ON Semiconductor

Enabling Energy Efficient Solutions

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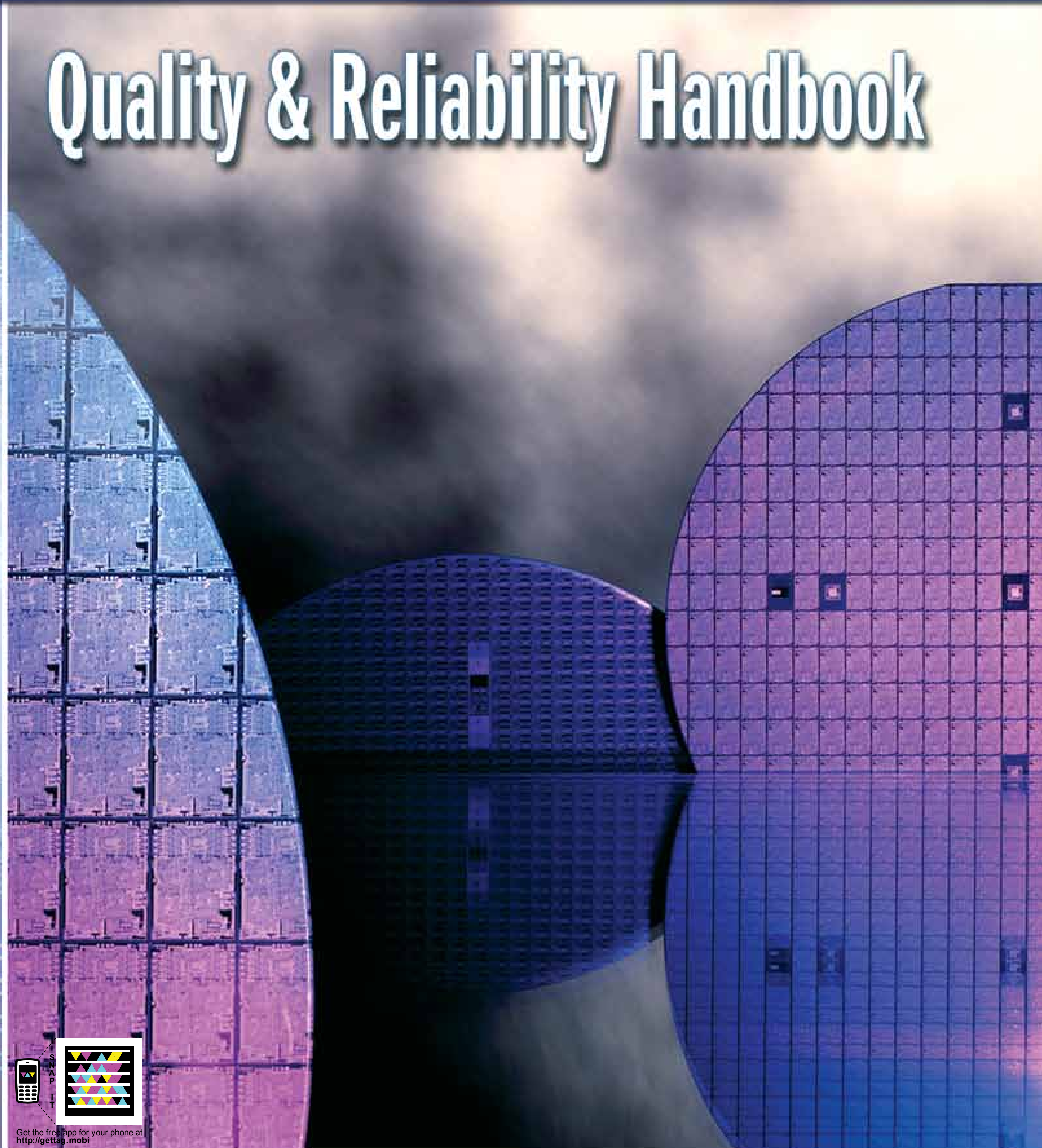
Quality & Reliability Handbook



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Dear Customer:

I am pleased to present you with the ON Semiconductor Reliability and Quality Handbook. By becoming QS-9000 certified on our first day of doing business as a new company in 2000, ON Semiconductor demonstrated our commitment to live by these stringent, internationally accepted requirements for “Reliability” and “Quality.” Since that time we became the first semiconductor company to become certified to ISO/TS16949:1999 and we have continually maintained our certification to the latest internationally recognized standards for Quality Systems. We recognize the integrated effectiveness of building both “Reliability” and “Quality” into our services, processes and products. We are committed to developing and maintaining a distinctive, world class Quality system, which transcends all international Quality standards and truly exceeds customer expectations.

This handbook is intended to provide basic information on the reliability and quality aspects of the products supplied by ON Semiconductor worldwide. ON Semiconductor maintains a portfolio that includes a broad spectrum of products in a full array of package technologies, including but not limited to, the following products:

- **Power Management Devices**: AC-DC Controllers & Regulators; DC-DC Controllers, Converters, & Regulators; Drivers; Thermal Management; Voltage & Current Management
- **Signal Management Devices**: Amplifiers & Comparators; Analog Switches; Digital Potentiometers; DSP Systems; EMI / RFI Filters; Interfaces
- **Logic Devices**: Clock Generation; Clock & Data Distribution; Memory; Standard Logic
- **Discrete Devices**: Bipolar Transistors; Diodes & Rectifiers; IGBTs & FETs; Thyristors
- **Custom Devices**: ASICs; Custom Foundry Services; Custom ULP Memory

ON Semiconductor is headquartered in Phoenix, Arizona (U.S.A.) and has a number of international facilities, which have on-site test, reliability testing and product analysis capabilities. ON Semiconductor has developed a global marketing, sales and field quality network to supply its customers with quality products, information and services.

ON Semiconductor is certified to ISO 9001:2008 and ISO/TS 16949:2009, AS 9001:2004 rev. B, MIL-PRF-38535 and ISO 14001:2004. ON Semiconductor’s Quality System and Business Operating System are synonymous. The company established a Core Business Process Model to ensure that we meet or exceed our customer’s expectations and our business goals. We’ve adopted the approach of taking the ISO 9001 requirements and aligning them within our existing Business Model.

Our Quality Policy states, “We will exceed Customer Expectations with our Superior Products and Services.” In addition, our Quality statement declares, “Every ON Semiconductor employee is personally responsible for ensuring the highest Quality in the products and services delivered to internal and external customers. Continuous improvement in the quality of our processes, products and service is fundamental to the achievement of customer satisfaction.” The policy emphasizes that the responsibility to achieve quality, both in services and products belongs to each and every one of us. I can’t over emphasize this point! ALL of us, every business leader, sales person, project manager, operator, engineer, EVERY ON Semiconductor employee, is personally responsible for the Quality of those products and services that we individually and collectively supply to our Customers.

And finally, because we believe “fulfilling customer requirements is the first step in customer satisfaction,” our Core Business process model begins with the customer and ends with the customer. The strength of our business initiatives and our focus on servicing our customers ensures ON Semiconductor’s success now and in the future.

For additional questions, please contact 1 (800) 282-9855 or email us at quality@onsemi.com.

Keenan Evans
Vice-President, Global Quality, Reliability & EHS
ON Semiconductor

Section 1 – Introduction

ON Semiconductor designs, manufactures and markets high performance and energy efficient innovative silicon solutions in the following:

- **Key Markets**: Computing, Consumer, Wired/Wireless Communications, Automotive, Industrial, Military/Aerospace, Power
- **Emerging Markets**: LED Lighting, Medical, Smart Grid (Energy Management)

The company's current portfolio numbers close to 20,000 products which includes full Pb-Free, ROHS compliant device offerings. We manufactured more than 32.6 billion in 2007 and over 26 billion each in 2008 and 2009 even with the downturn of the semiconductor industry These products are put in the hands of our customers through our highly responsive supply chain. With our global logistics network and strong portfolio of power semiconductor devices, ON Semi- conductor is a preferred supplier of power solutions to engineers, purchasing professionals, distributors and contract manufacturers in the computer, cell phone, portable devices, automotive and industrial markets.

Headquartered in Phoenix, Arizona, we are a public company and trade on the NASDAQ under the symbol (ONNN). We employ approximately 13,000 people worldwide and have manufacturing facilities in the United States, China, the Czech Republic, Japan, Malaysia, the Philippines, Thailand, Slovakia and Belgium

We strive to continuously meet our customers' current and anticipated semiconductor component needs so well that, "Customers will come to us first!" We enact this vision by each day fulfilling our mission to: Eliminate any reason for the customer to buy from other suppliers by providing the highest Quality components and services at competitive prices with the most reliable delivery and ease of purchase.

ON Semiconductor is both ISO/TS16949:2002 and ISO 9001:2000. The foundation of our success is customer satisfaction, customer confidence and continuous improvement. The extent of these efforts touches every function and region of our business. Our quality resolve is deeply ingrained in every employee.

This handbook is intended to review and provide information on the reliability and quality aspects of the semiconductor products supplied by ON Semiconductor worldwide.

In today's semiconductor marketplace, two important elements for the success of a company are its quality and reliability systems. They are interrelated, reliability being the quality extended over the expected life of the product. For any manufacturer to remain in business, its products must meet or exceed the basic quality and reliability standards. As a semiconductor supplier, ON Semiconductor has successfully established reliability and quality standards for products, processes, and services that exceed the basic standards and meet our customers' needs. For the purpose of this report, the most stringent and demanding definitions of quality and reliability are used.

Quality may be defined as:

- Reduction of variability around a target so that conformance to customer requirements and expectations can be achieved in a cost effective way.
- The probability that a device (equipment, parts) will have performance characteristics within specified limits.
- Fitness for use.

Reliability is defined as:

- Quality in time and environment (temperature, voltage, etc.).
- The probability that a semiconductor device, which initially has satisfactory performance, will continue to perform its intended function for a given time under actual usage environments.

ON Semiconductor®

QUALITY POLICY:

"We will exceed Customer Expectations with our Superior Products and Services."

QUALITY STATEMENT:

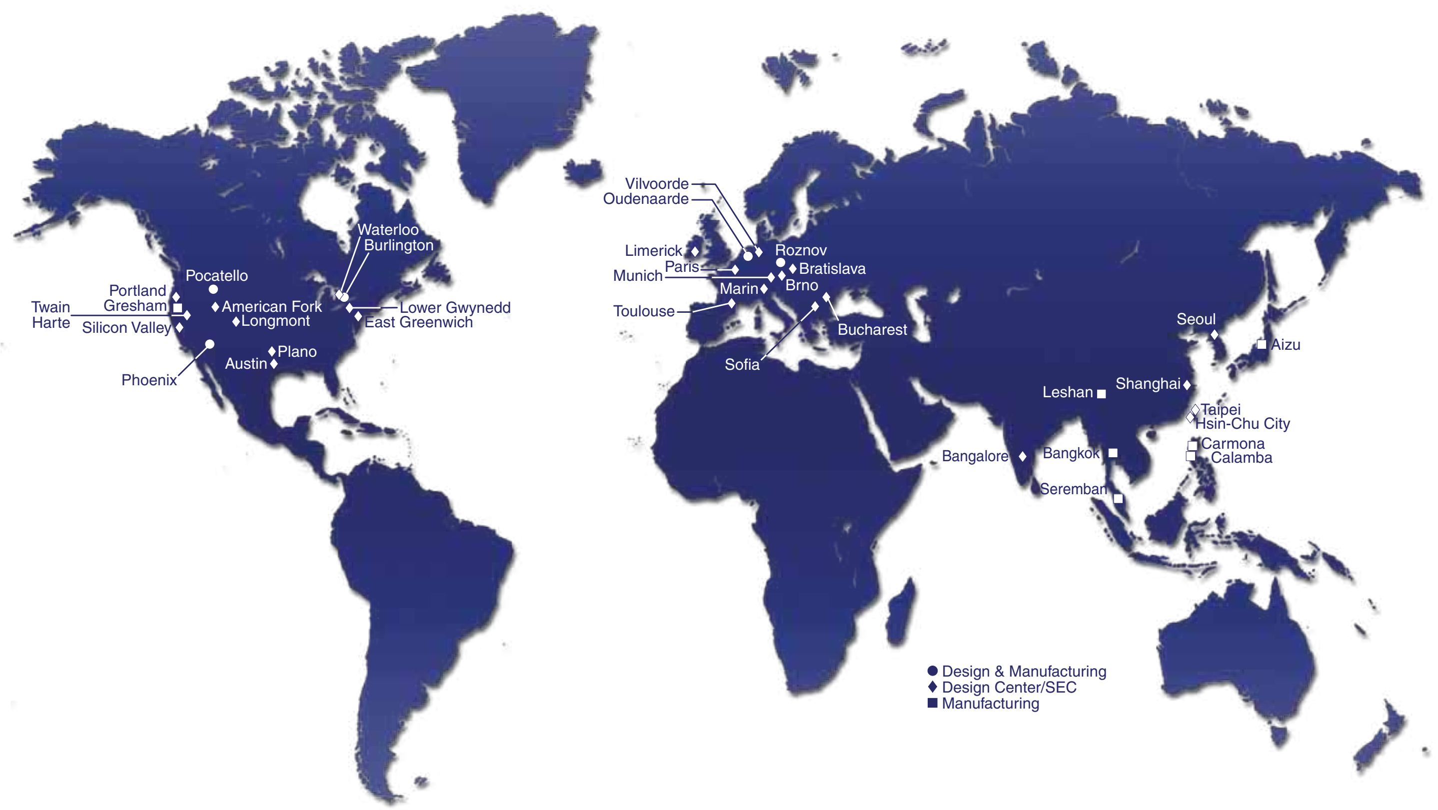
"Every ON Semiconductor employee is personally responsible for ensuring the highest Quality in the products and services delivered to internal and external customers. Continuous improvement in the quality of our processes, products and services is fundamental to the achievement of customer satisfaction.

Keith Jackson, President and CEO, ON Semiconductor

At ON Semiconductor, our reliability and quality assurance program is designed to generate ongoing data for both reliability and quality for the various product families. Both reliability and quality monitors are performed on the different major categories of semiconductor products. These monitors are designed to test the product's design and material as well as to identify and eliminate potential failure mechanisms to ensure reliable device performance in a real world application. Thus, the primary purpose of the program is to identify trends from the data generated and use that information to continuously improve our products. In addition, this reliability and quality data can be utilized by our customers for failure rate predictions.

This handbook is a compilation of reliability test results and quality data from all semiconductor operations. The data contained are annual summaries of many detailed tests and evaluations performed in ON Semiconductor locations worldwide.

Detailed reliability reports for product line or device types are available upon request and can be obtained through your local ON Semiconductor Sales or Customer advocacy representative, or from the sources indicated in this handbook.



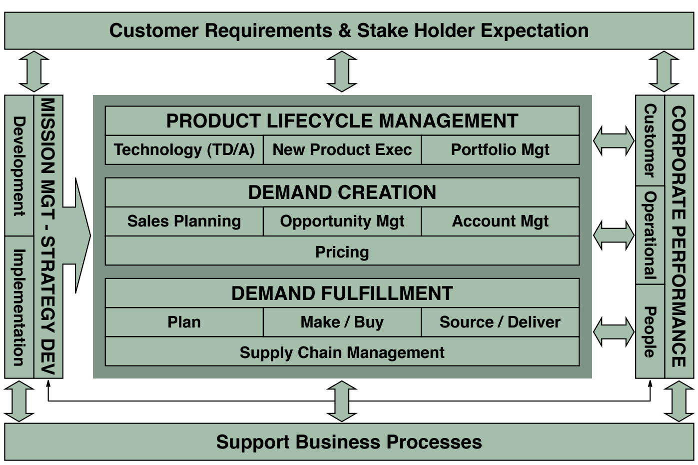
Section 2 – ON Semiconductor Quality System

(Based on our Core Business Process Model)

ON Semiconductor is registered to both ISO 9001:2008 and ISO Technical Specification (TS) 16949:2009. ON Semiconductor's Quality System and Business Operating System are synonymous. The company established a Core Business Process Model, which shown below ensures we meet or exceed our customer's expectations and our business goals. We've adopted the approach of taking the ISO 9001:2008 requirements and aligning them into our existing Business Model.

Our Quality Policy states, "We will exceed Customer Expectations with our Superior Products and Services." In addition, our Quality statement declares, "Every ON employee is personally responsible for ensuring the highest Quality in the products and services delivered to internal and external customers. Continuous improvement in the quality of our processes, products and service is fundamental to the achievement of customer satisfaction." Since we believe that, in other words, "fulfilling customer requirements is the first step in customer satisfaction", our Core Business process model begins with the customer and ends with the customer.

Customer Business Process Model & Structure



Our core business processes are link into our global work processes ensuring alignment between our business strategy and practices.

ON Semiconductor Certification Status

Each of our manufacturing sites, marketing and design groups have been certified by Lloyd's Registry Quality Assurance (LRQA).

Our Certificate of Approval:

http://www.onsemi.com/images/certappr.pdf

Our Certificate Schedule:

http://www.onsemi.com/images/certsched.pdf

Six Sigma®

ON Semiconductor is committed to the Six Sigma philosophy in both our manufacturing and business environments.

Our Six Sigma efforts for the new millennium and beyond will be to:

- Continue our efforts to achieve Six Sigma results - and beyond - in everything we do (products and services)
- Measure in parts per billion (ppb)

Customer Satisfaction

ON Semiconductor is engaged in a very competitive global marketplace. We will not grow if we continue to focus only on our heritage and our past accomplishments. We continually strive to understand our customers' needs for service and support by focusing on customer service.

A key factor here is the feedback we receive on the quality of our products and services. We need to understand this so well that we will be able to anticipate solutions to product and service needs our customers have yet to recognize. That means listening to their ideas about how we can better serve them from a total system's perspective - from idea introduction to successful delivery of product or service.

How will we determine this? By asking how our external customers perceive ON Semiconductor in terms of quality and by asking them about their expectations of ON Semiconductor. This will be accomplished by conducting the Annual Quality Survey. The objectives that will be accomplished through the Annual Quality Survey are:

- Continue strengthening our business operating system by determining our customers' current business expectations.
- Provide a baseline measurement of our performance against those expectations.
- Provide feedback on our performance against customer expectations on an annual basis (trends).
- Track changing expectations in order to modify our quality system accordingly.
- Provide a basis for a consistent set of customer satisfaction metrics that provides a check of our internal quality measurements.

Therefore, each business must develop customer driven indices - using factors established by the customer - and set aggressive improvement goals.

They will also change in time when customers raise the bar as we meet their current expectations.

ON Semiconductor Learning and Development

ON Semiconductor has instituted education and training that is directly linked to the strategic company goals identified by the Executive Council. All corporate driven training delivered is targeted toward those areas. To keep current with business needs, the training focus is reviewed annually in alignment with the corporate strategy. When the focus is determined, supporting training and education events are identified, designed, developed, and/or sourced to meet the need. This is a dynamic process with inputs from the organization, the employees and external market factors.

At the functional level, organizational capability is assessed, matched with current skills of the population to execute, and gaps are filled accordingly. The employee needs are factored in when looking at skill match. Does the employee have the right skills to execute to the strategic direction of the company and if not, what is the immediate development plan that would allow the employee to obtain the skill, real time. This job/skill match process allows alignment of business goals and job skill requirements.

The Black Belt training and SPC programs mentioned above are excellent examples of the many training programs developed for ON Semiconductor.

Section 3 – Introduction to Reliability & Quality Methods

For semiconductors, the often critical nature of the equipment in which they are used leaves no room for failure. By their very nature, properly designed semiconductor devices will far outlast the life expectancy of the equipment for which they are intended, and careful processing will ensure that each device meets the specifications to which it is designed.

The result of proper design and careful planning is a quality product.

The reliability and quality methods discussed in this handbook contribute to the attainment of Six Sigma performance in all of our operations.

Reliability Stress Tests

The following are brief descriptions of the tests commonly used in the reliability assessment. Not all of the tests listed are performed on each product. Other tests may be performed when appropriate. The information herein is typical of the testing performed. Variations to the following will be found throughout this document based on the limitations of the specific device being tested.

AUTOCLAVE

Autoclave is an environmental test which measures device resistance to moisture penetration and the resultant effects of galvanic corrosion. Autoclave is a highly accelerated and destructive test.

Typical Test Conditions: T_A = 121°C, rh = 100%, p = 1 Atmosphere (15 psig), t = 24 to 240 hours.

Common Failure Modes: Parametric shifts, high leakage and/or catastrophic failure.

Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing.

HIGHLY ACCELERATED STRESS TEST

Highly Accelerated Stress Test uses a pressurized environment to produce extremely severe temperature, humidity and bias conditions. HAST accelerates the same failure mechanisms as High Humidity High Temperature Bias.

Typical Test Conditions: T_A = 130°C, rh = 85% to 95%, p = 2 Atmospheres, Bias = 80% to 100% of Data Book maximum rating, t = 96 to 240 hours.

Common Failure Modes: Parametric shifts, high leakage and/or catastrophic failure.

Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing.

HIGH HUMIDITY HIGH TEMPERATURE BIAS

This is an environmental test designed to measure the moisture resistance of plastic encapsulated devices. A bias is applied to create an electrolytic cell necessary to accelerate corrosion of the die metallization. With time, this is a catastrophically destructive test.

Typical Test Conditions: T_A = 85°C to 95°C, rh = 85% to 95%, Bias = 80% to 100% of Data Book maximum rating, t = 96 to 1008 hours.

Common Failure Modes: Parametric shifts, high leakage and/or catastrophic failure.

Common Failure Mechanisms: Die corrosion or contaminants such as foreign material on or within the package materials. Poor package sealing.

HIGH TEMPERATURE FORWARD BIAS

This test is designed to measure the stability of the devices under a forward bias condition at high temperature.

Typical Test Conditions: T_A = 85°C to 100°C, Bias = 100% of Data Book maximum rating, t = 120 to 1008 hours.

Common Failure Modes: Parametric drifts in repetitive peak off state and reverse currents, gate trigger current and voltage.

Common Failure Mechanisms: Random oxide defects and ionic contamination.

HIGH TEMPERATURE GATE BIAS

This test is designed to electrically stress the gate oxide under a bias condition at high temperature.

Typical Test Conditions: T_A = 150°C, Bias = 80% of Data Book maximum rating, t = 120 to 1008 hours.

Common Failure Modes: Parametric shifts in gate leakage and gate threshold voltage.

Common Failure Mechanisms: Random oxide defects and ionic contamination.

HIGH TEMPERATURE REVERSE BIAS

The purpose of this test is to align mobile ions by means of temperature and voltage stress to form a high-current leakage path between two or more junctions.

Typical Test Conditions: T_A = 85°C to 150°C, Bias = 80% to 100% of Data Book maximum rating, t = 120 to 1008 hours.

Common Failure Modes: Parametric shifts in leakage and gain.

Common Failure Mechanisms: Ionic contamination on the surface or under the metallization of the die.

HIGH TEMPERATURE STORAGE LIFE

High temperature storage life testing is performed to accelerate failure mechanisms which are thermally activated through the application of extreme temperatures.

Typical Test Conditions: T_A = 125°C to 200°C, no bias, t = 24 to 1008 hours.

Common Failure Modes: Parametric shifts in leakage and gain.

Common Failure Mechanisms: Bulk die and diffusion defects.

INTERMITTENT OPERATING LIFE

The purpose of this test is the same as Operating Life in addition to checking the integrity of both wire and die bonds by means of thermal stressing.

Typical Test Conditions: T_A = 25°C, Pd = Data Book maximum rating, T_{on} = T_{off} = DTJ of 125°C to 175°C, t = 1000 to 15000 cycles.

Common Failure Modes: Parametric shifts and catastrophic failure.

Common Failure Mechanisms: Foreign material, crack and bulk die defects, metallization, wire and diebond defects.

OPERATING LIFE

The purpose of this test is to evaluate the bulk stability of the die and to generate defects resulting from manufacturing aberrations that are manifested as time and stress-dependent failures.

Typical Test Conditions: T_A = 25°C, Pd = Data Book maximum rating, t = 45 to 1008 hours.

Common Failure Modes: Parametric shifts and catastrophic failure.

Common Failure Mechanisms: Foreign material, crack die, bulk die, metallization, wire and die bond defects.

SOLDERABILITY

The purpose of this test is to measure the ability of device leads/ terminals to be soldered after an extended period of storage or shelf life.

Typical Test Conditions: Steam aging = 8 hours.

Common Failure Modes: Pin holes, dewetting, non-wetting.

Common Failure Mechanisms: Poor plating, contaminated leads.

SOLDER HEAT

This test is used to measure the ability of a device to withstand the temperatures as may be seen in wave soldering operations. Electrical testing is the endpoint criterion for this stress.

Typical Test Conditions: Solder Temperature = 260°C, t = 10 seconds.

Common Failure Modes: Parameter shifts, mechanical failure.

TEMPERATURE CYCLING (AIR-TO-AIR)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and transitions between temperature extremes. This testing will also expose excessive thermal mismatch between materials.

Typical Test Conditions: T_A = -65°C to 150°C, cycle = 100 to 1000.

Common Failure Modes: Parametric shifts and catastrophic failure.

Common Failure Mechanisms: Wire bond, cracked or lifted die and package failure.

THERMAL SHOCK (LIQUID TO LIQUID)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and sudden transitions between temperature extremes. This testing will also expose excessive thermal mismatch between materials.

Typical Test Conditions: T_A = -65°C to 150°C, cycle = 100 to 1000.

Common Failure Modes: Parametric shifts and catastrophic failure.

Common Failure Mechanisms: Wire bond, cracked or lifted die and package failure.

Reliability Data Analysis

Reliability is the probability a semiconductor device will perform its specified function for a specified time period under specified environmental conditions. In general, reliability can be thought of as maintaining acceptable quality performance over time and environmental conditions. A key characteristic of reliability is the hazard rate h(t). The hazard rate roughly represents the rate devices will fail as a function of time. The most widely used probability distribution used for analyzing semiconductor device reliability data is the exponential distribution. The hazard rate function for the exponential distribution l (this is usually called the failure rate) is not a function of time and is very simple to estimate. The point estimate of the failure rate is obtained by dividing the number of observed failures by the total number of device-hours from the stress test. Device-hours are defined as the product of the number of devices that are stress tested and the duration of the stress test. This is called the point estimate because it is based on a sample of devices from the population of all devices with similar characteristics, and it does not account for the uncertainty caused by estimating the failure rate from a sample. For modern semiconductor devices, the failure rates are extremely low and the failure rate is presented in units of FIT, where FIT is the number of failures per billion device-hours. These calculations are appropriate when the exact failure times are known. More complicated censoring situations can be analyzed using techniques presented elsewhere (e.g., Meeker and Escobar, "Statistical Methods for Reliability Data," (1998)).

In order to account for the uncertainty due to calculating the failure rate based on a sample, one must apply confidence limits to the point estimate. The relevant confidence interval for device reliability calculations is the one-sided upper confidence interval of the failure rate. The one-sided upper confidence interval provides an estimate the failure rate that is unlikely to be exceeded by any given point estimate at a given confidence level. The appropriate sampling distribution for the failure rate of the exponential distribution is the chi-square distribution χ^2. This means that if one were to calculate the failure rate of many independent samples drawn from the same exponential population, then the distribution of the point estimates of the failure rate would follow a χ^2 distribution. The one-sided upper confidence estimate of the exponential failure rate where the life test is time-censored is given by:

$$\lambda_{1\text{-sided}} = \frac{\chi^2\,(\alpha,\, 2 \cdot r + 2)}{2 \cdot n \cdot t} \cdot 10^9$$

where:

$\lambda_{1\text{-sided}}$ = one-sided upper confidence level failure rate estimate in FIT

χ^2 = the inverse cumulative distribution function for the chi-square distribution

α = (100 - confidence level)/100

r = number of failures observed during the stress test

n = number of devices in stress test sample

t = stress test duration in hours

Values of the inverse cumulative distribution function for the chi-square distribution for the 60% and 90% confidence levels are provided in Table 1.

Table 1. Chi-Square Inversion Cumulative Distribution Function

60% Confidence Level		90% Confidence Level	
No. Fails	χ^2 Quantity	No. Fails	χ^2 Quantity
0	1.833	0	4.605
1	4.045	1	7.779
2	6.211	2	10.645
3	8.351	3	13.362
4	10.473	4	15.987
5	12.584	5	18.549
6	14.685	6	21.064
7	16.780	7	23.542
8	18.868	8	25.989
9	20.951	9	28.412
10	23.031	10	30.813
11	25.106	11	33.196
12	27.179	12	35.563

Due to continuing process improvements and advances in device and package technologies, the failure rate of semiconductor devices is extremely low. To accurately assess the reliability of these devices, reliability engineers routinely use accelerated stress test conditions during reliability testing. These test conditions are carefully chosen to accelerate the failure mechanisms that are expected to occur under normal use conditions without introducing spurious failure mechanisms. Accelerated stress testing is used to provide estimates of device reliability performance under use conditions, and to assist in identifying opportunities for improving the reliability performance of the device. Failure mechanisms found during stress testing are traced to the root cause and eliminated, whenever possible.

The most commonly used stress accelerator is temperature. In most cases, elevated temperature increases the rate at which a given failure mechanism progresses. There are a few failure mechanisms that are accelerated by using lower temperatures. The simplest thermal acceleration model is the Arrhenius equation:
where:

$$\text{Rate} = Aoe^{\frac{Ea}{kT}}$$

Rate = rate of progress for a given failure mechanism

A_o = pre-exponential factor that is a characteristic of the given failure mechanism s^{-1}

Ea = Thermal activation energy of the failure mechanism in eV

k = Boltzman constant, $8.617 \cdot 10^{-5}$ eV/K

T = device junction temperature in degrees Kelvin

Using the Arrhenius equation, one can relate the failure rate at one stress condition to the failure rate at a different condition. The acceleration factor A_f is defined in the following manner:

$$A_f = \frac{\text{Rate (Condition 1)}}{\text{Rate (Condition 2)}}$$

where:

Rate (Condition 1) = rate of progress for a given failure mechanism at Condition 1 (i.e., T_1)

Rate (Condition 2) = rate of progress for a given failure mechanism at Condition 2 (i.e., T_2)

The thermal acceleration factor becomes:

$$A_f = e^{\frac{Ea}{kT}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

where:

T_1 and T_2 = device junction temperatures at stress conditions 1 and 2, respectively.

See Figure 1 for an example of how the acceleration factor is used to transform the stress testing time into the equivalent time at a typical use junction temperature.

ACTIVATION ENERGY

ON Semiconductor uses the industry-standard estimates for activation energies that are documented in EIA/JEDEC Publication No. 122, “Failure Mechanisms and Models for Silicon Semiconductor Devices.” The following table summarizes the most commonly used activation energies.

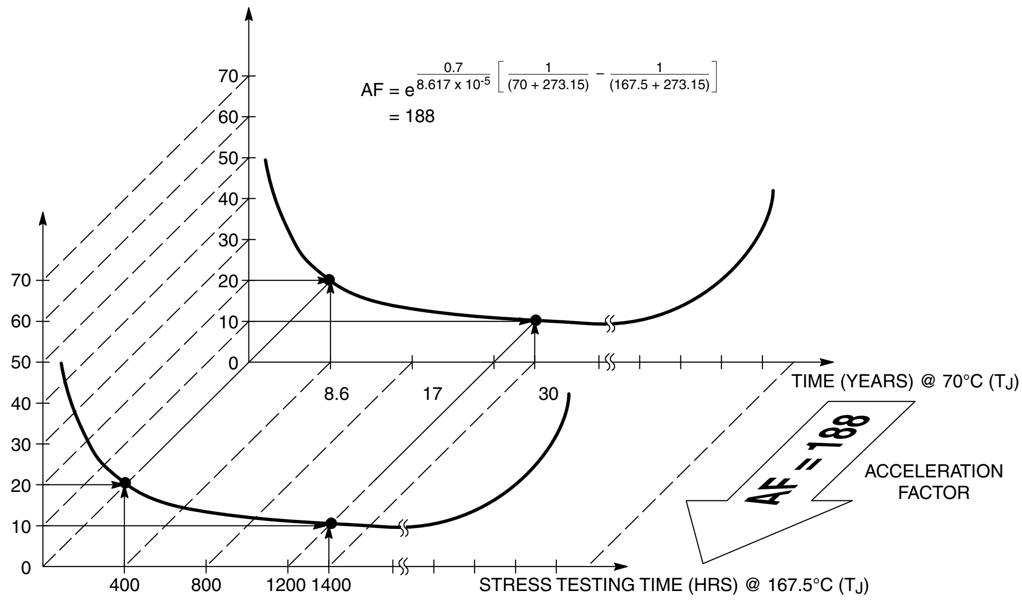


Figure 1. Example of Temperature Acceleration Factor
(0.7 eV Activation Energy)

Table 2. Activation Energy

Device Association	Failure Mechanism	Accelerating Failures	Typical Activation Energy (eV)
Silicon Surface Oxide	Surface Inversion	T, V	1.0
	Mobile Ions		1.0
	Charge Accumulation		1.0
	Surface Charge Spreading		0.7
Gate Oxide	Dielectric Breakdown	E, T	
	Thin Oxide (> 40 nm)		0.3
	Thick Oxide (≤ 40 nm)		0.7
Metallization	Electromigration	J, T	
	Pure Al		0.48
	AlSi (≤ 1.5%)		0.50
	AlSi (1.5%)		0.72
	AlCu (0.5%)		0.70
	AlCuSi (1% Si, 2% Cu)		0.70
	AlCu over TiW (>1% Cu)		0.71
	Corrosion	H, E/V, T, V	
	General		0.8
	With Chlorine		0.7
	With Phosphorus		0.53
Assembly Process	Intermetallics	T	
	Bromine-induced		1.0
	Halide-induced		0.5
	Chloride-induced		0.8
	Wire Bond	T, ΔT	0.75
	Die Attach	T, ΔT	0.30

T = Temperature, ΔT = Temperature Cycling, V = Voltage, E = Electric Field, J - Current Density, H = Humidity

THERMAL RESISTANCE

Circuit performance and long-term circuit reliability are affected by die temperature. Normally, both are improved by keeping the junction temperatures low.

Electrical power dissipated in any semiconductor device is a source of heat. This heat source increases the temperature of the die about some reference point, normally the ambient temperature of 25°C in still air. The temperature increase, then, depends on the amount of power dissipated in the circuit and on the net thermal resistance between the heat source and the reference point.

The temperature at the junction depends on the packaging and mounting system's ability to remove heat generated in the circuit from the junction region to the ambient environment. The basic formula for converting power dissipation to estimated junction temperature is:

$$T_J = T_A + P_D (\bar{\theta}_{JC} + \bar{\theta}_{CA})$$

or:

$$T_J = T_A + P_D (\bar{\theta}_{JA})$$

where:

T_J = maximum junction temperature
T_A = maximum ambient temperature
P_D = calculated maximum power dissipation, including effects of external loads when applicable
$\bar{\theta}_{JC}$ = average thermal resistance, junction-to-case
$\bar{\theta}_{CA}$ = average thermal resistance, case-to-ambient
$\bar{\theta}_{JA}$ = average thermal resistance, junction-to-ambient

Only two terms on the right side of equation (1) can be varied by the user, the ambient temperature and the device case-to-ambient thermal resistance, θ_{CA}. (To some extent, the device power dissipation can also be controlled, but under recommended use the supply voltage and loading dictate a fixed power dissipation.) Both system air flow and the package mounting technique affect the θ_{CA} thermal resistance term. θ_{JC} is essentially independent of air flow and external mounting method, but is sensitive to package material, die bonding method, and die area.

For applications where the case is held at essentially a fixed temperature by mounting on a large or temperature controlled heat sink, the estimated junction temperature is calculated by:

$$T_J = T_C + P_D \text{ (JC) } (\bar{\theta}_{JC})$$

where T_C = maximum case temperature and the other parameters are as previously defined.

AIR FLOW

Air flow over the packages (due to a decrease in θ_{CA}) reduces the thermal resistance of the package, therefore, permitting a corresponding increase in power dissipation without exceeding the maximum permissible operating junction temperature. For thermal resistance values for specific packages, see the ON Semiconductor Data Book or Design Manual for the appropriate device family or contact your local ON Semiconductor sales office.

Section 4 – Customer Process Change Notification

ON Semiconductor is committed to delivering superior quality products to our valued customers and providing cost effective solutions. This commitment to continuous improvement in quality and value requires us to periodically make changes to our product portfolio. These changes are handled in accordance with ON Semiconductor's change management system, described below, which is compliant to all international quality system standards such as ISO 9001 and ISO/TS16949, AS-9100, Mil-PRF-38535, JESD46C and JESD48B.

Along with our commitment to quality and value, ON Semiconductor manages necessary product changes with a rigorous evaluation and characterization methodology to make them fully "transparent" to our valued customers from an electrical, physical, and thermal performance standpoint. Our goal is to make customer evaluation of any changed product unnecessary.

Change Management Overview

All proposed changes are classified in one of three classes, as determined by the nature and scope of the proposed change. The classification level indicates the level of qualification testing and customer notification required. The classification level is assigned by the corporate Business Change Action Board, which is an independent body chartered to represent the customer's best interests. Prior to submittal for Business Change Action Board review, the local Manufacturing Change Action Board must review and approve any potential changes first. This two-tiered requirement for review and approval is intended to provide thorough analysis of all changes for proper evaluation and risk mitigation.

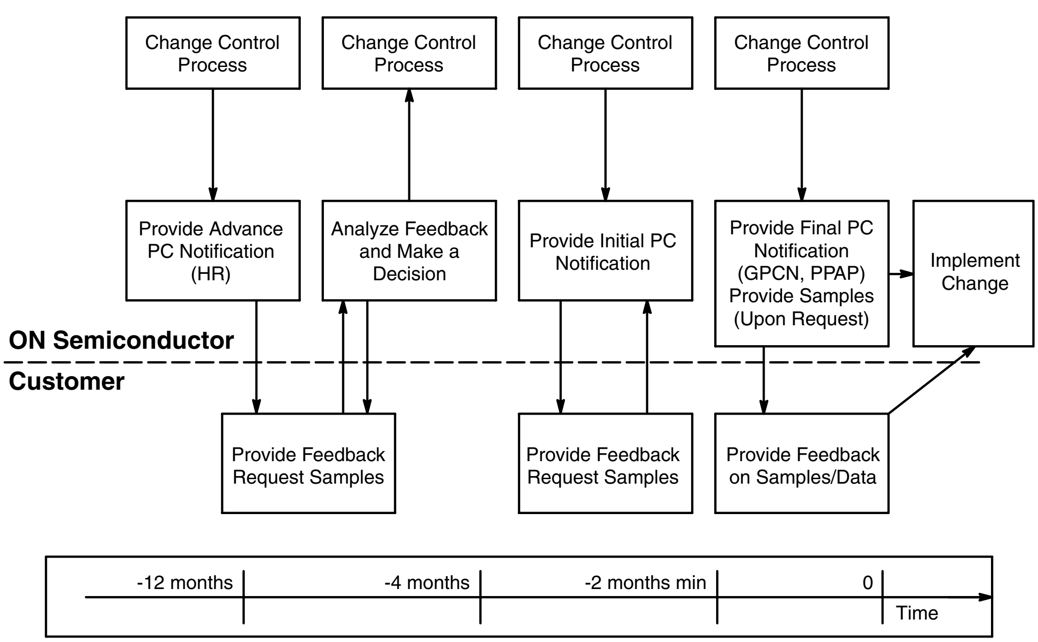
Level 1 changes include any minor change to the materials, process method, process equipment or design, which has no effect on the visual appearance, external dimensions and tolerances, or performance of the finished product. Level 1 changes do not require reliability testing or customer notification, but do require product characterization prior to implementation.

Level 2 changes include any substantial change to the materials, process method, process equipment or design, which has no effect on the external dimensions and tolerances or performance of the finished product. Level 2 changes may have an effect on the visual appearance if the difference is purely cosmetic in nature and does not impact customer usage of the product. Level 2 changes require product characterization and reliability testing but do not require customer notification prior to implementation.

Level 3 changes include any substantial change to the materials, process method, process equipment or design,

which do affect the visual appearance, external dimensions and tolerances, or performance of the finished product (also called 'major changes' in standard JESD46C). Level 3 changes also include the transfer of existing wafer fabrication or assembly processes to a new manufacturing site. Level 3 changes require both product characterization and reliability testing, and are communicated to customers.

Product Change Notification to Customers



ON Semiconductor's Change Management Policy is to inform customers about Level 3 product and/or process changes in as many as three stages of communication.

Horizon Report (HR) This "Advanced Notification" communication is intended to provide customers early warning about upcoming and potential changes. It is intended to give at least 6 - 12 months advance notification of all Level 3 changes. This notification usually just identifies a brief change description, products affected, and general timing of change. Information contained in the Horizon Report should be considered very preliminary and subject to modification. Horizon reports are optional and provided only to those ON Semiconductor customers who request them.

Initial Product/Process Change Notification (IPCN) This "Initial Notification" is the first, formal notification distributed to customers. The IPCN is optional and gets typically distributed at least 120 days from the effective date of the change. The IPCN contains the qualification plan which must be completed prior to implementation, which gives our valued customers the opportunity to request any additional testing they might require in order to approve the change. The content of the qualification plan is dependent on the nature and scope of the change, but in all cases must be in compliance with applicable JEDEC and AEC standards.

Final Product/Process Change Notification (FPCN) This 'Final Notification' completes the notification process. The FPCN must be distributed at least 90 days prior to the effective date of the change or earlier when approved by the customer. The FPCN must contain successful results of all characterization and reliability testing documented in the qualification plan. Prior to issuance of the FPCN the characterization and reliability data is again reviewed and approved by both the internal Manufacturing and Business Change Action Boards. The 60 day advance notification provides our valued customers with a final opportunity to communicate any additional requirements to accept the change prior to implementation if necessary.

Product Discontinuance (PD) Product Discontinuance is a special type of change where the product/process goes to end-of-life. The Product Discontinuance is distributed to customers 6 months for a last purchase (Last Time Buy) and another 6 months for last shipments.

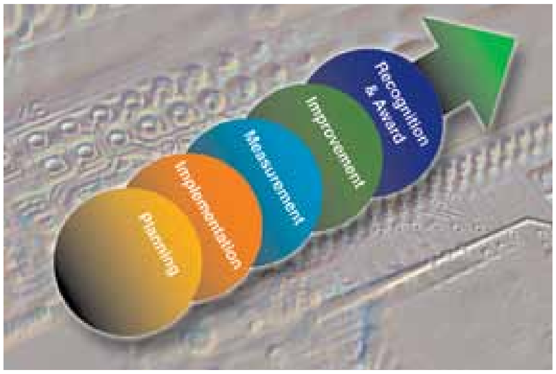
Process Change Management System (PCMS) The customer will receive an email notification with hyperlink to the PCNAlert system for all the changes of the customer's affected part numbers. Customer should acknowledge receipt of the PCN within 30 days of delivery of the PCN. Acknowledgement is done by downloading the Notification document through the PCNAlert system. Lack of acknowledgement of the PCN within 30 days constitutes acceptance of the change.

Section 5 – Supplier Quality Process

ON Semiconductor follows a five step Supplier Development process to improve the quality of goods and services delivered by our suppliers. The five steps of the process are: Planning, Implementation, Measurement, Improvement, and Recognition & Award.

During the Planning phase we establish general expectations of doing business with ON Semiconductor, and make our supplier selection based on their Quality System, Technical Capability, Value Added Services, Cost, Capacity, etc. Suppliers are requested to perform a Quality System self evaluation to TS-16949:2002 requirements.

Once a potential supplier has been selected they must pass our qualification process prior to making any production shipments; this is the Implementation step of our Supplier Development Process. In order to pass our qualification requirements suppliers must provide samples and data which demonstrates their product conforms to our specifications as well as their ability to manufacture the product consistently. This process will include a review of First Article Inspection data, Process Control and Measurement System Analysis data, and an on-site audit by ON Semiconductor (for new suppliers). Any significant process changes made by the supplier go through the same qualification process described above, and are managed through our Part Submission Warrant process.



Once a supplier has been qualified we enter into the Measurement stage. The material we use in production is verified in one of three ways prior to use in production, the three methods are: Inspection, Audits combined with measurement of acceptable performance, and/or receipt & review of SPC data. If it is determined that material has been received that is non-conforming to our specified requirements we utilize our automated corrective action tracking system to ensure suppliers respond to the problem using an 8D corrective action. On a quarterly basis we measure our supplier's performance in the areas of Quality, Cost, Delivery, Service and Technology. This data is shared with our suppliers both on-line as well as during Business Review Meetings. We also have an ongoing supplier assessment process (to TS-16949:2002 requirements) which is prioritized based on their certification status and ongoing performance as measured by our rating system.

In the Improvement stage we establish goals with our suppliers using our Supplier Goal Plan (SGP) Process. This enables us to clearly define priorities for our suppliers, and provides us with a method to follow-up and verifies suppliers are meeting our goals. The SGP is reviewed with suppliers during Business Review meetings.

ON Semiconductor understands the value of recognizing and awarding suppliers for their hard work and dedication. We believe that by recognizing our best suppliers for their superb performance we are setting a standard for all our suppliers to achieve. This is the final step in our Supplier Development Process; Recognition and Award.

Section 6 – Failure Analysis

Overview

Failure analysis is a process which entails vast analytical methods and techniques to solve the reliability and quality issues that may occur in either the manufacturing or application of our products. The process can be a rather complicated endeavor due to the many aspects associated with the ever advancing semiconductor and packaging technologies and the numerous engineering disciplines involved. The failure analyst must be proficient in design, process, assembly, test, and applications, which equates to electrical, physics, chemical, and mechanical engineering.

Failure analysis laboratories are available globally at all ON Semiconductor manufacturing sites. These same analytical tools are proactively utilized for good unit analysis, process characterization, destructive physical analysis, construction analysis, and even competitive benchmarking studies. Tool development for failure analysis is advancing at a similar rate as that of manufacturing. For the labs to stay current with technology, the analyst must be continually developing the associated tools and techniques. As the die features are shrinking and become covered with multiple layers of interconnects, the requirements for failure analysis needs to be anticipated as early as the design cycle. By incorporating these specialized test structures and functional test coverage, problems can more easily be diagnosed. In addition to tools, trained personnel, techniques, and procedures, an adequate database and tracking system should be employed to assist in expeditious problem solving.

At ON Semiconductor, the labs are equipped in a diverse range of instrumentation and engineering expertise to solve problems in all aspects of semiconductor and packaging analysis. The success of failure analysis is not only in a superior instrumentation set, but in its people and their approach to problem solving. While the failure analysis lab may be able to identify a failure mechanism, the road to root cause is just embarked upon. Depending on the manufacturing process complexity, root cause analysis may entail extensive experimentation and designed experiments to not only identify the root cause but to also verify potential corrective action effectiveness. The full process of problem solving entails multiple labs and techniques. These analytical professionals along with the subject matter experts, such as design or manufacturing, work in unison to solve the problem.

Generic Process Steps

The full sequence of the problem solving events is outlined in Section 11, Customer Returns. The following steps outline the basic procedures that a typical field return may be subjected to within the failure analysis lab.

Required Information

The more information the better! There is a minimum set of background information that greatly impacts the overall quality and cycle time of the problem solving process. The minimum set and some questions are as follows:

1. Failure history and failure rate at the customer site, in either this application or other products. Is this a new product or have any changes occurred in this time frame?
2. Length of time in application and the conditions upon failure should be included. Did any other components fail at the same time and if so, how did they fail? Can a schematic be sent? Are there any devices of this same date code still available?

3. What is the failure mode of the application and how can it be related to this device? How do you perceive that the device is failing (short, open, stuck logic levels, etc.)?
4. How was the device handled prior to receipt at ON Semiconductor? Precautions should be taken in the removal and handling (ESD) of the devices to insure that electrical or physical damage does not occur and testability of the package is maintained.

Receipt of Request

When the product is received in the failure analysis lab, the devices have generally been confirmed as failures through the use of automatic test equipment to achieve rapid failure verification by our customer support group. At this point, the background documentation, electrical results and historical failure data are reviewed to outline the appropriate course of analytical action. An external visual inspection is carried out, documenting the package's physical condition and markings.

Diagnostic Testing

The devices would most likely be subjected to a benign "pin-to-pin" test which quickly identifies parametric anomalies as compared to known good units. Depending on the failure mode, the device may be subjected to a more extensive bench test with stress conditions applied to match the customer's application or to stimulate the mechanism.

Non-destructive Testing

Failure analysis in itself is reverse engineering and in this vein, destructive in nature to the returned product. Since the package will be at least partially destroyed to expose the die, non-destructive techniques are carried out first to observe package or assembly related mechanisms. The most common techniques used are acoustic microscopy and radiographic (XRAY) inspections to look for internal assembly or molding anomalies.

Storage Bakes or Stress

Depending on the failure mode, the analyst may subject the device to a series of vacuum or storage bakes to observe parametric or functional shifts. If the original failure mode was not confirmed, stress testing (high temperature bias for instance), may be carried out to observe possible longer-term reliability concerns.

Decapsulation or Package Preparation

The general course of action at this point is to reveal the die surface. In the case of a plastic encapsulated component, this would entail a chemical decapsulation. There are however, many methods utilized for decapsulation or package preparation, dependent on the package, failure mode, and potential failure mechanism.

Internal Inspection

An internal optical inspection would then be carried out to check for any obvious assembly anomalies or wafer fabrication issues. If possible re-testing is recommended at this point to insure that the failure mode has not changed.

Internal Diagnostic Testing

In many cases, the internal inspection will not reveal an obvious failure mechanism. At this point, depending on the technology and level of testability, the lab would utilize one or more of the techniques available to isolate the failure site. This could entail extensive probing or a technique, such as liquid crystal or photoemission, to highlight potential anomalies. The majority of these techniques are attempting to observe the properties of the failure site, as in thermal dissipation or photon emission. From a probing standpoint, the use of navigational tools, a laser cutter or Focussed Ion Beam (FIB) may be employed to assist in device and circuit isolation.

Deprocessing

Deprocessing is an iterative process of removing layer of the die, which may entail both wet chemistry and dry plasma etching techniques to reveal the underlying structures. The proper techniques are critical at these steps due to the destructive nature of the process and the potential loss of vital information.

Analysis of Failure Site

Once a potential site has been determined or revealed, further documentation and analysis may be conducted. Further analytical techniques are employed depending on whether the morphology or material composition is required.

Report Conclusion

Upon completion of the analysis, a written report is generated documenting the work. The report should state the relationship of the physical anomaly to the failure mode. It should also include sufficient documentation for root cause analysis by the manufacturing site if warranted.

Summary

The cost of failure analysis is high due to the extensive instrumentation, highly technical staff, continual training and development, and associated analysis expenses (chemicals, fixtures, etc.). To enable the most efficient utilization of these resources, it is essential that the background documentation (see Required Information on the previous page) be complete upon receipt and that an open communication channel between ON Semiconductor and our customers exists. This will insure a timely resolution of the problem on either end.

Section 7 – Reliability Data Summary

ON Semiconductor performs extensive reliability stress testing on devices that span the full breadth of our product portfolio. Reliability data is collected as part of the ON Semiconductor Reliability Audit Program, and as part of the normal product qualification and re-qualification process. This data is periodically updated to include the most recent test results. The data is typically updated on a quarterly basis. The current data can always be located through the reliability data links on the onsemi.com website.

http://www.onsemi.com/PowerSolutions/reliability.do

The reliability data is presented in two parts:

1. Life Test Data that groups the data by business unit and product family or technology. This data provides information that pertains primarily to die design- and wafer fabrication-related failure mechanisms.
2. Package Test Data that groups the data by package case outline and product family or technology. This data provides information that pertains primarily to package design- and assembly process-related failure mechanisms.

The ON Semiconductor package outline reference is also included to make it easier to identify a specific case outline.

Section 8 – External Manufacturing Quality

ON Semiconductor utilizes subcontractor and joint venture partners to support our customers' increasing requirements for high quality, low cost semiconductors. Our global subcontractor and joint venture partners perform some or all areas of semiconductor manufacturing. This includes wafer fabrication, wafer probe, assembly, test, as well as product analysis, and reliability testing. When ON Semiconductor selects new manufacturing subcontractors, this requires an extensive review of the company's ability to meet our high quality, business and technical requirements. For current manufacturing partners, continuous improvement plans are required which outline aggressive improvement goals. Progress to these goals are periodically reviewed.

The new product introduction and process change control requirements and specifications are the same for internal ON Semiconductor factories as well as our external manufacturing partners. Quality systems vary from subcontractor to subcontractor; however, ON Semiconductor requires each supplier to manufacture our products with the same high standards as our internal factories. Prior to engaging with a subcontractor as a new supplier or when adding a new or expanded manufacturing line, ON Semiconductor performs an extensive assessment. This includes a review of the machine capability and maintenance, process documentation and control, training and certification of personnel, FMEA's, as well as many other areas. Detailed project management methodology is utilized to drive projects to a timely completion.

ON Semiconductor encourages each subcontractor and foundry to pursue outside certification to drive their quality system improvements.

Additionally, we drive many of our internal factories quality system practices into our external partners. Periodic subcontractor reviews are held to review progress to key metrics including customer quality and delivery. Joint corrective action plans are agreed upon to drive resolution and continuous improvements.

Section 9 – Customer Returns

ON Semiconductor's Global Customer Return or Incident process is focused on formal Problem Solving and Responsiveness. We use the 8D Problem Solving Methodology to determine Containment, Root Cause, and Corrective/Preventive Actions.

The Eight Disciplines are:

D1 - Establish the Team - Establish a cross functional team of people with the process/product knowledge to solve the problem.

D2 - Describe the Problem - Specify the customer's problem by identifying in quantifiable terms the who, what, where, why, how, and how many, for the problem.

D3 - Implement and Verify Containment - Define and Implement containment actions to isolate the effect of the problem from customers until the corrective actions are implemented.

D4 - Define and Verify Root Cause - Identify all potential causes that could explain why the problem occurred and how it escaped our testing. Isolate and verify root cause by testing each potential cause against the problem description.

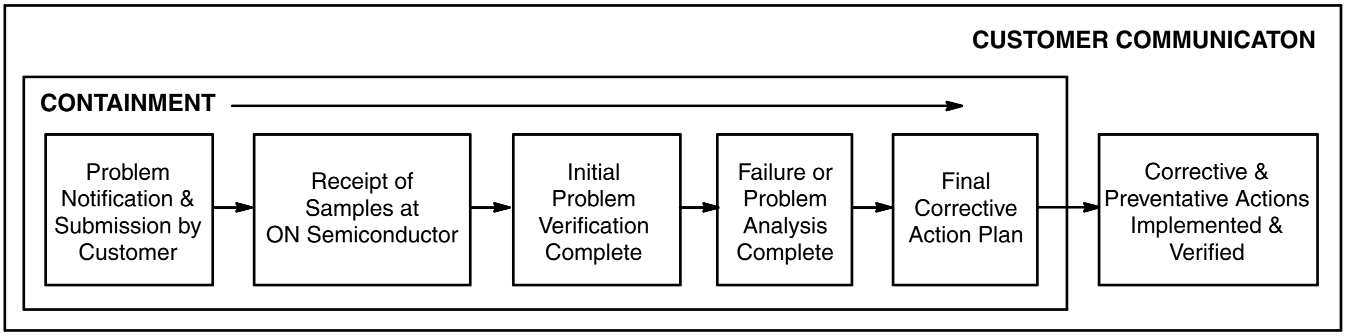
D5 - Choose and Verify Permanent Corrective Action - Identify all potential corrective actions for the Occur and Escape Root Causes. Verify which actions will correct the root cause.

D6 - Implement Permanent Corrective Action - Provide action plans for implementation of the verified corrective actions. Follow up on any outstanding actions.

D7 - Prevent Recurrence - Implement actions to address the "system" failure. Update control plans, FMEA specifications, process specifications. Fan-Out Corrective Actions to appropriate manufacturing sites, and other Technologies.

D8 - Congratulate the Team - We communicate to the customer throughout the process.

Customer Incident Process Map



Customer Incidents are tracked in our Customer Incident information system. Monthly customer incident metrics are compiled and distributed corporate-wide. Responsiveness metrics are used to drive continuous improvement in the Cycle Time arena. Failure Mechanism paretos are used to drive continuous improvement in the Product and Administrative Quality arenas. These metrics are also reviewed in our monthly Business Unit & Manufacturing Operations Reviews

Section 10 – Storage and Preservation

ON Semiconductor adheres in the proper storage and preservation of semiconductors in order to prevent damage or deterioration and ensure on-time delivery of superior quality products to our valued customers. The standard storage and preservation guidelines are tabulated below and followed by all ON Semiconductor manufacturing sites including subcontractors and distribution centers.

The storage durations are monitored in our Supply Chain and Finance information systems. These are tracked on a monthly basis to drive on-time delivery.

Table 3. Storage and Preservation

ON Semiconductor Product	Storage Condition	Storage Life	Remarks
Finished Wafer, Probe Wafer	Temperature 20-26°C Humidity 30-65% RH	36 months after probe date 36 months after fab-out date (un-probed wafers)	Maximum 12 months storage at condition 20-26°C, 30-65% RH. Afterwards storage in vacuum moisture bag with desiccant and humidity card. Storage in nitrogen cabinet allowed
Die in Tray or Pocket Tape	Temperature 20-26°C, Humidity 30-65% RH	24 months after die singulation/ sawing date	Maximum 12 months storage at condition 20-26°C, 30-65% RH. Afterwards storage in vacuum moisture bag with desiccant and humidity card. Storage in nitrogen cabinet allowed.
Die in Surf Tape, Wafers in Foil/Tape	Temperature 20-26°C, N2 storage or in vacuum moisture bag with desiccant and humidity card	3 months after tape date After 3 months quality of products needs to be validated	Storage in nitrogen cabinet allowed. Recommend to scrap after 12 months of storage
Finished/ Packaged Goods in tray. Tube or sealed in dry bag (MSL2 rated and above)	Temperature 20-26°C Humidity 30-65% RH	24 months after assembly date	Storage in vacuum moisture bag with desiccant and humidity card according ON Semiconductor rules. Check after 12 months, up on delivery humidity indicator. If NOK re-dry + re-seal must be done. If OK re-seal must be done
Finished/packaged Goods in Tray, Tube ir sealed in dry bag (MSL1 rated)	Temperature 20-26°C Humidity 30-65% RH	24 months after assembly date	–
Finished/Packaged Ceramics in Tray or Tube	Temperature 20-26°C Humidity 30-65% RH	36 months after assembly date	–

Section 10 – ON Semiconductor Corporate Social Responsibility and Sustainability

Corporate Social Responsibility Statement of Commitment

As a global supplier to customers worldwide, ON Semiconductor operates across a diverse range of cultures and international markets. We are committed to providing our customers with inventive, high quality products that are environmentally sound, conducting our operations in an environmentally, socially and ethically responsible manner and complying with all applicable laws and regulations of those countries worldwide where we do business. This commitment is deeply ingrained in our Core Values, certain policies and our Code of Business Conduct ("Code").

As further evidence of our commitment to corporate social responsibility, we have embraced specific standards that are modeled after the Electronic Industry Code of Conduct ("EICC). Many if not all of these standards are reflected already in one way or another in our Code and other policies which, like the EICC standards, address, among other things, conduct across several areas of social responsibility including labor practices, health and safety, environmental, ethics and which promote management systems designed to ensure conformance with these standards.

ON Semiconductor is committed to incorporating these standards into our facilities' auditing program and to work toward continuous improvement in these areas.

ON Semiconductor is committed to extend the EICC requirement for conflict free sourcing of metals to our supply base. We work collaboratively with our suppliers to encourage compliance ensuring that metals are not being sourced and purchased from mines in conflict areas and to ensure that the supplier comply with the Democratic Republic of the Congo (DRC) Conflict-free expectations.

Labor, Environmental, Health & Safety and Ethics Standards

I. Labor Standards

A) Freely Chosen Employment. Forced, bonded or indentured labor or involuntary prison labor is not to be used. All work is voluntary, and our employees are free to leave upon reasonable notice. Employees shall not be required to hand over government-issued identification, passports or work permits as a condition of employment.

B) Child Labor Avoidance. Child labor is not to be used in any stage of manufacturing. The term "child" refers to any person employed under the minimum age for employment in the country.

C) Working Hours. Workweeks are not to exceed the maximum set by local law. As a general policy and practice, workweeks should not exceed 60 hours per week and employees shall be allowed at least one day off per seven day week. In extreme or unusual situations, an employee(s) may voluntarily work more than 60 hours per week or work more than seven days straight. In such cases, all overtime is compensated in accordance with local law.

D) Wages and Benefits. Compensation paid to employees shall comply with all applicable wage laws, including those relating to minimum wages, overtime hours and legally mandated benefits. In compliance with local laws, employees shall be compensated for overtime at pay rates greater than regular hourly rates. Deductions from wages as a disciplinary measure are not permitted.

E) Humane Treatment. Harsh and inhumane treatment, including any sexual harassment, sexual abuse, corporal punishment, mental or physical coercion or verbal abuse of employees is not permitted.

F) Non-Discrimination. ON Semiconductor is committed to a workforce free of harassment and unlawful discrimination, and does not engage in discrimination based on race, color, age, gender, sexual orientation, ethnicity, disability, pregnancy, religion, political affiliation, union membership or marital status, or in hiring and employment practices such as promotions, rewards, and access to training.

G) Freedom of Association. The rights of employees to associate freely, join or not join labor unions, seek representation, join workers' councils in accordance with local laws are to be respected. Employees shall be able to communicate openly with management regarding working conditions without fear of reprisal, intimidation or harassment.

These standards are not intended to create new and additional third party rights, including for employees.

II. Health and Safety Standards

A) Occupational Safety. Employee exposure to potential safety hazards (e.g., electrical and other energy sources, fire, vehicle, and fall hazards) are to be controlled through design, engineering and administrative controls, preventative maintenance and safe work procedures (including lockout/ tagout). Where hazards cannot be adequately controlled by these means, employees are to be provided with appropriate personal protective equipment. Employees shall not be disciplined for raising safety concerns.

B) Emergency Preparedness. Emergency situations and events are to be identified and assessed, and their impact minimized by implementing emergency plans and response procedures, including: emergency reporting, employee notification and evacuation procedures, employee training and drills, appropriate fire detection and suppression equipment, adequate exit facilities and recovery plans.

C) Occupational Injury and Illness. Procedures and systems are to be in place to manage, track and report occupational injury and illness and should include the following components: i) encourage employee reporting; ii) classify and record injury and illness cases; iii) provide necessary medical treatment; iv) investigate cases and implement corrective actions to eliminate their causes; and v) facilitate return of employees to work.

D) Industrial Hygiene. Employee exposure to chemical, biological and physical agents is to be identified, evaluated, and controlled. When hazards cannot be adequately controlled by engineering and administrative means, employees are to be provided with appropriate personal protective equipment.

E) Physically Demanding Work. Employee's exposure to physically demanding tasks, including manual material handling and heavy lifting, prolonged standing and highly repetitive or forceful assembly tasks is to be identified, evaluated and controlled.

F) Machine Safeguarding. Physical guards, interlocks and barriers are to be provided and properly maintained for machinery used by employees.

G) Sanitation, Food and Housing. Employees are to be provided with clean toilet facilities, access to potable water and sanitary food preparation and storage facilities. If applicable, any employee dormitories provided by ON Semiconductor are to be clean, safe, and provide emergency egress, adequate heat and ventilation and reasonable personal space.

These standards are not intended to create new and additional third party rights, including for employees.

III. Environmental Standards

A) Environmental Permits and Reporting. All required environmental permits (e.g. discharge monitoring) and registrations are to be obtained, maintained and kept current and their operational and reporting requirements are to be followed.

B) Pollution Prevention and Resource Reduction. Waste of all types, including water and energy, are to be reduced or eliminated at the source or by practices such as modifying production, maintenance and facility processes, materials substitution, conservation, recycling and re-using materials.

C) Hazardous Substances. Chemical and other materials posing a hazard if released to the environment are to be identified and managed to ensure their safe handling, movement, storage, recycling or reuse and disposal.

D) Wastewater and Solid Waste. Wastewater and solid waste generated from operations, industrial processes and sanitation facilities are to be monitored, controlled and treated as required prior to discharge or disposal.

E) Air Emissions. Air emissions of volatile organic chemicals, aerosols, corrosives, particulates, ozone depleting chemicals and combustion by-products, as applicable, generated from operations are to be characterized, monitored, controlled and treated as required prior to discharge. F) Product Content Restrictions. ON Semiconductor adheres to all applicable laws and regulations regarding prohibition or restriction of specific substances including labeling laws and regulations for recycling and disposal. ON Semiconductor adheres to processes to comply with any agreed-upon, customer-specific restricted and hazardous materials list requirements.

IV. Ethics Standards

A) Business Integrity. The highest standards of integrity are to be expected in all business interactions. Any and all forms of corruption, extortion and embezzlement are strictly prohibited.

B) No Improper Advantage. Bribes or other means of obtaining undue or improper advantage are not to be offered or accepted.

C) Disclosure of Information. Information regarding business activities, structure, financial situation and performance is to be disclosed in accordance with ON Semiconductor policies, the ON Semiconductor Code of Business Conduct, applicable laws and regulations and prevailing industry practices.

D) Intellectual Property. Intellectual property rights of all parties are to be respected, and the transfer of technology or know-how is to be done in a manner that protects intellectual property rights.

E) Fair Business, Advertising and Competition. Standards of fair business, advertising and competition are to be upheld. Means to safeguard customer information should be available.

F) Protection of Identity. Programs that ensure the protection of supplier and employee whistleblower confidentiality are to be maintained.

G) Community Engagement. Community engagement is encouraged to help foster social and economic development.

These standards are not intended to create new and additional third party rights, including for employees

V. Management Systems

ON Semiconductor shall adopt or establish a management system whose scope is related to the preceding standards and the system shall be designed to ensure (a) compliance with applicable laws, regulations and customer requirements related to ON Semiconductor's operations and products; (b) conformance with these standards; and (c) identification and mitigation of operational risks related to these standards as well as facilitating continual improvement. Examples of elements such management system(s) could contain are:

A) Company Commitment: Corporate social and environmental responsibility statement affirming ON Semiconductor's commitment to compliance and continual improvement.

B) Management Accountability and Responsibility: Clearly identified company representative[s] responsible for ensuring implementation and periodic review of the status of the management systems.

C) Legal and Customer Requirements: Identification, monitoring and understanding of applicable laws, regulations and customer requirements.

D) Risk Assessment and Risk Management: Process to identify the environmental, health and safety and labor practice risks associated with ON Semiconductor's global operations and implementation of appropriate procedural and physical controls to ensure regulatory compliance to control the identified risks.

E) Improvement Objectives: Written standards, performance objectives, targets and implementation plans including a periodic assessment of performance against those objectives.

F) Training. Programs for training managers and employees to implement company policies, procedures and improvement objectives.

G) Communication. Process for communicating clear and accurate information about the company's performance, practices and expectations to employees, suppliers and customers.

H) Worker Feedback and Participation. Ongoing processes to assess employees' understanding of and obtain feedback on practices and conditions covered by these standards and to foster continuous improvement.

I) Audits and Assessments. Periodic self-evaluations to ensure conformity to legal and regulatory requirements, these standards and customer contractual requirements related to social and environmental responsibility.

J) Corrective Action Process. Process for timely correction of deficiencies identified by internal or external assessments, inspections, investigations and reviews.

K) Documentation and Records. Creation of documents and records to ensure regulatory compliance and conformity to company requirements along with appropriate confidentiality to protect privacy.

This information is available through our Sustainability website: **http://www.onsemi.com/PowerSolutions/content.do?id=16707**

Sales and Design Assistance from ON Semiconductor

ON Semiconductor Distribution Partners

AMSC Co.	www.amsc.co.jp	(81) 422 54 6622
Arrow Electronics	www.arrow.com	(800) 777-2776
Avnet	www.em.avnet.com	(800) 332-8638
Digi-Key	www.digikey.com	(800) 344-4539
EBV Elektronik	www.ebv.com/en/locations.html	(49) 8121 774-0
Fuji Electric Co.	www.fujiele.co.jp	(81) 3 3814 1411
Future & FAI Electronics	www.futureelectronics.com/contact	1-800-FUTURE1 (388-8731)
KH Electronics Inc.	www.khelec.com/kor	(82) 42 471 8521
Marubun	www.marubun.co.jp	(81) 3 3639 5630
Mitsui Electronics Inc.	www.btel.co.jp	(81) 3 6403 5900
Mouser Electronics	www.mouser.com	(800) 346-6873
Newark/Farnell	www.farnell.com/onsemi	(800) 4-NEWARK
Promate Electronic Co.	www.promate.com.tw	(886) 2 2659 0303
Segyung Britestone Co.	www.britestone.com	(82) 2 3218 1511
Serial Microelectronics, HK	www.serialsys.com.hk	(852) 2790 8220
Silica	www.silica.com	(49) 8121 777 02
Tokyo Electron Device Co.	hwww.teldevice.co.jp	(81) 45 443 4000
World Peace Industries Co.	www.wpi-group.com	(852) 2365 4860
WT Microelectronics Co.	www.wtmec.com	(852) 2950 0820
Yosun Electronics	www.yosun.com.tw	(886) 2 2659 8168

INTERNATIONAL

GREATER CHINA	Beijing	86-10-8518-2323
	Chengdu	86-28-8678-4078
	Hong Kong	852-2689-0088
	Nanjing	86-25-8453-5879
	Shanghai	86-21-6123-8798
	Shenzhen	86-755-8209-1128
	Taipei, Taiwan	886-2-8797-8110
FRANCE	Paris	33 (0)1 39-26-41-00
GERMANY	Munich	49 (0) 89-93-0808-0
INDIA	Bangalore	91-80-4113-9553
ISRAEL	Raanana	972 (0) 9-9609-111
ITALY	Milan	39 02 9239311
JAPAN	Tokyo	81-3-5773-3850
KOREA	Seoul	82-31-786-3700
MALAYSIA	Penang	60-4-226-9368
SINGAPORE	Singapore	65-6555-8260
SLOVAKIA	Piestany	421 33 790 2450
UNITED KINGDOM	Slough	44 (0) 1753 70 1676

For a comprehensive listing of ON Semiconductor Sales Offices, please visit:

www.onsemi.com/salessupport

AMERICAS REP FIRMS

Alabama	Huntsville	e-Components	(256) 533-2444
Brazil	Countrywide	Ammon & Rizos	(+55) 11-4688-1960
California	Bay Area	L2	(408) 433-9388
Canada	Eastern Canada	Astec	(905) 607-1444
	Western Canada	Sifore	(503) 977-6267
Connecticut	Statewide	Genesis Associates	(781) 270-9540
Florida	Statewide	e-Components	(888) 468-2444
Georgia	Atlanta	e-Components	(888) 468-2444
Illinois	St. Charles (South)	Stan Clothier Company	(847) 781-4010
	Palatine (North)	HLC Ltd.	(847) 358-6500
Indiana	Fishers	Bear VAI	(317) 570-0707
Iowa	Cedar Rapids	Essig & Associates	(319) 363-8703
Kansas	Overland Park	Stan Clothier Company	(913) 894-1675
Maryland	Columbia	Third Wave Solutions	(410) 290-5990
Massachusetts	Burlington	Genesis Associates	(781) 270-9540
Mexico	Countrywide	Ammon & Rizos	(+55) 11-4688-1960
Michigan	St. Joseph	Bear VAI	(440) 526-1991
Minnesota	Eden Prairie	Stan Clothier Company	(952) 944-3456
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