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Renesas Electronics Corporation

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Information

# QUALITY GRADES ON NEC SEMICONDUCTOR DEVICES

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## 1. INTRODUCTION

The application fields of the semiconductor products have been increasingly expanded and the application environments have been diversified. As the increasing number of LSIs are used to create an application system, the quality of the semiconductor products now have a significant influence on the quality of the overall system. Therefore, it is taken as a matter of course that the quality of the semiconductor improves even more. However, this means the increasing responsibility of the supplier of the semiconductor products for their quality.

NEC Corporation has established its own system of quality assurance that covers a wide range of items of quality control including the reflection of the quality the customer expects on the finished products, designing that guarantees high quality, quality control in production processes, reliability tests, delivery management, and after-sales service. The quality grades of semiconductor products have been conventionally classified by the quality requested by the application fields of the products and the cost required to guarantee the requested quality.

NEC has been standardizing its quality assurance program by establishing its own reliability quality guaranty standards (Quality grades) that satisfy the needs of each application field. This article introduces the outline of the NEC's quality grades.

## 2. QUALITY GRADES AND APPLICATIONS

In principle, the quality of not only the semiconductor products but also any other NEC's product must satisfy the quality level requested by the customer.

To achieve this requirement, NEC employs three types of quality grades on quality assurance program: "standard", "special" and "specific".

<IMPORTANT> Customers are expected to choose which quality grade should be applied, considering customers' incoming treatment, fail-safe design of the system, device failure influence on the system, and social impact of system failure.

Please choose appropriate quality grade referring to the following description. In the case of further requirement for additional screening, etc., please contact our sales staff.

### 2.1 Standard Grade

The standard grade products are designed and produced in accordance with the standard quality assurance program, on the assumption that the products are used in ordinary electronic systems. The recommended applications of these products include computers, OA equipment, communications equipment, measuring instruments, AV equipment, home electronic application, machine tools and personal electronic equipment.

### 2.2 Special Grade

The special grade products are designed and produced in accordance with more stringent quality assurance program than the standard quality assurance program, on the assumption that the products are used in the special industrial field. The recommended applications of these products include transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, safety equipment and medical equipment (not specifically designed for life support).

This quality assurance program is implemented for every product family considering reliability evaluation test, screening, operation temperature range, symbol in part number identification, and final inspection.

The examples of typical specification for the special grade are shown bellow.

**Note**: This content also varies from product family to family.

(1) The duration of reliability evaluation test (a comparison with standard grade)

| Test item | Special grade | Standard grade |
|---|---|---|
| High temperature storage | 2 000 hours | 1 000 hours |
| High temperature operation life | 2 000 hours | 1 000 hours |
| Humidity resistant | 2 000 hours | 1 000 hours |
| Pressure cooker (PCT) | 192 hours | 96 hours |
| Temperature cycle | 300 cycles | 100 cycles |

(2) Screening (a comparison with standard grade)

| Item | Special grade | Standard grade |
|---|---|---|
| Burn-in | 100 % performed | No |

(3) Operating temperature range

| Symbol | Operating temperature a range |
|---|---|
| (A) | –40 to +85 ˚C |
| (A1) | –40 to +110 ˚C |
| (A2) | –40 to +125 ˚C |

(4) The special grade symbol corresponding with the above table is reflected into the part number for distinguishing other grade products.

**Example**: μPD78312L(A)-999 **Note**: (A) denotes special grade

(5) Furthermore, by applications, special grade may be classified into two groups, special grade "I" and special grade "II". The assumed applications of special grade "I" products include direct control equipment and safety unit for transportation (engine control, ABS, Auto-cruiser, Air-bug, etc.), traffic control systems, safety equipment, etc. The assumed applications of special grade "II" products include indirect control unit for transportation (meter, air conditioner, navigation system).

The quality assurance program of special grade products are fixed depend on the customer's request. Therefore please contact our sales staff in advance.

### 2.3 Specific Grade

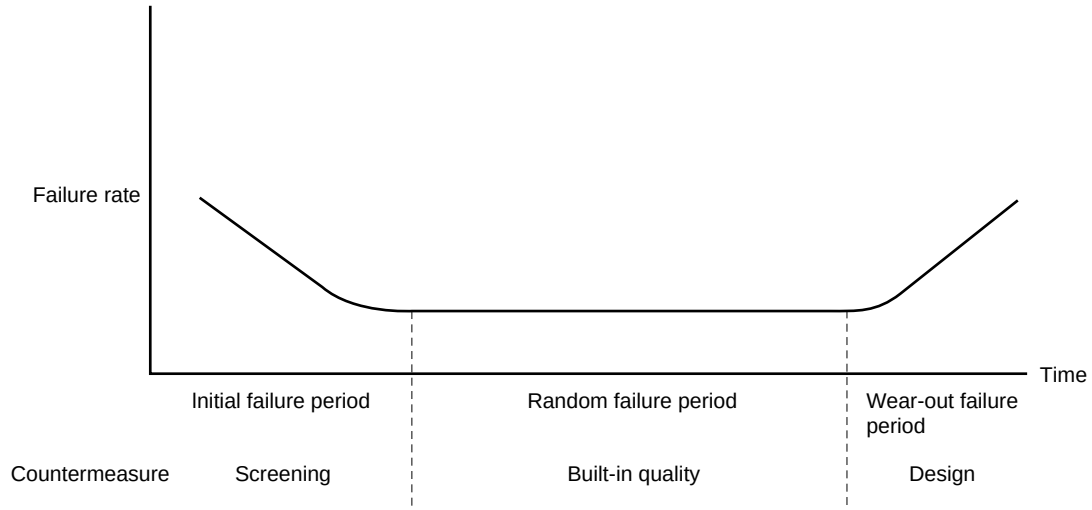
The quality grade established for specific applications called "specific grade". The assumed applications of specific grade products include aerospace systems, submersible repeaters, nuclear reactor control systems, medical equipment for life support, etc.

If you use NEC's products for these specific applications, it is necessary to make quality agreement with NEC for determination of quality assurance program for individual product. For details, please consult NEC.

## 3. BASIC RELIABILITY CONCEPT

The failure rate of devices is usually indicated by the well-known bath tub curve shown in Fig. 1. The bath-tub curve is divided into three areas: initial failure period, random failure period and wear-out failure period. Defects in the initial failure period are usually due to defects in manufacturing. After a certain time, the failure rate reaches a very low value. The random failure period occurs during on the effective area of the device's life, and the failure rate is regarded as nearly fixed. In the wear-out failure period, the failure rate in a specific defect mode increases suddenly, and is regarded as the end of the device's life. The durable life of semiconductor devices is usually very long, and random failure period exert the most influence on system reliability and maintainability.

**Fig. 1 Device failure rate (bath-tub curve)**




Devices with defects which may lead to failure in the initial failure period can be screened by accelerated tests such as burn-in. Wear-out failures should be considered in products such as laser diodes and in specific defective modes such as electromigration, but measures can be taken in the design stage to confirm quality by reliability evaluations. To achieve high reliability in semiconductor devices, the following are necessary.

(1) Building-in of reliability at the design stage and reliability confirmation in qualification tests
(2) Building-in of quality during the manufacturing process
(3) Reduction of potential initial failure by optional screening

## 4. QUALITY ASSURANCE PROGRAM

**(1) Targeted quality and reliability**

When NEC plans development of a new product, a market research is conducted to analyze the needs of the product and the quality and reliability to be required. Based on this research, the targeted values of quality and reliability are determined.

**(2) Quality design and design review**

To determine the quality of a product, the design is extremely important in that it determines the basic quality of the product. Especially, wear failure mode that determine the durability and life of the product, such as the migration failure of fine patterning, is determined by the design. Therefore, the design standard is determined based on the results of the reliability evaluation of TEG (Test Element Group).

To review the design, a check list which has been created taking into consideration the past experiences is used when a new product is designed or the design of an existing product is modified. Also, experts from the related fields participate in determining the design.

**(3) Reliability evaluation criteria**

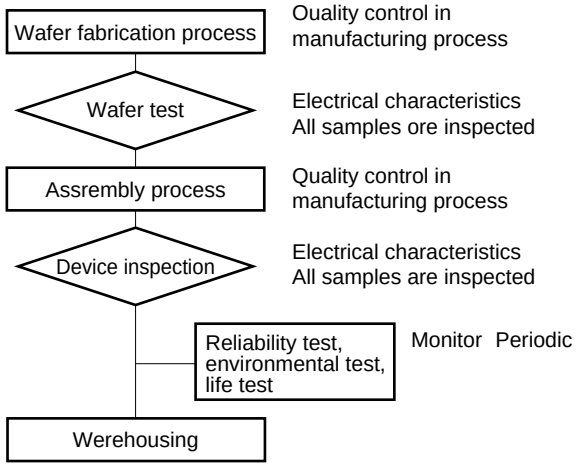
Not only the new products but also the existing products which are to be remodeled are thoroughly tested for their electrical characteristics and reliability to ascertain that the quality of the products satisfy the designed requirements. Of the reliability test items, those especially important are checked more stringently than the standard grade products.

**(4) Production process quality control**

To realize the designed quality, the quality of the parts and material are carefully checked, TPM (Total Productive Maintenance) activities are introduced, and the production environments such as temperature, humidity, and dust are thoroughly examined. In addition, the products are checked at many points during production, to reject defective products from a process, so that they do not proceed to the next process.

Fig. 2 shows an example of the flow of process control.

**Fig. 2 Process control flow**




**(5) Screening**

When producing LSI products of fine construction, it is possible to reduce products potentially having a failure cause at the production stage. The purpose of screening is to reject the products having defects that cause an initial failure.

NEC conducts burn-in screening that applies a temperature and voltage stress to the LSI, on request.

For the special grade products, burn-in screening is done to reduce the initial failure rate. In addition, a selection test at the high-temperature of the operation guarantee temperature range is also conducted for these products to reject defectives.

**(6) Periodic test to confirm reliability**

To monitor manufacturing quality and confirm reliability of products, reliability tests are periodically conducted. Their methods are shown in Tables 1 and 2.

It is defined that the products designed based on the same design criteria, having the same device construction using the same components and materials, and produced in the same process are in the same family and a reliability test is periodically conducted for the representative models of a family.

## Table 1 Example method of reliability test on semiconductor ICs

| Test Item | | Reference standared | | Testing method and conditions | Criteria | Minimum sample size (AC) |
|---|---|---|---|---|---|---|
| | | JIS C7022 | MIL-STD-883 | | | |
| Thermal environmental test | Resistance to soldering heat | A-1 Condition A | — | 260 ± 5 °C, 10 seconds | • Must conform to specifications for electrical characteristics<br>• Gross leak ***1** ... None<br>• Fine leak ***1**<br>... Less than $1 \times 10^{-8}$ atm cc/s | 18 (0) |
| | Temperature cycle | A4 | 1 010 Condition C | Lower than $T_{stg}$ MIN. for 30 minutes, Higher than $T_{stg}$ MAX. for 30 minutes, 10 cycle | | |
| | Thermal shock | A-3 Condition A | 1 011 Condition A | 100 °C for a MIN. 5 minutes, 0 °C for a MIN. 5 minutes, 15 cycles | | |
| Mechanical environmental test | Vibration, variable frequency | A-10 | 2 007 Condition A | Peak 20 G, 20 to 2 000 Hz, 4 minutes, 4 times in each direction X, Y and Z | | 18 (0) |
| | Mechanical shock | A-7 Condition F | 2 002 Condition B | 1 500 G, 0.5 ms, 3 times in each direction X, Y and Z | | |
| | Constant acceleration | A-9 Condition C | 2 001 Condition D | 20 000 G, for one minute once in each direction X, Y and Z | | |
| Solderability | | A-2 | 2 003 | 230 ±5 °C for 5 seconds, with flux | Solder must be deposited over an area of more than 95 %. | 5 (0) |
| Terminal strength (lead fatigue) | | — | 2 004 Condition B2 | Specified load, 90 ±5 °C, 3 times, any 3 terminals | No breakage or looseness | 5 (0) |
| Durability test | High temperature storage | B-3 | 1 008 | Higher than $T_{stg}$ MAX., more than 1 000 hrs | According to electrical characteristics specifications | 10 (0) |
| | High temperature operation life or high temperature voltage stress ***4** | B-1 | 1 005 | Ta: 125 °C or more, more than 1 000 hrs<br>The type of test and load conditions are determined individually. | | 20 (0) |
| | Intermittent operation life ***4** | B-2 | 1 006 | See High temperature operation life section.<br>The ON/OFF cycle is determined individually. | | 20 (0) |
| | Humidity resistant ***2** | B-5 Condition C | — | Ta: 85 °C, RH: 85 %<br>Individually determined if voltage is to be applied and load conditions are applicable.<br>More than 1 000 hrs. | | 20 (0) |
| | PCT ***2** | — | — | 125 °C, 2.3 atm, RH: 100 %, more than 96 hrs | | 18 (0) |
| | Temperature cycle ***3** | — | 1 010 | Lower than $T_{stg}$ Min. for 30 minutes, Higher than $T_{stg}$ MAX. for 30 minutes, more than 100 cycles | | 18 (0) |
| ESD ***3** | | — | 3 015 | C = 200 pF, R = 0 Ω or<br>C = 100 pF, R = 1.5 kΩ<br>Application pins, voltage, and number of times are individually specified. | According to electrical characteristics specifications | 5 (0) |

***1.** Applies only to hermetic sealed ICs.
***2.** Applies only to plastic packaged ICs.
***3.** Applies only to the qualification test.
***4.** Either continuous or intermittent operations are selected according to product type.

## Table 2 Example method of reliability test on discrete devices

| Test Item | | Reference standared | | Testing method and conditions | Criteria | Minimum sample size (AC) |
|---|---|---|---|---|---|---|
| | | JIS C7021 | MIL-STD-750 | | | |
| Thermal environmental test | Resistance to soldering heat | A-1 Condition A | 2 031 | 260 ±5 °C, 10 seconds | Within electrical characteristics specifications | 11 (0) or 22 (0) |
| | Temperature cycle | A-4 | 1 051 | Lower than $T_{stg}$ MIN. for 30 minutes, Higher than $T_{stg}$ MAX. for 30 minutes, 5 cycles | | |
| | Thermal shock | A-3 | 1 056 Condition B | 100 °C for a MIN. 5 minutes, 0 °C for a MIN. 5 minutes, 5 cycles | | |
| Mechanical environmental test ***1** | Vibration, variable frequency | A-10 Condition D | 2 056 | Peak 20 G, 100 to 2 000 Hz, 4 minutes, 4 times in each direction X, Y and Z | | 11 (0) or 22 (0) |
| | Mechanical shock | A-7 Condition F | 2 016 | 1 500 G, 0.5 ms, 3 times in each direction X, Y and Z | | |
| | Constant acceleration | A-9 Condition D | 2 006 | 20 000 G, for one minute once in each direction X, Y and Z | | |
| Solderability | | A-2 | 2 026 | 230 ±5 °C for 5 seconds, with flux | Solder must be deposited over an area of more than 95 %. | 11 (0) or 22 (0) |
| Terminal strength | Tension | A-11 Procedure 1 | 2 036 Condition A Condition E | Holding a specified load for 30 seconds | No breakage or looseness | 11 (0) |
| | Lead fatigue | — | | Specified load, 90 °, 3 times | | 11 (0) |
| Durability test | High temperature storage | B-10 | 1 031 | $T_{stg}$ MAX., more than 1 000 hrs | Individually specified | 20 (0) |
| | Steady-state operation life ***4** | B-1, -2, 04, -5, -13, -14 | 1 026 | Ta: 25 °C, specified power applied for more than 1 000 hrs. | | 20 (0) |
| | Intermittent operation life ***4** | B-6, -7 | 1 036 | See steady-state operation life section. The ON/OFF cycle is determined individually. | | 20 (0) |
| | Continuous current | B-15, -16 | — | Specified ambient temperature, specified current, for more than 1 000 hrs. | | 20 (0) |
| | High temperature reverse bias ***5** | B-3, -8, -9 | — | Specified ambient temperature, specified reverse bias, for more than 1 000 hrs. | | 20 (0) |
| | High temperature voltage application ***5** | B-19, -20 | — | Lower than TjMAX., specified peak reverse voltage is applied for more than 1 000 hrs. | | 20 (0) |
| | Humidity resistant ***2** | B-11 Condition C or B | — | Ta: 85 °C (or 60 °C), RH: 85 % (or 90 %) Individually determined if voltage is to be applied. More than 1 000 hrs. | | 20 (0) |
| | PCT ***2** | — | — | 125 °C, 2.3 atm, RH: 100 %, more than 96 hrs | | 11 (0) or 20 (0) |
| | Temperature cycle ***3** | — | 1 051 | $T_{stg}$ MIN. for 30 minutes, $T_{stg}$ MAX. for 30 minutes, more than 100 cycles | | 11 (0) or 20 (0) |
| ESD ***3** | | — | — | C = 200 pF, R = 0 Ω or C = 100 pF, R = 1.5 kΩ Voltage and number of times are individually specified. | | 5 (0) |

***1.** Applies only to hermetic sealed packages. ***2.** Applies only to plastic packages.
***3.** Applies only to the qualification test. ***4, *5.** One application method is selected per product group.

## 5. CONCLUSION

As we have shown, NEC classifies into the three quality grades: Standard, Special and Specific, so that customers can select devices of the appropriate quality in accordance with the functions, use environment and other factors related to electronic equipment. Each quality grade is maintained for stable quality level satisfying customer needs through advanced and rationalized quality assurance program.

NEC is determined to continue supplying highly reliable products through close communications with its customers.

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