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AU Optronics Corporation **Product Assurance Dept**

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MTBF Demonstration Test for AUO LCD Module

1.0 Purpose:

The purpose of this report is to 1) formally describe the procedure used by LCD vendor to demonstrate MTBF with a higher confidence level prior to mass production and show that this procedure is adequate to meet the requirements of the Customer and 2) formally establish the methodology that AUO and LCD system customer shall use to meet the Ongoing Reliability Requirements (ORT) goal.

2.0 Definitions:

LCD Module – LCD Module consists of LCD panel, LED Light Bar & LED Drive Board.
MTBF – Mean Time between Failures
θ_0 – Goal MTBF or Upper test MTBF. The upper test MTBF is an acceptable value of MTBF equal to the discrimination ratio times the lower test MTBF. Standard tests will accept, with a high probability, product with a true MTBF approaching θ_0.[1]
θ_1 – Lower test MTBF. The lower test MTBF is a value that is unacceptable and the standard test plans will reject, with a high probability, product with a true MTBF that approaches θ_1.[1]
D – Discrimination ratio. Discrimination ratio is the test plan envelope, d = θ_0/θ_1.[1]
β - Consumer's risk. Consumer's risk is the probability of accepting product with a true MTBF equal to the lower test MTBF (θ_1). The probability of accepting product less than θ_1 is less than β. [1]
α - Producer's risk. Producer's risk is the probability of rejecting product with true MTBF equal to the goal MTBF (θ_0). The probability of rejecting product with true MTBF greater than θ_0 is less than α. [1]

3.0 References:

1. MIL-STD-781. Department of Defense, 21 October 1977.
2. AUO Engineering Instruction (EI) Test Procedure, current revision.
3. AUO LCD Panel Product Specification.

[1] Definition from MIL-STD-781C

4.0 Test procedure of AUO to demonstrate MTBF prior to mass production:

"Reliability Demonstration Test Plan", the following test plan will be applied to all newly developed LCD modules or any LCD module that is modified in a considerable manner.

- MTBF Demonstration time: 100,000 hours
- Confidence Level: 90%
- Sample quantity: shall not be less than 10 units
- Demonstration time: shall not be less than 300 and no more than 1,200 hours/unit
- Temperature /Humidity: 40 ^{0}C - 70 ^{0}C / humidity should be ranged from. 25% -85% RH

Additional test conditions if applicable:

- Power cycling: 672 hours ON (TBD).

A time terminated reliability test will be performed with the following time requirements dependant on the numbers of failures:

Failures	MTBF	Time multiplier 90% confidence	Min. test hours with 0 failure	Sample size	Hours
0	100,000	2.30	230,000	20	11,500
1	100,000	3.89	389,000	20	19,450
2	100,000	5.32	532,000	20	26,600
3	100,000	6.68	668,000	20	33,400
4	100,000	7.99	799,000	20	39,950
5	100,000	9.27	927,000	20	46,350

Therefore the minimum "on test" time will be 100,000 hours with zero failures not considering acceleration factors. The demonstrated MTBF for this time with zero failures will be:

Demonstrated MTBF = (sample size) x (# days) x 24 (hours/day) x 11.64 (temp. accel @60C)
/2.3 (90% confidence level)
= 100,000 hours (0 failures)

Thermal acceleration factor based on Arrhenius model with eV = 0.6

Ambient temp.(T1)	Test temp.(T2)	Taf (Temp only)	Taf(consider humidity-80%RH)
25C/50%	35C	2.13	5.47
25C/50%	40C	3.06	7.84

25C/50%	45C	4.34	11.12
25C/50%	50C	6.09	15.68
25C/50%	55C	8.46	21.66
25C/50%	60C	11.64	29.79

5.0 To demonstrate MTBF growth to 100,000 hours with 90% confidence level following product introduction ORT:

Test parameters: θ_0 = 100,000 α = 0.10 d = θ_0/θ_1 = 2.0
θ_1 = 50,000 β = 0.10

Test plan: Sequential test Plan IIIC from Reference 1 (MIL-STD-781C)

Failures	Accept if >=		Reject if <=	
	Test multiple	Time[2]	Test multiple	Time[2]
0	4.4	220,000	***	***
1	5.79	289,500	***	***
2	7.18	359,000	***	***
3	8.56	428,000	0.7	35,000
4	9.94	497,000	2.08	104,000
5	11.34	567,000	3.48	174,000
6	12.72	636,000	4.86	243,000
7	14.1	705,000	6.24	312,000
8	15.49	774,500	7.63	381,500
9	16.88	844,000	9.02	451,000
10	18.26	913,000	10.40	520,000
11	19.65	982,500	11.79	589,500
12	20.6	1,030,000	13.18	659,000
13	20.6		14.56	
14	20.6		15.94	
15	20.6		17.34	
16	***		20.60	

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ORT testing conditions:

- Test time per set: 1080 hours/set
- Sample size: 20 pcs
- Environmental: 60 ^{0}C
- Power cycling: （Panel has been powered on all the time）

[2] Test time is found by multiplying the test multiple by the lower test MTBF (θ_1).

ORT test reporting:

- PRST chart of Test Plan IIIC from reference 1 will be updated on a monthly basis with the cumulative testing time (including pre-production MTBF testing of section 4.0) and cumulative number of ORT failures.

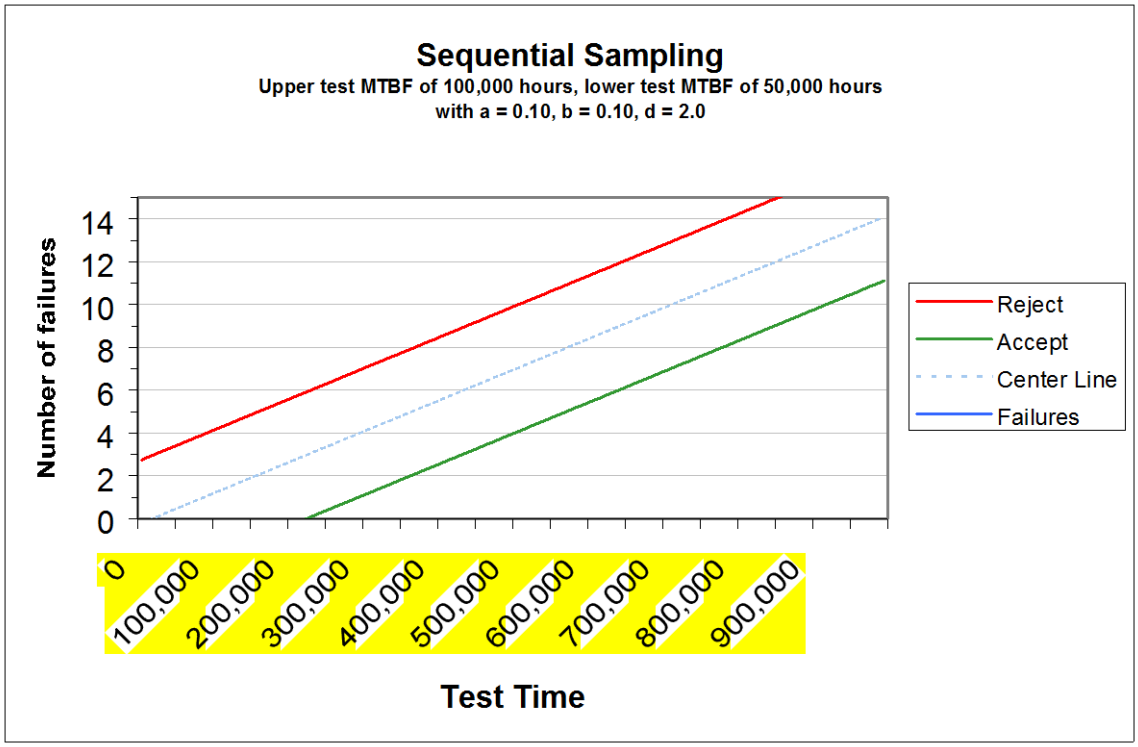
- Cumulative test time will be accelerated by the same factors used in section 4.0 due to same testing conditions to generate the demonstrated test time:

  Demonstrated time on test = Time on test x 11.64 (60°C)

  This demonstrated time on test is then plotted on the SPRT chart.

* The tracking and plotting of this data and following this test plan will be simplified by the use of the attached appendix A file: SPRT Exponential. xls.

  This file has the Plan IIIC chart built into it and will automatically calculate and plot the acceleration factors for demonstrated time on test. All that is required for the manufacturing facility is to take the data from their ORT logs once a month and enter the number of ORT failures that month and the total number of set hours on test for that month. An example of this file and output is shown in appendix A.


Sequential Sampling
Upper test MTBF of 100,000 hours, lower test MTBF of 50,000 hours
with a = 0.10, b = 0.10, d = 2.0
Number of failures
0
2
4
6
8
10
12
14
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000
900,000
Test Time
Reject
Accept
Center Line
Failures

6.0 Test result: demonstrate MTBF > 100,000 hours

6.1 Test equipment: Dynamic operation, DC power supply, Signal generator
6.2 Test location : AUS S01 Reliability Lab.
6.3 Test date : 2018/11/26-2019/1/15,
6.4 Sample size : 20units
6.5 Test condition: Temperature: 60 ^{0}C
6.6 Check point : Before/after test…
6.7 Check item :

1) The LCD module shall meet the Product Spec. after HTO test. No mal- function, screen quality and appearance.
2) The LCD cell shall meet the Functional Spec. after HTO test. No defect of function, screen quality and appearance. (Bezel deform action and polarizer abnormal were belong to fail. And the pixel defect shall not be increased after test)
3) The LCD array shall meet the Functional Spec. after HTO test. No defect of function, screen quality and appearance. (To put in normal temp, and check FOS at each time, the mura, bezel deform action and pixel defect increase shall not be allowed)

6.8 Test criteria : Confident Level: 90% ; MTBF ≥ 100,000 hours

6.9 Test result : PASS
MTBF = 101,217.4 **hours** ＞**100,000 hours**

Demonstrated MTBF = (sample size) x (# days) x 20 (hours/day) x 11.64 (Temperature: 60 ^{0}C) / 2.3 (90% confidence level)
= 20 x 1000 x 11.64/ 2.3
= 101,217.4hours