Product Quality Control and Reliability

Product Quality Control

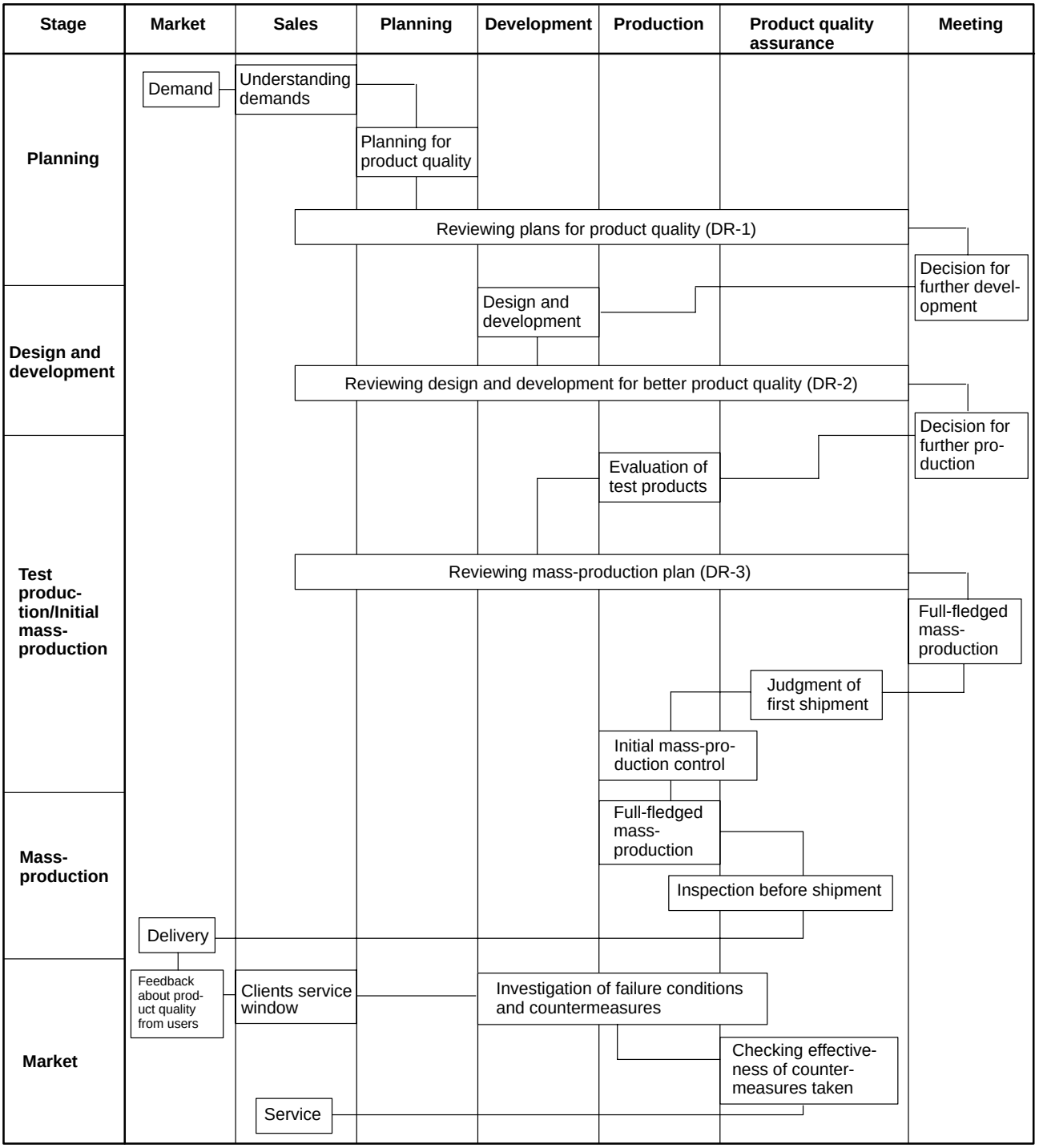
■ Basic Policy of Product Quality Control

OMRON has been attaching great importance to quality control of its products, with the view of making a contribution to society by producing high-quality products. The table below shows the contents of OMRON's quality control system including marketing surveys and quality control activities conducted by OMRON's various departments so that the products can be shipped in good condition.

The first step to product quality control is to reflect in the development of OMRON's products the users' demands for product quality. After setting the target, we aim at producing the products that are consistently high in quality and can meet the standards that we set. OMRON's basic concept is that each process of production is equally important as it plays an important role in product quality control.

To ensure the quality of OMRON's products in the product quality control system, we carry out various tests such as design check, process control, pre-shipment, and reliability tests.

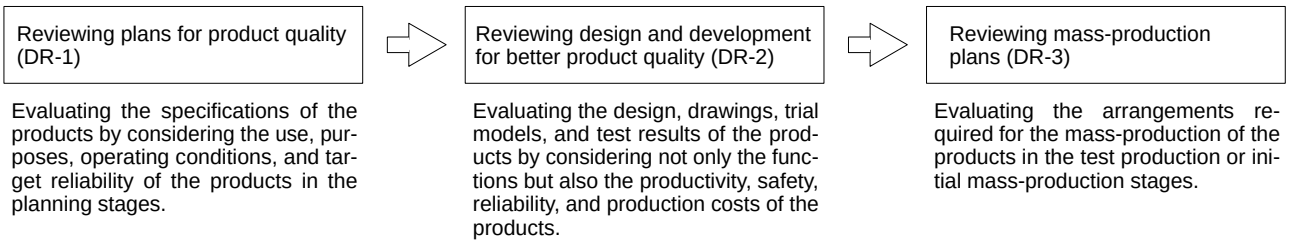
Figure 1: Product Quality Control Scheme



■ Quality Control of Products being Developed

The first step to product quality control is to reflect in the development of OMRON's products the users' demands for product quality. OMRON's DR (design review) system was made to achieve this before OMRON starts the mass production of any product. The DR system enables OMRON's engineers to review the quality of products during the planning, design and development, and initial mass-production stages to solve any quality problems and to maintain excellent product quality. Refer to the following for the steps of the DR system and the purposes of the steps.

Figure 2



■ Product Quality Control in Mass-production Stage

To improve the quality of the products in the mass-production stages of OMRON's products, OMRON attaches importance to its staff supervision, the equipment and machines used for the manufacture of the products, the materials of the products, and the manufacturing methods of the products. There are rules for the changes in the design and manufacturing methods of the products and the steps to deal with any abnormality in the mass-production stages to conduct the quality control of the products. Figure 3 shows the flowchart used for the quality control in all the production stages of the EE-SX1041 Through-beam Photomicrosensor.

Figure 3. Quality Control in EE-SX1041 Photomicrosensor Production Stages

Flowchart		Production stage	Quality control item
Material	Process		
Chip Frame		Die bonding	Temperature and bonding strength
Bonding wire		Wire bonding	Bonding conditions and bonding strength
Buffer material		Buffer coating (see note)	Resin application state
		Appearance test	Bonding state
Mold resin		Molding	Molding conditions
		Screening (see note)	Screening conditions
		Lead cutting	Equipment conditions
		Appearance test	Mold state and lead-cut state
	Both the emitter and receiver sides.	Characteristics test	Electrical characteristics
		Debugging (see note)	Test conditions
Case		Assembling	Assembling state
		Characteristics test	Electrical characteristics
		Marking	Marking state
		Appearance test	Appearance
		Inspection at random	Electrical characteristics, appearance, and reliability test
Shipment			

Note: Applied to the LED only.

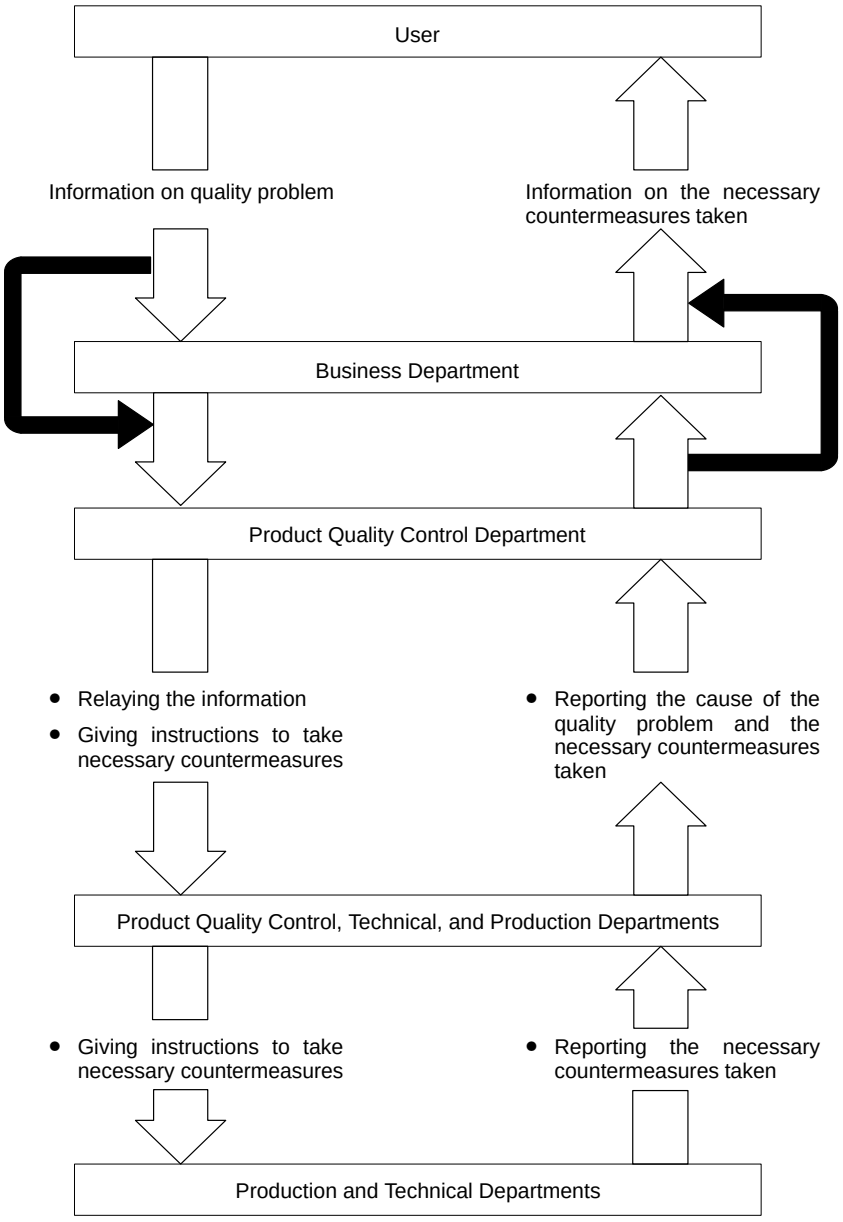
■ Shipment Product Quality Control

OMRON is conducting product quality control activities in the design and production stages of all OMRON's products. Recently, the failure rate tolerated by users has been less than 10 ppm, which cannot be achieved by any conventional product quality control system. OMRON is complying with OMRON product users' demand by not only conducting the above-mentioned product control activities but also properly managing its design and production stages, conducting tests of OMRON's products to ensure the reliability of the products, and strengthening its trouble-shooting technology.

■ Market Product Quality Control

OMRON is actively collecting comments on the quality of OMRON's products on the market to reflect the results toward the improvement in the quality and reliability of OMRON's all products including any product to be released by OMRON in the future.
The comments include complaints about the quality of OMRON products. If any OMRON product on the market has a quality problem, OMRON's Product Quality Control Department, in cooperation with the departments concerned, promptly finds the cause of the problem, takes necessary countermeasures to solve the problem, and prevents the recurrence of the problem by taking the steps shown in Figure 4.

Figure 4. Treatment of Complaint about Market Product Quality



- Analyzing the cause of the quality problem
- Planning the necessary countermeasures to be taken
- Keeping a record of the quality problems reported in the past
- Product and production stage investigations

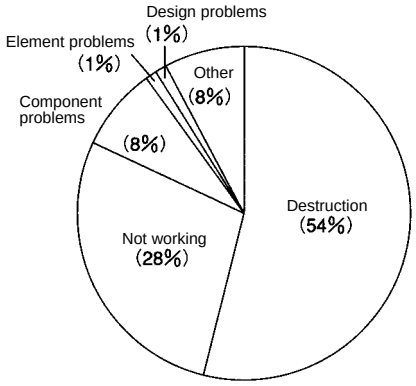
- Countermeasures to solve the quality problem
- Design and technical changes
- Training

Reliability

■ Market Product Quality

OMRON is making efforts so that OMRON's products can achieve a failure rate of only 10^{-7}/h.
OMRON will continue improving the quality of its products to comply with OMRON product users' demand for product quality while actively providing good after-sales service.
OMRON's products achieved a failure rate of 10 ppm in fiscal 1993. Figure 5 shows the reasons for the return of OMRON products between April 1993 and December 1993.
The reasons for approximately two-thirds of the products sent back were that they were not working or they were destroyed. It is possible that they were not working or they were destructed because excessive voltages were imposed on them or they were not operated properly according to their specifications. To solve such problems, OMRON is actively holding preliminary meetings with customers who will use OMRON products and advise them of the operating conditions required by the products while actively providing them with after-sales service.

Figure 5. Reasons for Products Sent Back (April 1993 to December 1993)



■ Reliability

The life of any Photomicrosensor depends on the secular changes of the optical output of the LED built into the Photomicrosensor. The following are the output characteristics of the Photomicrosensor, all of which depend on the optical output of the LED.

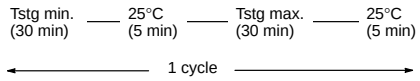
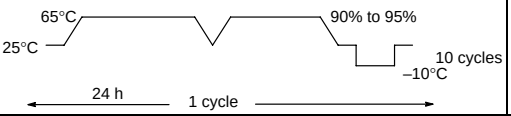
Phototransistor output	Light current (I_L)
Photo IC output	LED current I_{FT} with the photo IC output ON and OFF
Amplifier output (reflective sensor)	Sensing distance d

OMRON has been conducting reliability tests of each type of Photomicrosensor to check the secular changes of the optical output of the LED built into the Photomicrosensor.

■ Reliability Tests

In principle, Photomicrosensors conform to EIAJ standards. The following table shows the details of the reliability tests of Photomicrosensors conducted by OMRON.

Figure 6. Details of Reliability Tests

Classification	Test	Detail	Conforming standard	
Thermal condition test	Soldering heat resistivity	Evaluates the soldering heat resistivity of products. Usually, this test is conducted under the following conditions. Soldering temperature: 260±5°C Soldering time: 10±1 s	EIAJ-EDX-8121 EIAJ-SD-121: 01 JIS C7021: A1 IEC Pub68-2-20	
	Thermal shock	Evaluates the resistivity of products to radical temperature changes. Usually, this test is conducted under the following conditions. Ta: 0°C to 100°C (liquid bath) or TstgMIN to TstgMAX (liquid bath)	EIAJ-SD-121: 03 JIS C7021: A3 IEC Pub68-2-14	
	Temperature cycle	Evaluates the low- and high-temperature resistivity of products. 	EIAJ-EDX-8121 EIAJ-SD-121: 04 JIS C7021: A4 IEC Pub68-2-14	The five-minute storage periods at a temperature of 25°C in the test may be omitted.
	Temperature and humidity cycle	Evaluates the high-temperature and high-humidity resistivity of products. 	EIAJ-SD-121: 05 JIS C7021: A5 IEC Pub68-2-4	
Mechanical test	Soldering ease	Evaluates the terminal soldering ease of the products. Usually, this test is conducted under the following conditions. Soldering temperature: 260±5°C Soldering time: 5±1 s	EIAJ-EDX-8121 EIAJ-SD-121: 02 JIS C7021: A2 IEC Pub68-2-20	
	Terminal strength	Evaluates the resistivity of the terminals of products to the force imposed on the terminals while the products are mounted, wired, or operated. 1. Tension test On each terminal of products, a specified load is imposed for 30±5 s in the direction of the terminal. 2. Bending test On the tip of each terminal of products, a specified load is imposed to bend the terminal by 90° and to change it back.	EIAJ-EDX-8121 EIAJ-SD-121: 10 JIS C7021: A11 IEC Pub68-2-21	
	Shock resistance	Judges the structural resistivity and mechanical resistivity of products. The conditions of this test vary with the product structure. Usually, this test is conducted under the following conditions. Impact acceleration: 1,500G (14,700 m/s^2) Pulse width: 0.5 ms	EIAJ-EDX-8121 EIAJ-SD-121: 07 JIS C7021: A7 IEC Pub68-2-27	A product may be subjected to this test after it is packed up.
	Vibration resistance	Evaluates the vibration resistivity of products while they are transported or operated. Usually, this test is conducted under the following conditions. Frequency: 20 to 2000 Hz/4 min 1.5-mm amplitude or 10G (196 m/s^2)	EIAJ-EDX-8121 EIAJ-SD-121: 11 JIS C7021: A10 IEC Pub68-2-21	A product may be subjected to this test after it is packed up.
	Natural drop	Evaluates the irregular shock resistivity of products while they are handled, transported, or operated. Usually, this test is conducted under the following conditions. Height: 75 cm No. of times: 3	EIAJ-SD-121: 08 JIS C7021: A8 IEC Pub68-2-32	A product may be subjected to this test after it is packed up.

Classification	Test	Detail	Conforming standard	
Life expectancy test	Continuous operation	Evaluates the resistivity of products to a continuous, long-time electrical stress and temperature stress. Usually, this test is conducted under the following conditions. Ta: 25±5°C Bias: I_{FMAX} or P_{CMAX}	EIAJ-EDX-8121 EIAJ-SD-121: 201 JIS C7021: B4	A product may be subjected to this test at a high temperature, low temperature, or high temperature and humidity.
	High-temperature storage	Evaluates the resistivity of products to a high-storage temperature for a long time. Usually, this test is conducted under the following conditions. Ta: TstgMAX Time: 1,000 hrs	EIAJ-EDX-8121 EIAJ-SD-121: 115 JIS C7021: B10 IEC Pub68-2-2	
	Low-temperature storage	Evaluates the resistivity of products to a low-storage temperature for a long time. Usually, this test is conducted under the following conditions. Ta: TstgMIN Time: 1,000 hrs	EIAJ-EDX-8121 EIAJ-SD-121: 116 JIS C7021: B12 IEC Pub68-2-1	
	High-temperature and high-humidity storage	Evaluates the resistivity of products to a high-storage temperature and high storage humidity for a long time. Usually, this test is conducted under the following conditions. Ta: 60°C Humidity: 90% Time: 1,000 hrs	EIAJ-EDX-8121 EIAJ-SD-121: 117 JIS C7021: B11 IEC Pub68-2-3	
	High-temperature reverse bias	Evaluates the resistivity of products to a continuous electrical stress and temperature stress.	EIAJ-SD-121: 203 JIS C7021: B8	A product may be subjected to this test at a low temperature, high temperature, or high humidity.

■ Data of Reliability Tests

The following tables show the results of the reliability tests of Photomicrosensors conducted by OMRON.

Failure Rate (MTTF Data)

Phototransistor Output Models

Test	Condition	No. of samples	Test time	No. of failures	Failure rate/1,000 hrs (reliability level: 90%)	Estimated MTTF (h) (average life expectancy)
Soldering heat resistivity	260°C, 10 s	198	---	0	---	---
Thermal shock	0°C to 100°C, 5 times	55	---	0	---	---
Temperature cycle	100°C (30 min) to –40°C (30 min)	5,760	(100 times)	0	---	---
Temperature and humidity cycle	65°C to –10°C, 90% to 98%, 1 cycle/24 hrs, 10 cycles	66	---	0	---	---
Soldering ease	230°C, 5 s	165	---	0	---	---
Terminal strength	Tension: 0.5 kg Bending: 90° twice with a bending force of 0.25 kg each	143	---	0	---	---
Shock resistance	1,500G (14,700 m/s^2), 0.5 ms, 3 times each in ±X, ±Y, and ±Z directions	110	---	0	---	---
Vibration resistance	20 to 2,000 Hz/ 4 min, 1.5 mm or 10G, for 2 hrs each in X, Y, and Z directions	110	---	0	---	---
Natural drop	75 cm, 3 times	44	---	0	---	---
Continuous operation	Ta = 25°C, I_F = 50 mA	528	7.92×10^5	0	2.90×10^{-3}	3.44×10^5
High-temperature storage	Ta = 100°C	484	4.84×10^5	0	4.75×10^{-3}	2.10×10^5
Low-temperature storage	Ta = –40°C	484	4.84×10^5	0	4.75×10^{-3}	2.10×10^5
High-temperature and high-humidity storage	Ta = 60°C, 90%	396	3.96×10^5	0	5.81×10^{-3}	1.72×10^5
High-temperature reverse bias	Ta = 85°C, V_{CE} = 30V	308	3.08×10^5	0	7.47×10^{-3}	1.34×10^5

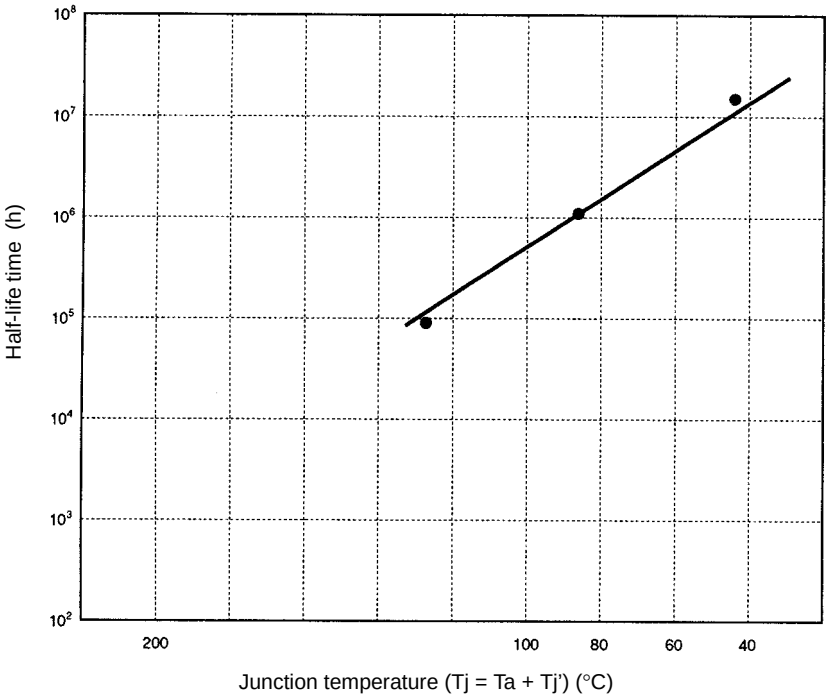
Photo IC Output Models

Test	Condition	No. of samples	Test time	No. of failures	Failure rate/1,000 hrs (reliability level: 90%)	Estimated MTTF (h) (average life expectancy)
Soldering heat resistivity	260°C, 10 s	33	---	0	---	---
Thermal shock	0°C to 85°C, 5 times	33	---	0	---	---
Temperature cycle	85°C (30 min) to –40°C (30 min)	5,040	(100 times)	0	---	---
Temperature and humidity cycle	65°C to –10°C, 90% to 98%, 1 cycle/24 hrs, 10 cycles	22	---	0	---	---
Soldering ease	230°C, 5 s	44	---	0	---	---
Terminal strength	Tension: 0.5 kg Bending: 90° twice with a bending force of 0.25 kg each	33	---	0	---	---
Shock resistance	1,500G (14,700 m/s^2), 0.5 ms, 3 times each in ±X, ±Y, and ±Z directions	22	---	0	---	---
Vibration resistance	20 to 2,000 Hz/ 4 min, 1.5 mm or 10G, for 2 hrs each in X, Y, and Z directions	22	---	0	---	---
Natural drop	75 cm, 3 times	22	---	0	---	---
Continuous operation	Ta = 25°C, I_F = 50 mA	330	6.60×10^5	0	3.48×10^{-3}	2.87×10^5
High-temperature storage	Ta = 85°C	264	2.64×10^5	0	8.71×10^{-3}	1.15×10^5
Low-temperature storage	Ta = –40°C	264	2.64×10^5	0	8.71×10^{-3}	1.15×10^5
High-temperature and high-humidity storage	Ta = 60°C, 90%	264	2.64×10^5	0	8.71×10^{-3}	1.15×10^5
High-temperature reverse bias	Ta = 75°C, V_{CC} = 16 V, Vout = 28 V	66	6.60×10^4	0	3.48×10^{-2}	2.87×10^4

Life vs. Forward Current and Ambient Temperature Characteristics

The life of a Photomicrosensor depends on the secular changes of the optical output of the LED built into the Photomicrosensor. The secular changes of the optical output of the LED depend on the junction temperature (Tj) of the LED. The junction temperature (Tj) is determined by the forward current of the LED and the ambient temperature. The following graph shows the relationship between the junction temperatures and half-life time characteristics of the LED, which OMRON obtained from life expectancy tests. The half-life time denotes the time needed to decrease the optical output of an LED to a half of its initial optical output. The light current (I_L) of the receiver element of a Photomicrosensor will decrease to a half of its initial value when the optical output of the LED built into the Photomicrosensor decreases to half of its initial optical output.

Figure 7. LED Junction Temperature vs. Half Life Time



Explanation

Tj and Tj can be obtained from the following formulas if I_F is 20 mA and Ta is 40°C.

Tj = 20 mA x 0.65 = 12°C
Tj = Ta + Tj = 40°C + 12°C = 52°C

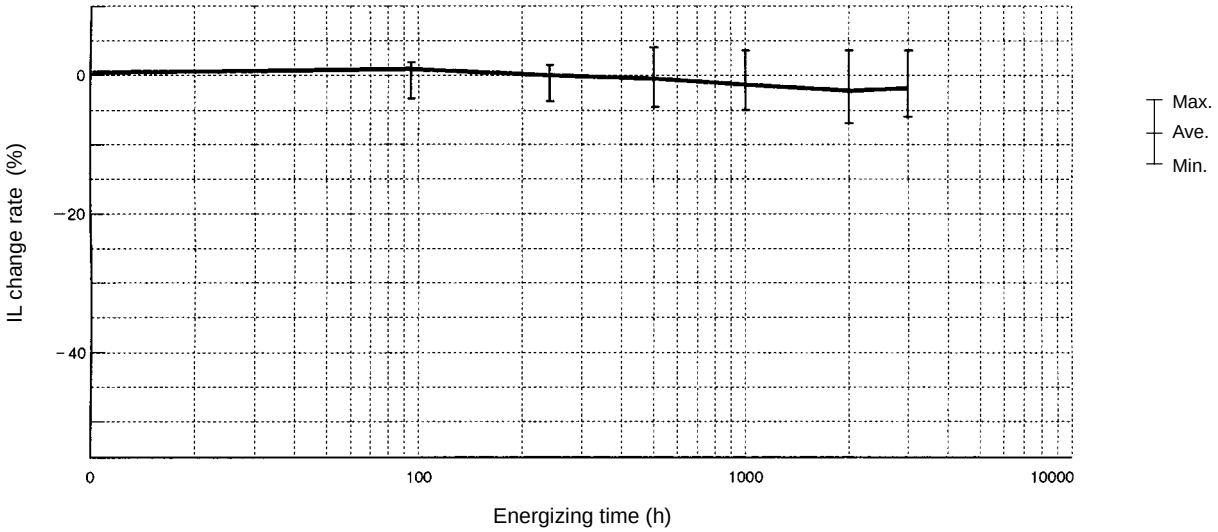
Therefore, if Tj is 52°C, the half-life time of the LED will be 9 x 10^6 hrs.

Note: 1. Tj: Junction temperature
Tj' = I_F (mA) x 0.65

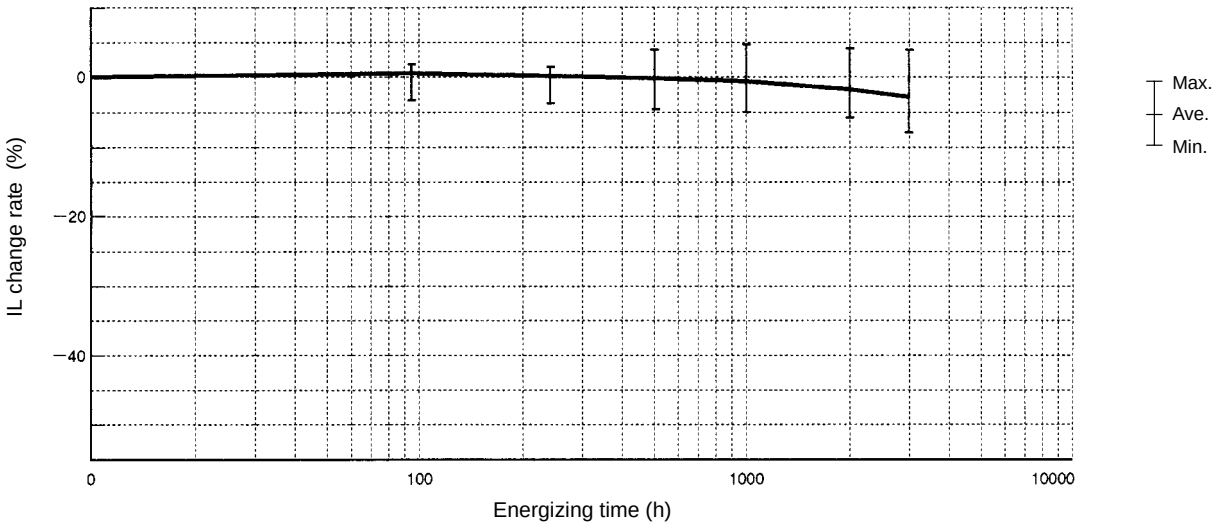
2. The above data was obtained on condition that the Photomicrosensor was under a constant temperature stress and electrical stress. Practically, Photomicrosensors must be used by considering various ambient condition changes.

Light Current (I_L) Secular Changes of Phototransistor Output Photomicrosensor

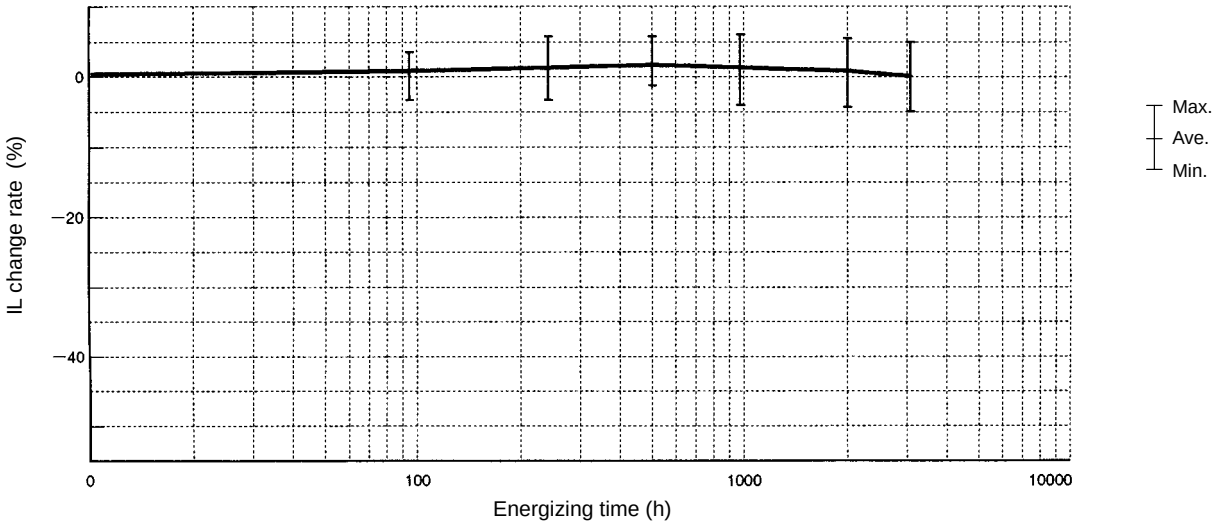
Ta = 25°C, I_F = 20 mA, n = 32



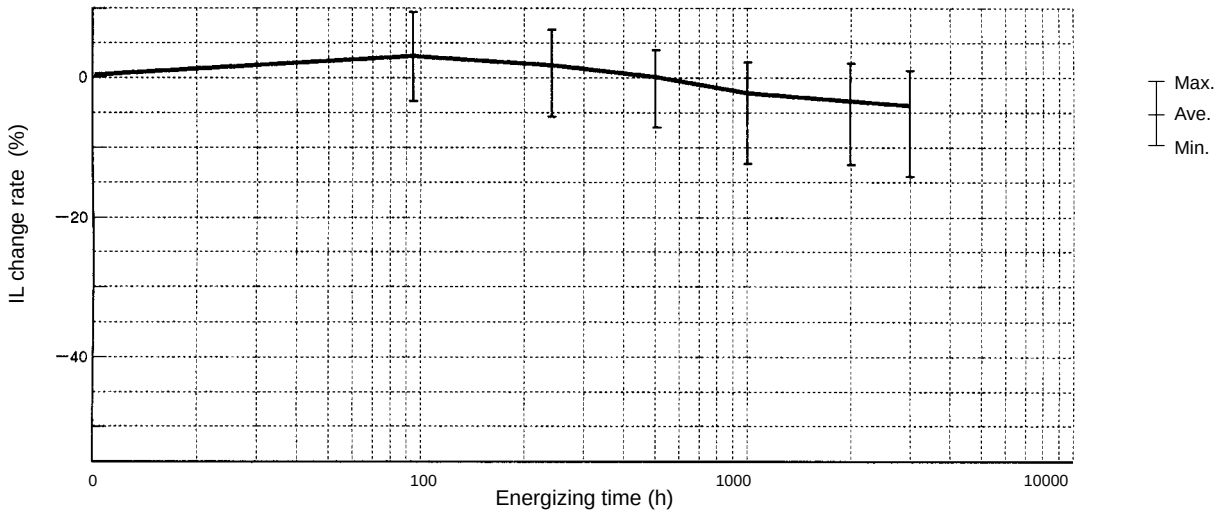
Ta = 25°C, I_F = 50 mA, n = 32



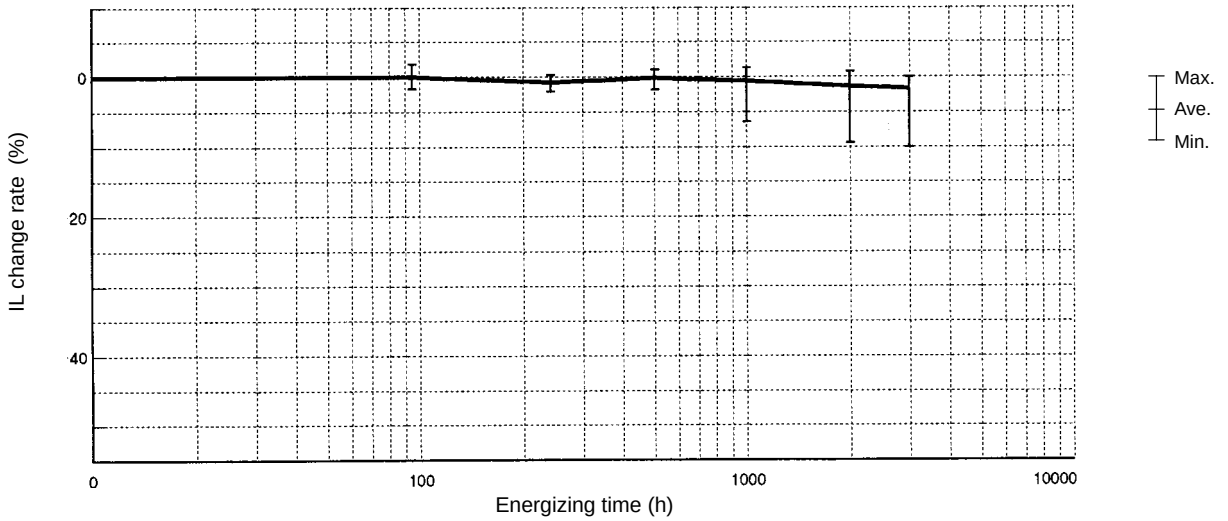
Ta = 85°C, I_F = 10 mA, n = 32



Ta = 85°C, I_F = 50 mA, n = 32



Ta = –40°C, I_F = 50 mA, n = 32



Security Trade Control

(As of April 1998)

■ Security Trade

The framework of Japan's security trade control has greatly changed and now its diversified purposes include restrictions on the spread of nuclear weapons, chemical weapons, biological weapons, mass destruction weapons, and missiles in both the northern and southern hemispheres in addition to restrictions on the export of the items designated by COCOM.

■ Foreign Exchange and Trade Control Regulations

Lists 1 and 2 of Japan's Foreign Exchange and Trade Control Regulations stipulate restrictions on the spread of products, machine parts, and technologies. The export or introduction of these items to any country from Japan is subject to the approval of the Japanese Minister of International Trade and Industry according to the procedures for the export or introduction of these items stipulated in the Foreign Exchange and Trade Control Regulations.

In addition, the export of weapons, nuclear cargo and technologies, and industrial high-tech cargo and technologies from Japan as well as the export of the conventional items designated by COCOM is subject to the approval of the Japanese Minister of International Trade and Industry.

■ Listed Products According to Voluntary Judgement and Announcement Rules

The foundation called NTLP??? publicly announced that the following OMRON models do not fall under the category of the items on List 1 of Japan's Foreign Exchange and Trade Control Regulations. This was made public at the request of OMRON, which voluntarily judged that these models do not fall under the category and requested the foundation to publicly announce it according to the voluntary judgement and announcement rules of the foundation.

Any asterisk added to the following model numbers may be replaced with an alphanumeric character, mark, or blank to indicate actual model numbers.

As for any model not listed here, contact your OMRON representative.

Model	Announcement no.	Announcement date
EE-SX1018***	0004501430000075	1991.06
EE-SX1025***	0004501430000078	1991.06
EE-SX1035***	0004501430000082	1991.06
EE-SX1041****	0004501430000086	1991.06
EE-SX1042**	0004501430000087	1991.06
EE-SX1046	0004501430000090	1991.06
EE-SX1070	0004501430000106	1991.06
EE-SX1071	0004500010000045	1991.11
EE-SX1080	0004500010000151	1992.11
EE-SX1081	0004501430000109	1991.06
EE-SX1088	0004500010000152	1992.11
EE-SX1096	0004500010000131	1992.08
EE-SX1235-P2	0004500010000101	1992.03
EE-SX129	0004501430000126	1991.06
EE-SX138***	0004501430000129	1991.06
EE-SX153**	0004501430000134	1991.06
EE-SX198****	0004501430000142	1991.06
EE-SX199	0004501430000143	1991.06
EE-SX1101***	0004500010000169	1993.05
EE-SX1102***	0004500010000170	1993.05
EE-SA102***	0004500010000001	1991.11
EE-SA103****	0004501430000011	1991.06
EE-SA104****	0004501430000012	1991.06
EE-SA105	0004501430000013	1991.06
EE-S5**	0004501430000009	1991.06
EE-SG3	0004501430000021	1991.06
EE-SG3-B******	0004500010000015	1991.11
EE-SH3	0004501430000024	1991.06
EE-SH3-B******	0004500010000024	1991.11
EE-SH3-C*	0004500010000025	1991.11
EE-SH3-D*	0004500010000026	1991.11
EE-SH3-G****	0004500010000027	1991.11
EE-SJ3-C	0004500010000030	1991.11
EE-SJ3-D*	0004500010000031	1991.11
EE-SJ3-G	0004500010000033	1991.11
EE-SJ5-B******	0004500010000039	1991.11
EE-SV3**********	0004501430000069	1991.06
EE-SX298****	0004501430000149	1991.06
EE-SJ3W-B***	0004500010000035	1991.11
EE-SK3W-*	0004501430000032	1991.06
EE-SM3	0004501430000035	1991.06
EE-SM3B**	0004501430000037	1991.06
EE-SX4009-P****	0004501430000179	1991.06
EE-SX301	0004500010000054	1991.11
EE-SX401	0004501430000180	1991.06

Model	Announcement no.	Announcement date
EE-SX4019-P*****	0004500010000172	1993.05
EE-SX305	0004501430000154	1991.06
EE-SX405	0004501430000187	1991.06
EE-SX3070	0004501430000156	1991.06
EE-SX4070	0004501430000188	1991.06
EE-SX3080	0004500010000158	1992.11
EE-SX4080	0004500010000160	1992.11
EE-SX3081	0004501430000158	1991.06
EE-SX4081	0004501430000189	1991.06
EE-SX3088	0004500010000159	1992.11
EE-SX4088	0004500010000161	1992.11
EE-SX4101**	0004500010000187	1993.12
EE-SX4235A-P****	0004500010000175	1993.05
EE-SX460-P1*	0004500010000072	1991.11
EE-SX461-P**	0004501430000206	1991.06
EE-SX384	0004501430000174	1991.06
EE-SX484	0004501430000212	1991.06
EE-SX493	0004501430000216	1991.06
EE-SX398****	0004501430000177	1991.06
EE-SX498	0004500010000103	1992.03
EE-SY110	0004500010000080	1991.11
EE-SY113	0004501430000232	1991.06
EE-SY169*	0004501430000248	1991.06
EE-SY171	0004501430000250	1991.06
EE-SB5	0004501430000015	1991.06
EE-SB5-B******	0004500010000002	1991.11
EE-SF5	0004500010000007	1991.11
EE-SF5-B*********	0004500010000008	1991.11
EE-SY201******	0004501430000252	1991.06
EE-SY310	0004501430000254	1991.06
EE-SY410	0004501430000256	1991.06
EE-SY313	0004500010000090	1991.11
EE-SY413	0004501430000258	1991.06
EE-SMR1********	0004501430000040	1991.06
EE-CB*****	0004501430000001	1991.06
EE-CF1*****	0004501430000002	1991.06
EE-CF2****	0004501430000003	1991.06
EE-CF4**	0004501430000004	1991.06
EE-CS**	0004501430000006	1991.06
EE-CT**	0004501430000007	1991.06