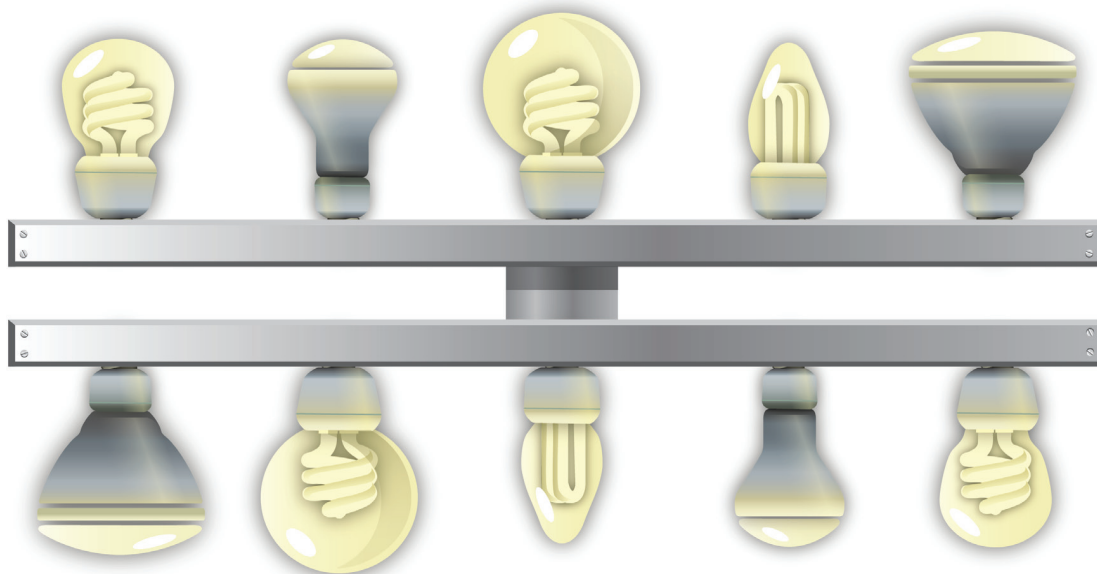


ENERGY STAR[®]

CFL THIRD PARTY TESTING AND VERIFICATION



Off-the-Shelf CFL Performance: Batch 3



February 2013



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Off-the-Shelf CFL Performance: Batch 3

February 1, 2012

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U.S. Environmental Protection Agency

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EXECUTIVE SUMMARY

As of July 31, 2012, the Independent ENERGY STAR CFL Third Party Testing and Verification Program had tested and verified the performance of 254 base models. By way of context, as of December 1, 2012 there were 3,221 ENERGY STAR qualified CFL models, based on 959 base models. Each product was procured “off the shelf” by an independent testing laboratory and subjected to the same tests that are required for initial qualification.

This is the third report under this program. The first report, published in May 2011, covers the 68 models that completed testing by February 5, 2011 (Batch 1), and the second report covers the 68 models that completed testing between February 6 and July 31, 2011 (Batch 2). The current report covers the 118 models that completed testing between August 1, 2011 and July 31, 2012. On average, the models in Batch 3 came on the market nearly 1 year after those in Batch 2, and thus represent newer models.

Every product included in Batch 3 passed the Efficacy and Power Factor Tests. Overall, 50% of models in Batch 3 failed at least one other test, as required for ENERGY STAR qualification. Covered lamps failed at a higher rate than bare spiral and bare specialty models. Of bare specialty and bare spiral models, 83% and 67% passed all tests, respectively, whereas 22% of covered models passed all tests.

Of the 56 lamps in Batch 3 that failed testing, 32 failed one test, and 24 failed two or more tests. Of the 24 that failed at least two tests, 20 were covered, 4 were bare spiral, and none were bare specialty models. Further, of the 56 models that failed testing, 28 significantly underperformed on at least one of the failed tests. This means the product's measured performance was more than two standard deviations away from the mean value.

Among original equipment manufacturers with more than 5 models tested through July 31, 2012, there was a wide range of performance. Overall failure rates range from 0% to 83%. These 9 OEM partners represent 75% of all models tested and 73% of all model failures in Batch 3; 6 had failure rates of at least 40%.

Use care when generalizing from the test results described in this report to the entire market of ENERGY STAR qualified CFLs. The sample of models tested is not representative of ENERGY STAR shipments, nor is it perfectly representative of the current list of ENERGY STAR qualified models.

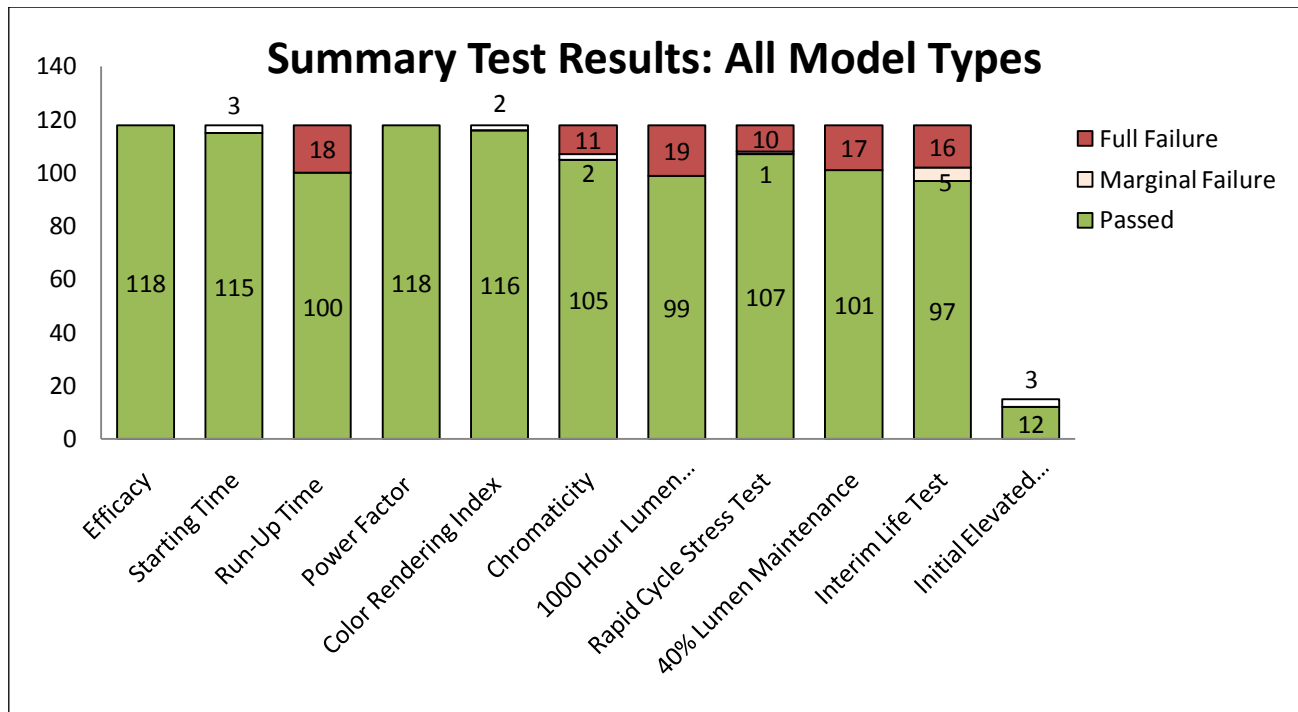
SUMMARY RESULTS

This is a summary of the results of verification testing completed between August 1, 2011 and July 31, 2012 (Batch 3). Batch 3 contains a total of 118 ENERGY STAR qualified models: 66 bare spiral models, 6 bare specialty models, and 46 covered models.¹

The results of verification testing completed before March 31, 2010 (Batch 1) are presented in the report first published in June 2011 and updated in July 2011.² The results of verification testing completed between April 2010 and July 2011 (Batch 2), are presented in a report published in February 2012. The final section of this report reviews aggregate results from all three batches.

As shown in Figure 1, every product included in Batch 3 passed the Efficacy and Power Factor Tests. Two models failed the Color Rendering Index Test, while three models each failed the Starting Time and Initial Elevated Temperature Output Tests. Between 10 and 19 models failed each of the remaining 6 tests.

Figure 1



Note: A marginal failure is defined as a tested unit with one less sample passing a test than required. For example, a product that failed the Rapid Cycle Stress Test with 4 of 6 samples passing instead of the required 5 of 6 is scored as a marginal failure. Models that have one or more marginal failure but no other failures must undergo a re-test.

¹ Bare specialty lamps include dimmable and 3-way bare lamps.

² D&R International, "ENERGY STAR CFL Third Party Testing and Verification Cycle 1: Results," May 2011. (www.energystar.gov/ia/partners/downloads/Cycle_1_Final_Report_Public_7-18-11.pdf)
D&R International, "ENERGY STAR CFL Third Party Testing and Verification Cycle 2: Off-the-Shelf CFL Performance, Trends, and Implications," May 2012. (www.energystar.gov/ENERGY_STAR_CFLs_Batch_2_Report_Public_2-2-12.pdf)

There was some variation in the results among different lamp types. The Rapid Cycle Stress Test and Chromaticity Tests had the highest failure rates for bare spiral models (9% failed), while the Run-Up Time and 1000-Hour Lumen Maintenance Tests were especially challenging for covered models (37% failed each). Covered models also had trouble with the 40% Lumen Maintenance Test (33% failed) and the Interim Life Test (24% failed). The only bare specialty failure occurred in the Starting Time Test (17% failed).

Figure 2

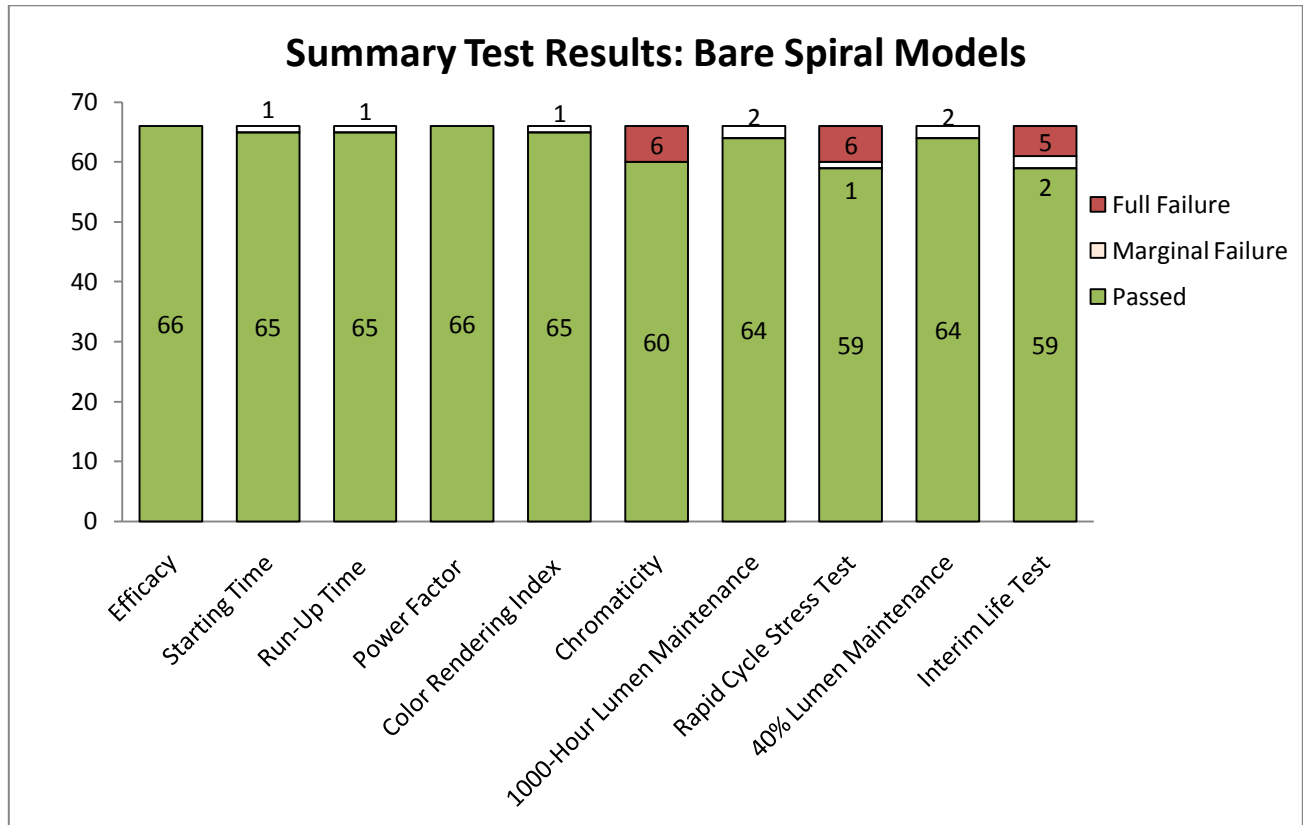


Figure 3

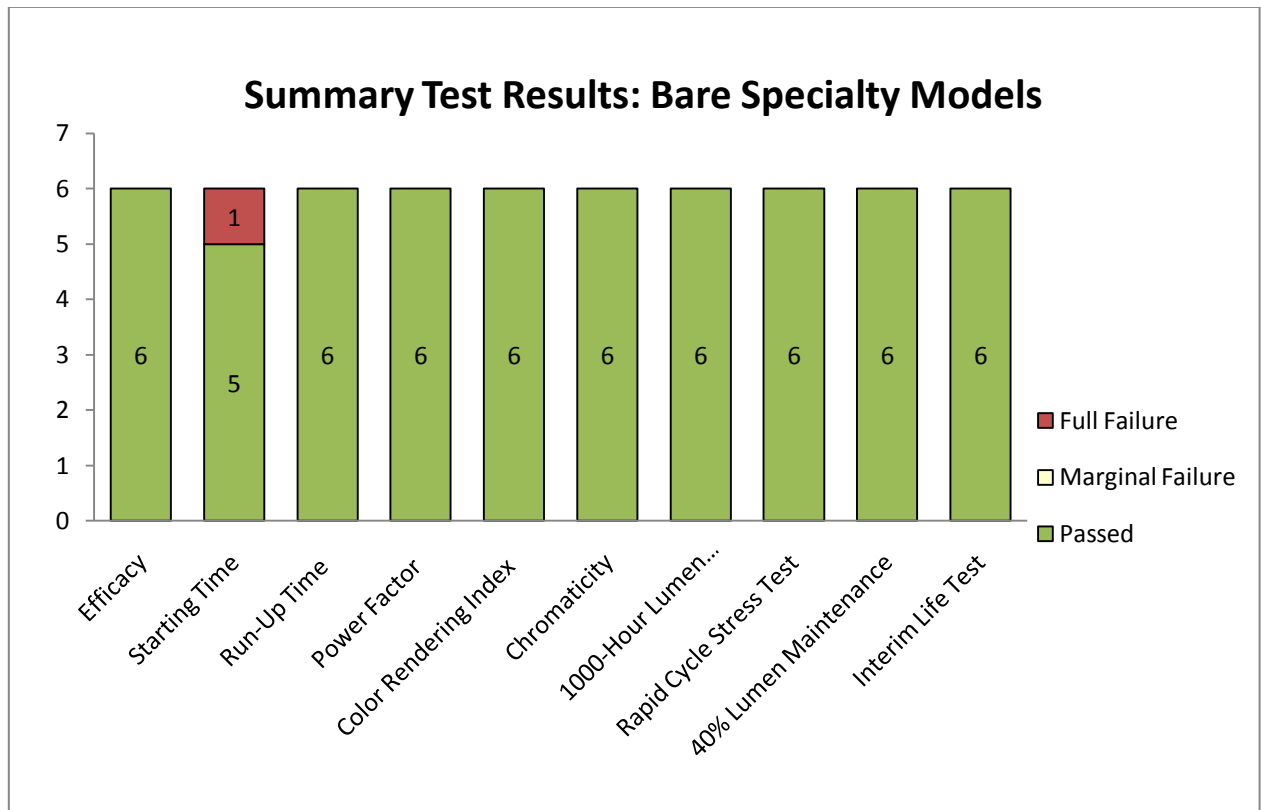


Figure 4

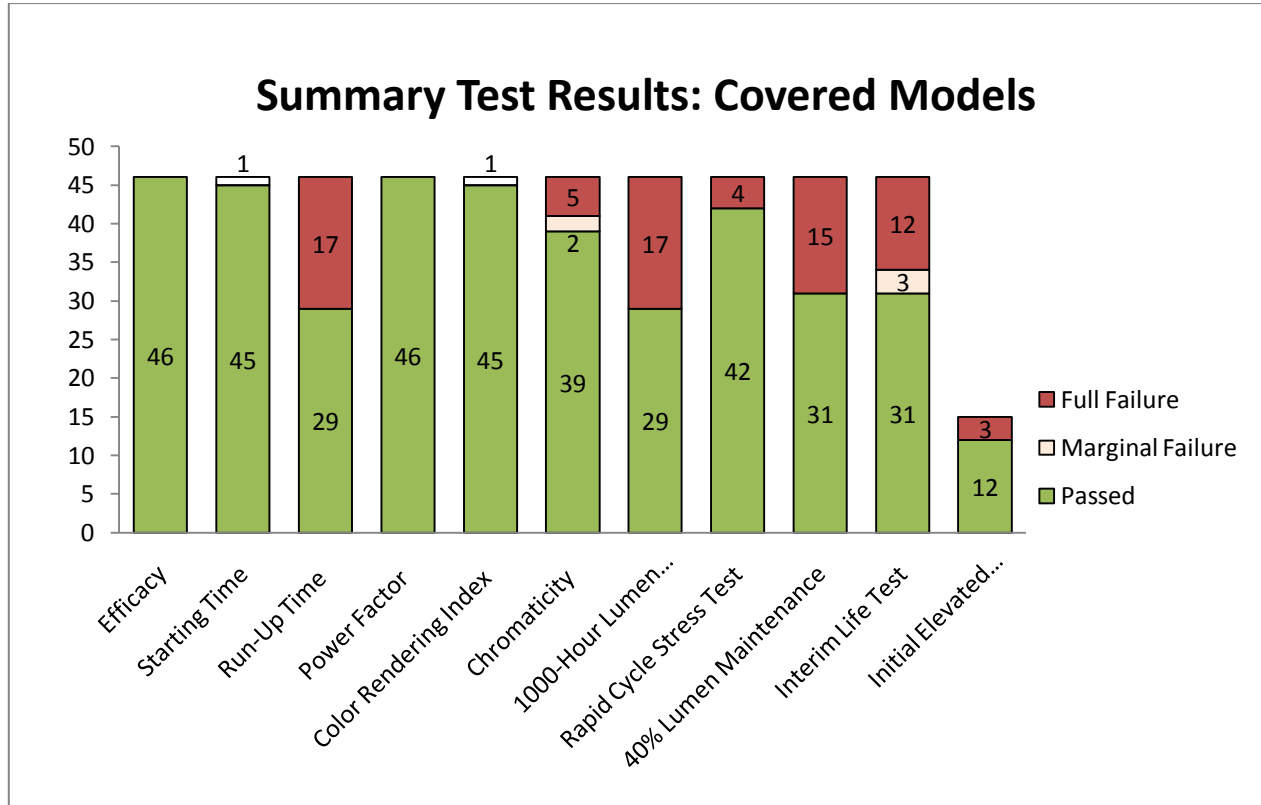


Table 1: Mean, Median, and Percent Passing and Failing Each Test by Lamp Type

Test	Model Type	Mean	Median	Passing Criteria	% Passed	% Failed (% Marginally Failed)
Efficacy	All Types	60.8	62.5	Varies by model type	100	0
	Bare Spiral	67	67.6		100	0
	Bare Specialty	68.2	67.5		100	0
	Covered	51.2	50.8		100	0
Starting Time	All Types	318	230	<1000 milliseconds	97	3
	Bare Spiral	258	190		98	2
	Bare Specialty	711	795		83	17
	Covered	352	263		98	2
Run-Up Time	All Types	76.8	48	<60 or <180 seconds	85	15
	Bare Spiral	39.4	35		98	2
	Bare Specialty	32.7	28.5		100	0
	Covered	134	123		63	37
Power Factor	All Types	0.58	0.57	>0.5	100	0
	Bare Spiral	0.58	0.58		100	0
	Bare Specialty	0.58	0.55		100	0
	Covered	0.58	0.56		100	0
Color Rendering Index	All Types	82.7	82.4	>80	98	0
	Bare Spiral	82.7	82.4		98	2
	Bare Specialty	82.2	82.2		100	0
	Covered	82.7	82.6		98	2
Chromaticity	All Types	12.5	10	9/10 coordinates inside ellipse or **17/20 coordinates inside ellipse	88	9 (3)
	Bare Spiral	12.4	10		91	9
	Bare Specialty	14.8	14.5		100	0
	Covered	12.4	10		85	11 (7)
1,000-Hour Lumen Maintenance	All Types	92%	93%	>90%	84	16
	Bare Spiral	93%	94%		97	3
	Bare Specialty	96%	96%		100	0
	Covered	89%	90%		63	37
Rapid Cycle Stress Test	All Types	7.5	6	5/6 survive to half of rated life or **10/12 survive to half of rated life	91	8 (1)
	Bare Spiral	7.6	6		89	9 (2)
	Bare Specialty	9	9		100	0
	Covered	7.1	6		91	9
40% Lumen Maintenance	All Types	84%	84%	>80%	86	14
	Bare Spiral	85%	86%		97	3
	Bare Specialty	86%	85%		100	0
	Covered	81%	83%		67	33

Interim Life Test	All Types	12.4	10	9/10 survive to 40% of rated life or **17/20 survive to half of rated life	82	14 (4)
	Bare Spiral	12.6	10		89	11 (3)
	Bare Specialty	15.4	18		100	0
	Covered	11.58	10		6	26 (7)
Initial Elevated Temperature Output Ratio						
	Covered	96%	97.40%	≤90%	80	20

**Double sample size

The 118 models tested each underwent 10 or 11 different tests.³ Of the 1195 total tests performed, there were 99 independent test failures, 28 of which significantly underperformed, as defined below. Seven of the eleven models that failed the Chromaticity Test significantly underperformed on that test. None of the models that failed the Starting Time or Initial Elevated Temperature Output Ratio Tests significantly underperformed. Table 2 summarizes the test failures.

Table 2: Summary of Test Failures for All Models Tested

	All Models	Full Failures		Significantly Underperforming Failures*		
	Mean	Failure Criteria	No. of Failures	Criteria	No. of Failures	% of Full Failures
Efficacy	60.8	Varies	0	Varies	0	0%
Starting Time	318	>1000 ms	3	>811 ms	0	0%
Run Up Time	76.8	>60/180 seconds	18	>112 / >205 seconds	5	28%
Power Factor	0.58	<0.50	0	<0.447	0	0%
Color Rendering Index	82.7	≤80.0	2	<80	1	50%
Chromaticity	12.5	≤7 samples or ≤16** samples	11	<6 samples or ≤13** samples	7	64%
1,000 Hour Lumen Maintenance	92%	≤90%	19	<83%	4	21%
Rapid Cycle Stress Test	7.5	<4 samples or <9** samples	10	<3 samples or <8** samples	4	40%
40% Lumen Maintenance	84%	<80%	17	<70%	5	29%
Interim Life Test	12.4	≤7 samples or ≤16** samples	16	≤6 samples or ≤13** samples	2	12.5%
Initial Elevated Temperature Output Ratio	96%	≤90%	3	<34%	0	0%
All Tests	n/a	n/a	99	n/a	28	27%

* Significant underperformance is defined here as having results more than two standard deviations away from the mean. Note that on the Starting Time Test, the distribution of performance was such that two standard deviations greater than the mean was still within the passing range and thus a significantly underperforming failure on this test would have been impossible.

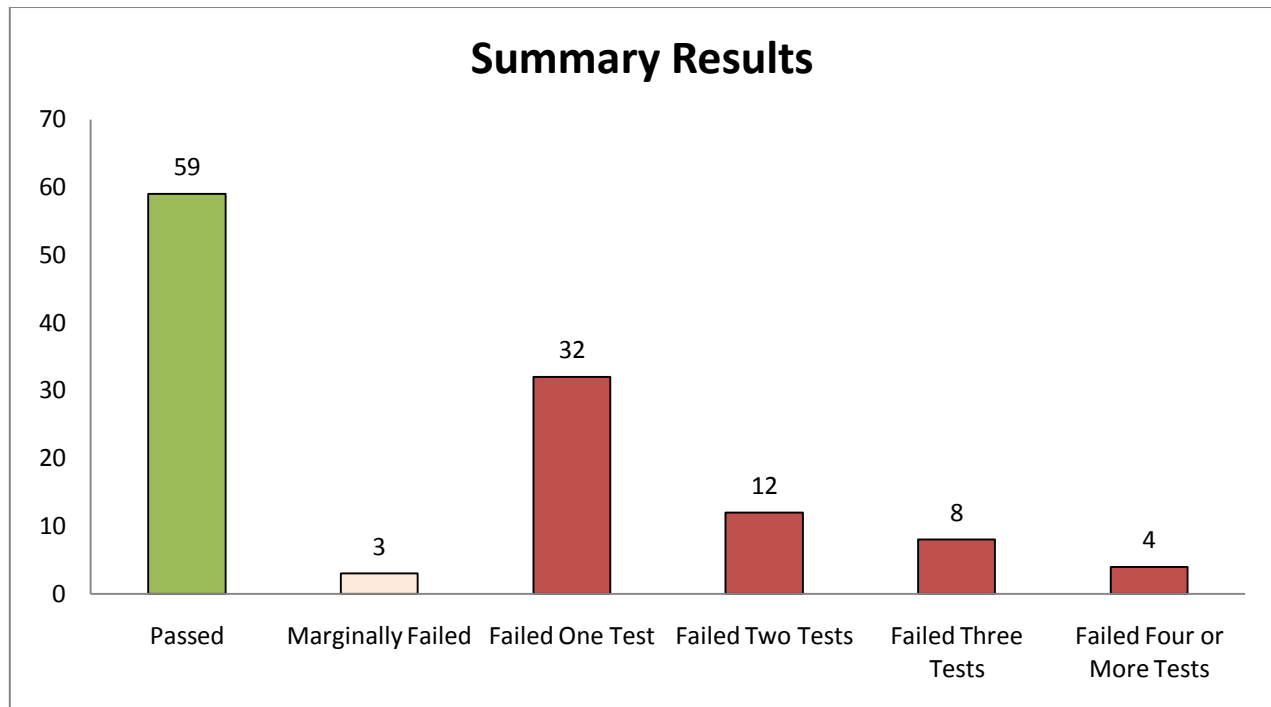
** Double sample size

³ While 103 of the tested products were subjected to 10 tests each, 15 of the covered products tested were verified for indoor use and therefore subjected to 11 tests each.

Of the 118 models tested, 59 (50%) passed all tests performed, 3 (3%) marginally failed one or two tests but had no full failures, and 56 (47%) fully failed at least one test. See Figure 5.

All models that marginally failed a test were subsequently retested. The results of those retests are not presented here because they were not available at the time this report was prepared.

Figure 5



Failure rates were much higher among covered models than among bare spiral and bare specialty models. While 67% of the bare spiral models and 83% of bare specialty models tested passed all tests, only 22% of covered models passed all tests.

Of the 56 models that fully failed at least one test, 28 significantly underperformed on at least one test, measured across all 118 models. No bare specialty models significantly underperformed, while 48% of covered and 22% of bare spiral models were significant underperformers. See Table 3.

Table 3: Failures for All Models Tested

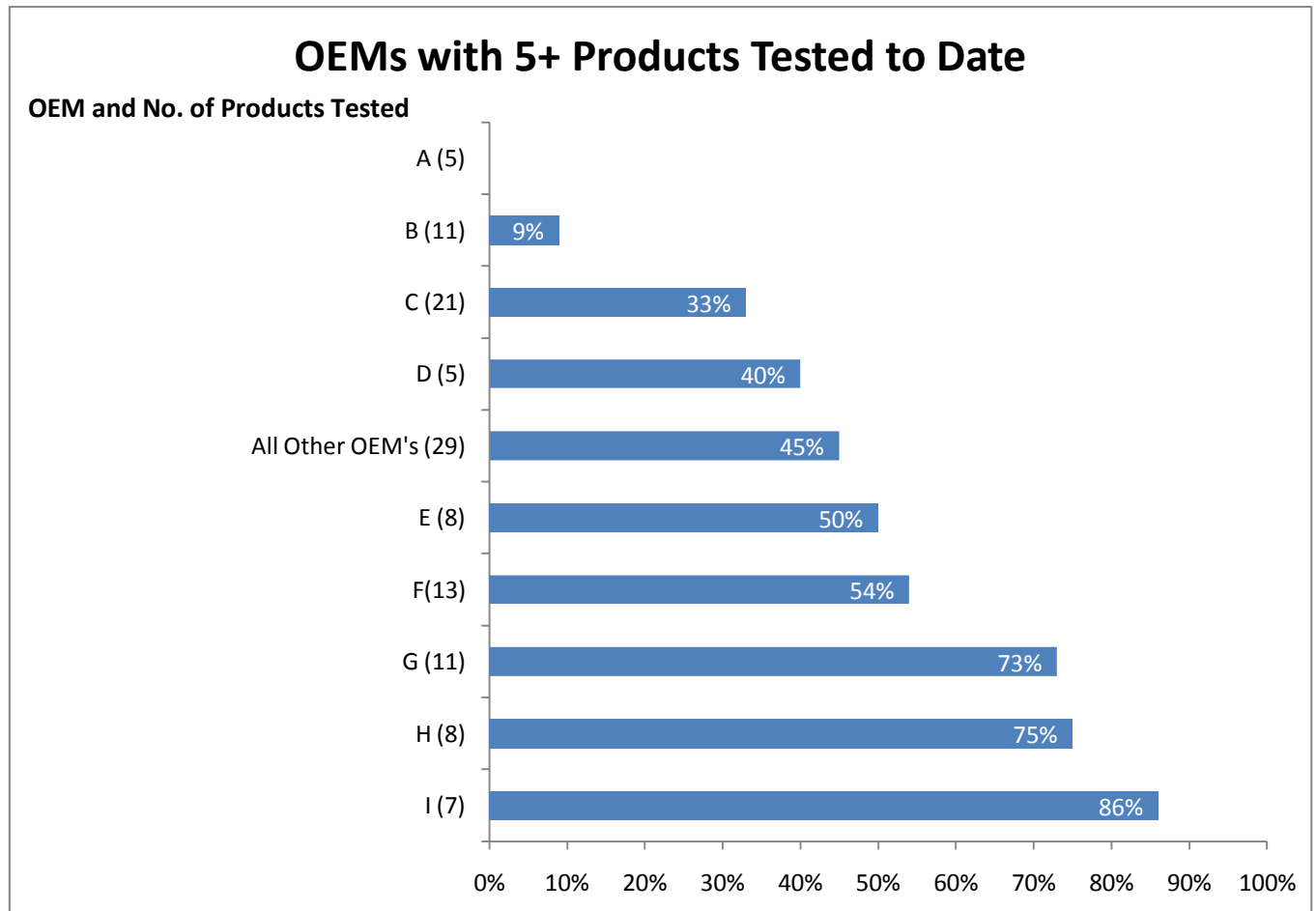
	All Lamp Types		Bare Spiral		Bare Specialty		Covered	
Results	#	%	#	%	#	%	#	%
Passed All Initial Tests	59	50%	44	67%	5	83%	10	22%
Marginally Failed	3	3%	3	5%	0	0%	0	0%
Failed at Least 1 Test	56	47%	19	29%	1	17%	36	78%
Failed 1 Test	32	27%	15	23%	1	100%	16	35%
Failed 2 Tests	12	10%	3	5%	0	0%	9	20%
Failed 3 Tests	8	7%	1	2%	0	0%	7	15%
Failed 4 or More Tests	4	3%	0	0%	0	0%	4	9%
Significantly Underperformed on at Least 1 Test*	28	24%	6	22%	0	0%	22	48%
Total Models Tested	118	100%	66	100%	6	100%	46	100%

* Significant underperformance is defined here as having results more than two standard deviations away from the mean.

Figure 6 shows the failure rates of OEM partners with at least five models tested in Batch 3. Their names have been omitted due to the confidential nature of this information.

Each partner listed below has at least 25 models listed on the Qualified Products List. The large number of models tested from these OEM partners gives a good indication of overall performance. The overall failure rate for each OEM was calculated using incidences of full failure, not marginal failure. Only 2 of the 10 OEM partners had failure rates under 30%.

Figure 6: Failure Rates of OEM Partners with ≥ 5 Models Tested in Batch 3



METHODOLOGY

PRODUCT SELECTION

Models were selected for testing in accordance with version 4.2 of the ENERGY STAR CFL Program Requirements, published on March 7, 2008 and effective December 2, 2008.⁴ These requirements specify that the program shall "target to test 20% of the total number of current [distinct ENERGY STAR] qualified bulbs during a calendar year; half of the models will be selected via a random generator, the other half will be selected by EPA and participating ENERGY STAR partners (utilities, manufacturers, states, efficiency program sponsors, or other government entities)."

This current (Batch 3) report presents results for the 118 models selected in Cycles 2 and 3 that completed testing between August 1, 2011 and July 31, 2012. Table 4 presents the breakdown of randomly selected and nominated models for each model type.

Table 4: Models Included in this Report (Batch 3)

Model Type	Nominated Models	Randomly Selected Models	Total
Bare Spiral	29	37	66
Bare Specialty	2	4	6
Covered	26	20	46
All Types	57	61	118

Many models are privately labeled and sold under multiple brand names. The 118 base models in Batch 3 represent 487 qualified models, 14.5% of the qualified products list.

PRODUCT PROCUREMENT

Partners were given two sample size options to test their models⁵:

- 6 or 12 samples for the Rapid Cycle Stress Test
- 10 or 20 samples for the other nine tests
- 1 sample for the Initial Elevated Temperature Output Ratio Test for covered products designated for indoor use

⁴ The ENERGY STAR CFL Program Requirements can be downloaded from the ENERGY STAR website: www.energystar.gov/ia/partners/product_specs/program_reqs/Compact_Fluorescent_Lamps_Program_Requirements.pdf.

⁵ Two or four additional bulbs were procured as backups in case of breakage.

The laboratories sought to purchase each product from at least two geographic regions and three different retail locations as requested by the CFL 4.2 Criteria, but in some cases, a product could be procured from only one or two locations.

PRODUCT TESTING

The tests performed on each product are listed in Table 5. Six (or twelve) samples of each product were used for the Rapid Cycle Stress Test and ten (or twenty) samples of each product were used for all other tests. For full details on product testing requirements, see the CFL 4.2 Criteria.

At the conclusion of each test, the laboratory sent the completed test report to the ENERGY STAR partner and to D&R International, Program Administrator for the CFL Third Party Testing and Verification program.

Table 5: Tests Required for ENERGY STAR Qualification and Verification

	Bare, Covered, or Outdoor Reflector Models	Reflector CFLs for Recessed Downlights/ Indoor Use (Reflectors)⁶	Test Type	Passing Criteria
1	Efficacy	Efficacy	Photometric	Varies by Type
2	Starting Time	Starting Time	Electronic	<1000 ms
3	Run-Up Time	Run-Up Time	Electronic	<60 s (amalgam) / <180 s (non-amalgam)
4	Power Factor	Power Factor	Electronic	>0.500
5	Color Rendering Index	Color Rendering Index	Photometric	>80.0
6	Chromaticity	Chromaticity	Photometric	9/10 samples/ ≥17/20 samples
7	1,000-Hour Lumen Maintenance	<i>Elevated Temperature</i> 1,000-Hour Lumen Maintenance	Photometric	>90%
8	Rapid Cycle Stress Test	Rapid Cycle Stress Test	Lifetime Performance	5/6 samples/ ≥9/12 samples
9	Lumen Maintenance at 40% of Rated Life	<i>Elevated Temperature</i> Lumen Maintenance at 40% of Rated Life	Lifetime Performance	> 80%
10	Interim Life Test	<i>Elevated Temperature</i> Interim Life Test	Lifetime Performance	9/10 samples/ ≥17/20 samples
11	N/A	Initial Elevated Temperature Output Ratio	Lifetime Performance	>90%

⁶Covered reflectors designated for indoor use underwent the Initial Elevated Temperature Output Ratio Test in addition to the 10 tests required by all other models.

DETAILED RESULTS FOR BATCH 3

This section presents detailed results of ENERGY STAR CFL verification testing completed between August 1, 2011 and July 31, 2012. The results of verification testing completed before August 1, 2011 are presented in reports published in June 2011 (Batch 1) and February 2012 (Batch 2).⁷ Results from all three batches are compared in the final section of this report.

For each of the 10 tests applicable to all models, results are shown for all lamp types, for each of the three lamp types—bare spiral, bare specialty, and covered—separately, and for nominated and randomly selected models separately. For the Initial Elevated Temperature Output Ratio test, results are shown only for covered indoor reflector models, the only models subjected to this test.

⁷D&R International, "ENERGY STAR CFL Third Party Testing and Verification Cycle 1," June 2011. (www.energystar.gov/ia/partners/downloads/Cycle_1_Final_Report_Public_6-23-11.pdf)

D&R International, "ENERGY STAR CFL Third Party Testing and Verification Cycle 2: Off-the-Shelf CFL Performance, Trends, and Implications," May 2012. (www.energystar.gov/ENERGY_STAR_CFLs_Batch_2_Report_Public_2-2-12.pdf)

LUMINOUS EFFICACY

Efficacy is light output divided by power; it is measured in lumens per watt. Models with a measured efficacy of at least the ENERGY STAR efficacy requirement for that model type (with a tolerance of 3%) pass the test. Normalized results are presented for this test because normalizing the data points by dividing the measured efficacy by the required efficacy shows how far each product is from its required result. The gray-shaded region of Figure 7 indicates test failure, and the cream-colored region indicates the 3% tolerance. All models passed this test.

Figure 7

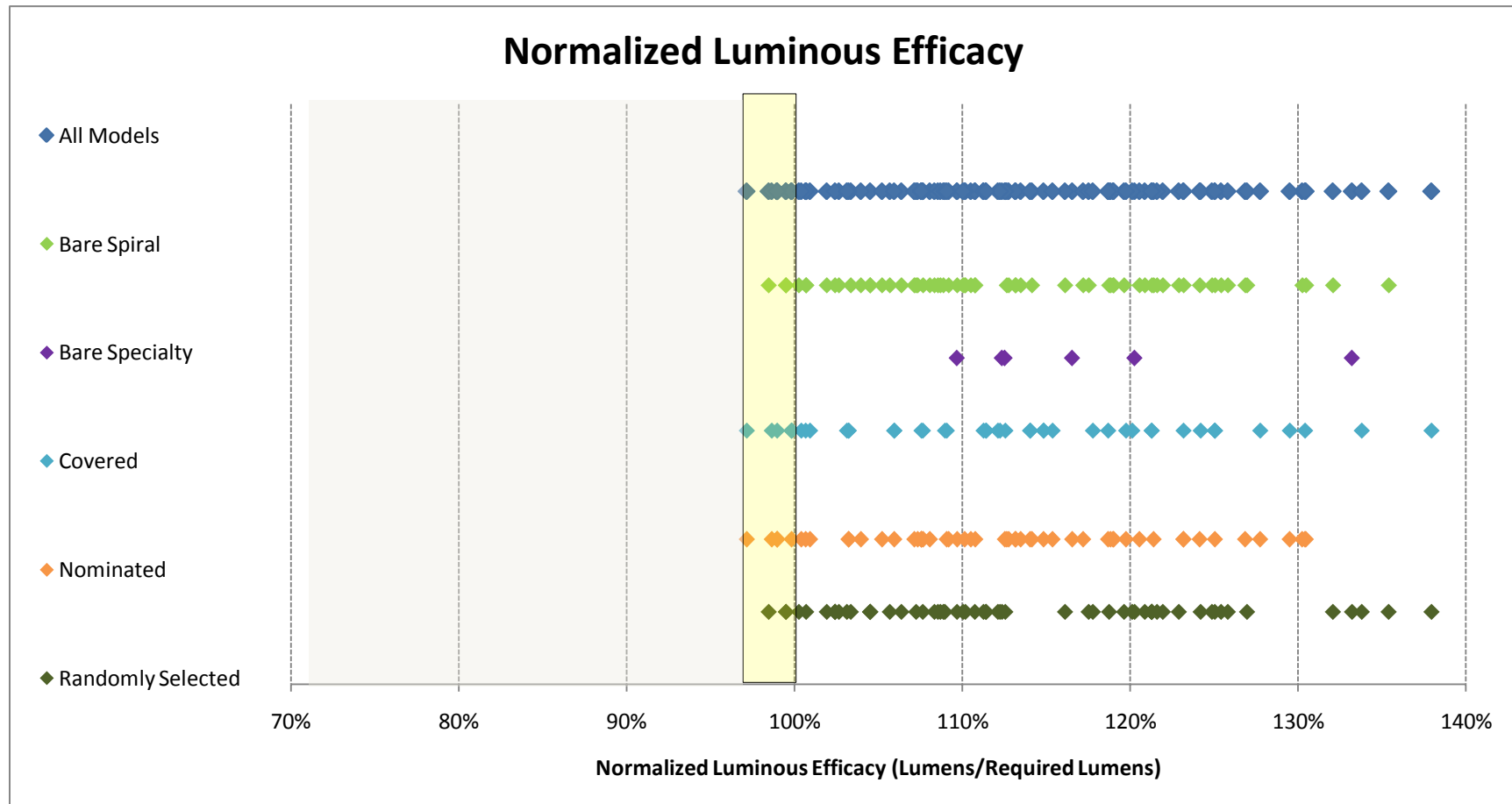


Table 6: Normalized Efficacy Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	118	100%	0%	0%	1.14	1.13
Bare Spiral	66	100%	0%	0%	1.14	1.13
Bare Specialty	6	100%	0%	0%	1.17	1.15
Covered	46	100%	0%	0%	1.12	1.11
Nominated	57	100%	0%	0%	1.14	1.13
Randomly Selected	61	100%	0%	0%	1.14	1.12

STARTING TIME

Starting time is the time needed after switching a CFL on for it to start fully and remain lighted. Models with start-up time measurements of <1,000 milliseconds pass the test; 97% of models passed this test. The gray-shaded region of Figure 8 indicates test failure.

Figure 8

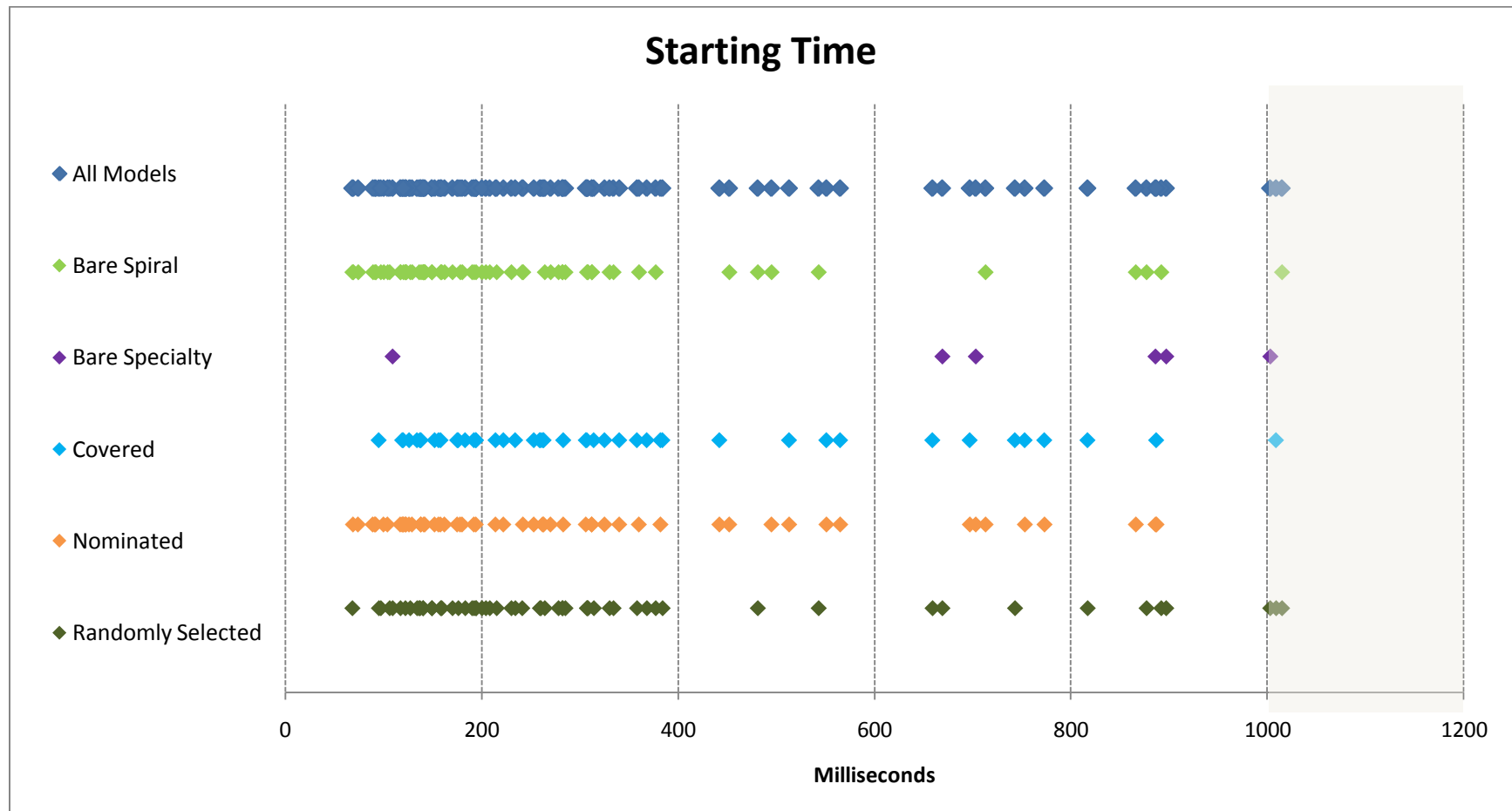


Table 7: Starting Time Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	118	97%	0%	3%	318	230
Bare Spiral	66	98%	0%	2%	258	190
Bare Specialty	6	83%	0%	17%	711	795
Covered	46	98%	0%	2%	352	263
Nominated	57	100%	0%	0%	304	214
Randomly Selected	61	95%	0%	5%	312	222

RUN-UP TIME

Run-up time is the time it takes a CFL to reach full brightness. Amalgam mercury models with run-up times <180 seconds and non-amalgam mercury models with run-up times <60 seconds pass the test. The gray-shaded regions of Figures 9 and 10 indicate test failure. Among the amalgam models, only covered models failed this test. Among the non-amalgam models, all 10 covered models and 9 of the 37 bare spiral models failed this test. The 6 bare specialty models all passed this test.

Figure 9

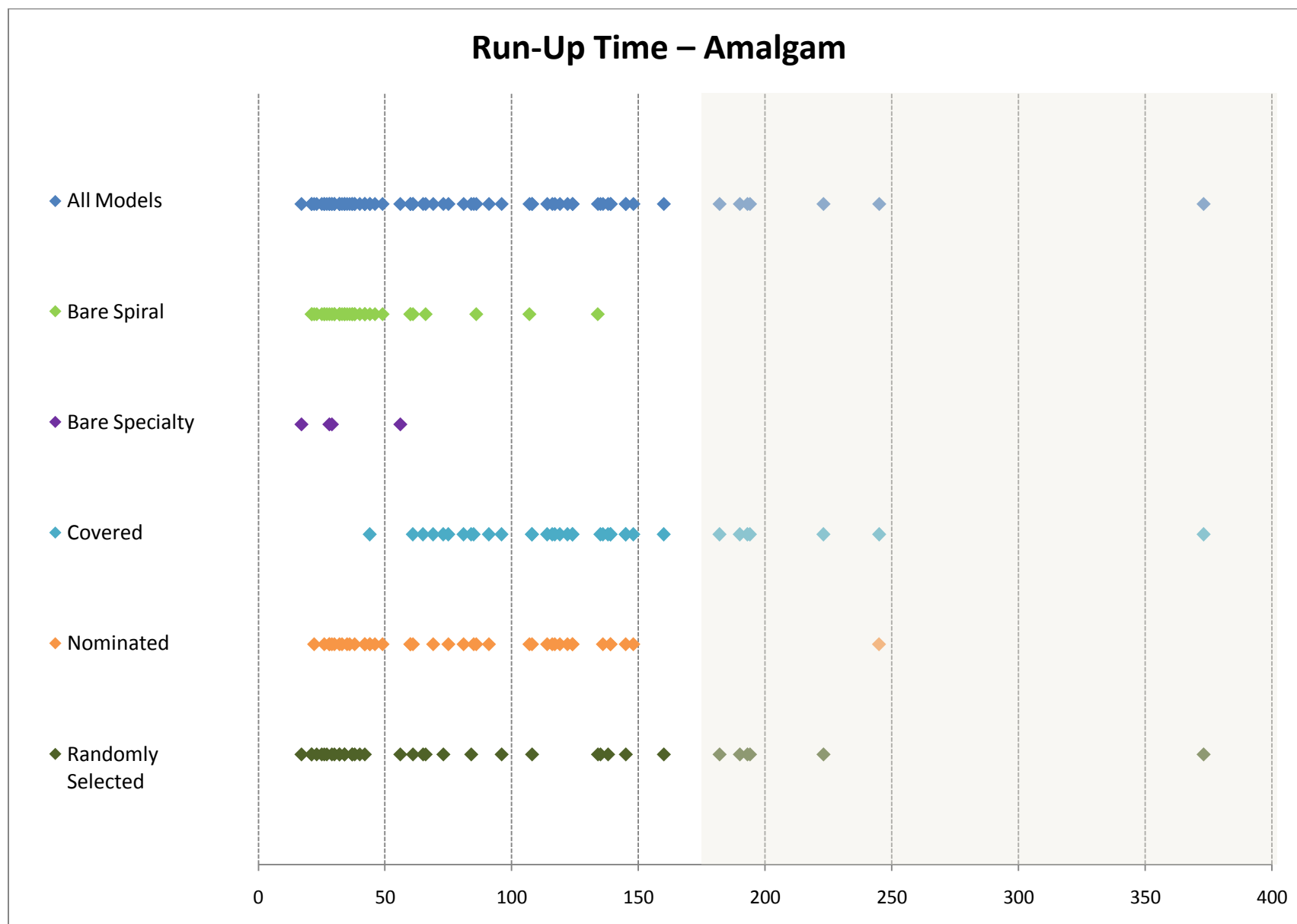


Figure 10

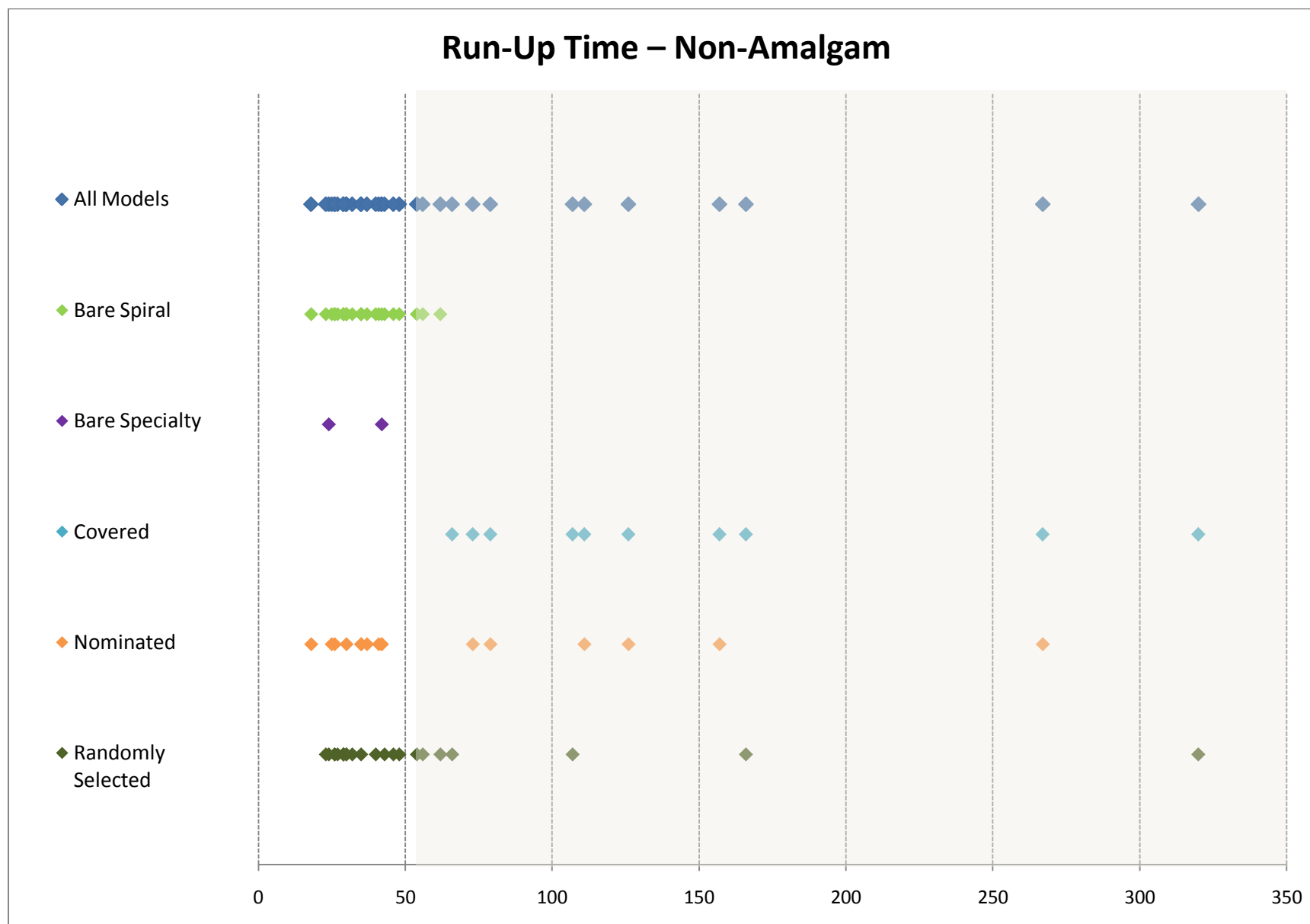


Table 8: Run-Up Time (Amalgam) Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	79	91%	0%	9%	83	61
Bare Spiral	39	100%	0%	0%	42	36
Bare Specialty	4	100%	0%	0%	33	29
Covered	36	81%	0%	19%	98	80
Nominated	41	98%	0%	2%	78	60
Randomly Selected	38	84%	0%	16%	87	41

Table 9: Run-Up Time (Non-Amalgam) Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	39	72%	0%	28%	67	40
Bare Spiral	27	96%	0%	4%	35	32
Bare Specialty	2	100%	0%	0%	33	33
Covered	10	0%	0%	100%	147	119
Nominated	16	63%	0%	37%	78	30
Randomly Selected	23	78%	0%	22%	59	35

POWER FACTOR

Power factor is the active power of the CFL divided by the apparent power. Models with a power factor >0.5 pass the test. The gray-shaded region of Figure 11 indicates test failure. All models passed this test.

Figure 11

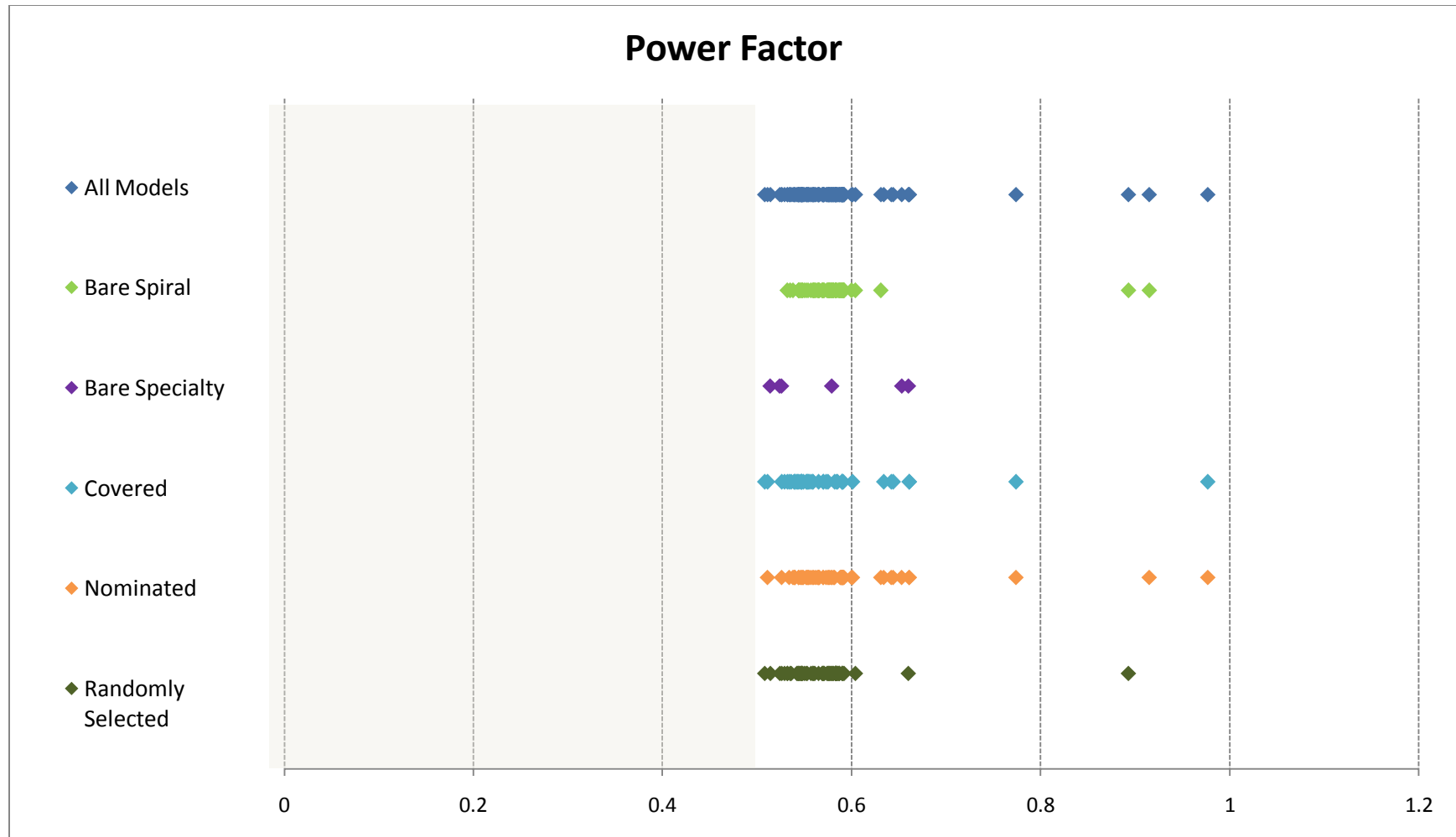


Table 10: Power Factor Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	118	100%	0%	0%	0.58	0.57
Bare Spiral	66	100%	0%	0%	1.0	1.0
Bare Specialty	6	100%	0%	0%	0.58	0.55
Covered	46	100%	0%	0%	0.58	0.56
Nominated	57	100%	0%	0%	0.59	0.57
Randomly Selected	61	100%	0%	0%	0.57	0.57

COLOR RENDERING INDEX

The Color Rendering Index (CRI) is a measure of a light source's ability to accurately render the color of illuminated objects; this is the effect of the CFL on the color appearance of the objects it illuminates. The CRI is defined according to the Commission Internationale de l'Eclairage's Publication No.13.3 1995. Models that have an average CRI >80 across the 10 samples tested and have no more than 3 samples with a CRI <77 pass the test. The gray-shaded region in Figure indicates test failure. Only one bare spiral and one covered product failed this test.

Figure 12

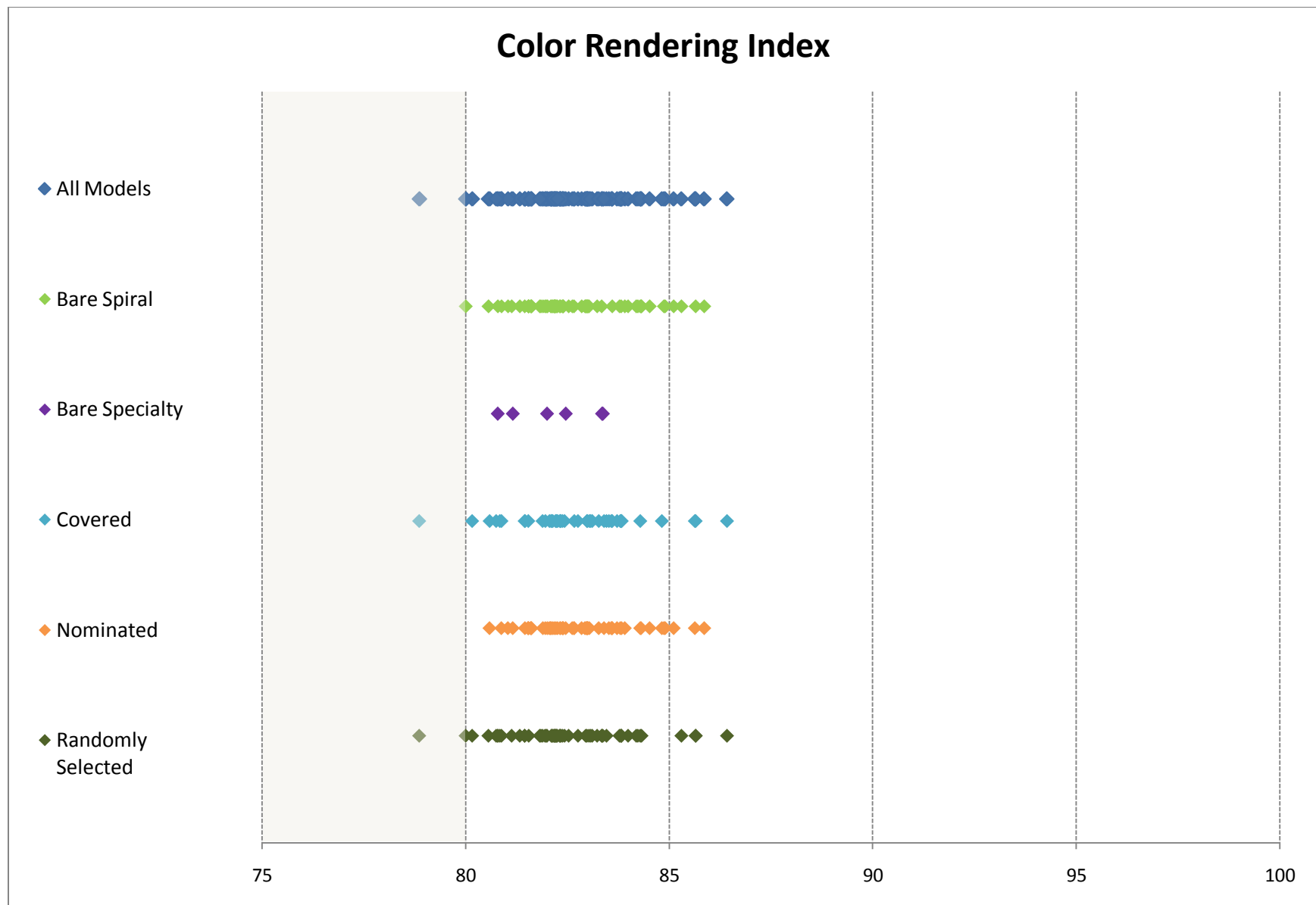


Table 11: Color Rendering Index Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	118	98%	0%	2%	82.7	82.4
Bare Spiral	66	98%	0%	2%	82.7	82.4
Bare Specialty	6	100%	0%	0%	82.2	82.2
Covered	46	98%	0%	2%	82.7	82.6
Nominated	57	100%	0%	0%	82.8	82.7
Randomly Selected	61	97%	0%	3%	82.6	82.3

CHROMATICITY

Chromaticity, or correlated color temperature (CCT), is a measure of the color appearance of a CFL, measured in Kelvin. CCT is scored based on the American National Standards Institute (ANSI) ellipse for the manufacturer's specified color temperature. Models with 9 or 10 samples (or at least 17, for double sample sizes) falling within the ANSI ellipse pass the test. Models with exactly eight samples falling within the ANSI ellipse score as marginal failures, indicated by the light gray-shaded regions in Figure 13(a,b) and Figure (a,b). There is no marginal failure for the double sample size option. The gray-shaded regions in these figures indicate test failure.

While 91% of bare spiral models passed this test, only 85% of covered models passed this test. All of the bare specialty models passed this test. The overall marginal failure rate was 3%.

Figure 13-a: Chromaticity Results for Single Sample Size Option (10 Samples)

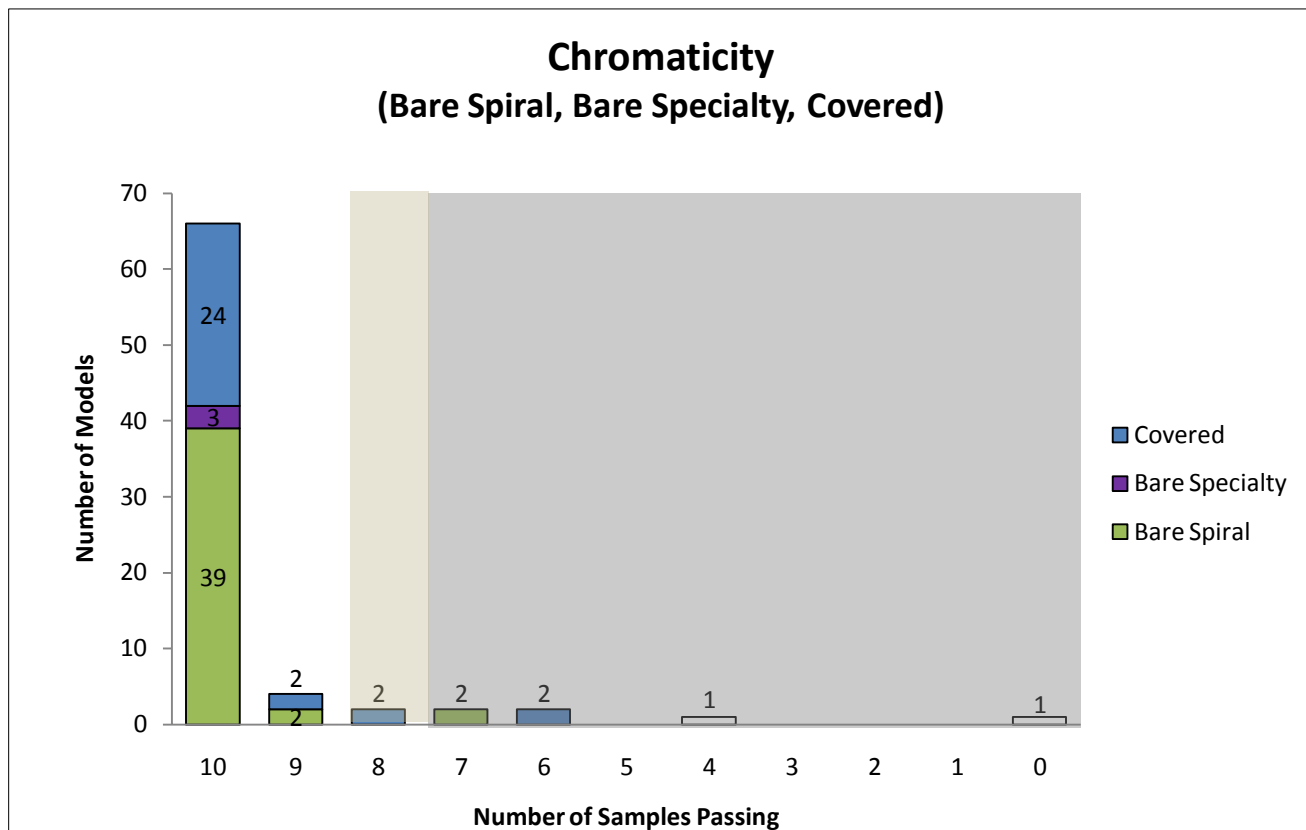


Figure 13-b: Chromaticity Results for Double Sample Size Option (20 Samples)

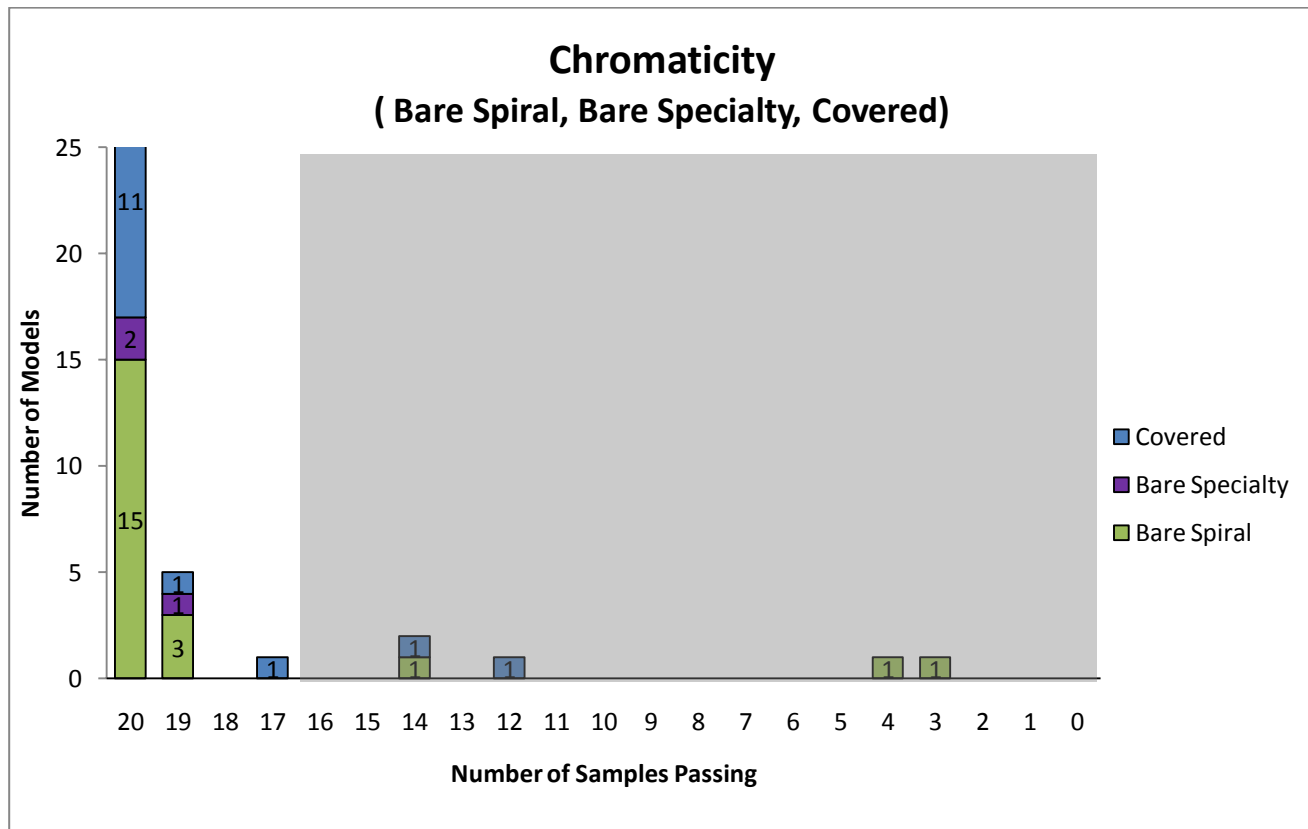


Figure 14-a: Chromaticity Results for Single Sample Size Option (10 Samples)

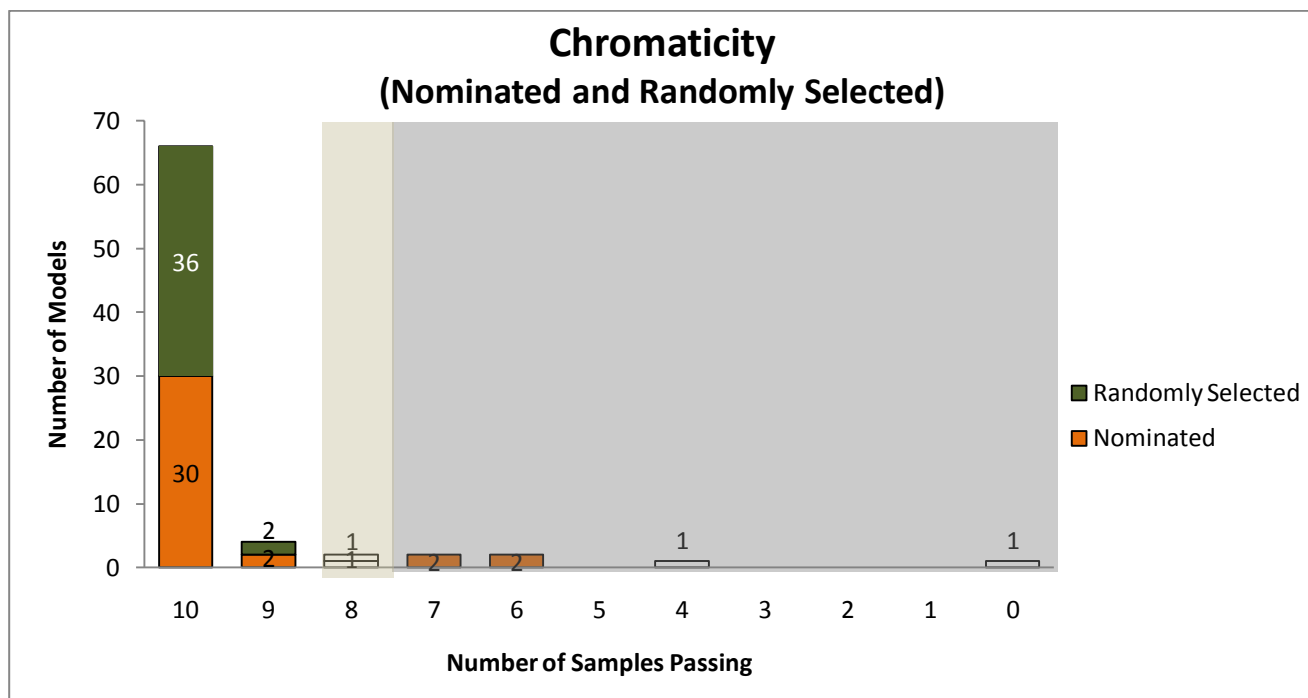


Figure 14-b: Chromaticity Results for Double Sample Size Option (20 Samples)

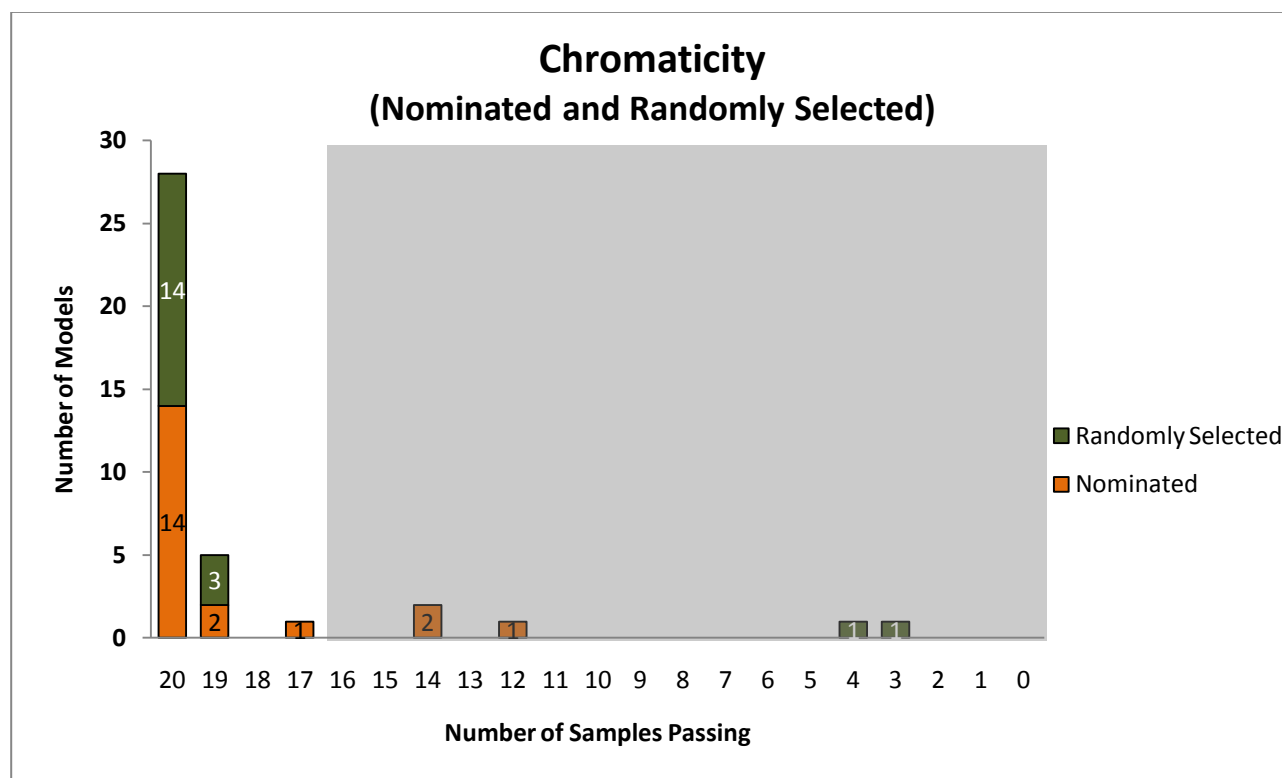


Table 12: Chromaticity Results

	Number of Models Tested	% of Models		
		Passed Initial Test	Marginal Failure (Retest)	Full Failure
All Models	118	89%	3%	9%
Bare Spiral	66	91%	0%	9%
Bare Specialty	6	100%	0%	0%
Covered	46	85%	4%	11%
Nominated	57	86%	2%	12%
Randomly Selected	61	91%	2%	7%

Note: Overall mean and median were not included because of single and double sample sizes.

1,000-HOUR LUMEN MAINTENANCE

The 1,000-Hour Lumen Maintenance Test is an initial measurement of how well a product maintains its light output level over time. Models that have light output at 1,000 hours that is greater than 90% of the 100-hour measurement (with a tolerance of 3%) and that have no more than 3 individual samples with lumen output less than 85% pass the test. The gray-shaded regions of Figures 15 and 16 indicate test failure, and the cream-shaded regions indicate the 3% tolerance.

Of the eleven tests, the 1000-Hour Lumen Maintenance Test had the lowest passing rate, with only 99 (84%) passing. All bare specialty models passed this test in full or with a 3% tolerance. Of the 66 bare spiral models, 64 (97%) passed; the remaining 2 failed this test. Of the 46 covered models, only 29 (63%) passed, the remaining 17 failed.

Figure 15

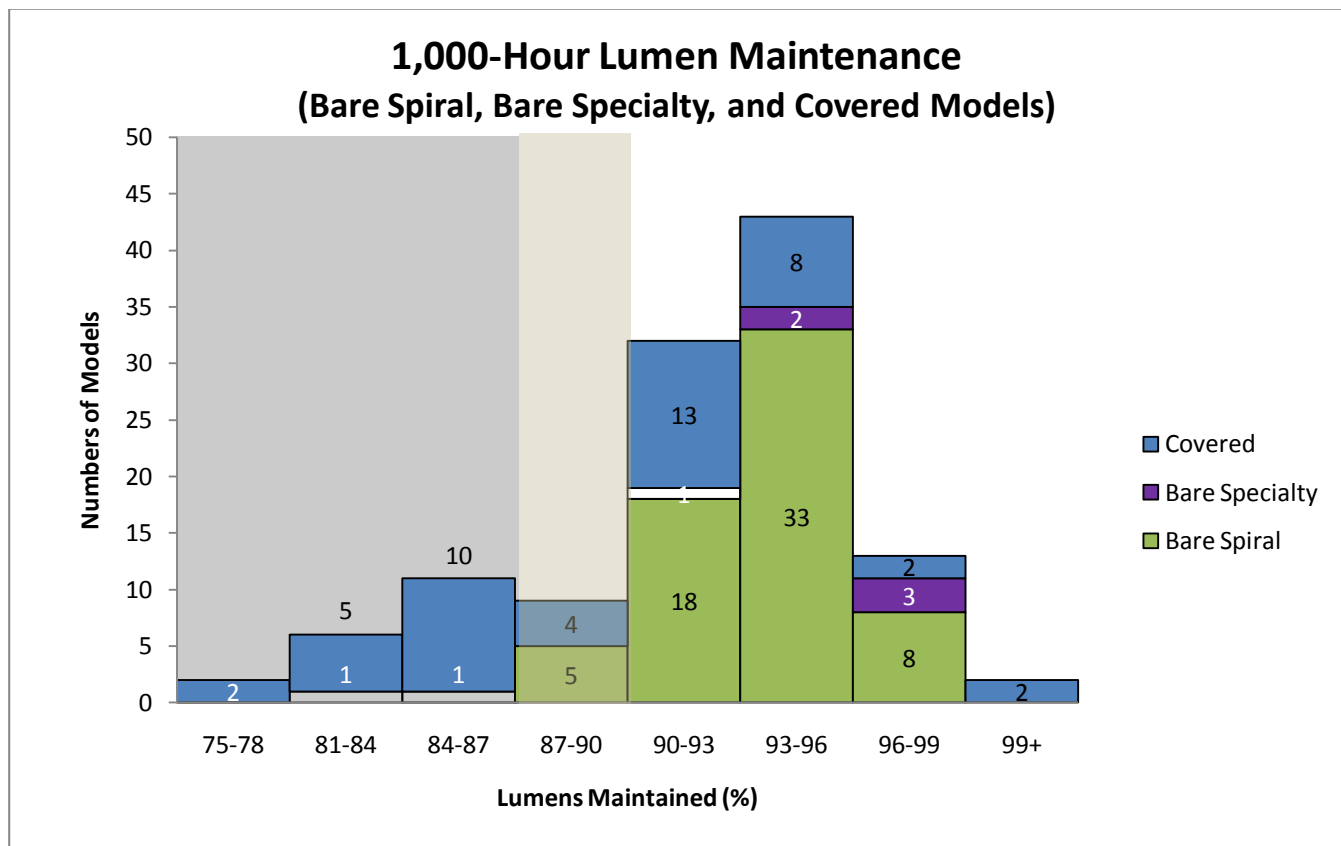


Figure 16

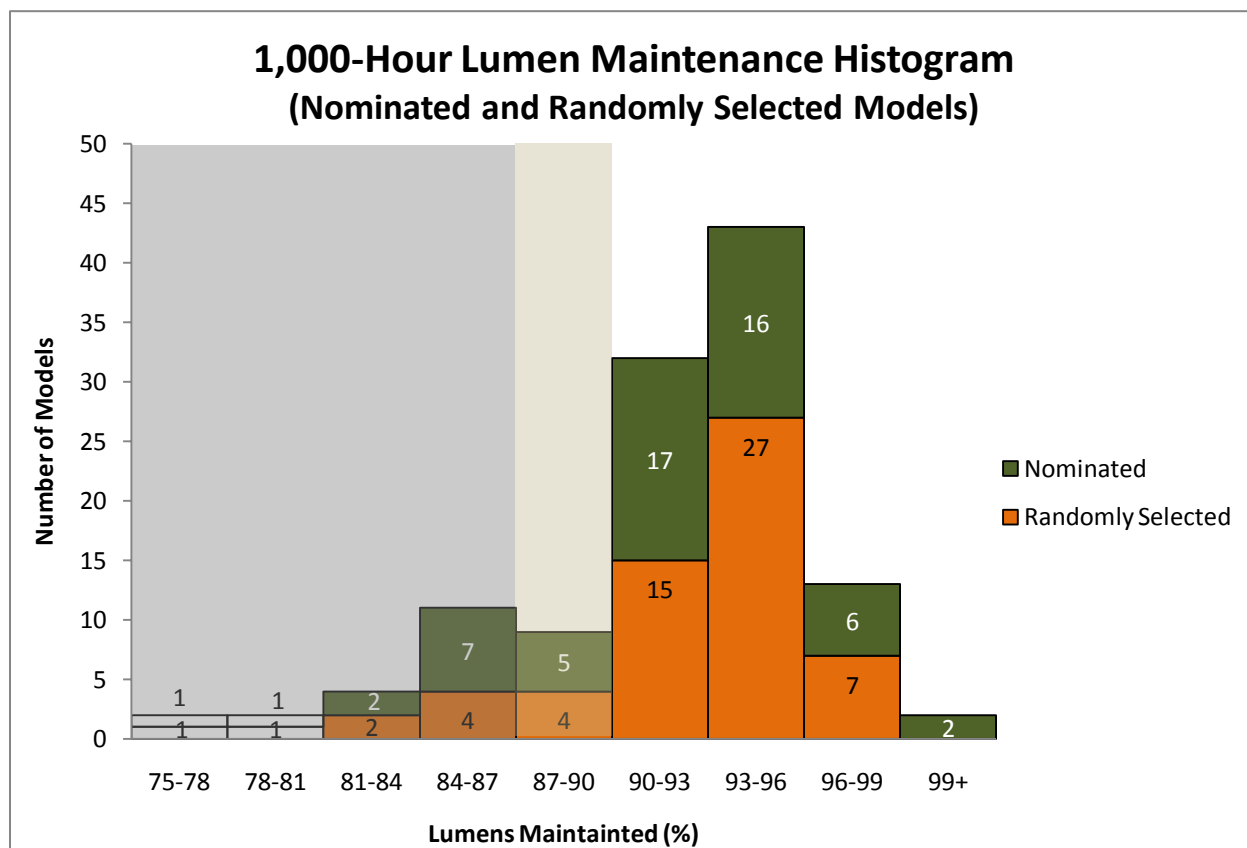


Table 13: 1,000-Hour Lumen Maintenance

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	118	84%	0%	16%	92%	93%
Bare Spiral	66	97%	0%	3%	93%	94%
Bare Specialty	6	100%	0%	0%	96%	96%
Covered	46	63%	0%	37%	89%	90%
Nominated	57	81%	0%	19%	92%	92%
Randomly Selected	61	87%	13%	0%	92%	93%

RAPID CYCLE STRESS TEST

The Rapid Cycle Stress Test tests how many on/off cycles a product can endure without failing. Models that have five or six samples (or at least nine, for double sample sizes) endure the test for a number of cycles equivalent to half the product's rated life pass the test. If exactly four samples survive, the product scores as a marginal failure. There is no marginal failure for the double sample size option. The gray-shaded region of Figure 17(a,b) and Figure 18(a,b) indicates test failure, and the cream-shaded region indicates marginal failure.

All bare specialty models, 89% of covered models, and 91% of bare spiral models passed this test. There was one marginal failure by a bare spiral product.

Figure 17-a: Rapid Cycle Stress Test Results for Single Sample Size Option (6 Samples)

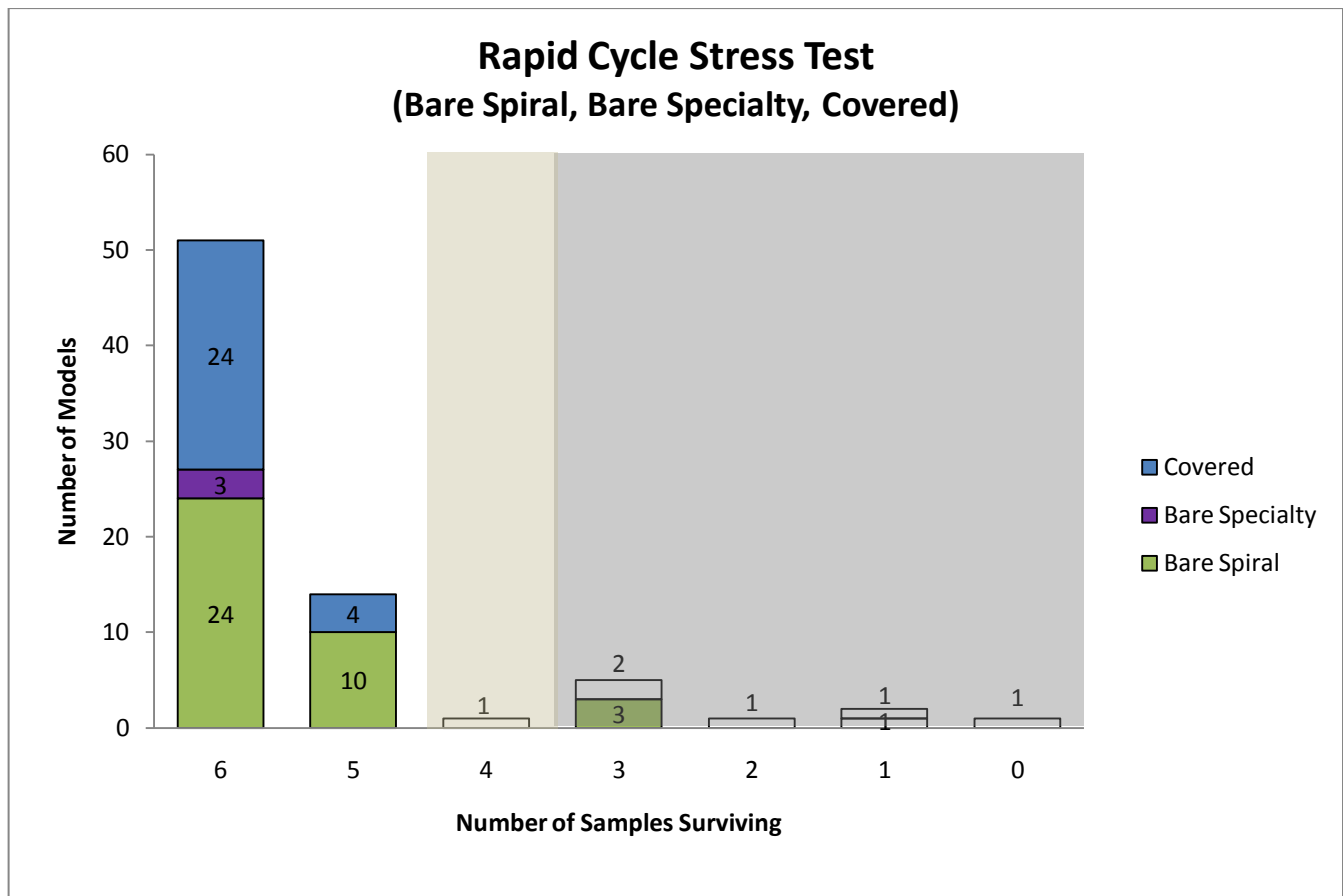


Figure 17-b: Rapid Cycle Stress Test Results for Single Sample Size Option (12 Samples)

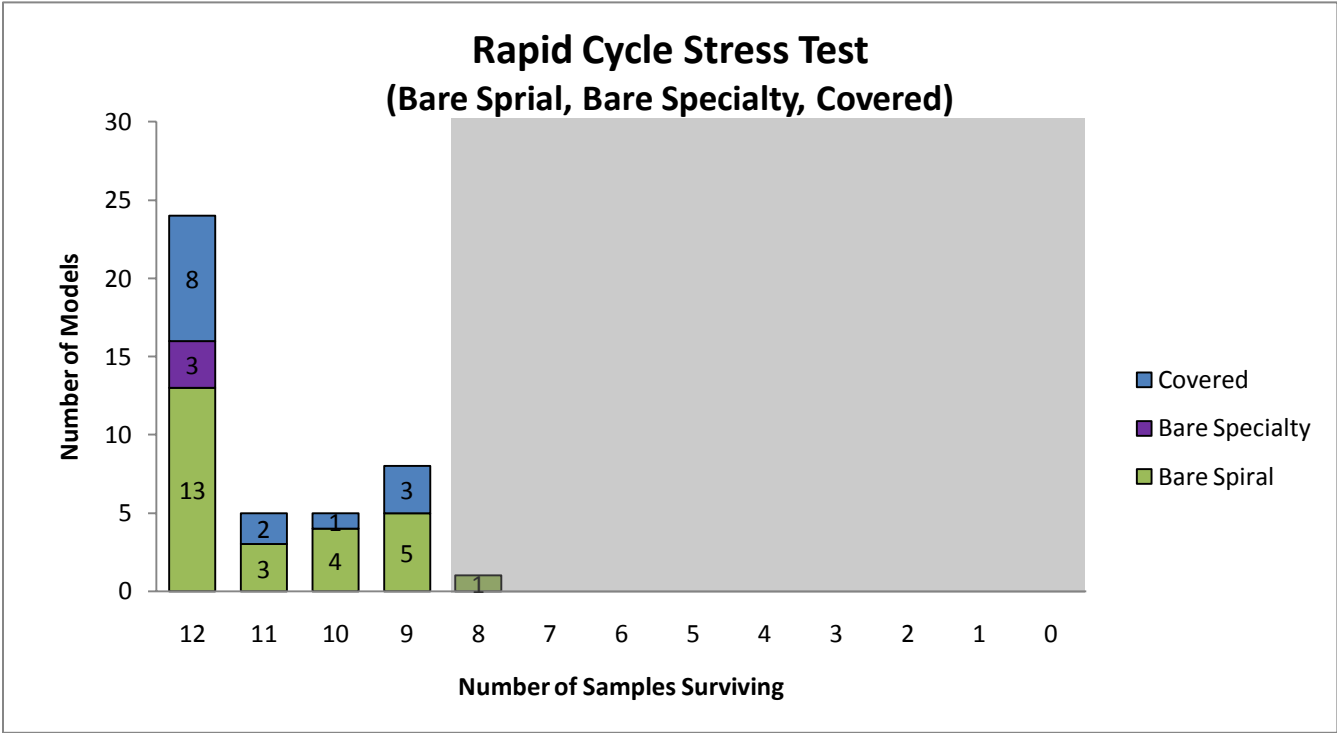


Figure 18-a: Rapid Cycle Stress Test Results for Single Sample Size Option (6 Samples)

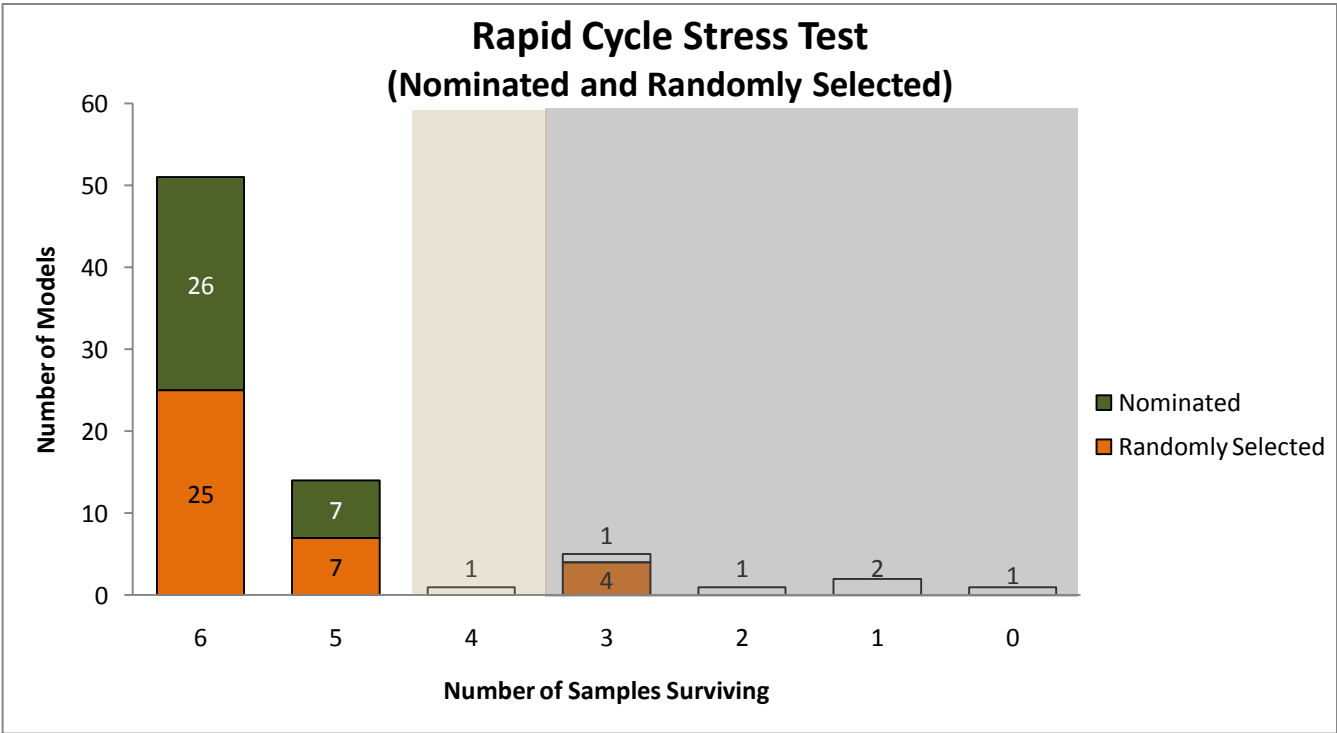


Figure 18-b: Rapid Cycle Stress Test Results for Double Sample Size Option (12 Samples)

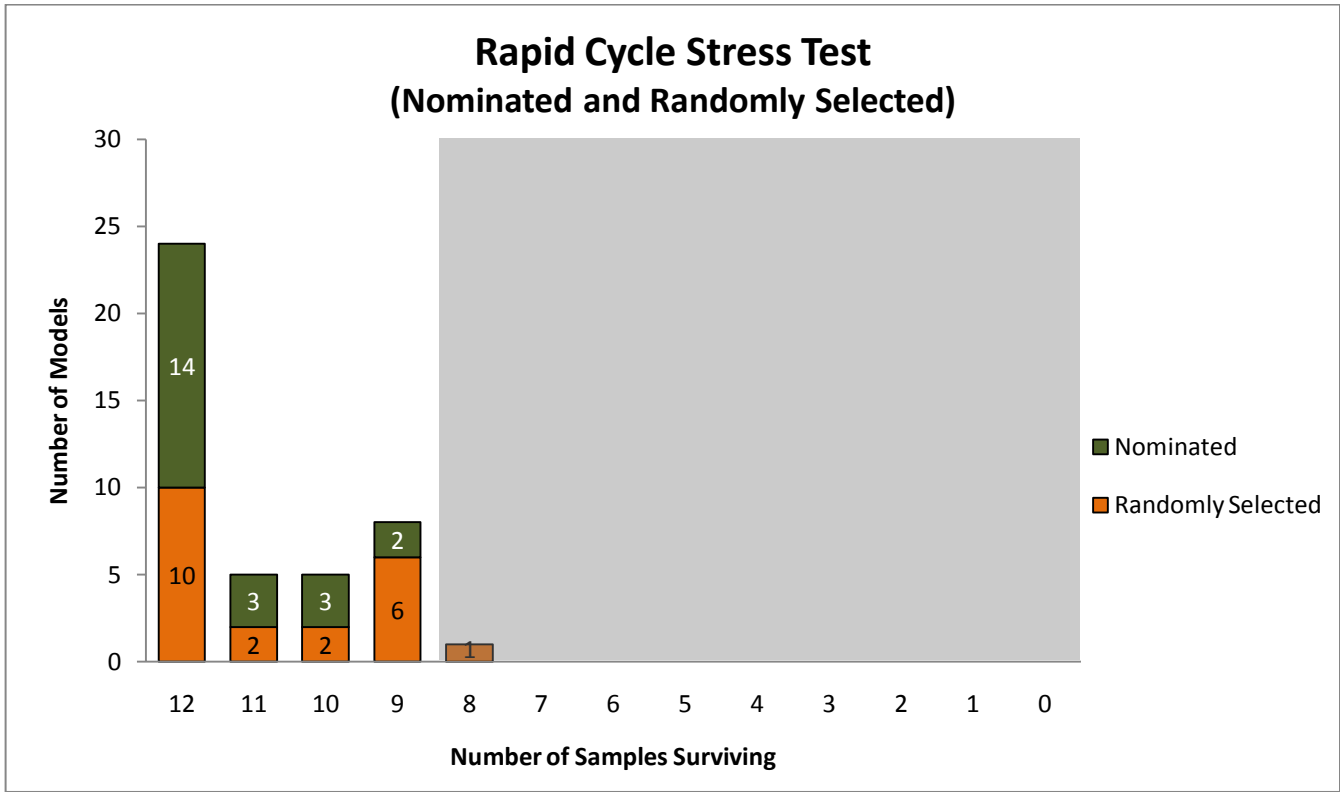


Table 14: Rapid Cycle Stress Test Results

	Number of Models Tested	% of Models		
		Passed Initial Test	Marginal Failure (Retest)	Full Failure
All Models	118	91%	1%	8%
Bare Spiral	66	89%	2%	9%
Bare Specialty	6	100%	0%	0%
Covered	46	91%	0%	9%
Nominated	57	96%	0%	4%
Randomly Selected	61	85%	2%	13%

Note: Overall mean and median were not included due to single and double sample sizes.

LUMEN MAINTENANCE AT 40% OF RATED LIFE

The 40% of Rated Life Lumen Maintenance Test is a secondary measurement of how well a product maintains its light output level over time. Models with light output at 40% of their rated life greater than 80% of their light output at 100 hours (with a tolerance of 3%) and with no more than three samples with light output less than 75% of light output at 100 hours pass the test. Table 16 shows the results of the 40% Lumen Maintenance Test. The gray-shaded regions of Figures 19 and 20 indicate test failure, and the cream-shaded regions indicate the 3% tolerance.

All the bare specialty models passed this test; 2 bare spiral and 15 covered models failed this test.

Table 15: 40% Lumen Maintenance Test Results

	Number of Models Tested	% of Models				
		Passed Initial Test	Marginal Failure (Retest)	Full Failure	Mean	Median
All Models	118	86%	0%	14%	84%	84%
Bare Spiral	66	97%	0%	3%	85%	86%
Bare Specialty	6	100%	0%	0%	86%	85%
Covered	46	67%	0%	33%	81%	83%
Nominated	57	89%	0%	11%	84%	85%
Randomly Selected	61	82%	0%	18%	83%	84%

Figure 19

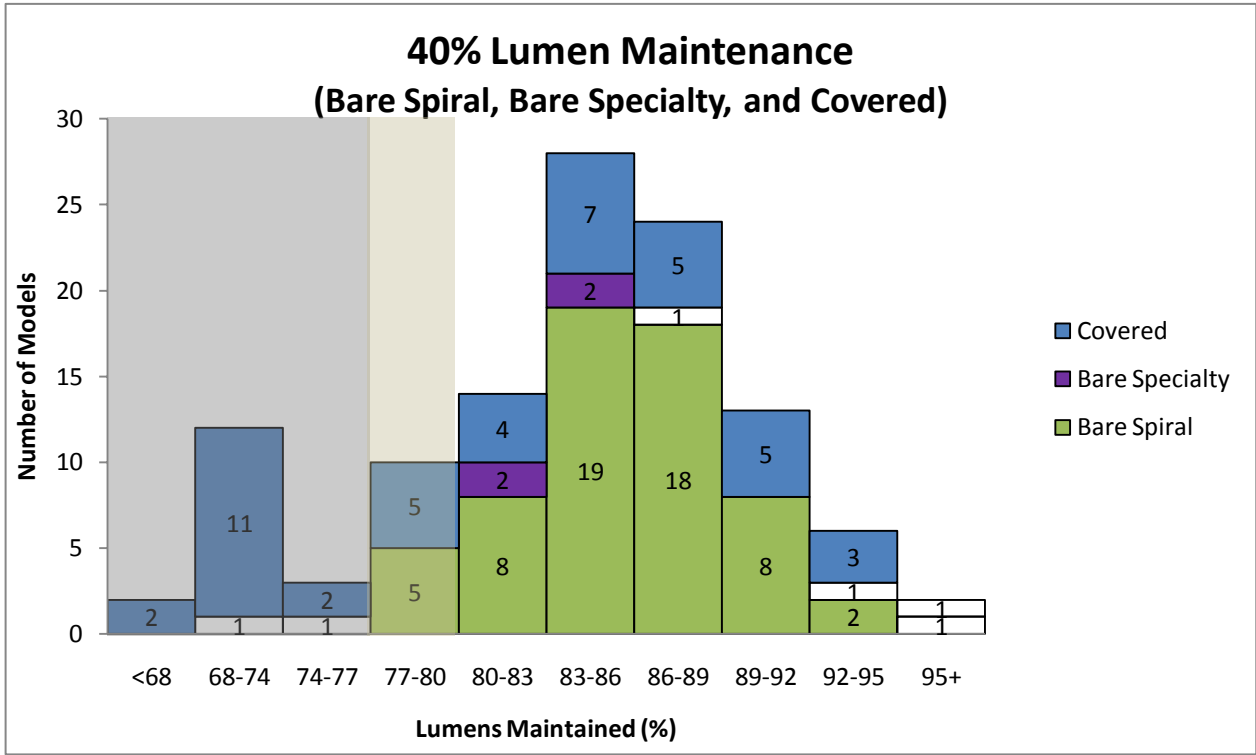
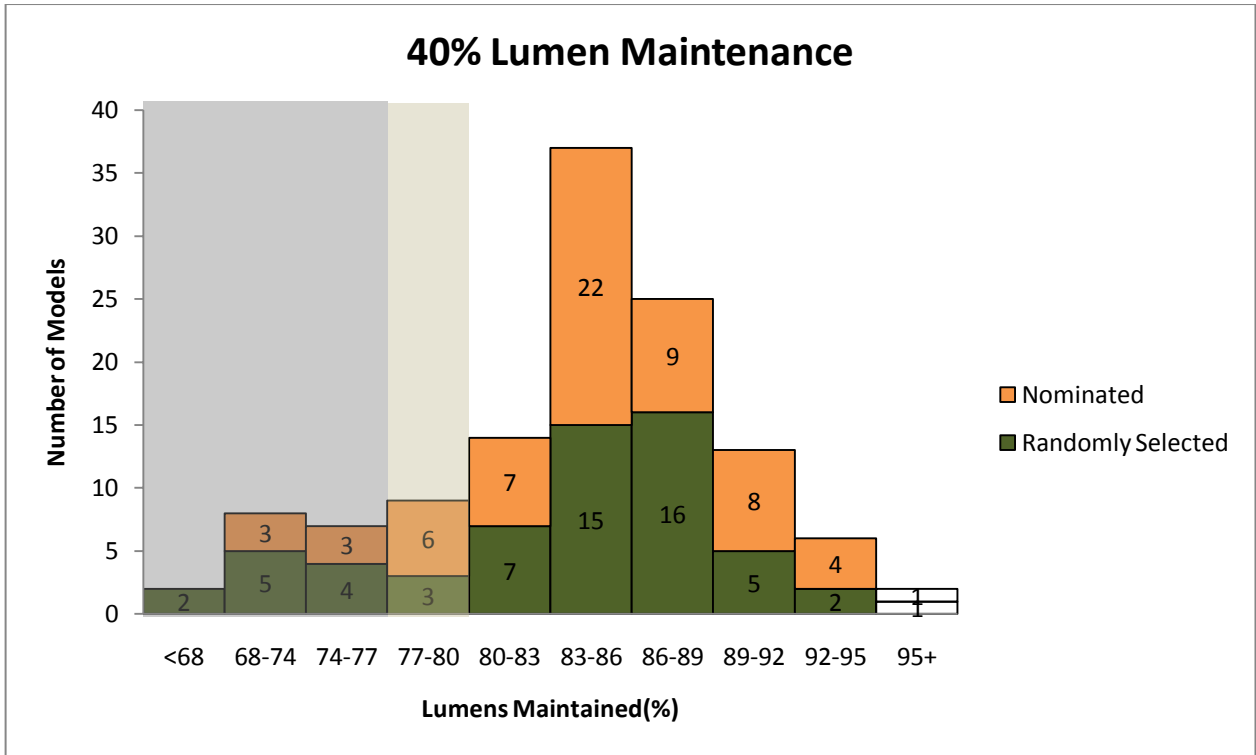


Figure 20



INTERIM LIFE TEST

The Interim Life Test measures how many of the 10 samples are still lit at 40% of the CFL's rated life. Models with 9 or 10 samples (or at least 17, for double sample sizes) still lit at 40% of rated life pass the test. If exactly 8 samples stay lit, the product scores as a marginal failure. There is no marginal failure for the double sample size option. The gray-shaded regions of Figures 21 (a,b) and 22 (a,b) indicate full test failure, and the cream-shaded regions indicate marginal failure.

Covered models were the worst performers, with only 67% of models passing (31 of 46 passed, 12 were full failures, and 3 were marginal failures). Bare spiral and bare specialty models had passing rates of 89% and 100%, respectively.

Figure 21-a: Interim Life Test Results for Single Sample Size Option (10 Samples)

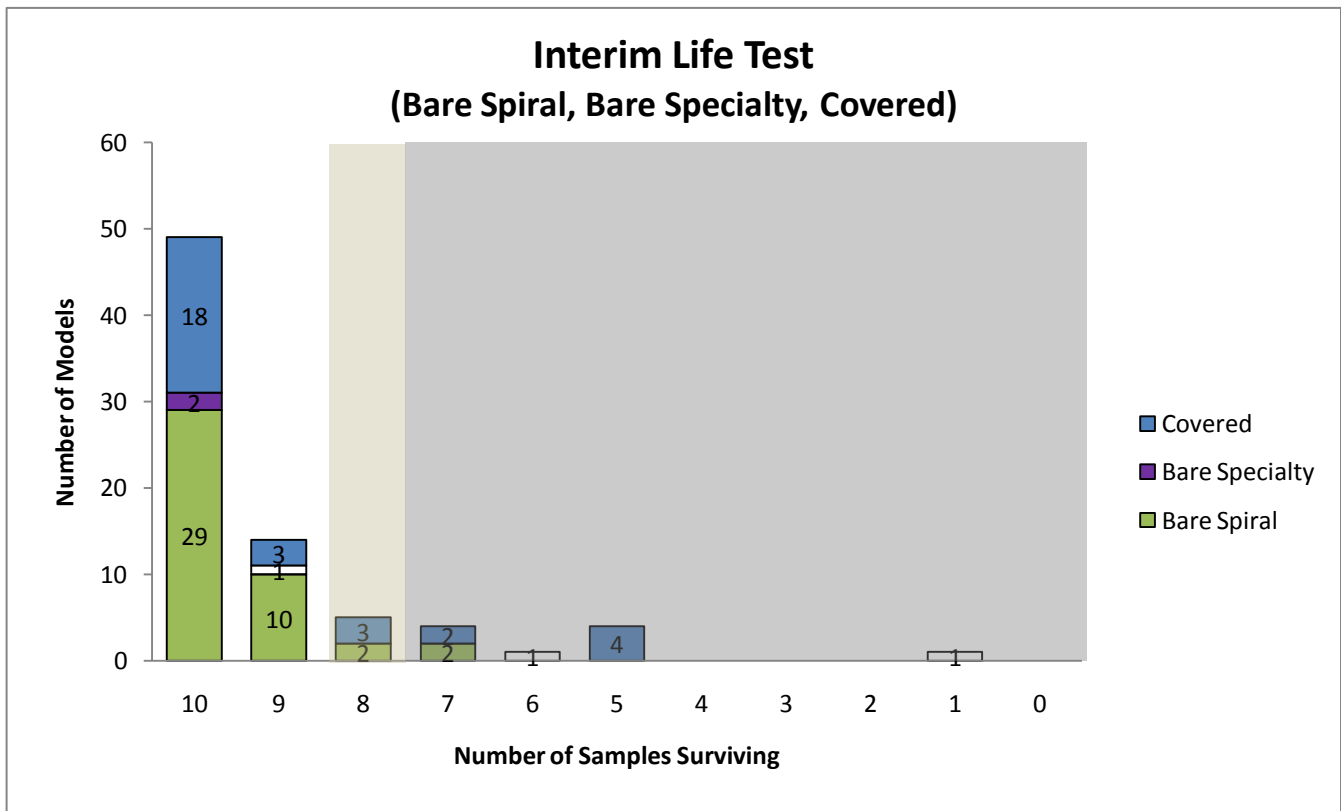


Figure 21-b: Interim Life Test Results for Double Sample Size Option (20 Samples)

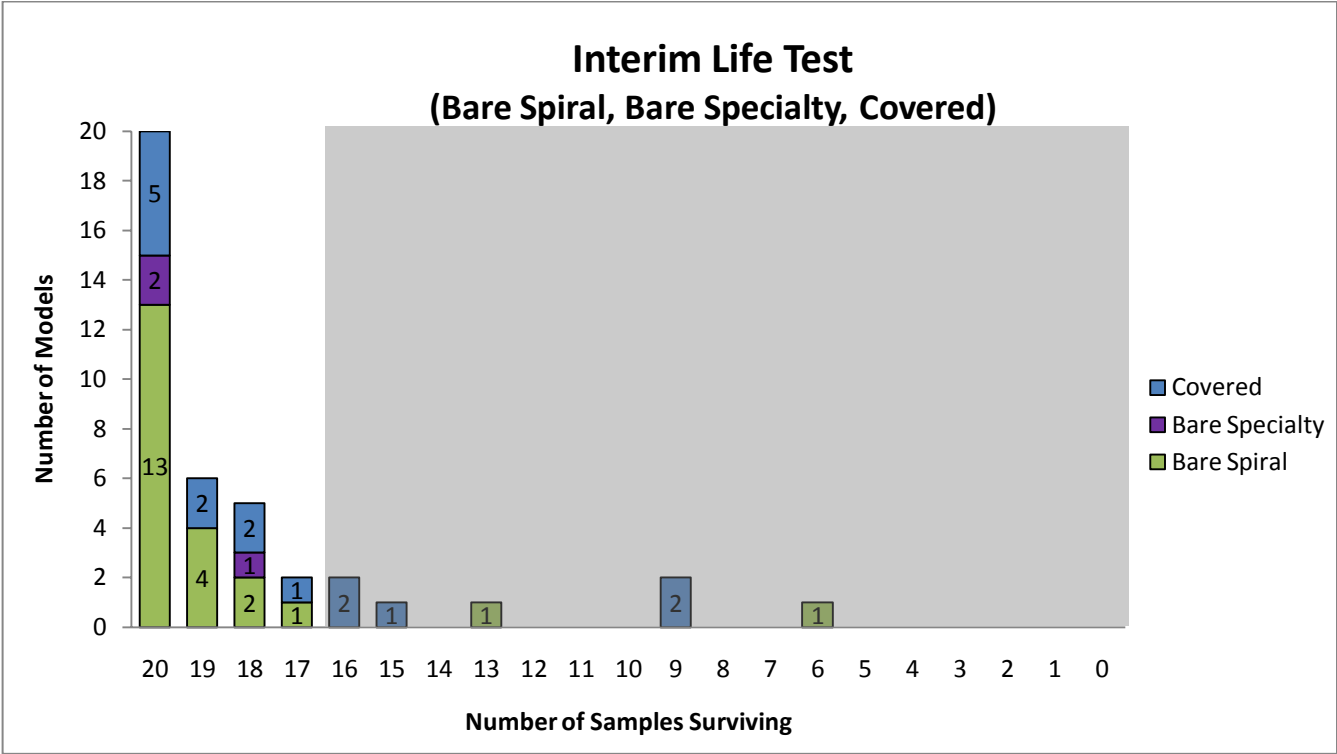


Figure 22-a: Interim Life Test Results for Single Sample Size Option (10 Samples)

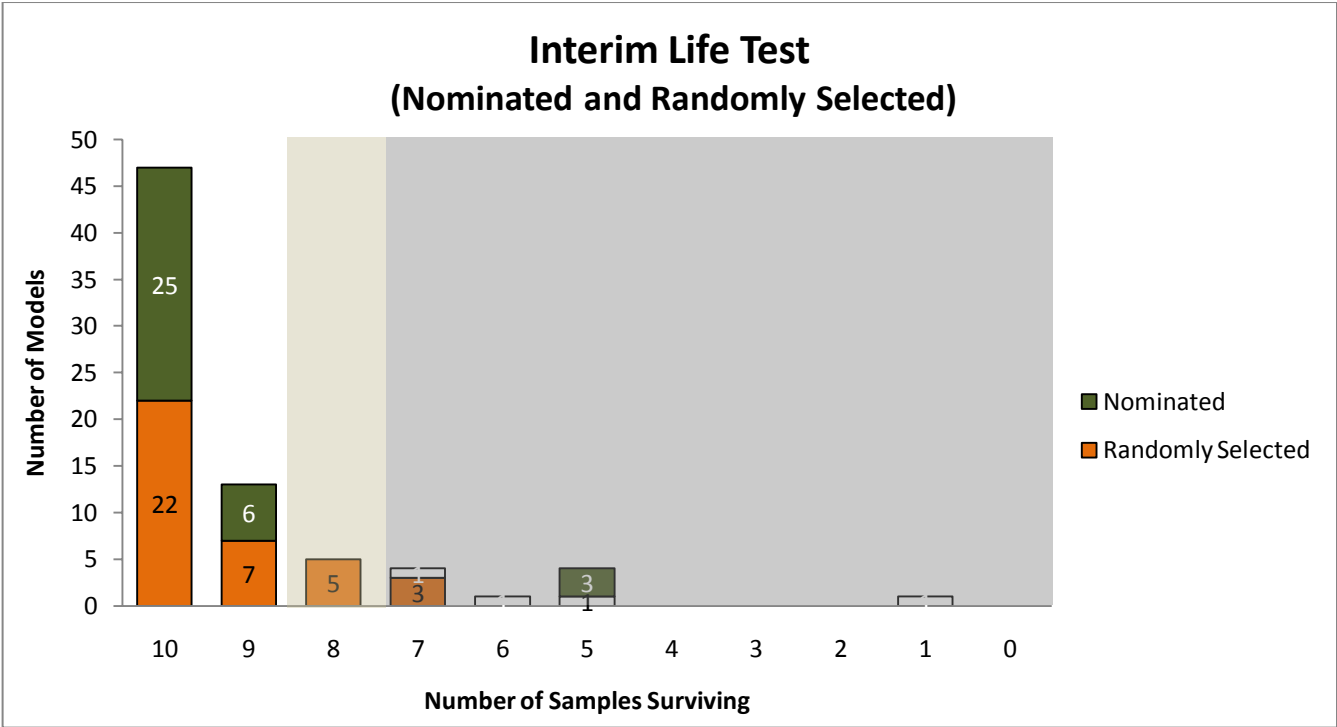


Figure 22-b: Interim Life Test Results for Double Sample Size Option (20 Samples)

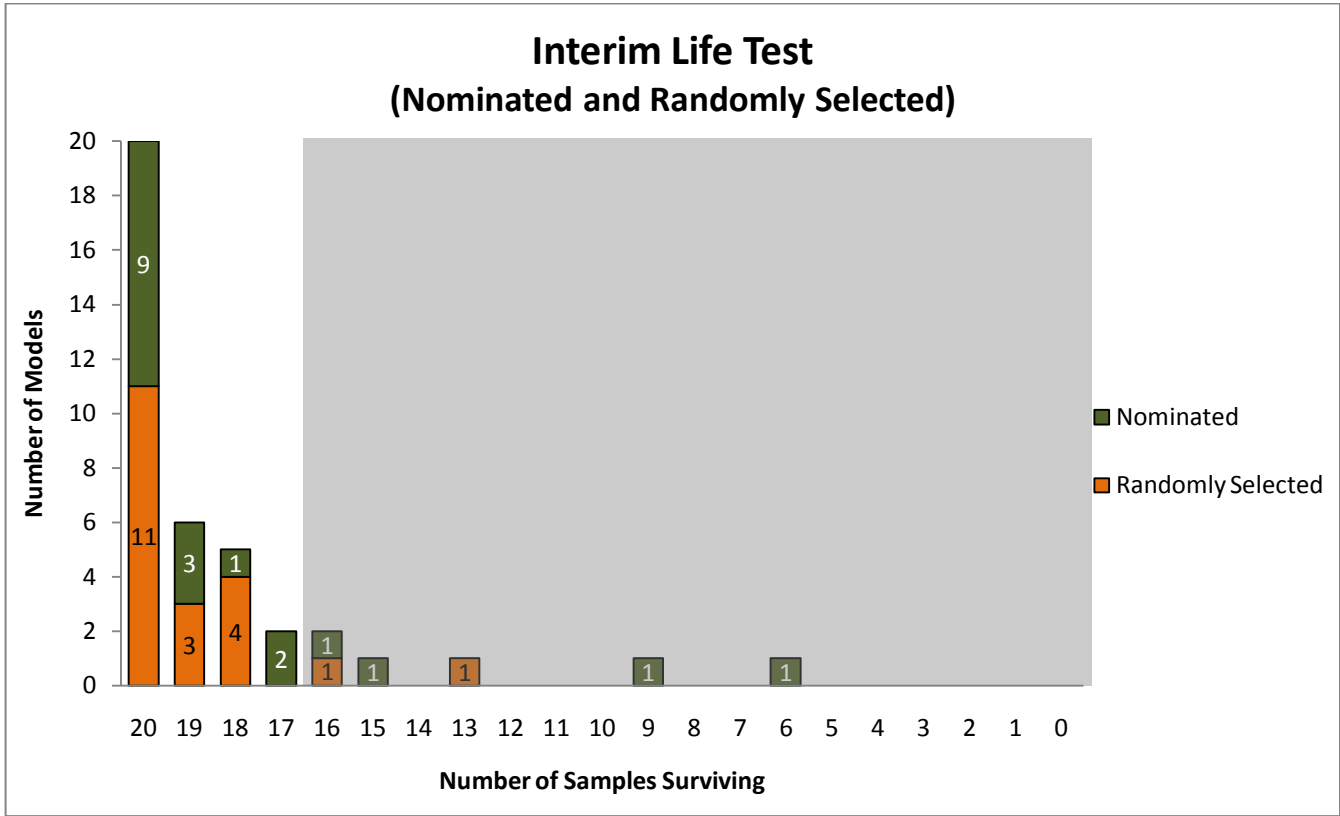


Table 16: Interim Life Test Results

	Number of Models Tested	% of Models		
		Passed Initial Test	Marginal Failure (Retest)	Full Failure
All Models	118	82%	4%	14%
Bare Spiral	66	89%	3%	8%
Bare Specialty	6	100%	0%	0%
Covered	46	67%	7%	26%
Nominated	57	82%	0%	18%
Randomly Selected	61	82%	8%	10%

Note: Overall mean and median were not included due to single and double sample sizes.

INITIAL ELEVATED TEMPERATURE OUTPUT RATIO

The Initial Elevated Temperature Output Ratio is a measurement of lumen output for indoor covered reflector models. The test is performed on only one sample; that sample must attain 90% of its claimed light output to meet ENERGY STAR requirements. The gray-shaded region in Figure 23 indicates full test failure.⁸

Figure 23

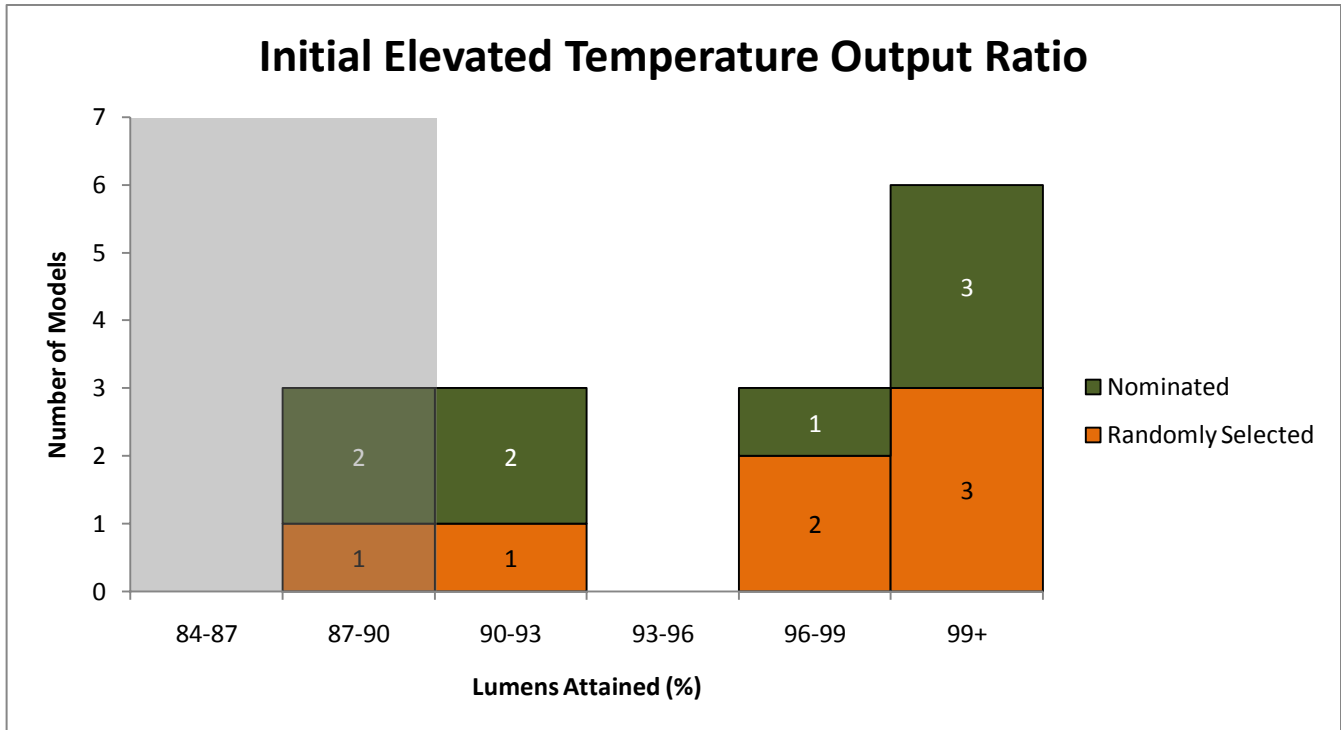


Table 17: Initial Elevated Temperature Output Ratio

	Number of Models Tested				
		Passed Initial Test	Full Failure	Mean	Median
Covered	15	80%	20%	96%	97%
Nominated	8	75%	25%	87%	92%
Randomly Selected	7	86%	14%	100%	99%

⁸ There is currently no defined marginal failure or 3% tolerance criteria for the Initial Elevated Temperature Output Ratio Test.

ALL TESTS

Of the 118 models in Batch 3, 59 (50%) passed all tests, 56 (47%) fully failed at least one test, and the remaining 3 (3%) had at least one marginal failure but no full failures. All tested models passed the Efficacy and Power Factor Tests. When marginal failures are included, the Interim Life, 1,000 Hour Lumen Maintenance, Run-Up Time, and Rapid Cycle Stress Tests had the highest failure rates, with 18%, 16%, 15%, and 15% of models failing, respectively. While the Interim Life Test had the highest failure rate, 22% of those failures were marginal. In contrast, all of the 1,000 Hour Lumen Maintenance and Run-Up Time test failures were full failures. Overall, 93% of all failures were full failures and 7% were marginal. See Table. The Initial Elevated Temperature Output Ratio Test had a failure rate of 20%, but this test was administered only to 15 covered indoor models.

Table 18: Detailed Results for All Tests

Summary	Efficacy	Starting Time	Run Up Time	Power Factor	1,000 Hour Lumen Maintenance	40% Lumen Maintenance	Color Rendering Index	Chromaticity Coordinates	Rapid Cycle Stress Test	Interim Life Test	Initial Elevated Temperature Output Ratio	Total Tests	Total Models
Passing Criteria	Minimum 33-60, depending on W and Model Type	<1,000 ms	<60 sec (non-amalgam), <180 sec (amalgam)	>0.5	>90%	>80% of 100-hour lumen average	>80	9/10 coordinates must fall inside ellipse	5/6 must meet rated life	9/10 must last 40% of rated life	>90%		
All												1195	118
Mean	60.8	318	76.8	0.58	92%	84%	82.7	12.5	7.5	12.4	96%		
Median	63.2	230	48.0	0.57	93%	84%	82.4	10.0	6.0	10.0	97%		
Full Failures	0	3	18	0	19	17	2	11	10	16	3	99	56
Bare Spiral Models	0	1	1	0	2	2	1	6	6	5	0	24	19
Bare Specialty Models	0	1	0	0	0	0	0	0	0	0	0	1	1
Covered Models	0	1	17	0	17	15	1	5	4	11	3	74	36
Marginal Failures								2	1	5	0	8	3

Bare Spiral Models								0	1	2	0	3	3
Bare Specialty Models								0	0	0	0	0	0
Covered Models								2	0	3	0	5	0
% Failing Test	0%	3%	15%	0%	16%	14%	0%	12%	15%	18%	20%		51%
% Full Failure	0%	100%	100%	0%	100%	100%	100%	75%	89%	78%	100%		87%
Passing Test	118	115	100	118	99	101	116	105	107	97	12	1088	59
Bare Spiral Models	66	65	65	66	64	64	65	60	59	59	N/A	633	44
Bare Specialty Models	6	5	6	6	6	6	6	6	6	6	N/A	59	5
Covered Models	46	45	29	46	29	31	45	39	42	32	12	396	10
% Passing Test	100%	97%	85%	100%	84%	86%	100%	88%	91%	82%	98%		50%
Nominated												578	57
Mean	60.9	304	78	0.59	92%	84%	82.8	12.8	7.9	12.2	87%		
Median	63.2	214	60	0.57	92%	85%	82.7	10	6	10	92%		
Full Failures	0	0	7	0	11	6	0	7	2	9	2	44	24
Bare Spiral Models	0	0	0	0	1	1	0	3	1	2	N/A	8	6
Bare Specialty Models	0	0	0	0	0	0	0	0	0	0	N/A	0	0
Covered Models	0	0	7	0	10	5	0	4	1	7	2	36	18
Marginal Failures								1	2	1	0	5	3
Bare Spiral Models								0	1	0	N/A	2	2
Bare Specialty Models								0	0	0	N/A	0	0
Covered Models								1	1	1	0	3	1
% Failing Test	0%	0%	12%	0%	19%	11%	0%	12%	4%	16%	4%		42%
% Full Failure	0%	0%	100%	0%	100%	100%	0%	88%	50%	88%	100%		89%

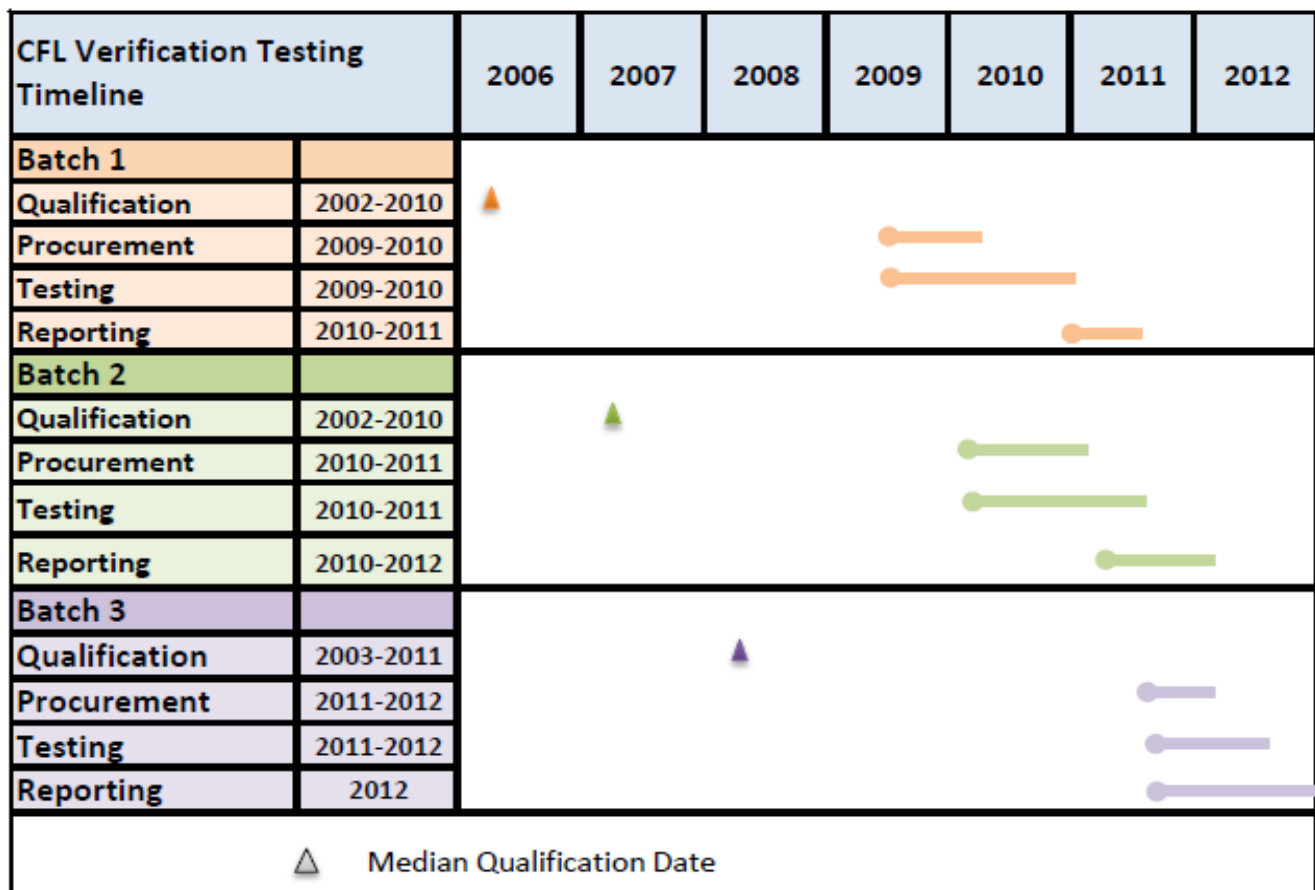
Passing Test	57	57	50	57	46	51	57	50	53	47	55	577	30
Bare Spiral Models	29	29	29	29	28	28	29	26	27	26	N/A	280	20
Bare Specialty Models	2	2	2	2	2	2	2	2	2	2	N/A	20	2
Covered Models	26	26	19	26	16	19	26	22	24	19	2	222	8
% Passing Test	100%	100%	88%	100%	81%	89%	100%	88%	93%	82%	96%		53%
Randomly Selected												617	61
Mean	60.9	313	74	0.57	92%	83%	82.6	12.4	7.3	12.7	106%		
Median	63.0	223	41	0.57	93%	84%	82.3	10	6	10	99%		
Full Failures	0	3	11	0	8	11	2	4	8	6	1	54	31
Bare Spiral Models	0	1	1	0	1	1	1	3	5	3	N/A	16	13
Bare Specialty Models	0	1	0	0	0	0	0	0	0	0	N/A	1	1
Covered Models	0	1	10	0	7	10	1	1	3	3	1	37	17
Marginal Failures								1	3	5	0	9	3
Bare Spiral Models								0	1	2	N/A	3	3
Bare Specialty Models								0	0	0	N/A	0	0
Covered Models								1	2	3	0	6	0
% Failing Test	0%	5%	18%	0%	15%	18%	3%	7%	18%	18%	2%		57%
% Full Failure	0%	100%	100%	0%	100%	100%	100%	80%	53%	55%	100%		89%
Passing Test	61	58	50	61	53	50	59	56	46	50	6	550	27
Bare Spiral Models	37	36	36	37	36	36	36	34	31	34	N/A	353	21
Bare Specialty Models	4	3	4	4	4	4	4	4	4	4	N/A	39	3
Covered Models	20	19	10	20	13	10	19	18	15	12	6	162	3
% Passing Test	100%	95%	82%	100%	87%	82%	97%	92%	75%	82%	86%		43%

AGGREGATED PERFORMANCE

This section compares the performance of models included in Batches 1, 2, and 3. Observed trends among the tested models suggest trends in the population of ENERGY STAR qualified CFLs at large, because the models included in Batch 3 were generally first qualified as ENERGY STAR models about 2 years later than those in Batch 1.

The models tested in Batch 1 were procured beginning in April 2009 and the models tested in Batch 2 were procured beginning almost a year later in February 2010. The median date of first qualification for Batch 1 models is January 1, 2007, while the median date for Batch 2 models is December 8, 2008, suggesting that the models included in Batch 2 were significantly newer to the market than the models included in Batch 1. See Figure 24.

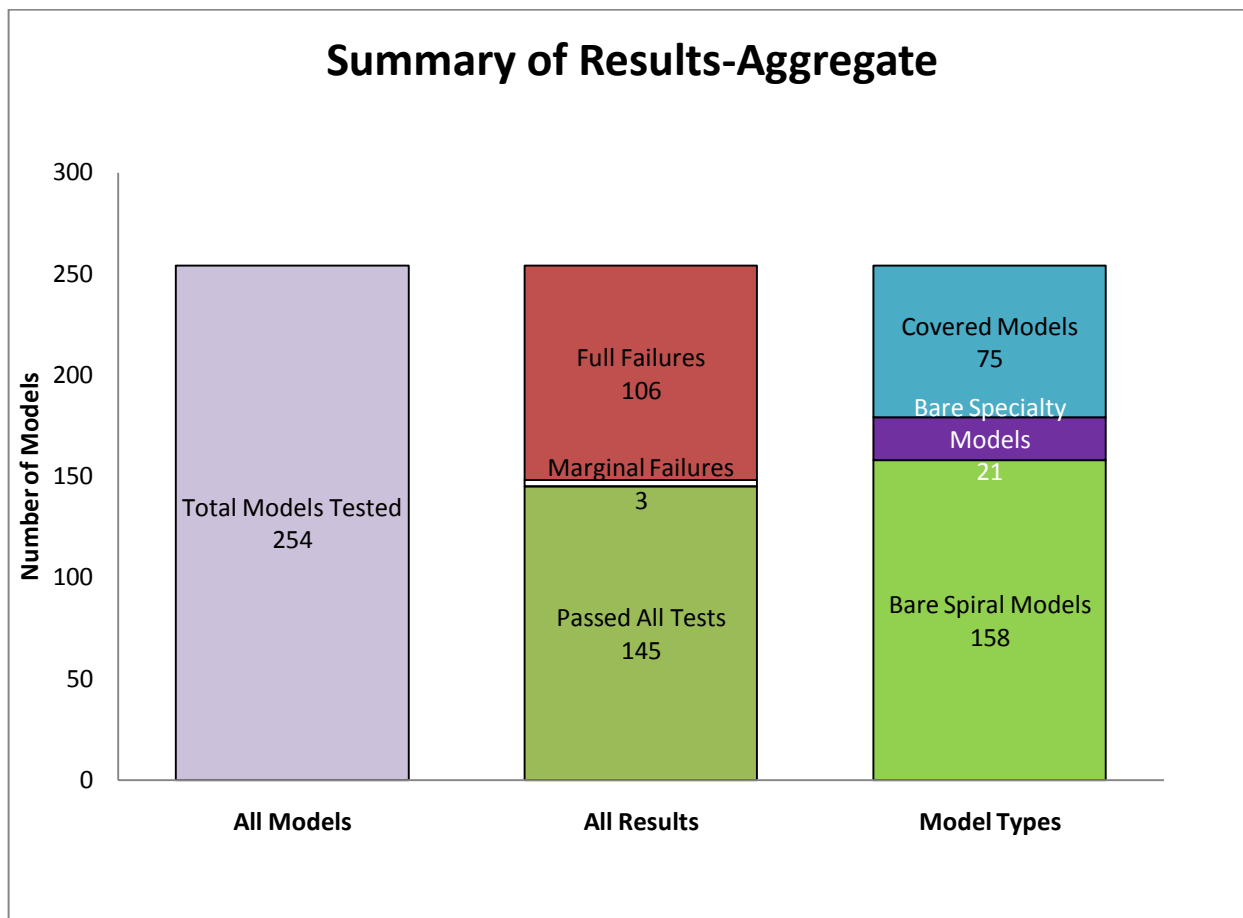
Figure 24



SUMMARY OF RESULTS BY PRODUCT TYPE

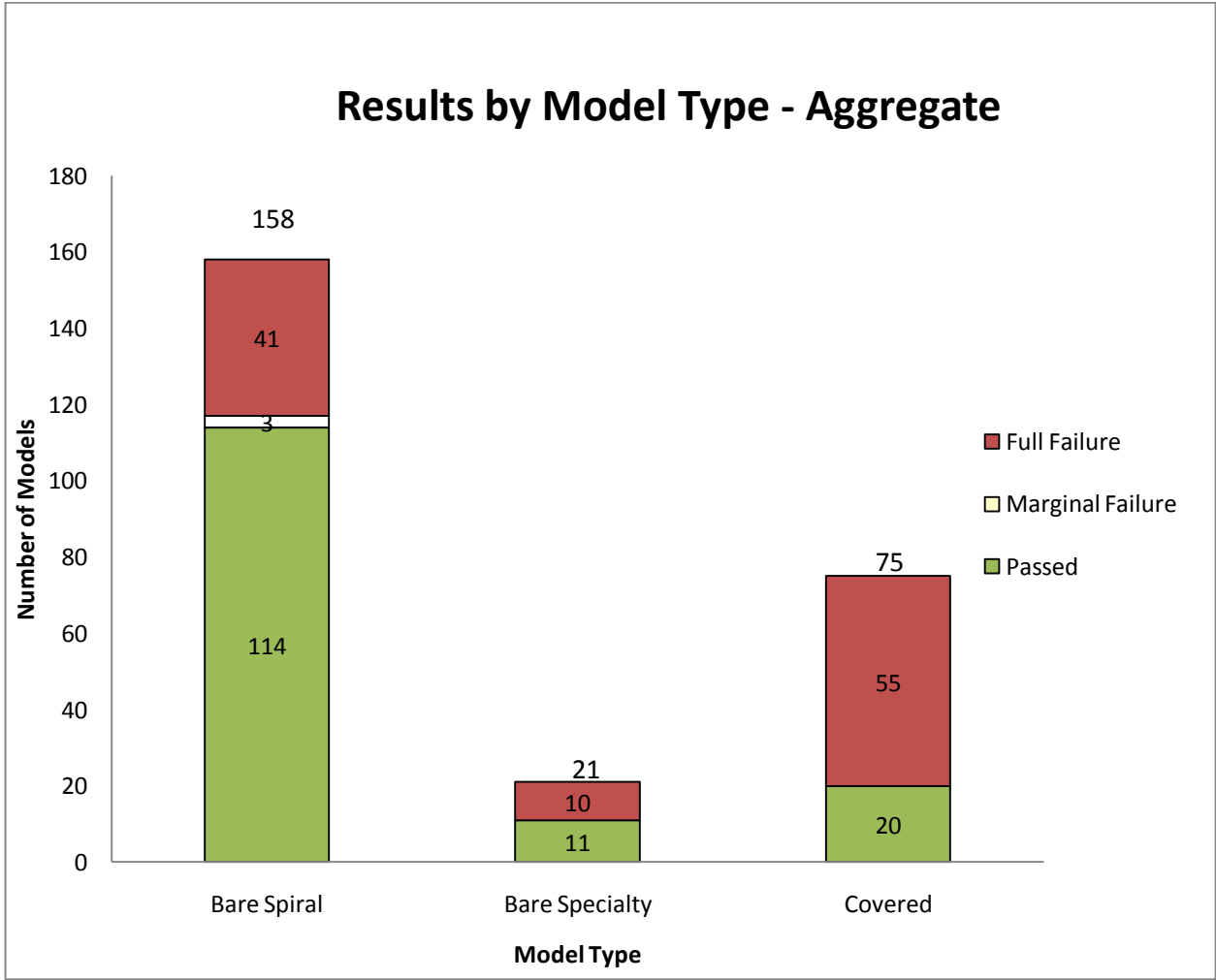
A total of 254 models had been tested as of July 31, 2012, with Batch 1 and Batch 2 each containing 68 models and Batch 3 containing 118 models. A majority (62%) of the models tested were bare spiral lamps, 8% were bare specialty lamps, and 30% were covered models. See Figure 25.

Figure 25



Over the 3 batches, bare spiral models had a 25% failure rate, bare specialty models had a 48% failure rate, and covered models performed worst, with 73% of models failing. See Figure 26.

Figure 26

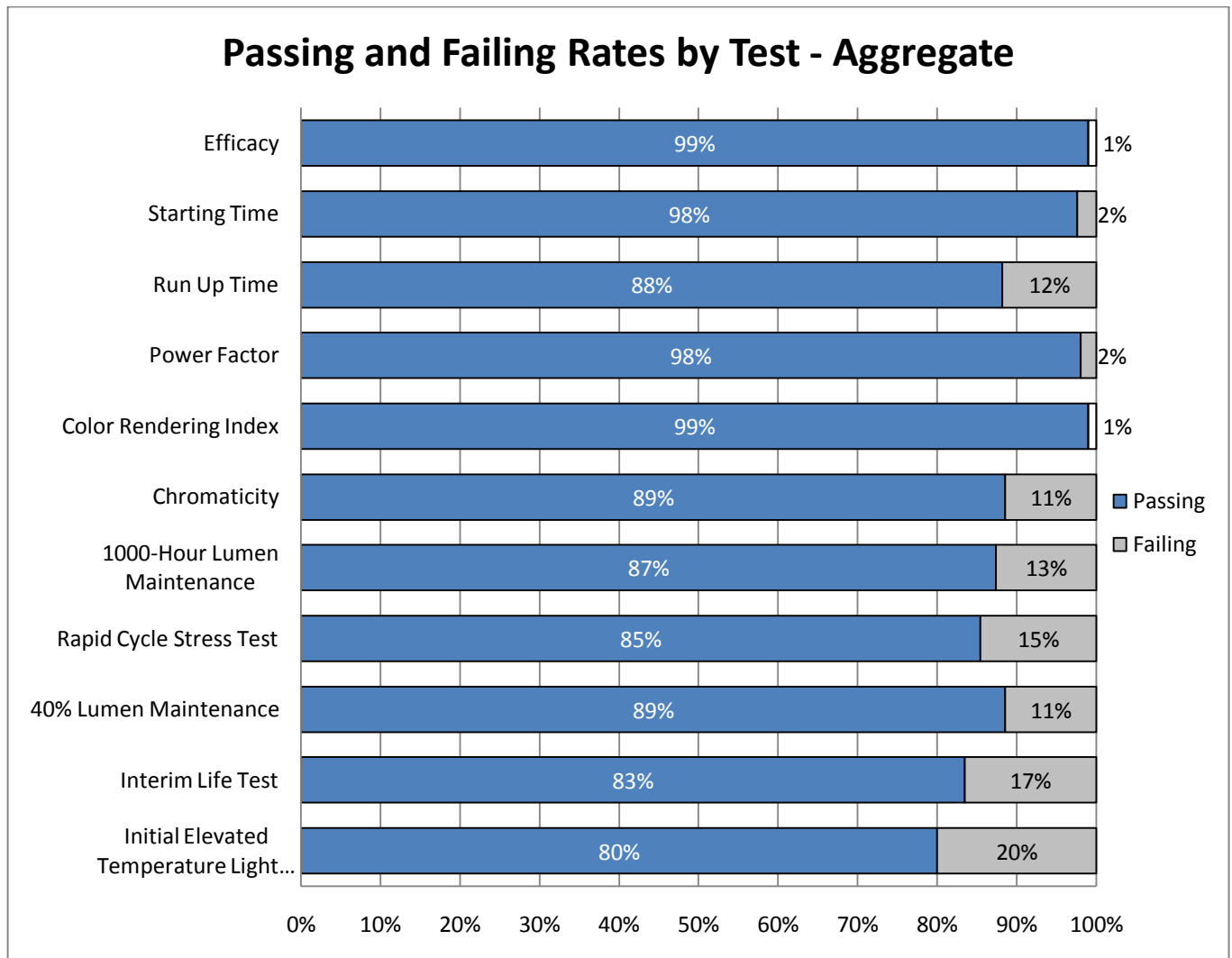


SUMMARY OF RESULTS BY TEST

This section compares product performance on each of the 11 tests for the three batches and the three product types.

In Batches 1, 2, and 3, no test maintained a 100% passing rate. Four tests had passing rates close to 100%: Efficacy, Starting Time, Power Factor, and Color Rendering Index. The following tests showed low passing rates overall, with only 82%-88% of all models passing: Run-Up Time, Chromaticity, 1000-Hour Lumen Maintenance, Rapid Cycle Stress Test, 40% Lumen Maintenance, and Interim Life. The Initial Elevated Temperature Light Output Ratio Test had a passing rate of 80%. See Figure 27.

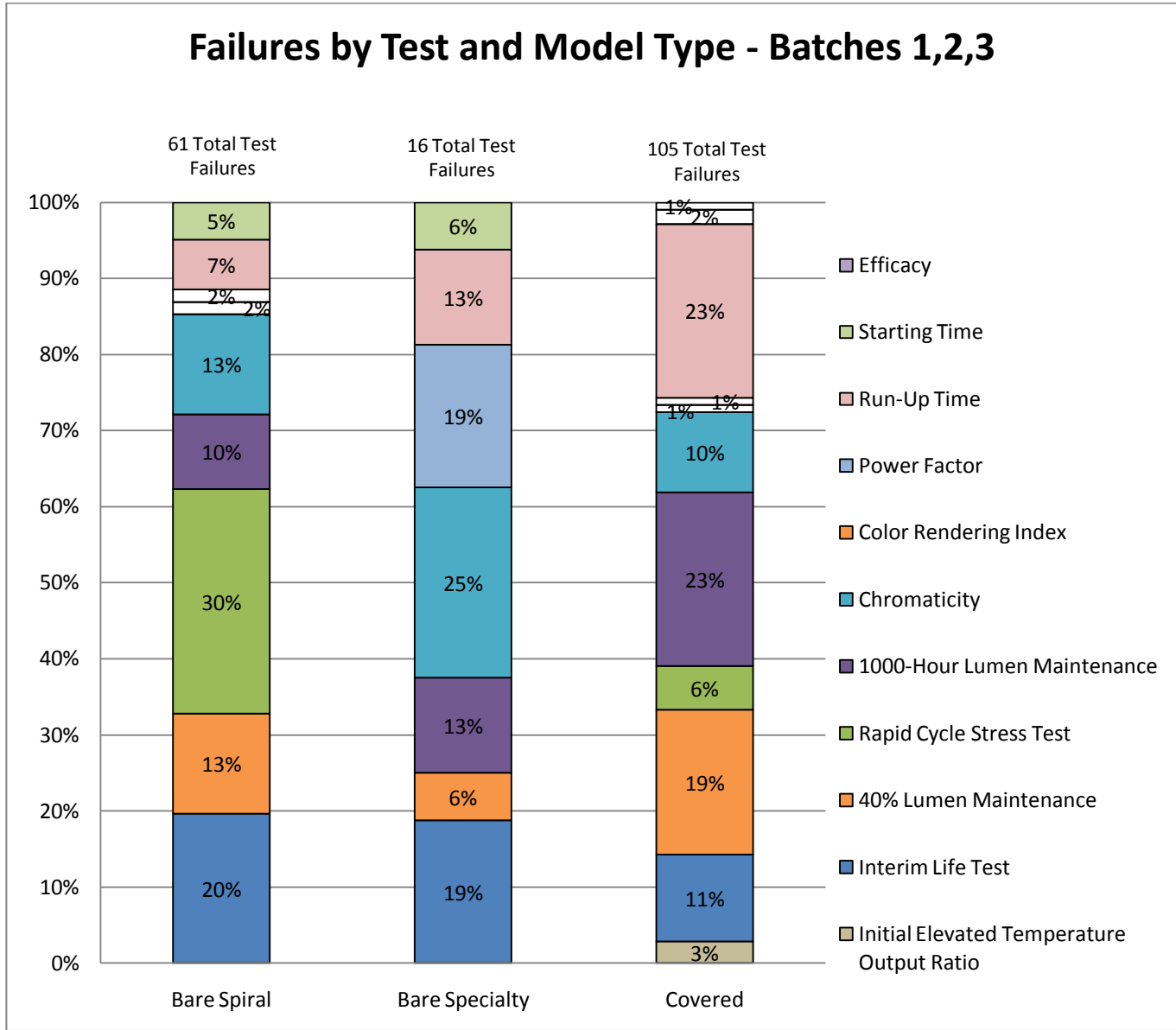
Figure 27



On the whole, passing rates varied little among Batch 1, Batch 2, and Batch 3. Marginal failures are included in the failing percentage.

Figure 28 shows how the test failures to date are distributed across the eleven tests for each of the three lamp types. For example, the Rapid Cycle Stress Test accounts for 30% of the test failures experienced by bare spiral models; more bare spiral models failed that test than any other. The Chromaticity Test accounts for 25% of bare specialty failures; that is the highest failure rate for bare specialty models. The Run-Up Time and 1,000-Hour Lumen Maintenance Tests had the highest failure rates for covered models; each test represented 23% of covered product failures. Marginal failures are not included in the test failure totals.

Figure 28



CONCLUSION

The performance of the 118 models in Batch 3 was mixed. Five tests had passing rates of less than 90%: Run-Up Time, Chromaticity, 1,000 Hour Lumen Maintenance, 40% Lumen Maintenance, and Interim Life Tests. On each of these tests, a sizeable proportion of the failures were significant underperformers (more than two standard deviations from the mean).

Only half of the 118 tested models passed all of the tests, although each of these models passed all of the tests to become ENERGY STAR qualified. Verification testing of these models resulted in the disqualification of approximately half of the tested models that were initially ENERGY STAR qualified.

Of the three lamp types, covered lamps performed the worst, with only 22% of models passing all tests. Covered models were more often significant underperformers than bare spiral and bare specialty models.

Program sponsors interested in the off-the-shelf performance of models they are incentivizing or considering incentivizing can ask current or potential suppliers to provide the results of any verification testing of those models. They can also require that suppliers grant the ENERGY STAR CFL Third Party Testing and Verification Program Administrator permission to confirm whether the product has undergone or is currently undergoing verification testing.

The verification testing program provides EPA with a mechanism for ensuring that ENERGY STAR qualified models available in the marketplace perform as promised. In addition, the test results likely reflect consumers' experiences with ENERGY STAR qualified CFLs in their homes and businesses. However, care should be exercised when generalizing from the test results described in this report to the entire market of ENERGY STAR qualified CFLs, as the sample of models tested is not representative of ENERGY STAR shipments. There are three key reasons why this is so.

First, the CFL Qualified Models List is highly dynamic. The tested models were purchased in 2011 and early 2012. Many of the models that were available then are no longer available, and many new models have been introduced since.

Second, certain subsamples of tested models are quite small. For example, only 21 bare specialty CFL models have been tested to date. Of course, the total number of models tested and the volume of data on those models will grow as additional cycles of verification testing are completed.

Third, the tested models are not representative of actual shipments of ENERGY STAR models. Some of the models that have been tested are sold in large volumes, while others have much smaller sales volumes. The test results are not weighted to reflect these differences.

APPENDIX

The ENERGY STAR CFL Third Party Testing and Verification Program exists to support the U.S. Environmental Protection Agency in ensuring that compact fluorescent lamps (CFLs) qualified and labeled as ENERGY STAR continue to meet all ENERGY STAR CFL qualification criteria. This report contains the results of all models tested by the program from August 1, 2011 through July 31, 2012.

KEY	
*	The product has been retired or discontinued since testing began.
(?)	The product could not be positively identified because its model number corresponds to multiple qualified models.
Failed	The product failed testing.
Significantly Underperforming	The product failed at least one test by more than two standard deviations
Marginal Failure	The product was a marginal failure, meaning that one less sample than required passed (e.g., if 9 out of 10 are required, only 8 out of 10 passed).
3% Applied	The product passed the Efficacy and/or Lumen Maintenance Test with performance between 97% and 99.9% of the minimum requirement.
Nominated	The product was nominated for testing.
p	The product passed.

Table A. Detailed Results for Each of the 118 Models Included in Batch 3

Model Type	Energy Used (Watts)	Light Output (Lumens)	Life (hours)	Color Temp (Kelvin)	Efficacy	Starting Time	Run Up Time	Power Factor	1,000 Hour Lumen Maintenance	40 Percent Lumen Maintenance	Color Rendering Index	Chromaticity Coordinates	Rapid Cycle Stress Test	Interim Life Test	Initial Elevated Temperature Output Ratio
Bare Spiral	20	1250	8000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	26	1260	6000	2700	p	p	267	p	89%	p	p	p	p	p	
Bare Spiral	13	900	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	23	1600	10000	2700	p	p	p	p	p	p	p	p	p	8	
Covered Globe	9	495	8000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	32	2030	8000	6500	p	p	p	p	p	p	p	4	p	p	
Covered A-line	9	470	8000	2700	p	p	107	p	88%	75%	p	p	p	p	
Bare Specialty	12/21/32	2280	10000	3500	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	1100	6000	2700	p	p	p	p	p	75%	p	p	2	p	p
Covered A-line	20	950	10000	2700	p	p	166	p	81%	71%	p	0	p	p	
Covered reflector	23	1300	8000	2700	p	p	p	p	83%	70%	p	8	p	8	p

Bare Spiral	15	520	8000	2700	p	p	p	p	p	p	p	p	p	13	
Bare Spiral	11	660	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	23	230	10000	2700	p	p	p	p	p	p	p	p	p	5	
Bare Spiral	13	900	10000	2700	p	p	p	p	p	p	p	p	3	p	
Covered-Candle	5	1200	10000	2700	p	p	126	p	84%	p	p	p	p	1	p
Bare Spiral	23	1600	8000	2700	p	p	p	p	p	p	p	14	p	p	
Covered reflector	20	950	8000	2700	p	p	p	p	87%	78%	p	p	p	p	
Covered reflector	15	700	8000	2700	p	p	73	p	85%	75%	p	p	p	16	p
Covered reflector	16	700	8000	2700	p	p	157	p	p	p	p	p	p	p	
Bare Spiral	23	1600	12000	6500	p	p	p	p	p	80%	p	p	p	p	
Bare Spiral	13	900	10000	2700	p	p	p	p	p	p	p	3	p	p	87.36%
Covered globe	9	500	10000	4100	p	p	p	p	p	p	p	p	p	7	87.7
Covered reflector	15	750	8000	3000	p	p	373	p	p	p	p	p	3	p	
Covered A-line	9	500	10000	4100	p	p	66	p	p	p	p	p	p	8	
Bare Spiral	23	1650	15000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	15	950	15000	2700	p	p	p	p	p	p	p	p	p	8	
Bare Spiral	13	794	10000	2700	p	p	p	p	89%	p	p	p	3	p	
Bare Spiral	13	900	10000	2700	p	p	p	p	p	p	p	p	p	p	

Bare Spiral	26	1625	12000	6500	p	p	p	p	90%	78%	p	p	p	p	
Bare Spiral	26	1660	8000	5000	p	p	p	p	89%	p	p	p	p	6	
Bare Spiral	13	855	8000	5000	p	p	p	p	89%	p	p	p	p	p	p
Bare Spiral	13	825	8000	2700	p	p	p	p	p	p	p	p	8	p	
Bare Spiral	24	1600	10000	5000	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	890	10000	5000	p	p	p	p	p	p	p	p	p	p	
Covered reflector	11	365	10000	2700	p	p	p	p	81%	69%	p	p	3	p	
Bare Specialty	12/20/26	1600	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	900	10000	4100	p	p	p	p	p	80%	p	p	p	7	
Bare Spiral	13	830	10000	2700	p	p	p	p	p	p	p	p	p	p	

Bare Specialty	13	900	12000	3000	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	800	10000	4100	p	p	62	p	p	p	p	p	p	p	
Covered reflector	15	750	8000	3000	p	p	p	p	p	p	p	p	p	p	
Covered reflector	23	1050	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	15	650	6000	2700	p	p	111	p	83%	77%	p	12	p	p	
Bare Spiral	18	1200	10000	2750	p	p	p	p	p	p	p	p	p	p	
Covered globe	9	550	10000	2700	p	p	p	p	89%	76%	p	p	p	8	
Bare Spiral	9	500	10000	2700	p	p	p	p	p	p	p	p	4	p	
Bare Spiral	13	900	12000	2700	p	p	p	p	p	p	80%	4	3	p	
Bare Spiral	14	850	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	20	1300	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered A-line	7	380	10000	2700	p	p	79	p	86%	72%	p	6	p	5	
Bare Spiral	9	500	10000	2700	p	p	p	p	p	p	p	p	1	p	

Bare Spiral	14	14	900	10000	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	15	900	10000	2700	p	p	p	p	p	p	p	p	p	7	
Bare Spiral	23	1650	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	25	1625	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	15	750	8000	2700	p	p	182	p	p	p	p	p	0	p	
Bare Spiral	20	1230	10000	2700	p	p	35	p	p	p	p	7	p	p	
Bare Spiral	20	1295	10000	2700	p	p	56	p	p	p	p	p	p	p	
Bare Spiral	13	800	10000	2700	p	p	36	p	p	p	p	p	p	6	
Bare Spiral	13	800	8000	6500	p	p	32	p	p	p	p	p	p	p	
Bare Spiral	23	1644	8000	2700	p	p	26	p	p	p	p	p	p	p	

Covered reflector	23	1200	8000	5000	p	p	223	p	90%	p	p	p	p	p	
Bare Spiral	18	1200	8000	2700	p	p	p	p	p	p	p	p	p	p	
Covered A-line	14	800	8000	2700	p	p	p	p	p	p	p	14	p	p	
Bare Specialty	18	1250	8000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Specialty	23	1600	8000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	23	1600	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	17	630	8000	2700	p	p	p	p	p	p	p	p	p	p	p
Covered reflector	24	1301	10000	2700	p	p	p	p	p	78%	p	p	p	p	
Bare Spiral	18	1250	12000	2700	p	p	p	p	p	78%	p	p	p	p	
Bare Spiral	23	1600	8000	6500	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	900	12000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	26	1750	10000	4100	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	9	570	10000	5000	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	23	1600	10000	2700	p	p	p	p	p	p	p	p	p	p	

Bare Spiral	4	250	8000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	9	300	8000	5000	p	p	p	p	p	p	p	p	p	p	
Covered reflector	15	700	8000	4100	p	p	245	p	p	p	p	p	p	p	89.74
Covered reflector	14	1100	10000	2700	p	p	p	p	84%	64%	p	p	p	5	p
Bare Spiral	13	900	10000	5000	p	p	p	p	p	p	p	p	p	p	
Covered A-line	19	1200	10000	2700	p	p	190	p	84%	70%	p	p	p	p	
Bare Spiral	13	950	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	900	10000	4100	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	20	1200	10000	4100	p	p	p	p	p	p	p	p	p	p	
Bare Specialty	25	1670	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered globe	11	635	8000	2700	p	p	p	p	90%	p	p	p	p	p	
Covered reflector	26	1283	10000	2700	p	p	194	p	p	p	p	p	p	16	
Bare Spiral	13	900	15000	5000	p	p	p	p	p	p	p	p	p	p	

Bare Spiral	13	900	15000	2700	p	p	p	p	p	p	p	p	p	p	
Covered A-line	14	800	8000	2700	p	p	p	p	p	p	p	p	p	p	p
Covered-globe	14	800	8000	2700	p	p	p	p	p	p	p	p	p	p	p
Covered-reflector	14	650	8000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	14	800	10000	5000	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	9	450	10000	3500	p	p	p	p	p	p	p	p	p	p	
Covered globe	14	14	800	8000	p	p	p	p	p	p	p	p	p	p	
Covered reflector	23	1090	10000	2700	p	p	p	p	84%	71%	p	p	1	p	
Bare Spiral	20	1250	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	18	1230	12000	2700	p	p	p	p	p	p	p	p	p	p	
Covered globe	9	495	8000	2700	p	p	p	p	77%	72%	p	p	p	p	
Covered A-line	16	800	8000	2700	p	p	p	p	87%	p	p	p	p	p	
Covered reflector	16	540	8000	2700	p	p	p	p	85%	75%	p	6	p	p	
Covered-Candle	9	420	8000	2700	p	p	p	p	86%	72%	p	p	p	p	
Covered reflector	15	750	8000	2700	p	p	p	p	p	p	p	p	p	15	

Bare Spiral	24	1600	10000	2700	p	p	p	p	85%	78%	p	7	p	p	
Covered reflector	23	1100	10000	2700	p	p	p	p	88%	79%	p	8	p	5	
Bare Spiral	26	1750	8000	2700	p	p	p	p	89%	p	p	p	p	p	
Bare Spiral	16	800	8000	2700	p	p	p	p	83%	78%	p	p	p	p	
Bare Spiral	13	850	10000	5000	p	p	p	p	p	76%	p	p	p	p	p
Covered reflector	16	750	8000	2700	p	p	p	p	84%	79%	p	p	p	p	
Covered reflector	14	450	8000	2700	p	p	320	p	77%	63%	p	p	p	7	p
Bare Spiral	23	1600	10000	2700	p	p	p	p	p	p	p	p	p	p	
Bare Spiral	13	800	8000	6500	p	p	p	p	p	p	p	p	p	p	
Covered A-line	14	800	8000	3500	p	p	p	p	p	p	p	p	p	p	
Covered reflector	23	1165	8000	5000	p	p	p	p	90%	76%	p	p	p	p	p
Bare Spiral	20	1300	10000	2700	p	p	p	p	p	p	p	p	p	p	

Bare Spiral	14	800	10000	2700	p	p	p	p	p	p	p	p	p	p	
Covered reflector	23	1300	10000	3000	p	p	193	p	p	p	p	p	p	p	

Table B: OEM Partners with Models in Batch 3

OEM Partner	No. of Models Tested	No. of Models Failed	Failure Rate of Models Tested (%)
<25 Qualified Models			
A	2	0	0%
B	1	1	100%
C	1	1	100%
25-75 Qualified Models			
D	2	1	50%
E	3	3	100%
F	8	6	75%
G	3	1	33%
H	2	1	50%
>75 Qualified Models			
I	5	2	40%
J	21	7	33%
K	3	1	33%
L	13	7	54%
M	7	6	86%
N	4	1	25%
O	2	0	0%
P	11	1	9%
Q	4	3	75%
R	11	8	73%
S	8	4	50%
T	5	0	0%
U	2	0	0%