

# Addendum B for TM-21-11: Projecting Long Term Lumen Maintenance of LED Light Sources

If you, as a user of IES's TM-21-11, believe you have located an error not covered by the following revisions, you should e-mail your information to Pat McGillicuddy, [pmcgillicuddy@ies.org](mailto:pmcgillicuddy@ies.org) or send a letter to Pat McGillicuddy, Manager of Technology, IES, 120 Wall St. 17<sup>th</sup> Floor, New York, NY 10005. Additions will be posted to this list online as they become available. This errata list was last updated **October 5, 2015**.

This Addendum replaces specified sections in document *IES TM-21-11* based on the post-publishing practice and users' inputs. This Addendum supersedes and nullifies the statements made in Addendum A for TM-21-11: Projecting Long Term Lumen Maintenance of LED Packages.

## 4.3 Luminous Flux Data Collection and Selection

Additional measurements after the initial 1000 hours at intervals smaller than 1000 hours (including every 1000 hour points) are encouraged. Additional measurements beyond 6000 hours are encouraged and will provide the basis for more accurate lumen maintenance predictions.

Data collected within a  $\pm 48$  hour window of each "1000 hour measurement point", e.g., from 952 hours to 1048 hours, from 1952 hours to 2048 hours, etc., are acceptable for use in product lumen maintenance projections. The  $\pm 48$  hour window is also applicable to other intervals smaller than 1000 hours. The exact time designation shall be used in the projection calculation.

### 5.2.3 Data Used for Curve-fit

For data sets of test duration,  $D$ , from 6000 hours up to 10000 hours, the data used for the curve-fits shall be the last 5000 hours of data. Data before the 1000 hour reading shall not be used for the curve fit.

Data collected within a  $\pm 48$  hour window of each "1000 hour measurement point", e.g., from 952 hours to 1048 hours, from 1952 hours to 2048 hours, etc. shall be acceptable as each "1000 hour reading" and shall be used for luminous flux maintenance projection with the actual measured elapsed time value. The  $\pm 48$  hours window is also applicable to other intervals smaller than 1000 hours. The actual measured elapsed time values shall be used in the projection calculation.

The data collection points used in the projection calculation shall be equally dispersed in time (to within  $\pm 48$  hours). No two consecutive data collection intervals after the initial 1000 hours shall differ by more than 96 hours in length. For example, data may be used in the projection calculation which are collected every 1000 hours ( $\pm 48$  hours), every 500 hours ( $\pm 48$  hours) etc.,

but not every 1000 hours and occasionally at 500 hours, since this will give excessive statistical weight to certain data points.

For data sets of test duration greater than 10000 hours, the data for the last 50% of the total test duration shall be used for curve-fit. In other words, all data points between  $D/2$  and  $D$  shall be used. For example, if the test duration is 13000 hours, use all data points between 6500 hours and 13000 hours. If there is no data point at  $D/2$ , then the next lower time point shall be included in the data fitting. For example, for 0 of 13000 hours of data taken every 1000 hours, use the data points between 6000 and 13000 hours.

## 6.0 Temperature Data Interpolation

When in-situ DUT case temperature,  $T_{s,i}$ , is different from the temperatures used for *LM-80-08* tests, the following procedures should be used to predict lumen maintenance life of the DUTs corresponding to the in-situ case temperature with the same operational condition (e.g., drive current).

## 6.5 Limit for Extrapolation

Extrapolation of any  $L_p$  value above the operating temperature used in the *LM-80-08* test shall not be performed. For example, if the highest *LM-80-08* test temperature is 85°C, an  $L_p$  at 100°C shall not be extrapolated.

If the actual operating temperature is below the lowest temperature that is used in the *LM-80-08* test, the reported  $L_p$  value shall use the lowest temperature in *LM-80-08* test. For example, if the lowest *LM-80-08* test temperature is 55°C, an  $L_p$  at 45°C shall use  $L_p$  at 55°C.

For interpolation between case temperatures with test durations of unequal lengths, in instances where the higher temperature has shorter testing duration, projections shall not extend beyond 6 times the test duration of the higher temperature for 20 or more samples (5.5 times for 10 to 19 samples). In instances where the lower temperature has shorter testing duration, projections shall not extend beyond 6 times the linearly interpolated testing duration for 20 or more samples (5.5 times for 10 to 19 samples).

## 7.0 Report

The report of lumen maintenance life projection shall include the following information shown in **Table 1**. The reported  $L_{70}$  values shall be rounded to 3 significant digits.  $\alpha$  and  $B$  values shall be rounded to 4 significant digits.

**Table 1 - Recommended information to be included in the report at each *LM-80-08* test condition.**

Description of LED light source tested (manufacturer, model, catalog number, etc.)	
Sample size	
Number of failures	
DUT drive current used in the test	mA
Test duration	hours
Test duration used for projection	hour to hour
Tested case temperature	°C
$\alpha$	
$B$	
Reported $L_{70}(Dk)$	hours

When interpolation is used, the additional following information shall be presented, as shown in **Table 2**.

**Table 2 - Recommended information to be included in the report for interpolation (refer to Section 6 for definitions).**

$T_{s,1}, (^{\circ}C)$	
$T_{s,1}, (^{\circ}K)$	
$\alpha_1$	
$B_1$	
$T_{s,2}, (^{\circ}C)$	
$T_{s,2}, (K)$	
$\alpha_2$	
$B_2$	
$E_a/k_B$	
$A$	
$B_0$	

The Calculated and Projected  $L_p(Dk)$  are not to be reported in **Table 1** or **Table 2**. These values are set for the purpose of calibrating the calculation tools for the users. Due to the statistical uncertainty stated in **Annex D**, the calculated result in hours beyond reported projection limit set in **Section 5.2.5** does not have any practical or meaningful value.

These Tables within **Annex E - Data Test Set for Validation of Calculation – Examples** are to be replaced with the versions presented in this Addendum B.

**Table E3** - Least square curve-fit for 6000 hours *LM-80-08* test data at temperature point  $T_{s,1} = 55\text{ }^{\circ}\text{C}$ .

Point #	Time [h]	ln (Average)	xy	x	y	x <sup>2</sup>
1	1000	-0.03252	-32.5	1000	-0.0325	1.000E+06
2	2000	-0.02850	-57.0	2000	-0.0285	4.000E+06
3	3000	-0.03387	-101.6	3000	-0.0339	9.000E+06
4	4000	-0.04093	-163.7	4000	-0.0409	1.600E+07
5	5000	-0.04573	-228.7	5000	-0.0457	2.500E+07
6	6000	-0.04688	-281.3	6000	-0.0469	3.600E+07
	Sums	-0.2284	-864.8	21000	-0.2284	9.100E+07
	Slope	-3.730E-06				
	Intercept	-2.502E-02				
	$\alpha_1$	3.730E-06				
	$B_1$	9.753E-01				
	Reported $L_{70}(6k)$	>36,000				

**Table E4** - Least square curve-fit for 6000 hours *LM-80-08* test data at temperature point  $T_{s,2} = 85\text{ }^{\circ}\text{C}$ .

Point #	Time [h]	ln (Average)	xy	x	y	x <sup>2</sup>
1	1000	-0.03718	-37.2	1000	-0.0372	1.000E+06
2	2000	-0.03459	-69.2	2000	-0.0346	4.000E+06
3	3000	-0.04625	-138.8	3000	-0.0463	9.000E+06
4	4000	-0.05911	-236.4	4000	-0.0591	1.600E+07
5	5000	-0.06571	-328.6	5000	-0.0657	2.500E+07
6	6000	-0.06785	-407.1	6000	-0.0679	3.600E+07
	Sums	-0.31069	-1217.2	21000	-0.3107	9.100E+07
	Slope	-7.416E-06				
	Intercept	-2.582E-02				
	$\alpha_1$	7.416E-06				
	$B_1$	9.745E-01				
	Reported $L_{70}(6k)$	>36,000				

**Table E5** - Parameters of interpolation using 6000 hours of *LM-80-08* data for in-situ case temperature  $T_{s,i} = 70$  °C.

$T_{s,1}$ , (°C)	55
$T_{s,1}$ , (K)	328.15
$\alpha_1$	3.730E-06
$B_1$	0.9753
$T_{s,2}$ , (°C)	85
$T_{s,2}$ , (K)	358.15
$\alpha_2$	7.416E-06
$B_2$	0.9745
$E_a/k_B$	2692
$A$	1.365E-02
$B_0$	9.749E-01

**Table E9** - Least square curve-fit for 10000 hours *LM-80-08* test data at temperature point  $T_{s,1} = 55$  °C.

Point #	Time [h]	ln (Average)	xy	x	y	$x^2$
1	5000	-0.04573	-228.7	5000	-0.0457	2.500E+07
2	6000	-0.04688	-281.3	6000	-0.0469	3.600E+07
3	7000	-0.04604	-322.3	7000	-0.0460	4.900E+07
4	8000	-0.05087	-407.0	8000	-0.0509	6.400E+07
5	9000	-0.05477	-492.9	9000	-0.0548	8.100E+07
6	10000	-0.05182	-518.2	10000	-0.0518	1.000E+08
	Sums	-0.29611	-2250.3	45000	-0.2961	3.550E+08
	Slope	-1.684E-06				
	Intercept	-3.672E-02				
	$\alpha_1$	1.684E-06				
	$B_1$	9.639E-01				
	Reported $L_{70}(10k)$	>60,000				

**Table E10** - Least square curve-fit for 10000 hours *LM-80-08* test data at temperature point  $T_{s,1} = 85\text{ }^{\circ}\text{C}$ .

Point #	Time [h]	ln (Average)	xy	x	y	x <sup>2</sup>
1	5000	-0.06571	-328.6	5000	-0.0657	2.500E+07
2	6000	-0.06785	-407.1	6000	-0.0679	3.600E+07
3	7000	-0.07021	-491.5	7000	-0.0702	4.900E+07
4	8000	-0.07753	-620.2	8000	-0.0775	6.400E+07
5	9000	-0.08251	-742.6	9000	-0.0825	8.100E+07
6	10000	-0.07893	-789.3	10000	-0.0789	1.000E+08
	Sums	-0.44274	-3379.3	45000	-0.4427	3.550E+08
	Slope	-3.354E-06				
	Intercept	-4.863E-02				
	$\alpha_1$	3.354E-06				
	$B_1$	9.525E-01				
	Reported $L_{70}(10k)$	>60,000				

**Table E11** - Parameters of interpolation using 10000 hours of *LM-80-08* data for in-situ case temperature  $T_{s,i} = 70\text{ }^{\circ}\text{C}$ .

$T_{s,1}, (^{\circ}\text{C})$	55
$T_{s,1}, (\text{K})$	328.15
$\alpha_1$	1.684E-06
$B_1$	0.9639
$T_{s,2}, (^{\circ}\text{C})$	85
$T_{s,2}, (\text{K})$	358.15
$\alpha_2$	3.354E-06
$B_2$	0.9525
$E_a/k_B$	2699
$A$	6.283E-03
$B_0$	9.582E-01