QUALITY ASSURANCE

Introduction

Sharp develops and produces a wide range of consumer and industrial-use semiconductor products.

In recent years, the applications of ICs have expanded significantly, into fields where extremely high levels of quality are critical.

In response, Sharp has implemented a total quality assurance system that encompasses the entire production process from planning to aftersales service. This system ensures that quality is a priority in the planning development and production and confirm product reliability through rigorous reliability testing. We compiled the “Sharp Semiconductor Reliability Handbook, IC Edition” to introduce you to the results of some of our research and to our quality and reliability philosophy and programs. We hope that it is informative and that it will help Sharp customers develop and refine their quality and reliability assurance and control activities. We will introduce a part of this system here.

The Quality Assurance System

Sharp’s quality assurance system has been established to ensure the manufacture of the high-quality and high-reliability integrated circuit devices at every step. This begins at the planning stage and extends through to design and development, production, shipping and marketing in accordance with the international quality assurance standards of the ISO 9000 family.

Three ISO 9000 Family Quality Assurance Models :

1. ISO 9001 Quality System : quality assurance model for development, design, manufacture, installation and after-sales service.

2. ISO 9002 Quality System : quality assurance model for manufacture, installation and after-sales service.

3. ISO 9003 Quality System : quality assurance model for final inspections and testing.

Vital user feedback is incorporated in the design process during planning. Basic customer requirements are identified, such as the purpose for which the product will be used and the required quality and reliability. During this stage, Sales and Marketing, Product Planning, Engineering, Reliability Control and other related divisions thoroughly study the function, circuitry and operating conditions of the product as well as other aspects such as target reliability, cost and delivery date. A development plan is then proposed, based on these studies.

In the design and development stage, quality and reliability are designed into the product. A stringent Design Review and Reliability Assessment is implemented to assure that the targeted standards will be achieved. Sharp also sets up an engineering committee and meetings to discuss improvements in design quality to support the design review process, effectively enhancing basic technology and preventing quality problems before they may occur.

Appropriate measures are implemented as necessary during production to maintain, at a consistent level, the quality and reliability designed into the product. The Computer Integrated Manufacturing (CIM) system is implemented, Total Productive Maintenance (TPM) activities are promoted and Statistical Process Control (SPC) employing biased Process Capability indices (Cpk) is carried out. Additionally, Sharp consistently monitors every detail of the production process.

While engaging in quality assurance activities to control, modify or correct raw materials, the manufacturing environment, production environment, test instruments and vendors, Sharp continually works to maintain the highest levels of knowledge and ethics in the fields of quality and reliability. This is promoted and achieved through education, study and training both on the job and in the classroom for every technician and process operator involved with a project. Also, small group activities are emphasized.

At the market level, immediate processing of market quality information together with the collection of quality data and reliability test data provide Sharp with the ability to assess products in order to better serve the customer.

Fig.1a and **Fig.1b** illustrate the Sharp integrated circuit device Quality Assurance System.

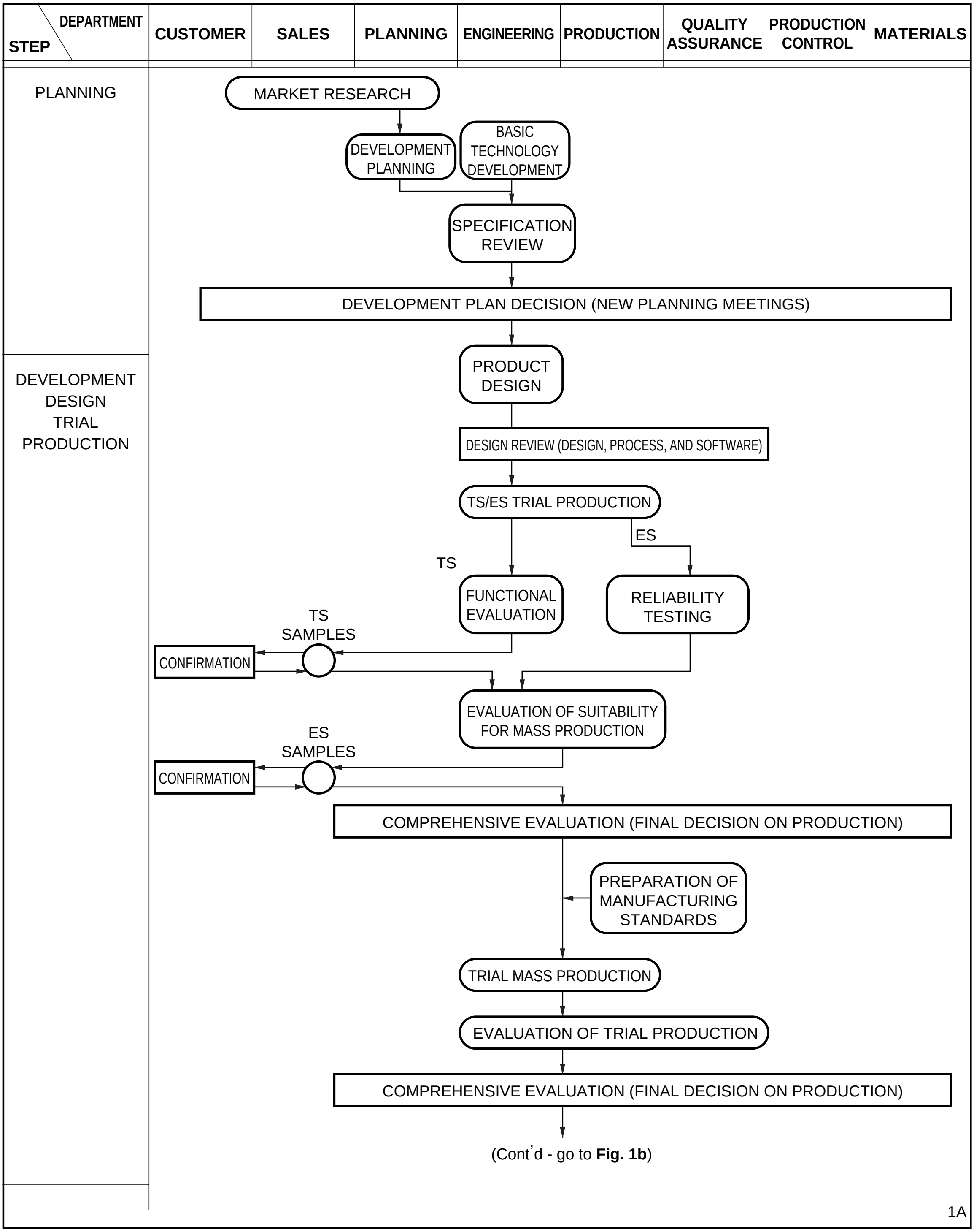


Fig. 1a Quality Assurance System

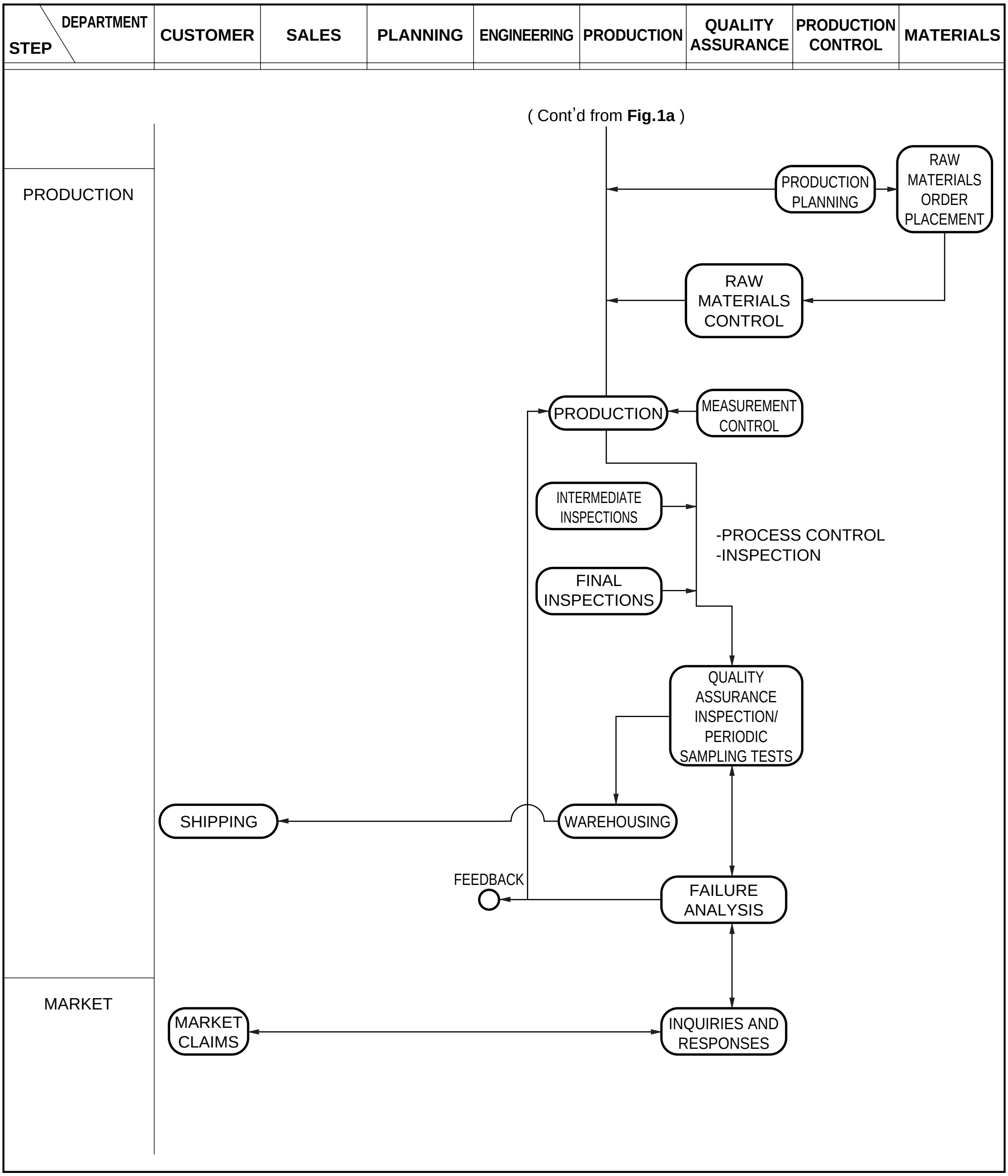


Fig. 1b Quality Assurance System (cont'd)

General Reliability Tests

(1) Reliability Test Items

Table 1
An Example of General Reliability Tests

CLASSIFICATION	TEST	PURPOSE AND CONDITIONS	REFERENCE STANDARDS
Mechanical Tests	Variable Frequency Vibration	To determine resistance to vibration during transportation and use. Standard test conditions : Frequency : 100 to 2 000 Hz in 4 min, total 48 min Acceleration : 200 m/s^2 Orientation : four (4) times in each of the orientations of X, Y, Z	JIS C 7022 : A-10 EIAJ ED-4701 : A-121 MIL-STD 883 : 2007
	Mechanical Shock	To determine resistance to shocks during transportation and use. Standard test conditions : Acceleration : 15 000 m/s^2 Pulse duration : 0.5 ms Orientation : three (3) pulses in each of the orientations ±X, ±Y and ±Z	JIS C 7022 : A-7 EIAJ ED-4701 : A-122 MIL-STD 883 : 2002
	Constant Acceleration	To determine resistance to constant acceleration. Standard test conditions : Acceleration : 200 000 m/s^2 Orientation : applied for one (1) min in each of the orientations ±X, ±Y and ±Z	JIS C 7022 : A-9 EIAJ ED-4701 : A-123 MIL-STD 883 : 2001
	Terminal Strength	To determine resistance to installation and handling mechanics. 1. Tensile strength. Standard test conditions : A specified load is applied in-line with terminal direction for 10±1 s. 2. Bending strength. Standard test conditions : A specified load is applied to the tip of each lead and the lead is bent once through a + and – 90° arc and back. (The specified force is determined by nominal cross section or nominal section modulus). ∗TCP (tape carrier package) : N/A ∗J-lead packages : N/A	JIS C 7022 : A-11 EIAJ ED-4701 : A-111 MIL-STD 883 : 2004
	Solderability	To determine the solderability of terminals after transportation and storage. Standard test conditions : Solder bath temperature : 230±5°C Dip time : 5±0.5 s Solder composition : Pb : Sn = 4 : 6, used with rosin flux. Test performed after steam and/or heat aging.	JIS C 7022 : A-2 EIAJ ED-4701 : A-131 MIL-STD 883 : 2003

Table 1 (cont'd)
An Example of General Reliability Tests

CLASSIFICATION	TEST	PURPOSE AND CONDITIONS	REFERENCE STANDARDS
Thermal Environment Tests	Soldering Heat Resistance	To determine the resistance to heat during installation. (Refer of **Table 2** for SMD) Standard test conditions : Solder bath temperature : 260±5°C Dip time : 10±1 s Solder composition : Pb : Sn = 4 : 6	JIS C 7022 : A-1 EIAJ ED-4701 : A-132
	Temperature Cycling	To determine resistance to high and low temperatures and to temperature changes during transportation and use. Standard test conditions : Ta = Tstg MIN. to Tstg MAX. [gas phase]	IS C 7022 : A-1 EIAJ ED-4701 : B-131 MIL-STD 883 : 1010
	Thermal Shock	To determine resistance to sudden changes in temperature during transportation and use. Standard test conditions : Ta = Tstg MIN. to Tstg MAX. [liquid phase]	JIS C 7022 : A-3 EIAJ ED-4701 : B-141 MIL-STD 883 : 1011
	Temperature & Humidity Cycling	To determine resistance to conditions of high temperature and high humidity during transportation and use. Standard test conditions : –10 to 65°C, 90 to 96% RH, one (1) cycle every 24 hours.	JIS C 7022 : A-5 EIAJ ED-4701 : B-132 MIL-STD 883 : 1004
	Hermeticity	To determine the effectiveness of the seal in hermetically sealed package devices. 1. Fine leak detection (helium) : measured with a helium detector after storage in an He atmosphere at a prescribed pressure for a designated time period. 2. Gross leak observation (bubbles) : observation of bubbles formed by a fluorocarbon on silicone oil.	JIS C 7022 : A-6 EIAJ ED-4701 : B-142 MIL-STD 883 : 1014
	Salt Atmosphere	To determine resistance to corrosion in a salt spray. Standard test conditions : Salt concentration : 5±1 wt% Spray rate : 10 to 50 g/m^2/d Store for designated time period under salt spray conditions with salt spray temperature 35±2°C.	JIS C 7022 : A-12 EIAJ ED-4701 : B-144 MIL-STD 883 : 1009
	High Temperature Operation	To determine resistance to prolonged operating stress, electrical and thermal. Standard test conditions : Ta = Topr MAX. Operating test source voltage = MAX. specified source voltage	JIS C 7022 : B-1 EIAJ ED-4701 : D-101 MIL-STD 883 : 1005

Table 1 (cont'd)

An Example of General Reliability Tests

CLASSIFICATION	TEST	PURPOSE AND CONDITIONS	REFERENCE STANDARDS
Thermal Environment Test	High Temperature Storage	To determine resistance to prolonged high temperature storage. Standard test conditions : Ta = Tstg MAX.	JIS C 7022 : B-3 EIAJ ED-4701 : B-111 MIL-STD 883 : 1008
	Low Temperature Storage	To determine resistance to prolonged low temperature storage. Standard test conditions : Ta = Tstg MIN.	JIS C 7022 : B-4 EIAJ ED-4701 : B-112
	High Temperature/ High Humidity Bias	To determine resistance to prolonged temperature, humidity and electrical stress. Standard test conditions : 85°C, 85% RH Applied test source voltage = MAX. specified source voltage.	JIS C 7022 : B-5 EIAJ ED-4701 : B-122
	High Temperature/ High Humidity Storage	To determine resistance to prolonged storage at high temperature and humidity. Standard test conditions : 60°C, 90% RH, or 85°C, 85% RH	JIS C 7022 : B-5 EIAJ ED-4701 : B-121
Miscellaneous	Steam Pressure	To evaluate moisture resistance in a short period of time. Standard test conditions : 121°C, 100% RH, 2 x 10^5 Pa, no electrical load.	EIAJ ED-4701 : B-123 5. Reference
	Electrostatic Discharge Strength	To determine resistance to electrostatics stress (ESD). Standard test conditions : 1. Human body model : Equivalent Capacitance C = 100 pF Equivalent Resistance R = 1.5 kΩ 2. Machine model : Equivalent Capacitance C = 200 pF Equivalent Resistance R = 0 Ω 3. Charged device model	MIL STD 883 : 3015 EIAJ ED-4701 : C-111A EIAJ EDX-4702 (CDM)
	Latch-Up Strength	To determine resistance to latch-up. Standard test conditions : 1. Pulse current injection method 2. Vcc bump method 3. Voltage bump method	EIAJ ED-4701 : C-113 JEDEC JESD17
	Mark Permanency	To determine resistance to solvents in displays or coatings. Standard test conditions : Brushing for 5 min after 10 min immersion at 20 to 25°C. Solvents : Isopropyl and ethyl alcohol, acetone	EIAJ ED-4701 : C-121
	Erase/Write Cycle	To determine Erase/Write endurance. (Applicable to EEPROM, flash memory, etc.) Standard test conditions : Ta = Topr MAX. and Topr MIN.	
	Soft Error	To evaluate resistance to soft errors from α particles (primarily released from package materials). (Applicable mainly to DRAM and SRAM).	

Table 2

An Example of General Test Items for Surface Mounted Devices

CLASSIFICATION	TEST	PURPOSE AND CONDITIONS	REFERENCE STANDARDS
Surface Mounted Device Tests	Soldering Heat Resistance	To determine the soldering heat resistance on resin-sealed surface-mount devices (SMDs). Standard test conditions : Prepare by prolonged exposure to specified temperature and humidity conditions before heat exposure. 1. Infrared reflow 230 to 240°C, within 15 s. 2. Solder bath immersion 260±5°C, 10±1 s.	EIAJ ED-4701 : A-133
	Dry Pack Testing	To determine heat and moisture tolerance in a resin-sealed surface-mounted device during storage and use. Standard test conditions : After bake and moisture exposure, subject units to surface mount application conditions prior to use in other specified environmental tests.	EIAJ ED-4701 : B-101

(2) Failure Determination Criteria

Table 3

Failure Determination Criteria

TEST ITEM	FAILURE DETERMINATION CRITERIA
Terminal Strength	No fractures, looseness or interface gaps between the lead and the device.
Solderability	At least 95% of the immersed area must be coated with solder. Pin holes or other defects must not be concentrated in one area nor exceed 5%.
Hermeticity	Must not exceed leak rate specified by internal volume.
Salt Spray	Must satisfy the electrical characteristics in the specification. Must have no unclear markings, surface peeling, pitting or corrosion.
Mark Permanency	Marking must not rub off.
Solder Heat Resistance/Dry Pack Test	Must satisfy the electrical characteristics in the specification. No package cracks.
Other Items	Must satisfy specified electrical characteristics.

Reliability Tests

Reliability Tests Methods

Reliability tests should always have good reproducibility. Thus, reliability tests for IC devices are based on standardized test methods. Such uniform testing standards include those established by JIS (Japanese Industrial Standard), MIL (U.S. MILitary Standard) and EIAJ (Electronic Industries Association of Japan). As indicated in ***Table 1 to 3***, however, Sharp has established its own testing method based on these standards.

Failure Analysis

Advances in semiconductor device technology are astonishing, and they call for higher quality and reliability standards. Improved failure analysis techniques are, therefore, necessary to ensure semiconductor device reliability.

The causes of semiconductor device failure are becoming increasingly diverse. This diversity is the result of element and interconnect miniaturization required for higher integration. It is also due to an increasingly complex manufacturing process with an increased number of steps from the wafer fabrication process to the assembly process.

Failure analysis is the use of human, physical and electrical analytical procedures to clarify the failure mechanisms of defective parts. It is used to evaluate defective items appearing throughout the life of parts : during the semiconductor manufacturing process, outgoing inspections and reliability testing; during the user's incoming inspections, processing and reliability testing; and during operation in the field.

The ultimate goal of failure analysis is to prevent the recurrence of failure. It is necessary to establish various measures based on the results of failure analysis and to feed those measures back to the manufacturing process and product users.

Quality Control in the Marketplace

Sharp has an on-going program of supplying users with our own quality data, reliability test data, etc., upon request. It is just one of Sharp's efforts to maintain a high degree of user service. ***Fig. 2*** illustrates Sharp's Quality Information Routes.

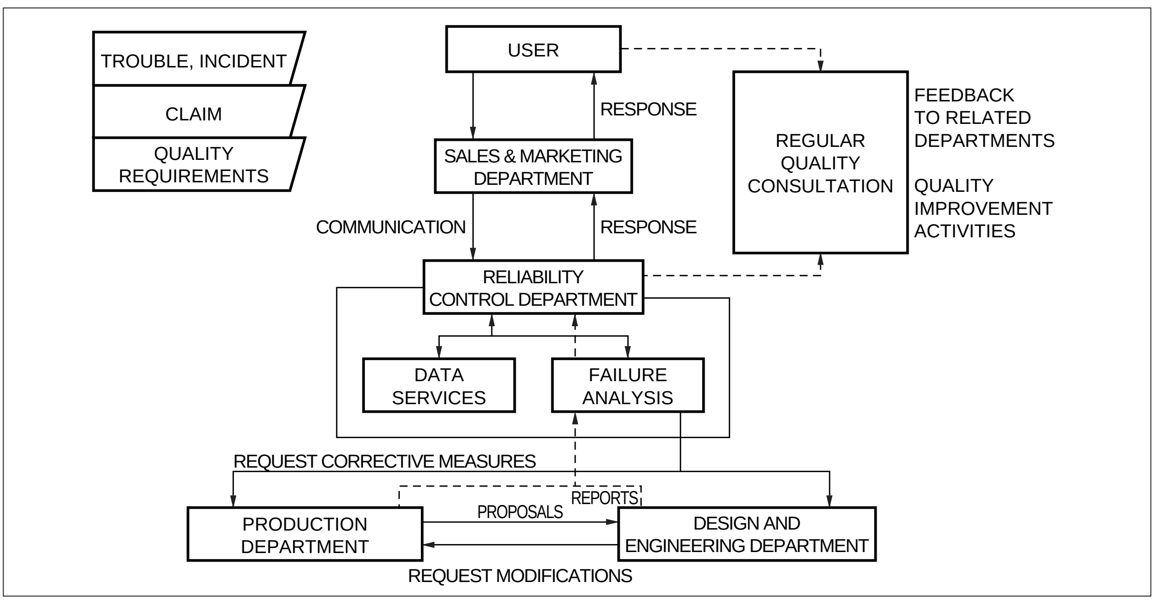


Fig. 2 Routes Through Which Malfunctions Outside The Company Are Handled

Handling Precautions

All the semiconductor products listed in this data book are manufactured based on exacting designs and under comprehensive quality control. However, to take full advantage of the features offered and to assure each products' long-life service, please refer to the following items.

Maximum Ratings

It is generally known that the failure rate of semiconductor products increases as the temperature increases. It is, therefore, necessary that the ambient temperature be within the maximum rated temperature. Further, it is desirable from the standpoint of reliability that the ambient temperature be lowered as much as possible. The voltage, current, and electric power used are also factors that significantly influence the life of semiconductor products. Voltage or current that exceeds the rated level may damage the semiconductor products; even if applied only momentarily and the unit continues to operate properly, excessive voltage or current will likely increase the failure rate.

Therefore, in actual circuit design, it is important that the semiconductor products have an allowance with respect to the voltage, current and temperature conditions under which they will be used. The greater this allowance, the fewer the failures that will occur. To keep failures to a minimum, the circuit should be designed so that under all conditions to absolute maximum, the ratings are not exceeded even momentarily and so that the maximum values for any two or more items are not achieved simultaneously. In addition, remember that the circuit functions of semiconductor products are guaranteed within the operating temperature range (Topr) or the absolute maximum ratings, but that storage temperature (Tstg) is the range in a nonoperating condition.

Storage Precautions

General Storage Precautions

a. Storing product in the packing in which it is shipped is recommended. If transferred to a different container, use one that will not readily carry an electrostatic change.
b. Store at conditions of normal temperature (5 to 35°C) and normal humidity (45 to 75% RH).
c. Avoid storing product in the presence of corrosive gases or dusty areas.
d. Avoid storing product in areas of direct sunlight or where sudden temperature changes will occur.
e. Avoid stacking product or otherwise applying heavy loads.
f. In the case of extended storage, take particular care against corrosion and deterioration in lead solderability. Inspecting such product before use is recommended.

Basic Electrostatic Discharge Countermeasures

Semiconductor device mounting requires exacting precautions to avoid applying excessive static electricity to the semiconductor. Item (a)-(c) below are basic electrostatic discharge countermeasures.

a. Use humidifiers and the like to ensure against excessively low relative humidity in the work environment. (Maintaining relative humidity consistently above 50% is ideal).
b. To prevent sudden electrostatic discharge, spread high-resistance electroconductive mats (about $10^6\ \Omega$) over workbenches and have workers wear wrist (ground) straps.

Have workers wear clothing made of charge-resistant cotton, noncharging materials (10^9 to 10^{14} Ω) or static electricity dissipating materials (10^5 to $10^9\ \Omega$). Anti-static foot apparel is also effective.

c. Ionizers (ionized air blowers) are effective when it is difficult to discharge static electricity from mounting equipment, contacting dielectrics and semiconductors.

Sharp recommends using static electricity measuring devices to quantify electrostatic charges and develop effective countermeasures.

When forming the lead wires of semiconductor products to be mounted, forceps or a similar tool that will prevent stress from being applied to the base of the wires should be used.

To prevent the input terminals of semiconductor products on completed printed circuit boards from becoming open during storage or transport, the terminals of the circuit board should be shortcircuited or the entire circuit board itself should be wrapped in aluminum foil.

Soldering and Cleaning

When a semiconductor product is solder-bonded, specify the best conditions according to ***Table 5***. If using a soldering iron, use one that doesn't leak from the soldering tip. An 'A Class' soldering iron with an insulation resistance of less that 10 MΩ is recommended. When using a solder bath, it should be grounded to prevent an unstable electric potential.

Using a strongly acidic or alkaline flux for soldering can cause corrosion of the lead wires. A rosin flux is ideal for this type of soldering.

To assure the reliability of a system, removal of the solder flux is generally required.

To prevent stress of semiconductor products and circuit boards when using ultrasonic cleaning, a cleaning method must be used that will shadow the main unit from the vibrator and specify the best conditions according to the following :

Table 4
Recommended Conditions for PC Board Cleaning

Ultrasonic Power	less than 25 W/l
Cleaning Conditions	less than one minute total
Cleaning Solution Temperature	15 to 40°C

Adjustment and Tests

When the set is to be adjusted and tested upon completion of the printed circuit board the printed circuit board must be checked to ensure that there are no solder bridges or cracks before the power is turned on. Also, if the market-rated voltage and current are to be used, it is wise to use a current limiter.

Whenever a printed circuit board is to be removed or mounted, or mounted on a socket, the power must be turned off.

When testing with a probe, care must be taken to assure that the probe dose not come in contact with other signals or the power supply. If the test location has been decided beforehand, it is wise to set up a specially designed testpin for testing.

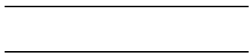
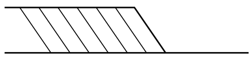
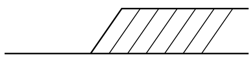
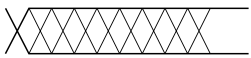
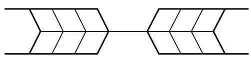
When testing in high and low temperatures, the constant-temperature bath must be grounded and measures taken to protect the set inside the bath from static electricity.

Table 5 outlines the semiconductor soldering conditions. (Refer to the specification sheet of each device.)

Table 5
SOLDERING CONDITIONS

MOUNTING METHOD	TEMPERATURE AND TIME	MEASUREMENT POINT
Infrared reflow	Peak temp. 240˚C or less 230˚C or more within 15 s Heating speed : 1 to 4°C/s	Surface IC package
Flow dipping	245˚C or less Within 3 s/cycle Within 5 s in total	Solder bath
VPS	215˚C or less 200 to 215˚C within 40 s	Steam
Hand soldering (Using a soldering iron)	260˚C or less, within 10 s	IC outer lead

TIMING DIAGRAM CONVENTIONS

TIMING DIAGRAM	INPUT FUNCTIONS	OUTPUT FUNCTIONS
	HIGH or LOW	HIGH or LOW
	HIGH-to-LOW transitions allowed	HIGH-to-LOW transitions during designated interval
	LOW-to-HIGH transitions allowed	LOW-to-HIGH transitions during designated interval
	Don't care	State unknown or changing
	(Does not apply)	Centerline is high-impedance