chip to break down.



If the storage or operating temperature exceeds the absolute maximum rating, the device internal circuitry may deteriorate and the bonded areas may open or the package airtightness may deteriorate due to the differences between the thermal expansion coefficients of the materials from which the device is constructed.

Although absolute maximum ratings differ from product to product, they essentially concern the voltage and current at each pin, the allowable power dissipation, the connecting area temperatures, and storage temperatures.

Note that the term "maximum rating" which appears in the respective technical datasheets and the like refers to the "absolute maximum rating."

3-3-2. Operating Range

The operating range is the range of conditions necessary for the device to operate as specified in the respective technical datasheets. Care must be exercised in the design of equipment. If a device is used under conditions that do not exceed absolute maximum ratings but exceed the operating range, the specifications related to device operation and electrical characteristics may not be met, resulting in a decrease in reliability.

If greater reliability is required, derate the device’s operating ranges for voltage, current, power and temperature before use.

3-3-3. Derating

The term “derating” refers to ensuring greater device reliability by setting operating ranges reduced from rated values and taking into consideration factors such as current surges and noise.

While derating generally applies to electrical stresses such as voltage, current and power, and environmental stresses such as ambient temperature and humidity, the level of derating greatly affects reliability.

3-3-4. Unused Pins

If unused pins are left open, some devices exhibit input instability, resulting in faulty operation such as a sudden increase in current consumption. In addition, if unused output pins on a device are connected to the power supply, GND or other output pin, the IC may malfunction or break down.

Since the treatment of unused input and output pins differs for each product and pin, please refer to the explanations in the respective technical datasheets. If no treatment method is described in the respective technical datasheets, please seek guidance from our sales contact.

CMOS logic IC inputs, for example, have extremely high impedance. If an input pin is left open, it can readily pick up noise and become unstable. In this case, if the input reaches an intermediate level, both the P-channel and N-channel transistors will become conductive, allowing unnecessary power supply current to flow. It is therefore necessary to ensure that the unused input gates of a device are connected to the power supply pin or ground (GND) pin of the same product. For treatment of heat sink pins, refer to the respective technical datasheets.

3-3-5. Latch-Up

Devices sometimes transition to an inherent condition referred to as “latch-up.” This condition mainly occurs in CMOS devices. This happens when a parasitic PN-PN junction (thyristor structure) built in the semiconductor product itself is turned on, causing a large current to flow between the power supply voltage and GND, eventually causing the device to break down.

Latch-up occurs when the voltage impressed on an input or output pin exceeds the rated value, causing a large current to flow in the internal element, or when the voltage impressed on the power supply voltage pin exceeds its rated value, forcing the internal element to breakdown. Once the element falls into the latch-up state, even though the excess voltage may have been applied only for an instant, the large current continues to flow between the power supply voltage and GND, potentially causing product explosion or combustion. To avoid this problem, observe the following:

(1) Do not allow the voltage levels on the input and output pins to rise above the power supply voltage or decrease below GND. Consider the timing of power supply activation as well.

(2) Do not allow any abnormal noises to be applied to the device.

(3) Set the electrical potential of unused input pins to the power supply voltage or GND.

(4) Do not create an output short.

3-3-6. Input/Output Protection

Wired-logic configurations in which outputs are connected together directly cannot be used since the outputs short-circuit with the configurations. Outputs should never be connected to the power supply voltage or GND. In addition, products with tri-state outputs can undergo product deterioration if a shorted output current continues for a long period of time. Design the circuit so that the tri-state outputs will not be enabled simultaneously.

3-3-7. Load Capacitance

Certain devices exhibit an increase in delay times and a large charging and discharging current if a large load capacitance is connected, resulting in noise. In addition, since outputs are shorted for a long period of time, wiring can become fused. Use the load capacitance recommended for each product.

3-3-8. Thermal Design

The failure rate of devices largely increases as the operating temperatures increase. As shown in Figure 3-3-1, the thermal stress applied to device internal circuitry is the sum of the ambient temperature and the temperature rise caused by the power consumption of the device.

Chapter 3. General Usage Considerations

Please refer to the considerations for thermal design in the respective technical datasheets. To achieve even higher reliability, take into consideration the following thermal design points:

(1) Conduct studies to ensure that the ambient temperature (Ta) is maintained as low as possible, avoiding the effects of heat generation from the surrounding area.

(2) If the device's dynamic power consumption is relatively large, conduct studies regarding use of forced air-cooling, circuit board composed of low thermal resistance material, and heat sinks. Such measures can lower the thermal resistance of the package.

(3) Derate the device's absolute maximum ratings to minimize thermal stress from power consumption.

$\Theta ja = \Theta jc + \Theta ca$

$\Theta ja = (Tj - Ta)/P$

$\Theta jc = (Tj - Tc)/P$

$\Theta ca = (Tc - Ta)/P$

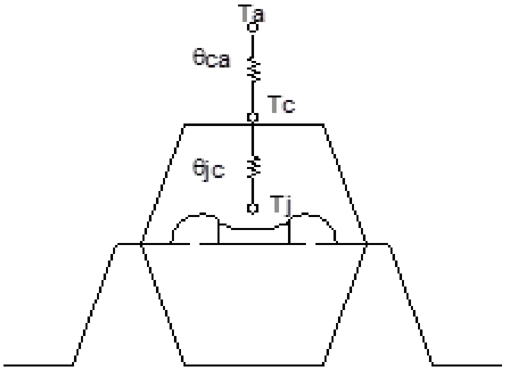


Figure 3-3-1. Thermal Resistance of Package

Θja: Thermal resistance between junction and ambient air (°C/W)

Θjc: Thermal resistance between junction and package surface, or internal thermal resistance (°C/W)

Θca: Thermal resistance between package surface and ambient air, or external thermal resistance (°C/W)

Tj: Junction temperature or chip temperature (°C)

Tc: Package surface temperature or case temperature (°C)

Ta: Ambient temperature (°C)

P: Power consumption (W)

3-3-9. Mechanical Stress

Applying mechanical stress to packages can degrade the adhesion strength of the packages and allow moisture and contaminants to seep into the packages, thereby degrading the quality of the devices.

3-3-10. Interfacing

When connecting devices with different input and output voltage levels, make sure that the input voltage (VIL/VIH) and output voltage (VOL/VOH) levels match. Otherwise, the devices may malfunction.

To transfer data between two pins, make the input setup/hold times and the output transmission delay consistent. Otherwise, the devices may malfunction. In addition, when connecting devices with different power supply voltages, such as in a dual power supply system, device breakdown may result if the power-on and power-off sequences are incorrect.

For memory-product interface details, refer to the respective technical datasheets. In addition, if you have any questions about interfacing, contact your nearest Kioxia office or distributor.

3-3-11.Decoupling

Spike currents generated during switching can cause power supply voltage and GND voltage levels to fluctuate, causing ringing in the output waveform or a delay in the response speed. (The power supply and GND wiring impedance is normally 50 to 100 Ω.) For this reason, the impedance of the power supply lines with respect to high frequencies must be kept low.

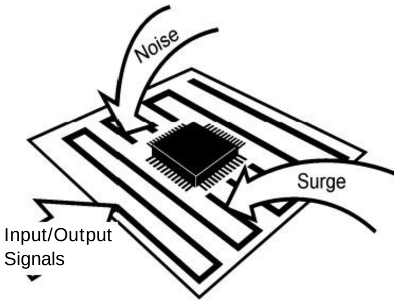
Specifically, this is ideally accomplished by routing thick and short power supply and GND lines and by inserting decoupling capacitors (of approximately 0.01 to 1 μF) as high-frequency filters between the power supply and GND into each required location on the circuit board.

For low-frequency filtering, it is appropriate to insert a 10 to 100 μF capacitor in each circuit board. However, conversely if the capacitance is excessively large (such as 1000 μF), latch-up may result. An appropriate capacitance value is therefore required.

On the other hand, in the case of high-speed logic ICs, noise is caused by reflection, crosstalk or common power supply impedance. Reflections cause increased signal delay, ringing, overshoot and undershoot, thereby reducing the device’s noise margin. One effective wiring measure for preventing reflections is to reduce the wiring length by increasing the mounting density so as to lower the wiring inductance (L) and capacitance (C). This measure, however, also requires consideration with regard to crosstalk between wires. In actual pattern design, both of these factors must be considered.

3-3-12. External Noise

When externally induced noise or surges are applied to a printed circuit board with long I/O signals or signal lines, malfunction may result, depending on the device.



To protect against noise, protective measures against surges must be taken such as lowering the impedance of the signal line or inserting a noise-canceling circuit. For details of the required protection, refer to the respective technical datasheets.

3-3-13.Electromagnetic Interference

Radio and TV reception problems have increased in recent years as a result of increased electromagnetic interference radiated from electrical and electronic equipment. To use radio waves effectively and to maintain the quality of radio communications, each country has defined limitations on the amount of electromagnetic interference that designated devices can generate.

The types of electromagnetic interference include noise propagated through power supply and telephone lines, and noise from direct electromagnetic waves radiated from equipment. Different measurement methods and corrective actions are used for each type.

Difficulties in countering electromagnetic interference derive from the fact that there is no means for calculating at the design stage the strength of the electromagnetic waves produced from each component in a piece of equipment. As a result, measurements are taken after the prototype equipment has been completed using dedicated instruments to determine for the first time the strength of the electromagnetic interference.

Yet it is possible during system design to incorporate measures for the prevention of electromagnetic interference, which can facilitate corrective action after design completion. One effective method, for example, is to design the product with several shielding options, and then select the optimum shielding method based on the results of the measurements subsequently taken.

3-3-14.Peripheral Circuits

In many cases, devices are used with peripheral circuits and components. The input and output signal voltages and currents in these circuits must be designed to match the specifications of the device, taking into consideration the factors below.

(1) Input voltages and currents that are not appropriate with respect to the input pins may cause malfunction. Some devices contain pull-up or pull-down resistors, depending on specifications. Design your system taking into account the required voltage and current.

(2) The output pins on a device have a predetermined external circuit drive capability. If a drive capability exceeding this value is required, either insert a compensating circuit or take that fact into account when selecting components for use in external circuits.

3-3-15.Safety Standards

Each country and region has established safety standards that must be observed. These safety standards sometimes include requirements for quality certification systems and insulation design standards. The safety standards of the respective countries and regions must be taken fully into account to ensure compliant device selection and design.

3-3-16.Other

(1) When designing a system, incorporate fail-safe and other measures according to system application. In addition, debug the system under actual mounting conditions.

(2) If a plastic package device is placed in a strong electric field, surface leakage may occur due to charge-up, resulting in malfunction. When using such a product in a strong electric field, take measures by, for example, protecting the package surface with a conductive shield.

(3) With memory devices, attention is required at power on and reset release. To ensure that your design is appropriate for a memory product, refer to the respective technical datasheets.

(4) Do not shut off the power supply while rewriting flash memory. High electric fields generated inside the package due to the power shutting off can destroyits internal elements.

(5) Design the casing to ensure that no conductive material (such as a metal pin) can drop from an external source onto a terminal of a mounted device, causing a short.

3-4. Inspection, Testing and Evaluation

3-4-1. Grounding

⚠CAUTION	
❗ **Instructions**	Check that there is no electrical leakage before grounding any measuring equipment or soldering irons. Electrical leakage may cause electric shock or the device you are testing or soldering to electrically break down.

3-4-2. Inspection Sequence

⚠CAUTION	
🛇 **Prohibited**	Do not insert devices in the wrong orientation or incorrectly. Make sure that the positive and negative terminals of power supplies are connected properly. Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the semiconductor-product breakdown, damage or deterioration, and may result injury by explosion or combustion. In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.
❗ **Instructions**	In an evaluation, inspection or test, be sure to connect the test equipment’s electrodes or probes to the pins of the device before turning the power on. When you have finished, discharge any electrical charge remaining in the device. Failure to do so may cause electric shock, resulting in injury.

(1) Apply voltage to the device after inserting it into the test jig. At this time, observe the power supply activation and shutdown standards, if there are any.

(2) After test completion, be sure that the voltage applied to the device is off before removing the semiconductor product from the test jig. Removing the semiconductor product with the power supply on can cause device deterioration or breakdown.

(3) Make sure that no surge voltages from the measuring equipment are applied to the semiconductor product.

(4) Note that X-ray radiation can change product characteristics during X-ray inspection.

3-5. Mounting

Our memory products are packaged surface-mount devices (SMDs). Reliability of SMDs mounted on a printed circuit board (PCB) is affected by contamination by flux or thermal stresses during the soldering process. Particularly for SMD, thermal stresses applied to entire packaged SMDs during solder reflow is the most significant problem. Different soldering techniques may be used for SMDs with different IC chip sizes and lead frame designs. For details, refer to the technical datasheets for individual memory products.

Vibrations, impacts or stresses to soldered areas, solder joints or solder interconnects on a printed circuit board (PCB) can cause solder joint failure or damage integrated circuit (IC) elements. Strong vibrations, impacts or stresses can cause package or IC chip cracks in packaged SMD. Vibrations, impacts and stresses must be carefully considered in PCB level and system level designs.

3-5-1. Soldering Temperature Profile

Soldering techniques and a typical reflow soldering temperature profile are shown below. Different soldering techniques and conditions may be applicable to different products. For appropriate soldering techniques and conditions to individual memory products, refer to the applicable technical datasheets. For inquiry about special soldering techniques or conditions, contact our local representatives.

3-5-1-1. Soldering Iron (For TSOP Types)

Complete a hand soldering process using a soldering iron at a temperature of 350°C within 3 seconds.

3-5-1-2. Infrared Reflow Soldering (Typical Example)

(1) During a reflow cycle, the solder joint temperature (lead or ball surface temperature) must reach 230°C for 10 or more seconds. The package surface temperature must reach 220°C for no more than 60 seconds. The package peak temperature must not exceed 260°C. The ramp-up rate must be 3°C/second maximum.

(2) Refer to Figure 3-5-1 for a temperature profile example.

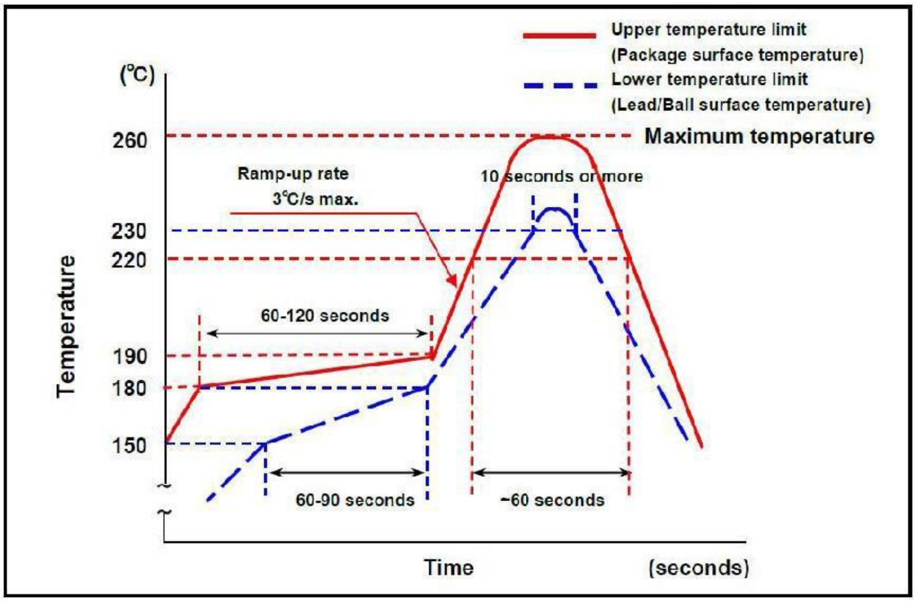


Figure 3-5-1. Example of Temperature Profile

In the temperature profile in Figure 3-5-1, the upper temperature limit is defined from the maximum heat-resistant temperature of the device. The lower temperature limit is defined from the solder wettability. Set appropriate preheat temperature and heating temperature to the solder paste type and other conditions you use within the specified temperature profile.

3-5-1-3. Flow Soldering and Dip Soldering

Our memory products support neither the flow soldering nor the dip soldering.

3-5-2. Flux Cleaning

(1) Remove flux in a way that no reactive ions such as sodium or chlorine remain. Some organic solvents react with water and generate hydrogen chloride and other corrosive gases, which can deteriorate the devices.

(2) Ensure that no reactive ions such as sodium or chlorine remain after water wash.

(3) Do not rub the laser-marked surface of the devices with a brush or hand during cleaning or while flux remover/cleaner remains on the devices. Doing so can rub off the markings.

(4) Flux removal methods by immersion, shower and steam use chemical reaction of solvents. Appropriate conditions of these methods must be determined based on recommendations by manufacturers of the flux remover/cleaner and at your own discretion.

(5) Ultrasonic cleaning must be completed in a short time. Long-time ultrasonic cleaning may deteriorate the adhesion between the mold compound and lead frame. The recommended basic ultrasonic cleaning conditions are shown below.

Frequency: 27 to 29 kHz

Ultrasonic power: 15 W/L or less

Cleaning time: 30 seconds or less

Place populated printed circuit boards into a ultrasonic bath in a way to ensure that the boards float in the cleaner liquid and neither the printed circuit boards nor the devices touch with an ultrasonic vibrator.

3-5-3. No Flux Cleaning

No flux cleaning may cause minute leakage between leads or migration depending on the flux grades. Make sure whether the flux type you use needs flux cleaning or not. Be sure to use no-clean flux if you do not perform flux cleaning.

3-5-4. Socket Mounting

(1) Use device sockets that fit the device package type you mount on a printed circuit board (PCB).

(2) Use device sockets that exert appropriate contact pressure on contact planes. Repeated insertions and removals may cause contact failure or may deform terminals of the devices if the contact pressure is strong.

(3) Use device sockets designed to prevent flux ingress to contact planes or to be washable so that remaining flux is fully removed.

(4) Avoid contact of conformal coating, applied to a PCB to protect from moisture ingress, with contact planes of device sockets.

(5) If a rework is really necessary to correct leads of the devices severely deformed by insertions to and removals from device sockets, allow only one rework. Do not allow two or more reworks.

(6) If populated PCBs are externally vibrated, use device sockets that exert a large contact pressure in order to prevent vibration between the devices and the device sockets.

3-5-5. Chips Mounting

Bare chips are more susceptible to external stresses than plastic-encapsulated (plastic-packaged) devices. Handle bare chips with due care.

(1) Mount care chips in a clean room to protect the bare chips from atmospheric contaminants and chemical substances.

(2) Protect the bare chips from ESD damage during handling and mounting. It is recommended to mount the bare chips on a PCB after all other neighboring components are mounted on the PCB.

(3) Make sure that etchant or chemical is completely removed from a PCB on which the bare chips are mounted.

(4) Make sure that the bare chip mount technology you use ensures appropriate electrical, thermal and mechanical characteristics provided as a device.

*For details about bare chips, refer to the relevant datasheet specification.

3-5-6. Conformal Coating

You may use printed circuit boards (PCB) to which conformal coating is applied in order to improve the reliability of the PCB and components on the PCB and to protect them from moisture, corrosive gases, dusts and other harmful environmental factors. Make sure that the coating material produces less stresses.

3-5-7. Rework and Reuse of Mounted Devices

Do not remount or reuse the mounted devices if they have been (1) desoldered, (2) reverse-mounted or energized in the reversed polarity or (3) reworked in lead forming. Remounting or reusing such devices can cause critical problems in characteristics and/or reliability.

3-6. Operating Environment

3-6-1. Temperature

The devices are generally more sensitive to temperature than other electromechanical components. Electrical characteristics of the devices are limited by operating temperatures. Make sure that temperature derating is considered in designing the surface-mount technology you use. Operating the devices outside the rated temperatures will impede the proper performance of designed electrical characteristics and hasten the deterioration of the devices.

3-6-2. Humidity

Plastic-encapsulated (plastic-packaged) devices are hermetically not complete. Prolonged use of the devices in high-humidity environments can cause deterioration or failure of the IC chip in the devices by moisture ingress into the devices. Use in environments where condensation can occur can cause oxidation or migration of leads of the devices. If a conventional printed circuit board (PCB) is used, high humidity environments can lower the impedance between traces. If such PCB is used in a system having high impedance of the signal source, such leakage in the PCB or between terminals of the devices can cause malfunction. In such a case, moisture-barrier treatment should be applied to the device surface. In low-humidity environments, electrostatic discharge (ESD) damage is concerned. PCB-level and system-level designs should allow use in operating relative humidity environments within the range from 40 to 70%RH.

3-6-3. Corrosive Gases

Devices may experience corroded leads or degraded characteristics when used under conditions with corrosive gases such as SOx, NOx, or H2S.
Especially when corrosive gas and a high humidity environment overlap, the speed of degradation increases to a rapid pace, and a chemical reaction may cause an electrical leakage between leads. For example, sulfidizing gas may be generated from rubber products, which may lead to corrosion of the leads of devices and leakage between leads. Therefore, the use of rubber products around devices requires consideration.

3-6-4. Radioactive and Cosmic Rays

Devices are not designed with protection against radioactive and cosmic rays. Therefore, devices must be shielded if they will be used in environments that may result in exposure to radioactive or cosmic rays above the levels that exist in the natural environment.

Furthermore, depending on the product, unexpected errors, such as bit inversion in the memory cell and data inversion of the latch circuit, may occur due to external radiation or the influence of cosmic rays reaching the ground. This is called a soft error.
When designing equipment, it is necessary to design sufficient shielding or prepare a safety design according to the operating environment of the system by applying ECC, etc.

3-6-5. Strong Electrical and Magnetic Fields

Devices exposed to magnetic fields can undergo a polarization phenomenon in the plastic material or within the chip, which gives rise to abnormal conditions such as impedance changes or leak current increases. Malfunctions have been reported in LSIs mounted near television deflection yokes. In such cases, the LSI mounted locations must be changed or the device must be shielded against the electrical or magnetic field. Shielding against magnetism is especially required in an alternating magnetic field due to the electromotive forces generated.

3-6-6. Interference from Light (such as Ultraviolet Rays, Sunlight, Fluorescent Lamps, Incandescent Lamps)

Light striking a device generates electromotive force due to photoelectric effects, sometimes causing malfunction. Devices in which the chip is visible through the package are especially affected by such light. When designing the circuits, make sure that the devices are protected against light interference. Not just optical semiconductor products, but all types of devices are affected by light.

3-6-7. Dust and Oil

Similar to corrosive gases, dust and oil cause chemical reactions in devices, sometimes adversely affecting product characteristics. Be sure to use devices in an environment that will not result in dust or oil adhesion. Similarly, solvent and oil contained in heat release sheets may result in device quality deterioration, characteristic deterioration or disconnection. Be sure to use such products with care.

3-6-8. Smoke and Ignition

Devices and modularized devices are not noncombustible; they can emit smoke or ignite when excessive current or failure occurs. When this happens, poisonous gases may be produced. Be sure to develop a safe design that protects the device from excessive current so as to ensure excessive current does not flow within the product during operation or in the event of failure.

To prevent the propagation of fire caused by a smoking or ignited Kioxia product and to ensure that Kioxia products do not emit smoke or ignite due to the surrounding conditions, do not use them in close proximity to combustible, heat-generating, ignitable or flammable materials.

3-7. Disposal

Each country and region has laws and regulations regarding the proper disposal of devices and packing materials. Be sure to follow these laws and regulations when performing disposal.

Appendix

1. Derating Concepts and Methods

1-1. Concepts of Derating

Reliability greatly changes based on the level of derating, even within rated values. The usage conditions of devices are left to system designers and they affect the mean time between failures (MTBF) of a system and its useful life span. Therefore, system designers must consider the reliability characteristics of devices and check individual derating factors. Temperature and power derating factors particularly need be modeled with consideration for environmental conditions.

Here is an example of derating. These conditions include those for worst case scenarios, including surges.

Temperature: Tj = 80% Tj MAX or less

* Assuming approximately 10 years of intermittent use (about three hours per day)

Tj = 50% Tj MAX or less

* Assuming approximately 10 years of 24-hour use in applications that require high reliability

※ Tj should be replaced by a temperature rating specified in the datasheet (e.g., Ta or Tch) if the product is not rated with Tj.

Voltage: 80% of the maximum rating or less (Integrated circuits: within the recommended operating range)

Current: Average current 80% of the maximum rating or less (rectifying elements: 50% of the maximum rating or less)

Peak current: 80% of the maximum rating or less

Power: 50% of the permissible maximum loss or less

Appendix

For high reliability, a further derated design is required. Derating factors should be determined, referring to the technical datasheets of individual products and their reliability data. In addition, there are safe operation areas (SOAs) and other factors that must be observed during product design. Therefore, be sure to follow the specifications of each individual component.

It is no exaggeration to say that the reliability of an end product depends on that of its constituent components. To realize high reliability, an appropriate derating design is required, considering the reliability characteristics of devices.

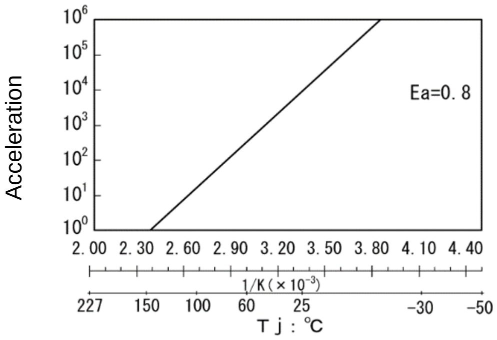
1-2. Methods of Derating

It has been verified that KIOXIA's memory products do not enter the wear- out failure period of the bathtub curve within the reliability test time. For system design, the ratings of devices must be derated so that they will not reach the wear-out failure period (within the reliability test time) in each failure mode under the assumed actual usage conditions.

The following shows how to calculate reliability test conditions for commonly used failure modes, based on the results of KIOXIA's past reliability testing.

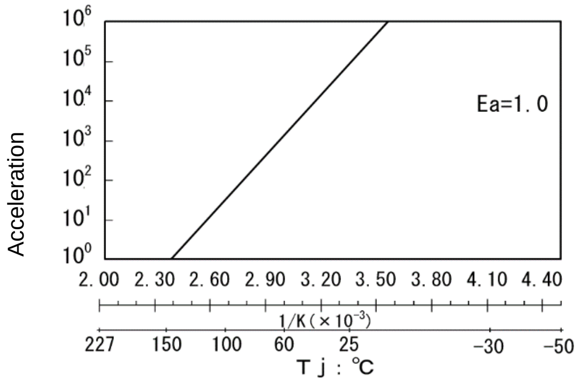
Appendix

(1) Characteristics variations (Vth, hFE, etc.)

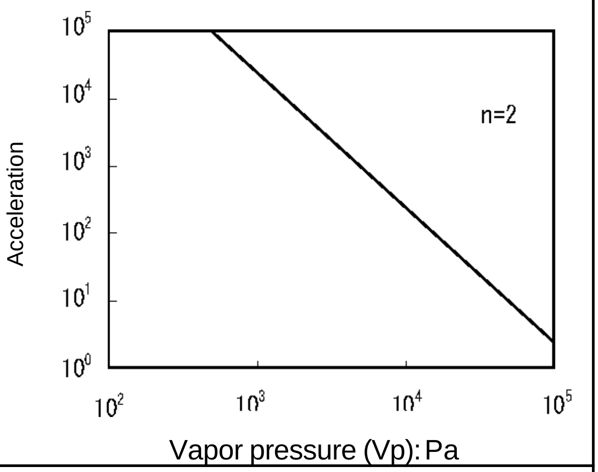
Acceleration model	Arrhenius model: $\alpha \infty \exp(-Ea/k \cdot 1/T)$ Ea: Activation energy (0.8 eV) k: Boltzmann’s constant T: Absolute temperature (in Kelvin) 
Reliability test conditions	High-temperature operation test or high-temperature bias test; e.g., Tj = 150°C, 1000 h
Assumed condition examples	Only the On periods are assumed. Tj = 120°C, 10 h ・・・(a) Tj = 90°C, 2000 h ・・・(b) Tj = 60°C, 48000 h ・・・(c)
Conversion	The assumed conditions can be converted to reliability test conditions as follows (e.g., Tj = 150°C): (a): $\exp\{-0.8/8.617 \times 10^{-5} \cdot (1/393 - 1/423)\} \times 10\ \text{h} = 1.9\ \text{h}$ (b): $\exp\{-0.8/8.617 \times 10^{-5} \cdot (1/363 - 1/423)\} \times 2000\ \text{h} = 53.2\ \text{h}$ (c): $\exp\{-0.8/8.617 \times 10^{-5} \cdot (1/333 - 1/423)\} \times 48000\ \text{h} = 127.4\ \text{h}$ (a) + (b) + (c) = 182.5 h

Appendix

(2) Metal interconnect faults (Delamination of bonding balls due to the growth of Au-Al alloy)

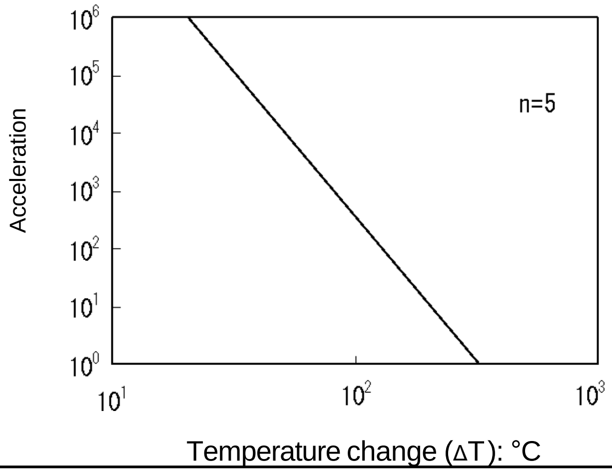
Acceleration model	Arrhenius model: $\alpha\infty\exp(-Ea/k \bullet 1/T)$ Ea: Activation energy (1.0 eV) k: Boltzmann's constant T: Absolute temperature (in Kelvin) 
Reliability test conditions	High-temperature storage test; e.g., Tj = 150°C, 1000 h
Assumed condition examples	Both the On and Off periods are assumed. Tj = 120°C, 100 h ・・・ (a) Tj = 90°C, 7000 h ・・・ (b) Tj = 60°C, 80000 h ・・・ (c)
Conversion	The assumed conditions can be converted to reliability test conditions as follows (e.g., Tj = 150°C): (a): $\exp\{-1.0/8.617 \times 10^{-5} \cdot (1/393 - 1/423)\} \times 100$ h = 12.3 h (b): $\exp\{-1.0/8.617 \times 10^{-5} \cdot (1/363 - 1/423)\} \times 7000$ h = 75.1 h (c): $\exp\{-1.0/8.617 \times 10^{-5} \cdot (1/333 - 1/423)\} \times 80000$ h = 48.2 h (a) + (b) + (c) = 135.6 h

(3) Metal interconnect faults (Al corrosion)

Acceleration model	Absolute vapor pressure model: $\alpha \infty Vp^{-n}$ Vp: Absolute vapor pressure n: Acceleration factor (n = 2 is used.) 
Reliability test conditions	High-temperature/high-humidity storage test or high-temperature/high-humidity bias test; e.g., Ta = 85°C, RH = 85%, 1000 h
Assumed condition examples	Both the On and Off periods are assumed. Ta = 30°C/RH = 85% (Vapor pressure: 3608.2Pa), 18000 h ・・・(a) Ta = 20°C/RH = 70% (Vapor pressure: 1636.7Pa), 55000 h ・・・(b) Ta = 10°C/RH = 65% (Vapor pressure: 797.8Pa), 18000 h ・・・(c) * When the test equipment is on, an increase in the temperature of the equipment causes the relative humidity to decrease. However, it is assumed that the vapor pressure remains unchanged. * The vapor pressure data is an excerpt from Chronological Scientific Tables compiled by the National Astronomical Observatory of Japan.
Conversion	The assumed conditions can be converted to reliability test conditions as follows (e.g., Ta = 85°C/RH = 85% (vapor pressure: 49146.2 Pa)): (a): $(49146.2/3608.2)^{-2} \times 18000\ \text{h} = 97.0\ \text{h}$ (b): $(49146.2/2376.2)^{-2} \times 55000\ \text{h} = 128.6\ \text{h}$ (c): $(49146.2/797.8)^{-2} \times 18000\ \text{h} = 4.7\ \text{h}$ $(a) + (b) + (c) = 230.3\ \text{h}$

Appendix

(4) Faults caused by repetitive thermal stress (package cracks, degradation of die bond)

Acceleration model	Eyring model: $\alpha\infty\ \Delta T^{-n}$ ΔT: Temperature change n: Acceleration factor (n = 5 is used.) 
Reliability test conditions	Temperature cycling test; e.g., 100 cycles between –55°C and 150°C (Ta)
Assumed condition examples	ΔT = 60°C, 7950 cycles ・・・(a) (Temperature change of the device itself and the ambience from 20°C to 80°C when the test chamber is switched on) ΔT = 15°C, 2650000 cycles ・・・(b) (Temperature change of the ambience from 80°C to 95°C when the test chamber is on)
Conversion	The assumed conditions can be converted to reliability test conditions as follows (e.g., ΔT = 205°C): (a): $(205/60)^{-5}$ × 7950 cycles = 17.1 cycles (b): $(205/10)^{-5}$ × 2650000 cycles = 5.6 cycles (a) + (b) = 22.7 cycles

[Bibliography]

1) JEITA EDR-4704, “Application guide of the accelerated life test for semiconductor devices”

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