

RA introduction

RA Test Items

■ Device qualification:

- ELFR(Early Life Failure Rate) ... JESD22-A108
- HTOL(High Temperature Operating Life test) ... JESD22-A108
- LTOL(Low Temperature Operating Life test) ... JESD22-A108
- HTSL(High Temperature Storage Life test) ... JESD22-A103

■ Package qualification:

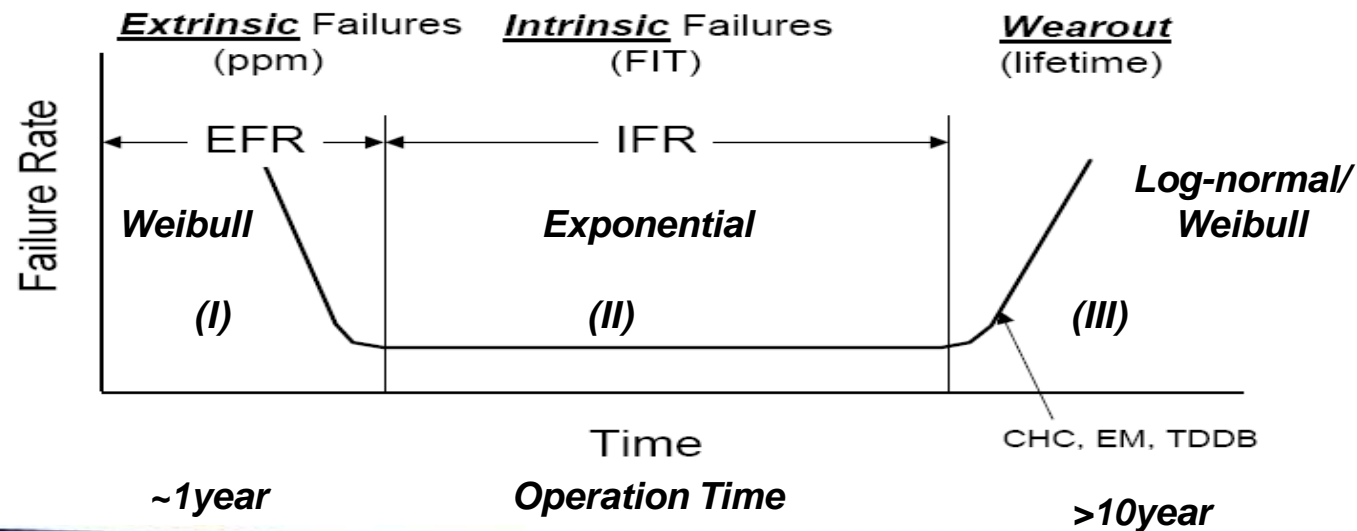
- Pre-Con. (Pre-conditioning) ... JESD22-A113 & J-STD-020
- HTSL (High Temperature Storage test) ... JESD22-A103
- LTSL (Low Temperature Storage Life) ... JESD22-A119
- THB (Temperature Humidity Bias life test) ... JESD22-A101
- HAST (Highly-Accelerated Stress Test) ... JESD22-A110
- UHAST (Un-bias HAST) ... JESD22-A118
- PCT (Pressure Cook Test) ... JESD22-A102
- TCT (Temperature Cycling Test) ... JESD22-A104

Device qualification

- Over many years, and across a wide variety of mechanical and electronic components and systems, people have calculated empirical population failure rates as units age over time and repeatedly obtained a graph such as shown below. Because of the shape of this failure rate curve, it has become widely known as the "Bathtub" curve.

Bathtub Curve

Steady state



How to evaluate the reliability of IC products

- *It is impossible to evaluate the reliability of IC product with **normal operation conditions**. It will take a **long time** and it's impractical.*
- *How to apply a **minimum sample size and shortest time period** to evaluate IC product reliability is crucial.*
- *Through accelerated test, we can evaluate the reliability of IC product with **minimum sample size and shortest time period**. Some kind of **acceleration tests stimulate or accelerate** all the possible stresses, including **thermal, electrical, humidity**, etc.*

How to evaluate the reliability of IC products

HTOL: High Temp Operation Life



Temp = 85 °C, Voltage = Vdd



Temp = 85 °C, Voltage = Vdd+20%



Temp = 125 °C, Voltage = Vdd+20%



LTPD Table

LTPD Sampling Table based on the Mil-S-19500 and Mil-M-38510

Max % Defective	20%	15%	10 %	7%	5%	3%	2%	1.5%	1%	0.7%	0.5%
Acceptance Number (c); rejects=c+1	Minimum Sample Size Needed										
0	11	15	22	32	45	76	116	153	231	328	461
1	18	25	38	55	77	129	195	258	390	555	778
2	25	34	52	75	105	176	266	354	533	759	1056
3	32	43	65	94	132	221	333	444	668	953	1337
4	38	52	78	113	158	265	398	531	798	1140	1599
5	45	60	91	131	184	308	462	617	927	1323	1855

Device qualification

ELFR

- ◆ *Purpose:*
It's performed to screen out potential early life failures.
- ◆ *Test condition:*
125°C, 48~168 Hours, 1.1Vcc(Vcc maximum) with dynamic pattern.
- ◆ *Sample size:*
Hundreds to thousands parts. See ELFR table.
- ◆ *Read Point:*
48,168

Device qualification

ELFR

Table B — Minimum sample size to demonstrate various ELFR targets in FPM
(Failures per million) at 60% confidence level

Number of observed failures	Equivalent failures at 60% Confidence Level ($\chi^2/2$)	Minimum sample sizes required to meet FPM target at 60% confidence level					
		4000	2000	1000	500	250	100
		FPM	FPM	FPM	FPM	FPM	FPM
0	0.92	229	458	916	1,833	3,665	9,163
1	2.02	505	1,011	2,022	4,045	8,089	20,223
2	3.11	778	1,553	3,105	6,211	12,422	31,054
3	4.18	1004	2,088	4,175	8,351	16,701	41,753
4	5.24	1310	2,618	5,237	10,473	20,946	52,366
5	6.29	1573	3,146	6,292	12,584	25,168	62,919
6	7.34	1835	3,671	7,343	14,685	29,371	73,426
7	8.39	2098	4,195	8,390	16,780	33,559	83,898
8	9.43	2358	4,717	9,434	18,868	37,736	94,340
9	10.48	2620	5,238	10,476	20,951	41,903	104,757
10	11.52	2800	5,758	11,515	23,031	46,061	115,153

Device qualification

HTOL

- ◆ **Purpose:**
To simulate the devices' operating condition in an accelerated way, to achieve an equivalent life point with a shorter stress duration.
- ◆ **Test condition:**
125°C, 1000Hours, 1.1Vcc(Vcc maximum) with dynamic pattern.
- ◆ **Read point:**
168, 500, 1000hrs.

Table 1 – Additional Stress Requirements for parts not tested within 96 hours

Hours by which 96 hour window has been exceeded	> 0 but ≤ 168	> 168 but ≤ 336	> 336 but ≤ 504	Other
Additional stress hours required prior to performing electrical test	24	48	72	24 hours for each 168 hours (week) by which the 96 hour window has been exceeded

Device qualification

Example:

$E_a=0.7\text{eV}$

Use temperature=55 °C

Stress Temperature=125 °C

Calculate the acceleration factor--

Arrhenius equation:

$$\begin{aligned} AF &= \exp \left[\left(\frac{E_A}{k} \right) \cdot \left(\left(\frac{1}{T_{USE}} \right) - \left(\frac{1}{T_{STRESS}} \right) \right) \right] \\ &= \exp \left[\left(\frac{0.7\text{eV}}{8.6 \cdot 10^{-5} \text{eV/K}} \right) \cdot \left(\left(\frac{1}{(55 + 273)^\circ\text{K}} \right) - \left(\frac{1}{(125 + 273)^\circ\text{K}} \right) \right) \right] \\ &= 78.6 \end{aligned}$$

1000Hours stress duration is equivalent 9 years of use

Device qualification

Failure Rate calculation:

Failure Rate:

$$\lambda = \frac{x_{(\alpha, 2 \cdot n + 2)}^2 \cdot 10^9}{2 \cdot AF_T \cdot DH}$$

where,

λ = Failure Rate (FITS)

χ^2 = Failure Estimate

α = 1 - Confidence Level

n = Number of Failures

AF_T = Acceleration Factor

DH = Device Hours

FIT(Failure in Time) : Failure per 10^9 device hours

Device qualification

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

Device qualification

LTOL

◆ **Purpose:**

It's performed to determine the reliability of devices under low temperature conditions over an extended period of time.

The LTOL test is usually performed to check for hot carrier effects.

◆ **Test condition:**

-40 °C, 1000Hours, 1.1Vcc(Vcc maximum) with dynamic pattern.

◆ **Read point:**

168, 500, 1000hrs.

Device qualification

OLT作業時程

作業階段	客戶須提供資料	資料提供時程
Survey/Quote	POD/sample size	
Socket manufacture (非標準包裝)	Dummy sample	Socket完成前3週
BIB/DUT/Socket card manufacture	Pin assignment/Ball out/Application circuit	實驗前3週 (BIB:實驗前6週)
IC verify	Pattern (Atpg / Bist)	實驗前1週

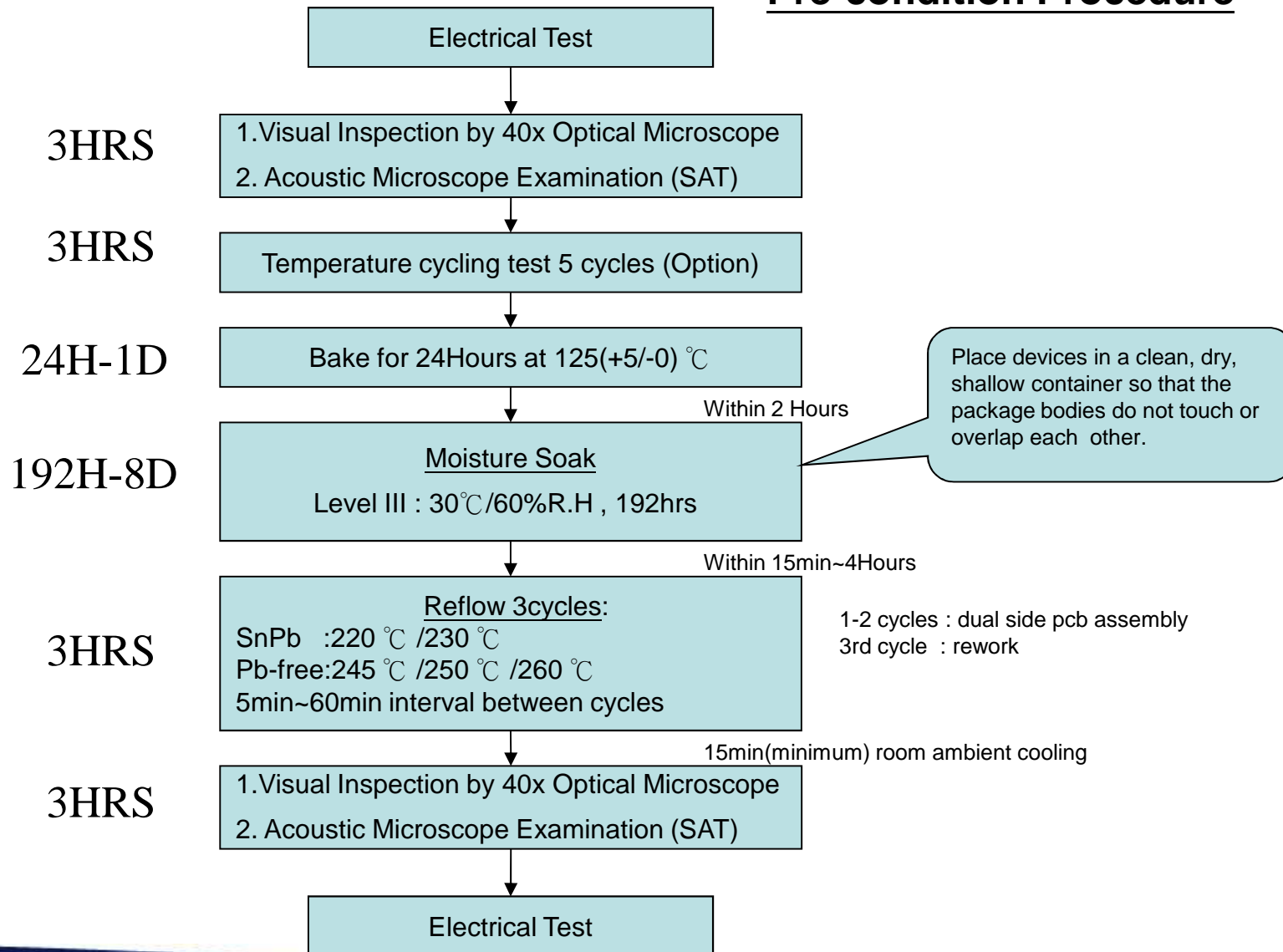
Package qualification

Pre-con

- *To ensure that a device will be able to withstand multiple assembly cycles.*
- *Pre-conditioning is now required before all package test*

Package qualification

Pre-condition Procedure



Moisture Sensitivity Levels

Table 5-1 Moisture Sensitivity Levels

LEVEL	FLOOR LIFE		SOAK REQUIREMENTS				
			STANDARD		ACCELERATED EQUIVALENT ¹		
					eV 0.40-0.48	eV 0.30-0.39	CONDITION
	TIME	CONDITION	TIME (hours)	CONDITION	TIME (hours)	TIME (hours)	
1	Unlimited	≤30 °C/85% RH	168 +5/-0	85 °C/85% RH	NA	NA	NA
2	1 year	≤30 °C/60% RH	168 +5/-0	85 °C/60% RH	NA	NA	NA
2a	4 weeks	≤30 °C/60% RH	696 ² +5/-0	30 °C/60% RH	120 +1/-0	168 +1/-0	60 °C/60% RH
3	168 hours	≤30 °C/60% RH	192 ² +5/-0	30 °C/60% RH	40 +1/-0	52 +1/-0	60 °C/60% RH
4	72 hours	≤30 °C/60% RH	96 ² +2/-0	30 °C/60% RH	20 +0.5/-0	24 +0.5/-0	60 °C/60% RH
5	48 hours	≤30 °C/60% RH	72 ² +2/-0	30 °C/60% RH	15 +0.5/-0	20 +0.5/-0	60 °C/60% RH
5a	24 hours	≤30 °C/60% RH	48 ² +2/-0	30 °C/60% RH	10 +0.5/-0	13 +0.5/-0	60 °C/60% RH
6	Time on Label (TOL)	≤30 °C/60% RH	TOL	30 °C/60% RH	NA	NA	NA

Package qualification

HTS

- *Purpose:*
To evaluate the life time of IC products that are stored in high ambient temperature and remain inactive for several years before their actual use.
- *Test condition:*
150°C, 1000Hours.
- *Read point:*
168, 500, 1000 hrs.

Package qualification

THB

- *Purpose:*
To evaluate the moisture resistance of IC products in high temperature and high humidity with bias stress condition and to accelerate moisture related failure mechanisms.
- *Test condition:*
85 °C, 85% R.H. , 1000Hours, 1.1xVcc(Vcc maximum), static bias.
- *Read point:*
168, 500, 1000 hrs

Package qualification

HAST

- *Purpose:*
HAST is a test used to accelerate the THB test.
Either HAST or THB may be chosen.
- *Test condition:*
130°C, 85% R.H. , 1.1xVcc(Vcc maximum), static bias,
2.3 atms.96Hours.
*110°C, 1.2 atms, 264Hours be used for **BGA** type packages.*
- *Read point:*
96/264 hrs

Package qualification

UFAST

- *Purpose:*

Used to identify failure mechanisms internal to packages, the unbiased HAST aims at evaluating the reliability of non-hermetic packaged solid-state devices in humid environments.

If THB or HAST is run, then UFAST need not be run.

- *Test condition:*

130 °C, 85% R.H. ,96Hours, 2.3 atms.

Package qualification

PCT

- *Purpose:*
To evaluate the moisture resistance of IC products in high temperature, high humidity and high pressure stress condition and to accelerate moisture related failure mechanisms.
- *Test condition:*
121 °C, 100% R.H., 168Hours, 15 PSIG (2 ATM).

Package qualification

TCT

- **Purpose:**
To evaluate the integrity of interfaces between various materials which have different thermal expansion coefficients in IC products. IC products are exposed to repeated temperature variation cycles from high temperature to low temperature by circulating air (air to air).
- **Test condition:**

Temperature cycling test conditions (°C)											
Step	Minutes	A	B	C	G	H	I	J	K	L	M
Cold	Min. 1,5,10,15	-55 °C	-55 °C	-65 °C	-40 °C	-55 °C	-40 °C	-0 °C	-0 °C	-55 °C	-40 °C
Hot	Min. 1,5,10,15	85 °C	125 °C	150 °C	125 °C	150 °C	115 °C	100 °C	125 °C	110 °C	150 °C

Package qualification

Condition B: -55 to 125 °C, $\Delta T = 180$ °C.

Condition C: -65 to 150 °C, $\Delta T = 215$ °C.

Condition G: -40 to 125 °C, $\Delta T = 165$ °C.

****Test Conditions that exceed 125 °C for
Ts(max) are not recommended to Pb/Sn solder
compositions.***

Appendix

Equipment - HTOL

Signality B1120

- ◆ Up to 150°C
- ◆ 96 Channel
- ◆ 60 slots (6 Zone, 10 slots per zone)
- ◆ DC POWER 0V to 11V ,2sets, 15A/5A
- ◆ Pattern Vector Depth : 128k
- ◆ Formatter : RZ ,RO, NRZ
- ◆ Period Rate : Max 5Mhz



Equipment - HTOL

KYE680/681

- ◆ Up to 150°C (KYE681: -55~ 150°C)
- ◆ 180 Channel
- ◆ 36 Slots (KYE-681 12 Slots)
- ◆ DC POWER 0V to 10V ,4sets, 20A for DPS1/2 ,3A for DPS3/4
- ◆ Pattern Vector Depth : 2M
- ◆ Formatter : RZ , NRZ
- ◆ Period Rate : 5Mhz



Equipment - SAT

SONIX

- ◆ A,B,C scan
- ◆ T scan
- ◆ TAMI
- ◆ Pulse generator : 15MHz,35MHz,
75MHz,110MHz



Equipment - Reflow

台技-SMD-10M14HANO

- ◆溫度範圍: ~360℃
- ◆輸送網寬:25cm
- ◆輸送網速度:20~100cm/Min



Equipment – THB / TH / Soak

泰琪MHU-225SB/MHU-225NB

◆ Temperature Range: -70~100℃ / -70~150 ℃

◆ Rising Time:

-70 ~ 100℃ --60Min

+20 ~ -70 ℃ --75Min

◆ Humidity : 10%~98% RH

◆ Chamber Size:

500(W)x750(H)x600(D)mm



Equipment - TCT

ESPEC TSA-71H-W

- ◆ Temperature Range : -70~200°C
- ◆ Chamber Size : 410(W) x 460(H) x 370(D)
- ◆ Recovery time: 5min



Equipment – HAST / PCT

ESPEC EHS-221

- ◆ Temperature Range : 105~142°C
- ◆ Humidity : 75% ~ 100% RH
- ◆ Pressure : 0.020~0.196MPa
- ◆ Chamber Size :
410(W) x 460(H) x 370(D)



Equipment – HTSL/Bake / BLT or HTOL with external pattern

ESPEC PV-211

- ◆ Temperature Range: RT~200°C
- ◆ Chamber Size :
600 x 600 x 600mm



Burn in board Introduce

◆ Dedicate burn in board

- One time use
- Same Product re-use (same package/same pin out)
- 製作成本較低,setup 較容易

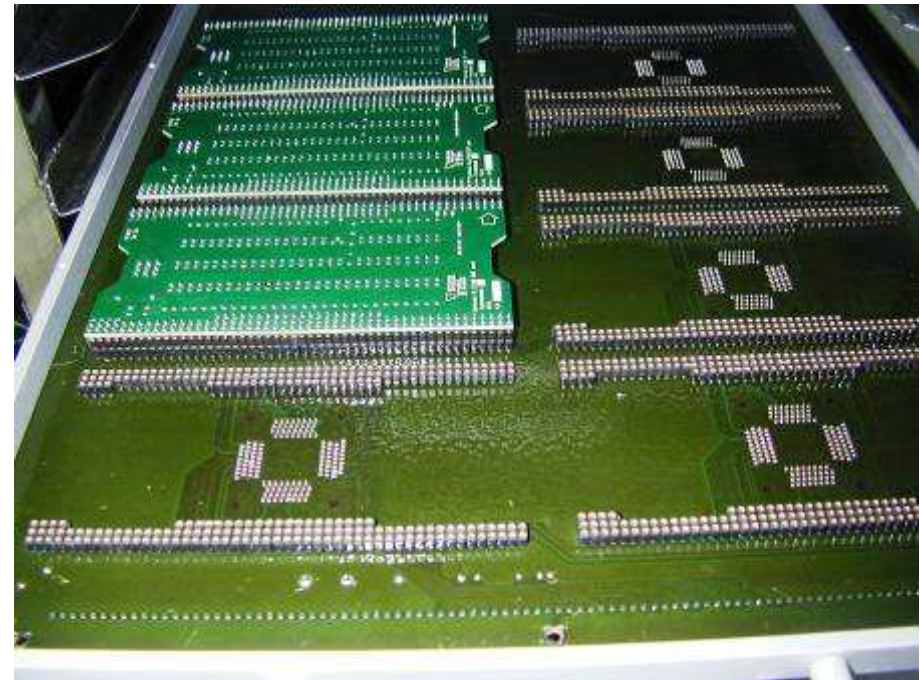
◆ Universal burn in board

- Burn in board repeat use to save money
- 製作成本較高,可重複使用
- Setup 較複雜,花費時間較長
 - Socket on board
 - DUT card for the same package but different application circuit
 - Socket card
 - Socket card for different package
 - Socket re-use
 - DUT card for different application circuit

Dedicate burn in board



Universal—Socket on board



Universal—Socket card

