



0.18um Family FIT Summary

SUMMARY

The FIT data represented below is comprised of recent qualification HTOL device-level stress data for 0.18um Split Gate Flash masksets manufactured in the **TSMC Fab10** facility . Materials represented in these calculations are from the same technology and processes. These values are measures of observed accelerated life stress data and do not constitute guarantees of future performance levels. See below for actual results and FIT/MTTF assessments.

High Temperature Operational Life – TSMC Fab10

STRESS	READ POINT	Qty of DEVICES	Qty of REJECTS	% REJECTS
Q223690, MKE02Z64 (TSMC10, 0N22J), 2.2V/core, 125C	1008	240	0	0
Q223690, MKE02Z64 (TSMC10, 0N22J), 2.2V/core, 125C	264	80	0	0
Q225030, MKE04/06Z128(TSMC10, 2N45K), 2.2V/core, 125C	264	80	0	0
Q224015, MKE04Z8 (TSMC10, N40J), 2.2V/core, 125C	1008	80	0	0
Q225921, S9KEAZ128 (TSMC10, N45K), 2.2V/core, 125C	3024	160	0	0
Q225771, S9KEAZN8(TSMC10, N40J), 2.2V/core, 125C	1008	80	0	0
Q225910, S9KEAZN64 (TSMC10, N22J), 2.2V/core, 125C	1008	80	0	0
Q228218, MC9S08PT60(TSMC10, 0N21P), 2.2V/core, 125C	264	80	0	0

Note: Stress data collected in the above table is from initial qualification studies and onwards

FIT Rates are calculated for each die size using the above data:

MKE04/06Z128(N45k): Current FIT data stands at 2.9 FIT at 60% Upper Confidence Limit at 55°C Tj constant duty cycle. Respective MTTF calculations are 38820.

MKE02Z64 (N22J): FIT data stands at 2.2 FIT at 60% Upper Confidence Limit at 55°C Tj constant duty cycle. Respective MTTF calculations are 51830.

MKE04Z8 (N40J): FIT data stands at 1.7 FIT at 60% Upper Confidence Limit at 55°C Tj constant duty cycle. Respective MTTF calculations are 67302.

MC9S08PT60 (N21P): FIT data stands at 2.1 FIT at 60% Upper Confidence Limit at 55°C Tj constant duty cycle. Respective MTTF calculations are 53853.

MC9S08PA4 (N22P): FIT data stands at 1.3 FIT at 60% Upper Confidence Limit at 55°C Tj constant duty cycle. Respective MTTF calculations are 88764.

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, 2.2 Volts

To determine the constant failure rate of the product at the specified operating temperature (usually 55-70°C), 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 0.54 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 **0.54eV** assumed for the activation energy.

Temperature Acceleration Factor, **$A_{ft} = \exp(\theta/k(1/T_o - 1/T_t))$**

Where: θ is activation energy (eV)
 k is Boltzmann's constant (8.617×10^{-5} eV/K) ($K = -273.16^\circ\text{C}$)
 $T_o = T_a(\text{op}) + (P_d \times \theta_{ja})$
 $T_t = T_a(\text{tst}) + (P_d \times \theta_{ja})$

And: $T_a(\text{op})$ is the ambient user operating temperature (K)
 $T_a(\text{tst})$ is the ambient temperature on stress test (K)
 P_d is power dissipated by the device (W)
 θ_{ja} is thermal resistance of the package ($^\circ\text{C/W}$)

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, **$F_a = Z / (2 \times N \times h \times A_{ft})$**
quantity

where: Z is Chi-square (χ^2) reject

N is number of devices on test
 h is test duration (hours)

* F_a is multiplied by 10^9 to give the result in FITS

(1 FIT = 1 failure in 10^9 device hours).

* F_a is multiplied by 10^5 for % per 1000 hours.



χ^2 value Z, is derived from statistical tables using $(2 \times \text{Qty. fails} + 2)$ for the Degrees of Freedom:

Qty fails	60% confidence level χ^2 qty	90% confidence level χ^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, **$A_{fv} = \exp \beta[V_t - V_o]$**

Where:

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

V_t = 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 6*