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Test Report For:

COMPANYNAME

Failure Mode Verification Test (FMVT®)
on

Client PO:

_____
Alex Porter
Engineering Development Manager

Test Name	Failure Mode Verification Test (FMVT®)
Test Classification	Comparison Testing
Requester	Client
Part Description	Four Models of Night Lights

DATE RECEIVED: **4/14/2004**
DATES TESTED: **4/14/2004**

DESCRIPTION OF SAMPLES:

Four different kinds of night lights.

A - Incandescent
B - LED - Butterfly
C - Flat
D - LED - Mouse

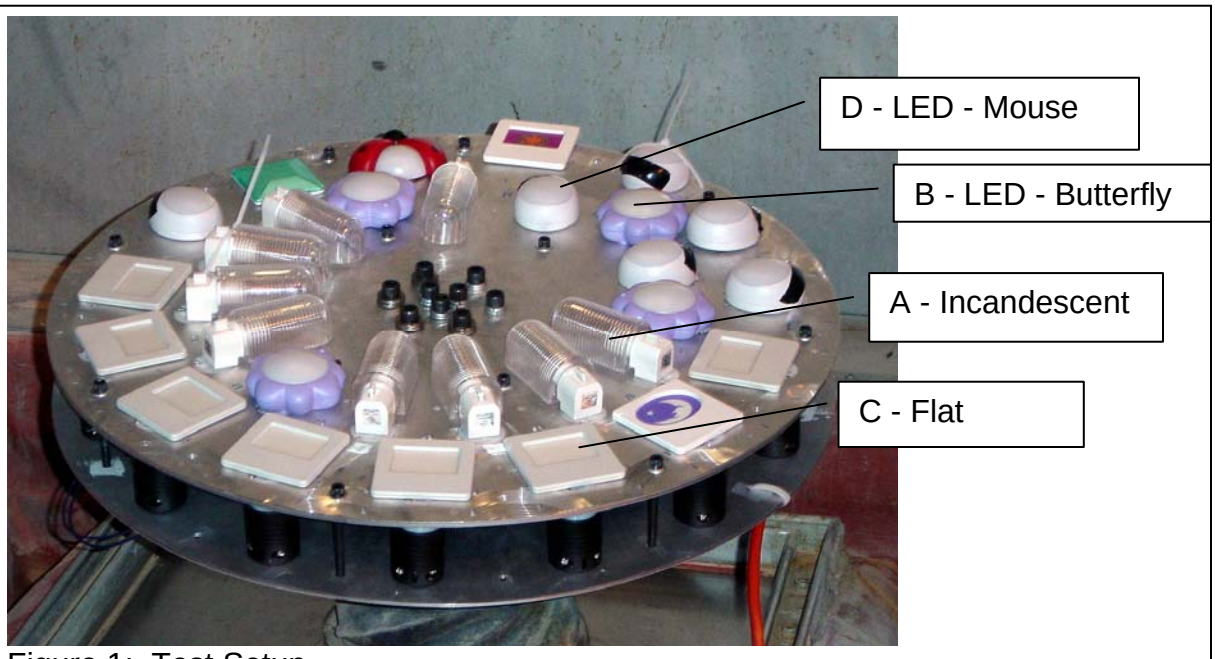


Figure 1: Test Setup

OBJECTIVE:

To identify potential failure modes of the part/system and to differentiate the relative durability of the different types of night lights using Failure Mode Verification Test Methodology (FMVT®).

Failure Mode Verification Testing or FMVT® is a patented process that incorporates accelerated testing techniques to find failures in test subjects or specimens. The objective is to quickly evaluate design concepts, compare competing designs and/or to track real world failures such as warranty. Utilizing FMVT, the design inherent weaknesses and technological limits are determined in order to allow for fast design change turn around.

The process begins by identifying failure modes or potential failure modes of the design. These failure modes are normally caused by environmental stimuli such as temperature, vibration, humidity, mechanical actuation, electrical exposure, etc.

Once defined, these environments are then combined and modified in incremental steps. Each step is harsher than the last and will drive the test subject to its eventual limits. By recording failures and times of failures from the beginning to the end of the test, it is then possible to determine the state of the design relative to its Design Maturity (DM) level.

WORK REQUESTED APPLICABLE DOCUMENTS:

FMVT® with the stress source and operational checks as described in this report. This information is provided in **Appendix A** of this report.

SPECIFIC STRESS SOURCES:

The stress sources within the FMVT on the part/system included:

Figure 2 Voltage, Sag, Swell

Figure 3: Temperature Hot, Cold, Humidity

Figure 4: Dust

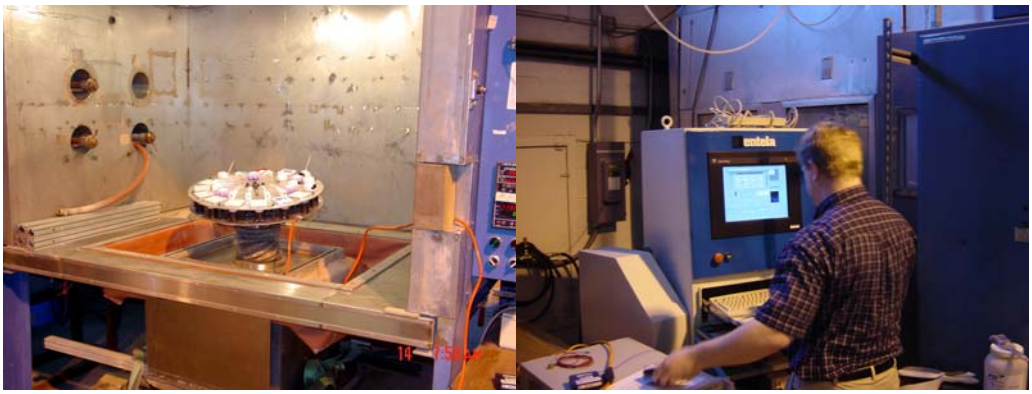


Figure 5: Impact, Hairspray, Vibration.

TEST PLAN:

Table I details the FMVT stress level plan.

level	Voltage	Sag	Swell	Temperature hot	Temperature cold	Humidity	Dust	Impact	Hairspray	Vibration
1	110	10%	10%	40.0	10.0	75%	10	1	1	5
2	108	20%	20%	46.7	5.6	77%	20	1	1	8
3	106	30%	30%	53.3	1.1	79%	30	1	1	11
4	104	40%	40%	60.0	-3.3	82%	40	1	1	14
5	102	50%	50%	66.7	-7.8	84%	50	1	1	17
6	100	60%	60%	73.3	-12.2	86%	60	1	1	20
7	98	70%	70%	80.0	-16.7	88%	70	1	1	23
8	96	80%	80%	86.7	-21.1	91%	80	1	1	26
9	94	90%	90%	93.3	-25.6	93%	90	1	1	29
10	90	100%	100%	100	-30	95%	100	1	1	30

SPECIFIC OPERATIONAL CHECKS:

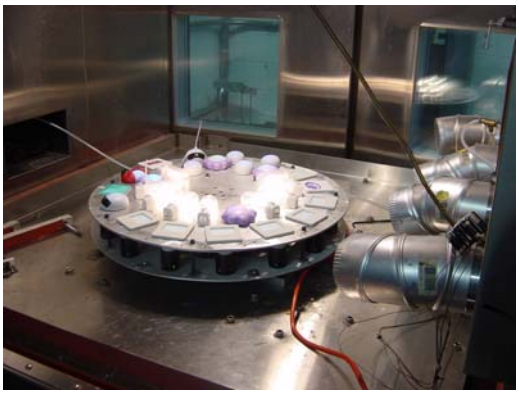
The operational checks within the FMVT on the part/system included:

Current and power draw
Visual inspection of light
Visual inspection for cracking

Figure 6: After Level one

Test Results

Four different parts completed ten levels of the FMVT. Three of the four designs exhibited failure modes. One of the designs completed ten levels without it exhibiting any significant failures. The design maturity will be calculated for each design separately.



As Received

Level Three

Level Five

Level Five

Figure 7

DESIGN MATURITY:

Design Maturity is a measure of the average potential for improvement in a design. Design Maturity quantifies the spread or distribution of individual failure modes in a product. (See Figure 1)

DESIGN MATURITY (cont.):

The maturity of the design is measured by conducting an FMVT and plotting the failure mode progression. Design Maturity is:

$$DM = ((Tmax-Tmin)/(Count-1))/Tmin$$

Where:

Tmax = Time to the last unique failure found
Tmin = Time to the first unique failure found
Count = The number of unique failures found

Predicted values for the Design Maturity can also be calculated by assuming that one or more of the earliest failure modes are corrected. The Predicted Design Maturity (PDM) is then determined by:

$$PDM_i = ((Tmax-T_{(i+1)})/(Count-1-i))/ T_{(i+1)}$$

Where:

Tmax = Time to the last unique failure found
T(i+1) = Time to the ith+1 unique failure found
Count = The number of unique failures found.
i = i^{th} Failure Mode

	Type A	Type B	Type C	Type D
Design Maturity	7199.8	0.5	0	n/a
PDM1	2.653226	1		
PDM2	0.166667			
	0.25			
	0.2			

Type A lights failed early and often.
Type B has a moderate potential for improvement. However, fixing the first failure does not help unless the second failure is fixed also.
Type C is theoretically at its limit. However only two failures were found . Therefore, if one of the failures is addressed the other should be also.
Type D had not reached any significant failures before the end of the test so its maturity could not be determined.

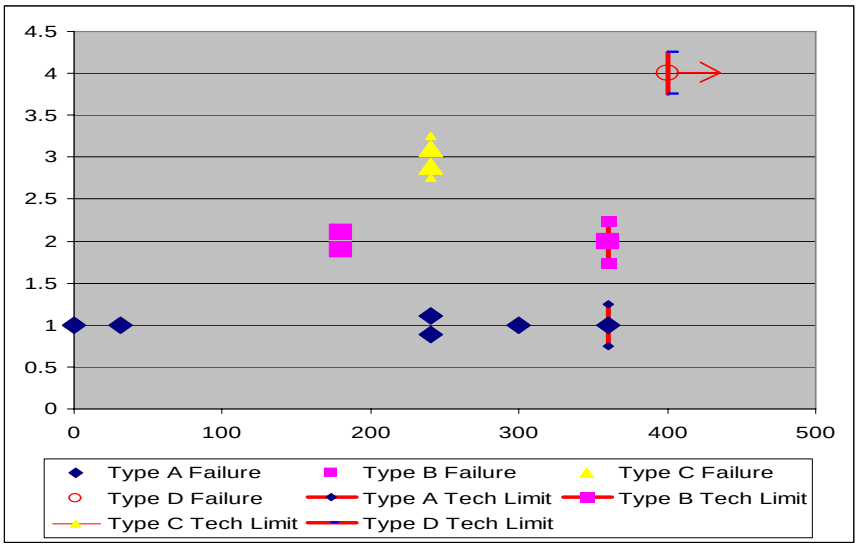


Figure 8: Failure Mode Progression

TECHNOLOGICAL LIMIT:

Technological Limit (TL) is a theoretical limit on a design's potential for improvement. The Technological Limit is the time when the Predicted Design Maturity is less than 0.1. (TL = $T_{(i+1)}$ where PDMi <0.1). A Design Maturity of > 0.1 is the point where fixing any additional failures would produce less than a 10% improvement in the product. Therefore, failures that occur before the technological limit are of particular interest.

For the four models type A through C did not reach their technological limit before the units failed completely. This means that fixing all of the known failures would not necessarily result in a mature design. After fixing the failures, the units would have to be tested again to determine the resulting maturity.

Type D did not exhibit any significant failures, therefore the design is considered to be mature. The unit would have to be tested further to quantify how mature it is. The technological limit is assumed to be beyond the end of the test.

HISTOGRAM OF FAILURES:

In addition to determining the maturity of a design and the technological limit, the re-occurrence of a failure during the test is of interest. A failure that occurs once (see failure 2 below) and then never reproduced is of little concern. While a failure that is chronically reproduced, starting below the technological limit and continuing throughout the test, is of great concern. Figure 2 shows the histogram of the failure modes by level.

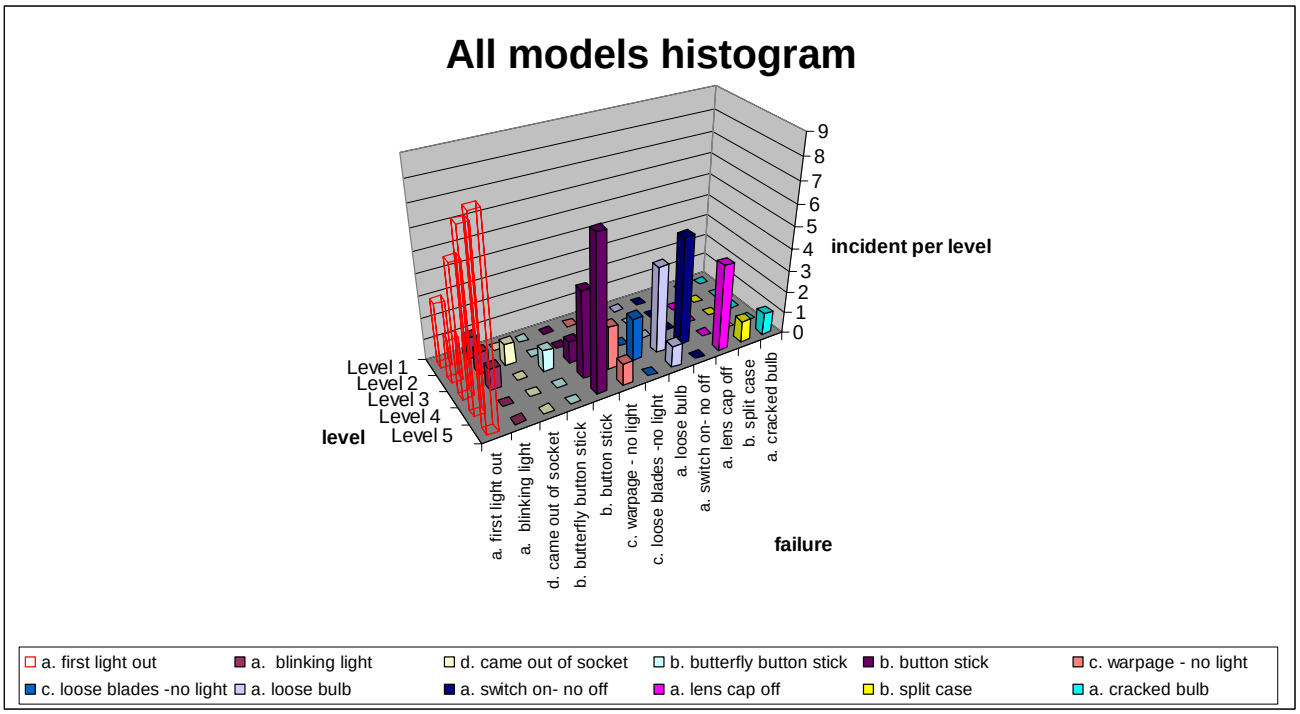


Figure 9: Histogram of Failures by Level: Levels are labeled.

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RESULTS:

The part/system exhibited 12 failures:

Type A	Type B	Type C	Type D
first light out	button stick	warpage - no light	came out of socket
blinking light	split case	loose blades -no light	
loose bulb		appears to be off	
switch on- no off			
lens cap off			
cracked bulb			

Nightlight FMVT Evaluation Results

Type A: All failures should be addressed and the unit retested.

Light Out, Loose Bulb, and Lens Cap – Being replaceable, the client may have called these non-failures. This would be addressed prior to conducting the test in determining the information goal. Blinking light may be a precursor to the Light Out Failure Mode, but may warrant further investigation - both from safety and performance perspectives. Switch On-No Off warrants further investigation - both from safety and performance perspectives. Since we did not have access to the Bill of Materials, we may have exceeded material temperature limits. All parameters of stress sources are defined prior to conducting the testing in determining the information goal. Cracked Bulb – this Failure occurred during the last level and only happens on one sample. However, before calling it a failure mode that is insignificant, we would recommend further investigation – both from safety and performance perspectives.

Type B: All failures should be addressed and the unit retested.

Button Stick – The failure occurred early on and we would recommend further investigation – both from safety and performance perspectives. Split Case – Although the failure occurred late, we would recommend further investigation – both from a safety and performance perspectives.

Type C: Appears To Be Off, Warpage and Loose Blades – These failures occurred midway through and should be looked at for premature failure. We would recommend further investigation – both from safety and performance perspectives.

Type D: No significant failures found. If the unit is to be improved, the test will have to be re-run with much more severe maximum level stresses.

Observation Description.

Number	Observation	Time (min)	Level	Failure Number
1	test setup	0	0	0
2	a first light out	0.01	1	1
3	a two lights out	0.01	1	1
4	a light out	9	1	1
5	a blinking light	31	1	2
6	b click between modes not solid click	60	1	0
7	a light out	90	2	1
8	c appears to be off	61	2	0
10	a flicker is worse	90	2	2
11	a light out	110	2	1
12	d came out of socket	120	2	3
13	d full of water as a result of falling out	120	2	0
14	a light out	140	3	1
15	a light out	140	3	1
16	a light out	140	3	1
17	a light flickering	140	3	2
18	a light out	142	3	1
19	b sample with click problem not changing colors	147	3	0
20	a light out	180	3	1
21	a light out	180	3	1
22	b butterfly button stick	180	3	4
23	b button stick	180	3	5
24	a light flickering bulb was loose	180	3	0
25	a light out	195	4	1
26	a light out	195	4	1
27	a light out	205	4	1
28	a flicker	210	4	0
29	a flicker	215	4	0
30	c warpage - no light	240	4	6
31	c loose blades -no light	240	4	7
32	c warpage -no light	240	4	6
33	c loose blades-no light	240	4	7
34	a light out	240	4	1
35	a light out	240	4	1
36	a light out	240	4	1
37	a light out	240	4	1
38	a light out	240	4	1
39	a loose bulb	240	4	8
40	a loose bulb	240	4	8
41	a loose bulb	240	4	8
42	a loose bulb	240	4	8
43	a switch on- no off	240	4	9
44	a switch on- no off	240	4	9
45	a switch on- no off	240	4	9
46	a switch on- no off	240	4	9
47	a switch on-no off	240	4	9
48	b button stick -can't turn on	240	4	5
49	b buttonstick - can't turn on	240	4	5
50	b button stick - can't turn on	240	4	5
51	b button stick-can't turn on	240	4	5
52	stick buttons can be switch by impact - not by button	240	4	0
53	c - warpage-working	240	4	0
54	a light out	270	5	1
55	a light out	270	5	1
56	a light out	270	5	1
57	a light out	270	5	1
58	a light out	270	5	1
59	a light out	270	5	1
60	a light out	270	5	1
61	a light out	270	5	1
62	a light out - strobing	270	5	1
63	b switched off - impact possible	280	5	5
64	b switched off -impact possible	280	5	5
65	c warped on - flopping around	280	5	6
66	b switched off -impact possible	290	5	5
67	b switched off-impact possible	290	5	5
68	b switched off-impact possible	290	5	5
69	a lens cap off	300	5	10
70	a lens cap off	300	5	10
71	b switched back on	310	5	5
72	a lens cap off	310	5	10
73	a loose bulb - possible glass separation	310	5	8
74	a lens cap off	312	5	10
75	b switched back off	310	5	5
76	b split case	360	5	11
77	a cracked bulb	360	5	12

TERMS AND CONDITIONS

The following terms and conditions apply to all work performed by Intertek, Unless specifically exempted in writing by an officer of Intertek.

1. Intertek represents to the client that testing is done in accordance with standard procedures as applicable and that reported test results are accurate within generally accepted commercial ranges of accuracy, unless a specific measure of greater accuracy has been agreed to in writing by Intertek and the client.

2. Intertek reports apply only to the specific sample(s) tested under stated test conditions and test results are not necessarily indicative of the qualities of apparently identical or similar test or operating conditions. Intertek shall have no liability for any deductions, inferences or generalizations drawn by the client or others from Intertek reports.

3. When Intertek performs services, its work and reports are not governed by the Uniform Commercial Code. Except as stated in Paragraph 1, Intertek disclaims all warrants of merchantability or fitness for a particular purpose. Intertek assumes no liability for incidental or consequential damages of any nature whatsoever.

4. The client shall not advertise or publish the name, the seal or servicemark, reports, test results, documentation or procedures of Intertek without written authorization from Intertek Any test reports provided to client by Intertek shall not be reproduced **except *in full*** without the approval of Intertek The client's actual or threatened failure to abide by this Paragraph 4 may result in legal action by Intertek for injunctive and other relief.

5. Payment for the services rendered is the obligation of the client issuing the purchase order or accepting the proposal. The obligation is not contingent on any specific result from Intertek's services and may not be assigned without the written permission of Intertek

6. If services are to be supplied to a client who has not established credit with Intertek, or in connection with a legal action, a retainer equal to the estimated cost is required with the order, which retainer may be applied at Intertek's option to its final billings. The minimum retainer required for services to be performed in connection with a legal action is $1,000.

7. If the service to be performed requires more than one (1) month for completion, Intertek will make monthly billings of the approximate percentage of the work completed each month, supplying with the interim invoice a progress report showing accomplishments to date. Terms of all invoices shall be net cash on receipt of invoice.

8. If the client desires forensic testing services, the client must mark each test sample and supporting documents and the test authorization form conspicuously as "LEGAL". Unless otherwise indicated in writing, prices quoted or charged by Intertek do not include charges for any court appearance, records retrieval/storage, expert witness testimony, deposition, or affidavit, or preparation thereof, in connection with forensic testing services. Such charges will be computed at Intertek's then prevailing hourly rates, plus expenses. All such charges must be prepaid by the client prior to such appearance, testimony, deposition or affidavit and, where required by law, advance court approval of charges must be obtained by the client at the client's expense.

9. In the event that Intertek, as a result of an order or subpoena issued by a court, is called upon to produce or testify in respect to a report, it will advise the client of the fact and the time and place of the scheduled hearing, if reasonable advance notice is given to Intertek If the client has any objections to Intertek complying with such order or subpoena, it will be the client's obligation to present such objections to the court at or prior to the time specified in such order or subpoena, and to give timely notice to Intertek of the results.

10. Intertek shall purchase, and client agrees to sell and convey title to any and all parts, assemblies, or products submitted for testing and analysis to Intertek for the sum of $1.00. Upon completion of testing and analysis any and all parts, assemblies or products used or consumed during the course of our work shall be sold to and title conveyed to Client for the sum of $1.00. Sample(s) will be destroyed thirty (30) days after the date of the final report, unless the client indicates otherwise in writing and prepays before the expiration of said 30-day period the entire cost of storing, packaging, and shipping the sample(s).

11. Prices quoted by Intertek are subject to change if not accepted by the client within thirty (30) days, or if the work involved is not commenced within forty-five (45) days of such acceptance through no fault of Intertek

12. Intertek's liability for damage to or loss or destruction of the client's property while it is in the possession of Intertek will be limited to the amount Intertek has agreed to charge the client for the services.

13. Any order or agreement for testing services by Intertek may be terminated in writing by the client before completion thereof with Intertek's written consent in which event the client shall pay to Intertek an amount to be determined by Intertek as being sufficient to reimburse Intertek for all direct and indirect costs and expenses, including (but not limited to) suppliers, materials, labor, and overhead incurred with respect to the order or agreement through the date of termination..

14. Intertek shall not be liable for any failure or delay in performance which is caused in whole or in part by fire, flood, accident, riot, war, operation of law, government action, strikes or other labor disturbances, fuel shortages, or any other cause beyond the control of Intertek

15. All contracts between Intertek and the client shall be deemed to be made in and governed by the laws of the State of Michigan.

16. Should Intertek be required to subcontract any testing or other services, the client will be informed of such arrangement either verbally or in writing. Intertek shall have no liability for any deductions, inferences, or generalizations drawn by the client or others from subcontractor's data.

17. Should witness of testing or services on Intertek premises be requested, the client shall comply with all applicable safety regulations and precautions. Client shall supply, if requested, evidence of workers compensation coverage prior to visit.

18. Any action taken by a client based on any consulting or recommendations as provided by Intertek are the sole responsibility of the client or recommendations as provided by Intertek are the sole responsibility of the client.