



# Reliability Report 52 Q3 2011



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## Overview

Altera® designs and manufactures Programmable Logic Devices (PLDs). These are user configurable integrated circuits used to implement custom digital logic functions. Altera offers a wide assortment of PLD and configuration device families. These are all described in detail in the appropriate device data sheet.

Product information, such as device architecture, detailed packaging information, handling and surface mount guidelines, and product change notifications can also be found at Altera's Web site: <http://www.altera.com>. Altera literature is available in Adobe Acrobat and postscript format.

Altera Technical Support is also available at Altera's Support web site, which includes mySupport <<https://www.altera.com/myaltera/mal-index.jsp>>, Altera's technical on-line support system and the Altera Knowledge Database, both of which can be used to find answers to technical questions. Additionally, Altera maintains a toll-free customer hotline for general assistance: 800-800-EPLD (1-408-544-8767 if calling from outside US).

Altera has a closed loop quality and reliability system that conforms to the requirements of ISO 9001:2008, MIL-I-45208 and JEDEC standards. Altera and all of its major suppliers are ISO 9000 certified. Altera's Reliability qualification and monitoring programs are also governed by internal specifications, which define procedures, pass/fail requirements, and corrective actions. Altera has been ISO9001 certified since October, 1994. Altera's ISO 9001 auditor is the National Standards Authority of Ireland, NSAI.

Altera's mission is to be a preeminent supplier of programmable silicon solutions to the electronics industry through product leadership, excellent value, and superior quality and service. To achieve and maintain this preeminent supplier status, Altera must provide cost-effective, state-of-the-art solutions to our customers in a timely manner while consistently meeting or exceeding their quality, reliability, and service expectations.

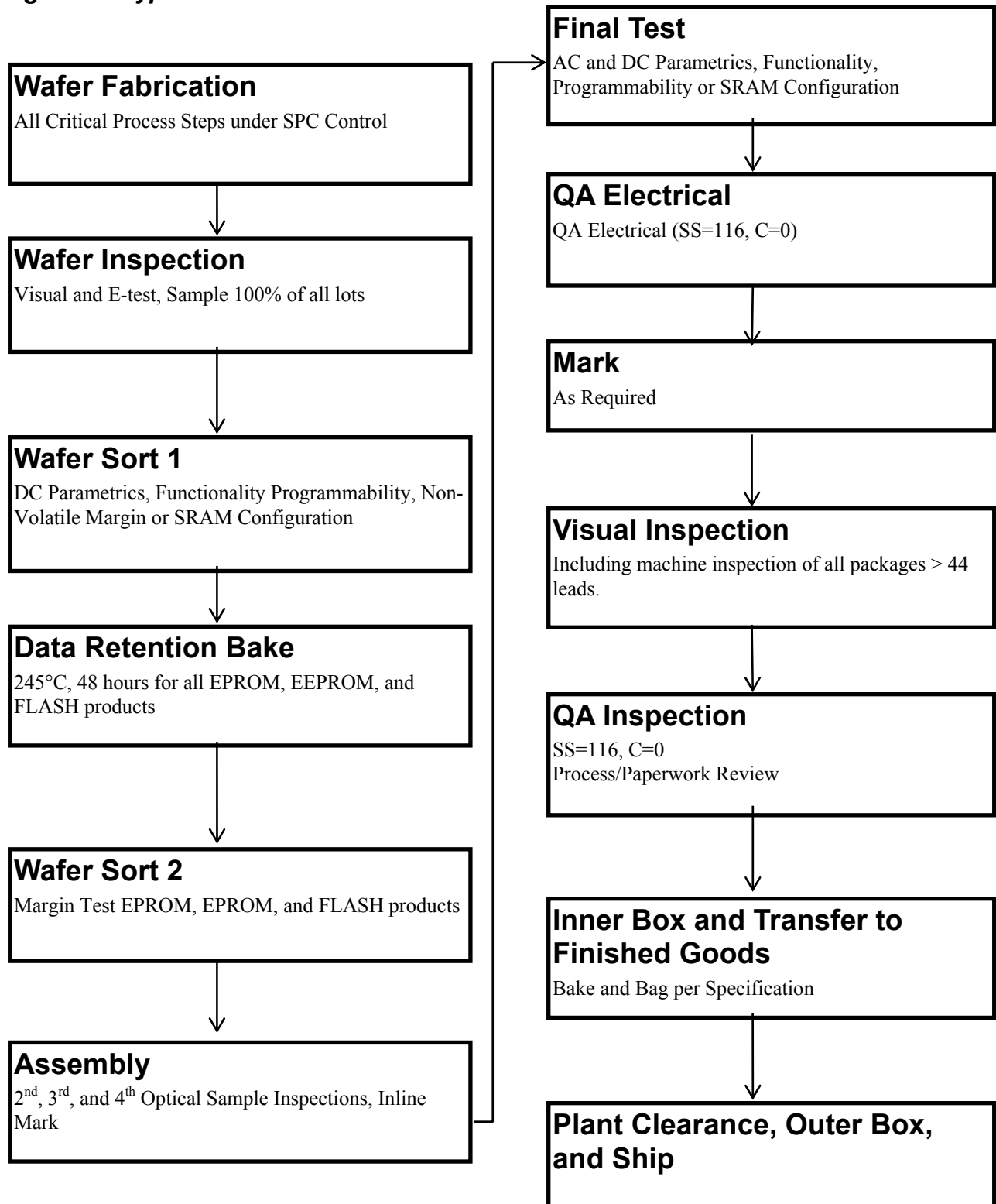
### Altera Quality Systems

Altera's quality system is designed to meet all the requirements of ISO 9001, and is described in Altera's Quality Manual, 11G-00000. Altera's quality systems have also been reviewed and assessed in great detail by some of its major customers, which include multinational corporations from all over the world. Altera maintains complete on-line documentation and computer aided manufacturing systems to control product manufacturing. Internal specifications are in compliance with applicable JEDEC standards. Altera's computer aided manufacturing enables complete fabrication and assembly lot traceability. Altera maintains a network of Applications and Quality engineering personnel to support customers in the design, debug, manufacturing, and distribution of its products.

Altera is able to provide the automotive supply chain with the highest levels of quality and reliability because all of Altera's manufacturing partners (TSMC, ASE and Amkor) are certified and registered to the ISO/TS 16949 automotive industry quality standard.

Altera performs comprehensive testing and manufacturing controls on all its products. Figure 1 shows a typical product manufacturing flow.

**Figure 1: Typical Product Flow Chart**



## Reliability Methodology

Reliability qualifications and monitoring are performed specifically for each product family. All members of a product family utilize the same circuit architecture, fabrication process, and share the same package types. Examples of Altera's product families are MAX<sup>®</sup> 3000, MAX 7000, Stratix<sup>®</sup>, Stratix GX, Cyclone<sup>®</sup>, Arria<sup>®</sup>, Stratix II, Stratix II GX, Cyclone II, Stratix III, Cyclone III, Stratix IV, Arria II, Cyclone IV, Stratix V, Arria V, Cyclone V, MAX II, MAX V and HardCopy<sup>®</sup>. A product family will contain several products, all based upon the same logic elements, embedded storage elements, and programmable interconnect technology. Product families have 2 to 10 members, with a range of densities and packaging options. For reliability purposes such as data reporting and failure rate prediction, a product family will be reported on a fabrication process technology. The fabrication process is described by the storage element technology (i.e. SRAM, EPROM, or EEPROM) and feature size (i.e. 0.13μ or 65 nm).

Product families are qualified based upon the requirements specified in Table I. Reliability monitors are based on the schedules specified in Table II. Product family qualification will include products with a range of densities, package types, and package leadcounts. If a new product is added to the product family with a significant increase (more than 50%) in logic elements, a product qualification will be performed.

Products shipped into the automotive market are also qualified to the Automotive Electronics Council standard AEC-Q100 requirements, which require a much larger sample size. Altera is a member of the AEC, and automotive products meet the requirements of AEC-Q100. Details may be found at [www.aecouncil.com](http://www.aecouncil.com).

Products shipped into the military/aerospace market are qualified to the requirements of the AQEC (Aerospace Qualified Electronic Component) standard, GEIA-Std-0002-1. Altera was the first semiconductor supplier to announce compliance to this standard for the Cyclone, Stratix and MAX II families. This standard emphasizes the communication between the IC supplier and the military/aerospace and defense contractors.

Customers are notified of changes to products through Altera's Product Change Notification system. Notifications are based on changes affecting form, fit, or function. Notifications are also found at Altera's Web site at [www.altera.com](http://www.altera.com). Customers can also sign up to Altera's PCN mailing list at <https://www.altera.com/literature/updates/registration/upd-registration.jsp>.

Reliability monitors are performed on a regular basis in order to assure that Altera's normal production testing and process control methodologies produce reliable products. The Reliability monitor program is also based upon a product family methodology. Different products and package types are procured from normal production on a Last In First Out (LIFO) schedule to monitor product reliability. Results in this report cover data gathered in the last 24 months.

**Table I: Reliability Qualification Requirements**

| <b>Table I: Reliability Qualification Requirements</b>             |   |   |                           |  |
|--|---|---|---------------------------|--|
| <b>TYPE OF TEST</b>  |   |   | <b>Full Qualification</b> |  |
| <b>MIL-STD-883 or JEDEC Std.</b>                                   | <b>METHOD /CONDITION</b>  | <b>SAMPLE SIZE</b>                                    | <b># of Lots</b>          | <b>Accept Criteria # Rej./Lot</b>  |
| Life Test<br>JESD22-A108   | 1000 hours<br>@ 1.1 - 1.2 x Vcc,<br>Tj: 110°C min, 140°C max<br>2000 hours for reference                            | ≤100 pins (77)<br>101-240 pins (45)<br>>240 pins (25) | 3                         | 1<br>1<br>0<br>< 200 FIT@55°C  |
| Retention Bake<br>JESD22-A103                                      | 1000 hours min. @<br>150°C,<br>168 hours min @ 245°C<br>for wafer level may be<br>substituted.                      | ≤100 pins 45<br>>100 pins 25                          | 3                         | 1<br>0   |
| Temperature<br>Cycling<br>JESD22-A104                              | Preconditioning + 700<br>cycles.<br>-55°C to +125°C<br>(condition B)  | ≤100 pins 45<br>>100 pins 25                          | 3                         | 1<br>0   |
| Biased<br>Humidity/Temp<br>JESD-A101<br>Or<br>H.A.S.T<br>JESD-A110 | Preconditioning + 85°C,<br>85% R.H.; 1000 hours<br>@ Vcc nom;<br>Or<br>130°C, 85% RH, 48 or 96<br>hours, @ Vcc nom. | ≤100 pins 45<br>>100 pins 25                          | 3                         | 1<br>0   |
| Autoclave<br>JESD22-A102<br>Or<br>Unbiased H.A.S.T<br>JESD-A118    | 121°C, 15 PSIG;<br>96 hours, 168 hours for<br>reference<br>Or<br>130°C, 85% RH,<br>96 hours                         | ≤100 pins 45<br>>100 pins 25                          | 3                         | 1<br>0   |
| ESD HBM<br>JESD22-A114<br>Mil Std 3015.7                           | 100pf, & 1500Ω. Record<br>Distribution of all Failing<br>Pins   | 3   | 1                         | ≥ 1000V  |
| ESD Charged<br>Device Model<br>JESD22-C101                         | field Induced Charge<br>Device  | 3   | 1                         | ≥ 500 V;<br>>200 V for pins >1GHz<br>See Note * for pins > 10GHz<br>(3units) |
| Latch-up<br>JESD 78  | (Icc nom. + 100mA) or<br>Icc nom. + 50% on I/O,<br>Vcc + 50% on Power<br>Supplies                                   | 6   | 1                         | 0  |
| Program/Erase<br>Cycling   | Program/Erase 100<br>cycles<br>(EEPROM or FLASH)  | 25  | 1                         | 0  |
| PCB Interconnect<br>Reliability<br>IPC 9701<br>JESD22-A104         | 0°C to +100°C, Single<br>Chamber  | 25  | 1<br>Daisy<br>Chain       | >2000 Cycles to<br>0.1% Predicted<br>Failure                                 |

\* Standard ESD characterization will be performed to classify the products performance according to their susceptibility to damage or degradation as defined in JESD22-C101 (Charge Device Model)

**Table II: Reliability Monitor Program**

| <b>Table II: Reliability Monitor Program</b>                         |   |   |                              |
|--|---|---|------------------------------|
| <b>TYPE OF TEST<br/>MIL-STD-883 or<br/>JEDEC Std.</b>                | <b>METHOD/CONDITION</b>   | <b>SAMPLE<br/>SIZE</b>                            | <b><u>FREQUENCY</u></b>      |
| Life Test<br><br>JESD22-A108   | 1000 hours @ 1.1 - 1.2 x Vcc nom.<br>T <sub>j</sub> : 110°C min, 140°C max<br>2000 hours for reference                | ≤100 pins 77<br>>100 -240 pins 45<br>>240 pins 22 | Any month of a Qtr./ Process |
| Retention Bake<br>Non-Volatile Products<br>JESD22-A103               | 1000 hours min. @ 150°C   | ≤100 pins 45<br>>100 pins 22                      | Any month of a Qtr./ Process |
| Temperature Cycling<br><br>JESD22-A104                               | Preconditioning + 700 cycles.<br>-55°C to +125°C Industrial,<br>0°C to +125°C Commercial,                             | ≤100 pins 45<br>>100 pins 22                      | Any month of a Qtr./ Process |
| Biased<br>Humidity/Temp.<br>JESD-A101<br>Or<br>H.A.S.T.<br>JESD-A110 | Preconditioning + 85°C, 85% R.H.<br>1000 hours min. @ Vcc nominal;<br>Or<br>130°C, 85% RH,<br>96 hours, @ Vcc nominal | ≤100 pins 45<br>>100 pins 22                      | Any month of a Qtr./ Process |
| Autoclave<br>JESD22-A102<br>Or<br>Unbiased H.A.S.T.<br>JESD-A118     | 121°C, 15 PSIG;<br>96 hours min. 168 hours for reference<br>Or<br>130°C, 85% RH,<br>96 hours                          | ≤100 pins 45<br>>100 pins 22                      | Any month of a Qtr./ Process |
| Program/Erase  | Program/Erase 100 cycles<br>(EEPROM or FLASH only)  | 22  | Any month of a Qtr./ Process |

## **Lifetest: Methodology and Failure Rate Prediction**

### ***Lifetest Methodology***

Altera performs a high temperature / high voltage Lifetest on its products to accelerate failure mechanisms. Failure mechanisms are accelerated by elevating the ambient temperature of the Lifetest chamber in order to increase the junction temperature to at least 125°C and by increasing the voltage of the Vcc power supply by 10-20%. In some cases where increasing junction temperature to 125°C is not possible because of risk of thermal runaway, a minimum junction temperature of 110°C is used. The lifetest boards have special high temperature sockets that maintain lead integrity.

FLEX, APEX, Mercury, Stratix, Stratix GX, Cyclone, Stratix II, Stratix II GX, and Cyclone II devices use a BI Test Mode. 65/60 nm and 40 nm products use dynamic life with a real clocked configuration. MAX 3000, MAX 7000, MAX 9000 devices (EEPROM devices), MAX II and MAX V (FLASH devices) are first subjected to 100 Program Erase Cycles before starting Lifetest.

Each device is tested using production test equipment to data sheet specifications before being stressed. All readouts are also done on the same production test equipment to data sheet parameters. A device is considered a failure if it does not pass data sheet specifications.

For non-volatile configuration elements except those on MAX II and V devices, there is a test mode that allows the configuration elements to be margin tested to determine the amount of charge on the floating gate. At each readout, the margin of every configuration element is tested and the lowest margin is recorded.

MAX II devices are uniquely designed so that the functionality of the device is only affected by charge gain on erased bits and will not be affected by charge loss on programmed bits. We challenge erased bits at 25 uA during MAX II testing, although 10 uA is all we need to assure functionality.

## Failure Rate Prediction

Altera uses industry standard techniques for failure rate prediction. Failure rates are predicted based upon an exponential distribution of failures in time (constant failure rate).

As noted above, both elevated temperatures and voltages are used to accelerate failures in lifetest, and the overall acceleration is simply the product of the thermal and voltage acceleration:

$$\text{Equivalent Hours in typical use conditions} = (\text{Hours in lifetest}) \times (\text{Acceleration factor})$$

$$\text{Acceleration Factor} = (\text{Thermal Acceleration}) \times (\text{Voltage Acceleration})$$

Thermal and voltage acceleration factors are based on standard acceleration formulas and published acceleration factors. Acceleration Factors are based upon JEDEC Publication JEP122. The formulas are presented below, and the acceleration factors are listed in Table III. As we are moving to thin gate-oxide (< 70 Å) technology, we have observed the power-law dependence on voltage acceleration. We use the power-law model for gate oxide voltage acceleration on 65 nm and smaller process technology.

Note that a dielectric breakdown acceleration factor of 0.7eV is used for all processes of 90 nm and larger. Published papers have demonstrated that modern oxides have higher thermal activation energy than the previously reported 0.3eV. Values of 0.3eV to 0.9eV have been reported.<sup>i ii</sup> Altera has verified through multiple temperature Burn-In studies that 0.7eV is applicable for 90 nm and larger process. Different acceleration factors are used on 65 nm and smaller process based on power-law model.

Junction temperatures, not ambient temperatures, must be used in calculating thermal acceleration factors. A designer can determine device power dissipation using the Early Power Estimator (EPE) available on [www.altera.com](http://www.altera.com), or using the PowerPlay power analyzer in the Quartus II design tool. Junction temperatures are calculated from ambient temperature or case temperature measurements using the thermal resistance values found in the Altera Device Package Information Data Sheet. Thermal resistance values are specific to each product and package combination. For convenience, formulas to calculate junction temperatures are included with the acceleration formulas below.

Note also that temperatures must be converted to Degrees Kelvin when using the Temperature Acceleration formula below. Degrees Kelvin = Degrees Centigrade + 273.

$$\text{Temperature Acceleration Factor} = \exp\left[\frac{E_a}{k(T_{\text{operation}})} - \frac{E_a}{k(T_{\text{stress}})}\right]$$

$$k = \text{Boltzmann's constant} = 8.62 \times 10^{-5} \text{ eV}/^\circ\text{K}$$

$$E_a = \text{Activation energy in eV (see Table III)}$$

$$T = \text{Junction Temperature in Degrees Kelvin}$$

$$kT(\text{eV}) = 0.0258 \times (\text{temperature in Centigrade} + 273)/298$$

$$\text{Gate Oxide Voltage Acceleration Factor} = \exp\left[\frac{\gamma}{(t_{\text{ox}}/10 \text{ nm})}(V_{\text{stress}} - V_{\text{operation}})\right]$$

$$\gamma = \text{Voltage exponent factor (see Table III)}$$

$$\text{Interlayer Dielectric Acceleration Factor} = \exp[\gamma(V_{\text{stress}} - V_{\text{operation}})]$$

$$\text{Junction Temperature} = (\text{Ambient Temperature}) + (\text{Power dissipation}) \times (\theta_{ja})$$

$$= (\text{Case Temperature}) + (\text{Power dissipation}) \times (\theta_{jc})$$

$\theta_{ja}$  and  $\theta_{jc}$  are found in the Altera Device Package Information Data Sheet.

**Table III: Common Failure Mechanisms and Acceleration Factors <sup>iii</sup>**

| Mechanism  | Activation Energy “Ea” [eV] | Voltage Exponent Factor                |
|--|-----------------------------|--|
| Gate Oxide Breakdown ( $\geq 90$ nm)*                      | 0.7                         | $\gamma = 3.2$                         |
| Interlayer defect  | 0.7                         | $\gamma = 2.0$                         |
| Via Voiding (0. 15 $\mu\text{m}$ & 0. 13 $\mu\text{m}$ )   | 0.8                         | 0.0                                    |
| Via Voiding ( $\leq 90$ nm)                                | 1.0                         | 0.0                                    |
| Silicon Junction Defect                                    | 0.8                         | 0.0                                    |
| Masking (Poly, Diffusion, etc.) Defect                     | 0.5                         | 0.0                                    |
| Metallization Defect                                       | 0.5                         | 0.0                                    |
| Al Electromigration  | 0.7 (Al-Si), 0.85 (Al-Cu)   | Current density dependence ( $1/J^2$ ) |
| Cu Electromigration (0. 13 $\mu\text{m}$ , FSG dielectric) | 0.8                         | Current density dependence ( $1/J^2$ ) |
| Cu Electromigration ( $\leq 90$ nm low-k dielectric)       | 0.9                         | Current density dependence ( $1/J$ )   |
| Contamination (Surface & Bulk)                             | 1.0                         | 0.0                                    |
| Data Retention   |                             |  |
| Charge Loss (EPROM)  | 0.6                         | 0.0                                    |
| Charge Detrapping (FLASH & EPROM, $\leq 168$ hrs)          | 1.1                         | 0.0                                    |
| SILC (FLASH & EPROM, $> 168$ hrs)                          | 0                           | 2.3                                    |

\* $\leq 65$  nm process uses different values with power-law model

Failure rates are calculated on a product family basis (as in the tables of data on the following pages). Device hours accumulated at the stress conditions are converted to normal use conditions using the acceleration factors described above. Equivalent hours are calculated at a typical use condition of  $V_{cc}$  nominal in a  $55^\circ\text{C}$  still-air ambient or  $70^\circ\text{C}$  junction.

Failure mechanisms are determined by failure analysis. For each failure mechanism observed in stress, the acceleration factor is calculated using the formulas and acceleration factors above. If two failure mechanisms are active, the failure rate due to each one is summed to produce a combined failure rate. If there are no failures, the failure mechanism with lowest acceleration factor is used to calculate failure rate.

Failure rates are expressed in terms of FITs or Failures In Time, where one FIT is equivalent to one failure in one billion or  $10^9$  device-hours. Altera calculates the FIT rate using the JESD85 (Methods for Calculating Failure Rates in Units of FITs) standard.

The failure rate is calculated using a Chi-squared distribution to predict a 60% confidence level from the small number of failures and limited sample size of the population tested. The Chi-squared value is calculated from the inverse Chi-squared distribution using the desired probability level and the degrees of freedom. <sup>iv</sup> The degrees of freedom are calculated as:  $\nu = 2n + 2$ , where  $n = \#$  of failures observed. The failure rate is then calculated from the Chi-squared value:

$$Failure\ Rate = \frac{X^2}{(2 * A.F. * Device\ hours)} \text{ failures / hour}$$

The FIT rate is  $10^9 * Failure\ Rate$  and the Mean Time to Failure is simply the inverse of the failure rate for an exponential distribution.







## APEX, Excalibur, and Mercury 0.18 $\mu$ Products

APEX 20KE, Excalibur, and Mercury products are fabricated on a 0.18 $\mu$  process technology that supports up to 8 layers of metallization. Devices are available in TQFP, PQFP, RQFP, FBGA, BGA & PGA packages with logic density ranging from 4,160 LEs to 42,240 LEs. The process technology operates with a 1.8V supply. Lifetests are conducted at 2.3V, which is over 25% overvoltage.

## APEX, Excalibur, and Mercury 0.18 $\mu$ Lifetest Results

| REL LOT #                | DEVICE     | PACKAGE TYPE | TA  | # UNITS       | L.T. HOURS     | # FAIL | DEVICE HOURS       | Interlayer EQUIV. HRS. | Date Code |
|--------------------------|------------|--------------|-----|---------------|----------------|--------|--------------------|------------------------|-----------|
| 10020023                 | EP20K100E  | 208 PQFP     | 125 | 46            | 1000           | 0      | 46000              | 3.31E+06               | 1001      |
| 9030002                  | EP20K160E  | 240 PQFP     | 125 | 45            | 1000           | 0      | 45000              | 2.20E+06               | 0907      |
| 10040002                 | EP20K200E  | 208 PQFP     | 125 | 45            | 1000           | 0      | 45000              | 2.08E+06               | 1007      |
| 11040003                 | EP20K300E  | 672 FBGA     | 125 | 28            | 1000           | 0      | 28000              | 3.25E+06               | 1115      |
| 8080013                  | EP20K300E  | 672 FBGA     | 125 | 25            | 1027           | 0      | 25675              | 2.98E+06               | 0825      |
| 9090020                  | EP20K300E  | 672 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 2.90E+06               | 0925      |
| 9060011                  | EP20K400E  | 672 FBGA     | 125 | 25            | 1063           | 0      | 26575              | 1.19E+06               | 0919      |
| 8070030                  | EP20K600E  | 672 FBGA     | 125 | 25            | 1043           | 0      | 26075              | 2.29E+06               | 0829      |
| 8100014                  | EP20K600E  | 672 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 2.35E+06               | 0837      |
| 8080026                  | EP20K600E  | 1020 FBGA    | 125 | 25            | 1020           | 0      | 25500              | 2.15E+06               | 0832      |
| 8110026                  | EP20K1000E | 672 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 7.84E+05               | 0843      |
|                          |            |              |     |               |                |        |                    | <b>2.55E+07</b>        |           |
|                          |            |              |     |               |                |        |                    |                        |           |
| <b>Failure Mechanism</b> |            |              |     | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FITs</b>            |           |
| Interlayer Defect        |            |              |     | 0             | 1.83           |        | 2.55E+07           | <b>35.9</b>            |           |

## APEX and Mercury 0.15μ Products

APEX 20KC, APEX II and Mercury products are fabricated on a 0.15μ process technology that supports up to 8 layers of Cu metallization. Devices are available in FBGA, QFP, BGA, and FlipChip FBGA packages with logic density ranging from 8,320 LEs to 67,200 LEs and 106Kbits to 1.1Mbits of embedded RAM. These devices offer 1 Gbps LVDS I/Os, Clock-Data Synchronization, and support for numerous high-speed memory interfaces. The APEX 20KC product family operates with a 1.8V supply and the lifestest is conducted at 2.3V, which is a 25% overvoltage. The APEX II product family operates at 1.5V and the lifestests are conducted at 1.8V, which is a 20% overvoltage.

## APEX and Mercury 0.15μ Lifestest Results

| REL LOT # | DEVICE    | PACKAGE TYPE | TA  | # UNITS | L.T. HOURS | # FAIL | DEVICE HOURS | Dielectric EQUIV. HRS. | Date Code |
|-----------|-----------|--------------|-----|---------|------------|--------|--------------|------------------------|-----------|
| 11050015  | EP20K400C | 672 FBGA     | 125 | 25      | 1000       | 0      | 25000        | 5.13E+07               | 1121      |
| 7050045   | EP20K400C | 672 FBGA     | 125 | 25      | 1000       | 1 a    | 25000        | 5.13E+07               | 0713      |
| 9020002   | EP20K400C | 672 FBGA     | 125 | 25      | 1000       | 0      | 25000        | 5.13E+07               | 0901      |
| 10090008  | EP20K400C | 672 FBGA     | 125 | 25      | 1000       | 0      | 25000        | 5.13E+07               | 1031      |

2.05E+08

| Failure Mechanism    | # Fail | Chi Sq. | Equiv. Hrs. | FITs |
|----------------------|--------|---------|-------------|------|
| Dielectric Breakdown | 1      | 4.04    | 2.05E+08    | 9.86 |

a - failed localline\_speed at 168 hrs, FA inconclusive. Assume oxide defect.

## Stratix, Stratix GX, Cyclone and HardCopy 0.13 $\mu$ Products

Stratix, Stratix GX, Cyclone and HardCopy products are fabricated on a 0.13 $\mu$  process technology that supports up to 9 layers of Cu metallization. Devices are available in FBGA, QFP, BGA, and FlipChip FBGA packages with logic density ranging from 2,910 LEs to 79,040 LEs and 59Kbits to 10.1Mbits of embedded RAM. Stratix devices offer DSP blocks, Clock-Data Synchronization, and support for numerous high-speed memory interfaces. Stratix GX devices add 3.125-Gbps I/Os to the Stratix features. Cyclone devices are optimized for low cost/Logic Element. The Stratix, Stratix GX, Cyclone and HardCopy product families operate with a 1.5V supply and the lifestest is conducted at 1.8V, which is a 20% overvoltage. A lifestest temperature of 100°C is used on some devices to keep junction temperature below absolute maximum ratings.

## Stratix, Stratix GX, Cyclone and HardCopy 0.13 $\mu$ Lifestest Results

| REL LOT #                                 | DEVICE | PACKAGE TYPE | TA  | # UNITS       | L.T. HOURS     | # FAIL | DEVICE HOURS      | Via voiding Fail. EQUIV. HRS. | Date Code |
|---|--------|--------------|-----|---------------|----------------|--------|-------------------|-------------------------------|-----------|
| 8110001                                   | EP1C4  | 324 FBGA     | 125 | 77            | 1016           | 0      | 78232             | 4.43E+06                      | 0831      |
| 8090002                                   | EP1C6  | 144 TQFP     | 125 | 77            | 1024           | 0      | 78848             | 4.50E+06                      | 0831      |
| 9050010                                   | EP1C6  | 144 TQFP     | 125 | 24            | 1000           | 0      | 24000             | 1.37E+06                      | 0918      |
| 9060034                                   | EP1C6  | 144 TQFP     | 125 | 77            | 1000           | 0      | 77000             | 4.40E+06                      | 0925      |
| 10030015                                  | EP1C6  | 144 TQFP     | 125 | 77            | 1000           | 0      | 77000             | 4.14E+06                      | 1012      |
| 10030016                                  | EP1C6  | 144 TQFP     | 125 | 77            | 1000           | 0      | 77000             | 4.14E+06                      | 1012      |
| 10040015                                  | EP1C6  | 144 TQFP     | 125 | 74            | 1000           | 0      | 74000             | 3.87E+06                      | 1007      |
| 9060004                                   | EP1C12 | 324 FBGA     | 125 | 75            | 1000           | 0      | 75000             | 4.12E+06                      | 0919      |
| 10050013                                  | EP1C12 | 324 FBGA     | 125 | 25            | 1000           | 0      | 25000             | 1.41E+06                      | 1019      |
| 10050014                                  | EP1C12 | 324 FBGA     | 125 | 25            | 1000           | 0      | 25000             | 1.41E+06                      | 1019      |
| 10050015                                  | EP1C12 | 324 FBGA     | 125 | 25            | 1000           | 0      | 25000             | 1.52E+06                      | 1019      |
| 10100017                                  | EP1C12 | 324 FBGA     | 125 | 77            | 1000           | 0      | 77000             | 5.85E+06                      | 1037      |
| 8060015                                   | EP1S25 | 1020 FBGA    | 125 | 57            | 1011           | 0      | 57627             | 3.72E+06                      | 0817      |
| 8110021                                   | EP1S30 | 780 FBGA     | 100 | 24            | 1000           | 0      | 24000             | 3.01E+05                      | 0843      |
| 9030008                                   | EP1S40 | 1020 FBGA    | 125 | 29            | 1058           | 0      | 30682             | 2.44E+06                      | 0911      |
| 9030007                                   | EP1S40 | 1508 FBGA    | 125 | 29            | 2027           | 0      | 58783             | 4.47E+06                      | 0913      |
| 8070017                                   | EP1S60 | 1020 FBGA    | 125 | 24            | 1000           | 0      | 24000             | 2.20E+06                      | 0826      |
| 8080021                                   | EP1S60 | 1020 FBGA    | 125 | 23            | 1002           | 0      | 23046             | 1.60E+06                      | 0832      |
| 10030002                                  | EP1S60 | 1020 FBGA    | 125 | 25            | 1000           | 0      | 25000             | 2.27E+06                      | 1001      |
| 10070028                                  | EP1S80 | 1020 FBGA    | 125 | 25            | 1000           | 0      | 25000             | 2.53E+06                      | 1028      |
| 8070008                                   | EP1S80 | 1508 FBGA    | 100 | 25            | 1000           | 0      | 25000             | 5.75E+05                      | 0825      |
| 8070027                                   | EP1S80 | 1508 FBGA    | 100 | 25            | 1004           | 0      | 25100             | 6.10E+05                      | 0827      |
| 8090026                                   | EP1S80 | 1508 FBGA    | 100 | 24            | 1045           | 0      | 25080             | 4.65E+05                      | 0838      |
| 8080002                                   | HC1S60 | 1020 FBGA    | 125 | 24            | 1000           | 0      | 24000             | 1.44E+06                      | 0825      |
|   |        |              |     |               |                |        |                   | <b>8.78E+07</b>               |           |
|   |        |              |     |               |                |        |                   |                               |           |
| <b>Failure Mechanism</b>                  |        |              |     | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs</b> | <b>FITs</b>                   |           |
| Via voiding Failure(Ea=0.8)               |        |              |     | 0             | 1.83           |        | 8.78E+07          | 10.4                          |           |
|   |        |              |     |               |                |        |                   |                               |           |
| <b>Note: Typical application Tj=70°C.</b> |        |              |     |               |                |        |                   |                               |           |

## Stratix II, Stratix II GX, Cyclone II, Arria GX and HardCopy II - 90 nm Products

Stratix II, Stratix II GX, Cyclone II, Arria GX and HardCopy II products are fabricated on a 90 nm process technology that supports up to 9 layers of Cu metallization and Low-k with one layer of Salicided polysilicon. Stratix II and GX devices are available in FlipChip FBGA packages with logic density ranging from 6,240 to 71,760 ALMs and 419 Kbits to 9.4 Mbits of embedded RAM. Cyclone II devices are available in QFP, FBGA and UBGA packages with logic density ranging from 4,608 to 68,416 LEs and 119 Kbits to 1.1 Mbits of embedded RAM. The Stratix II, Stratix II GX, Cyclone II, Arria GX and HardCopy II product families operate with a 1.2V supply and the lifetest is conducted at 1.44V, which is a 20% overvoltage. Lifetest was run at junction temperature of 125°C to keep it below absolute maximum ratings.

## Stratix II, Stratix II GX, Cyclone II, Arria GX and HardCopy II - 90 nm Lifetest Results

| REL LOT #                                 | DEVICE   | PACKAGE TYPE | Stress Tj (C) | # UNITS       | L.T. HOURS     | # FAIL | DEVICE HOURS       | Interlayer EQUIV. HRS. | Date Code |
|---|----------|--------------|---------------|---------------|----------------|--------|--------------------|------------------------|-----------|
| 8100002                                   | EP2C8    | 256 FBGA     | 125           | 25            | 1071           | 0      | 26775              | 1.14E+06               | 0837      |
| 10020010                                  | EP2C8    | 256 FBGA     | 125           | 77            | 1000           | 0      | 77000              | 3.28E+06               | 1001      |
| 11030026                                  | EP2C20   | 256 FBGA     | 125           | 77            | 1000           | 0      | 77000              | 3.28E+06               | 1049      |
| 9040021                                   | EP2C35   | 672 FBGA     | 125           | 77            | 1006           | 0      | 77462              | 3.30E+06               | 0913      |
| 8080029                                   | EP2C70   | 672 FBGA     | 125           | 25            | 1021           | 0      | 25525              | 1.09E+06               | 0831      |
| 9100029                                   | EP2C70   | 672 FBGA     | 125           | 25            | 1037           | 0      | 25925              | 1.10E+06               | 0942      |
| 10090028                                  | EP2C70   | 672 FBGA     | 125           | 76            | 1049           | 0      | 79724              | 3.40E+06               | 1025      |
| 8050014                                   | EP2S30   | 672 FBGA     | 125           | 31            | 1004           | 0      | 31124              | 1.33E+06               | 0818      |
| 8050015                                   | EP2S30   | 672 FBGA     | 125           | 62            | 1004           | 0      | 62248              | 2.65E+06               | 0818      |
| 10100001                                  | EP2S30   | 672 FBGA     | 125           | 23            | 1000           | 0      | 23000              | 9.80E+05               | 1039      |
| 11060011                                  | EP2S90   | 1020 FBGA    | 125           | 25            | 1008           | 0      | 25200              | 1.07E+06               | 1125      |
| 9020005                                   | EP2S90   | 1020 FBGA    | 125           | 25            | 2000           | 0      | 50000              | 2.13E+06               | 0901      |
| 9100003                                   | EP2S90   | 1020 FBGA    | 125           | 25            | 1086           | 0      | 27150              | 1.16E+06               | 0937      |
| 10040020                                  | EP2S90   | 1020 FBGA    | 125           | 28            | 1014           | 0      | 28392              | 1.21E+06               | 1013      |
| 8070018                                   | EP2S130  | 1020 FBGA    | 125           | 25            | 1004           | 0      | 25100              | 1.07E+06               | 0826      |
| 9010010                                   | EP2S130  | 1020 FBGA    | 125           | 25            | 1001           | 0      | 25025              | 1.07E+06               | 0901      |
| 8080017                                   | EP2S130  | 1508 FBGA    | 125           | 25            | 1001           | 0      | 25025              | 1.07E+06               | 0834      |
| 8110022                                   | EP2S130  | 1508 FBGA    | 125           | 23            | 2047           | 0      | 47081              | 2.01E+06               | 0843      |
| 9040029                                   | EP2S130  | 1508 FBGA    | 125           | 24            | 1004           | 0      | 24096              | 1.03E+06               | 0913      |
| 9090024                                   | EP2SGX90 | 1152 FBGA    | 125           | 25            | 1074           | 0      | 26850              | 1.14E+06               | 0931      |
| 8020004                                   | HC210    | 484 FBGA     | 125           | 80            | 1000           | 0      | 80000              | 3.41E+06               | 0801      |
| 8110011                                   | HC230    | 1020 FBGA    | 125           | 24            | 2004           | 0      | 48096              | 2.05E+06               | 0837      |
|   |          |              |               |               |                |        |                    | <b>3.99E+07</b>        |           |
|   |          |              |               |               |                |        |                    |                        |           |
| <b>Failure Mechanism</b>                  |          |              |               | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FITs</b>            |           |
| Interlayer Breakdown (Ea=0.7)             |          |              |               | 0             | 1.83           |        | 3.99E+07           | 22.9                   |           |
|   |          |              |               |               |                |        |                    |                        |           |
| <b>Note: Typical application Tj=70°C.</b> |          |              |               |               |                |        |                    |                        |           |

### Stratix III, Cyclone III and Cyclone IV - 65/60 nm Products

Stratix III, Cyclone III and Cyclone IV products are fabricated on a 65/60 nm process technology that supports up to 9 layers of Cu metallization and Low-k with one layer of Salicided polysilicon. Stratix III devices are available in FlipChip FBGA packages with logic density ranging from 47.5K to 337.5K LEs and 2,430 to 20,491 Kbits of total memory. Cyclone III and Cyclone IV devices are available in QFP, QFN, FBGA and UBGA packages with logic density ranging from 5,136 to 149,760 LEs and 414 to 6,480 Kbits of memory. The Stratix III product families operate with a 1.1V supply. Cyclone III and Cyclone IV product families operate with a 1.2V supply. Lifetest is conducted at 1.32V and 1.44V respectively, which is a 20% overvoltage. Lifetest uses dynamic life with a real clocked configuration and was run at junction temperature of 125°C to keep it below absolute maximum ratings.

### Stratix III, Cyclone III and Cyclone IV - 65/60 nm Lifetest

| REL LOT #                                 | DEVICE     | PACKAGE TYPE | Stress Tj (C) | # UNITS       | L.T. HOURS     | # FAIL | FAB PROCESS | DEVICE HOURS       | Interlayer EQUIV. HRS. | Date Code |
|---|------------|--------------|---------------|---------------|----------------|--------|-------------|--------------------|------------------------|-----------|
| 10010012                                  | EP3C5      | 144 EQFP     | 125           | 30            | 1033           | 0      | 65nm logic  | 30990              | 1.32E+06               | 1001      |
| 10040029                                  | EP3C5      | 144 EQFP     | 125           | 78            | 1066           | 0      | 65nm logic  | 83148              | 3.54E+06               | 1016      |
| 10050001                                  | EP3C16     | 144 EQFP     | 125           | 80            | 1010           | 0      | 65nm logic  | 80800              | 3.44E+06               | 1018      |
| 9090042                                   | EP3C25     | 144 EQFP     | 125           | 77            | 1019           | 0      | 65nm logic  | 78463              | 3.34E+06               | 0931      |
| 10020005                                  | EP3C25     | 144 EQFP     | 125           | 79            | 1004           | 0      | 65nm logic  | 79316              | 3.38E+06               | 1005      |
| 10120018                                  | EP3C120    | 780 FBGA     | 125           | 29            | 508            | 0      | 65nm logic  | 14732              | 6.27E+05               | 1052      |
| 10120018                                  | EP3C120    | 256 FBGA     | 125           | 29            | 1061           | 0      | 65nm logic  | 30769              | 1.31E+06               | 1052      |
| 10120016                                  | EP3C120    | 780 FBGA     | 125           | 28            | 1095           | 0      | 65nm logic  | 30660              | 1.31E+06               | 1052      |
| 10120017                                  | EP3C120*   | 780 FBGA     | 125           | 30            | 1006           | 0      | 60nm logic  | 30180              | 1.29E+06               | 1052      |
| 10120019                                  | EP3C120*   | 780 FBGA     | 125           | 28            | 1001           | 0      | 60nm logic  | 28028              | 1.19E+06               | 1052      |
| 11010015                                  | EP3C120*   | 780 FBGA     | 125           | 25            | 1000           | 0      | 60nm logic  | 25000              | 1.06E+06               | 1104      |
| 11040013                                  | EP3C120*   | 780 FBGA     | 125           | 30            | 1002           | 0      | 60nm logic  | 30060              | 1.28E+06               | 1117      |
| 10100014                                  | EP3C120*   | 780 FBGA     | 125           | 43            | 2014           | 0      | 60nm logic  | 86602              | 3.69E+06               | 1040      |
| 9070009                                   | EP3CLS200* | 780 FBGA     | 125           | 35            | 3004           | 0      | 60nm logic  | 105140             | 4.48E+06               | 0916      |
| 9070010                                   | EP3CLS200* | 780 FBGA     | 125           | 35            | 3004           | 0      | 60nm logic  | 105140             | 4.48E+06               | 0925      |
| 8040010                                   | EP3SE260   | 1152 FBGA    | 125           | 40            | 1000           | 0      | 65nm logic  | 40000              | 1.64E+06               | 0812      |
| 9040010                                   | EP3SL110   | 1152 FBGA    | 125           | 25            | 1000           | 0      | 65nm logic  | 25000              | 1.02E+06               | 0912      |
| 10100010                                  | EP3SL150   | 1152 FBGA    | 125           | 25            | 1000           | 0      | 65nm logic  | 25000              | 1.02E+06               | 1041      |
| 8020010                                   | EP3SL150   | 1152 FBGA    | 125           | 40            | 1000           | 0      | 65nm logic  | 40000              | 1.64E+06               | 0806      |
| 8030004                                   | EP3SL150   | 1152 FBGA    | 125           | 40            | 2000           | 0      | 65nm logic  | 80000              | 3.27E+06               | 0805      |
| 8050004                                   | EP3SL150   | 1152 FBGA    | 125           | 37            | 1000           | 0      | 65nm logic  | 37000              | 1.51E+06               | 0805      |
| 8110029                                   | EP3SL150   | 1152 FBGA    | 125           | 24            | 1010           | 0      | 65nm logic  | 24240              | 9.92E+05               | 0842      |
| 10100010                                  | EP3SL150   | 1152 FBGA    | 125           | 25            | 1000           | 0      | 65nm logic  | 25000              | 1.02E+06               | 1041      |
| 9040015                                   | EP3SL200   | 1152 FBGA    | 125           | 25            | 1001           | 0      | 65nm logic  | 25025              | 1.02E+06               | 0907      |
| 10080012                                  | EP3SL200   | 1152 FBGA    | 125           | 25            | 1066           | 0      | 65nm logic  | 26650              | 1.09E+06               | 1019      |
| 11030010                                  | EP4CGX15*  | 148 QFN      | 125           | 78            | 1000           | 0      | 65nm logic  | 78000              | 3.32E+06               | 1101      |
| 10020043                                  | EP4CGX15*  | 148 QFN      | 125           | 48            | 2000           | 0      | 60nm logic  | 96000              | 4.09E+06               | 1007      |
| 10080028                                  | EP4CGX15*  | 148 QFN      | 125           | 77            | 1000           | 0      | 60nm logic  | 77000              | 3.28E+06               | 1025      |
| * 60 nm Feature Size                      |            |              |               |               |                |        |             |                    | <b>6.07E+07</b>        |           |
| <b>Failure Mechanism</b>                  |            |              |               | <b># Fail</b> | <b>Chi Sq.</b> |        |             | <b>Equiv. Hrs.</b> | <b>FITs</b>            |           |
| Interlayer Breakdown (Ea=0.7)             |            |              |               | 0             | 1.83           |        |             | 6.07E+07           | 15.1                   |           |
| <b>Note: Typical application Tj=70°C.</b> |            |              |               |               |                |        |             |                    |                        |           |

## Stratix IV, Arria II GX and HardCopy III & IV - 40 nm Products

Stratix IV, Arria II GX and HardCopy III & IV products are fabricated on a 40 nm process technology that supports up to 11 layers of Cu metallization and one Al redistribution layer. Stratix IV and Arria II GX devices are available in FlipChip FBGA packages with up to 820K logic elements (LEs), 23.1 Mbits of embedded memory, and up to 1,288 18 x 18 multipliers. The Stratix IV, Arria II GX and HardCopy III & IV product families operate with a 0.9 V supply. Stratix IV lifetest is conducted at 1.1 x Vcc while Arria II and HardCopy III & IV lifetest is conducted at 1.2 x Vcc. Lifetest uses dynamic life with a real clocked configuration and was run at junction temperature of 125°C to keep it below absolute maximum ratings.

## Stratix IV, Arria II GX and HardCopy III & IV - 40 nm Lifetest

| REL LOT #   | DEVICE    | PACKAGE TYPE | Stress Tj (C) | # UNITS       | L.T. HOURS     | # FAIL | DEVICE HOURS       | Dielectric EQUIV. HRS. | Via voiding Fail. EQUIV. HRS. | Interlayer EQUIV. HRS. | Date Code |      |
|---|-----------|--------------|---------------|---------------|----------------|--------|--------------------|------------------------|-------------------------------|------------------------|-----------|------|
| 9090041   | EP4SGX230 | 1517 FBGA    | 125           | 27            | 2000           | 0      | 54000              | 7.62E+06               | 5.78E+06                      | 1.74E+06               | 0938      |      |
| 9100001   | EP4SGX230 | 1517 FBGA    | 125           | 30            | 1000           | 0      | 30000              | 4.23E+06               | 3.21E+06                      | 9.66E+05               | 0939      |      |
| 9100005   | EP4SGX230 | 1517 FBGA    | 125           | 30            | 2000           | 0      | 60000              | 8.46E+06               | 6.43E+06                      | 1.93E+06               | 0940      |      |
| 10080001  | EP4SGX230 | 1517 FBGA    | 125           | 11            | 1069           | 0      | 11759              | 1.66E+06               | 1.26E+06                      | 3.79E+05               | 0950      |      |
| 9120003   | EP4SGX290 | 1517 FBGA    | 125           | 27            | 2000           | 0      | 54000              | 7.62E+06               | 5.78E+06                      | 1.74E+06               | 0946      |      |
| 10010020  | EP4SGX530 | 1517 FBGA    | 125           | 29            | 2000           | 1      | b                  | 58000                  | 8.18E+06                      | 6.21E+06               | 1.87E+06  | 0952 |
| 10030004  | EP4SGX530 | 1517 FBGA    | 125           | 46            | 2000           | 0      | 92000              | 1.30E+07               | 9.85E+06                      | 2.96E+06               | 1008      |      |
| 10030036  | EP4SGX530 | 1517 FBGA    | 125           | 36            | 2000           | 1      | c                  | 72000                  | 1.02E+07                      | 7.71E+06               | 2.32E+06  | 1012 |
| 10100018  | EP4SGX530 | 1517 HBGA    | 125           | 31            | 1019           | 0      | 31589              | 4.46E+06               | 3.38E+06                      | 1.02E+06               | 1026      |      |
| 10110013  | EP4SGX530 | 1517 HBGA    | 125           | 28            | 2021           | 0      | 56588              | 7.98E+06               | 6.06E+06                      | 1.82E+06               | 1026      |      |
| 10080027  | EP2AGX65  | 358 UBGA     | 125           | 61            | 1000           | 0      | 61000              | 6.25E+07               | 6.53E+06                      | 2.40E+06               | 1034      |      |
| 10090017  | EP2AGX65  | 358 UBGA     | 125           | 60            | 1000           | 0      | 60000              | 6.14E+07               | 6.43E+06                      | 2.36E+06               | 1037      |      |
| 10090018  | EP2AGX65  | 358 UBGA     | 125           | 51            | 1000           | 0      | 51000              | 5.22E+07               | 5.46E+06                      | 2.01E+06               | 1037      |      |
| 10090019  | EP2AGX65  | 358 UBGA     | 125           | 65            | 168            | 0      | 10920              | 1.12E+07               | 1.17E+06                      | 4.29E+05               | 1037      |      |
| 10100012  | EP2AGX95  | 780 FBGA     | 125           | 12            | 1015           | 0      | 12180              | 1.25E+07               | 1.30E+06                      | 4.79E+05               | 1040      |      |
| 10110012  | EP2AGX125 | 780 FBGA     | 125           | 25            | 212            | 0      | 5300               | 5.43E+06               | 5.68E+05                      | 2.08E+05               | 1040      |      |
| 10110012  | EP2AGX125 | 780 FBGA     | 125           | 25            | 1500           | 0      | 37500              | 3.84E+07               | 4.02E+06                      | 1.47E+06               | 1040      |      |
| 10110012  | EP2AGX125 | 780 FBGA     | 125           | 25            | 1048           | 0      | 26200              | 2.68E+07               | 2.81E+06                      | 1.03E+06               | 1040      |      |
| 9120004   | EP2AGX125 | 780 FBGA     | 125           | 27            | 1000           | 0      | 27000              | 2.76E+07               | 2.89E+06                      | 1.06E+06               | 0940      |      |
| 10020045  | EP2AGX260 | 780 FBGA     | 125           | 22            | 2000           | 0      | 44000              | 6.21E+06               | 4.71E+06                      | 1.42E+06               | 1008      |      |
| 10060022  | HC335     | 1152 FBGA    | 125           | 29            | 1000           | 0      | 29000              | 2.97E+07               | 3.11E+06                      | 1.14E+06               | 1020      |      |
|   |           |              |               |               |                |        |                    | 4.07E+08               | 9.47E+07                      | 3.07E+07               |           |      |
| <b>Failure Mechanism</b>  |           |              |               | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FITs</b>            |                               |                        |           |      |
| Via voiding Failure(Ea=1.0)   |           |              |               | 1             | 4.04           |        | 9.47E+07           | <b>21.4</b>            |                               |                        |           |      |
| Dielectric Breakdown*(1)  |           |              |               | 1             | 4.04           |        | 4.07E+08           | <b>5.0</b>             |                               |                        |           |      |
| Interlayer Breakdown (Ea=0.7)   |           |              |               | 0             | 1.83           |        | 3.07E+07           | <b>29.8</b>            |                               |                        |           |      |
| <b>Combined Failure Rate</b>  |           |              |               |               |                |        |                    | <b>56.1</b>            |                               |                        |           |      |
| b- IPATPG reject at 2000 hours due to a faulty scan chain caused by a random defect. Suspect Via 1 failure. |           |              |               |               |                |        |                    |                        |                               |                        |           |      |
| c - CRAM min/max reject that is intermittent oxide failure at 500 hrs. Damaged during FA.                   |           |              |               |               |                |        |                    |                        |                               |                        |           |      |
| <b>Note: Typical application Tj=70°C.</b>   |           |              |               |               |                |        |                    |                        |                               |                        |           |      |
| <b>*(1) Using the Power-law TDDB model for thin-gate oxide</b>  |           |              |               |               |                |        |                    |                        |                               |                        |           |      |
| <b>tff=to*V<sup>-n</sup>*exp(Ea/kT)</b>   |           |              |               |               |                |        |                    |                        |                               |                        |           |      |
| <b>n and Ea values are available upon request.</b>  |           |              |               |               |                |        |                    |                        |                               |                        |           |      |

## MAX 7000S and MAX 9000 - Third Generation

These MAX 7000 and MAX 9000 products are fabricated on a 0.5 $\mu$  triple layer metal CMOS EEPROM process. Devices are available in logic densities from 32 to 560 macrocells and in PLCC, TQFP, PQFP, RQFP, and PGA packages. Lifetests are conducted at 6.0V, which is a 20% overvoltage.

### Third Generation MAX 7000S & MAX 9000 Lifetest Results

| REL LOT#                      | DEVICE   | PACKAGE TYPE | TA  | # UNITS       | Life Test HOURS | # Fail | DEVICE HOURS       | Data Retention Equiv Hrs. | Date Code |
|-------------------------------|----------|--------------|-----|---------------|-----------------|--------|--------------------|---------------------------|-----------|
| 9040002                       | EPM7032S | 44 PLCC      | 125 | 77            | 1055            | 0      | 81235              | 4.34E+06                  | 0907      |
| 9100028                       | EPM7064S | 44 TQFP      | 125 | 77            | 1000            | 0      | 77000              | 6.60E+06                  | 0937      |
| 10040017                      | EPM7064S | 44 TQFP      | 125 | 77            | 1000            | 0      | 77000              | 5.89E+06                  | 1007      |
| 10060027                      | EPM7064S | 44 TQFP      | 125 | 77            | 1000            | 0      | 77000              | 7.11E+06                  | 1019      |
| 11040002                      | EPM7064S | 44 PLCC      | 125 | 77            | 1000            | 0      | 77000              | 5.45E+06                  | 1101      |
|                               |          |              |     |               |                 |        |                    | <b>2.94E+07</b>           |           |
|                               |          |              |     |               |                 |        |                    |                           |           |
| <b>Failure Mechanism</b>      |          |              |     | <b># Fail</b> | <b>Chi Sq.</b>  |        | <b>Equiv. Hrs.</b> | <b>FITs</b>               |           |
| <b>Data retention failure</b> |          |              |     | 0             | 1.83            |        | 2.94E+07           | <b>31.17</b>              |           |

## MAX 7000A and MAX 3000A - Fourth Generation

The MAX 7000A and MAX 3000A products are fabricated on a 0.3/0.35 $\mu$  CMOS EEPROM process. This process supports up to four layers of metallization, which supports a 3.3V operating voltage. Devices are available in logic densities from 32 to 512 macrocells and in PLCC, TQFP, PQFP, BGA, and FBGA packages. Lifetest are conducted at 4.0V, which is a 20% overvoltage.

### Fourth Generation MAX 7000A and MAX 3000A Lifetest Results

| REL LOT#                 | DEVICE    | PACKAGE TYPE | TA  | # UNITS       | L.T. HOURS     | # Fail | DEVICE HOURS       | Data Retention Equiv Hrs. | Date Code |
|--------------------------|-----------|--------------|-----|---------------|----------------|--------|--------------------|---------------------------|-----------|
| 8080004                  | EPM3128A  | 100 TQFP     | 125 | 76            | 1000           | 0      | 76000              | 6.25E+06                  | 0825      |
| 8110004                  | EPM3512A  | 208 PQFP     | 125 | 44            | 1000           | 0      | 44000              | 1.09E+06                  | 0837      |
| 8030009                  | EPM7064AE | 44 TQFP      | 125 | 77            | 1000           | 0      | 77000              | 7.49E+06                  | 0801      |
| 9010009                  | EPM7064AE | 100 TQFP     | 125 | 232           | 2000           | 0      | 464000             | 2.96E+07                  | 0851      |
| 8010017                  | EPM7256AE | 144 TQFP     | 125 | 25            | 1000           | 0      | 25000              | 1.68E+06                  | 0801      |
| 9010008                  | EPM7256AE | 144 TQFP     | 125 | 274           | 1000           | 0      | 274000             | 1.84E+07                  | 0851      |
| 10100013                 | EPM7512AE | 208 PQFP     | 125 | 45            | 1000           | 0      | 45000              | 1.72E+06                  | 1037      |
| 9050031                  | EPM7512AE | 256 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 8.88E+05                  | 0922      |
| 10030018                 | EPM7512AE | 256 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 7.48E+05                  | 1001      |
|                          |           |              |     |               |                |        |                    | <b>6.79E+07</b>           |           |
| <b>Failure Mechanism</b> |           |              |     | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FITs</b>               |           |
| Data retention failure   |           |              |     | 0             | 1.83           |        | 6.79E+07           | 13.5                      |           |

## MAX 7000B - Fifth Generation

These MAX 7000B products are fabricated on a 0.22μ quadruple layer metal CMOS EEPROM process. Devices are available in logic densities from 32 to 512 macrocells and in PLCC, TQFP, UBGA, PQFP & FBGA packages. Lifetests are conducted at 3.0V, which is a 20% overvoltage.

### Fifth Generation MAX 7000 Lifetest Results

| REL LOT#                      | DEVICE   | PACKAGE TYPE | TA  | # UNITS       | L.T. HOURS     | # Fail | DEVICE HOURS       | Data Retention Equiv Hrs. | Date Code |
|-------------------------------|----------|--------------|-----|---------------|----------------|--------|--------------------|---------------------------|-----------|
| 7100002                       | EPM7256B | 144 TQFP     | 125 | 44            | 1016           | 0      | 44704              | 3.42E+06                  | 0737      |
| 8070001                       | EPM7256B | 256 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 3.90E+06                  | 0819      |
| 9080001                       | EPM7256B | 256 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 3.90E+06                  | 0919      |
| 7090012                       | EPM7512B | 256 FBGA     | 125 | 45            | 1049           | 0      | 47205              | 6.90E+06                  | 0731      |
| 10080013                      | EPM7512B | 256 FBGA     | 125 | 25            | 1000           | 0      | 25000              | 8.36E+06                  | 1025      |
|                               |          |              |     |               |                |        |                    | <b>2.65E+07</b>           |           |
|                               |          |              |     |               |                |        |                    |                           |           |
| <b>Failure Mechanism</b>      |          |              |     | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FITs</b>               |           |
| <b>Data retention failure</b> |          |              |     | 0             | 1.83           |        | 2.65E+07           | <b>34.6</b>               |           |



## Configuration Devices - EPROM

These Configuration EPROMs are fabricated on a 0.5µm double layer metal CMOS EPROM process. These devices are erasable with UV light when supplied in windowed hermetic packages for prototyping. Lifetests are conducted at least 6.0V, which is a minimum of 20% overvoltage.

### Third Generation Classic and Configuration Devices Lifetest Results

| REL LOT#                 | DEVICE  | PACKAGE TYPE | TA  | # UNITS       | L.T. HOURS     | # FAIL | DEVICE HOURS       | C.L. Equiv. Hrs. | Date Code |
|--------------------------|---------|--------------|-----|---------------|----------------|--------|--------------------|------------------|-----------|
| 8100011                  | EPC1    | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 3.34E+06         | 0831      |
| 9040001                  | EPC1    | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 3.70E+06         | 0907      |
| 9010014                  | EPC1441 | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 3.48E+06         | 0901      |
| 10020046                 | EPC1441 | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 3.63E+06         | 1001      |
| 11010014                 | EPC1441 | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 3.63E+06         | 1049      |
|                          |         |              |     |               |                |        |                    | <b>1.78E+07</b>  |           |
|                          |         |              |     |               |                |        |                    |                  |           |
| <b>Failure Mechanism</b> |         |              |     | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FTs</b>       |           |
| Data retention failure   |         |              |     | 0             | 1.83           |        | 1.78E+07           | 51.5             |           |

## Configuration Devices – Flash Memory

The EPC2 configuration device is fabricated on a 0.4 $\mu$  double layer metal CMOS Flash process. EPC4, EPC8 and EPC16 are stacked-dice configuration devices in which the controller die is fabricated on a 0.35 $\mu$  double layer metal CMOS logic process and the memory die is fabricated on 0.13 $\mu$  triple layer metal CMOS Flash process. These devices are electrically erasable. Lifetests are conducted at least at 6.0V and 4.0V for EPC2 and EPC16 respectively, which is a minimum of 20% overvoltage.

## Flash Memory Devices Lifetest Results

| REL LOT#                 | DEVICE | PACKAGE TYPE | TA  | # UNITS       | L.T. HOURS     | # FAIL | DEVICE HOURS       | Data Retention Equiv. Hrs. | Date Code |
|--------------------------|--------|--------------|-----|---------------|----------------|--------|--------------------|----------------------------|-----------|
| 8040003                  | EPC2   | 20 PLCC      | 125 | 76            | 1000           | 0      | 76000              | 1.63E+07                   | 0807      |
| 9070002                  | EPC2   | 20 PLCC      | 125 | 76            | 1000           | 0      | 76000              | 1.30E+07                   | 0919      |
| 10050020                 | EPC2   | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 1.84E+07                   | 1013      |
| 10110001                 | EPC2   | 20 PLCC      | 125 | 77            | 1000           | 0      | 77000              | 1.84E+07                   | 1037      |
| 8070005                  | EPC16  | 88 UBGA      | 125 | 77            | 1000           | 0      | 77000              | 1.33E+07                   | 0819      |
| 8080016                  | EPC16  | 88 UBGA      | 125 | 77            | 1000           | 0      | 77000              | 1.33E+07                   | 0831      |
| 10010008                 | EPC16  | 88 UBGA      | 125 | 77            | 1000           | 0      | 77000              | 1.29E+07                   | 0949      |
| 10080009                 | EPC16  | 88 UBGA      | 125 | 78            | 1000           | 0      | 78000              | 1.33E+07                   | 1019      |
|                          |        |              |     |               |                |        |                    | <b>1.19E+08</b>            |           |
| <b>Failure Mechanism</b> |        |              |     | <b># Fail</b> | <b>Chi Sq.</b> |        | <b>Equiv. Hrs.</b> | <b>FITs</b>                |           |
| Data retention failure   |        |              |     | 0             | 1.83           |        | 1.19E+08           | 7.71                       |           |

## High Temperature Storage

High temperature storage is performed at 150°C or greater. This stress detects bonding failures due to intermetallic formation in all product families and data retention failures in non-volatile memory elements. The ability of non-volatile memory elements to retain their charge is crucial for reliability. The leakage of charge off of the floating gate of a non-volatile configuration element can be measured by margin test modes built into every Altera device. Charge loss mechanisms in EPROMs and EEPROMs have been well documented in the literature. <sup>v vi</sup>

## High Temperature Storage Results

| REL LOT # | DEVICE    | PACKAGE TYPE | BAKE TEMP. | # UNITS | STRESS HOURS | # FAIL | Technology | Date Code |
|-----------|-----------|--------------|------------|---------|--------------|--------|------------|-----------|
| 10030015  | EP1C6     | 144 TQFP     | 150        | 77      | 2000         | 0      | 0.13μ SRAM | 1012      |
| 10030016  | EP1C6     | 144 TQFP     | 150        | 77      | 2000         | 0      | 0.13μ SRAM | 1012      |
| 10040015  | EP1C6     | 144 TQFP     | 150        | 77      | 2000         | 0      | 0.13μ SRAM | 1007      |
| 9050026   | EP1C6     | 240 PQFP     | 150        | 52      | 2000         | 0      | 0.13μ SRAM | 0918      |
| 10050015  | EP1C12    | 324 FBGA     | 150        | 25      | 1000         | 0      | 0.13μ SRAM | 1019      |
| 10100017  | EP1C12    | 324 FBGA     | 150        | 77      | 1000         | 0      | 0.13μ SRAM | 1037      |
| 9020006   | EP1C20    | 324 FBGA     | 150        | 77      | 2000         | 0      | 0.13μ SRAM | 0901      |
| 9080009   | EP1C20    | 400 FBGA     | 150        | 77      | 2000         | 0      | 0.13μ SRAM | 0931      |
| 10090006  | EP1K50    | 256 FBGA     | 150        | 25      | 2000         | 0      | 0.22μ SRAM | 1031      |
| 9030006   | EP1S10    | 672 FBGA     | 150        | 25      | 2004         | 0      | 0.13μ SRAM | 0907      |
| 9030017   | EP1S25    | 672 FBGA     | 150        | 24      | 2000         | 0      | 0.13μ SRAM | 0912      |
| 11030011  | EP1S40    | 1508 FBGA    | 150        | 25      | 1000         | 0      | 0.13μ SRAM | 1001      |
| 10070028  | EP1S80    | 1020 FBGA    | 150        | 17      | 2000         | 0      | 0.13μ SRAM | 1028      |
| 8120009   | EP20K160E | 144 TQFP     | 150        | 25      | 2000         | 0      | 0.18μ SRAM | 0901      |
| 10090008  | EP20K400C | 672 FBGA     | 150        | 25      | 1000         | 0      | 0.15μ SRAM | 1031      |
| 9020002   | EP20K400C | 672 FBGA     | 150        | 25      | 2000         | 0      | 0.15μ SRAM | 0901      |
| 8080026   | EP20K600E | 1020 FBGA    | 150        | 25      | 2000         | 0      | 0.18μ SRAM | 0832      |
| 10100015  | EP2AGX65  | 358 UBGA     | 150        | 25      | 2000         | 0      | 40 nm SRAM | 1039      |
| 9070013   | EP2AGX125 | 780 FBGA     | 150        | 22      | 2011         | 0      | 40 nm SRAM | 0929      |
| 9080006   | EP2AGX125 | 780 FBGA     | 150        | 24      | 2024         | 0      | 40 nm SRAM | 0933      |
| 9090013   | EP2AGX125 | 780 FBGA     | 150        | 21      | 2073         | 0      | 40 nm SRAM | 0937      |
| 10030009  | EP2AGX260 | 780 FBGA     | 150        | 25      | 2050         | 0      | 40 nm SRAM | 0910      |
| 10120006  | EP2AGX260 | 1152 FBGA    | 150        | 25      | 2002         | 0      | 40 nm SRAM | 1049      |
| 10020010  | EP2C8     | 256 FBGA     | 150        | 77      | 2000         | 0      | 0.09μ SRAM | 1001      |
| 11030026  | EP2C20    | 256 FBGA     | 150        | 77      | 1000         | 0      | 0.09μ SRAM | 1049      |
| 9040021   | EP2C35    | 672 FBGA     | 150        | 77      | 2000         | 0      | 0.09μ SRAM | 0913      |
| 10090028  | EP2C70    | 672 FBGA     | 150        | 77      | 2000         | 0      | 0.09μ SRAM | 1025      |
| 11010016  | EP2C70    | 896 FBGA     | 150        | 45      | 1000         | 0      | 0.09μ SRAM | 1104      |
| 10090025  | EP2S30    | 484 FBGA     | 150        | 25      | 1000         | 0      | 0.09μ SRAM | 1039      |
| 10100001  | EP2S30    | 672 FBGA     | 150        | 25      | 1576         | 0      | 0.09μ SRAM | 1039      |
| 9020005   | EP2S90    | 1020 FBGA    | 150        | 25      | 2003         | 0      | 0.09μ SRAM | 0901      |
| 10040020  | EP2S90    | 1020 FBGA    | 150        | 25      | 2000         | 0      | 0.09μ SRAM | 1013      |
| 9040029   | EP2S130   | 1508 FBGA    | 150        | 23      | 2002         | 0      | 0.09μ SRAM | 0913      |
| 10110006  | EP2S180   | 1508 FBGA    | 150        | 25      | 1000         | 0      | 0.09μ SRAM | 1037      |
| 10110015  | EP2S180   | 1508 FBGA    | 150        | 25      | 1000         | 0      | 0.09μ SRAM | 1044      |
| 10010012  | EP3C5     | 144 EQFP     | 150        | 45      | 1000         | 0      | 65 nm SRAM | 1001      |
| 10040029  | EP3C5     | 144 EQFP     | 150        | 45      | 1000         | 0      | 65 nm SRAM | 1016      |

| REL LOT # | DEVICE     | PACKAGE TYPE | BAKE TEMP. | # UNITS | STRESS HOURS | # FAIL | Technology  | Date Code |
|-----------|------------|--------------|------------|---------|--------------|--------|-------------|-----------|
| 10050001  | EP3C16     | 144 EQFP     | 150        | 45      | 1000         | 0      | 60 nm SRAM  | 1018      |
| 10040009  | EP3C16     | 240 PQFP     | 150        | 25      | 1000         | 0      | 65 nm SRAM  | 1014      |
| 11040006  | EP3C16     | 144 EQFP     | 150        | 30      | 1000         | 0      | 65 nm SRAM  | 1116      |
| 10040008  | EP3C25     | 240 PQFP     | 150        | 25      | 1000         | 0      | 65 nm SRAM  | 1014      |
| 11020010  | EP3C25     | 144EQFP      | 150        | 25      | 1000         | 0      | 65 nm SRAM  | 1107      |
| 10090012  | EP3C55     | 484 UBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1031      |
| 10050021  | EP3C55     | 780 FBGA     | 150        | 25      | 2000         | 0      | 60 nm SRAM  | 1013      |
| 10110024  | EP3C55     | 780 FBGA     | 150        | 25      | 2000         | 0      | 60 nm SRAM  | 1046      |
| 10010022  | EP3C80     | 484 UBGA     | 150        | 25      | 2000         | 0      | 65 nm SRAM  | 1003      |
| 10070020  | EP3C80     | 484 UBGA     | 150        | 25      | 2000         | 0      | 60 nm SRAM  | 1019      |
| 10120016  | EP3C120    | 780 FBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1052      |
| 10120017  | EP3C120    | 780 FBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1052      |
| 10120018  | EP3C120    | 780 FBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1052      |
| 10120019  | EP3C120    | 780 FBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1052      |
| 11010015  | EP3C120    | 780 FBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1104      |
| 9070009   | EP3CLS200  | 780 FBGA     | 150        | 45      | 3007         | 0      | 60 nm SRAM  | 0916      |
| 9070010   | EP3CLS200  | 780 FBGA     | 150        | 45      | 3003         | 0      | 60 nm SRAM  | 1043      |
| 11030015  | EP3SE50    | 780 FBGA     | 150        | 25      | 1000         | 0      | 65 nm SRAM  | 0925      |
| 9040010   | EP3SL110   | 1152 FBGA    | 150        | 25      | 2002         | 0      | 65 nm SRAM  | 0912      |
| 10070023  | EP3SL150   | 1152 FBGA    | 150        | 25      | 2000         | 0      | 65 nm SRAM  | 1027      |
| 9040015   | EP3SL200   | 1152 FBGA    | 150        | 25      | 2004         | 0      | 65 nm SRAM  | 0907      |
| 10080012  | EP3SL200   | 1152 FBGA    | 150        | 25      | 1500         | 0      | 65 nm SRAM  | 1019      |
| 10020043  | EP4CGX15   | 148 QFN      | 150        | 50      | 2000         | 0      | 60 nm SRAM  | 1007      |
| 10080028  | EP4CGX15   | 148 QFN      | 150        | 77      | 1000         | 0      | 60 nm SRAM  | 1025      |
| 11030010  | EP4CGX15   | 148 QFN      | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1107      |
| 10070022  | EP4CGX150  | 896 FBGA     | 150        | 30      | 2000         | 0      | 60 nm SRAM  | 1028      |
| 10090024  | EP4CGX150  | 896 FBGA     | 150        | 25      | 1000         | 0      | 60 nm SRAM  | 1038      |
| 9060033   | EP4SGX230  | 1517 FBGA    | 150        | 50      | 1158         | 0      | 40 nm SRAM  | 0923      |
| 11030012  | EP4SGX230  | 1517 FBGA    | 150        | 23      | 2014         | 0      | 40 nm SRAM  | 1108      |
| 10080018  | EP4SGX530  | 1517 HBGA    | 150        | 40      | 2088         | 0      | 40 nm SRAM  | 1027      |
| 10110014  | EP4SGX530  | 1517 HBGA    | 150        | 33      | 1001         | 0      | 40 nm SRAM  | 1040      |
| 10110014  | EP4SGX530  | 1517 HBGA    | 150        | 29      | 2550         | 0      | 40 nm SRAM  | 1040      |
| 10120022  | EP4SGX530  | 1517 HBGA    | 150        | 29      | 2549         | 0      | 40 nm SRAM  | 1048      |
| 9040001   | EPC1       | 20 PLCC      | 150        | 45      | 2000         | 0      | 0.5μ EPROM  | 0907      |
| 10020046  | EPC1441    | 20 PLCC      | 150        | 45      | 2000         | 0      | 0.5μ EPROM  | 1001      |
| 11010014  | EPC1441    | 20 PLCC      | 150        | 45      | 1000         | 0      | 0.5μ EPROM  | 1049      |
| 10050020  | EPC2       | 20 PLCC      | 150        | 45      | 2000         | 0      | 0.4μ FLASH  | 1013      |
| 10110001  | EPC2       | 20 PLCC      | 150        | 45      | 1000         | 0      | 0.4μ FLASH  | 1037      |
| 9050009   | EPC4       | 100 PQFP     | 150        | 45      | 2000         | 0      | 0.35μ FLASH | 0910      |
| 10070002  | EPC4       | 100 PQFP     | 150        | 45      | 2000         | 0      | 0.35μ FLASH | 1013      |
| 10010008  | EPC16      | 88 UBGA      | 150        | 45      | 2000         | 0      | 0.35μ FLASH | 0949      |
| 10030001  | EPF10K50A  | 240 RQFP     | 150        | 25      | 1000         | 0      | 0.3μ SRAM   | 1008      |
| 10050019  | EPF10K50S  | 256 FBGA     | 150        | 25      | 2000         | 0      | 0.22μ SRAM  | 1018      |
| 10040004  | EPF10K70   | 240 RQFP     | 150        | 25      | 2000         | 0      | 0.42μ SRAM  | 1013      |
| 10020042  | EPF10K100A | 240 RQFP     | 150        | 25      | 1000         | 0      | 0.3μ SRAM   | 1001      |
| 10040033  | EPF10K100A | 240 RQFP     | 150        | 25      | 2000         | 0      | 0.3μ SRAM   | 1016      |
| 9050030   | EPF10K100E | 256 FBGA     | 150        | 25      | 2017         | 0      | 0.22μ SRAM  | 0922      |

| REL LOT # | DEVICE     | PACKAGE TYPE | BAKE TEMP. | # UNITS | STRESS HOURS | # FAIL | Technology   | Date Code |
|-----------|------------|--------------|------------|---------|--------------|--------|--------------|-----------|
| 10120008  | EPF10K200S | 672 FBGA     | 150        | 25      | 1000         | 0      | 0.22μ SRAM   | 1050      |
| 10040030  | EPM240Z    | 100 MBGA     | 150        | 77      | 2000         | 0      | 0.18μ FLASH  | 1017      |
| 10120013  | EPM240Z    | 100 MBGA     | 150        | 102     | 1000         | 0      | 0.18μ FLASH  | 1050      |
| 11030013  | EPM240Z    | 100 MBGA     | 150        | 101     | 1000         | 0      | 0.18μ FLASH  | 1101      |
| 10020013  | EPM570     | 100 TQFP     | 150        | 77      | 2000         | 0      | 0.18μ FLASH  | 1001      |
| 10070003  | EPM570     | 100 TQFP     | 150        | 76      | 2000         | 0      | 0.18μ FLASH  | 1013      |
| 10120012  | EPM570Z    | 144 MBGA     | 150        | 102     | 1000         | 0      | 0.18μ FLASH  | 1050      |
| 11020001  | EPM570Z    | 256 FBGA     | 150        | 101     | 1000         | 0      | 0.18μ FLASH  | 1052      |
| 11010005  | EPM1270G   | 144 TQFP     | 150        | 140     | 1000         | 0      | 0.18μ FLASH  | 1052      |
| 10120004  | EPM1270    | 256 FBGA     | 150        | 45      | 1000         | 0      | 0.18μ FLASH  | 1037      |
| 11030028  | EPM1270G   | 256 FBGA     | 150        | 102     | 1000         | 0      | 0.18μ FLASH  | 1107      |
| 9020008   | EPM2210    | 256 FBGA     | 150        | 45      | 2000         | 0      | 0.18μ FLASH  | 0901      |
| 10080014  | EPM2210G   | 256 FBGA     | 150        | 25      | 1000         | 0      | 0.18μ FLASH  | 1032      |
| 10120007  | EPM2210G   | 256 FBGA     | 150        | 102     | 1000         | 0      | 0.18μ FLASH  | 1050      |
| 11020006  | EPM2210G   | 256 FBGA     | 150        | 25      | 2000         | 0      | 0.18μ FLASH  | 1106      |
| 11020007  | EPM2210G   | 256 FBGA     | 150        | 21      | 1501         | 0      | 0.18μ FLASH  | 1106      |
| 9040002   | EPM7032S   | 44 PLCC      | 150        | 45      | 2007         | 0      | 0.5μ EEPROM  | 0907      |
| 10040017  | EPM7064S   | 44 TQFP      | 150        | 45      | 2000         | 0      | 0.5μ EEPROM  | 1007      |
| 11040002  | EPM7064S   | 44 PLCC      | 150        | 45      | 1000         | 0      | 0.5μ EEPROM  | 1107      |
| 9010008   | EPM7256AE  | 144 TQFP     | 150        | 25      | 2000         | 0      | 0.3μ EEPROM  | 0851      |
| 10030018  | EPM7256AE  | 256 FBGA     | 150        | 25      | 2000         | 0      | 0.35μ EEPROM | 1001      |
| 9080001   | EPM7256B   | 256 FBGA     | 150        | 50      | 2000         | 0      | 0.22μ EEPROM | 0919      |
| 10100013  | EPM7512AE  | 208 PQFP     | 150        | 25      | 2000         | 0      | 0.35μ EEPROM | 1037      |
| 10080013  | EPM7512B   | 256 FBGA     | 150        | 25      | 1000         | 0      | 0.22μ EEPROM | 1025      |
| 8020005   | HC210      | 484 FBGA     | 150        | 50      | 1000         | 0      | 0.09μ SRAM   | 0801      |
| 8110011   | HC230      | 1020 FBGA    | 150        | 25      | 2024         | 0      | 0.09μ SRAM   | 0837      |
| 10020024  | HC335      | 1517 FBGA    | 150        | 28      | 2002         | 0      | 40 nm SRAM   | 0949      |

## Reflow Simulation and Moisture Preconditioning

Surface mount devices are subject to failure due to entrapped moisture that can rapidly expand during the reflow soldering process.<sup>vii viii</sup> Whereas dual in-line package devices are shielded from the rapid heat excursion of wave soldering by the printed circuit board, surface mount devices receive the full temperature shock of reflow soldering. Reflow soldering can be accomplished by Vapor Phase Soldering, Infrared Reflow Soldering, or Convection Reflow Soldering. Altera's reflow recommendations are contained in [Application Note 353](#). Reflow soldering typically has a preheat stage and then rapidly heats the device above the solder reflow temperature. Altera moisture soaks devices according to their J-STD-020D moisture classification and then passes them through simulated 100% convention reflow soldering 3 times. For the conventional tin-lead reflow, Altera uses a prebake cycle above 150°C for 2 minutes, a temperature ramp of 1°-3° C / second, time above 183°C of at least 1 minute, and a peak temperature of 220°C for large packages and 235°C for packages  $\leq 350\text{mm}^3$ . For lead free/ROHS Compliant reflow, Altera preheats the devices at temperature between 150°-200°C for 90 seconds, a temperature ramp of 2°-2.5°C / second, time above 217°C for 115 seconds, and a peak temperature between 245°-260° C suitable for the package size according to J-STD-020D standard. Devices are examined for package cracks and electrically tested after preconditioning and reflow soldering. The devices are then subjected to Temperature Cycle Condition B or Temperature Humidity Bias to assess reliability. The moisture preconditioning stress level is listed in the Temperature Cycling and Temperature/Humidity Bias tables for those devices that were subjected to moisture preconditioning. The moisture classification of Altera products is imprinted on the device's moisture barrier bag.

## Accelerated Moisture Resistance

Four different stresses are commonly used to assess moisture resistance of integrated circuits: Temperature Humidity Bias (THB) at 85°C/85%RH, Autoclave at 121°C/100%RH, Biased HAST at 130°C/85%RH and Unbiased HAST at 130°C/85%RH. All four stresses can detect metallization corrosion and moisture induced charge loss in nonvolatile devices. In addition, THB and biased HAST can detect galvanic corrosion since they are biased. Per JESD47F recommendation, BGA packages will no longer be subjected to Autoclave testing. Unbiased HAST will be used instead.

## Autoclave

The Autoclave stress subjects semiconductor devices to a 121°C saturated DI water steam environment. At 121°C in a sealed vessel this results in a 15 PSIG pressure, or two atmospheres. The chamber used by Altera uses temperature to control the stress environment. Using pressure to control the environment as in a pressure pot, results in drastic swings in temperature as steam is vented outside the chamber. The autoclave stress is designed to detect corrosion of the metallization of integrated circuits. This test can also detect charge loss in non-volatile memory elements due to increased leakage if moisture reaches the floating gate storage element.<sup>ix</sup>

## Unbiased HAST

In this stress devices are placed in a HAST chamber at 130°C/85%RH. The test does not subject the devices to a saturated moisture environment and there is no water condensed on the devices.

## Autoclave & Unbiased HAST Results

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST        | # UNITS | STRESS HOURS | # FAIL | Technology | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|-------------------------|---------|--------------|--------|------------|-----------|------------------|
| 10050024  | EP1C3     | 100 TQFP     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.13μ SRAM | 1020      | Yes              |
| 10040015  | EP1C6     | 144 TQFP     | PRECON 3- 121°C/100% RH | 77      | 96           | 0      | 0.13μ SRAM | 1007      | Yes              |
| 9060032   | EP1C6     | 240 PQFP     | PRECON 3- 121°C/100% RH | 25      | 168          | 0      | 0.13μ SRAM | 0918      | Yes              |
| 9100030   | EP1S25    | 672 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 0.13μ SRAM | 0942      | Yes              |
| 10070028  | EP1S80    | 1020 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.13μ SRAM | 1028      | Yes              |
| 10090021  | EP1S80    | 1020 FBGA    | PRECON 4- 130°C/85% RH  | 25      | 96           | 0      | 0.13μ SRAM | 1036      | Yes              |
| 10090022  | EP1S80    | 1508 FBGA    | PRECON 4- 130°C/85% RH  | 25      | 96           | 0      | 0.13μ SRAM | 1036      | Yes              |
| 9110032   | EP1SGX25  | 1020 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.13μ SRAM | 0943      | Yes              |
| 9060036   | EP20K30E  | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.18μ SRAM | 0926      | Yes              |
| 9050006   | EP20K100  | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 168          | 0      | 0.22μ SRAM | 0919      | Yes              |
| 10010021  | EP20K100E | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.22μ SRAM | 1001      | Yes              |
| 9030002   | EP20K160E | 240 PQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.18μ SRAM | 0907      | No               |
| 10120025  | EP20K200  | 356 BGA      | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.22μ SRAM | 1037      | No               |
| 10040002  | EP20K200E | 208 PQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.18μ SRAM | 1007      | Yes              |
| 11040003  | EP20K300E | 672FBGA      | PRECON 3- 130°C/85% RH  | 28      | 96           | 0      | 0.18μ SRAM | 1115      | Yes              |
| 10090008  | EP20K400C | 672 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.15μ SRAM | 1031      | Yes              |
| 11050015  | EP20K400C | 672 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.15μ SRAM | 1121      | Yes              |
| 9100004   | EP2AGX65  | 358 UBGA     | PRECON 3- 130°C/85% RH  | 29      | 96           | 0      | 40 nm SRAM | 0941      | Yes              |
| 10030006  | EP2AGX65  | 358 UBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 40 nm SRAM | 1003      | Yes              |

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST        | # UNITS | STRESS HOURS | # FAIL | Technology | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|-------------------------|---------|--------------|--------|------------|-----------|------------------|
| 10100015  | EP2AGX65  | 358 UBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 40 nm SRAM | 1039      | Yes              |
| 9100021   | EP2AGX65  | 780 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 40 nm SRAM | 0942      | Yes              |
| 10070038  | EP2AGX125 | 1152 FBGA    | PRECON 3- 130°C/85% RH  | 27      | 192          | 0      | 40 nm SRAM | 1027      | Yes              |
| 10050026  | EP2AGX260 | 1152 FBGA    | PRECON 3- 130°C/85% RH  | 30      | 192          | 0      | 40 nm SRAM | 1020      | Yes              |
| 9100006   | EP2C8     | 148 QFN      | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 0.09µ SRAM | 0940      | Yes              |
| 9100007   | EP2C8     | 148 QFN      | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 0940      | Yes              |
| 11060014  | EP2C8     | 256 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 1126      | Yes              |
| 10020010  | EP2C8     | 256 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.09µ SRAM | 1001      | Yes              |
| 11030026  | EP2C20    | 256 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.09µ SRAM | 1049      | Yes              |
| 9040021   | EP2C35    | 672 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.09µ SRAM | 0913      | Yes              |
| 9090021   | EP2C70    | 672 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.09µ SRAM | 0931      | No               |
| 9100029   | EP2C70    | 672 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 0.09µ SRAM | 0942      | Yes              |
| 10090028  | EP2C70    | 672 FBGA     | PRECON 3- 130°C/85% RH  | 76      | 96           | 0      | 0.09µ SRAM | 1025      | Yes              |
| 10060019  | EP2C70    | 896 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 1023      | Yes              |
| 11010016  | EP2C70    | 896 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.09µ SRAM | 1104      | Yes              |
| 10090025  | EP2S30    | 484 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 1039      | Yes              |
| 10100001  | EP2S30    | 672 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 0.09µ SRAM | 1039      | Yes              |
| 11060011  | EP2S90    | 1020 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 1125      | Yes              |
| 9010011   | EP2S130   | 1020 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 0.09µ SRAM | 0852      | Yes              |
| 9040029   | EP2S130   | 1508 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 0913      | Yes              |
| 10110015  | EP2S180   | 1020 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 1044      | Yes              |
| 10110006  | EP2S180   | 1508 FBGA    | PRECON 4- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 1037      | Yes              |
| 9090024   | EP2SGX90  | 1152 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.09µ SRAM | 0931      | No               |
| 10010012  | EP3C5     | 144 EQFP     | PRECON 3- 121°C/100% RH | 80      | 96           | 0      | 65 nm SRAM | 1001      | Yes              |
| 10040029  | EP3C5     | 144 EQFP     | PRECON 3- 130°C/85% RH  | 80      | 96           | 0      | 65 nm SRAM | 1016      | Yes              |
| 11020011  | EP3C10    | 144 EQFP     | PRECON 3- 130°C/85% RH  | 78      | 96           | 0      | 65 nm SRAM | 1107      | Yes              |
| 10050001  | EP3C16    | 144 EQFP     | PRECON 3- 121°C/100% RH | 80      | 96           | 0      | 60 nm SRAM | 1018      | Yes              |
| 11040006  | EP3C16    | 144EQFP      | PRECON 3- 130°C/85% RH  | 78      | 96           | 0      | 65 nm SRAM | 1116      | Yes              |
| 10050017  | EP3C25    | 144 EQFP     | PRECON 3- 130°C/85% RH  | 80      | 96           | 0      | 65 nm SRAM | 1019      | Yes              |
| 11020010  | EP3C25    | 144 EQFP     | PRECON 3- 130°C/85% RH  | 80      | 96           | 0      | 65 nm SRAM | 1107      | Yes              |
| 10040008  | EP3C25    | 240 PQFP     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 65 nm SRAM | 1014      | Yes              |
| 10050016  | EP3C25    | 256 FBGA     | PRECON 3- 130°C/85% RH  | 78      | 96           | 0      | 60 nm SRAM | 1019      | Yes              |
| 10060018  | EP3C25    | 256 FBGA     | PRECON 3- 130°C/85% RH  | 79      | 96           | 0      | 60 nm SRAM | 1019      | Yes              |
| 10040010  | EP3C40    | 240 PQFP     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 65 nm SRAM | 1014      | Yes              |
| 10060015  | EP3C40    | 484 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM | 1021      | Yes              |
| 10090012  | EP3C55    | 484 UBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 60 nm SRAM | 1031      | Yes              |
| 10120003  | EP3C55    | 484 UBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 60 nm SRAM | 1031      | Yes              |
| 10050021  | EP3C55    | 780 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 60 nm SRAM | 1013      | Yes              |
| 10110024  | EP3C55    | 780 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM | 1046      | Yes              |
| 11050010  | EP3C80    | 484 UBGA     | PRECON 3- 130°C/85% RH  | 78      | 96           | 0      | 65 nm SRAM | 1101      | Yes              |
| 11040001  | EP3C80    | 484 UBGA     | PRECON 3- 130°C/85% RH  | 80      | 96           | 0      | 65 nm SRAM | 1127      | Yes              |

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST        | # UNITS | STRESS HOURS | # FAIL | Technology  | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|-------------------------|---------|--------------|--------|-------------|-----------|------------------|
| 11060010  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 30      | 96           | 0      | 60 nm SRAM  | 1124      | Yes              |
| 11040010  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 60 nm SRAM  | 1117      | Yes              |
| 11040003  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 60 nm SRAM  | 1117      | Yes              |
| 10110026  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM  | 1048      | Yes              |
| 10120016  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 40      | 96           | 0      | 60 nm SRAM  | 1052      | Yes              |
| 10120017  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 40      | 96           | 0      | 60 nm SRAM  | 1052      | Yes              |
| 10120018  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 40      | 96           | 0      | 60 nm SRAM  | 1052      | Yes              |
| 10120019  | EP3C120   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 40      | 96           | 0      | 60 nm SRAM  | 1052      | Yes              |
| 9070009   | EP3CLS200 | 780 FBGA     | PRECON 3- 130°C/85% RH  | 28      | 192          | 0      | 60 nm SRAM  | 0916      | Yes              |
| 9070010   | EP3CLS200 | 780 FBGA     | PRECON 3- 130°C/85% RH  | 32      | 192          | 0      | 60 nm SRAM  | 0925      | Yes              |
| 10040013  | EP4CE40   | 484 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM  | 1014      | Yes              |
| 10040014  | EP4CE40   | 484 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM  | 1014      | Yes              |
| 11030015  | EP3SE50   | 780 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 65 nm SRAM  | 1043      | Yes              |
| 9040010   | EP3SL110  | 1152 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 65 nm SRAM  | 0912      | Yes              |
| 10100010  | EP3SL150  | 1152 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 65 nm SRAM  | 1041      | Yes              |
| 10070021  | EP3SL150  | 780 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 65 nm SRAM  | 1027      | Yes              |
| 10080012  | EP3SL200  | 1152 FBGA    | PRECON 4- 130°C/85% RH  | 25      | 96           | 0      | 65 nm SRAM  | 1019      | Yes              |
| 10040022  | EP4CGX15  | 148 QFN      | PRECON 3- 130°C/85% RH  | 23      | 192          | 0      | 60 nm SRAM  | 1015      | Yes              |
| 10080028  | EP4CGX15  | 148 QFN      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 60 nm SRAM  | 1025      | Yes              |
| 10060001  | EP4CGX15  | 169 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM  | 1022      | Yes              |
| 10060002  | EP4CGX15  | 169 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 60 nm SRAM  | 1022      | Yes              |
| 11050008  | EP4CGX15  | 148QFN       | PRECON 3- 130°C/85% RH  | 80      | 96           | 0      | 60 nm SRAM  | 1119      | Yes              |
| 10020008  | EP4SGX230 | 1517 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 40 nm SRAM  | 1005      | Yes              |
| 10090005  | EP4SGX230 | 1517 FBGA    | PRECON 3- 130°C/85% RH  | 25      | 192          | 0      | 40 nm SRAM  | 1005      | Yes              |
| 11030012  | EP4SGX230 | 1517 FBGA    | PRECON 3- 130°C/85% RH  | 24      | 192          | 0      | 40 nm SRAM  | 1108      | Yes              |
| 9050020   | EP4SGX530 | 1517 HBGA    | PRECON 3- 130°C/85% RH  | 29      | 192          | 0      | 40 nm SRAM  | 0921      | Yes              |
| 9060020   | EP4SGX530 | 1517 HBGA    | PRECON 3- 130°C/85% RH  | 87      | 192          | 0      | 40 nm SRAM  | 0924      | Yes              |
| 11010001  | EP4SGX530 | 1517 HBGA    | PRECON 4- 130°C/85% RH  | 25      | 192          | 0      | 40 nm SRAM  | 1101      | Yes              |
| 10090001  | EP4SGX530 | 1932 FBGA    | PRECON 3- 130°C/85% RH  | 38      | 192          | 0      | 40 nm SRAM  | 1030      | Yes              |
| 11060002  | EP5SGXA7  | 1517FBGA     | PRECON 4- 130°C/85% RH  | 38      | 192          | 0      | 28 nm SRAM  | 1122      | Yes              |
| 9070011   | EPC1      | 8 PDIP       | PRECON 1- 121°C/100% RH | 45      | 96           | 0      | 0.5μ EPROM  | 0929      | Yes              |
| 9040001   | EPC1      | 20 PLCC      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.5μ EPROM  | 0907      | Yes              |
| 10020046  | EPC1441   | 20 PLCC      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.5μ EPROM  | 1001      | Yes              |
| 11010014  | EPC1441   | 20 PLCC      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.5μ EPROM  | 1049      | Yes              |
| 10050020  | EPC2      | 20 PLCC      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.4μ FLASH  | 1013      | Yes              |
| 10110001  | EPC2      | 20 PLCC      | PRECON 3- 130°C/85% RH  | 45      | 96           | 0      | 0.4μ FLASH  | 1037      | Yes              |
| 10070002  | EPC4      | 100 PQFP     | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.35μ FLASH | 1013      | Yes              |
| 10010008  | EPC16     | 88 UBGA      | PRECON 3- 130°C/85% RH  | 45      | 96           | 0      | 0.35μ FLASH | 0949      | Yes              |
| 9050032   | EPF10K20  | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 168          | 0      | 0.42μ SRAM  | 0922      | Yes              |
| 10080023  | EPF10K30A | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.3μ SRAM   | 1019      | Yes              |
| 10030001  | EPF10K50  | 240 RQFP     | PRECON 3- 121°C/100% RH | 25      | 168          | 0      | 0.42μ SRAM  | 1008      | Yes              |

| REL LOT # | DEVICE     | PACKAGE TYPE | RELIABILITY TEST        | # UNITS | STRESS HOURS | # FAIL | Technology  | Date Code | ROHS Compliant ? |
|-----------|------------|--------------|-------------------------|---------|--------------|--------|-------------|-----------|------------------|
| 9120008   | EPF10K50E  | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.22µ SRAM  | 0943      | Yes              |
| 10040004  | EPF10K70   | 240 RQFP     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.42µ SRAM  | 1013      | Yes              |
| 10110029  | EPF10K70   | 240 RQFP     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.42µ SRAM  | 1048      | Yes              |
| 11040014  | EPF10K70   | 240 RQFP     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.42µ SRAM  | 1107      | Yes              |
| 9040003   | EPF10K100E | 208 PQFP     | PRECON 3- 121°C/100% RH | 24      | 96           | 0      | 0.22µ SRAM  | 0913      | Yes              |
| 9050001   | EPF10K100E | 208 PQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.22µ SRAM  | 0916      | Yes              |
| 9060024   | EPF10K130E | 240 PQFP     | PRECON 3- 121°C/100% RH | 25      | 168          | 0      | 0.22µ SRAM  | 0925      | Yes              |
| 11030014  | EPF6016A   | 208PQFP      | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.3µ SRAM   | 1101      | Yes              |
| 9070001   | EPF8282A   | 84 PLCC      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.42µ SRAM  | 0919      | Yes              |
| 10040030  | EPM240Z    | 100 MBGA     | PRECON 3- 130°C/85% RH  | 45      | 96           | 0      | 0.18µ FLASH | 1017      | Yes              |
| 10120013  | EPM240Z    | 100 MBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1050      | Yes              |
| 11030013  | EPM240Z    | 100 MBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1101      | Yes              |
| 10020013  | EPM570     | 100 TQFP     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1001      | Yes              |
| 10120012  | EPM570Z    | 144FBGA      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1050      | Yes              |
| 11010018  | EPM570Z    | 144TQFP      | PRECON 3- 130°C/85% RH  | 75      | 288          | 0      | 0.18µ FLASH | 1104      | Yes              |
| 11020001  | EPM570Z    | 256FBGA      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1052      | Yes              |
| 11010005  | EPM1270G   | 144TQFP      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1052      | Yes              |
| 11030028  | EPM1270G   | 256FBGA      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1107      | Yes              |
| 11050006  | EPM1270G   | 144TQFP      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1118      | Yes              |
| 11050011  | EPM1270G   | 256FBGA      | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1118      | Yes              |
| 10080014  | EPM2210G   | 256 FBGA     | PRECON 3- 130°C/85% RH  | 25      | 96           | 0      | 0.18µ FLASH | 1032      | Yes              |
| 10120007  | EPM2210G   | 256 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1050      | Yes              |
| 11010013  | EPM2210G   | 256 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1050      | Yes              |
| 11020006  | EPM2210G   | 256 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 288          | 0      | 0.18µ FLASH | 1106      | Yes              |
| 11020007  | EPM2210G   | 256 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 288          | 0      | 0.18µ FLASH | 1106      | Yes              |
| 11010004  | EPM2210G   | 324 FBGA     | PRECON 3- 130°C/85% RH  | 77      | 96           | 0      | 0.18µ FLASH | 1052      | Yes              |
| 10040017  | EPM7064S   | 44 TQFP      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.5µ EEPROM | 1007      | Yes              |
| 11040002  | EPM7064S   | 44 PLCC      | PRECON 3- 121°C/100% RH | 45      | 96           | 0      | 0.5µ EEPROM | 1101      | Yes              |
| 9020009   | EPM7128S   | 100 PQFP     | PRECON 3- 121°C/100% RH | 45      | 168          | 0      | 0.5µ EEPROM | 0848      | Yes              |
| 9010008   | EPM7256AE  | 144 TQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.3µ EEPROM | 0851      | No               |
| 9030015   | EPM7512AE  | 208 PQFP     | PRECON 3- 121°C/100% RH | 25      | 168          | 0      | 0.3µ EEPROM | 0918      | Yes              |
| 10100013  | EPM7512AE  | 208 PQFP     | PRECON 3- 121°C/100% RH | 25      | 96           | 0      | 0.3µ EEPROM | 1037      | Yes              |

## Temperature Humidity Bias

THB testing is commonly performed at 85°C/85%RH in order to keep condensation from forming on the devices under test. Voltage is applied to the devices under stress, but power consumption is kept low or cycled on and off to keep internal power dissipation from driving off moisture. Typical stress times are 1000 to 2000 hours, with 1000 hours used for qualification. An all stainless steel chamber and deionized (DI) water are used to ensure that contamination does not affect the results.

The chamber is loaded, then brought up to temperature, and finally humidity is applied to ensure no condensation occurs. When the chamber reaches temperature/humidity equilibrium, voltage is applied to the device under stress. The chamber is powered down in the following order to again ensure condensation does not occur: voltage to the device, humidity, and finally temperature. Devices are tested to datasheet parameters after 500, 1000, 1500, and 2000 hours of stress. Surface mount devices are subjected to moisture preconditioning and simulated 3 times through Convention Reflow Soldering before starting the THB stress. The JEDEC level of moisture preconditioning is listed in the table below.

## Temperature Humidity Bias Results

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST  | # UNITS | STRESS HOURS | # FAIL | Technology | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|-------------------|---------|--------------|--------|------------|-----------|------------------|
| 9030006   | EP1S10    | 672 FBGA     | PRECON 3-85/85THB | 24      | 1000         | 0      | 0.13μ SRAM | 0907      | Yes              |
| 9030017   | EP1S25    | 672 FBGA     | PRECON 3-85/85THB | 19      | 1000         | 0      | 0.13μ SRAM | 0912      | Yes              |
| 11030011  | EP1S40    | 1508 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.13μ SRAM | 1101      | Yes              |
| 9090008   | EP1S80    | 1020 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.13μ SRAM | 0936      | Yes              |
| 10070028  | EP1S80    | 1020 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.13μ SRAM | 1028      | Yes              |
| 10090021  | EP1S80    | 1020 FBGA    | PRECON 4-85/85THB | 25      | 1000         | 0      | 0.13μ SRAM | 1036      | Yes              |
| 8090026   | EP1S80    | 1508 FBGA    | PRECON 4-85/85THB | 25      | 1000         | 0      | 0.13μ SRAM | 0838      | Yes              |
| 9020002   | EP20K400C | 672 FBGA     | PRECON 3-85/85THB | 24      | 1000         | 0      | 0.15μ SRAM | 0901      | Yes              |
| 10090008  | EP20K400C | 672 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.15μ SRAM | 1031      | Yes              |
| 10120025  | EP20K200  | 356SBGA      | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.22μ SRAM | 1037      | Yes              |
| 10040006  | EP2AGX65  | 358 UBGA     | PRECON 3-85/85THB | 35      | 1000         | 0      | 40 nm SRAM | 1011      | Yes              |
| 10040007  | EP2AGX65  | 358 UBGA     | PRECON 3-85/85THB | 35      | 1000         | 0      | 40 nm SRAM | 1011      | Yes              |
| 10070038  | EP2AGX125 | 1152 FBGA    | PRECON 3-85/85THB | 27      | 2000         | 0      | 40 nm SRAM | 1027      | Yes              |
| 10050026  | EP2AGX260 | 1152 FBGA    | PRECON 3-85/85THB | 32      | 1000         | 0      | 40 nm SRAM | 1020      | Yes              |
| 10120006  | EP2AGX260 | 1152 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 40 nm SRAM | 1049      | Yes              |
| 10020010  | EP2C8     | 256 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.09μ SRAM | 1001      | Yes              |
| 11020013  | EP2C70    | 672 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.09μ SRAM | 1108      | Yes              |
| 10040020  | EP2S90    | 1020 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.09μ SRAM | 1013      | Yes              |
| 11030025  | EP2S130   | 1508 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.09μ SRAM | 1101      | Yes              |
| 10110006  | EP2S180   | 1508 FBGA    | PRECON 4-85/85THB | 25      | 1000         | 0      | 0.09μ SRAM | 1037      | Yes              |
| 10110015  | EP2S180   | 1020 FBGA    | PRECON 4-85/85THB | 23      | 1000         | 0      | 0.09μ SRAM | 1044      | Yes              |
| 10040029  | EP3C5     | 144 EQFP     | PRECON 3-85/85THB | 80      | 1000         | 0      | 65 nm SRAM | 1016      | Yes              |
| 11020011  | EP3C10    | 144 EQFP     | PRECON 3-85/85THB | 79      | 1000         | 0      | 65 nm SRAM | 1107      | Yes              |
| 10050001  | EP3C16    | 144 EQFP     | PRECON 3-85/85THB | 79      | 1000         | 0      | 60 nm SRAM | 1018      | Yes              |
| 10040009  | EP3C16    | 240 PQFP     | PRECON 3-85/85THB | 24      | 1000         | 0      | 65 nm SRAM | 1014      | Yes              |
| 11040006  | EP3C16    | 144EQFP      | PRECON 3-85/85THB | 78      | 1000         | 0      | 65 nm SRAM | 1116      | Yes              |

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST  | # UNITS | STRESS HOURS | # FAIL | Technology  | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|-------------------|---------|--------------|--------|-------------|-----------|------------------|
| 10040008  | EP3C25    | 240 PQFP     | PRECON 3-85/85THB | 30      | 1000         | 0      | 65 nm SRAM  | 1014      | Yes              |
| 11020010  | EP3C25    | 144EQFP      | PRECON 3-85/85THB | 79      | 1000         | 0      | 65 nm SRAM  | 1107      | Yes              |
| 10110024  | EP3C55    | 780 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 60 nm SRAM  | 1046      | Yes              |
| 11040001  | EP3C80    | 780 FBGA     | PRECON 3-85/85THB | 28      | 1000         | 0      | 60 nm SRAM  | 1127      | Yes              |
| 10070005  | EP3C120   | 780 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 60 nm SRAM  | 0951      | Yes              |
| 10090029  | EP3C120   | 780 FBGA     | PRECON 3-85/85THB | 25      | 2000         | 0      | 60 nm SRAM  | 1039      | Yes              |
| 11020005  | EP3C120   | 780 FBGA     | PRECON 3-85/85THB | 24      | 2000         | 0      | 60 nm SRAM  | 1018      | Yes              |
| 9090010   | EP3CLS200 | 780 FBGA     | PRECON 3-85/85THB | 44      | 1000         | 0      | 60 nm SRAM  | 0936      | Yes              |
| 9080011   | EP3SE50   | 780 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 65 nm SRAM  | 0925      | Yes              |
| 11030015  | EP3SE50   | 780 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 65 nm SRAM  | 1043      | Yes              |
| 9040010   | EP3SL110  | 1152 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 65 nm SRAM  | 0912      | Yes              |
| 10070023  | EP3SL150  | 1152 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 65 nm SRAM  | 1027      | Yes              |
| 10100010  | EP3SL150  | 1152 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 65 nm SRAM  | 1041      | Yes              |
| 10080012  | EP3SL200  | 1152 FBGA    | PRECON 4-85/85THB | 25      | 1000         | 0      | 65 nm SRAM  | 1019      | Yes              |
| 10020043  | EP4CGX15  | 148 QFN      | PRECON 3-85/85THB | 49      | 2000         | 0      | 60 nm SRAM  | 1007      | Yes              |
| 11030010  | EP4CGX15  | 148 QFN      | PRECON 3-85/85THB | 77      | 1000         | 0      | 60 nm SRAM  | 1101      | Yes              |
| 10090024  | EP4CGX150 | 896 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 60 nm SRAM  | 1038      | Yes              |
| 10090004  | EP4SE530  | 1760 FBGA    | PRECON 4-85/85THB | 25      | 1000         | 0      | 40 nm SRAM  | 1030      | Yes              |
| 9090032   | EP4SGX230 | 1517 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 40 nm SRAM  | 0938      | Yes              |
| 10020008  | EP4SGX230 | 1517 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 40 nm SRAM  | 1005      | Yes              |
| 10090005  | EP4SGX230 | 1517 FBGA    | PRECON 3-85/85THB | 25      | 1000         | 0      | 40 nm SRAM  | 1005      | Yes              |
| 11030012  | EP4SGX230 | 1517 FBGA    | PRECON 3-85/85THB | 21      | 1000         | 0      | 40 nm SRAM  | 1108      | Yes              |
| 10120006  | EP4SGX260 | 1152 FBGA    | PRECON 3-85/85THB | 24      | 1000         | 0      | 40 nm SRAM  | 1049      | Yes              |
| 11060002  | EP5SGXA7  | 1517FBGA     | PRECON 3-85/85THB | 24      | 1000         | 0      | 28 nm SRAM  | 1122      | Yes              |
| 9070011   | EPC1      | 8 PDIP       | PRECON 1-85/85THB | 45      | 1000         | 0      | 0.5μ EPROM  | 0929      | Yes              |
| 10010008  | EPC16     | 88 UBGA      | PRECON 3-85/85THB | 45      | 1000         | 0      | 0.35μ FLASH | 0949      | Yes              |
| 9090007   | EPM570    | 256 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.18μ FLASH | 0931      | Yes              |
| 9020008   | EPM2210   | 256 FBGA     | PRECON 3-85/85THB | 25      | 1000         | 0      | 0.18μ FLASH | 0901      | No               |
| 11040002  | EPM7064S  | 44 PLCC      | PRECON 3-85/85THB | 45      | 1000         | 0      | 0.5μ EEPROM | 1101      | Yes              |

## Highly Accelerated Stress Testing

HAST is an acronym for Highly Accelerated Stress Testing, which is a method for accelerating THB testing. HAST testing takes place in a closed stainless steel chamber that allows Temperature Humidity Bias to be performed under pressure. The ambient conditions are set up to ensure that the devices are stressed in an atmosphere that is not saturated so moisture cannot condense on the device leads. Altera runs its HAST conditions at 130°C / 85% RH, which has been shown to provide at least 10X acceleration in time over 85°C/85% RH testing.<sup>x</sup> Devices are biased similar to THB with alternate pin bias. Altera uses Polyimide printed circuit boards with buried PCB traces to keep them from corroding in the severe environment of HAST.

## HAST Results

| REL LOT # | DEVICE     | PACKAGE TYPE | RELIABILITY TEST  | # UNITS | STRESS HOURS | # FAIL | Technology  | Date Code | ROHS Compliant ? |
|-----------|------------|--------------|-------------------|---------|--------------|--------|-------------|-----------|------------------|
| 11060013  | EP1C3      | 144 TQFP     | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.13μ SRAM  | 1123      | Yes              |
| 10040015  | EP1C6      | 144 TQFP     | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.13μ SRAM  | 1007      | Yes              |
| 9050026   | EP1C6      | 240 PQFP     | PRECON 3-H.A.S.T. | 26      | 96           | 0      | 0.13μ SRAM  | 0918      | Yes              |
| 10100017  | EP1C12     | 324 FBGA     | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.13μ SRAM  | 1037      | Yes              |
| 9080009   | EP1C20     | 400 FBGA     | PRECON 3-H.A.S.T. | 76      | 96           | 0      | 0.13μ SRAM  | 0931      | Yes              |
| 11060014  | EP2C8      | 256FBGA      | PRECON 3-H.A.S.T. | 24      | 192          | 0      | 0.13μ SRAM  | 1126      | Yes              |
| 10050025  | EP1K50     | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.22μ SRAM  | 1013      | Yes              |
| 9100008   | EP20K100   | 356 BGA      | PRECON 3-H.A.S.T. | 24      | 96           | 0      | 0.22μ SRAM  | 0931      | Yes              |
| 10010021  | EP20K100E  | 144 TQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ SRAM  | 1001      | Yes              |
| 10020009  | EP20K160E  | 144 TQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ SRAM  | 1005      | Yes              |
| 10040002  | EP20K200E  | 208 PQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ SRAM  | 1007      | Yes              |
| 9060022   | EP20K200E  | 240 PQFP     | PRECON 3-H.A.S.T. | 25      | 192          | 0      | 0.18μ SRAM  | 0925      | Yes              |
| 11040003  | EP20K300E  | 672 FBGA     | PRECON 3-H.A.S.T. | 26      | 96           | 0      | 0.18μ SRAM  | 1115      | Yes              |
| 9080012   | EP20K600E  | 652 BGA      | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ SRAM  | 0935      | No               |
| 9040001   | EPC1       | 20 PLCC      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.5μ EPROM  | 0907      | Yes              |
| 11010014  | EPC1441    | 20 PLCC      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.5μ EPROM  | 1049      | Yes              |
| 10050020  | EPC2       | 20 PLCC      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.4μ FLASH  | 1013      | Yes              |
| 10110001  | EPC2       | 20 PLCC      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.4μ FLASH  | 1037      | Yes              |
| 10070002  | EPC4       | 100 PQFP     | PRECON 3-H.A.S.T. | 43      | 96           | 0      | 0.35μ FLASH | 1013      | Yes              |
| 10070002  | EPC4       | 100 PQFP     | PRECON 3-H.A.S.T. | 43      | 96           | 0      | 0.35μ FLASH | 1013      | Yes              |
| 9050032   | EPF10K20   | 144 TQFP     | PRECON 3-H.A.S.T. | 25      | 192          | 0      | 0.42μ SRAM  | 0922      | Yes              |
| 10080023  | EPF10K30A  | 144 TQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.3μ SRAM   | 1019      | Yes              |
| 10030001  | EPF10K50   | 240 RQFP     | PRECON 3-H.A.S.T. | 24      | 96           | 0      | 0.42μ SRAM  | 1008      | Yes              |
| 10040004  | EPF10K70   | 240 RQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.42μ SRAM  | 1013      | Yes              |
| 10110029  | EPF10K70   | 240 RQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.42μ SRAM  | 1048      | Yes              |
| 11040014  | EPF10K70   | 240 RQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.42μ SRAM  | 1107      | Yes              |
| 9080013   | EPF10K100A | 356 BGA      | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.3μ SRAM   | 0935      | Yes              |
| 10020025  | EPF10K100E | 356 BGA      | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.22μ SRAM  | 1001      | Yes              |
| 9060024   | EPF10K130E | 240 PQFP     | PRECON 3-H.A.S.T. | 25      | 192          | 0      | 0.22μ SRAM  | 0925      | Yes              |
| 11030014  | EPF6016    | 208PQFP      | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.3μ SRAM   | 0932      | Yes              |
| 9070001   | EPF8282A   | 84 PLCC      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.42μ SRAM  | 1101      | Yes              |

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST  | # UNITS | STRESS HOURS | # FAIL | Technology   | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|-------------------|---------|--------------|--------|--------------|-----------|------------------|
| 10070003  | EPM570    | 100 TQFP     | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.18μ FLASH  | 1013      | Yes              |
| 11020001  | EPM570Z   | 256FBGA      | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.18μ FLASH  | 1052      | Yes              |
| 10120012  | EPM570Z   | 144FBGA      | PRECON 3-H.A.S.T. | 76      | 96           | 0      | 0.18μ FLASH  | 1050      | Yes              |
| 11030018  | EPM570    | 100 TQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ FLASH  | 1112      | Yes              |
| 11030028  | EPM1270G  | 256FBGA      | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.18μ FLASH  | 1107      | Yes              |
| 11050006  | EPM1270G  | 144TQFP      | PRECON 3-H.A.S.T. | 75      | 96           | 0      | 0.18μ FLASH  | 1118      | Yes              |
| 11050011  | EPM1270G  | 256FBGA      | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.18μ FLASH  | 1118      | Yes              |
| 11060012  | EPM1270G  | 144TQFP      | PRECON 3-H.A.S.T. | 77      | 96           | 0      | 0.18μ FLASH  | 1123      | Yes              |
| 10120011  | EPM2210   | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ FLASH  | 1031      | Yes              |
| 10080014  | EPM2210G  | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.18μ FLASH  | 1032      | Yes              |
| 10120007  | EPM2210G  | 256 FBGA     | PRECON 3-H.A.S.T. | 78      | 96           | 0      | 0.18μ FLASH  | 1050      | Yes              |
| 10040027  | EPM3064A  | 100 TQFP     | PRECON 3-H.A.S.T. | 80      | 96           | 0      | 0.35μ EEPROM | 1007      | Yes              |
| 10110005  | EPM3512A  | 208 PQFP     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.3μ EEPROM  | 1037      | Yes              |
| 10010030  | EPM7032AE | 44 TQFP      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.35μ EEPROM | 1001      | Yes              |
| 9010009   | EPM7064AE | 100 TQFP     | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.3μ EEPROM  | 0851      | No               |
| 9100028   | EPM7064S  | 44 TQFP      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.5μ EEPROM  | 0937      | Yes              |
| 10040017  | EPM7064S  | 44 TQFP      | PRECON 3-H.A.S.T. | 45      | 96           | 0      | 0.5μ EEPROM  | 1007      | Yes              |
| 9030016   | EPM7128AE | 100 TQFP     | PRECON 3-H.A.S.T. | 25      | 192          | 0      | 0.3μ EEPROM  | 0920      | Yes              |
| 9050022   | EPM7128AE | 100 TQFP     | PRECON 3-H.A.S.T. | 25      | 192          | 0      | 0.3μ EEPROM  | 0920      | Yes              |
| 9080001   | EPM7256B  | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.22μ EEPROM | 0919      | No               |
| 10080013  | EPM7256B  | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.22μ EEPROM | 1025      | Yes              |
| 9030015   | EPM7512AE | 208 PQFP     | PRECON 3-H.A.S.T. | 25      | 192          | 0      | 0.3μ EEPROM  | 0918      | Yes              |
| 10030018  | EPM7512AE | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.35μ EEPROM | 1001      | Yes              |
| 10080013  | EPM7512B  | 256 FBGA     | PRECON 3-H.A.S.T. | 25      | 96           | 0      | 0.22μ EEPROM | 1025      | Yes              |

## Temperature Cycling

Temperature cycling accelerates the effects of changes in temperature on integrated circuits. Changes in temperature cause the different materials used in an integrated circuit to expand and contract at different rates since they have different coefficients of expansion. For example, coefficients of expansion vary from  $17 \times 10^{-6}$  mm/mm/°C for many molding compounds & AlCu leadframes to 4.2 for Silicon & Alloy 42 leadframes. The temperature extremes in temperature cycling give rise to mechanical stresses from the difference in thermal coefficients of expansion.<sup>xi</sup> The stress is greatest for large die and large packages. Altera uses dual chamber temperature cycling machines. The top chamber is maintained at the high temperature and the bottom chamber is maintained at the low temperature. The devices under stress are placed in an elevator platform that transfers the devices between the two chambers. The devices are transferred between chambers in a few seconds and reach the chamber temperature within 5 minutes, and are maintained at that temperature for a minimum of 5 minutes. Altera uses the MIL Std. 883 condition B (-55°C to +125°C) for temperature cycling. Devices are tested after 500, 700 and 1000 cycles. 700 cycles is all we need for qualification per new JESD47F standard. 1000 cycles reading is for reference only. Devices, which have been moisture preconditioned, are listed by the JEDEC moisture level.

## Temperature Cycling Results

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST    | # UNITS | # OF CYCLES | # FAIL | Technology | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|---------------------|---------|-------------|--------|------------|-----------|------------------|
| 10050024  | EP1C3     | 100 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 1020      | Yes              |
| 9050010   | EP1C6     | 144 TQFP     | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.13μ SRAM | 0918      | Yes              |
| 9060034   | EP1C6     | 144 TQFP     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.13μ SRAM | 0925      | Yes              |
| 10040015  | EP1C6     | 144 TQFP     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.13μ SRAM | 1007      | Yes              |
| 9050012   | EP1C6     | 240 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 0918      | Yes              |
| 9050026   | EP1C6     | 240 PQFP     | PRECON 3-TEMP CYC B | 27      | 1000        | 0      | 0.13μ SRAM | 0918      | Yes              |
| 10100017  | EP1C12    | 324 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.13μ SRAM | 1037      | Yes              |
| 9020006   | EP1C20    | 324 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.13μ SRAM | 0901      | No               |
| 9080009   | EP1C20    | 400 FBGA     | PRECON 3-TEMP CYC B | 76      | 1000        | 0      | 0.13μ SRAM | 0931      | Yes              |
| 10050025  | EP1K50    | 256 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ SRAM | 1013      | Yes              |
| 9030006   | EP1S10    | 672 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 0907      | Yes              |
| 9100030   | EP1S25    | 672 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 0942      | Yes              |
| 11030011  | EP1S40    | 1508 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 1101      | Yes              |
| 10070028  | EP1S80    | 1020 FBGA    | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.13μ SRAM | 1028      | Yes              |
| 10090021  | EP1S80    | 1020 FBGA    | PRECON 4-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 1036      | Yes              |
| 11040009  | EP1S80    | 1508 FBGA    | PRECON 4-TEMP CYC B | 26      | 1000        | 0      | 0.13μ SRAM | 1112      | Yes              |
| 9110032   | EP1SGX25  | 1020 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM | 0943      | Yes              |
| 9060036   | EP20K30E  | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0926      | Yes              |
| 10120025  | EP20K200  | 356 BGA      | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ SRAM | 1037      | Yes              |
| 10010021  | EP20K100E | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 1001      | Yes              |
| 10020009  | EP20K160E | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 1005      | Yes              |
| 9030002   | EP20K160E | 240 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0907      | No               |
| 10040002  | EP20K200E | 208 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 1007      | Yes              |
| 9060022   | EP20K200E | 240 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0925      | Yes              |
| 11040003  | EP20K300E | 672 FBGA     | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.18μ SRAM | 1115      | Yes              |

| REL LOT # | DEVICE     | PACKAGE TYPE | RELIABILITY TEST    | # UNITS | # OF CYCLES | # FAIL | Technology | Date Code | ROHS Compliant ? |
|-----------|------------|--------------|---------------------|---------|-------------|--------|------------|-----------|------------------|
| 10090008  | EP20K400C  | 672 FBGA     | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.15μ SRAM | 1031      | Yes              |
| 11050015  | EP20K400C  | 672 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.15μ SRAM | 1121      | Yes              |
| 9060011   | EP20K400E  | 672 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0919      | No               |
| 9080012   | EP20K600E  | 652 BGA      | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0935      | No               |
| 9010012   | EP20K1000E | 672 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0849      | Yes              |
| 9010013   | EP20K1000E | 672 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ SRAM | 0849      | Yes              |
| 9100004   | EP2AGX65   | 358 UBGA     | PRECON 3-TEMP CYC B | 29      | 700         | 0      | 40 nm SRAM | 0941      | Yes              |
| 10010029  | EP2AGX65   | 358 UBGA     | PRECON 3-TEMP CYC B | 25      | 1300        | 0      | 40 nm SRAM | 0950      | Yes              |
| 10100015  | EP2AGX65   | 358 UBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM | 1039      | Yes              |
| 10100012  | EP2AGX95   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM | 1040      | Yes              |
| 10070038  | EP2AGX125  | 1152 FBGA    | PRECON 3-TEMP CYC B | 27      | 1000        | 0      | 40 nm SRAM | 1027      | Yes              |
| 10050026  | EP2AGX260  | 1152 FBGA    | PRECON 3-TEMP CYC B | 30      | 1000        | 0      | 40 nm SRAM | 1020      | Yes              |
| 9100006   | EP2C8      | 148 QFN      | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 0940      | Yes              |
| 10020010  | EP2C8      | 256 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.09μ SRAM | 1001      | Yes              |
| 11030026  | EP2C20     | 256 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.09μ SRAM | 1049      | Yes              |
| 10090028  | EP2C70     | 672 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.09μ SRAM | 1025      | Yes              |
| 11010016  | EP2C70     | 896 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.09μ SRAM | 1104      | Yes              |
| 10090025  | EP2S30     | 484 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 1039      | Yes              |
| 9100003   | EP2S90     | 1020 FBGA    | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.09μ SRAM | 0937      | Yes              |
| 10040020  | EP2S90     | 1020 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 1013      | Yes              |
| 11060011  | EP2S90     | 1020 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 1125      | Yes              |
| 9040029   | EP2S130    | 1508 FBGA    | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.09μ SRAM | 0913      | Yes              |
| 10110015  | EP2S180    | 1020 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 1044      | Yes              |
| 10110006  | EP2S180    | 1508 FBGA    | PRECON 4-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 1037      | Yes              |
| 9090024   | EP2SGX90   | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM | 0931      | No               |
| 10010012  | EP3C5      | 144 EQFP     | PRECON 3-TEMP CYC B | 79      | 1000        | 0      | 65 nm SRAM | 1001      | Yes              |
| 10040029  | EP3C5      | 144 EQFP     | PRECON 3-TEMP CYC B | 80      | 1000        | 0      | 65 nm SRAM | 1016      | Yes              |
| 10010010  | EP3C10     | 144 EQFP     | PRECON 3-TEMP CYC B | 73      | 1000        | 0      | 65 nm SRAM | 1001      | Yes              |
| 10050001  | EP3C16     | 144 EQFP     | PRECON 3-TEMP CYC B | 80      | 1000        | 0      | 60 nm SRAM | 1018      | Yes              |
| 10040009  | EP3C16     | 240 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 1014      | Yes              |
| 11020010  | EP3C25     | 144 EQFP     | PRECON 3-TEMP CYC B | 80      | 1000        | 0      | 65 nm SRAM | 1107      | Yes              |
| 10040008  | EP3C25     | 240 PQFP     | PRECON 3-TEMP CYC B | 25      | 2000        | 0      | 65 nm SRAM | 1014      | Yes              |
| 10050016  | EP3C25     | 256 FBGA     | PRECON 3-TEMP CYC B | 78      | 1000        | 0      | 60 nm SRAM | 1019      | Yes              |
| 10060018  | EP3C25     | 256 FBGA     | PRECON 3-TEMP CYC B | 79      | 1000        | 0      | 60 nm SRAM | 1019      | Yes              |
| 10040010  | EP3C40     | 240 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 1014      | Yes              |
| 10060015  | EP3C40     | 484 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1021      | Yes              |
| 10120003  | EP3C55     | 484 UBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1031      | Yes              |
| 10050021  | EP3C55     | 780 FBGA     | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 60 nm SRAM | 1013      | Yes              |
| 10110024  | EP3C55     | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1046      | Yes              |
| 10010022  | EP3C80     | 484 UBGA     | PRECON 3-TEMP CYC B | 24      | 700         | 0      | 65 nm SRAM | 1003      | Yes              |
| 11040001  | EP3C80     | 484 UBGA     | PRECON 3-TEMP CYC B | 80      | 1000        | 0      | 60 nm SRAM | 1127      | Yes              |
| 11050010  | EP3C80     | 484 UBGA     | PRECON 3-TEMP CYC B | 78      | 1000        | 0      | 60 nm SRAM | 1101      | Yes              |

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST    | # UNITS | # OF CYCLES | # FAIL | Technology | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|---------------------|---------|-------------|--------|------------|-----------|------------------|
| 10110026  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1048      | Yes              |
| 10120016  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1052      | Yes              |
| 10120017  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1052      | Yes              |
| 10120018  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1052      | Yes              |
| 10120019  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 700         | 0      | 60 nm SRAM | 1052      | Yes              |
| 11040010  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 60 nm SRAM | 1117      | Yes              |
| 11040013  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 60 nm SRAM | 1117      | Yes              |
| 11060010  | EP3C120   | 780 FBGA     | PRECON 3-TEMP CYC B | 30      | 1000        | 0      | 60 nm SRAM | 1124      | Yes              |
| 9070009   | EP3CLS200 | 780 FBGA     | PRECON 3-TEMP CYC B | 28      | 1000        | 0      | 60 nm SRAM | 0916      | Yes              |
| 9070010   | EP3CLS200 | 780 FBGA     | PRECON 3-TEMP CYC B | 44      | 1000        | 0      | 60 nm SRAM | 0925      | Yes              |
| 11030015  | EP3SE50   | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 1043      | Yes              |
| 9040010   | EP3SL110  | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 0912      | Yes              |
| 9040011   | EP3SL110  | 1152 FBGA    | PRECON 3-TEMP CYC B | 34      | 1000        | 0      | 65 nm SRAM | 0912      | Yes              |
| 9100013   | EP3SL150  | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 0942      | Yes              |
| 9100015   | EP3SL150  | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 0942      | Yes              |
| 9100016   | EP3SL150  | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 0942      | Yes              |
| 9100035   | EP3SL150  | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 700         | 0      | 65 nm SRAM | 0944      | Yes              |
| 10100010  | EP3SL150  | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 1041      | Yes              |
| 10070021  | EP3SL150  | 780 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 1027      | Yes              |
| 9040015   | EP3SL200  | 1152 FBGA    | PRECON 3-TEMP CYC B | 20      | 1000        | 0      | 65 nm SRAM | 0907      | Yes              |
| 10080012  | EP3SL200  | 1152 FBGA    | PRECON 4-TEMP CYC B | 25      | 1000        | 0      | 65 nm SRAM | 1019      | Yes              |
| 10040013  | EP4CE40   | 484 FBGA     | PRECON 3-TEMP CYC B | 23      | 1000        | 0      | 60 nm SRAM | 1014      | Yes              |
| 10040014  | EP4CE40   | 484 FBGA     | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 60 nm SRAM | 1014      | Yes              |
| 10040022  | EP4CGX15  | 148 QFN      | PRECON 3-TEMP CYC B | 23      | 1000        | 0      | 60 nm SRAM | 1015      | Yes              |
| 10080028  | EP4CGX15  | 148 QFN      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 60 nm SRAM | 1025      | Yes              |
| 11030010  | EP4CGX15  | 148 QFN      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 60 nm SRAM | 1101      | Yes              |
| 10040028  | EP4CGX15  | 169 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1017      | Yes              |
| 10040032  | EP4CGX15  | 169 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1017      | Yes              |
| 10060001  | EP4CGX15  | 169 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1022      | Yes              |
| 10060002  | EP4CGX15  | 169 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1022      | Yes              |
| 10120024  | EP4CGX150 | 484 FBGA     | PRECON 3-TEMP CYC B | 30      | 1000        | 0      | 60 nm SRAM | 1052      | Yes              |
| 10080015  | EP4CGX150 | 672 FBGA     | PRECON 3-TEMP CYC B | 30      | 1000        | 0      | 60 nm SRAM | 1028      | Yes              |
| 10090024  | EP4CGX150 | 896 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 60 nm SRAM | 1038      | Yes              |
| 10110002  | EP4CGX150 | 896 FBGA     | PRECON 3-TEMP CYC B | 30      | 1000        | 0      | 60 nm SRAM | 1044      | Yes              |
| 9040019   | EP4SGX230 | 1152 FBGA    | PRECON 3-TEMP CYC B | 11      | 1000        | 0      | 40 nm SRAM | 0915      | Yes              |
| 9050021   | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 22      | 1000        | 0      | 40 nm SRAM | 0921      | Yes              |
| 9060021   | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 43      | 1000        | 0      | 40 nm SRAM | 0924      | Yes              |
| 9090031   | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM | 0938      | Yes              |
| 9090032   | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM | 0938      | Yes              |
| 10020008  | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 25      | 2000        | 0      | 40 nm SRAM | 1005      | Yes              |
| 11010007  | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM | 1101      | Yes              |
| 11030012  | EP4SGX230 | 1517 FBGA    | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 40 nm SRAM | 1108      | Yes              |

| REL LOT # | DEVICE     | PACKAGE TYPE | RELIABILITY TEST    | # UNITS | # OF CYCLES | # FAIL | Technology  | Date Code | ROHS Compliant ? |
|-----------|------------|--------------|---------------------|---------|-------------|--------|-------------|-----------|------------------|
| 11010008  | EP4SGX530  | 1152 HBGA    | PRECON 4-TEMP CYC B | 16      | 1000        | 0      | 40 nm SRAM  | 1103      | Yes              |
| 11010011  | EP4SGX530  | 1152 HBGA    | PRECON 4-TEMP CYC B | 17      | 1000        | 0      | 40 nm SRAM  | 1103      | Yes              |
| 11010001  | EP4SGX530  | 1517 HBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM  | 1101      | Yes              |
| 9060020   | EP4SGX530  | 1517 FBGA    | PRECON 3-TEMP CYC B | 87      | 1000        | 0      | 40 nm SRAM  | 0924      | Yes              |
| 11010001  | EP4SGX530  | 1517 HBGA    | PRECON 4-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM  | 1101      | Yes              |
| 9050033   | EP4SGX530  | 1932 FBGA    | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 40 nm SRAM  | 0922      | Yes              |
| 9100036   | EP4SGX530  | 1932 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM  | 0944      | Yes              |
| 10090001  | EP4SGX530  | 1932 FBGA    | PRECON 3-TEMP CYC B | 40      | 1000        | 0      | 40 nm SRAM  | 1030      | Yes              |
| 9040001   | EPC1       | 20 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.5μ EPROM  | 0907      | Yes              |
| 9070011   | EPC1       | 8 PDIP       | PRECON 1-TEMP CYC B | 45      | 1000        | 0      | 0.5μ EPROM  | 0929      | Yes              |
| 10020046  | EPC1441    | 20 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.5μ EPROM  | 1001      | Yes              |
| 11010014  | EPC1441    | 20 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.5μ EPROM  | 1049      | Yes              |
| 10050020  | EPC2       | 20 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.4μ FLASH  | 1013      | Yes              |
| 10110001  | EPC2       | 20 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.4μ FLASH  | 1037      | Yes              |
| 9010017   | EPC4       | 100 PQFP     | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.35μ FLASH | 0910      | Yes              |
| 10070002  | EPC4       | 100 PQFP     | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.35μ FLASH | 1013      | Yes              |
| 9090001   | EPC8       | 100 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.35μ FLASH | 0935      | Yes              |
| 9090043   | EPC8       | 100 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.35μ FLASH | 0935      | Yes              |
| 10010008  | EPC16      | 88 UBGA      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.35μ FLASH | 0949      | Yes              |
| 11030014  | EPF6016    | 208 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.42μ SRAM  | 1101      | Yes              |
| 9050032   | EPF10K20   | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.42μ SRAM  | 0922      | Yes              |
| 10080023  | EPF10K30A  | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ SRAM   | 1019      | Yes              |
| 10030001  | EPF10K50   | 240 RQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.42μ SRAM  | 1008      | Yes              |
| 9050005   | EPF10K50V  | 356 BGA      | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ SRAM   | 0913      | Yes              |
| 10110029  | EPF10K70   | 240 RQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.42μ SRAM  | 1048      | Yes              |
| 11040014  | EPF10K70   | 240 RQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.42μ SRAM  | 1107      | Yes              |
| 9080013   | EPF10K100A | 356 BGA      | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ SRAM   | 0935      | Yes              |
| 9050001   | EPF10K100E | 208 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ SRAM  | 0916      | Yes              |
| 9050030   | EPF10K100E | 256 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ SRAM  | 0922      | Yes              |
| 10020025  | EPF10K100E | 356 BGA      | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ SRAM  | 1001      | Yes              |
| 9080008   | EPF6016A   | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ SRAM   | 0932      | Yes              |
| 9070001   | EPF8282A   | 84 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.42μ SRAM  | 0919      | Yes              |
| 10120013  | EPM240Z    | 100 MBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1050      | Yes              |
| 11030013  | EPM240Z    | 100 MBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1101      | Yes              |
| 11030018  | EPM570     | 100 TQFP     | PRECON 3-TEMP CYC B | 24      | 1000        | 0      | 0.18μ FLASH | 1112      | Yes              |
| 10120012  | EPM570Z    | 144FBGA      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1050      | Yes              |
| 11020001  | EPM570Z    | 256FBGA      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1052      | Yes              |
| 11010005  | EPM1270G   | 144TQFP      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1052      | Yes              |
| 11030028  | EPM1270G   | 256FBGA      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1107      | Yes              |
| 11050006  | EPM1270G   | 256FBGA      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1118      | Yes              |
| 11050011  | EPM1270G   | 256FBGA      | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1118      | Yes              |
| 10120007  | EPM2210    | 256 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH | 1050      | Yes              |

| REL LOT # | DEVICE    | PACKAGE TYPE | RELIABILITY TEST    | # UNITS | # OF CYCLES | # FAIL | Technology   | Date Code | ROHS Compliant ? |
|-----------|-----------|--------------|---------------------|---------|-------------|--------|--------------|-----------|------------------|
| 10120011  | EPM2210   | 256 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.18μ FLASH  | 1031      | Yes              |
| 11020006  | EPM2210G  | 256 FBGA     | PRECON 3-TEMP CYC B | 77      | 1000        | 0      | 0.18μ FLASH  | 1106      | Yes              |
| 11020007  | EPM2210G  | 256 FBGA     | PRECON 3-TEMP CYC B | 75      | 1000        | 0      | 0.18μ FLASH  | 1106      | Yes              |
| 10040027  | EPM3064A  | 100 TQFP     | PRECON 3-TEMP CYC B | 80      | 1000        | 0      | 0.35μ EEPROM | 1007      | Yes              |
| 10010030  | EPM7032AE | 44 TQFP      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.35μ EEPROM | 1001      | Yes              |
| 10040017  | EPM7064S  | 44 TQFP      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.5μ EEPROM  | 1007      | Yes              |
| 11040002  | EPM7064S  | 44 PLCC      | PRECON 3-TEMP CYC B | 45      | 1000        | 0      | 0.5μ EEPROM  | 1101      | Yes              |
| 9050022   | EPM7128AE | 100 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ EEPROM  | 0920      | Yes              |
| 9010008   | EPM7256AE | 144 TQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ EEPROM  | 0851      | No               |
| 9080001   | EPM7256B  | 256 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ EEPROM | 0919      | No               |
| 10070004  | EPM7256E  | 192 PGA      | PRECON 3-TEMP CYC B | 50      | 1000        | 0      | 0.5μ EEPROM  | 1025      | No               |
| 9030015   | EPM7512AE | 208 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.3μ EEPROM  | 0918      | Yes              |
| 10100013  | EPM7512AE | 208 PQFP     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.35μ EEPROM | 1037      | Yes              |
| 10030018  | EPM7512AE | 256 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.35μ EEPROM | 1001      | Yes              |
| 10080013  | EPM7512B  | 256 FBGA     | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.22μ EEPROM | 1025      | Yes              |
| 8080002   | HC1S60    | 1020 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.13μ SRAM   | 0825      | No               |
| 8020006   | HC210     | 484 FBGA     | PRECON 3-TEMP CYC B | 80      | 1000        | 0      | 0.09μ SRAM   | 0801      | Yes              |
| 8110011   | HC230     | 1020 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 0.09μ SRAM   | 0837      | Yes              |
| 10090007  | HC4GX25   | 1152 FBGA    | PRECON 3-TEMP CYC B | 25      | 1000        | 0      | 40 nm SRAM   | 1036      | Yes              |

## Solder Joint Reliability

Solder Joint Reliability is measured by temperature cycling devices on a printed circuit board from 0°C to 100°C at 1-2 cycles per hour. This test is designed to identify failures due to the mismatch of temperature coefficients of expansion between the device and printed circuit board. Devices are soldered onto a 2.36 mm thick, 40cm long, and 10cm wide FR4 printed circuit board by convection reflow soldering. MBGA (0.5 mm pitch) package is soldered on 1.6 mm thick FR4 printed circuit board in addition to 2.36 mm thick one. QFN package is soldered on 0.8 mm thick FR4 printed circuit board. The devices are continuously monitored for failure of second level interconnects. Creep failures occur in the solder ball at points of maximum stress. The actual fatigue life is obtained by fitting failure data using a log-normal or Weibull distribution to predict the number of cycles to 0.1% fail. In many cases no failures are observed and the test was stopped after 5000 cycles. The effects of various package and printed circuit board parameters can be predicted via finite element modeling.<sup>xii xiii</sup> The results of finite element modeling are used to optimize package reliability and to extend the results to similar die/package combinations.

## Tin-Lead (Sn-Pb) Solder Joint Reliability

| Package           | Substrate pad size | Pitch   | Technology                                 | heat sink | Die Size (mm) | MTTF            | Cycles to 0.1% fails (Extrapolated) |
|-------------------|--------------------|---------|--|-----------|---------------|-----------------|-------------------------------------|
| U88               | 0.4 mm             | 0.8 mm  | Wire-bonded Stacked Die + 2L FR4 substrate | None      | 6.9 * 4.6     | 4068            | 3162                                |
| E144              | NA                 | 0.5mm   | lead frame + ground pad                    | None      | 5.12 * 5.21   | 0 fails to 6000 | 0 fails to 6000                     |
| tsCSP148          | NA                 | 0.5mm   | lead frame + ground pad                    | None      | 5.12 * 5.21   | 2839            | 2119                                |
| F256              | 0.45mm             | 1.0mm   | low k die + Wire Bond + 4 Layer BT         | None      | 5.80*6.22     | 4798            | 3775                                |
| F256              | 0.45mm             | 1.0mm   | low k die + Wire Bond + 4 Layer BT         | None      | 5.80*6.22     | 5058            | 3236                                |
| F256              | 0.45mm             | 1.0mm   | low k die + Wire Bond + 4 Layer BT         | None      | 5.80*6.22     | 4194            | 2161                                |
| F256              | 0.45 mm            | 1.0 mm  | Wire Bond + 2 Layer BT                     | None      | 8.8 * 7.9     | 4437            | 3687                                |
| F256 thin outline | 0.45 mm            | 1.0 mm  | low k die + Wire Bond + 4 Layer BT         | None      | 7.68 * 6.81   | 3574            | 2888                                |
| B356              | 0.58 mm            | 1.27 mm | Wire Bond + 2 Layer BT                     | None      | 9 * 9.8       | 0 fails to 5000 | 0 fails to 5000                     |
| U358              | 0.4mm              | 0.8mm   | Lid-less Flip-Chip + 4L build up BT        | None      | 10.11*10      | 2777            | 2740                                |
| U484              | 0.4mm              | 0.8mm   | low k die + Wire Bond + 4 Layer BT         | None      | 8.4 * 8.03    | 0 fails to 5000 | 0 fails to 5000                     |
| B652              | 0.58 mm            | 1.27 mm | Wire bond + 1 Layer Tape                   | Cu        | 17.01 * 15.38 | 0 fails to 5000 | 0 fails to 5000                     |
| B724              | 0.55 mm            | 1.27 mm | Flip Chip + 6 layer build-up BT            | 2 pc Cu   | 18.1 * 13.4   | 0 fails to 2800 | 0 fails to 2800                     |
| F484              | 0.45 mm            | 1.0 mm  | Wire bond + 2 layer BT                     | None      | 11.5 * 11.5   | 6534            | 3408                                |
| F672              | 0.45 mm            | 1.0 mm  | Wire Bond + 4 Layer BT                     | None      | 11.19*11.12   | 5601            | 4448                                |

| Package | Substrate pad size | Pitch  | Technology                                  | heat sink | Die Size (mm) | MTTF            | Cycles to 0.1% fails (Extrapolated) |
|---------|--------------------|--------|---|-----------|---------------|-----------------|-------------------------------------|
| F672    | 0.45 mm            | 1.0 mm | Wire Bond + 4 Layer BT                      | None      | 16 * 11.8     | 0 fails at 5200 | 0 fails at 5200                     |
| F672    | 0.45 mm            | 1.0 mm | Wire Bond + 4 Layer BT                      | None      | 16 * 11.8     | 0 fails at 5400 | 0 fails at 5400                     |
| F672    | 0.45mm             | 1.0mm  | Low K die + Wire Bond + 4 Layer BT          | None      | 8.4 * 8.03    | 0 fails to 5400 | 0 fails to 5400                     |
| F672    | 0.55 mm            | 1.0 mm | Flip Chip + 8 layer build-up BT             | AlSiC     | 19.1 * 16.5   | 4419            | 3284                                |
| F672    | 0.55 mm            | 1.0 mm | Flip Chip + 8 layer build-up BT             | AlSiC     | 19.1 * 16.5   | 0 fails to 5700 | 0 fails to 5700                     |
| F672    | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | AlSiC     | 16.5 * 13.1   | 5304            | 3437                                |
| F672    | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | AlSiC     | 16.5 * 13.1   | 4130            | 3487                                |
| F672    | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | AlSiC     | 16.5 * 13.1   | 0 fails to 5100 | 0 fails to 5100                     |
| F672    | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 16.5 * 13.1   | 0 fails to 5400 | 0 fails to 5400                     |
| F780    | 0.45mm             | 1.0mm  | Wire bond + 4Layer BT                       | None      | 10.7 5* 11.62 | 5087            | 3413                                |
| F780    | 0.45mm             | 1.0mm  | Wire bond + 2Layer BT                       | None      | 10.7 5* 11.62 | 5318            | 4380                                |
| F780    | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 16.3 * 13.5   | 5890            | 4614                                |
| F780    | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 16.3 * 13.5   | 0 fails to 4500 | 0 fails to 4500                     |
| F896    | 0.45 mm            | 1.0 mm | Wire bonded + 4 layer BT                    | None      | 8.86 * 9.96   | 0 fails to 4000 | 0 fails to 4000                     |
| F896    | 0.45 mm            | 1.0 mm | Wire bonded + 4 layer BT                    | None      | 11.19*11.12   | 5148            | 3080                                |
| F1020   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | AlSiC     | 22.6 * 19.9   | 0 fails to 6000 | 0 fails to 6000                     |
| F1020   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | AlSiC     | 22.6 * 19.9   | 8897            | 5670                                |
| F896    | 0.45 mm            | 1.0 mm | Wire Bond + 2 Layer BT                      | None      | 13.16 X 12.39 | 3911            | 2927                                |
| F1020   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 22.1 * 19.4   | 5781            | 5174                                |
| F1020   | 0.55mm             | 1.0mm  | Low k Die + Flip Chip + 8 layer BT build-up | 2 pc Cu   | 15.33 * 14.24 | 5432            | 4510                                |
| F1020   | 0.55mm             | 1.0mm  | Low k Die + Flip Chip + 8 layer BT build-up | 2 pc Cu   | 15.33 * 14.24 | 4333            | 3705                                |
| F1020   | 0.55mm             | 1.0mm  | Low k Die + Flip Chip + 8 layer BT build-up | 2 pc Cu   | 22.56 * 25.54 | 5579            | 4603                                |
| F1020   | 0.55mm             | 1.0mm  | Flip Chip + 8 layer BT build-up             | 2 pc Cu   | 22.6X19.9     | 0 fails to 4000 | 0 fails to 4000                     |
| F1020   | 0.55 mm            | 1.0 mm | Lidless Flip Chip + 6 layer build-up BT     | None      | 17.62*15.94   | 4804            | 3104                                |

| Package | Substrate pad size | Pitch  | Technology                                  | heat sink | Die Size (mm)             | MTTF | Cycles to 0.1% fails (Extrapolated) |
|---------|--------------------|--------|---|-----------|---------------------------|------|-------------------------------------|
| F1020   | 0.55 mm            | 1.0 mm | Lidless Flip Chip + 6 layer build-up BT     | None      | 18.03*17.29               | 4551 | 3168                                |
| F1152   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 16*14                     | 4106 | 3216                                |
| F1152   | 0.55 mm            | 1.0 mm | Lidless Flip Chip + 6 layer build-up BT     | None      | 16*14                     | 4421 | 3474                                |
| F1508   | 0.55mm             | 1.0mm  | Low k Die + Flip Chip + 8 layer BT build-up | SPL       | 22.17 * 19.24             | 6506 | 3651                                |
| F1508   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 23.9 * 23.3               | 4233 | 2694                                |
| F1508   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | 2 pc Cu   | 23.9 * 23.3               | 3074 | 2040                                |
| F1508   | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT             | SPL       | 23.9 * 23.3               | 4797 | 3182                                |
| F1517   | 0.55 mm            | 1.0 mm | Flip Chip + 14 layer build-up BT            | 2 pc Cu   | 25.6 * 26.5 (N40 ELK die) | 4497 | 3564                                |
| F1517   | 0.55 mm            | 1.0 mm | Flip Chip + 14 layer build-up BT            | SPL       | 25.6 * 26.5 (N40 ELK die) | 4733 | 4100                                |
| F1760   | 0.55 mm            | 1.0 mm | Flip Chip + 12 layer build-up BT            | 2 pc Cu   | 20.0 * 20.0 (N40 ELK die) | 3541 | 2572                                |
| F1932   | 0.55 mm            | 1.0 mm | Flip Chip + 14 layer build-up BT            | 2 pc Cu   | 25.6 * 26.5 (N40 ELK die) | 3552 | 2932                                |

**\*tsCSP used 0.8 mm board thickness. All others used 2.36 mm.**

## Pb-Free Solder Joint Reliability

| Package           | Substrate pad size | Pitch  | Technology                                    | Heat Sink | Die Size (mm) | MTTF            | Cycles to 0.1% fails (Extrapolated) |
|-------------------|--------------------|--------|---|-----------|---------------|-----------------|-------------------------------------|
| M100              | 0.3 mm             | 0.5 mm | Wire Bond + 2 Layer BT                        | None      | 3.2 * 3.2     | 0 fails to 6000 | 0 fails to 6000                     |
|                   |                    |        |   |           |               | 0 fails to 6000 | 0 fails to 6000                     |
| M256              | 0.3 mm             | 0.5 mm | Wire Bond + 4 Layer BT                        | None      | 3.9 * 3.9     | 0 fails to 6000 | 0 fails to 6000                     |
|                   |                    |        |   |           |               | 0 fails to 6000 | 0 fails to 6000                     |
| U88               | 0.4 mm             | 0.8 mm | Wire-bonded Stacked Die + 2L FR4 substrate    | None      | 6.9 * 4.6     | 0 fails to 6000 | 0 fails to 6000                     |
| T144              | N/A                | 0.5 mm | lead frame                                    | N/A       | 4.9*6.0       | 0 fails to 5500 | 0 fails to 5500                     |
| E144              | NA                 | 0.5mm  | lead frame + ground pad                       | None      | 5.12 * 5.21   | 0 fails to 6000 | 0 fails to 6000                     |
| tsCSP148          | NA                 | 0.5mm  | lead frame + ground pad                       | None      | 5.12 * 5.21   | 2938            | 2511                                |
| F256 thin outline | 0.45 mm            | 1.0 mm | Wire Bond + 4 Layer BT                        | None      | 7.68 * 6.81   | 0 fails to 5000 | 0 fails to 5000                     |
| F256              | 0.45mm             | 1.0mm  | low k die + Wire Bond + 4 Layer BT            | None      | 5.80*6.22     | 0 fails to 6000 | 0 fails to 5000                     |
| Q240              | N/A                | 0.5 mm | lead frame                                    | N/A       | 8.0*7.9       | 0 fails to 6000 | 0 fails to 6000                     |
| U358              | 0.4mm              | 0.8mm  | Lid-less Flip-Chip + 4 Layer build up BT      | None      | 10.11*10      | 0 fails to 6000 | 0 fails to 6000                     |
| U484              | 0.4mm              | 0.8mm  | low k die + Wire Bond + 4 Layer BT            | None      | 8.4 * 8.03    | 0 fails to 3500 | 0 fails to 3500                     |
| F484              | 0.45 mm            | 1.0 mm | Wire-bonded + 4 layer BT                      | None      | 10.8 * 8.8    | 0 fails to 6000 | 0 fails to 6000                     |
| F672              | 0.45 mm            | 1.0 mm | Wire Bond + 4 Layer BT                        | None      | 11.19*11.12   | 0 fails to 6000 | 0 fails to 6000                     |
| F896              | 0.45               | 1.0 mm | Wire-bonded + 4 layer BT                      | None      | 8.86 * 9.96   | 0 fails to 4000 | 0 fails to 4000                     |
| F780              | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT               | 2 pc Cu   | 16.3 * 13.5   | 0 fails to 5000 | 0 fails to 5000                     |
| F896              | 0.45 mm            | 1.0 mm | Wire bonded + 4 layer BT                      | None      | 11.19*11.12   | 0 fails to 6000 | 0 fails to 6000                     |
| M1019             | 0.3 mm             | 0.5mm  | Lid-less Flip-Chip + 3-2-3 build up substrate | None      | 10.16*10.52   | 0 fails to 6000 | 0 fails to 6000                     |
| F1020             | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT               | 2 pc Cu   | 22.6 * 19.9   | 0 fails to 5887 | 0 fails to 5887                     |
| F1020             | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT               | SPL       | 17.62*15.94   | 0 fails to 6000 | 0 fails to 6000                     |
| F1020             | 0.55 mm            | 1.0 mm | Lidless Flip Chip + 6 layer build-up BT       | None      | 17.62*15.94   | 0 fails to 6000 | 0 fails to 6000                     |
| F1020             | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT               | SPL       | 18.03*17.29   | 0 fails to 6000 | 0 fails to 6000                     |
| F1020             | 0.55 mm            | 1.0 mm | Lidless Flip Chip + 6 layer build-up BT       | None      | 18.03*17.29   | 0 fails to 6000 | 0 fails to 6000                     |
| F1508             | 0.55 mm            | 1.0 mm | Flip Chip + 6 layer build-up BT               | 2 pc Cu   | 23.9 * 23.3   | 0 fails to 6000 | 0 fails to 6000                     |

## Serial Configuration Devices

The EPCS4, EPCS16 and EPCS64 serial configuration devices are fabricated on Micron 0.11  $\mu\text{m}$  CMOS process technology, EPCS1 is on 0.15  $\mu\text{m}$  and EPCS128 on 65 nm. These products operate at a nominal  $V_{cc}$  of 3.3V. The EPCS1, EPCS4 and EPCS 16 are available in the 8-pin small outline integrated circuit (SOIC) package while EPCS64 and EPCS128 are available in 16-pin SOIC package.

### 0.15 $\mu\text{m}$ process - Die Related Results

| Test Procedure                  | Test Conditions   | Lot 1        | Lot 2        | Lot 3          |
|---------------------------------|---|--------------|--------------|----------------|
| High Temperature Operating Life | 140°C, 4.2V<br>504hrs<br>1008hrs  | 0/80<br>0/80 | 0/77<br>0/77 | 0/80<br>0/80   |
| Low Temperature Operating Life  | -40°C, 4.2V<br>504hrs   | 0/80         | 0/77         | 0/80           |
| High Temperature Bake           | 200°C,<br>504hrs<br>1008hrs   | 0/80<br>0/80 | 0/77<br>0/77 | 0/626 *1<br>-- |
| Erase/Write Cycles and Bake     | 10,000 E/W cycles + Bake 200°C, 48hrs<br>100,000 E/W cycles + Bake 200°C, 48hrs | 0/77<br>0/77 | 0/77<br>0/77 | 0/77<br>0/77   |
| Electrostatic Discharge         | Human body model: 1.5k $\Omega$ , 100pF   | >2000V       | >2000V       | >2000V         |
| Latch-up                        | Class II - Level A (at 85°C)  | Pass         | Pass         | Pass           |

Note: \*1. Trials conducted at wafer level at 150°C.

### 0.11 $\mu\text{m}$ process - Die Related Results

| Test Procedure                  | Test Conditions  | Lot 1                | Lot 2                | Lot 3                |
|---------------------------------|--|----------------------|----------------------|----------------------|
| High Temperature Operating Life | 140°C, 4.2V<br>168 hrs<br>500 hrs  | 0/77<br>0/77         | 0/77<br>0/77         | 0/77<br>0/77         |
| Low Temperature Operating Life  | -40°C, 4.2V<br>168 hrs   | 0/15                 | 0/15                 | 0/15                 |
| High Temperature Bake           | 250°C,<br>168 hrs<br>500 hrs   | 0/77<br>0/77         | 0/77<br>0/77         | 0/77<br>0/77         |
| Erase/Write Cycles and Bake     | 10,000 E/W cycles<br>100,000 E/W cycles<br>+ Bake 250°C, 168 hrs             | 0/77<br>0/77<br>0/77 | 0/77<br>0/77<br>0/77 | 0/77<br>0/77<br>0/77 |
| Electrostatic Discharge         | Human body model: 1.5k $\Omega$ , 100pF<br>Machine Model: 0 $\Omega$ , 200pF | >2000V<br>>200 V     | >2000V<br>> 200 V    | >2000V<br>>200 V     |
| Latch-up                        | Class II - Level A (at 150°C)  | Pass                 | Pass                 | Pass                 |

### 65 nm process – Die Related Results

| Test Procedure                  | Test Conditions  | Lot 1            | Lot 2 | Lot 3 |
|---------------------------------|--|------------------|-------|-------|
| High Temperature Operating Life | 125°C, 4.2V  |                  |       |       |
|                                 | 168 hrs  | 0/77             | 0/77  | 0/77  |
|                                 | 500 hrs  | 0/77             | 0/77  | 0/77  |
| High Temperature Bake           | 150°C  |                  |       |       |
|                                 | 168 hrs  | 0/77             | 0/77  | 0/77  |
|                                 | 500 hrs  | 0/77             | 0/77  | 0/77  |
|                                 | 1,000 hrs  | 0/77             | 0/77  | 0/77  |
| Erase/Write Cycles and Bake     | 10,000 E/W cycles + Bake 150°C, 168 hrs                    | 0/77             | 0/77  | 0/77  |
| Electrostatic Discharge         | Human body model: 1.5kΩ, 100pF<br>Machine Model: 0Ω, 200pF | >2000V<br>> 200V | —     | —     |
| Latch-Up                        | Class II - 150°C   | 0/6              | 0/6   | 0/6   |

### Package Qualification Data

| Package | Qualification Test                     | Read Out | Lot 1 | Lot 2 | Lot 3 |
|---------|--|----------|-------|-------|-------|
| SOIC8   | High Temp Storage Life @ 150°C         | 1000 hrs | 0/77  | 0/77  | 0/77  |
|         | Temp Humidity Bias (85°C /85%RH)       | 1000 hrs | 0/77  | 0/77  | 0/77  |
|         | Temperature Cycle “C” (-65°C to 150°C) | 500 cyc  | 0/77  | 0/77  | 0/77  |
|         | Unbiased HAST (130°C / 85%RH)          | 96 hrs   | 0/77  | 0/77  | 0/77  |
| SOIC16  | High Temp Storage Life @ 150°C         | 1000 hrs | 0/77  | 0/77  | 0/77  |
|         | Temp Humidity Bias (85°C /85%RH)       | 1000 hrs | 0/77  | 0/77  | 0/77  |
|         | Temperature Cycle “C” (-65°C to 150°C) | 500 cyc  | 0/77  | 0/77  | 0/77  |
|         | Unbiased HAST (130°C / 85%RH)          | 96 hrs   | 0/77  | 0/77  | 0/77  |

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