Customer Guidelines for External Failure Analysis Request (EFAR)

Rev.3.0

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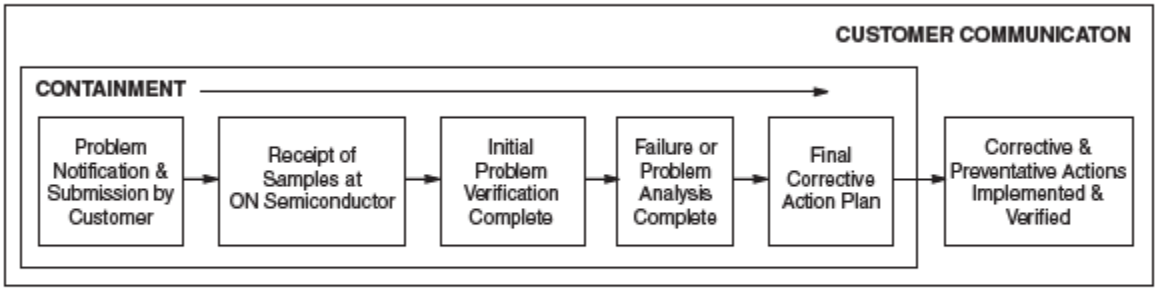
1. Purpose and Scope

The purpose of this document is to provide guidelines to be used by customers when requesting failure analysis from **onsemi** when a customer incident is encountered. Use of these guidelines will help in providing customers with accurate and timely information related to a reported customer incident or product failure.

The **onsemi** failure analysis process is focused on formal problem-solving techniques and responsiveness. The 8D Problem Solving Methodology is utilized to determine containment, root cause, and corrective/preventive actions. The customer incident process is mapped in the figure below.

Customer Incident Process Map



Our Customer Incident Information system tracks Customer Incidents. Monthly customer incident metrics are compiled and distributed corporate-wide. Responsiveness metrics drive continuous improvement in the Cycle Time arena. Failure Mechanism Pareto Charts are used to drive continuous improvement in the Product and Administrative Quality arenas. We review these metrics in our monthly Business Unit & Manufacturing Operations Reviews.

The guidelines can be used for incidents related to electrical, mechanical, and logistical issues e.g., shipment packing damage.

Failure analysis is a process entailing vast analytical methods and techniques to help identify the reliability and quality issues that may occur in either the manufacturing or application of our products. The process can be a complicated endeavor due to the many aspects of the ever-advancing semiconductor and packaging technologies; and the numerous engineering disciplines involved. The accuracy and detail of the information provided to **onsemi** will help identify the proper resources and analysis techniques to produce the correct root cause analysis and corrective actions.

2. Failure Analysis Request

onsemi seeks to continuously improve the quality and the reliability of our products. We do this internally with continuous improvement programs, yield improvement programs and other initiatives. Another important tool we utilize is the processes involved in post-sales support to our customers. Each customer complaint is studied in detail and in the context of past history of the specific product, the product and package family, and other related attributes such as the wafer fabrication process. If the specific customer complaint (External Failure Analysis request or EFAR) represents an opportunity to improve the quality or reliability of our products, we make every effort to thoroughly investigate the units under the EFAR and implement corrective and preventative actions. If, however, the issue related to the complaint is a well understood historical issue, the company may elect to signature analyze the incident. In all cases, we are sensitive to the specific circumstances each EFAR represents and will work with our customers in order to resolve the complaint in a manner that is satisfactory to both onsemi and the customer.

To help with this objective, we kindly ask for a detailed description of the incident and provide as much data as possible to allow us to expedite the investigative process. **onsemi** requests the following information with any returns:

Basic information	
	onsemi Part Number
	Customer Part Number
	Purchase source (**onsemi** or distributor name)
	Device marking (clear photo of top mark is helpful)
	Date code
	LOT number on label and purchase order number (clear photo of label is helpful)
	Total number of units being returned for analysis (equals the number of suspect failures + number of reference (good) devices)
Detection	
	Point of failure (incoming inspection, module assembly, outgoing test, field, etc.
	Usage conditions in which failure was observed (voltage, temperature, frequency, etc.)

	How it failed; detailed description of failure including all available symptoms; and how the symptoms are related to the returned unit. Length of time in the application including the conditions upon failure.
	Failure rate: ppm (how many units failed, out of total numbers of units)
	Customer application. Is the product new or have any changes occurred if an existing product?
	Did any other components fail at the same time, and if so, how did they fail?
	Are there any devices of this same date code/same lot still available?

Problem Description	
	Include the related failing parameter from the product specification, datasheet or any shared application diagram. For image sensor products, please include Outgoing Defect Specification (ODS) of failing parameter if applicable.
	Describe the part of the circuit where the problem exists
	What is the application's failure mode and how can it be related to the device?
	How do you perceive the device is failing (short, open, stuck logic levels)?
	How was the device handled before receipt at **onsemi**? Were precautions taken in removing and handling (ESD/thermal) the devices to ensure that electrical or physical damage does not occur, and the package's testability is maintained?
What investigation has already been done by the customer?	
	Photos of failure analysis units and evaluation environment
	Waveform of evaluation (failure case vs normal case)
	Schematic of application and evaluation environment. If entire schematic cannot be provided, the section containing the component and any connections to it is needed.
	Setting conditions. Register setting. Imaging Products: Lens condition (w/wo, F#), Image streaming mode, Brightness condition
	Measurement equipment, conditions.
	Evaluation result report

A minimum set of background information significantly impacts the overall quality and cycle time of the problem-solving process so the more information, the better.

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). The background documentation must be completed upon receipt to enable those resources' most efficient utilization. An open communication channel between **onsemi** and our customers exists to ensure a timely resolution of the problem on either end.

3. Failure Analysis Units

Proper care of the failure analysis units is imperative to preserve the failure mechanism and ensure all analysis techniques can be used to identify the root cause of failure.

3-1. Failure Analysis Units Removal from Printed Circuit Board

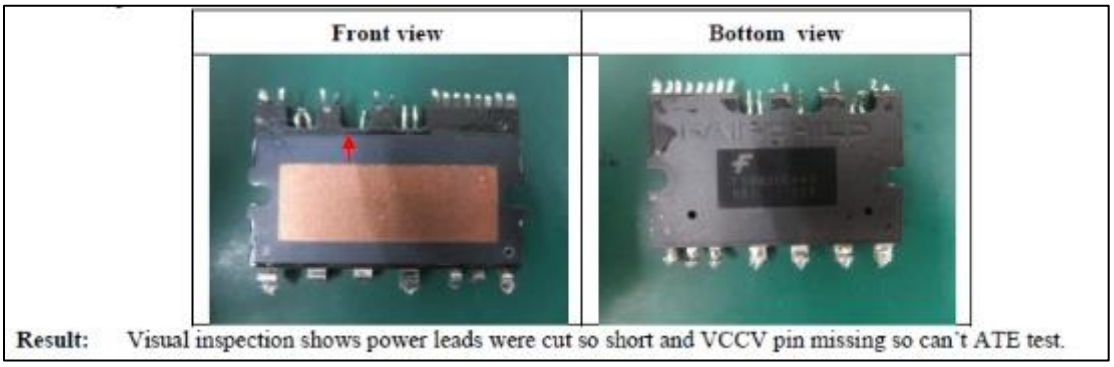
It is preferred to have failure analysis units removed from the customer's printed circuit board (PCB). Care should be taken when removing devices from the PCB to ensure electrical (ESD) damage or physical damage does not occur. For example, for moisture sensitive devices, follow industry MSL requirements. onsemi can provide further guidance upon request. So, another failure mechanism is not introduced and the package's testability on automated test equipment is maintained. Please refer to Section 8 of this guide for ESD control and prevention.

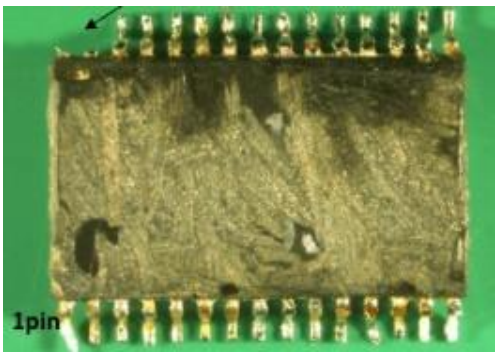
3-2. Targeted Units, Damage, and Testability

To ensure failure analysis units can be tested,

- Desolder parts (do not cut-off leads/pins)
- Prevent mechanical damage to the leads/pins or package
- Remove solder residues (especially between pins)
- Remove coating material

The following examples of components are not acceptable for failure analysis due to missing leads, leads cut too short, bent leads and excess solder on the leads:





In this example, a coating material covering the leads prevents testing on automated test equipment (ATE).

As noted previously, damage to leads/pins makes it much more difficult to perform ATE testing for confirmation of electrical conditions and comparison with production test data.

3-3. Shipping and Handling the Failure Analysis Units

During handling of semiconductors, it is recommended to use antistatic material and conductive packing for storage as well as moisture control. The **onsemi** primary containers i.e., trays, tape and reels, tubes, etc., are static dissipative so shipping the failure analysis units in these containers is recommended to prevent development of a static electrical charge. Do **not** use standard plastic bags for shipments as these bags allow electrical charges to build on the units inside the bag. Static protective bags may be

used and can be identified by symbols and wording on the outside of the bag as in the example below:

It is recommended to minimize movement of parts inside of the shipping box with appropriate packing materials.

Having reference devices (known good units or KGUs) often aids the failure analysis so including 2 to 3 KGUs along with the failing devices is recommended. The number of reference devices should be noted in the failure analysis request form in the field provided. The good reference samples should be identified “reference devices” and be separated from the failing units. The number of reference devices should not be included in the number of failing devices.

onsemi may choose not to support a failure analysis request if the failure analysis units do not meet the above requirements.

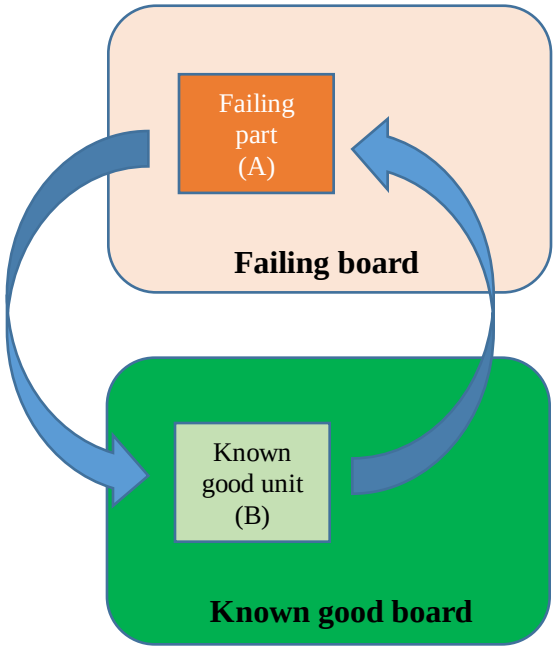
4. Verification by Customer

It is beneficial for analysis efficiency if the customer conducts their own initial verification if possible or practical to isolate the failure to the component.

4-1. ABA Swap

If the package does not have physical damage (see Section 5-1) as would occur from a large EOS event, an ABA swap is recommended to confirm the failure of the suspected unit/units:

- “A”: Remove suspected unit from the “failing” board.
- “B”: Place known good unit onto “failing” board and confirm failing board is now working correctly under the same conditions.
- “A”: Place the suspect unit onto known good board and confirm same failure under same conditions.

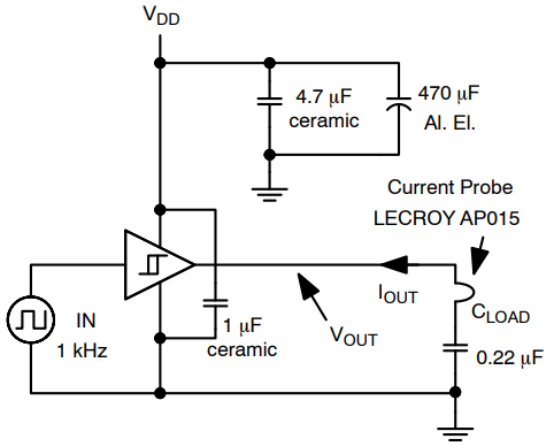


4-2. Waveform

Confirm failure with waveform of passing and failing cases using the same conditions, (supply voltage, temperature, setup condition, sequence until failure, etc.).

4-3. Schematic/Circuit Information

It is recommended to provide a schematic/circuit illustration which is related to the failure analysis unit as in the following example.



4-4. Imaging Products: Comparison with Outgoing Defect Specification (ODS)

Regarding imaging products, the ODS contains the image quality data and conditions in which they were tested noting the image quality using the following keywords:

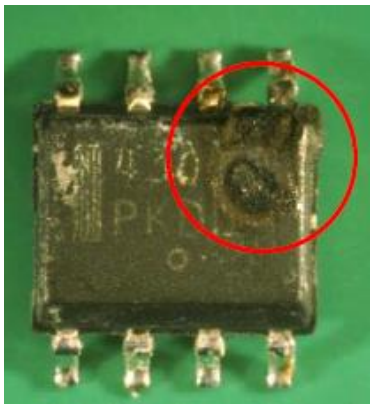
- White Dots, Black Dots, Color Dots, Bright Dot, Dark Dot
- Dead Pixel, Dark pixel, Bright Pixel, Pixel Defect
- Cluster Defect
- Horizontal Line
- Row/Column FPN

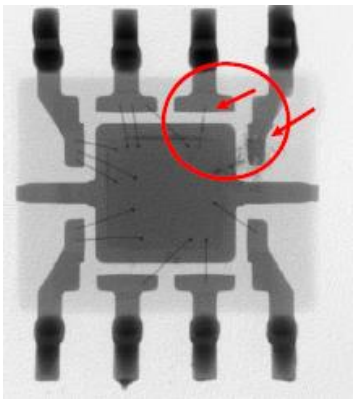
Please note there is a certain number of these defects allowed as noted in the product ODS. Please verify before declaring a product defective and requesting analysis. A customer must compare failed images and conditions with ODS and not processed RAW images to verify images are outside the ODS when the failure mode relates to keywords shown above. RAW images should be provided when failure analysis request is submitted.

5. Feedback from Past Failure Analysis Results

5-1. Massive, Visible Electrical Overstress Failure

Visible electrical overstress (EOS) damage as shown in the photographs below may mask the root cause of the incident of failure. It will be difficult to understand the root cause without an investigation of the application conditions. **onsemi** will review the customer request with the past data of failure analysis to potentially determine next course of action.

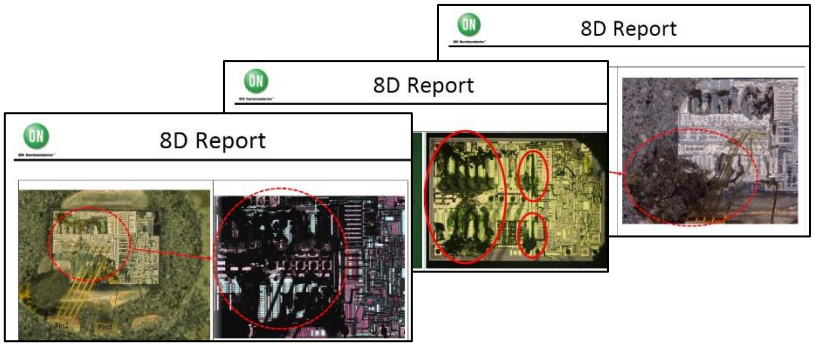




5-2. Repeated EOS Failure

For repeated EOS failures occurring on the same component and same application, an application-level approach will be most effective for the investigation.

The customer design team and **onsemi** application engineers may be needed to support the investigation into the root cause of EOS rather than to perform another device level failure analysis. Repeatedly analyzing at the component level without investigating EOS causes at the application-level only addresses one side of the coin i.e., a systems approach is necessary.



If **onsemi** receives a 2nd failure analysis request whose previous result was EOS with the same application, **onsemi** may request the results from your application-level investigation from the 1st failure analysis report prior to proceeding with the 2nd failure analysis.

5-3. Repeated No Trouble Found (NTF) Failure

The customer's design team will need to investigate the application for the root cause when the result of component level analysis by **onsemi** is NTF. Without a confirmed component failure, device level failure analysis by **onsemi** is not possible.

An NTF result from FA can be due to the reasons listed below. If the result is NTF, it is advised the items below are reviewed to ensure onsemi was provided with the full details of the failure.

- lack of detailed information
- setting and condition of failure on the application
- other device failure on the application
- gaps between customer condition and **onsemi** condition
- required special sequence to create the failure
- special environmental conditions
- wrong information

For imaging products, a common hardware platform between the customer and **onsemi** is helpful with the analysis. A demo kit can be used for the common platform so if the customer has one, reproduction of the failure using the kit and providing the INI file and register settings from the failure reproduction can accelerate the analysis.

5-4. Same Failure Mode and Root Cause Confirmed in Past Failure Analysis

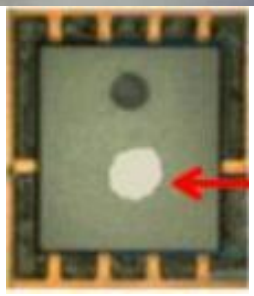
If a new failure analysis request is received for a component with the same failure mode attributed to an **onsemi** root cause, **onsemi** will check the implementation dates for the corrective actions (CA) to verify if the new failures are from before or after the CA implementation. If pre-CA, the report issued in the past will be provided again. For these types of requests, the analysis is redundant and will not be effective for improving the quality of the component or the customer's product. If it is the same issue occurring after the implementation of corrective actions, **onsemi** will investigate the incident.

5-5. Visual/Cosmetic Failure or Contamination Issue

When a visual or cosmetic failure on a device is detected, photos of the affected part will be effective to investigate the incident. The photos should be of the whole part and close-up of the failure area. Please identify the defect or area of concern in all photos with circles or arrows along with an explanation of the concern.

These images show the whole part along with the concerns marked by arrows or circles but do not have the required close-up image of the concern.



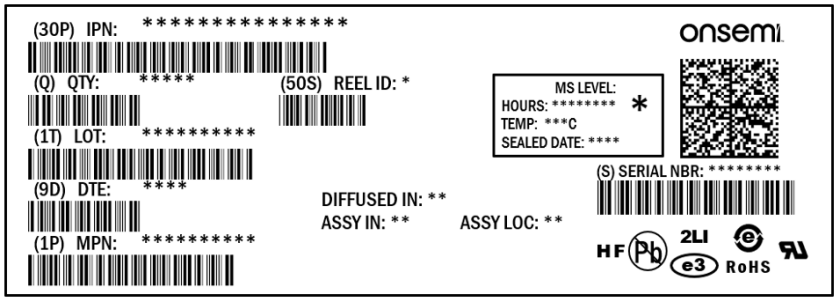
The image below is not effective with communicating the concern since it does not include a picture of the whole part nor does it identify the concern with an arrow or circle.

If the device is an imaging product, all visual/cosmetic failures and contamination issues affecting image quality except moving particle on active pixels (e.g. scratch/contamination on a glass lid or active pixels), the concern should be verified against the ODS to establish validity for requesting failure analysis.

Generally, failure analysis is not valid for these cosmetic issues with image sensors:

- Cannot be visible with up to 20x magnification microscope
- Visible only by tilting or by inspecting at an angle
- Can be cleaned by **onsemi** recommended cleaning method
- Outside of active pixels the defect is <50um (on top of active array), and does not impact image quality under ODS conditions
- Defect is <100um on top of periphery (not on top of active array)

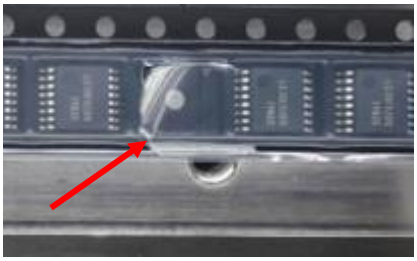
A visual or cosmetic related incident may have a risk which could impact multiple units. Information of affected lots and reference lots will help **onsemi** investigate the root cause quickly. The **onsemi** packing label as shown below is effective when investigating the lot so photos of the label should be provided to **onsemi**.



5-6. Logistic Issues

Logistic issues are related to labeling, wrong deliveries, damaged shipping boxes, tape/reel damage, etc. When a packing problem or damage on the shipment is detected, the photos of the concern will be helpful to investigate the root cause. Photos should identify the concern using circles or arrows. A description of the concern is also required. Packing label information should also be provided as it is effective in determining the cause.

The images below are effective at identifying the concern visually.



5-7. Soldering or Board Mount Related Failure

Soldering and board mounting related failures may be component related but might have multiple factors on the application side like board layout, chemicals, materials, solder stencil thickness, temperature conditions, reflow profile, and device conditions to name a few. A system approach, i.e., component-level and application-level analysis, is best for determining the root cause so the customer and **onsemi** will need to work together closely to investigate processes at both companies.

The **onsemi** “Soldering and Mounting Techniques Reference Manual” contains valuable guidelines for mounting components to boards as well as removal techniques. This manual can be downloaded from the **onsemi** web site, www.onsemi.com. The manual can be searched by the title or the item number SOLDERRM from the main search box.

6. Data Analytics

Data Driven Signature Analysis (DDSA)

As a technology company, **onsemi** uses advanced data driven analytics to improve the effectiveness and efficiency of our customer returns process. Our decades of device data, advanced analytic techniques and experienced analysts allow for accurate data mining and the quick assessment of many issues. By employing data analytics early in the process, we can significantly reduce our overall response time and increase the accuracy of product analysis. Data analysis is conducted utilizing an analytics engine which includes attributes such as date code, package type, wafer fabrication facility, wafer process technology, assembly site, and test site information. When data analytics are utilized, the customer returned product is retained intact in case further analysis becomes critical in the future.

The three possible outcomes of a “DDSA” investigation are:
1) Electrically Passing Unit,
2) Electrical Overstress with a high degree of confidence, or
3) Random defect not related to a systemic manufacturing issue.

7. Failure Analysis Support

7-1. End of Life (EOL) Parts Failure Analysis

Because EOL devices are no longer in production, corrective actions will not be generated for the failure analysis report. For EOL product, only the failure analysis will be performed using limited resource to primarily determine if the parts meet specification and if not, identify what is failing in the device. If a more in-depth analysis is required, the reasoning to perform the deeper failure analysis must be provided. The determination to move forward with the deeper analysis will be at the discretion of **onsemi** after reviewing the reasoning.

7-2. Parts from Unauthorized Sales Channels

onsemi provides no warranty for our product(s) purchased through unauthorized sales channels. As such, failure analysis services are not offered for products purchased from unauthorized sales channels.

7-3. Prototype Devices, Engineering Samples (ES)

Prototype devices and engineering samples (ES) are for the purpose of evaluating function only. The devices may not have completed all production related requirements or reliability testing. No or limited failure analysis for these devices is available. All samples provided free of charge are categorized as engineering samples. Failure analysis on free samples will be at the discretion of **onsemi**.

7-4. Customer Evaluation Samples for Failure Analysis

onsemi cannot support the failure analysis for components evaluated under special conditions like reliability testing which does NOT follow public industry standards such as JEDEC/AEC conditions.

7-5. Failure Analysis Request Through Authorized Sales Channels

For indirect purchases:

Customers purchasing parts through an **onsemi** authorized sales channel (distributor) requesting failure analysis should contact the distributor from whom parts were purchased to arrange the return of samples to **onsemi**. The distributor will handle the product return with the Quality Center (QCenter) at **onsemi** based on the country where the product was shipped. The distributor will manage the formal failure analysis request with the QCenter but will likely have the customer to complete the **onsemi** Failure Analysis Request form with the required information about the complaint. When the form is received by the QCenter, an EFAR number will be created, and shipping instructions will be emailed. After the samples have shipped to **onsemi**, a regional Customer Quality Engineer (CQE) in either EU, US, Asia, or Japan will manage the case. The email with shipping

instructions will include the name and email for the CQE managing the case.

For direct business with onsemi:

1. When **onsemi** product needs to be returned for failure analysis and/or credit, first contact the **onsemi** QCenter using the QCenter group email address below according to the region where product was shipped.
2. Complete the form provided by **onsemi** including detailed information regarding your complaint.
3. Email the completed Failure Analysis Request form back to the QCenter.
4. Once the completed form is received by **onsemi**, the QCenter will provide the shipping address with routing instructions.

QCenters:

QCenters are the initial point of contact for analysis requests. For all product returns, please send an email to the QCenter group address below based on the region where product was shipped for directions on the returns process and shipping instructions. A regional Customer Quality Engineer/Manager or other **onsemi** employee will assist in the product returns process.

The email addresses for the regional QCenters are listed below:

USA:	QCenter_AMERICAS@onsemi.com
Europe:	QCenter_EMEA@onsemi.com
Asia:	QCenter_ASIA@onsemi.com
Japan:	QCenter_Japan@onsemi.com

7-6. Misusing Non-automotive Grade Device for Automotive Applications

onsemi does not support failure analysis for customers usage of non-automotive grade devices for automotive applications.

8. Electrostatic Discharge (ESD) Control

Semiconductors are sensitive to ESD and therefore need to have special care during handling. *Improper handling of failure analysis samples can induce ESD damage in addition to the original cause of failure potentially leading to errors with the root cause analysis*. Basic ESD control is meant to eliminate the source of static electrical charge. The following are generic actions for reducing static electrical charge. These actions should be implemented for assembly, test, packing, shipping and transportation, delivery, incoming, rework and storage. After mounting parts on PCB, the same controls will be required.

1) Environment, Equipment, Facility

Static electrical charge can be generated under low relative humidity conditions. The recommended humidity for handling semiconductors is between 45 to 55%RH. Do not put material that generates static electricity around the device or PCB. Regular monitoring of ESD controls is important to assure compliance with ESD control systems. For preventing static electrical charge, any measurement system, test system, worktable and tool must be connected to ground. A conductive mat (105 to 109Ω) is required on worktables and floors. If sufficiently low ESD conditions can't be achieved, an ionizer is helpful in removing electric charge.

2) Human

Operators must wear wrist strap or foot strap connected to conductive mats on worktables, floors or ESD grounding locations. For protecting humans and products, a resistor (1M to 10MΩ) for prevention of electric shock and voltage drop of discharge needs to be connected in series to ground. When handling products, antistatic gloves or fingercots are required for preventing direct contact with products. Work clothes and work shoes will charge by friction, so it is recommended to use conductive smock and shoes (or shoe coverings). Generally, a 1M to 100MΩ resistivity is recommended for smocks and shoe/shoe covering. When wearing conductive clothing, avoid contacting high DC currents in equipment to prevent electric shock.

3) Working Method

When using a soldering iron, a low voltage spec like 12V to 24V for semiconductors is recommended. The tip of solder iron must be grounded through 1M to 10MΩ resistor.

During handling of semiconductors, use antistatic material and conductive packing for storage. It is recommended to use trays and tubes; however, the anti-static properties of trays and tubes can change over time with repeated usage and from contaminants so attention to their condition is needed. Friction during transportation will generate static electrical charge so minimizing movement of parts inside the box is recommended.