C55FG Family FIT Summary

The FIT data represented below is comprised of Qualification activity and ongoing Reliability Monitors used to make up generic data for the C55FG family masksets manufactured in the TSMC14 facility. Materials represented in these calculations are from the same technology and processes.

High Temperature Operational Life Data Summary

STRESS	READ POINT	Qty of DEVICES	Qty of REJECTS	% REJECTS
Calypso6M_SPC5748/ N81M/ 125C	1008	240	0	0
Calypso6M_SPC5748/ N81M/ 125C	48	800	0	0
Calypso6M_SPC5748/ N78S / 125C	168	77	0	0
Calypso3M_SPC5745/ N06M/ 125C	1008	231	0	0
Calypso3M_SPC5745/ N06M/ 125C	48	800	0	0
Castor4_Custom Part / N17T/ 125C	1008	240	0	0
Racerunner cut 3.2_SPC5775/ N76P / 125C	504	77	0	0
Racerunner cut 3.1_SPC5775/ N76P / 125C	168	120	0	0
Racerunner cut 2.0_SPC5775/ N38M / 125C	336	240	0	0
Racerunner cut 1.0_SPC5775/ N47G/ 125C	1008	79	0	0
Racerunner cut 2.0_SPC5775/ N38M / 125C	48	2400	0	0
Quasar3 cut 1.0_Custom Part/ N93H/ 125C	2016	240	0	0
Quasar3 cut 2.0_Custom Part/ N83S/ 125C	504	77	0	0
Quasar3 cut 2.0_Custom Part/ N83S/ 125C	48	800	0	0
Quasar2 cut 1.0_Custom Part/ N60F/ 125C	168	240	0	0
Quasar2 cut 2.0_Custom Part/ N76J/ 125C	2016	231	0	0
Quasar2 cut 2.0_ Custom Part/ N76J/ 125C	48	800	0	0
Quasar0 cut 1.0_Custom Part/ N32H/ 125C	800	48	0	0
Quasar0 cut 1.0_Custom Part/ N32H/ 125C	77	336	0	0
Panther_SPC5744 / N65H/ 125C	1008	231	0	0
Panther_SPC5744 /N15P/ 125C	168	77	0	0
Panther_SPC5744 /N15P/ 125C	48	2400	0	0
Rainier_MPC5746 / N94H/ 125C	504	240	0	0
Rainier_MPC5746 / N94H/ 125C	48	800	0	0
Matterhorn cut 1.0_MPC5777/ N60F/ 125C	1008	231	0	0
Matterhorn cut 2.0_MPC5777 / N78H / 125C	1008	120	0	0
Matterhorn cut 2.0_MPC5777 / N78H / 125C	48	2400	0	0
Cobra55_cut 1.0_MPC5777C / N45H / 125C	1008	240	0	0
Cobra55_cut 1.0B_MPC5777C / N45H / 125C	168	80	0	0
Cobra55_cut 1.0_MPC5777C / N45H / 125C	48	800	0	0
Halo_cut 2.0_MAC57D54H / N87P / 125C	408	240	0	0
Halo_cut 2.0_MAC57D54H / N87P / 125C	48	48	0	0

Calypso6M (N81M): Current FIT data stands at 0.39 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 290876.

Calypso3M (N06M): Current FIT data stands at 0.27 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 426769.

Cobra55 (N45H): Current FIT data stands at 0.50 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 228925.

Castor4 (N17T): Current FIT data stands at 0.27 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 426769.

Rainier (N94H): Current FIT data stands at 0.39 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 292366.

Panther (N15P): Current FIT data stands at 0.24 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 334926.

Racerunner (N76P): Current FIT data stands at 0.55 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 209351.

Quasar 0 (N32H): Current FIT data stands at 0.21 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 538889.

Quasar 2 (N83S): Current FIT data stands at 0.31 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 371603.

Quasar 3 (N32H): Current FIT data stands at 0.60 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 189351.

Matterhorn (N78H): Current FIT data stands at 0.62 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 185320.

Halo (N87P): Current FIT data stands at 0.57 FIT at 60% Upper Confidence Limit at 70℃ Tj constant duty cycle. Respective MTTF calculations are 201856.

Please note; larger die size results in higher FIT rates and lower MTTF values; therefore each mask calculation is provided above. Lower junction temperatures and duty cycles will result in lower FIT rates and higher MTTF values.

DESCRIPTION OF STRESS TEST

High Temperature Operational Life test (HTOL)

125°C or 150°C, 1.8 Volts for core, 6.0V For I/O

To determine the constant failure rate of the product at the specified operating temperature (usually 55-70℃), by accelerating temperature and voltage-activated failure mechanisms to produce device failures.

A dynamic electrical bias is applied to stimulate the device during the life test. Microcontrollers are cycled through software routines, developed to stress the devices to simulate actual use, at elevated temperature and voltage. Reject quantities at the test temperature are modified by the Chi-squared distribution function at 90% confidence levels. The failure rates are then calculated and derated to the required temperature using the Arrhenius equation with a 0.7 eV activation energy assumed as an average for the failure mechanisms. Further details are given in 'Calculation of Failure Rates'.

CALCULATION OF FAILURE RATES

Life test is a technique for determining constant failure rate. To derate from the temperature at which the life test is carried out to the maximum operating temperature an acceleration factor is applied. This calculation uses the Arrhenius equation, with **0.7eV** assumed for the activation energy.

Temperature Acceleration Factor, **Aft = exp (θ/k (1/To - 1/Tt))**

Where: θ is activation energy (eV)
k is Boltzmann's constant (8.617×10^{-5} eV/K) (K = -273.16℃)
To = Ta (op) + (Pd x θja)
Tt = Ta (tst) + (Pd x θja)

And: Ta (op) is the ambient user operating temperature (K)
Ta (tst) is the ambient temperature on stress test (K)
Pd is power dissipated by the device (W)
θja is thermal resistance of the package (℃/W)

Rejects obtained in the sample must be modified at a stated confidence level to obtain the rejects which would occur were the entire population tested. This is done using the Chi-square distribution function.

Failure Rate, **Fa = Z / (2 x N x h x Aft)**

where: Z is Chi-square ($\chi 2$) reject quantity
N is number of devices on test
h is test duration (hours)

* Fa is multiplied by 10^9 to give the result in FITS (1 FIT = 1 failure in 10^9 device hours).
* Fa is multiplied by 10^5 for % per 1000 hours.

$\chi 2$ value Z, is derived from statistical tables using (2 x Qty. fails + 2) for the Degrees of Freedom:

Qty fails	60% confidence level $\chi 2$ qty	90% confidence level $\chi 2$ qty
0	1.833	4.605
1	4.045	7.779
2	6.211	10.645
3	8.351	13.362
4	10.473	15.987
5	12.584	18.549
6	14.685	21.064
7	16.780	23.542
8	18.868	25.989
9	20.951	28.412

Voltage Acceleration is also taken into account when determining the life of devices. This is calculated by taking the oxide thickness into consideration and derating from the stress test voltage to the life operating voltage.

Voltage Acceleration Factor, **Afv = exp** $\beta^{[Vt - V_O]}$

Where:

Vo = Gate voltage under typical operating conditions (in Volts) *

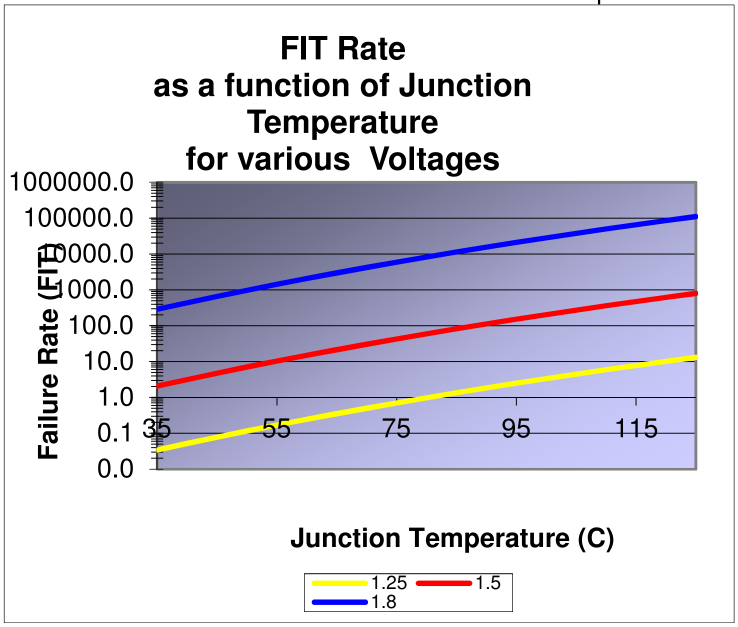
Vt = Gate voltage under accelerated test conditions (in Volts) *

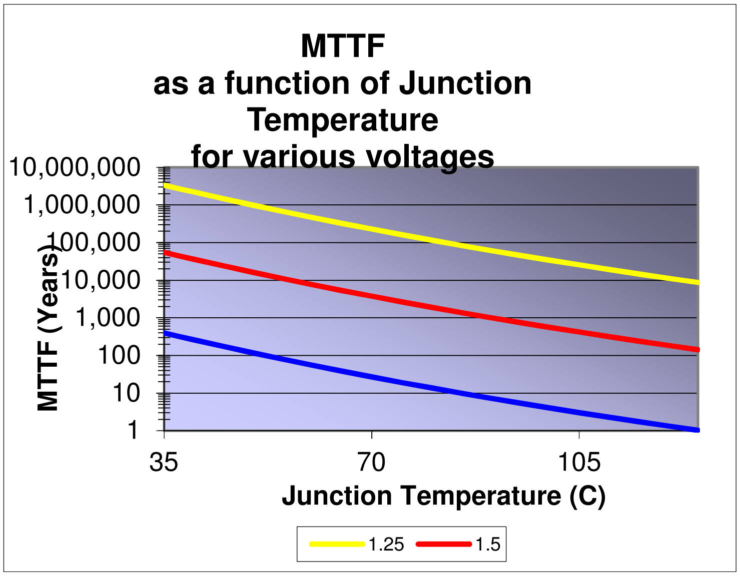
β = Voltage acceleration factor (in 1/Volts)

** For devices with dual gate oxide, the thin gate oxide voltages are applicable.*

*** Specified by technology in the Reliability Model document 68MWS00084B.*

Cobra55 60% FIT Curve Based on HTOL Stress data provided above





Note about FIT and MTTF curves: These plots are extrapolations of the FIT calculation as described above. They do not constitute guarantees of performance at extended temperatures.