Submitted by ESF to RoHS Exemption Stakeholder Consultation 4 September 2012, concerning Ex. No. 9. Stakeholder states that "This document shows the USA has a very similar situation, as is technology. On page 8-25 you can find description of the arguments of ISA, our counterpart organisation". Part 2

Base case Description:	PE Cell Controlled Sign
Installed cost:	$200.00

Enter kW schedule for base case

	Daytime base			Night time base		
Hour	M-F	Sat	Sun	M-F	Sat	Sun
1				0.18	0.18	0.18
2				0.18	0.18	0.18
3				0.18	0.18	0.18
4				0.18	0.18	0.18
5				0.18	0.18	0.18
6				0.18	0.18	0.18
7				0.18	0.18	0.18
8				0.18	0.18	0.18
9				0.18	0.18	0.18
10				0.18	0.18	0.18
11				0.18	0.18	0.18
12				0.18	0.18	0.18
13				0.18	0.18	0.18
14				0.18	0.18	0.18
15				0.18	0.18	0.18
16				0.18	0.18	0.18
17				0.18	0.18	0.18
18				0.18	0.18	0.18
19				0.18	0.18	0.18
20				0.18	0.18	0.18
21				0.18	0.18	0.18
22				0.18	0.18	0.18
23				0.18	0.18	0.18
24				0.18	0.18	0.18

Only day time hours during this schedule are kWh or TDV calculated

Only night time hours during this schedule are kWh or TDV calculated

Proposed case description:	Astronomic Time Switch Control / PE
Installed cost:	$500.00

Enter kW schedule for proposed case

	Daytime proposed			Night time proposed		
Hour	M-F	Sat	Sun	M-F	Sat	Sun
1						
2						
3						
4						
5				0.18	0.18	0.18
6				0.18	0.18	0.18
7				0.18	0.18	0.18
8				0.18	0.18	0.18
9				0.18	0.18	0.18
10				0.18	0.18	0.18
11				0.18	0.18	0.18
12				0.18	0.18	0.18
13				0.18	0.18	0.18
14				0.18	0.18	0.18
15				0.18	0.18	0.18
16				0.18	0.18	0.18
17				0.18	0.18	0.18
18				0.18	0.18	0.18
19				0.18	0.18	0.18
20				0.18	0.18	0.18
21				0.18	0.18	0.18
22				0.18	0.18	0.18
23				0.18	0.18	0.18
24				0.18	0.18	0.18

Only day time hours during this schedule are kWh or TDV calculated

Only night time hours during this schedule are kWh or TDV calculated

Table 6: Day and night schedules for Astronomical Time Switch measure

Table 7: Maintenance cost calculation including 3% real discount rate

	Maintenance Costs		Maint Savings	Future Value
Year	Base case	Proposed case	PV $	Multiplier
1			$0.00	97%
2			$0.00	94%
3			$0.00	92%
4			$0.00	89%
5			$0.00	86%
6			$0.00	84%
7			$0.00	81%
8	$ 200.00	$ 250.00	-$39.47	79%
9			$0.00	77%
10			$0.00	74%
11			$0.00	72%
12			$0.00	70%
13			$0.00	68%
14			$0.00	66%
15			$0.00	64%
Total			-$39.47	

Table 7 shows the assumed maintenance costs for the base and proposed cases. In the base case, the photocell is replaced and it is assumed that the entire of the cost of the initial installation will be spent. In the proposed case, it is assumed that either a photoelectric cell is replaced or that the astronomic time switch has to be reprogrammed and that this will cost slightly more. For the purpose of the analysis, it is assumed in both cases that the maintenance will occur at the halfway point of the system's life. Since the maintenance cost is higher for the proposed system, it is represented as a negative maintenance cost savings for this measure

Table 8 summarizes the energy and cost savings. For each hour of the day, the table shows the savings for total kWh, TDV kBtu, energy cost PV $, maintenance PV $ and total PV $. It also shows the incremental cost for the measure and the benefit / cost (B/C) ratio. The objective is to select measures which have positive PV $ savings and a B/C ratio greater than 1.0, which indicates that the measure has life cycle savings greater than its cost and therefore is cost effective.

Table 8: Hourly energy and cost savings and B/C ratio summary

Energy and Cost Savings Summary: Astronomic Time Switch Control / PE

	Savings	Savings	Savings	PV Savings	Cost Savings
Hour	Total kWh	TDV kBtu	Energy Cost PV $	Maint. PV $	Total PV $
1	66	1,022	$ 86		
2	66	981	$ 83		
3	66	952	$ 80		
4	66	949	$ 80		
5	0	0	$ -		
6	0	0	$ -		
7	0	0	$ -		
8	0	0	$ -		
9	0	0	$ -		
10	0	0	$ -		
11	0	0	$ -		
12	0	0	$ -		
13	0	0	$ -		
14	0	0	$ -		
15	0	0	$ -		
16	0	0	$ -		
17	0	0	$ -		
18	0	0	$ -		
19	0	0	$ -		
20	0	0	$ -		
21	0	0	$ -		
22	0	0	$ -		
23	0	0	$ -	PV Savings	Cost Savings
24	0	0	$ -	Maint. PV $	Total PV $
Total	**263**	**3,905**	**$ 329**	**-39**	**$290**
				Incremental Cost	**$300**
				B/C ratio	**1.0**

Table 9 below summarizes all of the proposed measures for signs. As shown, all of the measures have a B/C ratio greater than 1.0 or are “immediate.” If the B/C ratio is immediate, then the measure costs less than the base case.

For the neon high efficiency power supply measure, a group of neon signs of varying tube lengths was compared. In the base case, the signs were supplied by standard neon transformers. In the proposed case, the signs were supplied by high efficiency power supplies. Power values were obtained from manufacturers’ literature. Two scenarios were considered for energy savings. In one scenario, 24 hour operation was evaluated. In the second scenario, nighttime operation was evaluated. As shown in the table, the savings are positive and the incremental cost is negative which results in an immediate benefit.

For the astronomic time switch measure the base case schedule was derived from SCE data as described in the example for the Astronomic Time Switch Control / PE measure above. For all of the proposed measures, the load schedule was assumed on from dusk to midnight, off at midnight and then back on from 4 am to dawn. The load was varied in the various measures to determine a threshold value for application into the Standards. As shown in the table, the savings are positive and the B/C ratios are greater than 1.0 which results in cost effective measures.

Table 9:Sign efficiency measure summary - energy savings and B/C ratios

Energy and Cost Savings Summary: Signs								
	Size	**Energy Savings**					**Incremental Cost**	**Benefit / Cost Ratio**
Sign Measure Description	**kW**	**Total kWh**	**TDV kBtu**	**Energy Cost PV $**	**Maint. PV $**	**Total PV $**	**PV $**	
Neon Minimum Efficiency Transformer or Power Supply - 24 Hr	0.68	420	8,129	$ 686	-$78	$ 608	$123	5.0
Neon Minimum Efficiency Transformer or Power Supply - Night	0.68	192	3,243	$274	-$78	$196	$123	1.6
Astronomic Time Switch Control / PE	.18	263	3,90 5	$329	-$39	$290	$300	1.0
Portable sign - manual switch	0.18 kW	131	2,594	$219	-$2	$217	$175	1.2
1 x 4 LED Monochromatic Short Range Dimming	0.24	625	10,539	$889	$172	$1,029	$1,000	1.0
1 x 4 LED Monochromatic Medium Range Dimming	0.24	625	10,539	$889	$367	$1,187	$1,000	1.2
2 x 4 LED Monochromatic Long Range Dimming	0.96	2,501	42,156	$3,556	$498	$3,959	$1,000	4.0

For the LED dimming measures, the use of automatic dimming controls was evaluated for three cases as shown in the table above. Small monochromatic outdoor message centers for short, medium and long range viewing were chosen for the analysis. In the base cases, it was assumed that the signs would operate at 100% output 24 hours per day. In the proposed cases it was assumed that the signs would operate at 100% output during daytime hours and at 35% output during nighttime hours. The loads were obtained from manufacturer's literature. As shown in the table, the savings are positive and the B/C ratios are greater than 1.0 which results in cost effective measures.

Demand response results

The California investor owned utilities are installing an automated meter infrastructure (AMI) that includes the capability of signaling customers when electricity process are exceptionally high and also

when there is a system reliability emergency. The societal value of controls that can respond to this demand response signal is given in Table 10.

Table 10: Value of economic and emergency demand response

Value of Economic DR Resource	
Economic program top 10 days 1 -5 pm	
Resource value PV$/kW	$409.67
Productivity loss	20%
Net resource value PV$/kW	$327.74
Adjustment factors	
Participation rate	70%
Signal received	97%
Signal not over ridden	90%
Fraction ON during DR event	100%
Combined economic adjustment Factor	61%
Adjusted Net Resource Value PV$/kW	**$250**
Value of emergency DR	
Value of loss of service per kWh	$42.00
Negative impact on productivity	$2.50
Average outage time per year (h/yr)	2.4
annual net impact $/kW	$94.80
15 year present worth multiplier	$11.94
15 year discounted net impact PV $/kW	$1,132
Adjustment factors	
Fraction not participating in economic program	30%
Fraction in economic program normally overriding	7%
Total impacted by mandatory control	37%
Fraction of emergency signal not over ridden	90%
Fraction receiving the DR signal	97%
Fraction ON during DR event	100%
Combined emergency adjustment factors	32%
Adjusted net impact PV$/kW controlled	**$366**
Emergency and Economic Value PV$/kW	**$616**

This value is made up of two components:

1) the economic value of the capacity offered by customers who participate in demand response programs or rates and

2) the value of responding to system emergencies to prevent blackouts. This value is based on the economic distress that results from a loss of service (blackout).

The analysis in Table 10 assumes a participation rate of 70% in a program that gives incentives within the customer rate to curtail loads during the most expensive hours of the year. This assumption is based on a scenario that when the sign starts operating, the default utility rate is either real time based or a critical peak pricing type rate that passes through most of the costs on an hour by hour basis. In addition, this scenario assumes that regardless of participation in a rate or other program to voluntarily shed loads, that the utility can invoke an emergency load shed of lighting during the few hours per year that electrical system reliability is in peril. On average this occurs only 2.4 hours per year. Avoiding blackouts has a societal benefit of $42/kWh. When discounted over 15 years and accounting for productivity losses during this time period, this has a net value of $1,132/kW. When all of the derating factors are included, the overall direct economic benefit to the overage customer is PV$250/kW controlled and another PV$366/kW due to avoiding losses associated with blackouts for a total societal (economic + emergency) value of PV$616/kW.

The measure is based on reducing the power consumption of signs by 30% during the demand response period in response to receipt of the utility's load shed signal. Since this demand response period is typically during the summer between the hours of noon and 6pm, this measure applies to signs that are normally on during the day. We considered two sign types: cabinet signs and message centers. Some cabinet signs are illuminated during the day in indoor locations. Message centers could be either indoor or outdoors.

To identify the sign size at which a demand responsive control would be required, the fixed costs of installing a demand responsive control was compared to the life cycle savings of the control. To assure the outcome was conservative (i.e. the life cycle cost savings was greater than the initial cost) the threshold value of minimum sign size was calculated based on a Benefit/Cost ratio of 1.5.

Table 11 below shows the results of the analysis. For each scenario and demand response option there is a corresponding load in kW and size of sign. For cabinet signs, the analysis assumes a load of 12 W/sf. For LED message centers, the analysis assumes a load of 50 W/sf. If the full societal benefits are calculated, the minimum total sing power rating that could be cost-justify demand responsive controls with a 1.5 B/C ratio is 3.2 kW for cabinet signs and 8.1 kW for message centers. That is to say that the life cycle energy cost savings and value of blackouts avoided is worth $600 for a 3.2 kW cabinet sign, while the incremental implementation cost is only $400.

If one considers only the economic value of the energy displaced by reducing sign power consumption by 30% for the 10 days with the highest electricity costs for four hours per day, a minimum cabinet sign size of 8 kW and a minimum LED message center size of 20 kW would be required to justify the expense of the controls while maintaining a 1.5 Benefit /Cost ratio.

Table 11:Demand response – threshold sign size to assure a 1.5 B/C ratio

			Cost-effective Threshold @1.5 B/C ratio		Sign Size	
			Economic Value @ PV$250/kW	Economic + Emergency @PV$616/kW	Economic Value	Emergency Response
Sign Type	**Fraction Controlled**	**Implementation Cost**	**kW**	**kW**	**SF**	**SF**
Cabinet Sign	30%	400	8.0	3.2	666	271
LED Message Center	30%	1000	20.0	8.1	399	162

Statewide Energy Savings

Statewide energy savings estimates are based on unit energy savings multiplied by estimates of statewide quantities of signs. This statewide analysis will be included in the final Signs CASE report.

Recommendations

The following revisions to the Standards are recommended:

Proposed Mandatory Requirements

1. Require time schedule lighting controls for all outdoor signs.

2. Require automatic dimming controls for outdoor signs that are illuminated during daytime hours. Exemption for non-mercury containing discharge lamps as these sources are difficult to dim.

3. Require manual switch controls for portable electric sign receptacles and show window receptacles.

4. Require demand responsive controls for larger signs that are illuminated during daytime hours.

Proposed Prescriptive Requirements

1. High efficiency power supplies for neon sources in accordance with temperature limitations of the technology. Either high efficiency magnetic or non-linear power supplies can meet the proposed efficiencies

2. Optional high efficiency metal halide ballasts reflecting the requirements of Title-20 in lieu of meeting the existing lighting power density requirements.

Proposed Standards Language

Original standards language is in black font, the proposed deleted text is ~~in red text with hard strikeouts~~ and added language contained is in blue font and underlined

SECTION 101 – DEFINITIONS AND RULES OF CONSTRUCTION

DEMAND RESPONSE PERIOD is a period of time during which the local utility is curtailing electricity loads by sending out a demand response signal.

DEMAND RESPONSE SIGNAL is an electronic signal sent out by the local utility indicating a request to their customers to curtail electricity consumption.

SECTION 132 – OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

(a) **Outdoor Lighting.** All permanently installed outdoor luminaires employing lamps rated over 100 watts shall either: have a lamp efficacy of at least 60 lumens per watt; or be controlled by a motion sensor.

EXCEPTIONS to Section 132 (a):

1. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
2. Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the California Electrical Code.
3. Searchlights.
4. Theme lighting for use in theme parks.
5. Lighting for film or live performances.
6. Temporary outdoor lighting.
7. Light emitting diode, neon and cold cathode lighting.

(b) **Luminaire Cutoff Requirements.** All outdoor luminaires that use lamps rated greater than 175 watts in hardscape areas including parking lots, building entrances, sales and non-sales canopies, and all outdoor sales areas shall be designated Cutoff for light distribution. To comply with this requirement the luminaire

shall be rated Cutoff in a photometric test report that includes any tilt or other non-level mounting condition of the installed luminaire. Cutoff is a luminaire light distribution classification where the candela per 1000 lamp lumens does not numerically exceed 25 at or above a vertical angle of ninety degrees above nadir, and 100 at or above a vertical angle of eighty degrees above nadir. Nadir is in the direction of straight down, as would be indicated by a plumb line. Ninety degrees above nadir is horizontal. Eighty degrees above nadir is 10 degrees below horizontal.

EXCEPTIONS to Section 132 (b):

1. Internally illuminated, externally illuminated, and unfiltered signs.
2. Lighting for building facades, public monuments, statues, and vertical surfaces of bridges.
3. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
4. Temporary outdoor lighting.
5. Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the California Electrical Code.

(c) **Controls for Outdoor Lighting**

1. All permanently installed outdoor lighting shall be controlled by a photocontrol or astronomical time switch that automatically turns off the outdoor lighting when daylight is available.

EXCEPTION to Section 132 (c) 1.:

1. Lighting in parking garages, tunnels, and large covered areas that require illumination during daylight hours.
2. Sign lighting as covered by Section 133.

2. For lighting of building facades, parking lots, garages, sales and non-sales canopies, and all outdoor sales areas, where two or more luminaires are used, an automatic time switch shall be installed that (1) turns off the lighting when not needed and (2) reduces the lighting power (in watts) by at least 50% but not exceeding 80% or provides continuous dimming through a range that includes 50% through 80% reduction. This control shall meet the requirements of Section 119 (c).

EXCEPTIONS to Section 132 (c) 2:

1. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
2. Lighting for steps or stairs that require illumination during daylight hours.
3. Lighting that is controlled by a motion sensor and photocontrol.
4. Lighting for facilities that have equal lighting requirements at all hours and are designed to operate continuously.
5. Temporary outdoor lighting.
~~6. Internally illuminated, externally illuminated, and unfiltered signs~~.

SECTION 133 – SIGN LIGHTING CONTROLS

(a) **Designation of Daytime Use**. If an outdoor sign is planned to be illuminated by electric lighting for more than 1 hour per day while the sun is above the horizon, the sign shall be designated as "Normally On during Daytime." Any outdoor sign that is not designated as "Normally On during Daytime," shall be designated as "Normally Off during Daytime."

(b)**Controls for Outdoor Signs Normally Off during Daytime**. All permanently installed outdoor signs that are designated normally off during daytime shall be controlled by a photocontrol and an automatic-time switch complying with Section 119(c) or an outdoor astronomical time switch complying with Section 119(j), that automatically turns off the outdoor signs when daylight is available.

EXCEPTIONS to Section 133 (b):
1. Signs required by a health or life safety statute, ordinance, or regulation, including but not limited to, exit and egress signs.
2. Outdoor signs in parking garages, tunnels, and large covered areas that require illumination during daylight hours.

(c) **Controls for Outdoor Signs Normally On during Daytime**. All permanently installed outdoor signs that are designated Normally On during Daytime shall be controlled by a photocontrol and an automatic-time switch complying with Section 119(c) or an outdoor astronomical time switch complying with Section 119(j), that automatically dims and reduces sign power draw by a minimum of 65% between the times of 30 minutes after sunset and 30 minutes before sunrise.

EXCEPTION 1 to Section 133 (c): Outdoor signs in parking garages, tunnels, and large covered areas that require illumination during daylight hours.

EXCEPTION 2 to Section 133 (c): : Signs illuminated by gas discharge lamps not containing mercury gas

(d)**Controls for Indoor Signs.**

1. All portable indoor signs shall be connected to an electrical receptacle controlled by a readily accessible manual switch.

2. All show window receptacles shall be controlled by a readily accessible manual switch.

e) **Controls for All Signs**:

1. All permanently connected signs shall have an automatic time switch control that complies with Section 119(c).

2. Demand Responsive Sign Controls. If the electrical service to a sign is provided with a demand response signal by the local utility, demand responsive sign controls shall be installed under following conditions

i. Unfiltered signs illuminated during the day and having a connected load greater than 20 kW, shall have controls installed capable of receiving a demand response signal to reduce the sign load by a minimum of 30%.

ii. Filtered signs illuminated during the day and having a connected load greater than 8 kW, shall have controls installed capable of receiving a demand response signal to reduce the sign load by a minimum of 30%.

EXCEPTION to Section 133 (e)2: : Signs illuminated by gas discharge lamps not containing mercury gas are not required to have demand response controls

SECTION 148 – REQUIREMENTS FOR SIGNS

This section applies to all internally illuminated, ~~and~~ externally illuminated and unfiltered signs, both indoor and outdoor. Each sign shall comply with either subsection (a) **or** (b), as applicable~~, or with one of the alternatives that immediately follow subsection (b).~~

(a) For internally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 12 watts per square foot. For double-faced signs, only the area of a single face shall be used to determine the allowed lighting power.

~~(b)~~ For externally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 2.3 watts per square foot.~~-~~Only areas of an externally lighted sign that are illuminated without obstruction or interference, by one or more luminaires, shall be used.

~~ALTERNATIVE to 148(a) and (b):~~

(b) The sign complies with this Section if it is:~~1. Equipped~~ equipped only with one or more of the following light sources:

~~1. high pressure sodium, pulse start and ceramic metal halide, neon, cold cathode, light emitting diodes, barrier coat rare earth phosphor fluorescent lamps, or compact fluorescent lamps that do not contain a medium base socket (E24/E26), or~~

~~2. Equipped only with electronic ballasts with a fundamental output frequency not less than 20 kHz.~~

1. high pressure sodium lamps,

2. pulse start metal halide lamps served by a ballast with a minimum efficiency of 88%, where ballast efficiency is the measured output wattage to the lamp divided by the measured operating input wattage when tested according to ANSI C82.6-2005.

3. neon, with transformer or power supply efficiency, the ratio of the output wattage to the input wattage at 100% tubing load, greater than or equal to following minimum efficiencies:

(a) a minimum efficiency of 77% when the transformer or power supply rated output current is less than 50 mA, otherwise

(b) a minimum efficiency of 68% when the transformer or power supply rated output current is 50 mA or greater

4. cold cathode or fluorescent lamps with barrier coat rare earth phosphors and equipped only with electronic ballasts having a fundamental output frequency not less than 20 kHz,

5. compact fluorescent lamps that do not contain a medium base socket (E24/E26)

6. light emitting diodes

EXCEPTION 1 to Section 148: ~~Unfiltered signs and~~ traffic signs.
EXCEPTION 2 to Section 148: Exit signs shall meet the requirements of the Appliance Efficiency Regulations.

SECTION 149 – ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING BUILDINGS THAT WILL BE NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES AND TO EXISTING OUTDOOR LIGHTING FOR THESE OCCUPANCIES AND TO INTERNALLY AND EXTERNALLY ILLUMINATED SIGNS

…

(b) **Alterations.** Alterations to existing nonresidential, high-rise residential, or hotel/motel buildings or alterations in conjunction with a change in building occupancy to a nonresidential, high-rise residential, or hotel/motel occupancy not subject to Subsection (a) shall meet either Item 1 or 2 below.

1. **Prescriptive approach.** The altered envelope, space conditioning, lighting and water heating components, and any newly installed equipment serving the alteration, shall meet the applicable requirements of Sections 110 through 139; and

   G. New internally and externally illuminated signs shall meet the requirements of Sections 133, and 148.

   H. Alterations to existing indoor lighting systems that increase the connected lighting load or replace more than 50 percent of the luminaires shall meet the requirements of Sections 119, 130, 131, 132, and 146; and

   I Alterations to existing outdoor lighting systems that for any lighting application increase the connected lighting load or replace more than 50 percent of the luminaires shall meet the requirements of Section 147; and

   J Alterations to existing internally and externally illuminated signs that increase the connected lighting load, replace and rewire more than 50 percent of the ballasts, or relocate the sign to a different location on the same site or on a different site shall meet the requirements of Sections 133, and 148; and

   NOTE: Replacement of parts of an existing sign, including replacing lamps, the sign face or ballasts, that do not require rewiring or that are done at a time other than when the sign is relocated, is not an alteration subject to the requirements of Section 149 (b) 1 J.

Alternate Calculation Manual

Outdoor lighting is not included in the ACM manual, thus there are not changes proposed.

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Michael F. Neils, Principal Investigator, of M. Neils Engineering, Inc. performed most of the analysis and reporting presented here. Juan José Villatoro and Danielle Neils, Lighting Analysts of M. Neils Engineering, Inc. provided technical support. Jon McHugh of the Heschong Mahone Group provided technical and editorial review.

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EGL Neon Facts*, White and Colored Neon now 25 to 300% Brighter*

EGL NEON FACTS

NEWS AND INFORMATION FOR DESIGNERS AND SPECIFIERS OF CORPORATE SIGNAGE AND ARCHITECTURAL LIGHTING

White and colored neon now 25 to 300% brighter

Radically improve the visibility, color intensity and accuracy of channel letters, open signage and architectural lighting

C.L. Designer® white neon tubing 35-60% brighter than conventional white neon

High-output C.L. Designer® neon is the brightest white neon tubing ever developed, boosting the visibility range of signage by up to 1000 feet.

Performance of the new whites is the result of proprietary phosphor coating blends that produce light emissions of exceptional brilliance and stability.

The new whites also maintain their high output levels significantly longer than conventional white neon tubing, and offer superior cold weather performance.

EGL now offers eight high-output whites: C.L. 24 (warmest, equivalent to 2400° Kelvin), 28, 30, 35, 41, 65, 71 and 83 (coolest, equivalent to 8300° Kelvin).

This broad range of high-output whites enables architects, graphic designers and other corporate identity specifiers to match color schemes more precisely and consistently than possible with conventional fluorescent lamps, L.E.D.s, or conventional white neon tubing.

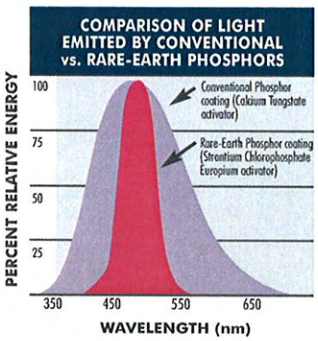
In addition to channel letters, C.L. Designer whites can improve the aesthetic and functional qualities of architectural lighting, spectaculars, billboards, accent graphics, and other illuminated signage.

Rare Earth neon tubing 25-300% brighter than conventional colored neon

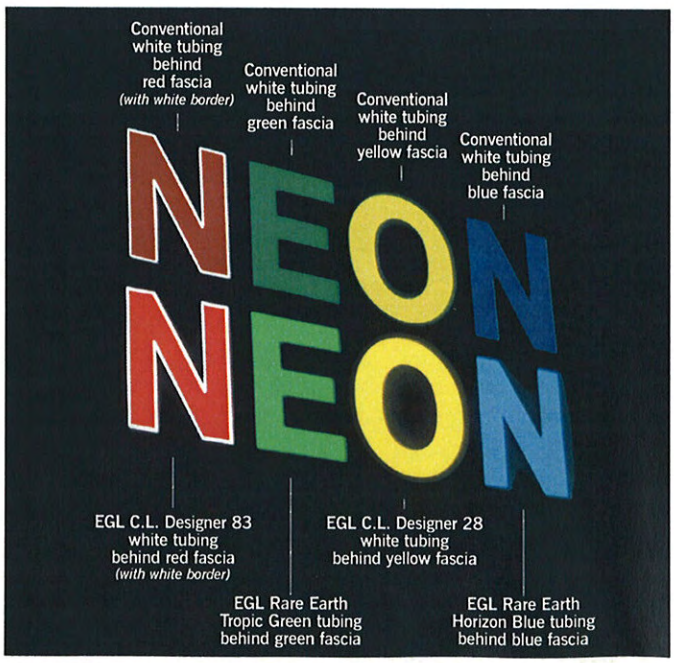
Rare-Earth neon tubing in six colors provides significantly greater brightness, purity, accuracy and longevity than all conventional colored neon tubing.

EGL utilizes rare earth phosphor coatings to line the inside of the tubing—the same rare earth phosphors utilized in the latest generation of televisions to boost lumen output, color brilliance and stability.

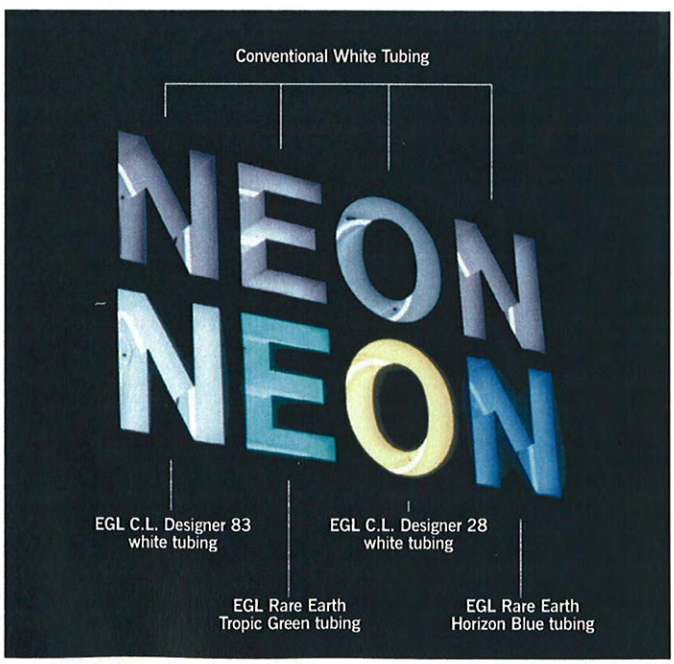
These coatings emit extremely narrow bandwidths of light—significant because the narrower the bandwidth, the brighter, purer and more vivid the light emission... the wider the bandwidth, the dimmer and more washed-out.



As a result, this tubing outperforms all other neon on all counts, setting an entirely new standard for every colored neon application.



EGL C.L. Designer® white neon and Rare Earth colored neon (bottom) produce significantly brighter and more colorful light than conventional white neon (top) when illuminating identical plastic fascias.



Plastic fascias are removed to show the C.L. Designer® white neon and Rare Earth neon (bottom) that produce brighter and more colorful channel letters than conventional white neon (top).

EGL®

Identical green plastic fascias illuminated by EGL's C.L. Designer Tropic Green neon tubing (right) are significantly brighter and more vivid than fascias illuminated by conventional white tubing (left).

Using colored C.L. Designer tubing behind colored plastic fascias produces signage that is not only brighter but much more vivid. Compare identical blue plastic fascia colors illuminated by conventional white tubing (left) and EGL's Horizon Blue (right).

More vivid fascia colors
Super-bright C.L. Designer® white tubing boosts the vividness and intensity of translucent vinyl and rigid fascias far beyond that of conventional white tubing.

Superior visibility
25 to 300 percent higher output significantly boosts the brilliance and visibility of all rigid and vinyl plastic channel letter fascias—including blues and greens that were previously difficult to illuminate. Higher output can also allow the number of tubing runs to be reduced, cutting material and labor costs significantly.

Superior color matching
EGL's C.L. Designer® whites in eight high-output hues from cool to warm allow fine tuning of illuminated plastic fascia colors to match corporate color schemes precisely.

Enhanced stability
Enhanced color stability, and resistance to staining and output depreciation, keep channel letters looking brighter and more colorful significantly longer than letters containing conventional neon tubing.

EGL C.L. Designer® 24, 28, 30, 35, 41, 65, 71 and 83 white tubing for:

- Channel letters of every type, size and color
- Open signage containing white tubing
- Architectural lighting including cove lighting and border tubing

EGL Rare Earth neon tubing in Horizon Blue, Tropic Green, Coral Pink, Seacrest, Violet and Flamingo for:

- Open signage of all types
- Channel letters having color fascias
- Architectural lighting of all types

Q-0178

Color representations are subject to the limitations of 4-color printing.

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EGL Neon News*, Dispelling the "Inefficient Neon" Myth* (Spring 2006)

EGL NEON NEWS

NEWS AND INFORMATION FOR THE SIGN INDUSTRY

Spring 2006

Dispelling the "Inefficient Neon" Myth

By Bernard Diffin, Ph. D. Head of Product Development, The EGL Company, Inc.

When considering illuminated signage, probably the most important factor to be taken into account is sign brightness. From the point of view of attracting attention to your business or promoting your corporate identity, generally speaking, brighter is better. For many years neon in its multitude of colors has been the medium of choice for performing this task - either in the exposed form or as a means of illuminating channel letters. This type of gas discharge lighting has always been considered very energy efficient, but this attribute has recently come into question, due mainly to the introduction of LED based products. Schemes such as the LEED system (Leadership in Energy and Environmental Design) and legislation (such as California's Title 24) have also focused attention on the efficiency of light sources. So, just how efficient is neon and how does it compare to other sources? As we shall see, in most instances, neon based illumination systems still provide superior performance in terms of "light out for dollar in" - particularly when we take into account relatively recent advances in the areas of phosphor and transformer technologies.

Light Source Efficiency

Lumens/watt (lm/W) is often used as a measure of the efficiency (or to be technically correct, efficacy) of a source in converting electrical energy to light. The lumen output of a source is a measure of the total amount of light emitted. It is sometimes provided by a light source manufacturer but is very difficult to confirm without employing the services of a testing laboratory. Watts are a measure of power consumed, and there are two types of power - real power, which is measured with a wattmeter, and apparent power, which is obtained by multiplying input voltage by input current (also called VA). Real power is what you pay the electricity company for, and it's important to verify that real power is being referred to when discussing lm/W figures.

Lumens per watt is a fairly good comparative unit, as long as light sources of similar color are being compared. To put things in perspective, for white light sources, an incandescent bulb has an efficacy of 17-20 lm/W, while at 100 lm/W, a modern T5 fluorescent lamp is one of the most efficient common sources. The best white LEDs used for signage have efficacies of 10-20 lm/W. How do neon sources compare?

High efficiency phosphors and transformers

There is an enormous range of colors available to the neon sign manufacturer today, made possible by the blending of different luminescent phosphor types, but this was not always the case. Up until the late 1940's very few, relatively inefficient, phosphors were available. The subsequent introduction of the calcium halophosphate family of phosphors together with improvements in the standard blue and green emitters enabled the neon sign industry to offer a full spectrum of color together with a large range of whites of different color temperature. These phosphors and their blends are still in use today - albeit with some subsequent improvement in efficiency. A typical halophosphate white, for example 6500K Snow White, running on a correctly loaded standard ferromagnetic 30mA transformer has an output of 150 lumens per foot of tube for 15mm diameter glass resulting in an efficacy of 35-45 lm/W.

Source	Efficacy (lm/W)
6500K std. white neon / magnetic transformer	43
6500K tri-phosphor white neon / magnetic transformer	60
6500K tri-phosphor white neon / electronic transformer	78
White LED	10-25
Std green neon / magnetic transformer	48
Rare-earth green / magnetic transformer	69
Rare-earth green / electronic transformer	90
Typical green LED (channel letter module)	12
High power green LED	25
Std blue neon / magnetic transformer	25
Rare-earth blue / magnetic transformer	23
Rare-earth blue / electronic transformer	30
Typical blue LED (channel letter module)	2
High power blue LED	15
Clear red neon / magnetic transformer	8
Clear red neon / electronic transformer	10
Typical red LED (channel letter module)	11

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Dispelling the "Inefficient Neon" Myth

The real breakthrough came in the 1960's with the development of rare-earth phosphors that emit light in narrower wavelength bands giving deeper, more saturated colors. In the 1970's and 80's additional rare-earth phosphors were developed and adopted by the lighting industry for use in fluorescent lamps, resulting in light sources which remain among the most efficient available. The trickle down effect finally reached the neon industry in the mid 90's. Lumen per foot output increased by over 30% for whites, leading to efficacies of 50-60 lm/W. Nowadays, all manufacturers of coated tubing offer a large range of colors and many different color temperatures of white based on blends of these "tri-phosphors".

Rare-earth phosphors are particularly efficient when used to illuminate channel letters. Standard "broadband" phosphors have much of their light filtered by colored acrylic faces, but the narrow wavelength bands emitted by rare-earths means that more of the available light is transmitted, giving a brighter, more vibrant sign. For example using rare-earth green neon behind green acrylic results in the face being 25% brighter than when using standard green, and 300% brighter than with standard 6500K Snow White.

Following the successful introduction of high efficiency electronic ballasts into the fluorescent lamp market, in the early 90's, many companies began to market electronic transformers for driving neon. Today there are several companies that make electronic transformers with excellent reliability records. The use of these high frequency power supplies further boosts the efficacy of neon; for example the 50-60 lm/W figure for tri-phosphor white neon is increased to around 78 lm/W at 30mA.

Watts per foot

For linear light sources such as neon, watts per foot is sometimes used as a measure of energy consumption. Note that this measurement does not have a lumen component and tells us nothing about how bright a sign may be. For example LED channel or border lighting may have a lower W/ft rating compared to the neon equivalent, but yields far less light because it is a less efficient source. Watts per foot figures for LED modules can also be misleading since they depend on how the modules are laid out. One manufacturer provides a guide on its channel letter module spacing and expected sign brightness; for its green LEDs the recommended layout to achieve only 45% of the brightness of rare-earth green neon (green acrylic face) results in an energy usage of 9.9 W/ft. Using its high output white LEDs (white acrylic face) results in a consumption of 11.9 W/ft and a sign only 80% as bright as that with 6500K rare-earth white neon. The neon in both cases, when powered with electronic transformers, would consume around 3.5 W/ft. A study of channel letter lighting by the Lighting Research Institute found that to produce the same amount of light, white LEDs consumed 2-8 times more energy than standard 6500K Snow White neon (30mA ferromagnetic transformer). If a white tri-phosphor and electronic transformer had been used in this comparison, the difference would be even greater.

For the currently available range of LED channel letter modules, only red is able to approach neon in terms of brightness and energy efficiency when used with certain, sometimes specially developed, red acrylic faces. Red (clear) neon has an efficacy of approximately 10 lm/W and a power consumption of 3.5-4 W/ft when run on an electronic transformer. The corresponding figures for the best red LED units used in sign applications are similar at 11 lm/W and 3 W/ft. This small difference is in stark contrast to the often quoted statement from LED proponents that the use of LEDs can result in 90% energy savings. For this to be the case, a red LED would need to have an efficacy of 100 lm/W, or in terms of energy use, the neon would need to consume 30W/ft!

If in doubt- prototype

Whether illuminating channel letters or lighting borders, high efficiency, rare-earth based phosphor neon will almost always result in the brightest, most energy efficient signage, especially when used in combination with electronic (solid state) transformers. Although these phosphor products have been available for several years, there has been a certain amount of resistance to their use from sign companies, due mainly to perceived cost issues. Rare-earth (tri-phosphor) coated tubing may cost double that of standard tubing, but when put in the context of a completed sign the increase is minimal, around 30¢/ft, when compared with the benefits its use brings. In many cases it may be required for a specifier to directly request that the sign company uses these products. If any doubt exists as to the best illumination solution, the coated tubing manufacturer should always be available for consultation and to provide appropriate samples for test. Prototype building is sometimes necessary - in fact this is to be encouraged, since it allows different products to be compared. For example for channel letters, the sign can be scrutinized for pantone color match, comparative surface brightness can be determined with a relatively simple light meter, and power draw (real and apparent) measured with one of any number of commercially available power meters.

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U.S. Department of Energy, *DOE Solid-State Lighting CALiPER Program: Summary of Results: Round 5 of Product Testing* (May 2008)

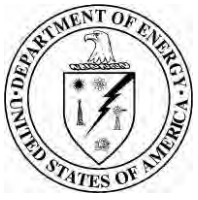
DOE Solid-State Lighting
CALiPER Program

Summary of Results:
Round 5 of Product Testing

U.S. Department of Energy

May 2008

Building Technologies Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy



DOE Solid-State Lighting CALiPER Program

Summary of Results: Round 5 of Product Testing

Round 5 of testing for the DOE Commercially Available LED Product Evaluation and Reporting (CALiPER) Program was conducted from January to April 2008. [1] In Round 5 of the testing program, 28 products were selected for testing representing a range of products and technologies. Products were typically tested with both spectroradiometry and goniophotometry using absolute photometry, following the recently published IESNA LM-79 testing method.[2] Testing also included measurements of surface temperatures (taken at the hottest accessible spots on the luminaire) and off-state power consumption for products with an on/off switch.

The products selected for testing in Round 5 covered a range of applications (downlights, replacement lamps, task lamps, and outdoor fixtures), with two focused series of tests conducted on recessed downlights and on 4-foot replacement fluorescent tube products. In all, Round 5 included 17 SSL products and 11 benchmark products (including spiral CFL, reflector CFL, Cold-Cathode CFL, fluorescent tubes, halogen, incandescent, and metal halide), encompassing a wide range of product shapes, sizes, and applications. Round 5 also included testing variability across product samples and on-going testing of lumen depreciation in products tested during previous CALiPER rounds.

Round 5 CALiPER Testing Results

Tables 1a, 1b, and 1c summarize results for energy performance and color metrics — including light output, luminaire efficacy, correlated color temperature (CCT), and color rendering index (CRI) — for all products tested under CALiPER in Round 5. In addition to performing product testing following LM-79, photometric data published by manufacturers for SSL products (in the form of standard IES photometric data files) were collected and analyzed in order to compare manufacturer performance claims with measured performance results. Additional data on each set of testing results and related manufacturer information are assembled in a detailed report for each product tested. [3]

In Round 5, a focused series on recessed downlight products included 10 types of replacement or retrofit lamps: three SSL products, a reflector CFL (RCFL), a spiral CFL, a cold-cathode CFL (CCFL), a halogen infrared (HIR), a reflector incandescent (R30), and two A19 incandescent lamps. Two units of each lamp were tested first as bare lamps in an integrating sphere; the more efficacious unit of each pair was then mounted in a recessed downlight can in an insulated enclosure and tested with a goniophotometer.[4] Table 1a assembles the performance results for

[1] Summary reports for Rounds 1-4 of DOE SSL testing are available online at http://www.netl.doe.gov/ssl/comm_testing.htm.
[2] Please see the Appendix A for more detailed description of CALiPER testing methods and product selection processes.
[3] Detailed test reports for products tested under the DOE's SSL testing program can be requested online: http://www.netl.doe.gov/ssl/comm_testing_request.htm.
[4] See Appendix B for a complete description of the recessed can and insulated enclosure.

this series of tests. Further discussion of these results is provided in the "Recessed Downlight Series" section of this report.

Table 1a. DOE SSL CALiPER ROUND 5 SUMMARY – Downlight Series

--SSL testing following IESNA LM-79 --Integrated Sphere --25º C ambient temperature	DOE CALiPER TEST ID	Total Power (watts)	Output (initial lumens)	Efficacy (lm/W)	CCT	CRI
Replacement Lamps for Downlights – Bare Lamp Testing						
SSL Retrofit 12W	07-31	11	673	59	2753	93
SSL PAR30 18.6W	08-14*	15	627	42	5151	74
SSL PAR38 21W	08-15*	13	323	24	3127	67
RCFL 15W	08-06*	16	841	53	2740	82
CCFL Retrofit 18W	08-18*	15	513	33	2843	80
CFL Spiral 13W	08-27*	12	806	67	2703	82
HIR PAR38 50W	08-05*	46	524	11	2719	99
INC R30 65W	08-13*	65	732	11	2681	99
INC A19 60W, name brand	08-49*	61	739	12	2703	100
INC A19 60W, value brand	08-04*	55	353	7	2491	99

--Goniophotometry --25º C ambient temperature	DOE CALiPER TEST ID	Total Power (watts)	Output (initial lumens)	Efficacy (lm/W)	Fixture Efficiency** (in situ)
Replacement Lamps In Situ (Mounted in Insulated Recessed Can)					
SSL Retrofit 12W – in situ	07-31D	11	639	57	88%
SSL PAR30 18.6W – in situ	08-14A	14	556	39	87%
SSL PAR38 21W – in situ	08-15B	12	283	23	85%
RCFL 15W – in situ	08-06B	13	653	49	77%
CCFL Retrofit 18W – in situ	08-18A	15	534	35	101%
CFL Spiral 13W – in situ	08-27A	10	466	46	58%
HIR PAR38 50W – in situ	08-05B	47	529	11	93%
INC R30 65W – in situ	08-13A	65	678	11	92%
INC A19 60W – in situ, name brand	08-49B	61	446	7	59%
INC A19 60W – in situ, value brand	08-04B	54	238	4	64%

All values are rounded to the nearest integer for readability in this table.

Tests 08-06,08-18, 08-27, 08-05, 08-04, 08-13, and 08-49 were conducted on CFL, halogen, or traditional incandescent lamps for the purposes of benchmarking. All lamps have Edison socket base except the CCFL.

See "Recessed Downlight Series", for details on the geometries and configurations of the various downlight units and further discussion of results.

* For products shown with an asterisk, two units were tested; results show average between two units. The extent of variation between units is discussed under "Variability and Repeatability."

** Calculated fixture efficiency based on *(in situ* output)/(bare lamp output) for the specific sample used for in situ testing. Values over 100% possible due to expected testing variation between integrating sphere and goniophotometry tests.

Table 1b assembles the results for a focused series of testing on 4-foot replacement linear fluorescent lamps. Four SSL products and two fluorescent (baseline) products were selected for testing. Two samples of each product were tested as bare lamps in an integrating sphere and then mounted in typical housings for *in situ* testing with a goniophotometer. Further discussion of these results is provided under the "Replacement Tube Lamps Series" section of this document.

Table 1b. DOE SSL CALiPER ROUND 5 SUMMARY – Troffer Series

--SSL testing following IESNA LM-79 --Integrated Sphere --25º C ambient temperature	DOE CALiPER TEST ID	Total Power (watts)	Output (initial lumens)	Efficacy (lm/W)	CCT	CRI
Linear Replacement Lamps (4ft) – Bare Lamp Testing						
4ft Replacement lamp, SSL	07-56*	25	1058	42	3494	75
4ft Replacement lamp, SSL	08-17*	20	849	43	12583	72
4ft Replacement lamp, SSL	08-19*	18	345	19	2971	72
4ft Replacement lamp, SSL	08-37*	19	1016	52	7739	76
F32T8, 4ft linear fluorescent	08-28*	32	3081	96	3932	81
F40T12, 4ft linear fluorescent	08-30*	39	3101	80	2884	84

--Goniophotometry --25º C ambient temperature	DOE CALiPER TEST ID	Total Power (watts)	Output (initial lumens)	Efficacy (lm/W)	Fixture Efficiency*** (in situ)
4ft Linear Replacement Lamps In Situ -- Mounted in Lensed T12 Troffer Housing**					
2x4ft Replacement lamp, SSL	07-56	80	2125	27	***
2x4ft Replacement lamp, SSL	08-17	40	1451	36	85%
2x4ft Replacement lamp, SSL	08-19	36	613	17	89%
2x4ft Replacement lamp, SSL	08-37	40	1693	43	83%
2x4ft F40T12, linear fluorescent	08-30	88	4453	51	72%
4ft Linear Replacement Lamps In Situ -- Mounted in Parabolic T8 Troffer Housing**					
2x4ft Replacement lamp, SSL	07-56	47	1566	33	***
2x4ft Replacement lamp, SSL	08-17	40	1399	35	82%
2x4ft Replacement lamp, SSL	08-19	36	597	17	86%
2x4ft Replacement lamp, SSL	08-37	39	1711	43	84%
2x4ft F32T8, linear fluorescent	08-28	58	3675	63	60%

All values are rounded to the nearest integer for readability in this table.

Tests 08-28 and 08-30 were conducted on fluorescent lamps for the purposes of benchmarking.

See "Replacement Tube Lamps Series" for details on the various troffer geometries and further discussion of results.

* For products shown with an asterisk, two units were tested; results show average between two units. The extent of variation between units is discussed under "Variability and Repeatability."

**In Situ tests were conducted with two lamps of each product type installed in a troffer housing. SSL products 08-17, 08-19, and 08-37 do not use troffer ballasts—installation instructions call for bypassing the ballast. SSL product 07-56 is powered by the troffer ballasts.

** Calculated fixture efficiency based on (*in situ* output) /(bare lamp output A + bare lamp output B). Bare lamp testing on 07-56 was conducted with a reference ballast at 25W, so fixture efficiency is not calculated for use in the troffers for this product.

Table 1c. DOE SSL CALiPER ROUND 5 SUMMARY – Other Applications

Photometrics based on IESNA LM-79 for --Luminaires and replacement lamps --25º C ambient temperature	DOE CALiPER TEST ID	Total Power (watts)	Output (initial lumens)	Efficacy (lm/W)	CCT	CRI
Replacement Lamps						
Replacement - MR16	07-58*	5	90	19	2691	67
Replacement - MR16	08-07*	2	34	17	6254	75
Replacement – A-lamp (~A19)	08-03*	3	81	31	3127	92
Replacement – A-lamp (~A19)	08-25**	5	194	39	3418	86
Downlights						
Downlight (2' x 2' panel)	08-29	75	3456	46	4346	71
Task Lamps						
Desk	08-01	9	156	16 [12]	3579	73
Desk	08-02	11	301	27 [11]	6255	74
Undercabinet	08-16	9	196	21	2926	78
Undercabinet	08-26	6	144	24	3639	79
Outdoor						
Outdoor Spot (LED)	08-08†	10	90	9	6469	78
Outdoor Spot (Halogen 20W)	08-12†	22	185	8	2873	97
Outdoor Roadway, Metal Halide	08-09‡	77	4013	52	--	--

All values are rounded to the nearest integer for readability in this table. All lamps use LED sources unless otherwise noted.

Tests 08-09 and 08-12 were conducted on metal halide and halogen fixtures for the purposes of benchmarking.

Adjusted efficacy values in brackets [ ] include the effect of measured off-state power consumption assuming 3 hours on-time per day. See below for discussion of the impact of off-state power consumption on average yearly efficacy.

* For products shown with an asterisk, two units were tested; results show average between two units. The extent of variation between units is discussed under "Variability and Repeatability."

** Ten units of product 08-25 were tested; two units failed before testing could commence; results show average between eight units. The extent of variation between units is discussed under "Variability and Repeatability."

† Tests 08-08 and 08-12 are conducted on the same fixture model available in two different versions, one using an LED source and one using a halogen source.

‡ Outdoor fixture 08-09 was not tested for color qualities in an integrating sphere due to fixture size and weight.

Table 1c summarizes performance results for the remaining tests conducted in CALiPER Round 5: four replacement lamp products, one large downlight, two desk lamps, two undercabinet fixtures, and three outdoor fixtures. Two of the outdoor fixtures are alternate versions of the same product, one using an LED source and one using a halogen source. An outdoor roadway fixture using a metal halide source and innovative design was tested for benchmarking purposes.

These results are analyzed and discussed below in the broader context of test results from earlier rounds of testing and with respect to particular areas of interest — product performance in different application categories, measurements of color quality, power factors, and repeatability and variability of SSL testing.

Observations and Analysis of Test Results: Overall Progression in Performance of Products

Energy Use and Light Output

A key point to observe when studying CALiPER results is the wide range of performance levels across products irrespective of product geometries and application categories. Table 2 shows the minimum and maximum levels of measured power, light output, luminaire efficacy, CCT, and CRI for all products tested in Round 5. Naturally, different products target different applications and are designed with different light output or color objectives in mind. How effectively a given design implements LED chips to deliver light output at a desired level, in a desired direction, and of a desired color quality is another huge variable. The wide disparity in performance levels observed in these test results reflects not only differences in design, but also difference in effectiveness of SSL implementation.

Table 2. Range of SSL Luminaire Characteristics Tested in CALiPER Round 5

	from		*to*
Power	2 W	↔	75 W
Output	34 lm	↔	3456 lm
Efficacy	9 lm/W	↔	59 lm/W
CCT	2691	↔	12583
CRI	67	↔	93

The downlight series described in the following pages illustrates how SSL products can effectively use directionality of the LED light source to clearly compete with CFL sources in these applications. Conversely, the troffer series shows that despite benefiting from directionality, SSL technology may not yet be capable of competing in some arenas, such as those occupied by highly efficacious 4-foot fluorescent tube lighting.

The replacement MR16 style lamps that were tested did not perform significantly better than similar products tested in Round 4. However, these products fulfilled the test of full disclosure, meeting or exceeding the performance levels published in their own product literature. Conversely, the replacement A-lamps that were tested did perform better than similar products in earlier rounds of testing, but still suffered from overstated performance claims in their product literature and raised questions regarding product reliability or warranty deficiencies.

Task lamps represent a niche application where LED directionality and small form factors could be used to implement SSL effectively. Yet, the four task lamps tested in Round 5 show that these products are still not able to meet minimum levels in all areas of performance. For example, while light output for a product may be sufficient, it may have poor efficacy or poor color quality.

It is essential to keep in mind the nuances of various performance parameters and the variety of products and applications that are studied in the pages that follow.

Recessed Downlight Series

Round 5 included a focused series of tests on lamps that can be used in recessed downlights. To enable direct comparison of SSL downlight products to other light sources, 10 replacement or retrofit lamps were selected: three SSL products (one retrofit, one PAR30, one PAR38), a reflector CFL (RCFL), a spiral CFL, a cold-cathode CFL (CCFL), a halogen infrared (HIR), a reflector incandescent (R30), a name-brand soft white, incandescent A19, and a value-brand, long-life, frosted incandescent A19. The selection represents an array of products that residential customers might purchase and install in a 6-inch diameter recessed can downlight, each expected to provide fairly similar light output levels (but not similar light distributions).

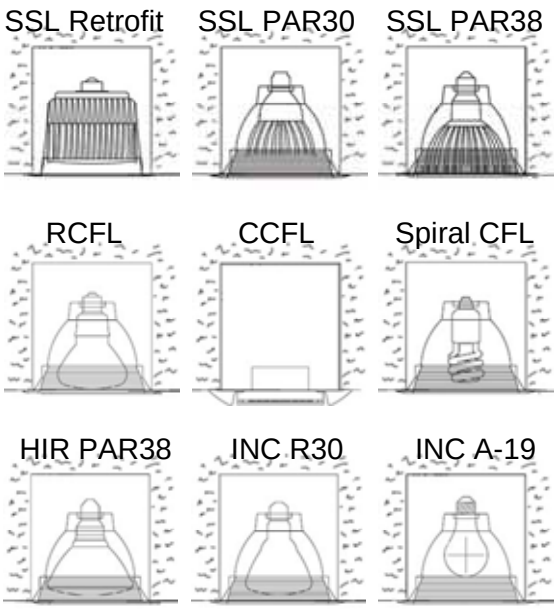


Figure 1. Schematic drawings of replacement and retrofit lamps in recessed can mounted in an insulated enclosure.

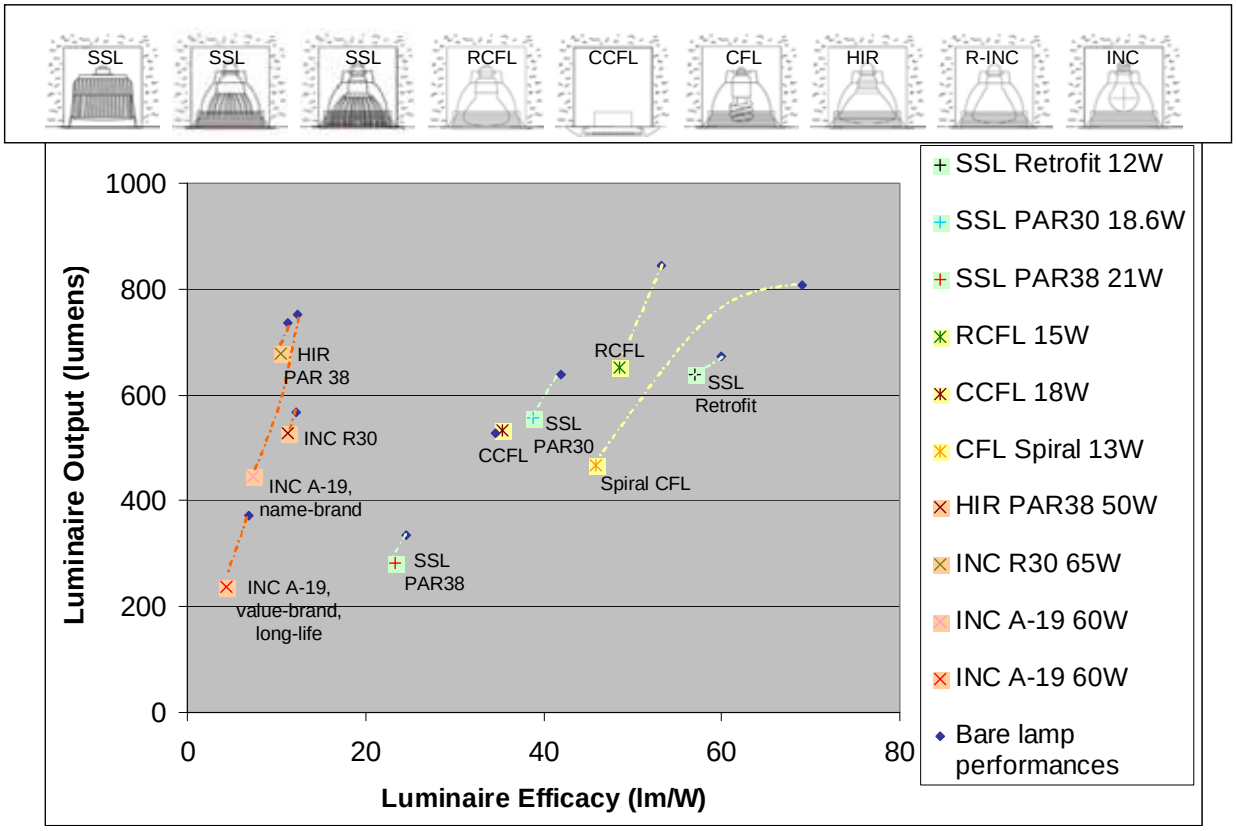
Two units of each lamp were tested first as bare lamps in an integrating sphere. The better performing unit of each pair was then mounted in a recessed downlight in an insulated UL 1598 enclosure representing an insulated-ceiling (IC) installation and tested with a goniophotometer. Figure 1 provides side-by-side sketches of each lamp mounted in the recessed IC can (the two incandescent A-19 lamps share the same geometry). The CCFL and SSL retrofit had an incorporated trim and mounting system. All other lamps had medium-base sockets and mounted in a standard trim kit. More details about the testing setup and insulated enclosure are provided in Appendix B. The goniophotometry testing in the insulated, recessed can emulates *in situ* conditions, allowing explicit understanding of fixture impacts of these products — both thermal and directional effects of operating *in situ*.

Figure 2 provides a visual summary of the light output and efficacy of these ten lamps (from data summarized in Table 1a). Both the bare lamp and *in situ* results are plotted for each lamp. The two omni-directional lamps, the A19 incandescents and the spiral CFL, and the reflector CFL show the greatest fixture loss (36 and 4% loss for the A19s, 42% for the spiral CFL, and 23% for the RCFL). The two SSL replacement lamps lost 13-15% in the fixture, probably primary due to thermal effects. All of the other products (the retrofit SSL, the CCFL retrofit, HIR PAR38, and incandescent R30) lost 8% or less of their output when mounted *in situ*.

Figure 2 also allows comparison of performance across these products. The value-brand, long-life A19 lamp provided both the lowest light output and lowest luminaire efficacy of all of the samples tested *in situ*. One of the SSL products, the PAR38, had fairly low output, only beating

the value-brand A19 for *in situ* performance, while its efficacy was higher than the incandescents and HIR products, but lower than all three fluorescent sources. The other two SSL products were comparable to the fluorescent products and HIR and incandescent R30 in output level and clearly competitive with both the RCFL and spiral CFL in efficacy under *in situ* conditions. For bare lamp testing, the highest efficacy products were the RCFL and spiral CFL; however, when these products were mounted and operated *in situ*, they had much larger losses than the SSL retrofit. Overall, the efficacy of the SSL retrofit mounted in an insulated recessed can surpassed the next-highest performing source by 15%, and it was 10 times more efficacious than the value-brand, long-life A19 incandescent lamp.

Figure 2. Downlight In Situ Losses. Performance of 6" Recessed Downlight with Different Sources



Appendix B provides further visual analysis of the results of this series of tests, showing the different illuminance levels and intensity distributions of these sources *in situ*. As expected, the two PAR38 lamps resulted in the most focused beam patterns.

The difference between manufacturers' ratings and tested performance of the bare lamps is a final point of interest for this series of tests. The manufacturer literature for the SSL PAR38 lamp significantly overstated the light output of this product. Similarly, the CCFL, the value-brand, long-life A19 incandescent, and the PAR38 HIR lamp manufacturers' literature also significantly overstated ratings. The SSL retrofit, SSL PAR30, RCFL, spiral CFL, and R30 incandescent all

met or exceeded their manufacturers' ratings. The name-brand A19 is close to meeting manufacturer ratings. For this set of 10 products, one-third of the products — whether SSL or not—had misleading or inaccurate product literature. Appendix B provides tabulated data indicating differences between manufacturer reported performance and measured output and efficacy of these products.

T8 & T12 Troffer Series

Round 5 also included a focused series of tests on 4-foot tube lamps that can be used in troffer housing to replace 4-foot fluorescent tubes. Four SSL replacement tube products were selected, along with one typical fluorescent T8 and one typical fluorescent T12 product. Two samples of each product were tested.

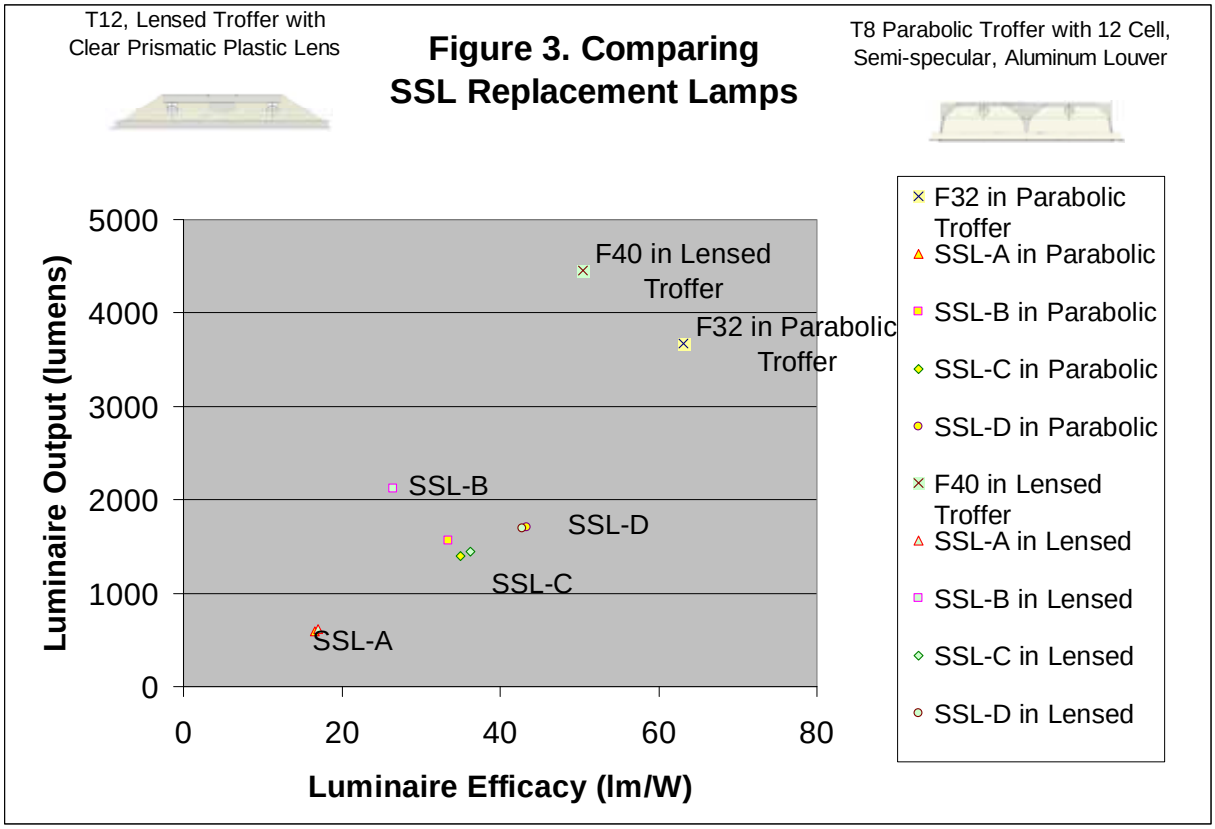
Two typical troffer housings were also selected — one prismatic, A12 pattern lensed troffer, and one parabolic, louvered troffer. The F40T12 fluorescent tubes were tested in the lensed troffer housing. The F32T8 fluorescent tubes were tested in the parabolic, 12-cell, louvered troffer. The SSL products were all tested in both troffer types. All bare lamps were also tested in an integrating sphere.

The goniophotometric testing of the lamps in the troffers allowed the study of the lamps' operation under *in situ* conditions and the direct comparison to fluorescent product performance under the same *in situ* conditions. Because of the directional nature of the SSL replacement tube products — as opposed to the omni-directional light emission of the fluorescent product —, the SSL tubes exhibited less fixture loss than the fluorescent tubes. In the lensed troffer, the fixture loss for the SSL products was, on average, 14%; the F40T12 lamps in the same lensed troffer lost 28%. In the same parabolic troffer, the fixture loss for the SSL products was 16% for the SSL products and 40% for the F32T8 lamps. [5]

Despite having lower fixture losses than the fluorescent tubes, none of the SSL products rivals the fluorescent products, whether as bare lamps or when installed in lensed or parabolic troffers. Figure 3 plots the output and efficacy of each pair of products tested in the troffer housings. A considerable range of performance was observed across the four different SSL products, with nearly a three-fold difference in output and efficacy between the lowest- and highest-performing SSL products.

For the three SSL products that bypass the fluorescent ballast, performance did not vary significantly between the lensed troffer and parabolic troffer mounting conditions. The fourth SSL product (labeled as SSL B in Figure 3) produced higher output at a lower efficacy level when operated with the F40T12 ballast than when operated with the F32T8 ballast. The SSL products do not provide even 50% of the output *in situ* of F32T8 and F40T12 fluorescent lamps. The SSL products also all achieve lower efficacy levels than the fluorescent tubes —one SSL product had only one-third the efficacy of the fluorescent tubes *in situ*.

[5] Note that one of the SSL products relies on the fluorescent ballast for its power supply, so these bare lamps were tested using a reference ballast first, then using the troffer ballasts for the goniophotometry tests. Fixture efficiencies were not calculated for this product given the different power levels of operation under these different power supplies. The other three SSL products all bypass the fluorescent ballasts.



-- 4 different SSL replacement tube products were used (2 samples each)
-- SSL-B uses troffer ballast. SSL-A, C, & D bypass troffer ballast

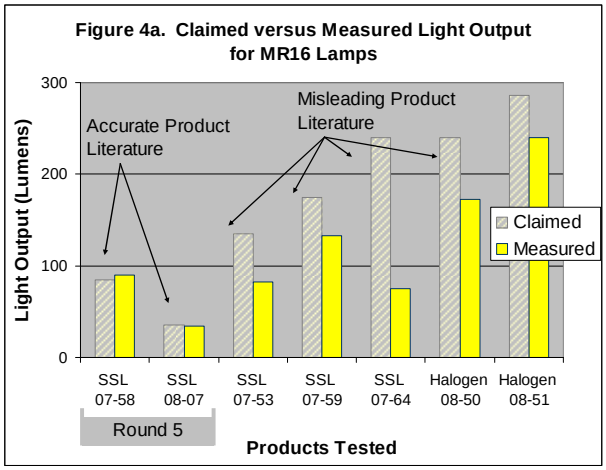
All four SSL replacement tube products mounted in the troffers result in narrower distribution of light than the fluorescent tubes mounted in the same troffers, with the SSL products emitting about 8% more out of their total light output in the 0 to 3° range.

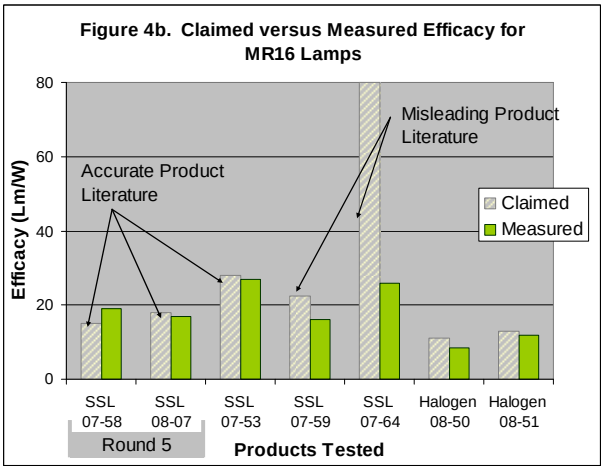
All four SSL replacement tube products had output or efficacy claims in manufacturer literature that significantly overstated their measured performance. Furthermore, the correlated color temperatures of three of the SSL products are entirely different than those stated in product literature (two products had CCTs well over 6000K). These results show that SSL is not yet competitive with fluorescent tubes in output or efficacy for this application. In general, SSL linear replacement products are not competitive in troffers as a replacement for linear fluorescent lamps at this time. However, the better-performing SSL replacement tube products might be appropriate for specific applications where fluorescent lamps are not suitable (e.g., cold or rugged environments or low output needs).

Other Replacement Lamps

In addition to the replacement lamps tested for the downlight and troffer series, Round 5 also included two MR16 products and two A-lamp style replacement lamps.

Figures 4a and 4b summarize the light output and efficacy of all MR16s tested to date, compared to the performance values for these products suggested in product specification sheets or Web pages. While the three MR16 products tested in Round 4 all had inaccurate manufacturer performance claims, the two MR16 products tested in Round 5 both provided complete and accurate performance claims. Two 20W halogen MR16 lamps were also tested for benchmarking purposes (both standard lamps from major manufacturers).[6] Figure 4a illustrates that the light output of the SSL products is not comparable to the output levels of the two SSL MR16 products, though one SSL product, 07-59, tested in Round 4, achieves about three-quarters of the output level of the lower performing halogen MR16. Figure 4b shows that the SSL products have better efficacies than the halogen products. The SSL MR16s tested to date achieve CBCP levels ranging from one-sixth to three-quarters of the CBCP of halogen MR16s with similar beam angles.





Two A-lamp style, medium-base (screw-in), omni-directional lamps were tested in Round 5. These lamps are both about equivalent in size to an A19 lamp. Table 3 summarizes the performance results for these two products as compared to a range of incandescent A-lamps.[7] One lamp, 08-03, claims to replace 20W lamps and the other, 08-25, claims to replace 40W lamps. To a certain extent, both lamps are commendable for the levels of output, efficacy, and color quality that they achieve in a small package. On the other hand, the products failed to meet the performance claims made by the manufacturers in product literature, and both products have poor power factor (one as low as 0.32). Product 08-03 would be more justified in claiming to replace a 10-15W incandescent lamp (as opposed to the 20W equivalence claimed) and product 08-25 statements would be more accurate if claiming to replace a 25W incandescent lamp (as

[6] Note that manufacturer literature for the halogen MR16 products does not indicate efficacy levels. For 08-50, the rated lamp lumens divided by a power level of 22W (rated power + 10%) was used to calculate rated efficacy. For 08-51, only CBCP is published, so a typical halogen efficacy of 13 lm/W and output of 286 lm is used in place of manufacturer values. These products were CALiPER tested for benchmarking purposes subsequent to Round 5 testing. Detailed reporting on these tests is not included in Round 5.

[7] CALiPER Tests 08-47, 08-48, 08-49 were performed subsequent to Round 5 testing for benchmarking purposes on typical incandescent A-lamps from major lamp manufacturers. Three samples of each lamp were submitted for absolute photometric testing. Detailed reporting on these tests is not included in Round 5.

opposed to the 40W equivalence claimed). Both products also drew at least 10% more power than claimed. Product 08-25 claims a correlated color temperature of 2800K, where the average measured color temperature across 8 samples was 3418K (ranging from 3261K to 3701K).

Table 3. Summary of Replacement A-Lamp Performance

Replacement Lamps	Manufacturer Reported Performance	CALiPER Measurements					
		Power (W)	Output (lm)	Efficacy (lm/W)	CCT	CRI	Power Factor
SSL (08-03)	95-105 lm (41-46 lm/W)	3	81	31	3127	92	0.55
SSL (08-25)	230 lm (57 lm/W)	5	194	39	3418	86	0.33
INC 25 W (08-47)	210 lm (8.4 lm/W)	24	181	8	2551	99	1
INC 40W (08-48)	390 lm (9.8 lm/W)	39	387	10	2610	99	1
INC 60 W (08-49)	780 lm (13 lm/W)	61	739	12	2703	100	1

Product 08-25 also raises considerable concern regarding product reliability. This product was selected for variability testing, so ten units were purchased and tested. Two of those ten units failed entirely before photometric testing commenced (during setup and stabilization). When these products were returned to the manufacturer to request replacement, the purchaser was informed that returns are only accepted within 14 days of the shipping date, despite the product packaging claim of "Lifetime 35 years."

Other Downlights

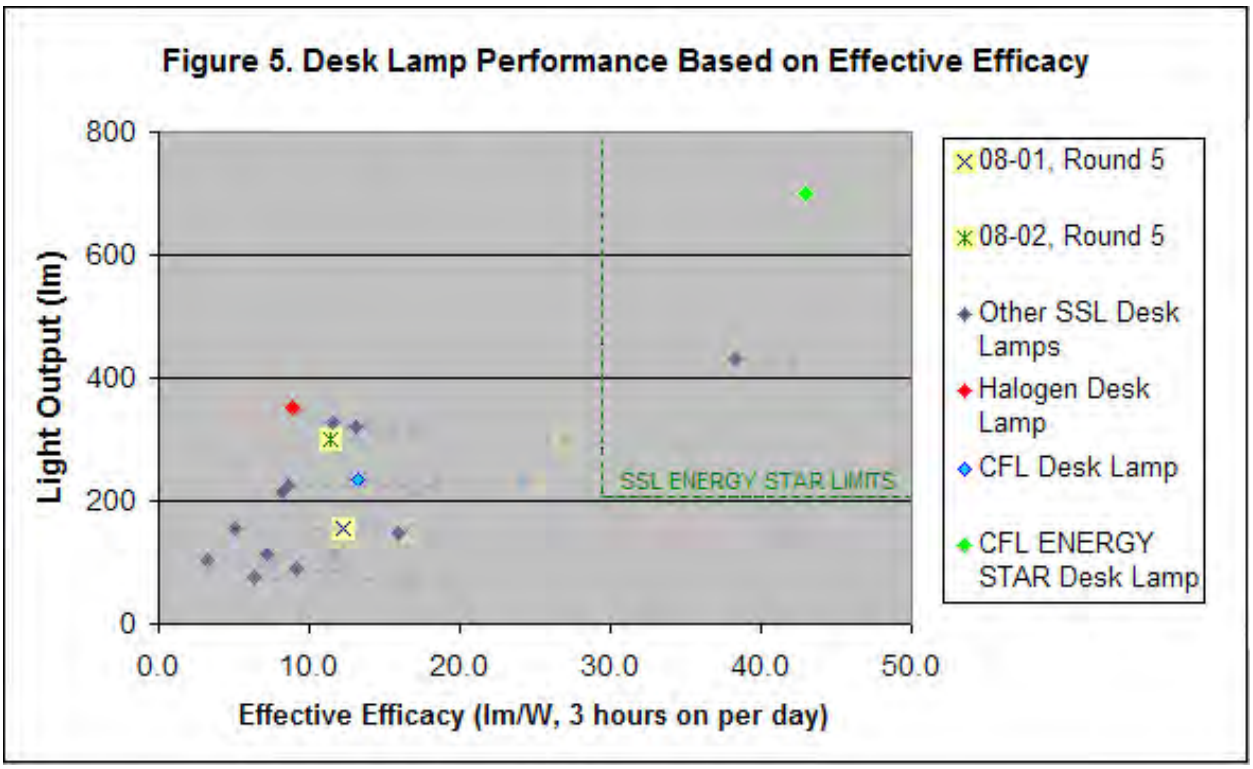
In addition to the troffer series and the series of downlight tests on replacement and retrofit lamps in a recessed can, one 2-foot by 2-foot square downlight luminaire, 08-29, was tested. This luminaire is a larger product with higher wattage level than downlights that have been tested in previous CALiPER rounds. With a CCT of 4346K and CRI of 71, this luminaire achieved an efficacy of 46 lm/W, with a total lumen output of 3456 lm. This efficacy far exceeded the efficacy of downlight products using incandescent and halogen sources, and surpassed the efficacy of all four SSL replacement tube products mounted in both lensed and parabolic louvered troffers as previously described. The efficacy of this2-foot by 2-foot ' luminaire was close to the overall luminaire efficacy of the F40T12 fluorescent tubes (08-30) mounted in a lensed troffer, and the output level was close to the output of the F32T8 lamps mounted in the parabolic louvered troffer. Unfortunately, the power factor of this product was only 0.58. This product could be a suitable choice for environments where the use of fluorescent lamps is inappropriate.

Task Lamps

Round 5 of testing included two SSL desk lamps, and two SSL undercabinet fixtures. None of these four SSL task lights met the DOE ENERGY STAR® criteria for their niche application

categories — each missed the mark on one or more criteria (such as efficacy, output, off-state power, light distribution and/or CCT requirements). [8]

The two SSL desk lights tested in this round provided outputs of 156 and 301 lm, and efficacies of 16 and 27 lm/W (if off-state power is not considered).[9] For example, 08-02 which has a measured luminaire efficacy of 27 lm/W also draws 2.2 W of power when turned off. , This resulted in effective efficacy — which takes into account off-state power consumption — that was quite poor. Figure 5 illustrates how these lamps compared to SSL lamps tested in earlier CALiPER rounds and benchmark lamps using CFL or halogen light sources. The sphere tested efficacy values for these lamps are also shown in muted points, to demonstrate how these lamps could perform if they didn't draw power when in the off state. The green lines indicate the lower limits for output and efficacy required for SSL products to meet ENERGY STAR criteria. Product 08-02 would be close to meeting the ENERGY STAR efficacy and output requirements if it did not draw power in the off state, but its color temperature (over 6000) would disqualify it. Product 08-01 only slightly exceeded the halogen benchmark example in efficacy and was far from achieving ENERGY STAR performance levels.



*Muted points show efficacy without including off-state power loss. Products without a corresponding muted point are those that do not draw off-state power.

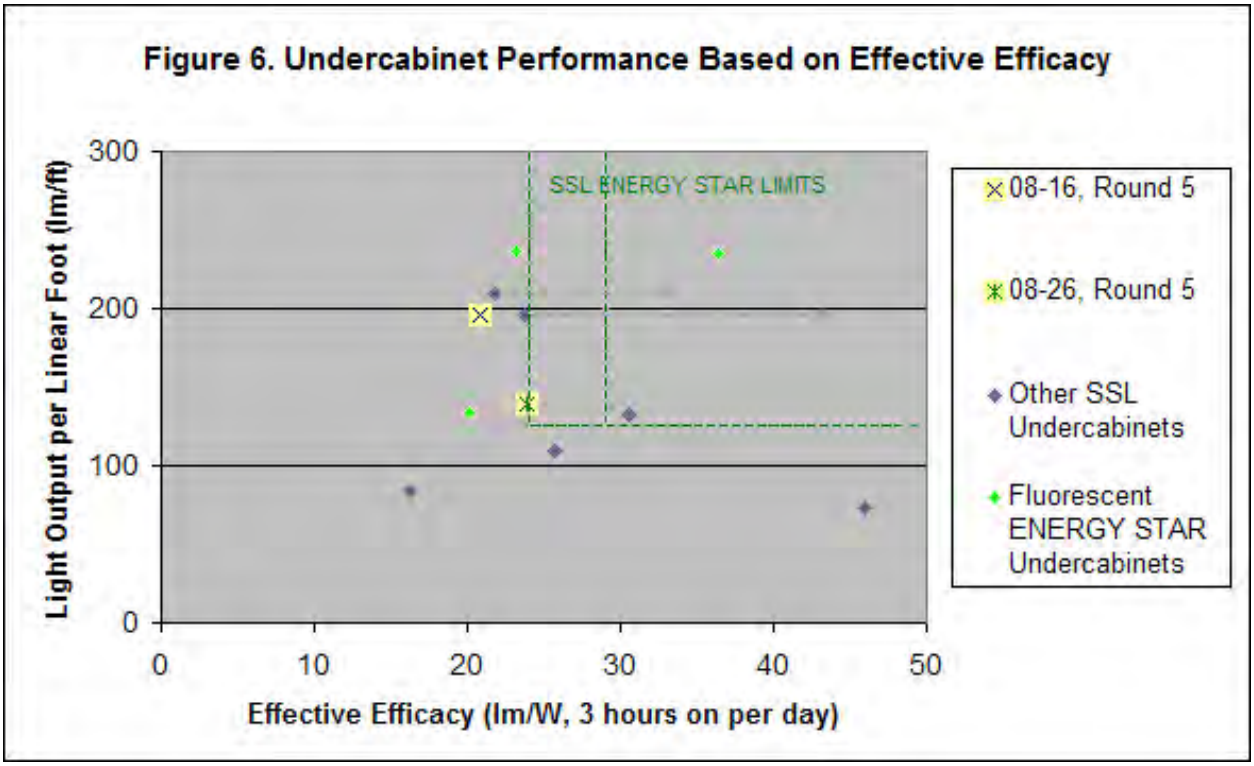
[8] ENERGY STAR® Program Requirements for Solid State Lighting Luminaires Eligibility Criteria Version 1.0 (09/12/07) are available online: http://www.netl.doe.gov/ssl/energy_star.html.

[9] Off-state power consumption, also called standby power consumption or 'vampire' loading, refers to power drawn by an electronic device while it is, in essence, switched off. Some electronic devices do need to power circuitry continuously for control purposes or for other functional purposes, but many electronic devices consume power when turned off simply due to inefficient electrical design. In most cases (outside of specific applications), there is no functional reason for lamps and luminaires to draw power when they are turned off.

The two SSL undercabinet lights tested in this round provided outputs of 196 and 139 lm per linear foot, and efficacies of 21 and 24 lm/W. Both had fairly warm color temperatures, and acceptable CRIs, but as illustrated in Figure 6, their efficacy fell just below the lower limit for ENERGY STAR qualification. These two products would also not qualify for ENERGY STAR based on light distribution. More than 90% of their output falling in the 0 to 60° vertical angles, so their beams were too directional (too narrow) for this application.

While one of the four task lights tested had no marketing literature claims regarding performance, the other three had manufacturer literature that included misleading or overstated performance claims. Product 08-01 claimed to be as bright as a 40-60W incandescent and to draw only 8.8 W, yet it produced only 156 lm (less than expected from even a 40W incandescent in a desk lamp) and drew 9.5W. For product 08-02, two sets of information were found — one published by the manufacturer and one by a product distributor. The performance values declared by the distributor were fairly accurate, while the manufacturer's brochure significantly overstated the performance. The brochure claimed 08-16 produced 250 lm with only 7W of power, but tests measured 195 lm produced with 9.5W. Furthermore, this brochure claimed that the product meets ENERGY STAR requirements, but this product would fail on the basis of insufficient efficacy, too narrow a beam, and a poor power factor.

Figure 6. Undercabinet Performance Based on Effective Efficacy



*Muted points show efficacy without including off-state power loss. Products without a corresponding dimmed point are those that do not draw off-state power.

Outdoor Fixtures

Two different types of outdoor fixtures were included in Round 5: one roadway, metal halide fixture tested for benchmarking purposes and two outdoor spot lights (the same model, using two different sources—LED and halogen).

The metal halide roadway fixture was selected as an award-winning product using a traditional source and innovative design for light distribution. The performance results for this product fall directly within the ranges that were identified by CALiPER benchmark studies of manufacturer data for similar outdoor products. This test serves to further confirm the benchmark levels that CALiPER is using in this product category; it also confirms that the higher-performing SSL outdoor products (tested in Round 3) are indeed directly competitive with products using these traditional sources based on initial luminaire efficacy.

The two outdoor spotlights (from the same product line) were chosen to provide a direct comparison between SSL and halogen luminaires. As illustrated in Table 4, the LED-based version produces only half the output of the halogen product with negligibly better efficacy. The manufacturer provides IES files for these lamps which provide information for both the LED version and the halogen version that might be misleading or difficult to interpret. The IES file for the halogen spot light indicates a fixture efficiency of over 250%, resulting in an IES photometric output of 823 lm (as opposed to 185 lm measured in CALiPER testing). The IES file for the LED spotlight indicates a lamp output of 45 lm/LED, and fixture efficiency of 100%, resulting in an IES photometric output of 135 lm (versus 90 lm measured through CALiPER). The manufacturer also claims that its LED product is comparable to its MR16 product, although the LED product achieved only one-half the light output. For lighting systems designed for lower light levels, the LED version may be an appropriate, energy-saving alternative, but it would not be suitable as a direct replacement for the halogen MR16 version.

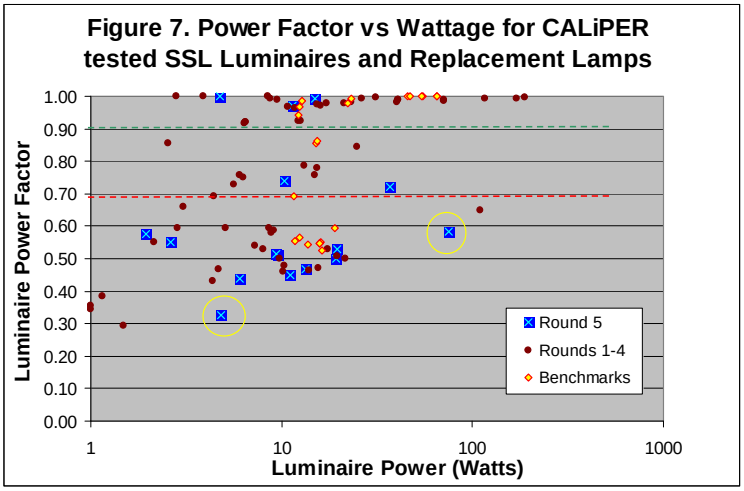
Table 4. Comparison: Same Outdoor Spot Fixture, Two Different Sources

Source/Power	Halogen (22W)	LED (10W)
Luminaire Output (lm)	185	90
Luminaire Efficacy (lm/W)	8	9
CCT	2873	6469
CRI	97	78
Power Factor	0.98	0.74
Manufacturer lamp output (from IES)	322 lm/lamp	45 lm/LED (3 LEDs)
Manufacturer luminaire output (IES)	823 lm	135 lm
Manufacturer claim	“The LED 16 is comparable to our MR-16”	

Measurements of Color Quality

As in earlier rounds, the SSL products tested in Round 5 represent a range of white- light levels, with most available in the warm white (~2700-~3000K) and neutral white (~3500-~4000K) ranges. The average CRI of SSL products tested in Round 5 is 77 — a slight increase over earlier rounds of testing. There were five products tested in Round 5 with CCTs over 6000K. In particular, two 4-foot replacement tube products have CCTs over 7000 — well outside the nominal ranges for white light and a far colder white than would be expected for this application.

Power Factor



The power factor of products tested to date is plotted in Figure 7, along with the luminaire power. The median power factor of all SSL products tested to date is 0.73 — exceeding the minimum power factor, 0.7, currently required for residential products in the ENERGY STAR® Program Requirements for Solid-State Lighting Luminaires.[10] The majority of products tested in Round 5 have lower-than-acceptable power factor. Of particular concern in Round 5 testing is one high-wattage product with a relatively low power factor and a smaller, highly publicized replacement lamp with a very low power factor of 0.32, both circled in yellow in Figure 7.

Performance Reports in Manufacturer Literature

In all rounds of CALiPER testing, significant discrepancies have been observed between the light outputs and efficacies published by manufacturers and their CALiPER-tested performance. The accuracy of manufacturer performance reporting for the 17 SSL products in Round 5 of CALiPER testing can be summarized as follows:

- Accurate performance reporting (4): Four SSL products tested meet or exceed the performance levels published in manufacturer literature.
- No performance reporting (1): For one product, no manufacturer-published information was found regarding output or efficacy.
- Overstated performance reporting (12): For the other twelve SSL products, information published by manufacturers regarding product output and/or efficacy overstated performance. Values were often overstated by about 25 to 100%, though in some cases either output or efficacy or both are even more exaggerated.

[10] ENERGY STAR® Program Requirements for Solid State Lighting Luminaires Eligibility Criteria Version 1.0 (09/12/07) are available online: http://www.netl.doe.gov/ssl/energy_star.html.

For the products with overstated or misleading claims, some misleadingly compared the outputs of their products to incandescent products and some published explicit values for output or efficacy of their luminaire. In many cases, the manufacturer published a somewhat overstated value for luminaire output, along with an understated value for power. If a consumer used these values to calculate the efficacy of the luminaire the results would be highly misleading.

Three products in Round 5 have measured CCT which is significantly cooler than the value announced in product literature. One undercabinet fixture claimed as well to meet the DOE ENERGY STAR requirements— a claim that was false for two reasons. First, the ENERGY STAR criteria for SSL products is not yet in effect; and second, the particular product would fail to meet the upcoming ENERGY STAR criteria on three counts.

Of the benchmark products tested in Round 5, seven out of ten products met or exceeded product performance ratings, but the other three published incorrect values or misleading statements. One of these three products is a CCFL product which did not publish explicit ratings, but highly overstated the product's performance by comparing it to a 26W CFL in a recessed can (where it fails to meet the performance of even a 13W CFL in a recessed can).

Another traditional product with incorrect ratings is a halogen HIR MR16 20W lamp. The misinformation on this lamp stems primarily from distributor-published ratings for one model of lamp that were packaged and shipped with a lamp with the same product description, but a different product code and different performance characteristics. (In many cases, two lamps have the same description in the lamp manufacturer's catalog, but different product codes and different ratings. In these cases, the buyer may receive a product which doesn't entirely correspond to what was ordered.) In this case, the tested product 08-05, when compared to the manufacturer ratings for the same product (same product code) the performance was nevertheless below the rated value for both specimens that were tested. A discrepancy of 22% for unit A and of 5.5% for unit B was observed — so even if the correct product had been received, it would not have met performance ratings. While a performance that is 5.5% below rated performance may be within normal tolerance for typical variation in large production runs, the sample that performed 22% below rated values gives more cause for concern.

One halogen spotlight also provided misleading performance information, as described previously in the outdoor lights section. In this case, the error appears to stem entirely from incorrect IES files, both for the halogen and LED versions of this product.

These examples of incorrect or misleading performance information regarding traditional products and (and examples from earlier CALiPER reports) suggest the divergence between claimed and actual tested values for SSL products may stem from a number of issues:

- Misinterpretation or lack of experience relative to SSL testing concepts (e.g., LED device performance vs. luminaire performance, lamp efficacy vs. luminaire efficacy, relative photometry vs. absolute photometry)
- Lack of industry standardization in LED device performance testing and reporting and infeasibility of determining luminaire performance based on reported LED device performance

- Confusion or lack of clear distinction in marketing literature between LED device performance and luminaire performance
- Use of inconsistent testing methods including alternatives to LM-79 (such as Japanese or Chinese standards) that may yield different results
- Manufacturers' product literature that does not clearly indicate what specific product configuration was tested to produce the performance values published (e.g., differences in LED devices, drivers, and optics may greatly influence results)
- Different basis of comparison used in manufacturer literature (such as comparing performance based only on illuminance levels for specific sources or applications, or based, for example, on Center Beam Candle Power)
- Possible inflation of performance claims (or selection of test conditions not representative of actual use; e.g., chilled or pulsed device testing)

It is hoped that the recent publication of the IESNA LM-79 testing method for SSL replacement lamps and luminaires will help improve this situation. As manufacturers make wider use of this new methodology, SSL testing and reporting practices will become more consistent and accurate. Performing appropriate SSL testing and providing accurate, understandable information regarding product performance will increase confidence in SSL technology.

In addition to questions concerning photometric performance claims for SSL, a few of the products in Round 5 raised questions regarding warranty deficiencies or purchasing irregularities. One extreme example is a product (08-25) announced to have 35-year lifetime but that has only a 14 day return policy. For another product (08-17), the invoicing and billing statements for the product did not carry the same company name and the product received did not correspond to the product ordered — and the company (whose name was on the packaging box and on the original invoice) refused to exchange the product for the one which was originally ordered. While these may be isolated cases, establishing long-term market confidence in SSL technologies is likely to be affected by concerns regarding warranty and returns policies and by purchasing and acquisition irregularities.

Variability and Repeatability

In all CALiPER testing, a certain number of tests are designed and conducted to assess facets of variation and repeatability — among samples, among testing methods or equipment, and even between two identical test runs. Over the first five rounds of CALiPER testing, these verifications have allowed us to determine, for example that on average, two samples of a given SSL product do not show any more variation in performance than two samples of incandescent or fluorescent products that have been similarly tested and compared to each other. Note that this is on average, so in some cases two samples of a product show greater divergence. Similarly, CALiPER regularly compares integrating sphere results to goniophotometry results for luminaire output and efficacy. These comparisons confirm consistently that in the great majority of cases, integrating sphere and goniophotometry tests provide similar results for total lumen output and efficacy for a given product.

In Round 5, one replacement lamp product, 08-25, was selected for broader variability testing on 10 samples of the same product. The 10 samples were purchased in three separate lots ordered at

one-month intervals. All samples were submitted to the same independent testing laboratory for integrating sphere tests. Two of the products were also tested in a goniophotometer.

Out of these 10 samples submitted for testing, all were operating when received, but two samples failed during test setup and stabilization. The remaining, functioning samples were photometrically tested. Table 5 summarizes the key performance parameters from these eight samples, showing the average, minimum, maximum, and average deviation of each of the measurements across the eight samples. The average deviation as a percentage of the average measured value for power, output, efficacy, CCT, and CRI is less than 4% across these samples, and there are no significant outliers. While this small amount of variation across eight units is reassuring, the fact that two out of 10 products failed within the first few hours of operation raises serious concerns about the reliability or robustness of the product design.

Table 5. Variation Across 8 Samples of SSL Replacement Lamp 08-25
(2 failed units not included)

Measured Quantity	Average	Minimum	Maximum	Average Deviation	Ave. Deviation/ Average Value
Power (W)	5	4.8	5.3	0.1	2.4%
Output (lm)	194	172	206	7.6	3.9%
Efficacy (lm/W)	39	36	42	1.5	3.8%
CCT	3418	3261	3701	96	2.8%
CRI	86	83	89	1.5	1.7%

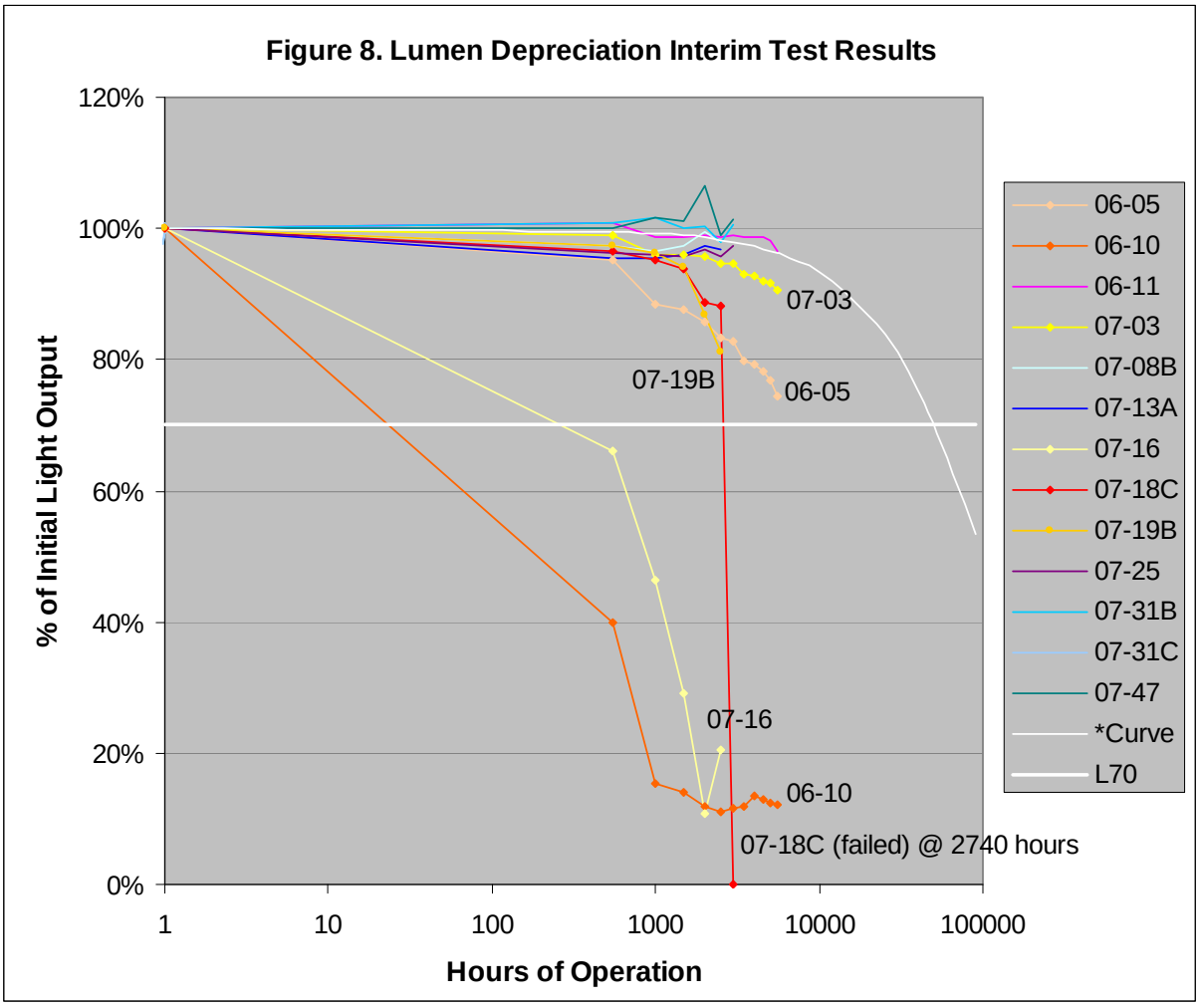
Reliability: Lumen Depreciation Testing

In addition to testing the photometric performance of products, the CALiPER program is also investigating their reliability — studying how *in situ* conditions may affect product performance and how product performance varies over time by measuring lumen depreciation. Standardized testing procedures are not yet available for performing *in situ* or lumen depreciation on SSL luminaires and replacement lamps. The CALiPER program has defined testing procedures for these situations in conjunction with qualified independent testing laboratories and has drawn on standards for similar procedures where available or under development for other product types. CALiPER *in situ* and lumen depreciation testing is ongoing, so results presented below should be considered as preliminary, introductory information only.

Lumen Depreciation Interim Examples

While LED devices — and hence SSL products — are expected to have long lives, the true rate of lumen depreciation of SSL luminaires and replacement lamps is largely unknown. Lumen depreciation characteristics for LED devices may be available from device manufacturers, but when those devices are integrated in luminaires, the LED device's long-term performance will be affected by many factors stemming from the luminaire as a whole. These factors include, most obviously, operating point characteristics (such as forward current) and thermal management (such as heat sinking and thermal bonding), but also other factors such as the use of materials during manufacturing which may effect LED device lifetime such as cyanoacrylates (super glue) and O-rings. Lumen depreciation of the LED source is not the only failure mode contributing to the reliability of SSL luminaires, but it is a primary facet of luminaire reliability that is being studied by the CALiPER program.

Figure 8 summarizes the lumen depreciation interim testing results for13 SSL products that were first included in earlier rounds of CALiPER testing. The lumen depreciation testing is not



*Note that the white curve is provided only as an example of exponential depreciation which would reach L70 (70% of initial output) at 50,000 hours. The horizontal white line indicates L70.

completed for any of these samples, but these interim results already provide insight. The two white lines in the plot are provided as reference curves: the horizontal white line indicates the level at which light output drops to 70% of the initial output (L_{70}), and the descending white curve represents a typical logarithmic decay that would reach L_{70} at 50,000 hours.

These 13 products cover a range of product configurations, including task lamps, replacement lamps, retrofit lamps, and outdoor area luminaires. At this point in this long-term testing and given the small sample size, no general observations about the speed of depreciation for any particular category of products (based on size or application) can be drawn.

Of note in these results:

- One product, a 10W medium-base socket-based directional replacement lamp, 07-18C, failed abruptly after 2740 hours of operation. This sample had depreciated to 88% of initial output prior to failing.
- Two products, 06-10 and 07-16, dropped significantly in output during the first few thousand hours of operation. 06-10 is an undercabinet product which uses only a copper core printed circuit board as a heat sink. 07-16 is a desk lamp.
- A desk lamp (07-03), a 17W PAR30 replacement lamp (07-19B) and an outdoor area luminaire (06-05) are also showing considerable depreciation during the first few thousand hours of operation, although they are still operating above the L_{70} threshold.
- Desk lamps 06-11 and 07-03 are both made by the same manufacturer, using the same design for the LED device package and driver but different thermal management. The shape, size, and sheathing of the heat sinks used are different. To determine whether lumen depreciation differences between these two fixtures stem from simple variation across samples or from differences between the two thermal management designs, testing of more units would be required.
- Seven out of these thirteen products are producing over 96% of their initial output at this point in testing.[11]

Note that these results are only interim results. These tests, and lumen depreciation testing on other products, is an on-going, long-term endeavor.

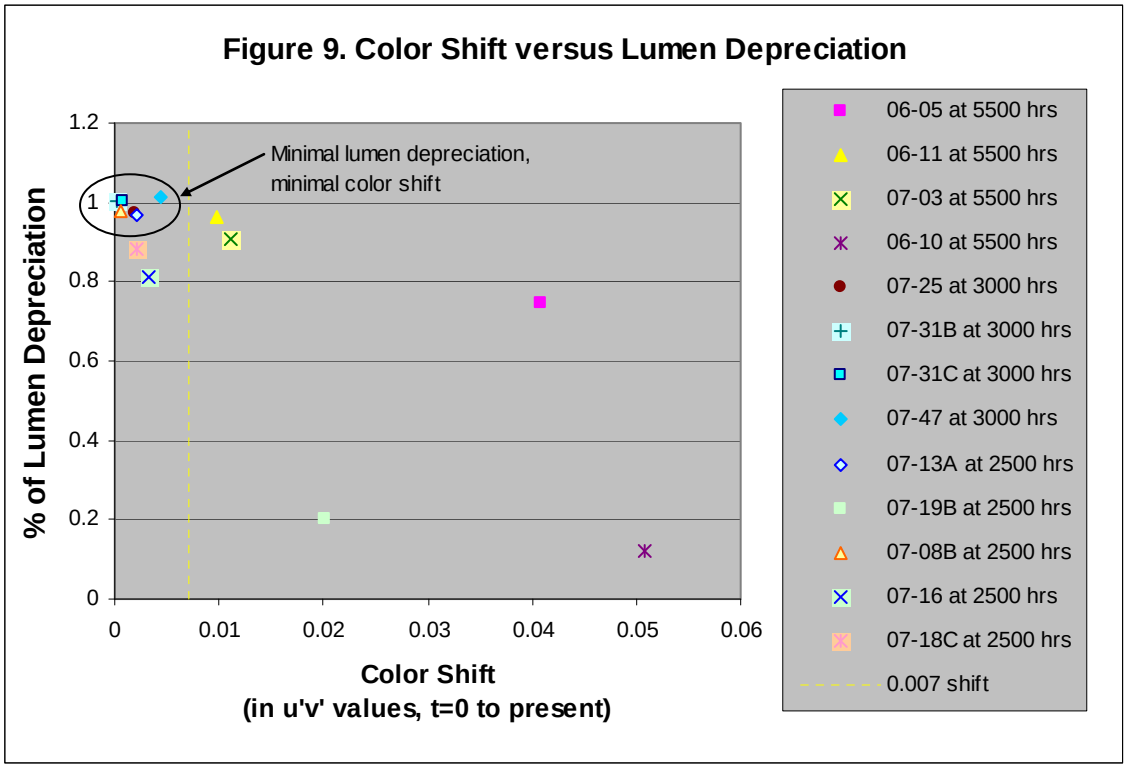
Color Shift

In addition to measuring shifts in output and efficacy due to lumen depreciation over time, this CALiPER testing is also studying shifts in color. Spot spectral measurements are taken along with spot illuminance measurements in each case. The DOE ENERGY STAR® Criteria for Solid-State Lighting requirement for color maintenance currently states, “The change of chromaticity over the lifetime of the product shall be within 0.007 on the CIE 1976 (u’, v’) diagram.”

[11] Different sets of lumen depreciation testing are at different stages of advancement. The thirteen products being tested at this time have been operated from 2500 to 5500 hours, depending on the start date of the various tests.

Figure 9 illustrates the degree of color shift of each of these products in relation to the extent of measured lumen depreciation for each. A dotted vertical line is included to mark the current ENERGY STAR cut off for lifetime change in chromaticity at 0.007. Analysis of the initial color shift results must take into consideration that the uncertainty factors for these spot color shift measurements have not yet been determined and may be relatively large. Nevertheless, Figure 9 shows clearly that products with higher lumen depreciation also exhibit greater color shift.

As noted above, all lumen depreciation and color shift test results reported here are from interim testing using relative photometry. Measurement uncertainties for this testing have not been calculated. Products will be retested in an integrating sphere after 6000 hours of operation to recheck the correlation of relative photometry to absolute photometry for these samples.



Conclusions from Round 5 of Product Testing

Key Points

As with earlier rounds of CALiPER testing, the results from Round 5 are nuanced, with some positive performance results and visible progress but also some disappointing results for specific products or certain application categories.

The series of testing on downlights in an insulated recessed can provides solid points of comparison between SSL products and a number of other light sources. For operation in an

insulated recessed can, the product with the best overall luminaire efficacy was the SSL retrofit lamp. The value-brand A19 lamp provided the lowest output and worst overall luminaire efficacy. Two out of the three SSL products included in this series met or exceeded the levels of luminaire output and efficacy of the three fluorescent products (RCFL, spiral CFL, and cold cathode fluorescent) *in situ*. These three fluorescent products and two SSL products provided output levels similar to the incandescent R30 and HIR PAR38 tested *in situ*, while using less than one-quarter the energy—the SSL retrofit use one-fifth to one-sixth of the energy of the incandescent or halogen for similar output level. While the three SSL downlight products varied in performance, they all exhibited lower fixture losses than the spiral CFL, the RCFL, and the incandescent A-19 lamp, making their performance more competitive with these other light sources *in situ*.

The series of testing on 4-foot replacement lamps in troffers also allowed the examination of the benefits of directionality of SSL products. In this application, however, LED sources have to compete with highly efficient fluorescent lamps. The results for all four SSL 4-foot replacement tube products show that SSL is not yet able to compete in this application area: even when installed in troffers, the SSL replacement tubes did not provide half the output of fluorescent tubes in the same troffers and fail to achieve the luminaire efficacy levels of the fluorescents in the troffers. The better performing SSL replacement tube products or the 2-foot x 2-foot downlight panel tested might be appropriate to consider for specific applications where fluorescent is not suitable (e.g., cold or rugged environments or low output needs); otherwise SSL is not competitive in troffers as a replacement for fluorescent tubes at this time.

For MR16 replacement lamps, both products tested in Round 5 met or exceeded their ratings. Although they do not achieve the output levels of 20W halogen MR16 lamps, they matched the high end of the range of efficacies expected for halogens and exceeded the measured efficacy of benchmark halogen MR16s that have been CALiPER tested,. These products may be suitable for applications requiring lower light levels than provided by 20W halogens.

The two A-lamp replacement products tested in this round show significant promise. The efficacy and color quality is better than for similar products tested in earlier CALiPER rounds. Unfortunately these products have poor power factor results and exaggerated rated performance. The catastrophic failure of two out of 10 samples of one of these products should serve as a serious caution regarding product reliability. These failures underscore the importance of return policies and warranties for SSL luminaires and replacement lamps.

Desk lamps and undercabinet luminaires continued to provide mixed results. None of the four task lamps tested in this round of testing would pass ENERGY STAR® Program requirements for solid-state lighting. The desk lamps continue to have off-state power consumption which diminishes their effective efficacy to the level of halogen desk lamps. The undercabinet luminaires are close to meeting ENERGY STAR requirements and match the color quality and output and efficacy levels of some of the benchmark fluorescent undercabinet products.

The direct comparison between two identical outdoor spotlights, one using a halogen source and one using SSL, once again illustrated that mounting an LED source in an existing fixture does not appear to be an effective design option for SSL. In this case, as in earlier direct comparisons,

the resulting SSL product did not achieve the performance expected from LED technology and did not provide significant advantages over the halogen option.

The intermediate results from lumen depreciation testing serve as a reminder that the reliability of SSL products is still largely theoretical, and claims of consistent color maintenance in luminaires and 50,000-hour lifetimes (or more) are largely speculative at this point. Decisions which take into account the expected life of an SSL product should consider product guarantees, knowledge about which LED devices are used in a product, the credibility of the manufacturer of the LED devices used in the luminaire, and the credibility of a luminaire's manufacturer.

Next Steps for the Industry and CALiPER efforts

With the recent publication of IESNA LM-79 testing method for SSL and with the DOE ENERGY STAR for SSL coming into effect in the fall of 2008, CALiPER testing will continue at a fast pace. Along with basic photometric testing of SSL products, CALiPER has scheduled additional benchmarking, round-robin testing, and variability and repeatability testing in the coming months. CALiPER will continue to work closely with standards development efforts and testing laboratory experts to better understand the nuances of SSL testing.

DOE plans to create a guidance committee for the CALiPER program made up of utilities and energy efficiency program sponsor representatives to guide CALiPER program planning and growth. This committee will provide feedback on which products to test, how products are tested, and how results are analyzed and characterized. The goal is to increase the value of CALiPER to the public and to utilities and energy efficiency programs.[12] The CALiPER test reports and analysis have been well received by lighting manufacturers and have had a direct impact on industry awareness and discussion about testing and reporting practices.

[12] A DOE SSL Update e-mail was issued on May 13, 2008 introducing the DOE plans to create this guidance group. More information regarding the formation of this group will be posted on the DOE CALiPER program web pages (http://www.netl.doe.gov/ssl/comm_testing.htm) during the summer of 2008.

Appendix A

Testing Methods

The lighting testing laboratories were instructed to follow test procedures specified in the draft LM-79 standard (IESNA Guide for Electrical and Photometric Measurement of Solid-State Lighting Products) which covers '…SSL fixtures as well as SSL sources used in conventional light source fixtures (e.g., replacement of screw base incandescent lamps).'[13] This method tests the luminaire or replacement lamp as a whole — as opposed to traditional testing methods that separate lamp ratings and fixture efficiency or as opposed to testing LED devices or arrays without control electronics and heat sinks. There are two main reasons for this: 1) there is no industry standard test procedure for rating the luminous flux of LED devices or arrays; and 2) because LED performance is particularly temperature sensitive, luminaire design has a material impact on the performance of LEDs used in the luminaire. Similarly for replacement lamps, the integration of LED devices, heat sinks, drive electronics, and optics within an integral replacement lamp impacts the performance of the LED components within the lamp. For these reasons, luminaire efficacy (efficacy of the whole luminaire or integral replacement lamp) is the measure of interest for assessing energy efficiency of SSL products, as specified in LM-79.

Products sold as luminaires are tested using the entire luminaire. Products sold as replacement lamps are mounted for testing in standard lampholders corresponding to the format of the replacement lamp and the geometry of the measurement instrument used for a given test. Performance results for replacement lamps are thus for the bare lamp, to which appropriate fixture losses should be applied to determine the luminaire output for the replacement lamp installed in a given fixture.[14]

Selection of Products for CALiPER Testing

The general policy of the CALiPER program is to test units of products that are commercially available and have been purchased by the CALiPER program through distributors or other market mechanisms. In some cases, sample products are accepted for testing, either because there is no market for purchasing small quantities of a product or because other DOE SSL programs request CALiPER testing of fixture samples. Detailed CALiPER test reports always indicate whether a product tested was purchased or was a sample product. Detailed CALiPER test reports are issued only for those products that are considered to be commercialized (available or soon to be available for purchase on the open market).

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[13] The testing standard entitled "IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products," designated LM-79, is now published. This testing procedure was developed by the Subcommittee on Solid-State Lighting of the IESNA Testing Procedures Committee (http://www.iesna.org/about/committees/) in collaboration with the ANSI Solid State Lighting Committee. This method describes the procedures to be followed and precautions to be observed in performing reproducible measurements of total luminous flux, electrical power, luminous efficacy (lumens per watt), and chromaticity, of solid-state lighting (SSL) products under standard conditions. It covers LED-based SSL products with control electronics and heat sinks incorporated, that is, those devices that require only AC mains power or a DC voltage power supply to operate. It does not cover SSL products that require special external operating circuits or external heat sinks.

[14] De-rating factors for specific fixtures or fixture and lamp combinations are not specified, recommended, nor studied by the DOE at this time.

Appendix B

Downlight Series — Additional Results

After testing the bare lamps in an integrating sphere, the better performing unit of each pair of samples was mounted in a Juno IC22 insulated ceiling recessed can. The IC can was mounted in an insulated enclosure (19.75" x 19.75" x 14" high and filled with polyurethane insulating foam sealant), representing a UL1598 environment. The two retrofit products (one SSL and one CCFL) included their own white trim. The replacement lamps were mounted using a standard white baffle/trim kit, 28W-WH Airlock kit.

Figure B-1 below assembles iso-footcandle plots for nine of the downlight lamps mounted and tested in the recessed can in an insulated enclosure. Each plot is established based on a 5-foot mounting height and also indicates the footcandle value at the nadir. The beam patterns can be compared visually. The two PAR38 lamps (one SSL and one HIR) show a very tight beam with high intensity at the center. The long-life, value-brand A19 and R30 and SSL PAR30 lamps share somewhat tight beam patterns, while the SSL retrofit, the CCFL and the RCFL have the widest beam spreads. The two non-directional sources (the spiral CFL and the incandescent, long-life A19) show relatively low levels of illuminance, with only 3-4 fc at nadir.

Table B-1 summarizes the bare lamp measured performance and manufacturer published values for these lamps. The right-hand columns indicate the differences between manufacturer ratings and measured values for light output and efficacy of the replacement lamps. Two of the SSL products and the RCFL have manufacturer values that understate their performance. One SSL product, the CCFL product, the value-brand A19, and the HIR lamps all have manufacturers' claims that overstate the product's performance.

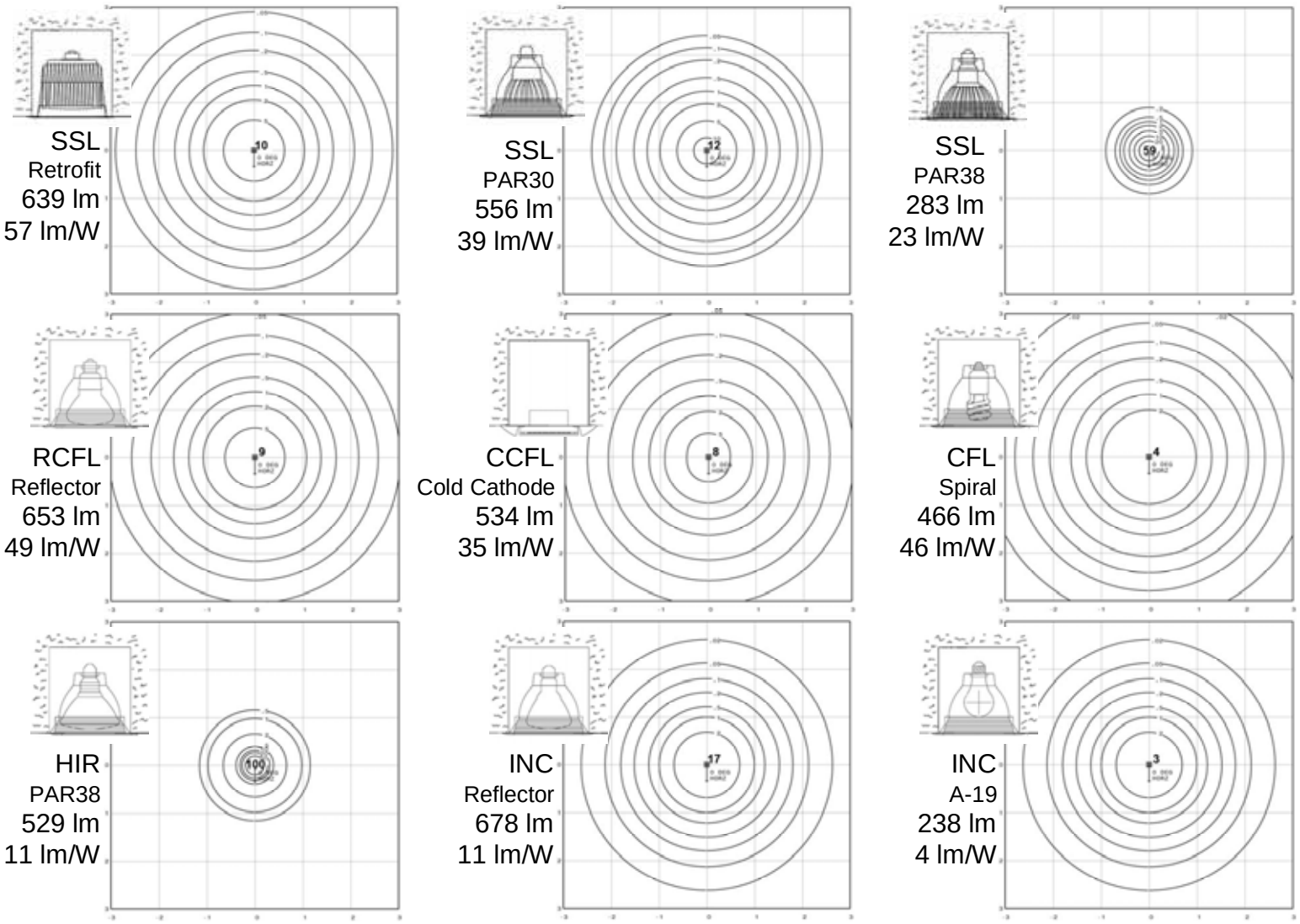


Figure B-1. Iso-footcandle Plots at 5' Mounting Height
(same scale, same insulated recessed can, different sources)

Table B-1. Performance of Bare Lamps for Downlight Series

Sample description	Sphere Measurements			Manufacturer Published Values				Difference of Measured Output or Efficacy vs. Manufacturer Rating	
	Power (W)	Output (lumens)	Efficacy (lm/W)	Rated Power (W)	Rated Lumens	Calculated Efficacy (lm/W)	Life (hours)	output	efficacy
SSL									
SSL downlight retrofit 12W, warm white	12	673	59	12	650	54	--	-4%	-10%
SSL Par30 18.6W, Cool white	15	627	42	18.6	500-675	27-36	50000	-7%	-33%
SSL Par38 21W, Warm white	13	323	24	21	560	27	--	42%	10%
Incandescent, Halogen, CFL									
R30 CFL 15W, name brand reflector CFL	16	841	53	15	750	50	8000	-12%	-6%
CCFL 18W, cold cathode retrofit	15	513	33	18	750	42	25000	32%	20%
Spiral CFL 13W, name brand spiral A-lamp	12	806	67	13	825	63	8000	2%	-6%
Par38 Halogen 50W, name brand HIR*	46	524	11	46/50	600/850	13/17	3000	13%--38%	13%--33%
R30 incandescent 65W, name brand EPACT R-lamp	65	732	11	65	755	12	2000	3%	3%
A19 incandescent 60W, soft white, major brand	61	739	12	60	780	13	2000	5%	7%
A-19 inc. 60W, long-life, frosted, value-brand lamp**	55	353	7	53	466	9	14100	24%	26%

Where numerical rated values are not published by manufacturers, rated values are estimated based on manufacturer performance claims.
Where ranges of rated values are available, the average of the range is used to calculate differences.
*The HIR PAR 38 lamp was ordered based on advertised ratings corresponding to a particular PC code, the product received had same description, but different PC. Manufacturer ratings for these two versions of the same product differ.
**The value-brand incandescent is a long-life lamp (rated at 5000 hours for 130VAC operation, 14100 hours for 120VAC operation). Testing is conducted at 120VAC, so table indicates ratings for 120VAC operation.

B-17

Bill Dundas, *Fiber Optics in the Sign Industry*, SIGNS OF THE TIMES (Mar. 1998)

Fiber Optics in the Sign Industry

Applications rise with the neon tide

By Bill Dundas (02-06-2006)

Invariably, new and alternative technology is perceived as a threat to established interests. Sometimes that threat is real, and traditional methods rapidly become obsolete. In the case of neon and fiber optics, however, it seems evident that what's good for the goose is equally good for the gander.

Although neon is clearly ascendant in the sign industry today, its unparalleled success has created new opportunities for fiber optics. Each technology involves a colored light source that can be molded to a variety of custom shapes and forms; this core concept has strong appeal to retail designers. Given the basic differences between neon and fiber optics, the vast market for malleable lighting obviously presents many instances where fiber optics represents a sensible and desirable alternative. In view of neon's unabated boom , fiber optics shouldn't be perceived as a threat, but as an enhancement to a vigorous sector of the industry.

Harrahs Las Vegas features a spectacular exterior facade, which incorporates fiber optic cove lighting and accents for the gold court jesters.

Applications

Both end-lit and side-lit fiber optic (FO) cables are utilized in signage and accent lighting applications. Smaller enclosed channel letters can be illuminated with end-lit cables installed through the letter backings. Large channel letters and plastic-faced signs are internally illuminated with side-lit cables arranged in rows like neon tubes. Side-lit cables can also be used in place of neon border tubing for cove lighting, or to accent building outlines. Bridges, towers and other structures can also be high-lighted with side-lit FO cables.

End-lit cables are also used in exposed applications to form letters, or to create star-field displays. Inwave Corp. (Eugene, OR) has developed a fiber optic matrix where individual end-lit FO cables are employed as pixels in a full-color display. The non-electrical nature of illuminated FO cable makes it suitable for many applications where neon may not be possible or desirable. The following are some examples:

• Signs and accent lighting for inaccessible or severe-weather locations (bridges, towers, piers, etc.).

• Signs and lighting located where accidental human contact is likely (to eliminate the hazards of electrical shocks or broken glass).

• Lighting and signage used under water or in connection with fountains and waterfalls (pools, public aquariums, waterparks).

• Accent lighting used to trim around signs, poles and awnings: In recent years, many sign companies have increased the use of neon to highlight the perimeters of plastic-faced signs. In these applications, neon-system faults can ignite the sign faces, or the tubing can be broken during maintenance.

• Inlaid applications for architectural signs, graphics and lighting: FO cable can be embedded in a variety of substrate surfaces, because the clearances and maintenance access required for neon do not apply. Examples include FO cables installed in pavements, railings, masonry walls, or stone, marble and granite surfaces.

• Automobile, truck, marine and aircraft markings: Because it's not affected by shocks, vibration or weather, FO cable is a sensible choice for all types of vehicles.

Franchised fiber

Recognition as a mainstream technology in the sign industry begins when nationwide corporations climb aboard your bandwagon. **Nexxus Lighting** (Orlando, FL) took a major stride in that direction as a result of the firm's relationship with Red Lobster Restaurants (Orlando, FL).

SuperVision's 5/8-in.-diameter side-lit FO cable was installed in the center of a white, metal U-channel extending around the entire perimeter of the Waterford, MI, location's exterior. According to Fritz Meyne, Jr., SuperVision's vice president of sales, "The advantage of fiber optics in a very cold environment like this is that colors other than red can be used without any dimming effect." Also, the fact that 100 ft. of FO cable can be run between illuminators gives the user a continuous line of lighting. Although some local codes don't permit it, the Waterford installation incorporates synchronized color changing.

Inside, Red Lobster's custom-made, hand-painted signs (manufactured by Nautical Furnishings, Ft. Lauderdale, FL) employ 3/8-in.-diameter side-lit FO cable for the illuminated lettering. The need to ship complete interior signs from the manufacturer to various restaurant locations made unbreakable FO cable an excellent choice for Red Lobster. Each sign consumes a maximum of 200 watts of electricity, and the FO illuminators are UL-rated as portable lamps, allowing them to be plugged into ordinary wall or ceiling receptacles. The new interior FO signs are being installed in Red Lobster's remodeled locations, as well as many new restaurants.

In another sign-related application, Lumenyte Intl. Corp. (Costa Mesa, CA) provided FO cable to illuminate portions of the ornate facade at Harrahs Las Vegas. The facade was designed by Henry Conversano and Assoc. (Oakland, CA), and the fiber-optic lighting scheme was designed by the Henry Elwyn Gee Group (Novato, CA). The indirect cove lighting at the top and bottom of the facade consists of Lumenyte's Linear Emitting Fiber (LEF), which is lighted with 60-watt Quiet Lightning™ xenon metal halide illuminators. The gold court jesters on the facade are accented with 19mm Lumenyte end-lit cables.

SuperVision furnished color-changing, 5/8 -in. side-lit fiber optic cable for the perimeter lighting of Waterford, MI's Red Lobster restaurant. Interior signs also incorporate fiber optics.

Fiber futures

Although neon retains bragging rights in terms of sheer lighting punch, fiber optics continues to improve in quality, while new applications are found that capitalize on its unique characteristics. The ultimate impact of fiber optics in the sign industry will obviously be significant. Equally clear is the fact that this future success won't necessarily come at the expense of a thriving neon trade. In contrast to some of the early hype, the current situation benefits the industry by expanding the options for sign specifiers and designers.

Source List

The following companies produce fiber optic cable for sign and related applications.

Atohaas Americas Inc.
100 Independence Mall W.
Philadelphia, PA 19106
(215) 592-3000
Fax: (215) 592-2445

Fiber Optic Systems Inc.
2 Railroad Ave.
Whitehouse Station, NJ 08889
(800) 809-3674
Fax: (908) 534-2272

Fiberstars, Inc.
2883 Bayview Dr.
Fremont, CA 94538
(800) 327-7877
Fax: (510) 490-3247

Inwave Corp.
750 Commercial St.
Eugene, OR 97402
(541) 343-1334
Fax: (541) 342-3806

Lumenyte Intl. Corp.
350 Lear Ave.
Costa Mesa, CA 92626
(714) 556-6655 Fax: (714) 556-9329
Internet: http://www.lumenyte.com

SuperVision Intl.
8210 Presidents Drive
Orlando, FL 32809
(407) 857-9900 Fax: (407) 857-0050
E-mail (sales): mailto:meyne@svision.com

B-18

Marcus Thielen, *Too Cold For Neon? How to Avoid Winter Dimming of Neon Signs* (2006)

Too Cold for Neon?

How to avoid winter dimming of neon signs

By Marcus Thielen (02-10-2006)

This month's topic is intended for those readers who live in parts of the United States and Canada, where winter months are damned cold.

When temperatures fall below freezing, outdoor neon signs can turn ugly. Argon/mercury-filled tubes dim in some (or all) parts; they may flicker or show delayed starting. On the other hand, red, neon-filled tubes usually remain unaffected. But what actually causes such dimming problems?

Considering a sign's environment and selecting the proper materials are a few ways to safeguard neon from severe, winter conditions. Photo credit: Neon World, by Dusty Sprengnagel.

Gas physics

Every type of matter has a condensation point (at a given pressure), where it changes from a gaseous state to either a liquid or solid state. For example, water vapor condensates at atmospheric pressure (1013 mbar) at 212° F (100° C) to liquid water.

A physicist defines a gas as "ideal" when it's far above the condensation point (higher temperatures and/or lower pressures), where it behaves according to simple pressure/volume/temperature relations. For convenient comparison between different gases, physicists use the so-called critical temperature, above which, a gas can't be condensed or liquefied.

Based on a neon tube's internal conditions (a few millibars of pressure and wall temperatures in the range of zero to 150° F), we can tell that the filling gases -- argon (Ar) and neon (Ne) -- can easily be considered ideal gases. The critical temperature of Ar is -188° F (-122° C) at a pressure of 49 bar; the critical temperature of Ne is -379° F (-228° C) at a pressure of 27 bar.

On the other hand, mercury has a critical temperature of 2642° F (1450° C) at a pressure of 1076 bar. (All data was taken from F. Kohlrausch's Tables to Practical Physics, 22nd edition, 1968.) Mercury has an extremely wide range of temperatures at which it can be in a gaseous state; its gas (or vapor) pressure is very temperature-dependent **(Fig. 1)**.

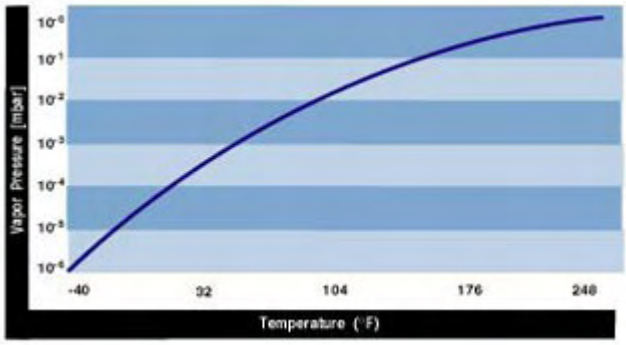


Fig. 1: As shown here, mercury's gas or vapor pressure is temperature-dependent.

In our tubes, the rare gas doesn't change pressure within the operating temperature range, but mercury vapor changes pressure over this temperature range by about a ratio of 1 to 10,000.

Theory tells us that a tube's lowest temperature point will determine the total vapor pressure of mercury in the whole tube -- which is true only in a state of equilibrium. But a neon tube will never reach equilibrium. Thus, local environmental conditions affect vapor pressure more than the overall lowest temperature point within the tube.

To understand the connection between temperature, vapor pressure and winter sign blues, we must consider the working principle of a mercury tube.

In an argon/mercury neon tube, the electrical current passing through the gas mainly ionizes the argon atoms, which pass the energy they gain during the ionization process onto the mercury atoms by collision, thus ionizing the mercury vapor. The ionized mercury vapor recombines and thereby emits light, mainly in the ultraviolet region of the spectrum, with a maximum at 254nm wavelength.

In addition to vapor pressure, the atomic-mass relation between argon and mercury plays a major role during the process of ionizing the mercury. For this reason, pure neon and krypton aren't used for backfilling mercury tubes.

Internal heating

Electrical energy not transformed into light by a neon tube is emitted primarily as heat. For heat dissipation, the tube's volume-to-surface ratio is quite important, as emphasized by the measurements on 12- and 26mm tubing in **Fig. 2**.

If the air around the tube is still, cooling takes place by convection, and there's not much difference between a 12- and 26mm tube. Experiments have shown that, when tubes are mounted vertically, their upper portions will be brighter due to rising, warm air. But when outdoor signs incorporate exposed neon, the tubes are subject to wind chill.

The red lines in **Fig. 2** show that, with wind chill, the bigger tube diameter will emit more light at low temperatures because the volume-to-surface ratio is higher. Consequently, in cold environments, it's best to install argon/mercury tubes covered to prevent additional cooling by the wind.

Increasing the electrical power input also reduces the drop in mercury vapor pressure. Using a 60mA transformer, instead of a 30mA device (correct electrode size presumed), almost doubles the amount of heat and light generated, and warms the tube in a cold environment.

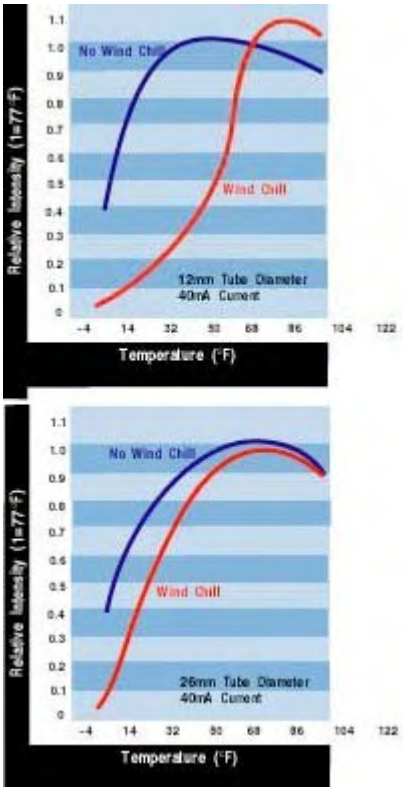


Fig. 2: These diagrams explain the temperature dependence of relative light output for 12- and 26mm tubes at 40mA (the red lines represent output results with wind chill).

The "cold weather" gases

Increasing the electrical-power input to a sign by using high-current transformers isn't the only way to reduce the drop in mercury vapor pressure. As light output of a tube mainly depends on the current passing through, increasing the tube's operating voltage will elevate power consumption (which is equal to current times voltage), thus increasing the internal heating of the tube.

The correct way to raise the operating voltage is to use another backfilling gas, while keeping in mind the facts (discussed earlier in this article) about ionization. In other words, don't use pure argon -- use a combination of gases.

The electrical-lamp industry has long used different gas mixes for various mercury-discharge-lamp purposes. Increasing the operating voltage of the tube is accomplished by increasing the resistance of the positive column. In general, only other inert gases are added to argon, even if some marketers have touted the use of "secret ingredients."

The rare gases show an increase in their resistance from xenon (lowest) over krypton, argon itself or neon to helium (highest).

Helium generates the most heat of all inert gases in a gas discharge, and, therefore, is recommended for flushing in the bombarding procedure. But keep in mind that simply using pure helium as backfill gas doesn't provide desired results.

Because the helium atom is too lightweight, it can't transfer the energy and momentum gained during ionization to the heavy mercury atom. For example, mercury tubes backfilled with pure neon would appear completely red in cold weather. Thus, a small amount of argon is always required to transfer the energy and ionize the mercury.

In history, several gas mixes have been used, depending on their application **(Table 1)**. But even No20 doesn't provide enough heat for exposed signs in extremely cold locations. Rarely available, but useful for such applications, is the "Alaska mix," which incorporates 12% to 20% He, 30% Ar and 50% to 68% Ne. This mixture provides enough resistance to operate mercury tubes in winter-like, Yukon territories.

Table 1: Typical cold-weather mixes and their composition:

Tradename	**Composition**
Pure argon	100% Ar
No50/B10	80% Ar, 20% Ne
K4 or H-Gas	25% Ar, 75% Ne
B17	20% Ar, 80% Ne
No20	20% Ar, 78% Ne, 2% He

Sad but true, every gain has its cost. When the resistance of the neon tube is increased to obtain more heat, the electrical power input of the tubes rises. To be precise, the ignition and operating voltage rises. Therefore, transformer loading must be corrected accordingly, even though, in most loading tables supplied by transformer manufacturers today, the readings for "blue tubes" imply a backfilling gas ranging from argon to K4/H-gas.

For such gases as B17 and No20, the loading tables for red tubes (due to their high neon content) should be used. When using the "Alaska mix," it's best to multiply the real tube length by 0.8 and then reference the "red-tubes" tables.

The best approach is to always check every transformer with every set of tubes. If you don't have a high-voltage voltmeter handy, you can use an mA meter and a variac (key term here is "flicker test," which is performed by connecting a variac to the transformer's primary, and slowly reducing the input voltage until the tubing begins to flicker) for proper loading.

Keep in mind that, when you switch on a cold mercury tube in winter, the tube's ignition voltage can be as much as 20% higher than in summer because almost no mercury vapor is present first, and the discharge parameters are determined by the pure backfilling gas. Thus, during a shop loading test, it's best to count in a 10% to 15% reserve in the transformer's output voltage than actually needed. Otherwise, signs could flicker or not illuminate at all on the next cold night.

Temperature-independent brightness?

Much effort has been made to eliminate mercury completely from neon tubing. However, for the most part, such attempts have proven futile because mercury vapor converts electricity to ultraviolet light with the highest efficiency.

In cases where a sign should be visible, yet not illuminate its entire surroundings, the use of pure xenon, rather than argon/mercury, is an option. Pure xenon behaves like an ideal gas, and thus, shows no changes in low-temperature environments.

Xenon, which has a high-ignition voltage but low resistance (low-operating voltage, and therefore, low power consumption), emits light in the far ultraviolet wavelength range, like mercury vapor. As a result, xenon will also excite fluorescent powders. But the resulting color of coated tubes filled with xenon is a little different than the color of tubes filled with argon/mercury because, in the visible range, xenon emits a dark, lavender light, as opposed to argon/mercury, which emits a bright, blue light. The visible light of the gas discharge will mix with the light from the fluorescent powder to create the final color, thus, the difference.

When working with xenon, use smaller diameter tubes and 40mA to 50mA transformers with electrodes designed for 60mA to 80mA. Further, backfill with a lower-pressure than you would fill pure argon gas.

While xenon eliminates environmental and winter dimming problems, it has also been discovered that most phosphors don't display staining, or they don't experience, over time, light-output reduction (a common problem of mercury tubes). Overall, xenon's advantages offset its high costs in those applications where high light output is not the prime task.

We can conclude that most dimming problems encountered during the winter months arise due to improper material selection and failure to consider a sign's operating environment.

If you're thinking about the additional expenses you may incur from preventing the winter sign blues, think again. If you don't think right now, the next winters will come for sure -- first for your signs, then for your business.

Attachment C

Sample Neon Color Chart

The tubing colors shown are a partial representation of EGi colors available. Color accuracy is subject to the limitations of four color process printing.
Please contact EGL for a color selector guide and/or samples for accurate color matches. *Denotes Accuvail® color. See our color chart on the web at www.eglneon.com/chart1.htm

Attachment D

Route 66 Neon Restoration

2003 Route 66 Neon Restoration Gallery

Tonight there are nine new reasons to rediscover Route 66 in New Mexico. In 2003, nine vintage Route 66 neon signs have been restored to their former brilliance. From the wonderful TeePee Curio Shop sign in Tucumcari, to the wild and crazy neon Rotosphere in Moriarty, to the elegant Lexington Hotel sign in Gallup, the beauty and artistry of classic neon is once again dazzling and delighting Route 66 enthusiasts.

Vintage Photo of Albuquerque Neon

There was a time when Mercury Meteors, Olds Rocket 88s, and the Pontiac Star Chiefs would trek through a galaxy of neon on Route 66. The streets with illuminated with a palette of ruby reds, sapphire blues, and emerald greens that broadcast promises of adventure, discovery, and gratification. Neon cowboys, Indians, sombreros, teepees, cactus, longhorn steers, thunderbirds, swallows, wiener dogs, ponies, and other critters and characters would come out at night to greet visitors. Places with neon lit names like the Bow and Arrow, the Royal Palacio, the Pig Stand, the Lariat, the Oasis, the Arrowhead, the Desert Sun, and the Trails West called out with invitations to stop and experience something unique.

Visualizing a Neon Restoration Project

Elmo Baca, the former New Mexico State Historic Preservation Officer, must have recalled the neon galaxy that was far-far-away in his memory and envisioned a project to rekindle appreciation of vintage neon and its importance to Route 66. In 1999, the Route 66 Corridor Preservation Act was passed by the U.S. Congress and money was designated for Route 66 preservation. The National Park Service was charged with administering the project and a Route 66 Corridor Preservation Office was established. led by Michael Romero Taylor. When the first request for proposals for Route 66 preservation projects was issued, Elmo came forward with his bold idea to restore neon signs. The project was funded and after a competitive bidding process, the New Mexico Route 66 Association was selected to execute the project.

Johnnie V, the New Mexico Route 66 Association President, volunteered to lead the project. In order to bring guidance, wisdom, and experience to the project, an all-star panel was assembled. The panel members were Dr. David Kammer, Don Usner, Steve Fitch, and Michael Wallis. David is a well-known historian in New Mexico who appeared in the PBS special Route 66 in New Mexico and has published studies of historic properties on Route 66. Steve Fitch is an accomplished neon tube bender, contributor to the book Vintage Neon, and author of several books including Diesels and Dinosaurs, a photoessay on roadside culture. Don Usner is a published author whose most recent work is New Mexico Route 66 on Tour – The Legendary Architecture from Glenrio to Gallup. Michael Wallis is the Pulitzer Prize nominated author, speaker, and champion for Route 66 and roadside culture. The panel was empowered to draw up evaluation criteria and select the projects for restoration.

At the conclusion of the process, the Association had 16 applications for restoration projects. At first, business owners were skeptical that there could be a government program that was intended to directly help mom & pop business owners. But after one-on-one discussions, it was accepted; the little guy had a chance!

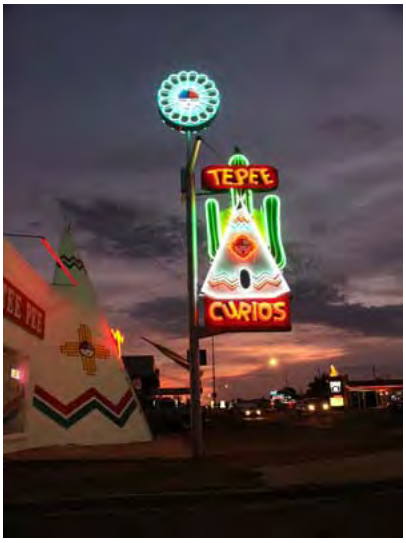
Through a combination of business owner in-kind contributions, third party donations, donation of the project management fee by the Association, and contractor negotiations, nine signs were chosen for restoration with contracts awarded to five neon contractors.

After meeting all the participants in the project, it was realized that the project was worthy of a film documentary. The Association presented the opportunity to film the project.to Michael Kamins, the Producer of the Rocky Mountain Emmy award-winning documentary “Route 66 in New Mexico.” Michael

agreed to a partnership to produce a 26-minute documentary that will air on the local PBS show Colores. The film will be offered for national syndication and is scheduled to be the first quarter of 2004.

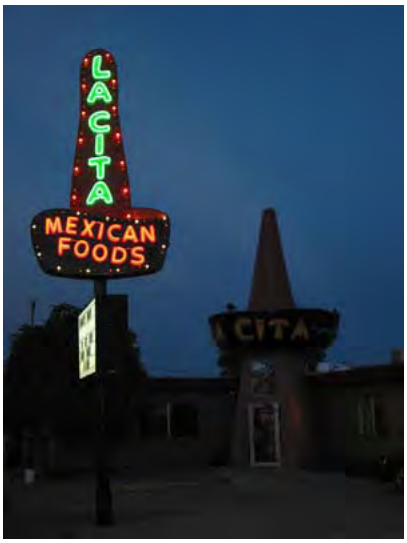
Tucumcari Tonite!

Tucumcari has always had an outstanding array of vintage neon highlighted by the Blue Swallow Motel. But now, it's even better with three new restorations.



The TeePee Curio Shop sign, an elaborate neon TeePee, has been restored based on vintage photographs and inspection of the sign. Mike Callens, the owner, did the preparation work. Mike erected scaffolding on the back of his pickup truck and spent several weeks painstakingly removing dead paint, applying primer, and painting details with great care and skill. The detail included individually painted cactus needles on the cactus arms. The neon restoration was completed by Clovis Sign Company. The location of the TeePee is within line-of-sight of the Blue Swallow Motel and the close proximity of these two properties creates an impressive streetscape.

Heading west to the busiest intersection in town, you'll find the restored La Cita restaurant sign in front of the famous sombrero capped building. The restoration of the La Cita Restaurant was based on a vintage postcard. The restoration, including the motorized rotation of the sign and the rebuilding of the peripheral "chaser" lights, was performed by Clovis Sign Company.



At the far west end of town is the restored Paradise Motel sign, which presented the biggest surprise in the project. The unrestored sign included a lower section depicting portrait images of Tocom and Kari, characters from a tale of a tragic Indian couple from whom Tucumcari is said to have received its name. The project was bid as a restoration based on its existing Tocom-Kari features. However, subsequent research yielded an early photo on file at LaDeane Studios in Tucumcari.

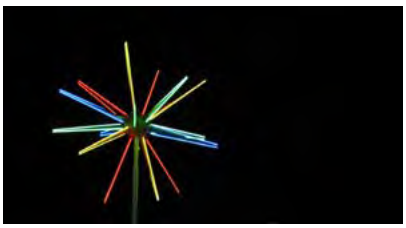
The older photo revealed a very different sign that included a wonderful diving bathing beauty diving into a pool splash. After consulting with the Historic Preservation Division, it was decided that the restoration should include the original motif. At the same time, the creative use of the pool splash as a headdress for the Indian images and the quality of the images could be appreciated as folk art.

Therefore, the decision was made to allocate funding that would provide for the original restoration and also preserve the images of Tocom and Kari. The original "can" that included the two images was removed and installed on a pedestal in the vicinity of the sign while a new replica can consistent with the restoration was constructed. A remaining obstacle was the fact that the old sign displayed "POOL" in neon, yet the pool had been filled in and was no longer usable. It was decided to replace the word "POOL" with the word "OPEN" since the neon insulators supported four letters. In addition, it can be noted that both "POOL" and "OPEN" share two letters, "O" and "P." Close enough!

The restoration contract was modified to include the fabrication of the diving bathing beauty on a scale indicated by the old photo. The finished restoration is an accomplishment where the cooperation of Clovis Sign Company was instrumental to the success.

Sun N Sand in Santa Rosa

The Sun-N-Sand sign stands tall in the middle of Santa Rosa. A vintage postcard of the Sun-N-Sand was located and provided a reference for the restoration. The sign features the Zia sun symbol with its characteristic round center with “sun rays” extending at the edges. Southwest Outdoor Electric of Albuquerque rebuilt the sign with neon work by A Brighter Image Neon of Albuquerque. Mike Minnear of Albuquerque was subcontracted to refurbish and repaint the sheet metal. Mike specializes in sign restoration and proudly says, “Check my business card, it’s the only one you’ll see in New Mexico that says ‘sign restoration.’” Mike’s attention to detail and extraordinary craftsmanship was admired by all that observed his work. Sitting in the Sun-N-Sand restaurant and enjoying the award winning cherry dump cake while admiring the classic Sun-N-Sand neon motel sign, that is a Route 66 experience.

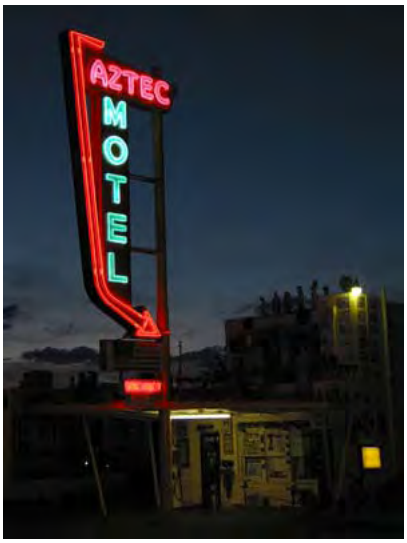


Moriarty’s UFO

Over at the El Comedor restaurant in Moriarty is where the project got wild and crazy with the restoration of Rube Goldberg type device called a rotosphere. When folks first encounter the rotosphere, it is hard not to say, “What in tarnation is that?” The rotosphere consists of two vertically

counter-rotating spiked hemispheres with the entire unit rotating horizontally above a pole. The drive mechanism is an electric motor driven Ford Model A differential. The rotosphere was overhauled and refurbished by Soutwest Outdoor Electric of Albuquerque. The 8-foot long rainbow-colored spikes are individually outlined in neon by A Brighter Image Neon of Albuquerque. To see it in person is to witness an 18 foot diameter kaleidoscopic UFO. The El Comedor rotosphere is believed to be the only operational rotosphere along the length of Route 66. Bring a lawn chair and enjoy but be careful, you may get mesmerized.

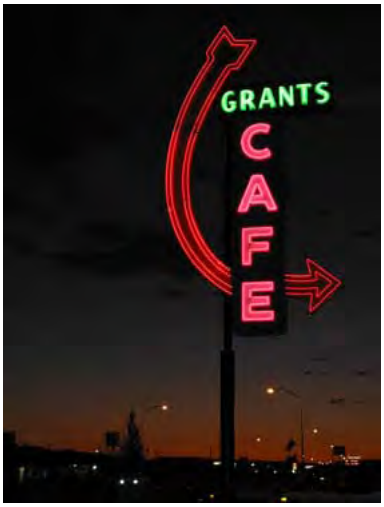
Neon Cactus and the Aztec Arrow in Albuquerque.



In Albuquerque, two classic motel signs were restored, the Aztec Motel and the Westward Ho Motel. Everybody loves the funky Aztec Motel with its amazing array of geegaws that have been attached like barnacles to the building. The Motel was built in 1931 and is on the National Register of Historic Places. The Aztec Motel sign is distinguished by the fact that the sign faces are colored porcelain enamel rather than painted steel. The porcelain was in fine condition with rich original colors enabling a relatively inexpensive restoration. Zeon Sign Company of Albuquerque originally designed and installed the sign and was the restoration contractor. The sweeping arrow on the Aztec sign flashes on and off in synchronization with the heartbeat of the old Route.

The Westward Ho Motel, built in 1948, is located on West Central in Albuquerque boasts a sign representing a saguaro cactus. The postcard image of the sign showed darker colors than the existing sign however the colors on the card appeared saturated and not realistic. The postcard appeared to show the neon cactus extending up into the face of the sign and intercepting the “MOTEL” letters and partially covering the neon “vacancy” wording. This appeared to be a liability in terms of readability and the apparently extended cactus neon was not restored to cover the face of the sign.

The sign was in good condition with the “MOTEL” neon operational. The owners of the Westward Ho refinished and repainted the sign. The neon glasswork and electrical work was performed by Brite-Lite Neon of Albuquerque. What would Route 66 be without a neon cactus?



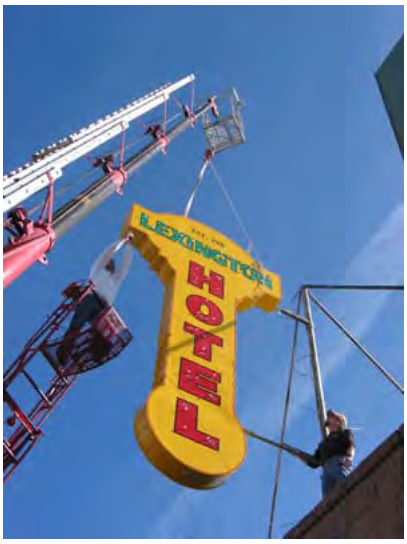
Extreme Restoration in Grants

The Grants Café sign represents an extreme in restoration challenges. The sign was blown down from its signpost several years ago as a result of gusty winds and was abandoned in a field several miles from its original location

The Association located three very different vintage images. Which configuration should we restore? The folks at the Historic Preservation Division advised that we should apply the “period of most significance” test. The 1950s configuration was chosen since it represented the version that existed while the Route 66 was a commissioned highway. The contractor for the sign restoration was SignArts of Albuquerque. SignArts determined that a competitor, Zeon Signs, had originally installed the sign and contacted Zeon to determine if old drawings and patterns existed. Zeon, a member of the restoration team as contractor on the Aztec Motel sign, was able to locate the

[redacted] original patterns as well as the original Work Order from 1958. The work order specifies the original neon colors and configuration. The restored sign is certainly a commanding and impressive sight on the Historic Route in a town without many other signature signs.

Elegance in Gallup



The Lexington Hotel Sign is a roof-mounted sign located in the downtown area on Route 66 in Gallup. Although historical sources were consulted, no vintage photos of this sign were located. However, the sign finish and much of the original tubing remained to allow a faithful restoration. The restoration was performed as an in-shop job by Hinkley Signs of Gallup. The presence of peeling paint indicated that a complete stripping was required in order to apply a primer basecoat that would prevent future peeling. Restoration consisted of stripping, rewiring, reprimering, and repainting with a sprayed acrylic automotive style paint. The sign profile is sculptural and evocative of styles of the 1930s. The prominent location of this sign adds to the historic character of the building and adds jazz to the downtown streetscape.

Follow-up Project

During the application process for the neon sign project, a number of applications were received requesting assistance to restore architectural/ornamental neon. An example of this type of neon is the neon tubes used to line motel roof eaves. A review of vintage postcards revealed that architectural neon was integral to many historic Route 66 properties. However, the existing project did not provide for the restoration of architectural neon. Subsequently, a grant application was submitted by the New Mexico Route 66 Association that was funded for the year 2003 by the National Park Service Route 66 Corridor Preservation Office. It is expected that the restored architectural neon will further enhance the nighttime streetscapes in New Mexico's Route 66 communities.

The Pride is Back

The restoration of these classic Route 66 signs has resulted in renewed pride in ownership among business owners whose signs have been restored. In addition, the restoration of prominent classic neon signs has renewed community pride. Sign companies who practice neon signmaking have a renewed pride in their contribution to the cultural and historical value of Route 66.

Parallel with the neon restoration project, the New Mexico Heritage Preservation Alliance has published two documents with funding from the Route 66 Corridor Preservation Office. The first is a brochure titled, "Saving New Mexico's Route 66 Historic Signs" along with a "Model Sign Ordinance" that encourages preservation of historic signs and the use of new artistic neon signs that enhance streetscapes. Call the Alliance at 505-989-7745 for information.

Although photos communicate the beauty of classic neon signs, the signs really can't be fully appreciated except in person. These signs come alive at night, flashing, spinning, rotating and whirling. It has the feeling of a close encounter of the third kind. You are out there at night, brightly colored lights flash in the sky, and you hear the buzz of the high voltage transformers. A galaxy of neon awaits you, see for yourself!

See our Newest Restoration - The El Rey Theater

Back to Home Page

Attachment E

Light Transmission and Reflectance

T E C H N I C A L D A T A

Acrylite® GP ACRYLIC SHEET

Acrylite® FF ACRYLIC SHEET

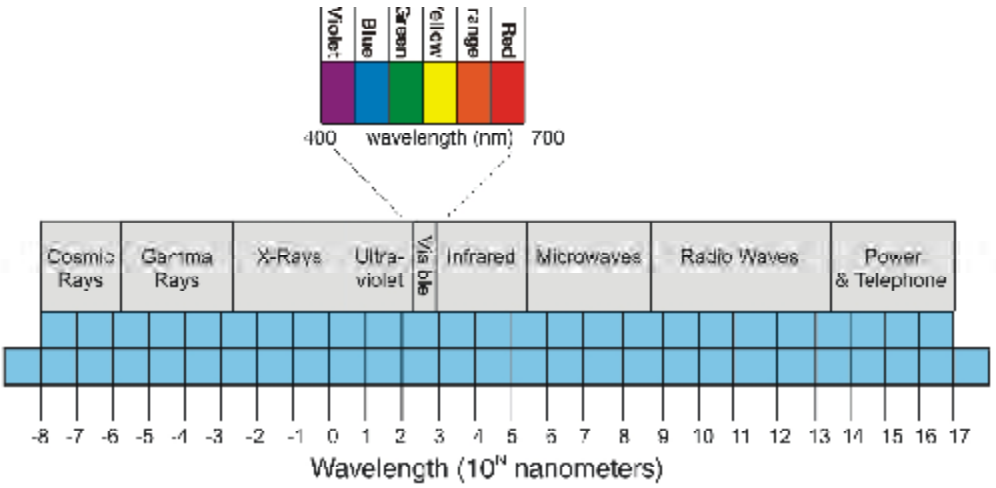
CYRO Industries
279 Interpace Parkway
Parsippany, NJ 07054
www.cyro.com

Light Transmission and Reflectance

Light and Radiation

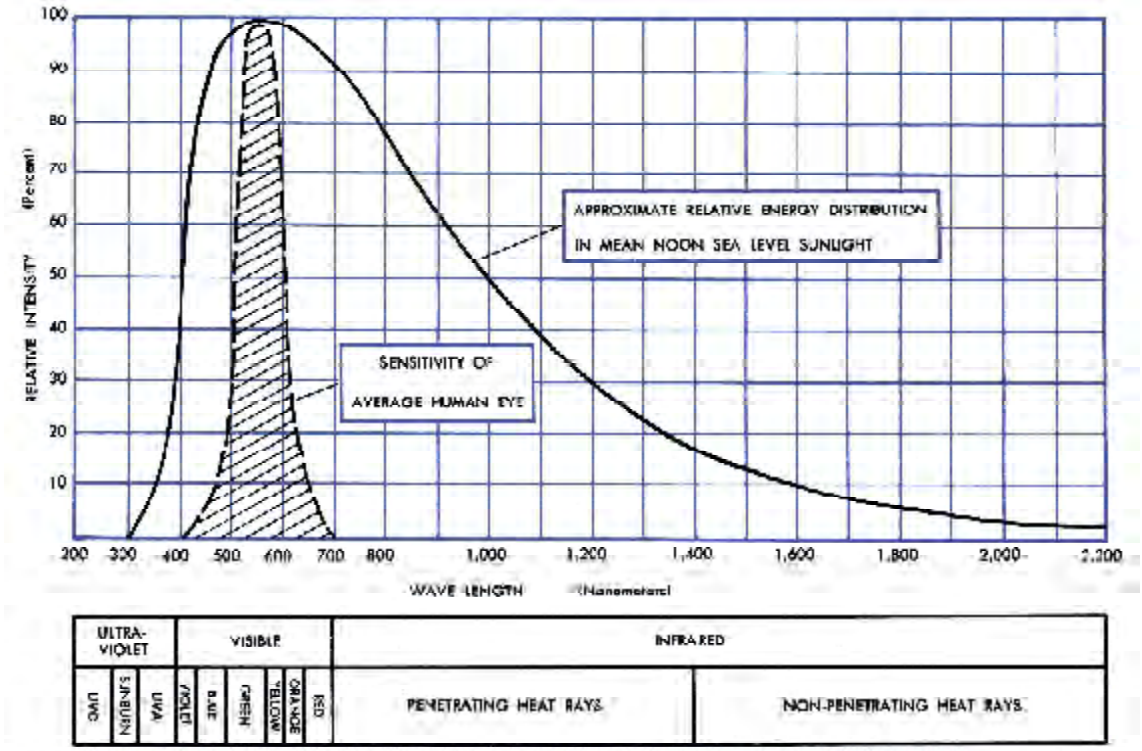
Light or electromagnetic radiation can be divided into several bands or categories each defined by a specific wavelength range. Visible light is the most common type of electromagnetic radiation. Examples of other types of electromagnetic radiation are ultraviolet light, x-rays, radio waves and infrared light (Figure 1).

Figure 1: Electromagnetic Spectrum



Solar radiation is the naturally occurring radiation that reaches the earth's surface. It includes visible light as well as ultraviolet and infrared light (Graph 1). The visible band of the electromagnetic spectrum, which is the only range that can be detected by the human eye, falls between 400 and 700 nanometers. Energy in the visible band is sensed as "light" due to the sensitivity of the human retina, which acts as a detector for energy at this wavelength. On either side of the visible light band are ranges of similar electromagnetic radiation undetectable by the human eye.

Graph 1: Relative Distribution of Solar Energy



The primary wavelengths of interest are those that fall between 200 and 2200 nanometers (nm). This section of the electromagnetic spectrum can be divided into three components:

1. **Ultraviolet (UV) band, 200 – 400 nm**
2. **Visible Spectrum, 400 – 700 nm**
3. **Near Infrared Band, 700 – 2200 nm**

Nanometers (nm) are commonly used for measuring wavelengths in the three bands listed above. One nanometer equals one billionth (1×10^{-9}) of a meter.

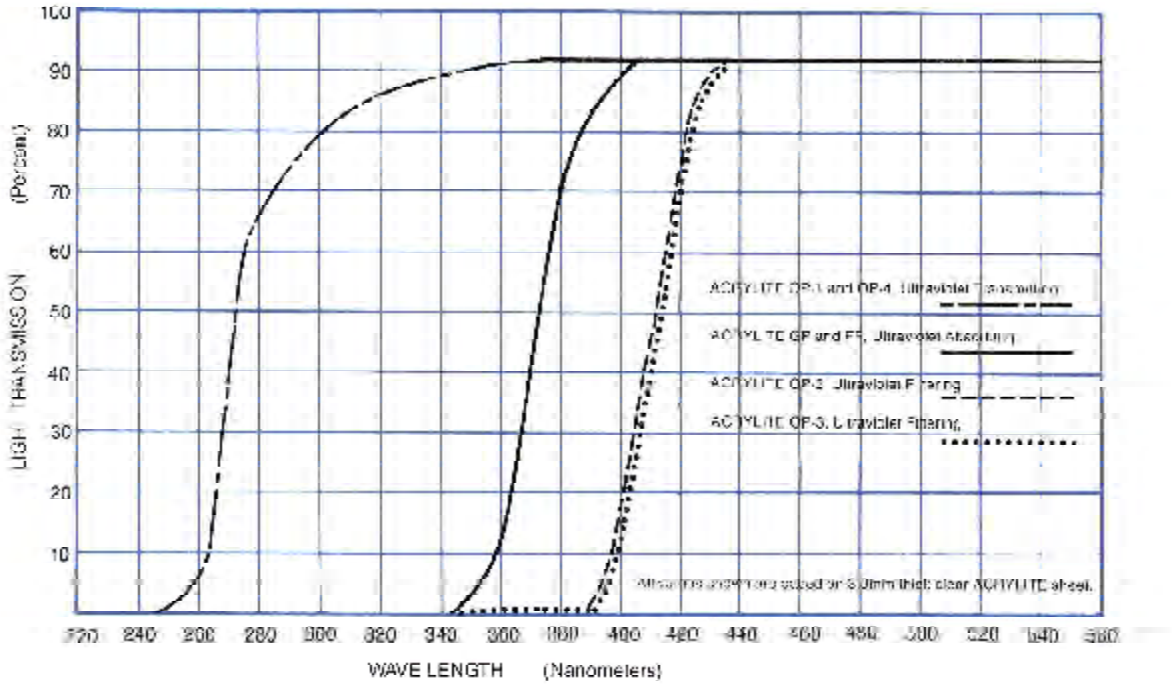
The intensity of the solar radiation that penetrates the atmosphere and reaches the earth varies considerably, depending on the altitude, ozone levels, concentration of water vapor, carbon monoxide, dust and other types of contamination. The approximate relative distribution of solar energy (mean noon sea level sunlight) from 200 to 2200 nm is represented in Graph 1. The ultraviolet band accounts for approximately 3% of the total solar energy, whereas the visible band accounts for 45% and the infrared band accounts for 52%.

X-ray Transmission

X-rays and gamma rays are characterized by wavelengths shorter than those in the ultraviolet spectrum, thus they are not included in Graph 1. Colorless ACRYLITE® GP and ACRYLITE® FF acrylic sheet do not shield x-rays or gamma rays very effectively. They shield approximately 1/100 to 1/400 as much as lead of the same thickness. The transmission characteristics are like those of flesh; therefore these materials can be used in medical as well as industrial applications where x-ray transmission is required.

Ultraviolet Radiation

Graph 2: UV Light Transmission of Colorless ACRYLITE GP, ACRYLITE FF, ACRYLITE OP-1, ACRYLITE OP-2, ACRYLITE OP-3 and ACRYLITE OP-4 sheet *(Approximation only – not a specification).*



Although ultraviolet (UV) radiation amounts to only 3% of the total radiation that reaches the earth, it is energetic enough to cause chemical reactions, weathering of polymers, fading of certain dyes and even eye damage.

The UV spectrum is commonly divided into three ranges:

1. **UV-C, 200 – 290 nm**
2. **UV-B, 290 – 315 nm**
3. **UV-A, 315 – 400 nm**

Wavelengths in the UV-A range are responsible for tanning and pigmentation of the human skin. Wavelengths in the UV-B range cause the most photochemical degradation in plastics as well as sunburn. UV-C radiation is absorbed in the ozone layer and never reaches the earth's surface.

Colorless ACRYLITE GP (cell cast) and ACRYLITE FF (continuously manufactured) sheet have very small amounts of light transmission below 345 nanometers. In the range from 345 to 395 nanometers, the light transmission varies with sheet thickness. Between 395 and 1000 nanometers, all thicknesses transmit 92%. Smooth, colorless ACRYLITE GP and ACRYLITE FF sheet are warranted for ten (10) years to not undergo a change in light transmission exceeding 3%.

ACRYLITE® OP-1 (ultraviolet transmitting) acrylic sheet transmits much of the radiation in the range from 260 - 370 nanometers. Above 370 nanometers, it has light transmission properties similar to colorless ACRYLITE GP and ACRYLITE FF sheet. ACRYLITE OP-1 sheet is typically used in scientific and instrument applications where maximum UV light transmission is required. Because this product contains no stabilizers, it will degrade under intense and prolonged UV light exposure. Therefore, it is not suitable for use in sun tanning beds.

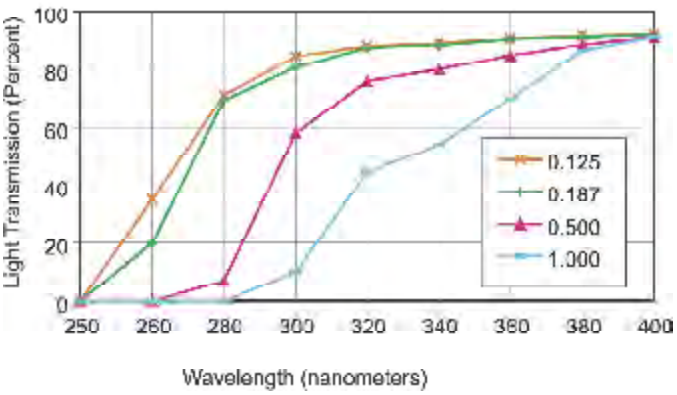
ACRYLITE® OP-2 (ultraviolet filtering) acrylic sheet is a cell cast sheet product that absorbs approximately 98% of the incident UV light. It is used in museums to protect historical documents and artifacts from the harmful effects of ultraviolet rays.

ACRYLITE® OP-3 (ultraviolet filtering) acrylic sheet is a continuously manufactured sheet product that absorbs approximately 98% of the incident UV light. It is used in picture frames and shadow boxes to protect photos, posters and other valuables from damaging ultraviolet rays.

ACRYLITE® OP-4 (ultraviolet transmitting) acrylic sheet is a cell cast sheet designed for use in sun tanning beds. It transmits much of the radiation in the range from 260 – 370 nanometers. Above 370 nanometers, it has light transmission properties similar to colorless ACRYLITE GP and ACRYLITE FF sheet. It is specifically formulated to resist the degradation caused by continuous exposure to the high-intensity ultraviolet radiation from tanning bed bulbs.

The light transmission of ACRYLITE OP-1 and ACRYLITE OP-4 sheet will vary with thickness in the range from 260 – 370 nanometers. This is shown on the following page in Graph 3.

Graph 3: Light Transmission vs. Thickness of ACRYLITE OP-1 and ACRYLITE OP-4 Sheet *(Approximation only – not a specification).*



Visible Light

The visible light band ranges from 400 – 700 nanometers. Within this band, colors occur in the sequence observed in the rainbow, ranging from violet, to blue, green, yellow, orange and red. Each wavelength in the visible light band causes a particular sensation of color. As shown in Graph 1, solar radiation is most intense in the visible light band. This band is also the area where the human eye is most sensitive to radiation. However, the eye is not equally sensitive to light emitted at all wavelengths; it is most sensitive to the light in the yellow and green areas of the spectrum.When a light beam strikes material, some light is transmitted, some reflected and the rest is absorbed. Light transmission depends on the reflectance at both surfaces of the material and the absorption of light into the material. Colorless ACRYLITE® acrylic sheet typically absorbs less than 0.5% of visible light per inch of thickness. However, some light is reflected at both surfaces. A beam of light striking a smooth ACRYLITE sheet perpendicular to the surface (at 0° angle of incidence) will lose approximately 4% of its light at each surface due to reflection, resulting in a total loss of 8%. Therefore, the overall light transmission will be approximately 92%. If light rays strike the sheet at angles greater than 30° from the vertical, the surface reflectance will be greater than 4% and the overall transmission will be smaller. For example, when light falls on colorless ACRYLITE GP or ACRYLITE FF sheet from all angles, as from a sky of uniform brightness, the transmission factor will be approximately 85%.

Colors

Acrylic sheet can be formulated in thousands of different colors and shades. This is because colorless acrylic sheet transmits visible light uniformly throughout the entire visible light spectrum. Therefore, its transmission characteristics can be predictably modified using dyes and pigments to create a variety of colored sheet. The addition of fillers and the application of surface textures or patterns are also used to vary the light transmission and reflection properties of the sheet. Ultimately, the color of the sheet results from the combination of transmitted and reflected light that the human eye receives from the sheet. Since the ratio of transmitted to reflected light and the nature of the light source can vary based on application parameters, the perceived color of a sheet can also vary with these parameters. Therefore, it is very important to evaluate colors under the intended end use conditions. To assist in color selection, light transmission and reflectance measurements can be used but actual evaluation in the end use is always recommended to ensure the expected results.

Light Transmission of White Translucent ACRYLITE GP and ACRYLITE FF Sheet

White translucent ACRYLITE GP and ACRYLITE FF sheet are available in different densities to provide a variety of options for light transmission, diffusion, lamp hiding power and surface brightness. For lighting applications, a formulation offering maximum diffusion combined with high light transmission is usually desirable.

The color transmission of each white ACRYLITE GP or ACRYLITE FF sheet will vary with the type and concentration of the pigment in the sheet. In addition, the light transmission of almost every translucent white color will decrease with an increase in thickness. (See Tables A and B and Graph 4.) This is due to the fact that the pigment concentration for most of the translucent white colors is not changed for different thicknesses. Although the pigment concentration remains constant, the amount of pigment absorbing the light that passes through the sheet will increase with the sheet thickness. For instance, when light passes through a 1/4” thick sheet it will pass through twice as much pigment as when it passes through an 1/8” thick sheet. Therefore, the 1/4” thick sheet transmits less light than the 1/8” inch thick sheet.

Table A: Light Transmission of White Translucent ACRYLITE GP Sheet

	Thickness		
Color Number	**3 mm (.118)**	**4.5 mm (.177)**	**6 mm (2.36)**
051-6	67%	54%	44%
020-4	51%	41%	32%
054-3	41%	32%	25%
049-3 *	40%	40%	40%
015-2	30%	22%	16%
048-2	21%	15%	11%

Above values are based on ASTM Test E-308, using CIE Illuminant C.

** The transmission of 049-3 is the same for all thicknesses.*

Graph 4: Light Transmission - White Translucent ACRYLITE GP and ACRYLITE FF Sheet

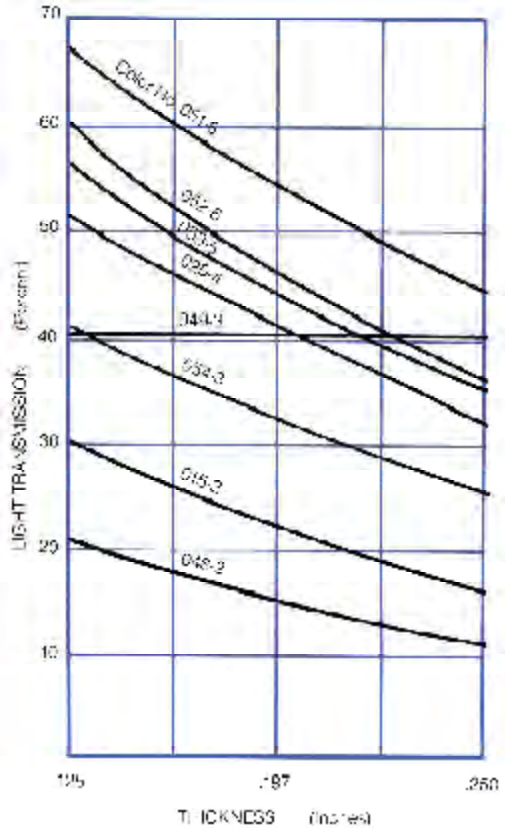


Table B: Light Transmission of White Translucent ACRYLITE FF Sheet

	Thickness		
Color Number	**3 mm (.118)**	**4.5 mm (.177)**	**6 mm (2.36)**
020-4	54%	43%	35%
015-2	31%	23%	18%

Above values are based on ASTM Test E-308, using CIE illuminant C.

Light Reflectance of White ACRYLITE GP and ACRYLITE FF Sheet

Light reflectance is also important in sign applications. Reflectance data is shown in Table C and D. When ACRYLITE GP or ACRYLITE FF sheet is used for a non-backlit sign panel, a nearly opaque white such as ACRYLITE GP sheet color 048-2 or ACRYLITE FF sheet color 015-2 having a reflectance value of 93% or 91% respectively, will provide good contrast for painted or fabricated letters that may appear on the sign.

Table C: Light Reflectance of White ACRYLITE GP Sheet

	Percent Reflected for 3 mm (.118")	
Color Number	**BLACK Back-up**	**WHITE Back-up**
051-6	18%	60%
020-4	37%	70%
054-3	55%	84%
049-3	56%	86%
015-2	70%	91%
048-2	79%	93%

Above values are based on ASTM Test E-308, using CIE illuminant C.

Table D: Light Reflectance of White ACRYLITE FF Sheet

	Percent Reflected for 3 mm (.118")	
Color Number	**BLACK Back-up**	**WHITE Back-up**
020-4	33%	68%
015-2	67%	89%

Above values are based on ASTM Test E-308, using CIE illuminant C.

When a backlit sign must be as effective during the day as at night, a compromise is in order. Select a white color that not only transmits a high percentage of light, but also reflects a sufficient amount of daylight. Otherwise, the sign will look gray during the day when it isn't illuminated from behind.

Because all white ACRYLITE GP or ACRYLITE FF sheet is translucent, the surface brightness (reflectance) will be influenced by the color of the material behind the sheet or behind the sample when measured.

This tech brief lists two kinds of reflectance values that have been obtained using two different test methods. The values shown in the left column in Tables C and D were obtained by measuring samples supported on black background material. In the right column of Tables C and D, the values were obtained by measuring the same sample supported on a standard white background. The right column of data simulates the performance of white sheet when used in a sign box painted white on the inside.

The percentages listed apply to 3 mm thick sheet. Other thicknesses will reflect different percentages of incident light. It is not practical to give a factor for all these sheet thicknesses, but any necessary information can be obtained from CYRO's Technical Center in Orange, CT by calling (203) 795-6081.

As you can see from the comparison of the transmission and reflectance values of various 3 mm white colors as listed in Tables A, B, C and D, light reflectance increases as light transmission decreases. For applications requiring high light transmission, color 020-4 (GP/FF) or 051-6 (GP only) may be used. For maximum light reflectance, either color 015-2 (GP/FF) or 048-2 (GP only) may be used.

Because light transmission and light reflectance vary with thickness, don't use a 3 mm thick sample of a white for selecting other thicknesses of the same color. Always evaluate the translucent white colors using samples that are the same thickness as the sheet that will be used in the final application.

Light Transmission of Translucent and Transparent Colors

Each white ACRYLITE GP or ACRYLITE FF sheet color's light transmission decreases with an increase in thickness. The percentage of light transmission for all thicknesses of a given translucent or transparent color other than white is the same. This is accomplished by adjusting the colorant concentration according to sheet thickness. See Tables E and F on page 6 for a sampling of standard colors. When any of these colors are selected for a sign application, samples should be checked under reflected light as well as with transmitted light. Some colors are quite similar in appearance under reflected light but transmit light at different rates.

Table E: Light Transmission of Translucent Colored ACRYLITE GP or ACRYLITE FF Sheet

Color Number			Percent Transmitted for 3 mm, 4.5 mm, 6 mm
047-2	Ivory	•	34%
202-0	Red		3%
205-0	Red	•	1%
207-0	Red		3%
209-0	Red		9%
211-1	Red	•	10%
303-0	Orange		6%
406-1	Yellow		17%
407-2	Yellow	•	21%
506-0	Green		8%
507-0	Green	•	2%
605-0	Blue	•	2%
606-0	Blue	•	1%
607-1	Blue		21%

Above values are based on ASTM Test E-308, using CIE illuminant C.

• - Available for ACRYLITE FF and ACRYLITE GP sheet.

Colors not marked are for ACRYLITE GP sheet only.

Table F: Light Transmission of Transparent Colored ACRYLITE GP or ACRYLITE FF Sheet

Color Number			Percent Transmitted for 3 mm, 4.5 mm, 6 mm
103-2	Gray	•	27%
104-1	Gray	•	13%
115-0	Gray		7%
126-4	Bronze	•	44%
131-2	Bronze	•	26%
210-0	Red		7%
311-1	Bronze	•	10%
408-5	Amber		45%
430-7	Yellow		75%
508-7	Green		76%
625-5	Blue		58%
668-0	Blue		10%

Above values are based on ASTM Test E-308, using CIE illuminant C.

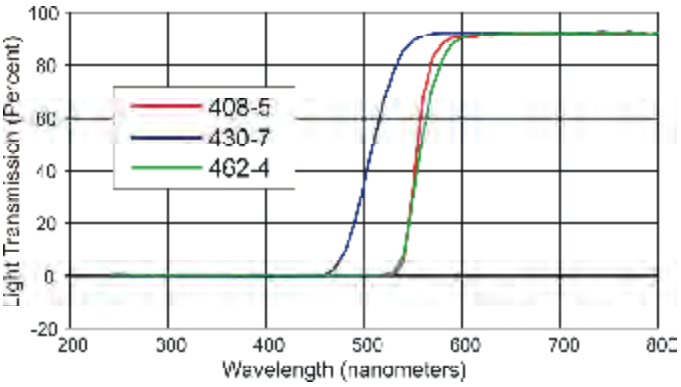
• - Available for ACRYLITE FF and ACRYLITE GP sheet.

Colors not marked are for ACRYLITE GP sheet only.

ACRYLITE GP Sheet: Amber, UV Filtering Colors

Amber colored sheet is frequently used to filter UV light in welding, laser cutting and UV curing operations. Proper choice of the appropriate amber color will depend on the exact parameters of the application. It is important to note that not all amber colors have effective UV filtering properties. Shown above in Graph 5 are the transmission curves for several amber colors having good UV absorption characteristics.

Graph 5: Light Transmission Curves of Amber, UV Filtering Colors (Approximate only– Not a specification)



ACRYLITE GP Black/White Sheet: Color 1124-1, P-95 Texture

ACRYLITE GP Black/White sheet (also referred to as day/night sheet) is intended for applications in sign channel letters and faces. This product offers sign manufacturers and designers an appearance which is black in daylight (with no backlighting) and translucent white at night, when backlit. A special combination of color and texture provides this versatility without any change to the physical, chemical and thermal properties, which are characteristic of ACRYLITE GP sheet.

For additional versatility, colored film or sheet can be placed behind ACRYLITE GP Black/White sheet, to alter the color of the sign when backlit.

ACRYLITE GP and ACRYLITE FF Sheet Color Coding System

The ACRYLITE GP and ACRYLITE FF sheet color coding system uses 4 or 5-digit numbers for all colors, including white and black.

The first digit identifies the color group as follows:

0 white and ivory	3 orange and brown	6 blue
1 gray and black	4 yellow and amber	7 violet
2 red	5 green	8-9 not assigned

The second, third and sometimes fourth digits are assigned to specific colors. These digits have no special significance and are not related in any way to the code used for the first digit. They are used only to label and identify different shades within each color group. The last digit indicates the approximate percentage range of light transmission. For example, -3 indicates a range from 30% to 39%.

Infrared Radiation

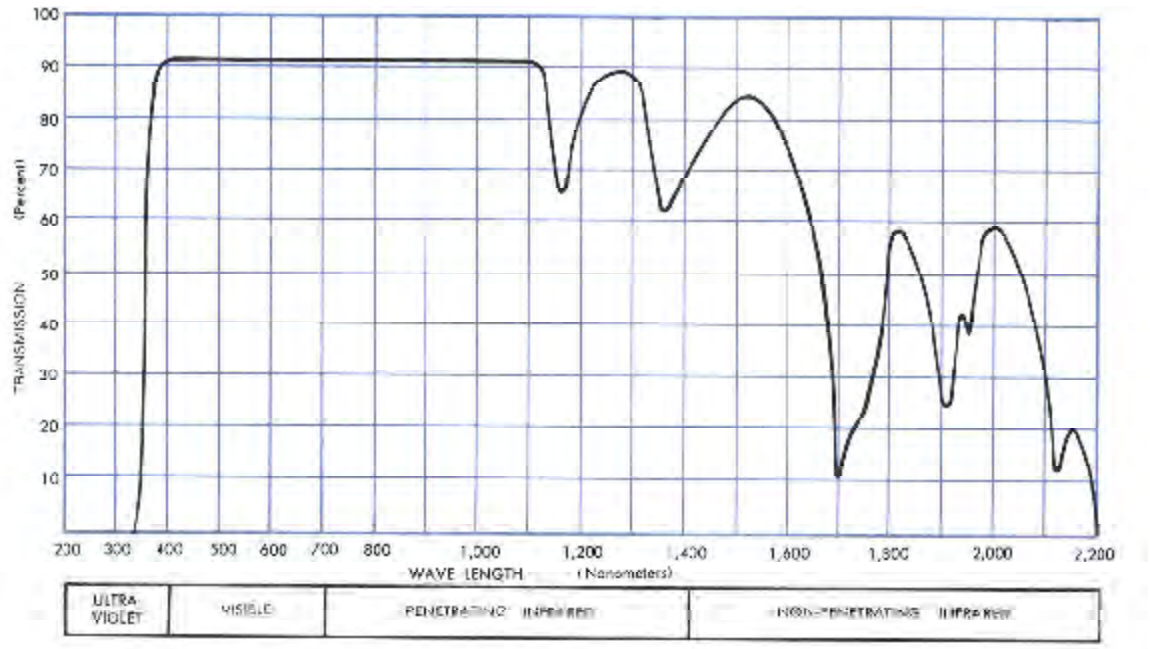
Infrared radiation is the long wavelength radiation beyond the sensitivity of the eye, ranging from 700 to 1,000,000 nanometers. Its source may be the sun, infrared heating elements or any hot object. Each type of infrared radiation is characterized by a specific range of wavelengths. We are primarily interested in the near infrared range (NIR) from 700 to approximately 10,000 nanometers.

Incandescent lamps and infrared heat lamps emit radiation in both the visible and infrared spectra. A major portion of energy,

especially in the case of infrared heat lamps, is radiated at wavelengths above 700 nanometers. As the temperature of the energy source decreases, radiation is emitted at longer wavelengths. All solar radiation as well as artificially created radiant energy will be converted into heat when absorbed and reradiated by any material.

In the penetrating infrared band from 700 to 1400 nanometers, clear 3 mm ACRYLITE GP sheet or 3 mm ACRYLITE FF sheet transmits approximately 90% of infrared radiation – see Graph 6. The transmission rate decreases slightly with increasing thickness. In the 1400 – 2200 nanometers range, ACRYLITE GP and ACRYLITE FF sheet transmit radiation at a gradually decreasing rate; at 2200 nanometers, transmission approaches zero.

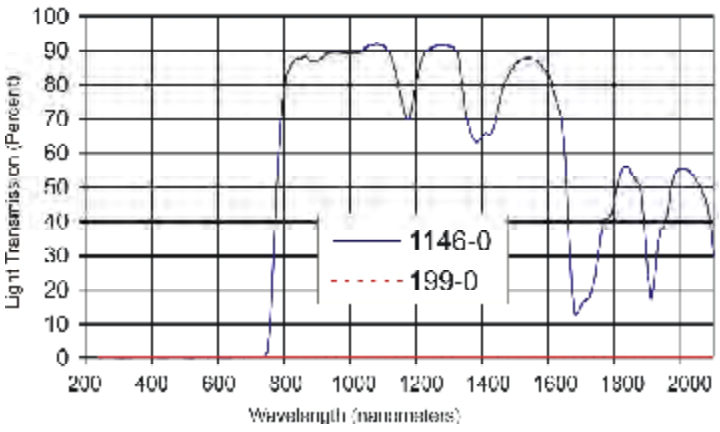
Graph 6: Light Transmission of Colorless ACRYLITE GP and FF Sheet (Approximation only not a specification)



ACRYLITE GP Black 1146-0 IR Transmitting Sheet

ACRYLITE GP sheet color 1146-0 is designed to transmit infrared light but to absorb visible light. This color is ideal for use in applications where it is desirable to conceal infrared security cameras or infrared transmitters and receivers. Below, Graph 7 shows the light transmission of color 1146-0 ACRYLITE GP sheet compared to color 199-0 black, ACRYLITE GP sheet.

Graph 7: Transmission of ACRYLITE GP Sheet, Colors 1146-0 (IRT) and 199-0



Greenhouse Glazing

Transmission characteristics of colorless ACRYLITE GP and ACRYLITE FF sheet are equal or superior to those of ordinary window glass. Colorless ACRYLITE GP and ACRYLITE FF sheet can be used for greenhouse glazing since plants will grow as well under these materials as they would under glass.

ACRYLITE GP and ACRYLITE FF sheet are opaque to long wave radiation above 2200 nanometers. Long wave radiation is emitted by the mass, such as soil or concrete, inside a greenhouse. This opacity creates the "greenhouse" or heat-trapping, effect.

Light Piping

The very low light absorption characteristic of ACRYLITE GP and ACRYLITE FF sheet makes it perfect for light piping applications, such as engraved signs, inspection lights, instrument dials and other similar items. To prevent excessive light loss at curves, the radius of curvature should not be less than three times the sheet's thickness. It's important that the sheet's surfaces be highly polished and free of scratches to assure optimum reflection and prevent light scattering.

The amount of light that enters a sheet from the edge depends on the sheet's thickness and the edge transparency. *Edges should be highly polished to maximize light transmission.* Edges through which light will not enter should be polished and covered or coated with a highly reflective material to increase internal reflection. Large sheets may need to be illuminated from two or all four edges.

Back-Lighting

For back-lighting applications such as signs or light boxes, textured finished sheets or white sheets are often used between the light source and the sign face to improve light diffusion. This helps to eliminate bright spots caused by the light source.

Sometimes textured sheets are used in combination with edge lighting. The textured surface provides a means of re-directing some of the piped light to the face of the sheet. Generally, this is not a very efficient method of back-lighting because textured sheet is not specifically designed or optimized for this purpose.

For more efficient back lighting using an edge mounted light source, a special type of sheet has been developed, ACRYLITE® GS 1001 light diffusing acrylic sheet. This sheet contains tiny beads that help diffuse piped light to its surface. By using beads of a specific refractive index and size, and by selecting the right concentration of beads, the efficiency of this back-lighting sheet has been optimized for edge lighting applications.

Alternately, back lighting using an edge mounted light source can also be accomplished by employing a sheet printed or painted with a white light diffusing pattern on one surface. The pattern density can be varied across the sheet surface as the distance from the light source changes to adjust the amount of light being reflected to the sheet surface.

Artificial Light

Ultraviolet, visible and infrared light can also be produced by artificial sources. Artificial light sources produce radiation with characteristics varying from source to source. Fluorescent lamps, mercury vapor lamps, germicidal lamps and welding arcs produce significant ultraviolet radiation. The typical emission curve for an incandescent bulb shows that its output increases from a low level at 400 nanometers to a high level at 700 nanometers, and then rises steeply into the infrared range. As a result, heat as well as light is emitted. Also, colors appear warmer or redder than in daylight.

In the case of fluorescent tubes, the wavelengths of light emitted by the tube depends on the type of phosphor coating used on the inside. Fluorescent lamps are available in a number of different types. Manufacturers publish the spectrophotometric distribution curves of each type.

Fire Precautions

ACRYLITE GP and FF acrylic sheet are combustible thermoplastics. Precautions should be taken to protect these materials from flames and high heat sources. ACRYLITE GP and ACRYLITE FF acrylic sheet usually burn rapidly to completion if not extinguished. The products of combustion, if sufficient air is present, are carbon dioxide and water. However, in many fires sufficient air will not be available and toxic carbon monoxide will be formed, as it will from other common combustible materials. We urge good judgment in the use of these versatile materials and recommend that building codes be followed carefully to assure they are used properly.

Important Notice

The information and statements herein are believed to be reliable but are not to be construed as a warranty or representation for which we assume legal responsibility. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE. Nothing herein is to be taken as permission, inducement or recommendation to practice any patented invention without a license.

Technical Service

For more information or specific questions about your project, contact CYRO's Technical Service Representatives.

Sales Offices

For the name of your local Authorized Distributor, call 800-631-5384, visit www.cyro.com or contact the nearest regional sales office.

We invite you to visit our TechKnowlogy Center on www.cyro.com.

Visitors have immediate access to frequently asked questions, technical concerns, physical properties, processing conditions, fabrication tips, regulatory compliance information, engineering guidelines, tips for troubleshooting, and hundreds of other facts about acrylics from one of North America's leading manufacturers of acrylic-based polymer and sheet products.

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CYRO

1213F-1001-5RA

Attachment F

Cost Comparisons of Neon and LED Sign Systems

F-1

Production Order Cost Comparison of Budweiser Neon and LED Signs

Production Order Cost Comparison of NEON Signs Verses LED Neon Look Alike Signs. 6/10/2008

Budweiser Bowtie Neon Signs

Construction - Standard metal skeleton frame Neon Beer sign.
Glass - Budweiser word 8MM warm white glass, pumped Argon w/mercury and dipped painted red.
- Backlit Grid 9mm white pumped Argon w/Mercury

Unit Cost $114.00
Tooling Cc $2,000.00

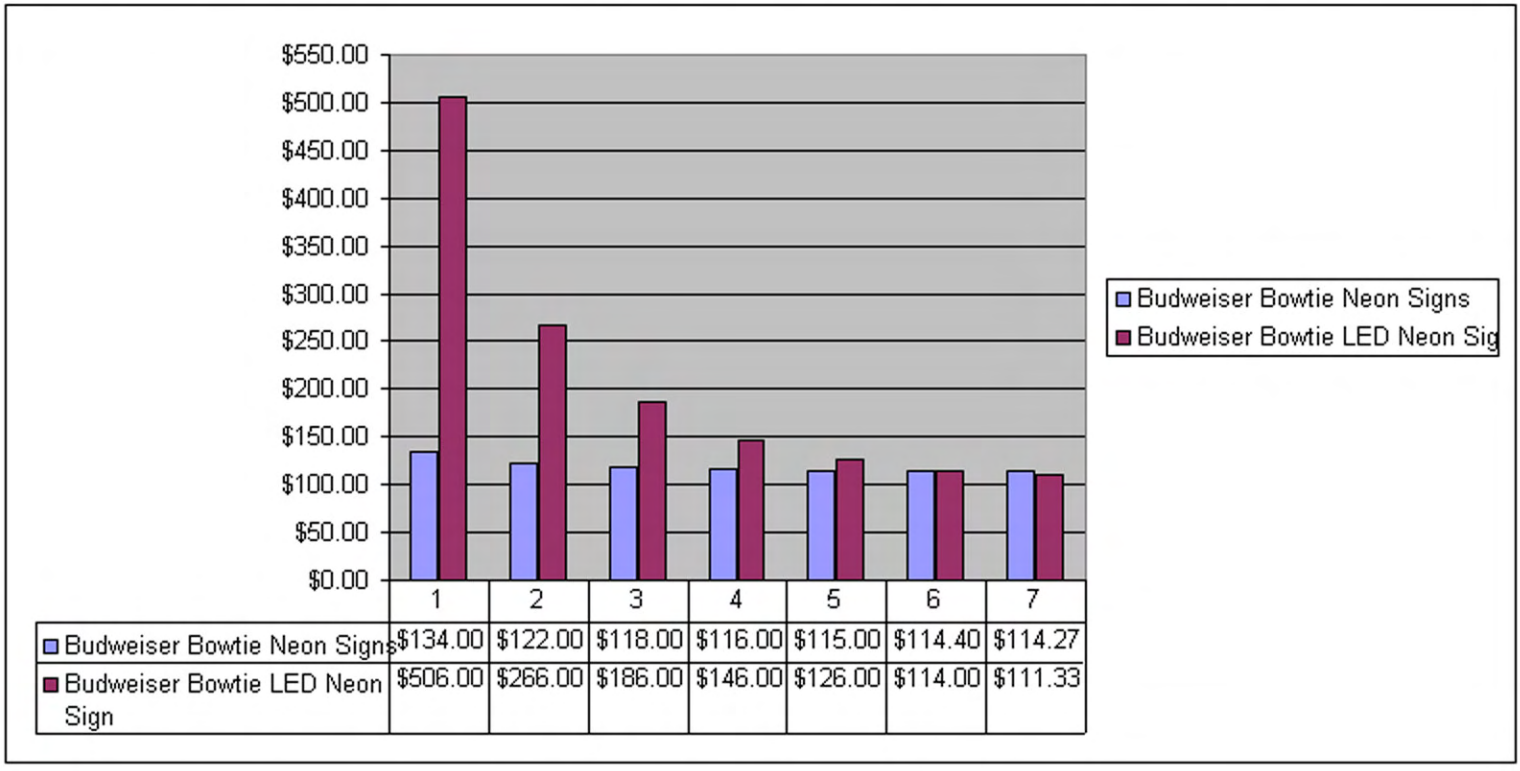
	Order Quantity						
	100	250	500	1,000	2,000	5,000	7,500
Unit Cost w/ Tooling	$134.00	$122.00	$118.00	$116.00	$115.00	$114.40	$114.27

Budweiser Bowtie LED Neon Sign

Construction - Injection molded Plastic LED Neon Look Alike Beer sign.
LED's - Budweiser word Red
- Backlit area lit with white LED's.
Housing - Injection molded Face, Letter and Case.

Unit Cost $106.00
Injection Tooling Cost $40,000.00

	Order Quantity						
	100	250	500	1,000	2,000	5,000	7,500
Unit Cost w/ Tooling	$506.00	$266.00	$186.00	$146.00	$126.00	$114.00	$111.33



F-2

EGL Neon vs. LED Comparison of Material Costs

(Light Source & Power Supplies)

Your Neon Source

The EGL Company, Inc.

Neon vs. LED Comparison of Material Costs (Light Source & Power Supplies)

The sign chosen for this comparison was "BED BATH & BEYOND. Jones Signs had worked on the neon layout for the sign, intending to use TFT's Octopus power supply system.

Three LED channel letter products were considered in this comparison – France, Gelcore and Permlight. Where applicable, LED modules were laid out to follow that of the neon – i.e. if a channel contained triple stroke neon, "triple stroke" LED layout was used. Sometimes this was contrary to the manufacturers guidelines (which generally called for less LEDs), but it was considered an acceptable approach if anywhere near equivalent sign brightness with neon was to be achieved.

No consideration is given to installation costs. It was assumed that the acrylic sign face would be the same cost for LED as for neon.

LED

France

France's LED modules come in 2 LEDs per module (red, orange, yellow, green, blue, white), 3 LEDs per module (green, blue, white), or 4 LEDs per module (red, orange, yellow). The 2 LEDs per module were not considered in this exercise. The modules are sold on a roll with 4" centers between modules (3 modules per foot). France's costs to the distributor were obtained. A 30% mark-up to the sign fabricator was assumed, giving the following costs:

Green, white, blue (3 LEDs per module)	$6.50 per module
Red, orange, yellow (4 LEDs per module)	$3.25 per module

Three sizes of power supply are offered, 20W, 50W and 100W. The 50W was used in this exercise. When wired according to instructions, it runs up to 140 of the 4 LED/module red, orange and yellow, and up to 70 of the 3 LED/module blue, green and white. Cost: $65 (distributor + 30%).

For red, orange or yellow:

modules required = 1782 at a cost of $5,578
power supplies required = 17 at a cost of $1,105

Total cost = $6,683

For blue, green or white:

modules required = 1782 at a cost of $11,583
power supplies required = 31 at a cost of $2,015

Total cost = $13,598

Gelcore

Gelcore's 6 LED/ft modules were considered for the red, orange, green and blue costings. Retail price from a distributor (Reece) are:

Red, orange:	$11.97/ft
Green, blue:	$7.50/ft

For white, the 3 module/ft Power White was used (same as tested at EGL). A cost of $30/ft was assumed, based upon the known price of $22 for the 2 module/ft product.

For this sign project, assume that the PS3 (56W) power supply would be used for the red and orange (runs 64 ft of 6 LED/ft product). The cost of this unit was assumed at $65 (estimated from known costs of other power supplies in the product range). The PS5 power supply would be used to operate the blue, green and white modules (runs 64 ft of blue or green, 20 ft of the 3 modules/ft Power White).

For red, orange:

ft required = 594 ft at a cost of $4,455
power supplies required = 14 at a cost of $910

Total cost = $5,365

For blue, green:

ft required = 594 ft at a cost of $7,110
power supplies required = 14 at a cost of $1344

Total cost = $8,454

For Power White:

ft required = 594 ft at a cost of $17,820
power supplies required = 31 at a cost of $2,976

Total cost = $20,796

Permlight

2 options were considered (prices taken from Permlight's web site, including volume discounts):

1. **PalleteLight** in red, white green and blue. Permlight recommend 1 module (8.4" long, 4 LEDs) for 1 foot of neon, (although this may be difficult to do in practice with 8.4" long modules).

   For red:
   Modules cost $5.11
   60W power supply (runs 77 units) cost $87.94
   30W power supply (runs 32 units) cost $55.88

   # modules needed = 594 at a cost of $3,035
   # power supplies needed (mixed types) = 14 at a cost of $975

   Total cost = $4010

   For white, blue, green:
   Modules cost $13.89
   60W power supply (runs 25 units) cost $87.94

   # modules needed = 594 at a cost of $8,251
   # power supplies needed (mixed types) = 26 at a cost of $2,286

   Total cost = $10,537
   Approx. power = 1426W (Permlight's figures)

2. **El Blanco white.** Permlight recommend this to "replace white neon in signs". They advise 1 module (3.3" long containing 2 high brightness LEDs) to replace 1 ft of neon. Calculations were run on this number, but also using 2 modules per linear foot of neon as it was thought that this quantity would be needed if the brightness of the sign was to approach that of tri-phosphor white on a 30mA electronic transformer.

   El Blanco modules cost $18.75
   Power supply (runs 80 units) costs $205.88

   a) **1 module/ft**
      # modules needed = 594 at a cost of $11,138
      # power supplies needed (mixed types) = 14 at a cost of $2,882

      Total cost = $14,020

b) **2 modules/ft**

modules needed = 1188 at a cost of $22,275
power supplies needed (mixed types) = 20 at a cost of $4,118

Total cost = $26,392

Neon

Sean Sulzbach provided approximate costs for supplying the neon glass work as laid out in the Jones Signs drawing:

594ft @ $5/ft = $2,970

Ventex 12000V/30mA electronic transformers were assumed to drive the neon. Cost of $60 per transformer was used.

Driving Hg tubes: 21 trans. @ $60 = $1,260

Driving neon tubes 24 trans. @ $60 = $1,440

Total neon material costs: **$4,230 (Hg tubes)**
$4,410 (Ne tubes)

Summary

	LED			NEON
	FRANCE	GELCORE	PERMLIGHT	
RED	$6,683	$5,365	$4,010	$4,410
ORANGE	$6,683	$5,365	-	$4,230
YELLOW	$6,683	-		
BLUE	$13,598	$8,454	$10,537	
GREEN	$13,598	$8,454	$10,537	
WHITE	$13,598		$10,537	
POWER WHITE	-	$20,796	$14,020[1]; $26,393[2]	

(1) 1 module per foot of neon
(2) 2 modules per foot of neon

B. Diffin
11/29/05

F-3

36” Channel Letter Cost Study

Walker, J.C.

From: Bill Dundas [Bill.Dundas@signs.org]
Sent: Friday, June 27, 2008 11:49 AM
To: Walker, J.C.
Subject: FW: cost comparisons

From: Wes Wilkens [mailto:wwilkens@persona-inc.com]
Sent: Friday, June 27, 2008 11:50 AM
To: Bill Dundas
Subject: cost comparisons

Hello everyone,

We are looking through some more history on channel letters that were quoted in both white LED and white neon. I have one set to offer up now. This is for a 36" set of channel letters for a popular Midwest convenience store. These total material and labor costs are an internal cost only with no margin added.

	Neon	***LED***
Labor	$620	$379
Materials	$797	$2087
Total	$1417	$2466

Wes

F-4

24” Channel Letter Cost Study

I

Walker, J.C.

From: Wes Wilkens [wwilkens@persona-inc.com]
Sent: Wednesday, June 11, 2008 5:53 PM
To: Bill Dundas; chucknelson@fallonneon.com; David Ablon; hevm@aol.com; luc@elbosigns.com; Loren Hudson; palarocque@electrobits.com; Bernard Diffin; Larry Catton; hevm@aol.com
Cc: Walker, J.C.; Rich Gottwald
Subject: RE: ISA Mercury Task Force - Conference Call - Wednesday, June 4, 10:00 am EDT

Bill,

Following is another cost study I did for a smaller channel letter set in the hospitality market:

Courtyard - 24"(23 1/2" C) - remote channel letters - green perf faces

24" remote letters - white tetra max leds

24" remote letters - white neon(15mm white) — did not use designer white neon actually required by program

		Approximate Amp Load
Led Letters	$2,2991.9	
Neon Letters	$1,82015.8	

Delta $479

Wes Wilkens
Product Development Engineer
Persona, Inc.
700 21st St. SW
Watertown, SD 57201
(605) 882-2244 x262

From: Bill Dundas [mailto:Bill.Dundas@signs.org]
Sent: Saturday, June 07, 2008 11:46 AM
To: chucknelson@fallonneon.com; David Ablon; hevm@aol.com; luc@elbosigns.com; Wes Wilkens; Loren Hudson; palarocque@electrobits.com; Bernard Diffin; Larry Catton; hevm@aol.com
Cc: walker@khlaw.com; Rich Gottwald
Subject: RE: ISA Mercury Task Force - Conference Call - Wednesday, June 4, 10:00 am EDT

Gentlemen,

Thank you for participating in the conference call last week. The following is a summary of the information requested and the task group members who will provide the data to complete ISA's exemption application for the IMERC states:

Attachment G

Industry Take Back and Recycling Proposal

International Sign Association

PROPOSAL

FOR A NATIONAL ENVIRONMENTAL SERVICES PROGRAM
RECYCLING LIGHTING AND ELECTRONIC WASTE

PREPARED FOR:

Bill Dundas
Director, Technical & Regulatory Affairs

Rich Gottwald
Education & Technical Initiatives
Vice President

PREPARED BY:

Mark Braniff
National Account Manager, Electronics Recycling
804-556-2850 Phone
804-399-3602 Cell

Veolia ES Technical Solutions, L.L.C.
www.VeoliaES.com

6/27/2008

Table of Contents

I. Proposal Overview

Veolia ES Technical Solutions, L.L.C., (VES) is pleased to submit this proposal for recycling of fluorescent lamps, neon tubes, ballast and associated materials. VES offers a cost effective, environmentally sound recycling and waste management program that combines excellent service, and superior risk management features.

We believe that no other environmental service company can offer this level of unique features and liability protection.

II. National Service Plan – Managing Lighting and Electronic Waste

A. Summary

The key features of the recycling program are the following:

1) Strong Regulatory and Risk Management Framework
2) Financial Strength and Stability
3) Technical Support
4) Competitive Pricing
5) Minimal Use of Subcontractors
6) Timely and Responsive Service
7) Experience

1) Strong Regulatory and Risk Management Framework

The four VES electronics recycling facilities operate under permits as follow: Stoughton, MA -a "Class C" recycling permit issued by the Massachusetts Department of Environmental Protection (MADEP); Port Washington, WI - a RCRA Part B permit issued by The Wisconsin Department of Natural Resources; Phoenix, AZ - a compliance agreement issued by the Arizona Department of Environmental Quality (RCRA Part B application under review); and Tallahassee - a recycling permit from the Florida Department of Environmental Quality. In addition, the Stoughton and Phoenix facilities hold PCB Commercial Storage Permits and Alternative Decontamination Sampling Plan Approvals issued by the US Environmental Protection Agency. Each regulatory agency performs routine inspections of VES's facilities and expects that VES will operate in full compliance with the provisions of its permit. Copies of these permits and approvals are available on request. A permit summary can be found in Section VI -A of this proposal. Permit conditions, as well as other risk management features of VES's operations, include the following:

- Facility Operation Plans
- Waste Analysis Plans and Procedures
- Security Plans
- Inspection Plans and Procedures
- Training Plans and Procedures
- Contingency Plans and Procedures
- Preparedness and Prevention Plans
- Employee Health & Safety Plans
- Closure Plans and Financial Assurance Requirements

- Pollution Liability Insurance (sudden and non-sudden)
- Contractors Operations & Professional Services (COPS)
- Customer Indemnification
- Waste Tracking and Record-keeping

These features, many of which are described in this proposal, ensure that your company is protected to the maximum feasible extent against future liability for its lighting and electronic waste.

2) Financial Strength and Stability

In addition to the service and risk management features outlined above, VES's proposal is supported by substantial financial and service resources. Veolia ES Technical Solutions, L.L.C., is part of VES North America, a national environmental service company with annual revenues in excess of $1.6 billion. VES is owned by Veolia Environnement, the largest environmental services corporation in the world with revenues over $30 billion. Audited financial statements for Veolia ES Technical Solutions, L.L.C. parent company can be forwarded upon request.

This proposal represents VES's total commitment to risk management and cost effective service.

3) Technical and Sales Support

VES offers the technical support of eight regional sales representatives, two national account managers, a national sales manager, an electrical equipment product line manager, an asset recovery specialist, a marketing manager, and regulatory compliance staff to provide technical guidance and information regarding the proper management of universal waste.

4) Competitive Pricing

This proposal includes competitive market adjusted prices from VES for a variety of programs so you can choose the best solution for your needs. Our pricing is competitive at every level of service. The pricing for lighting and electronic waste will be provided at a later date.

5) Minimal Use of Subcontractors

Under this proposal, recycling your lighting and electronic waste will be accomplished by VES ***with minimal use of subcontractors.*** VES will only use contractors for the transport of neon and fluorescent lamps and ballasts from some remote locations to VES recycling facilities, or service requests that are deemed priority. In most instances, VES vehicles will be used for waste transport. VES employees will process the neon and fluorescent lamps utilizing in house de-manufacturing and mercury distillation equipment. Lamp components will be shipped, when feasible as products from the facilities or, in the case of non-hazardous phosphor powder may be disposed of as non-hazardous waste using internal VES facilities.

6) Timely and Responsive Service

VES has demonstrated its ability to provide excellent service to a wide range of customers across North America. The service program proposed within this proposal will ensure that all requests for packaging, pickup, regulatory consultations, and other forms of assistance will be handled promptly and professionally at all times. As evidence of its superior customer service, VES is now servicing thousands of customers across the country. VES recycles lamps and ballasts for many of the nation's largest companies, including, JC Penney, National Grid, W.W. Grainger, N-Star, Graybar, Sears Holdings, and WESCO.

7) Experience

VES's team of experienced professional brings over 50 years experience in the environmental field, including service in the national hazardous waste companies and the USEPA. VES's trained drivers and

technicians have many years' experience serving customers in a variety of situations from very small pickups to truckload quantities.

B. Recycling Team Members

VES will be encouraging substantial contact between its general management, operations management, customer service and sales. By identifying, minimizing and committing the amount of personnel in contact, we believe communication, and thus, implementation to be successful.

1) Key Personnel

National Sales Manager

Barry Jordan – National Sales Manager

With over 28 years experience in the environmental field, Mr. Jordan is responsible for managing major national accounts for VES. He will maintain close scrutiny of all aspects of the account.

National Accounts Managers

Mark Braniff- Eastern National Accounts Manager

Mark Braniff is the National Account Manager, east of the Mississippi. He has worked for Veolia since February, 1988. He's been in sales since August, 1994 and has been an Account Manager in Tonawanda, NY, Marlboro, MA & Richmond, VA. He has a BS degree in Chemistry from Canisius College, Buffalo, NY and is a Certified Hazardous Materials Manager (CHMM).

Erin Moore- Western National Accounts Manager

Erin Moore is the National Account Manager based out of our Phoenix facility. She has held this position since January 2005. She is responsible for managing strategic and national accounts. She has worked for Veolia since 1998 with positions including mercury manager and regional account manager. Her past employment was with Tyco, Carlisle Plastics Division (Consumer Products Manager, Account Manager), and Neiman Marcus (Assistant Buyer).

Customer Service Managers

Amanda Poverchuk – North East Customer Service Manager

As the Customer Service Manager for the Northeast Region, Ms Poverchuk is responsible for ensuring that all requests for service are recorded accurately and responded to in a timely fashion. She will ensure that service requests are fulfilled in the Northeast and Mid-Atlantic Regions and she will monitor all service requests to ensure that all VES regions are responding in a timely fashion in compliance with requirements.

Steve Bierman – Midwest Customer Service Manager

Mr. Bierman has been employed at Veolia ES Technical Solutions, L.L.C. for 6 years. He is currently the customer service representative for the Midwest Region (WI, IL, MI, IN, OH, KY) along with a few national accounts. Responsibilities include: taking and placing orders for customers, handling any questions or problems, quoting small generators of material, overseeing national accounts/projects. Mr. Bierman will process all service requests from the Midwest Region.

James Chavez – Western Customer Service Manager

James Chavez is the Customer Service Supervisor for our Phoenix facility. He has worked for Veolia for five years. His duties include assisting sales and CSR's with pricing, training of new CSR's and resolving customers' inquiries or assistance with profiles/orders in the Western Region.

Regulatory Compliance Managers

Phil Ditter – Environmental Health and Safety Manager

Mr. Ditter is the EH&S Manager for Veolia ES Technical Solutions, L.L.C. He brings many years of environmental compliance to his responsibilities at VES. He will be responsible for ensuring that all aspects of the recycling services provided by VES are in compliance with federal, state and local environmental regulations.

Facility Personnel

Phoenix, AZ

Michael Bomgardiner – Acting General Manager

Mr. Bomgardiner is Acting General Manager for the Western Region and operates out of the VES Phoenix, AZ facility. He is responsible for overseeing and managing all aspects of Lamps, ballasts, and transformer recycling operations. Mr. Bomgardiner has been employed with VES since 2000 and brings over 11 years experience in the lighting recycling industry.

Port Washington, WI

Kevin Shaver- General Manager

Mr. Kevin Shaver serves as the General Manager for the Veolia ES Technical Solutions, L.L.C. - Port Washington, Wisconsin facility. Mr. Shaver graduated from the University of Wisconsin - Stevens Point with a Bachelor of Watershed and Resource Management. Mr. Shaver has twenty years experience in the environmental field. This experience includes ten years in environmental consulting, working with regional, national and international clients. For the past four years, Mr. Shaver has been responsible for the complete operation of the Port Washington hazardous waste storage facility with capabilities including RCRA storage, 10-day transfer, fluorescent lamp recycling and mercury retort. His achievements include coordination with retail, industrial, and government customers to streamline project implementation, regional pricing strategies, and management of projects. Mr. Shaver has extensive experience working to ensure compliance with federal and state regulations and profit responsibility as General Manager of the Port Washington facility.

Stoughton, MA

Paul Conca – General Manager

Mr. Conca is responsible for managing Veolia ES Technical Solutions, L.L.C. operations in the Northeast and Mid-Atlantic regions. He is responsible for management oversight of all operations in this territory, including major recycling projects.

Tallahassee, FL

Linda Dunwoody- General Manager

Linda Dunwoody is the Operations Manager for our Tallahassee facility. She has held this position since October 2005. She is responsible for all aspects of running the facility. Up until last year she was the Facility Services Supervisor in the Stoughton facility. She has worked for Veolia since July 2000. Her past employment includes sales and serving in the US Army.

C. Service Delivery - Bulk Recycling

VES will provide recycling services in compliance with all federal, state and local disposal regulations. The four VES electronics recycling facilities are strategically located to provide responsive bulk pickups for facilities and customers throughout the United States for lighting and electronic waste removed from these facilities through routine maintenance and re-lamp, retrofit, or renovation projects. This recycling program could also be used for damaged product, such as lamps broken during transit or handling, that are accumulated at various locations.

1) Program Mobilization

As a first step in setting up a national recycling program, VES would establish procedures for ongoing communication with environmental staff and other designated representatives. VES's National Account Manager, Mark Braniff, would be the primary contact and serve as a liaison with the VES Customer Service, transportation, operations, compliance or Accounting Departments. Regional Customer Service Managers will ensure that the specific elements and logistics of the recycling program are carried out - scheduling, routing, packaging, ordering, and monitoring procedures, reporting and documentation. If needed, at the beginning of the contract, and at other times, VES will provide personnel and contractors guidance on packaging, storage and labeling for all types of ballast, mercury-bearing lamps and electronic waste.

One of the most important elements of the mobilization phase will be identifying creative ways to develop efficiencies and cost savings by combining and maximizing the strengths of the two companies. This may include logistics, transportation and reverse distribution capabilities.

2) Ordering System (eFax)

The eFax ordering system is the simple, convenient way to order delivery and pick up services from VES. The system utilizes a toll-free fax number and broadcast emails to place orders and distribute the orders to all appropriate parties. The system creates a tracking system for orders placed, creates accountability, and ensures prompt, professional service. In addition, a toll-free phone number will be provided for assistance and support from VES.

The eFax process

- The VES customer completes and faxes a service request form (shown below) to a toll free fax number.
- This can be completed and faxed by the customer or by contractors in the field.
- eFax receives the fax and transmits the fax via email.
- eFax distributes the email to VES customer service across the nation.
- Often, the customer opts to be on the broadcast email list in order to track when orders are placed.
- The customer service department responsible for the region in which the service will occur will generate a service order and schedule transportation.
- The national customer service manager monitors and reviews the eFax process daily.

A sample of the eFax form is on the following page.

VEOLIA ENVIRONMENTAL SERVICES

BULK SERVICE FORM Rev. 08/04

BULK SERVICE REQUEST FORM

Contractor Name: _____ **Requested Pickup Date:** _____

Contractor Phone: _____ **Site Hours:** _____

Contractor Fax: _____

Date Faxed to VES: _____

Generator Pick-Up Location

Company Name: _____

Physical Address: _____

City/State/Zip: _____

Contact: _____

Phone: _____

Fax: _____

Email Address: _____

_____

EPA ID Number: _____

Bill to Information: ☐ Same as Pick-Up Location

Company Name: _____

Mailing Address: _____

City/State/Zip: _____

Contact: _____

Phone: _____

Fax: _____

Email Address: _____

Purchase Order: _____

The materials listed below, under "Materials" are properly identified and prepared for transportation in accordance with all applicable federal, state and local regulations.
I certify that this is true and correct.

Signature of Site Contact: X. _____ **Date:** X. _____

"Materials for Recycling"

# of Cartons	Carton Type and Size	Description of Waste	Quantity (lbs, lamps, etc.)	# of 4' Pallets	# of 8' Pallets

Special Notes: _____

If Ballasts are being picked up, please indicate the type: ☐ PCB ☐ NON-TSCA PCB ☐ NON-PCB

Packaging Request

Container Type:	QTY:

Site Attributes (Check all that Apply)

Is Hazardous Waste Manifest Required?	☐ Yes	☐ No	Is Pallet Shrink-Wrapped?	☐ Yes	☐ No
On Loading Dock?	☐ Yes	☐ No	Is Jack/Dolly Needed?	☐ Yes	☐ No
Is Lift Gate Needed?	☐ Yes	☐ No	Is Fork Lift Available?	☐ Yes	☐ No
Is Product Palletized?	☐ Yes	☐ No	Accessible by 48' Trailer	☐ Yes	☐ No

INTERNAL OFFICE USE ONLY- Do not write within this box

Order Taken by: **Date:**

Onyx Environmental Services, LLC
Electronics Recycling Division
2135 West Nordale Drive, Appleton, WI 54914
Phone (800) 556-5267, Fax (920) 749-8110

FAX ORDERS TO: (920) 749-8110

3) Service Request Processing and Response

Your designated representatives will send eFaxes to the VES toll-free number or via email to request shipments of empty packaging or waste pickups. The VES customer service department will create a sales order and arrange, with the transportation department for the trailer delivery and pickup within a time frame mutually agreed upon. Service requests can also be placed via a toll-free phone number 1-800-556-5267 or by e-mail. An example of an e-Fax is found on the next page.

4) Packaging and Storage Trailers

VES will provide any required packaging for fluorescent and neon lamps and VES can stage trailers for each major project location, if required. VES has in stock a wide variety of boxes, fiber drums, pails, steel drums, and cubic yard boxes or gaylord containers to accommodate all types of lighting and electronic wastes.

5) Waste Pickups and Transportation

VES will arrange for pickups using its own fleet of vehicles or approved transportation companies. Waste will be transported to one of four VES recycling facilities.

6) Waste Tracking

Each service request is assigned a unique tracking number when the order is placed. This number is entered into the VES computer system and is used on all shipping documents, labels, recycling certificates, invoices, and summary reports. It can also be used to track the status of a service request.

7) Waste Receiving & Verification

Each shipment of waste arriving at VES's facility is received and verified through standard procedures. The receiving department counts lamps in each shipment, and weighs ballasts, and electronics. After each shipment is received and verified, it enters the processing area. The receiving reports are then entered into the VES computer system using the assigned tracking number.

8) Waste Processing

All fluorescent and neon lamps and ballasts are processed at VES facilities. No "third party" facilities are used in any phase of lamp and ballast recycling. Any ballast components requiring incineration are sent to the VES treatment facility in Port Arthur, TX. VES utilizes approved third party facilities for processing some batteries and electronic equipment. Detailed information about VES's lamp and ballast processing is included later in this proposal.

9) Documentation, Administration & Reporting

Following processing of a shipment of waste from a customer, customer receives with the invoice a copy of the shipping documents and a Certificate of Recycling. In addition, VES can generate reports for that will summarize and provide detailed information about the types and amounts of waste generated over a given time period from the customer.

10) Quality Assurance - Project Monitoring & Evaluation

Our team of qualified, knowledgeable technical representatives will be in regular contact with your designated company representatives to ensure the project is being completed within expectations.

11) Marketing, Sales, and Customer Service Support

VES is prepared to commit significant resources to promote, sustain and expand the recycling service offering. VES has established a strong track record of working with distribution companies to increase

sales and maintain a high level of service to customers. VES promotes a partnership relationship with distributors, as opposed to a "vendor" relationship.

D. RECYCLEPAK "Kit" Recycling

VES can also offer the RECYCLEPAK recycling service. RECYCLEPAK provides a convenient, simple recycling service for small quantities of mercury-bearing lamps. The RECYCLEPAK could be used for managing lamps removed from service during routine maintenance at customer locations nationwide.

Under this "turnkey" program, the purchase price includes:

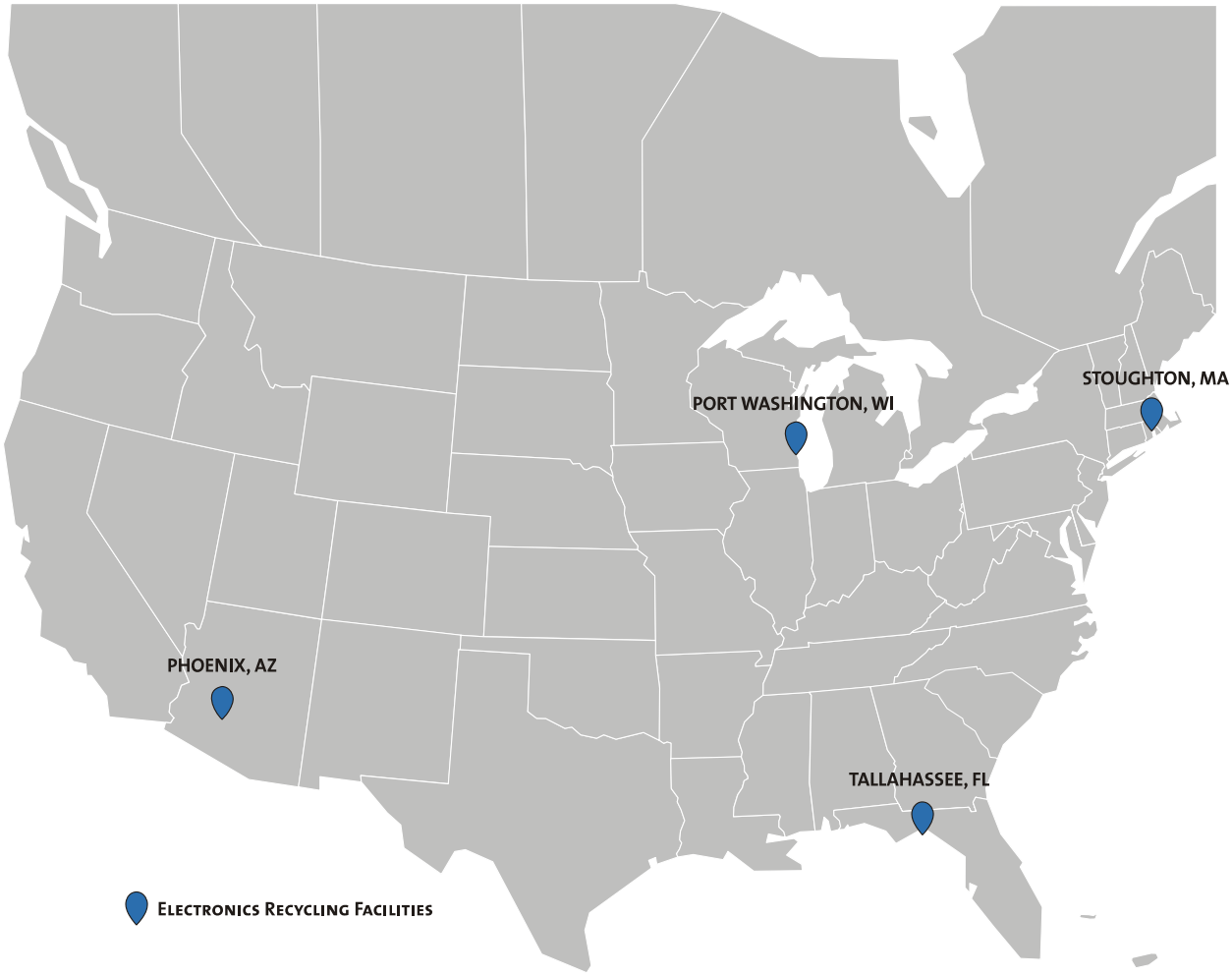
- the container
- storage and return shipping labels
- pickup and transportation to the VES recycling facility
- recycling of the waste
- certificate of reclamation.

Each kit includes simple instructions, a return shipping label, and a toll-free number to call for assistance. Once the container is filled, the customer completes the return shipping label and contacts FedEx Ground for the pickup. The lamps are then transported to a VES recycling facility where they are processed for recycling.

The RECYCLEPAK program is designed for use in the 48 contiguous states. A return shipping label is not included in RECYCLEPAK kits for use in Maine. Due to special requirements in Maine, RECYCLEPAK customers must contact the VES customer service department via a toll-free number to arrange for transportation to the VES recycling facility in Stoughton, Massachusetts.

III. Facility Information

VES PCB, Ballast, Mercury and Lamp Recycling Operations operate from four nationwide locations.



Service summaries provided are as follows:

VES Location	Permits and Approvals for Processing
Phoenix, AZ	PCB Transformers/Equipment, PCB Ballasts, Lamps and Mercury Retort
Port Washington, WI	Lamps and Mercury Retort
Stoughton, MA	PCB Ballast, Lamps and Mercury Retort
Tallahassee, FL	Lamps and Mercury Retort

Facility specific information appears on the following pages.

A. Veolia ES Technical Solutions, L.L.C. - Phoenix, AZ Facility

Facility Contact:	Heath Hildebrand
Facility Phone:	602-233-2955 or 800-368-9095
Facility Fax:	602-415-3030
Location:	5736 West Jefferson.
City:	Phoenix
Country:	USA
State:	AZ
Zip Code:	85043
USEPA ID#:	AZ0000337360
State Regulatory Agency:	http://www.adeq.state.az.us

Our Credentials:

Facility Information	EPA ID Number: AZ0000337360 ADEQ RCRA Part B Permit Submitted 10/14/98 ADEQ Compliance Agreement issued 9/02 Air Permit: ##000139 NPDES Permit AZMSG-12840 City of Phoenix: 03-10963-2CP TSCA Permit: AZD983473539 Alternate Disposal Technology issued by EPA Region IX 12/15/98 (40 CFR 761.60 (e)
	Pollution Insurance: PLS1364667 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO General Liability: GL 4177311 COMMERCE AND INDUSTRY INS. CO. COPS Insurance: COPS 1956720 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO
State EPA Contact:	Steve Miller Arizona Department of Environmental Quality 1110 West Washington Street Phoenix, Arizona 85007 (602) 771-4579
Copies of all permits:	Air permit, letter of approval to operate a recycling facility.
Copies of all permits:	Pass
Notices of Violations:	None

Facility Description:

The VES facility located in Phoenix, Arizona and is a strategically focused recovery and waste management facility which provides a variety of waste reduction and recycling services. VES Arizona operates a 96,000 square foot plant used to store, process and handle a variety of PCB and Non-PCB equipment and Mercury bearing waste. VES Arizona's waste reduction and recycling facility is fully permitted in accordance with all applicable USEPA and ADEQ regulations governing the handling and disposal of PCB and Mercury Waste. The following are examples of facility capabilities and operations:

- Lamp and Ballast Recycling Operations
- Battery Recycling Operation
- Computer CPU's and CRT's Management
- Mercury Extracting and Recycling Operation
- PCB and Non-PCB Electrical Equipment Management

B. Veolia ES Technical Solutions, L.L.C. - Port Washington, WI

Facility Contact:	Kevin Shaver
Facility Phone:	262-284-6855
Facility Fax:	262-284-3775
Location:	1275 Mineral Springs Drive
City:	Port Washington
Country:	USA
State:	WI
Zip Code:	53074
USEPA ID#:	WID988566543
Regulatory Agency:	http://www.dnr.state.wi.us/

Our Credentials:

Facility Information	EPA ID Number: WID988566543 RCRA Hazardous Waste Mgmt Part B Permit WDNR License: #6008 Solid Waste License: #03870 Air Permit: #01-DJH-339 WPDES Permit # WI-S067857-2
	Pollution Insurance: PLS1364667 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO General Liability: GL 4177311 COMMERCE AND INDUSTRY INS. CO. COPS Insurance: COPS 1956720 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO
State EPA Contact:	Dolores R. Hayden Hazardous Waste Management Specialist Wisconsin Department of Natural Resources 2300 N. Martin Luther King Jr. Drive PO Box 12436 Milwaukee, WI 53212-0436 (414) 263-8580
Copies of all permits:	Air permit, letter of approval to operate a recycling facility.
Copies of all permits:	Pass
Notices of Violations:	None

Facility Description:

The site consists of 11.45 acres. A security fence surrounds the active four acre portion of the site. There is only one gate to the facility, which is locked during off-hours. Previous use of the property was agricultural (fields). The property is located within a light industrial park. The nearest residential area is within one quarter mile. The population within a one-mile radius is approximately 500. The nearby city of Port Washington has an estimated population of 10,000. Schools and parks are more than one mile away from the facility. The nearest hospital is more than ten miles away. The facility storage building opened on December 27, 1989 and is located along the northwest end of the active portion of the site inside the security fence. The facility storage building is 82'x120' or 9,840 square feet. There are no underground or above ground storage tanks on site. The facility is exempt from regulation under certain portions of Chapter NR 600 Wis. Admin. Code because it meets the definition of "legitimate recovery" operations under NR 625.06 Wis. Admin. Code. PCB accumulation is exempt from commercial PCB storage requirements under section 144.44 (9) Wis. Stats. There are no industrial wastewater discharges from the facility. The Port Washington facility can handle the following types of waste: Mercury bearing lamps, mercury devices, mercury compounds, mercury debris, mercury soil, mercury contaminated phosphor, lamp ballast, small PCB capacitors (<9lbs), all types of batteries, computers and electronics.

C. Veolia ES Technical Solutions, L.L.C. - Stoughton, MA

Facility Contact:	Paul Conca
Facility Phone:	781-341-6080
Facility Fax:	781- 341-6088
Location:	218 Canton Street
City:	Stoughton
Country:	USA
State:	MA
Zip Code:	02072
USEPA ID#:	MA5000004713
State Regulatory Agency:	http://www.state.ma.us/dep/

Our Credentials:

Facility Information	EPA ID Number: MA5000004713 Recycling Permit: 1RC/2005 TSCA Permit: MA5000004713
	Pollution Insurance: PLS1364667 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO General Liability: GL 4177311 COMMERCE AND INDUSTRY INS. CO. COPS Insurance: COPS 1956720 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO
State EPA Contact:	Jim Miller MADEP 1 Winter Street, Boston, MA 02108 (617) 292-5574
Copies of all permits:	Air permit, letter of approval to operate a recycling facility.
Copies of all permits:	Pass
Notices of Violations:	None

Facility Description:

The VES facility in Stoughton, Massachusetts is a recycler of a variety of lighting and electronic wastes. VES utilizes state of the art recycling technologies to recover and re-use a wide variety of valuable materials. The Stoughton facility performs 100% recycling of fluorescent and HID lamps. VES de-manufactures these mercury-containing lamps, reclaiming the glass, metal, powder and mercury. The four lamp components are sold as product from the Stoughton facility. VES also reclaims mercury from other devices such as thermometers, thermostats, barometers, etc. VES operates its lamp recycling and mercury reclamation processes under a “Class C” Commercial Recycling Permit issued by the Massachusetts Department of Environmental Protection (MADEP). VES operates its PCB ballast recycling operations under a PCB Commercial Storage Permit and an Alternative Decontamination and Sampling Plan (40 CFR 761.79(h)) approved by USEPA.

VES de-manufactures PCB and DEHP ballasts in a controlled environment, producing clean components of metal casing and copper, which are sold for recycling. VES ships capacitors and potting compound removed from PCB lamp ballasts to an USEPA-approved incinerator or secure chemical landfill, depending upon customer requirements. VES recycles DEHP capacitors in accordance with all applicable state and federal regulations. VES is authorized by the Massachusetts Department of Environmental Protection to receive all types of batteries as a universal waste. After receiving, batteries are identified, sorted, or re-packaged for shipment to off-site reclamation facilities. Types of batteries, which can be recycled, include Alkaline, Mercury, Carbon Zinc, Nickel Cadmium and Lead Acid/Gel Cell. VES also receives cathode ray tubes (CRTs) and computer equipment for recycling.

D. Veolia ES Technical Solutions, L.L.C. - Tallahassee, FL

Facility Contact:	Linda Dunwoody
Facility Phone:	850-878-2259
Facility Fax:	850-878-3349
Location:	342 Marpan Lane
City:	Tallahassee
Country:	USA
State:	FL
Zip Code:	32305
USEPA ID#:	FLO000207449
State Regulatory Agency:	http://www.dep.state.fl.us

Our Credentials:

Facility Information	EPA ID Number: FL0000207449 Air Permit: 0730094-005-AO NPDES: FLR05F873 Solid Waste Permit: HO37-82472-004
	Pollution Insurance: PLS1364667 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO General Liability: GL 4177311 COMMERCE AND INDUSTRY INS. CO. COPS Insurance: COPS 1956720 AMERICAN INTERNATIONAL SPECIALTY LINES INS CO
State EPA Contact:	Jim Byer Florida Department of Environmental Protection 160 Government Center, Pensacola, FL 32501-5794 (850) 595-8360 ext 1264
Copies of all permits:	Air permit, letter of approval to operate a recycling facility.
Copies of all permits:	Pass
Notices of Violations:	None

Facility Description:

Veolia Environmental Services' (VES) Tallahassee facility is located in the northwest corner of a 27-acre industrial park. The building has 10,000 square feet processing and office space. The building is used to receive and process lamps for distillation/recycling. There are separate rooms for lamp disassembly and distillation. These rooms are maintained under negative pressure.

VES has the ability to recycle fluorescent and High Intensity Discharge (HID) lamps using a sophisticated and proven technology with a 17-year operating history. VES has the ability to provide complete on-site distillation which eliminates both the need for hazardous waste storage, and the shipment of hazardous waste from the facility. The facility is able to extract over 99% of the mercury from a lamp, and the recovered mercury is also over 99% pure.

VES is licensed as a hazardous waste recycler since the facility does not ship hazardous waste lamp components off-site.

IV. Process Information

A. Fluorescent and Neon Lamp Recycling Process Operations

Although there are variations between the equipment used at each facility all lamp-recycling processes utilize a dry separation process. Each machine is capable of processing 20,000 to 40,000 4-foot lamps per 8-hour shift with an asset recovery rate of approximately 100%. Of total bulb weight, roughly 96% is recovered as glass, 2% as aluminum, less than 2% as phosphor powder and less than 1% as mercury for refining. Routine monitoring of mercury values in all recovered materials, through TCLP and total mercury testing techniques, is standard operating procedures. The system utilizes dry crushing, dry separation and dry filtration operations. Lamps are brought into the recycling area on wrapped pallets, within cardboard boxes or lamp fiber drums. The lamps are brought to the lamp feed staging area where they enter the recycling process. In-feed to the process consists of manually opening the packaged containers and placing the lamps into the feed mechanism. The lamps are conveyed into a chamber where a breaker performs an initial particle size reduction of the lamps. Broken lamp pieces are then crushed to achieve a greater particle size reduction and transferred to a primary separator to separate the larger components (aluminum end caps). The remaining components are then further separated generating three process streams, glass cullet, glass fines, and phosphor powder.

The Vapor Collection System is designed to control mercury vapor and dust emissions from the process. The vapor collection system is comprised of a bag-house/cartridge filter equipped with a series of particulate filters, an air compressor for filter back purge, and an activated carbon vessel. The system draws mercury vapor and dust from the process equipment into the bag-house. The filter arrangement is designed to trap 99.99% of air-borne particles measuring 0.5 microns or larger. Dust accumulates in containers located underneath the bag-house. The air stream leaving the bag-house then passes through a sulfur-impregnated carbon vessel to further remove mercury vapors. Each stack is monitored using a real-time mercury vapor-monitoring instrument in accordance with facility's specific operating permit/plan.

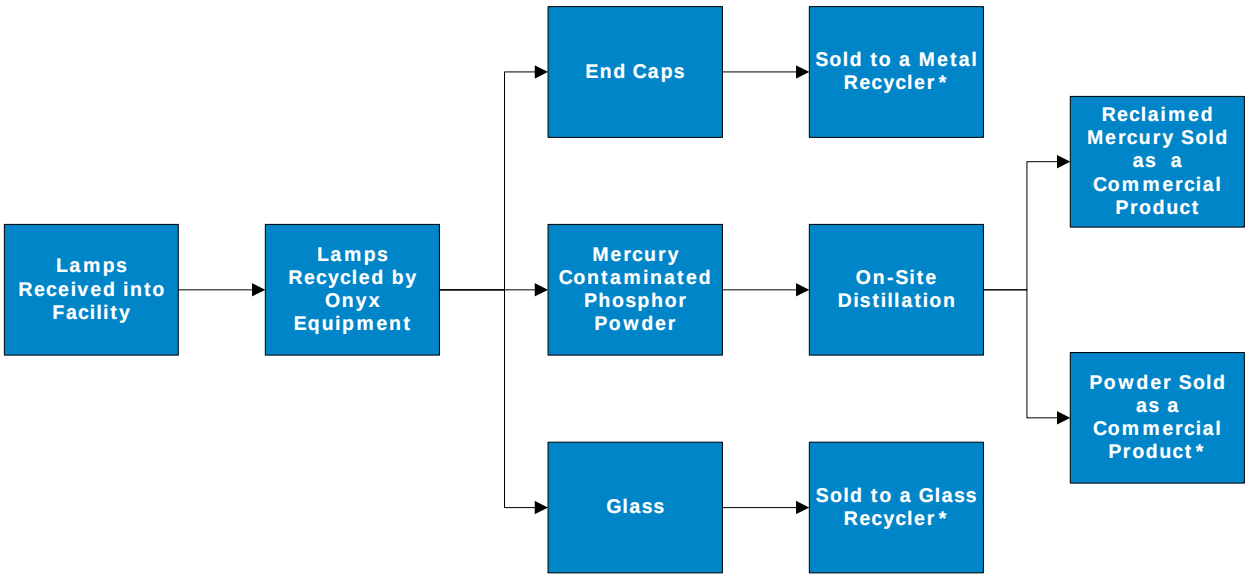
Environmental Controls

Environmental controls are required because of the toxicity of mercury. Mercury is a contaminant when introduced into the atmosphere, the soil or groundwater. The following controls are installed to minimize the hazard associated with handling of the lamps during the process: If lamps are broken in shipment, particulates, which may work their way out of shipping containers, are containerized for processing through the lamp recycling equipment. A portable Jerome mercury vapor analyzer is used to monitor mercury vapor concentrations in the air throughout the workplace, on a daily basis.

Mercury Bearing Lamp Material Process Flow

98-100% Recycling
*Phosphor powder deemed non-hazardous may be disposed of at an internal non-hazardous VES landfill.

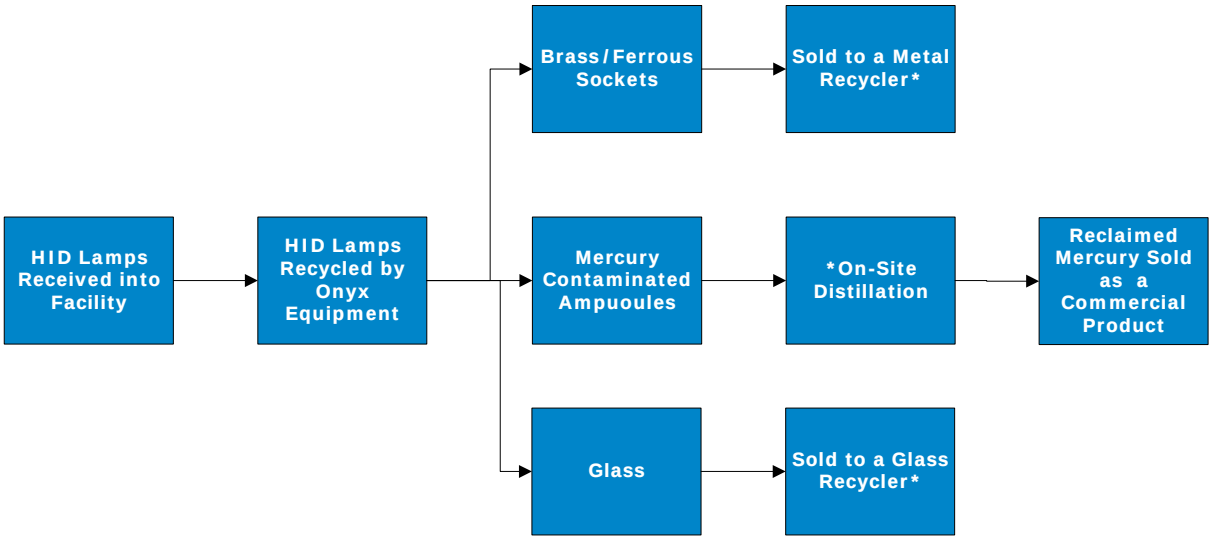
- Total Mercury
- TCLP- Mercury



HID Lamp Material Process Flow

100% Recycling
*Quality Control Chemical Analysis

- Total Mercury
- TCLP- Mercury



B. Ballast Processing Operations

Types of Ballast Waste and Containers Accepted

VES will accept ballasts in appropriate UN specification drums or boxes. Upon arrival at the facility, all containers are inspected. Any container that is leaking or damaged will be immediately re-containerized or over packed.

Waste Storage

PCB ballasts scheduled for either processing or disposal are stored in secondary containment. Each containment area is designed to accommodate drummed and palletized waste and has an internal containment capacity of greater than 25% of the total capacity of the storage area. Placement of containers within the containment systems is done in such a way as to facilitate inspection and to provide access for emergency equipment in case a container is found to be leaking. All aisles are designed to accommodate, without difficulty the movement of fire fighting, spill control and decontamination equipment and personnel.

Ballast Recycling System Capacity

VES's total processing capacity is 5,700 ballasts per day or 28,500 ballasts per week. The maximum feed rate is 350 ballasts per hour, regardless of the types and grouping of ballasts. The specific equipment currently in use limits the capacity. As market demand increases, additional capacity will be provided by installation of more equipment to expand capacity of both the PCB waste reduction process and metals recovery lines.

Ballast Recycling Process Description

In-feed to the process consists of whole lamp ballasts in drums. Before any processing operations occur the ballasts are placed into a freezer. The temperatures achieved in the freezing operation cause the potting compound inside the ballasts to become brittle, aiding in the separation of the potting compound from the remainder of the ballast. Non-leaking ballasts are supplied to a primary operator who shears the ends of the ballast. The base of the ballast is then manually separated from the cover. The contents of the ballast are removed. The contents of the ballast consist of three main components, the capacitor, the transformer section, and the potting compound. The potting compound and the capacitors are containerized for shipment to an off-site TSCA approved facility.

The transformer sections and metal casings proceed to a process area where additional potting compound is manually removed. The additional potting compound is combined with potting compound previously removed from ballasts. Ballast casings are then decontaminated using a physical removal process. The decontaminated casings are then tested to ensure the effectiveness of the decontamination procedure. After analytical results have been received documenting that the casings have been sufficiently decontaminated the casings are sold as scrap metal. The transformer sections are separated into two categories of material, wire windings and transformer cores. The wire windings are either manually or chemically decontaminated, depending on the facility. The decontaminated wires are tested to ensure the effectiveness of the decontamination procedure. After analytical results have been received documenting that the wires have been sufficiently decontaminated the wire is sold as a scrap metal.

Ballast Waste Disposal

The processes involved in the recycling of lamp ballasts generate a number of residual waste streams. Each waste stream is characterized based upon the chemical and physical composition of the waste and the process generating the waste. All wastes derived from the processing of PCB containing lamp ballasts are managed as TSCA regulated wastes.

Metals

VES produces three grades of non-ferrous, secondary "scrap" metals. These are prepared and packaged for sale in accordance with specifications developed by the Institute of Scrap Recycling Industries (ISRI).

Laboratory Analysis

VES contracts with outside laboratories, which typically perform analysis, such as:

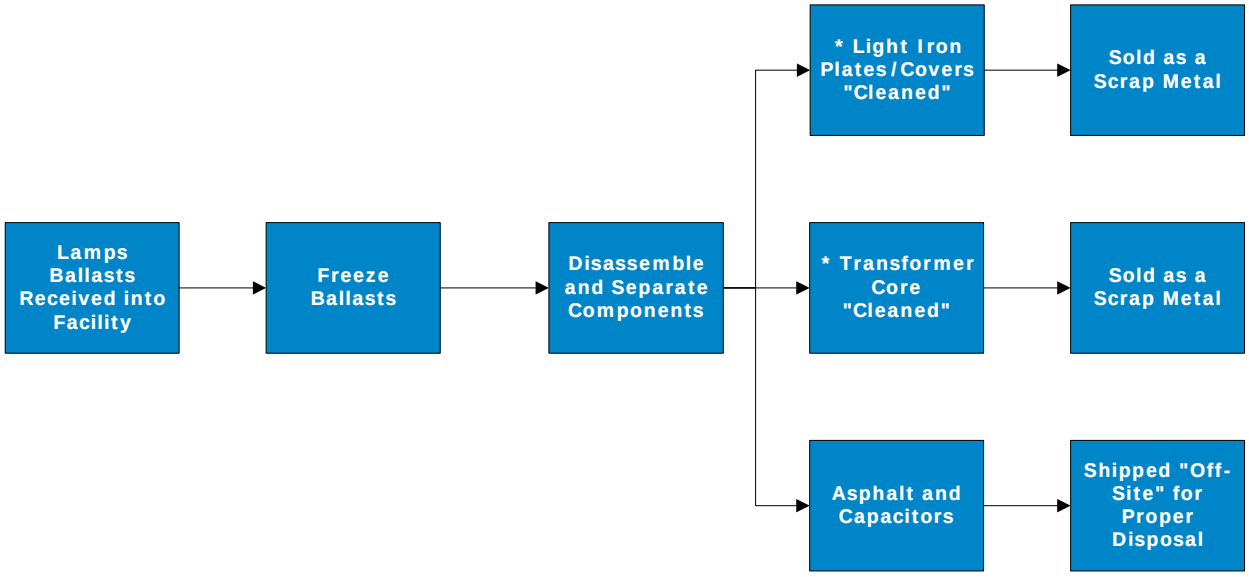
- Profiling of various types and groups of lamp ballasts
- Subsequent screening to determine conformity
- Identification of non-conforming materials and wastes
- Drum residues
- Contamination of equipment, fixtures, building, floor, etc.
- Waste stream characterization
- Metal alloy identification, purity and PCB contamination

In conjunction with contracted laboratories, VES maintains a strict quality control program to ensure sample integrity. The program objective integrates laboratory-related tasks such as source selection, sampling, sample preservation, analysis and testing, and all data generated there from, to be accurate and precise as well as representative of project goals. The program mandates and ensures defensible evidence of, proper documentation of unbroken custody, trace ability and adherence to applicable protocols.

PCB Lamp Ballast Process Flow

*Quality Control Chemical Analysis includes:

- PCB wipe tests (plates/covers)
- Total PCB concentration (cores)



C. NON- PCB Ballast Processing Operations

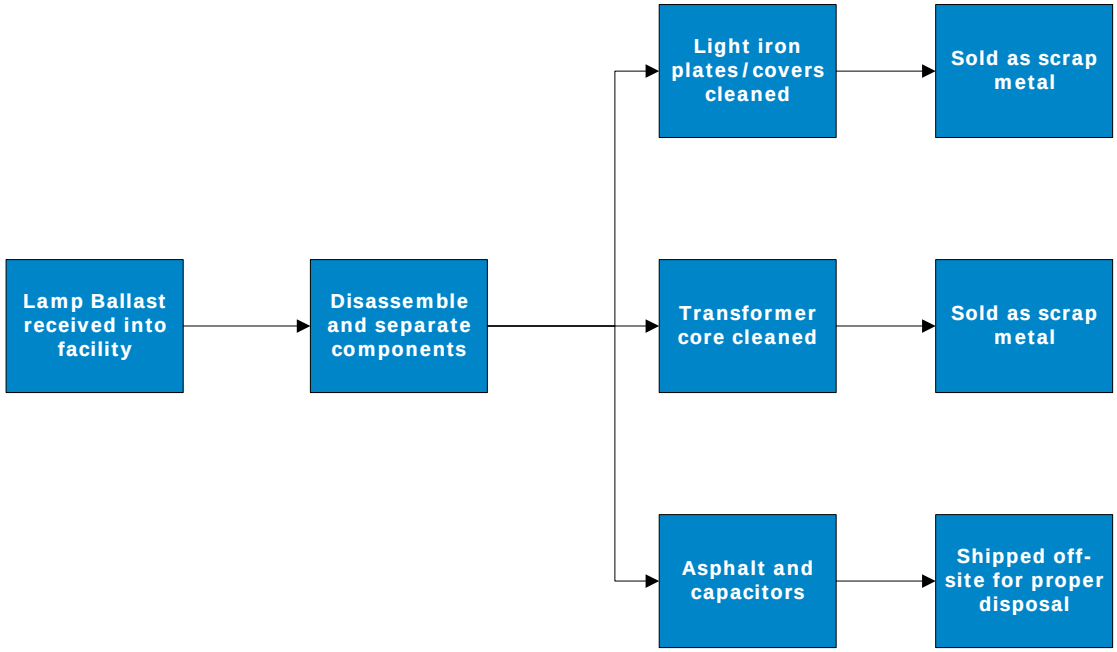
There are two options for managing non-PCB ballast.

The first option involves transporting the ballasts to one of the VES recycling facilities where they would be consolidated for shipment by VES as metal scrap to another VES-owned metals processing facility in Valparaiso, Indiana for reclaim and smelting.

The second option involves transporting the ballasts to either the Phoenix, AZ or Stoughton, MA recycling facilities where they would be stored and then de-manufactured into components. The metal cores and casings would be shipped off-site to the VES-owned metals processing facility in Valparaiso, IN, or to another smelter for reclamation. The potting compound and capacitors would be shipped to an EPA-approved disposal or incineration facility.

NON-PCB Lamp Ballast Process Flow
Option #1- Material recycled intact as scrap metal:

Option #2- Material de-manufactured, separated and recycled:



D. PCB Transformer/Equipment Recycling Operations

Overview

Since December 15, 1994 our PCB Commercial Storage and Recycling Facility has been operating in Phoenix, Arizona under formal approval issued by the USEPA, Region IX. Under the terms of the Commercial Storage approval, Veolia Environmental Services (VES) is authorized to accept and store for disposal PCB items, including transformers, bushings, capacitors, ballast, miscellaneous articles, debris, liquids, and PCB mixtures. Under the terms of the Alternate Disposal Technology Approval (ADTA), and the EPA PCB Disposal Amendments Final Rule (PCB Mega-rule) issued August 28, 1998, VES is authorized to recycle PCB contaminated equipment.

Waste Storage and Process Area

All of the equipment areas and processing locations incorporate continuous welded steel spill-containment floors, curbs, splash guards and other trade fixtures to isolate and prevent PCB contaminated materials escaping the processing room and equipment areas.

Waste Acceptance Parameters

VES has established waste analysis and materials testing procedures used to qualify a generator's PCB waste for acceptance and to ascertain quantity, weight, aging, chemical, physical and metals yield data necessary to determine:

- State regulatory requirements
- Method of containerization
- Appropriate container labels
- Method of loading/transportation
- Appropriate shipping documents
- Disposal method of non-recyclables
- Disposal method of oil/PPE
- Cost and subsequent pricing

Laboratory analytical verification and material profiles are required for all PCB equipment >50ppm. Additionally, VES may require MSDS sheets and/or manufacturer brochures prior to waste acceptance. Once approved, material profile sheets must be approved by one of the following VES staff prior to shipment to a VES facility:

- Corporate Waste Approvals Manager, or
- Environmental, Safety, and Health Manager

Process Overview

PCB Transformers/Equipment is received in the Phoenix location's loading dock 2 or 3 and placed in containment for inspection. Hazardous waste manifests/shipping papers are inspected and compared to material profiles to ensure waste acceptance compliance. PCB verification forms are reviewed to affirm PCB concentration. Material shipped to the facility without analytical paperwork will be placed on hold and subsequently tested for PCB concentration at an additional cost to the generator. Once material is approved for receipt, it is then assigned a unique container number with VES' computerized waste tracking system.

PCB & Non PCB Electrical Equipment

At VES, PCB containing electrical equipment is systematically drained, flushed, and mechanically disassembled with environmental integrity and maximum metal recovery being the goal. PCB containing materials including oils, debris, and rinsate are separated in secondary containment for

ultimate disposal at a TSCA incinerator or landfill. De-contaminated aluminum, iron, steel, and copper-based metals are packaged and shipped for further reclamation. The VES reclamation process recovers more than 90% of most equipment to be recycled, thereby reducing total disposal costs.

While not regulated by TSCA, Non-PCB equipment may fall under state and local laws that affect the disposal of oil-bearing items because of their oil content. Oil containing Non-PCB equipment is regulated under 40 CFR 279, which details the used oil management standards that are in place at the Federal level. At the same time, many States also have their own individual programs regarding the disposal of oil bearing items and may only authorize disposal at specific approved facilities. The Toxic Substance Control Act (TSCA) regulates the storage and disposal of PCB (Polychlorinated biphenyls), used extensively before 1978 as additives to dielectric and cooling oils. PCB's traditionally were used in electrical applications and are found in most electrical equipment including:

Transformers	Circuit breakers	Reclosers
Capacitors	Electromagnets	Switches
Voltage regulators	Cable	Bushings

Testing of electrical equipment to determine the PCB content of either the dielectric fluid or the mineral oil is not always practical and, in the case of capacitors, may not always be possible. If the equipment is labeled *"Non-PCB"*, then it has no PCB's. If the equipment is either unmarked or poorly marked, the generator should assume PCB content >500 PPM and dispose of in accordance with TSCA guidelines. Accordingly, disposal of Non-PCB electrical equipment needs to be managed with environmental concerns in the forefront. The VES environmental background and technological expertise in electrical equipment recovery provides the safety and controls necessary for the recycling and disposal of Non-PCB equipment. VES PCB and Non-PCB recycling services operates out of our 24,000 square foot production facility in Phoenix, Arizona.

TSCA FACILITY:

Veolia ES Technical Solutions, L.L.C.
Electronics Recycling
5736 West Jefferson Street
Phoenix, AZ 85043
EPA ID # AZ0000337360
Phone # 800 368-9095

E. Mercury Retort Operations

Systems Capacity

System capacity is dependent on the type of material being processed. VES can operate 24 hours a day, seven days per week to meet customer needs. VES's processing capacity is approximately 1000-Cu. Yd per year.

Process Description

All materials received are manually inspected. Preprocessing steps recover valuable non-contaminated recyclables such as glass, metals, and plastics. The remaining contaminated mercury debris is then retorted under vacuum. Retort time, temperature and cycle are dependent upon the composition of material to be retorted. Mercury from the retort operations is collected in a system tank and from this tank, 76-pound or metric ton mercury flasks are filled. Mercury is accumulated and shipped to a mercury supply house for purification and packaged for resale.

Environmental and Safety Controls

The processing room is kept under negative pressure relative to ambient. This is done to prevent the release of mercury vapor to the environment. A Jerome mercury monitoring system is in place to gauge mercury levels in the process room, and the process air scrubbing systems. Operational parameters are monitored. The company recognizes and fully appreciates the high levels of liability exposure associated with virtually every kind of business in today's world. It also recognizes its responsibility to its customers to minimize their ultimate liability, as well as its own. Accordingly, it has taken a number of carefully considered measures to accomplish this:

- In-house liability prevention responsibility is designated to oversee all aspects of liability exposure reduction, to assure well-organized and consistent accident response procedures and to assure a proper level of written record keeping, particularly concerning inspection and testing.
- Sales agreements and other documents are carefully worded so as to minimize liability exposure.
- Pollution Legal Liability insurance coverage is an integral part of the company's liability insurance program.

Waste and Materials Analysis Plan

The Waste and Material Analysis Plan outlines procedures for sampling and analysis of metals, glass and mercury/phosphor components derived solely from processed fluorescent, as well as the mercury retort operations. The plan provides a framework for routine analysis of all process materials and waste streams, beginning with sampling objectives and continuing through QA/QC protocol and final analysis of laboratory data. The plan is available upon request.

Laboratory Analysis

Subcontracted laboratories provide analytical services to the Mercury Retort Operations to perform the following:

- Pre-qualification of customer waste, as needed
- Subsequent fingerprinting of waste shipments to determine conformity, as needed
- Post-analysis of process waste materials to determine mercury content
- Post-analysis of recovered materials to determine mercury content
- Metal alloy identification impurity
- Identification of non-conforming waste materials

When required, pre-qualification analysis (TCLP) usually is completed within 3 weeks of receipt of sample, profile sheet and other necessary paperwork. All analyses are subcontracted to state–certified laboratories.

V. Corporate Programs and General Operations

A. Facility / Corporate Compliance Programs

VES maintains support systems, which assure safe and compliant handling of PCBs, hazardous, and toxic waste during all company operations. These activities include implementation of the waste analysis and materials testing plan, waste disposal plan, personnel training plan, inspection plan, occupational health and safety plan, emergency/contingency plan, SPCC plan, and closure plans. The contingency plan is required to assure safeguarding of public health and the environment. The company compliance programs are outlined as follows:

Facility Compliance Program:

- Facility inspections
- Facility personnel training
- Compliance with licenses, permits and applicable regulatory laws
- Maintenance of records and documents
- Compliance management plans
- Manifests
- Internal records
- Health surveillance
- Facility monitoring

Corporate Compliance Program:

- Permit procurement
- External facility regulatory auditing
- Internal regulatory auditing, QA/QC of compliance programs
- Regulatory report submission
- Regulatory interpretation, guidance and policies
- Development and implementation of health and safety policies and procedures

Transportation Compliance Program:

- US DOT driver training
- Maintenance of log books
- Transport operating report submissions, where required
- Fuel tax reporting and permitting
- Transportation permit applications and renewals
- Form use (e.g. manifests)

B. Employee Training Policy

All new company personnel are required to satisfactorily complete occupational safety training prior to assignment to work stations. Such training is conducted by VES personnel and includes major topics such as:

- Specific characteristics of hazardous chemicals and waste with emphasis on mercury.
- The general purpose and scope of community and employee right-to-know laws.
- The intent and scope of RCRA and TSCA.
- Recommended transportation, handling and storage procedures for hazardous chemicals and waste with emphasis on mercury.
- Emergency response procedures and site-specific contingency plans.
- Operation of waste reduction, material recovery and metals refining equipment.
- Identification of unsafe operating conditions and utilization of personal protective equipment.
- Spill control prevention methods.
- OSHA regulations for general employee safety.

Employees working within RCRA permitted storage areas are required to undergo 24 hours of formal training starting at their date of employment or the date of their assignment to that task. If on-the-job training is utilized to accomplish specialized training during this initial period, the employee will neither be permitted nor assigned to work in any unsupervised position until he or she has completed the training outlined above.

C. Health Surveillance

VES will conduct a complete health surveillance program addressing the four major areas of Pre-employment physical examinations, Employment physical examinations at hire, Annual physical examinations during employment and Exit physical examinations at termination of employment. VES contracts for health surveillance services utilizing locally approved medical centers supervised by a national occupational medicine provider.

D. Facility Inspections

Inspections are conducted by VES personnel on a routine basis and recorded on appropriately designed checklists Exceptions to standard conditions are corrected immediately. Inspection frequencies are based upon maximum deterioration rates and realistic probabilities that any given equipment malfunction or failure will impact human health or the environment. Areas subject to spills such as loading/off-loading; waste reduction, recycling and storage areas are inspected daily. VES's facility inspection plans were developed to address the types of problems associated with both the materials VES handles and the equipment used in their related processes. The general classifications of equipment covered in these plans are as follows:

- Monitoring equipment
- Logistics control equipment
- Recycling processing equipment
- Laboratory equipment
- Spill & decontamination equipment
- Material handling equipment
- Storage bins, conveyors & feed chutes
- Storage & containment systems
- Safety equipment
- Fire protection equipment
- Security equipment
- Structures

E. Safety Program

A major element of VES's Hazard Reduction Program is the emphasis on personnel safety and the assurance of safe practices. VES provides copies of safety policies and procedures to all employees. Training pertaining to employee safety is generally conducted as outlined previously. Additional safety meetings are conducted periodically and as needed. Personal protective equipment is maintained and provided by VES to all personnel required to use the equipment. Basic equipment includes:

Safety glasses, hearing protection, safety-toe boots, Tyvek disposable coveralls, Nitrile gloves, cut resistant gloves and sleeves and appropriate respiratory protection that may include dust masks, cartridge respirators or supplied air respirators.

Emergency equipment includes:

- Dry chemical fire extinguishers located throughout the facilities, including office areas.
- Spill control and clean-up materials maintained within the warehouse areas.
- First aid and basic medical supplies.

F. Contingency Plan / SPCC Plan

Contingency plans have been prepared for each facility. SPCC plans have been prepared for each facility subject to the SPCC planning requirements. The contingency plan describes the planned, organized and coordinated course of action personnel will follow in the event of a threat of or actual

incident of fire, explosion, spill or other release of hazardous material(s) which could threaten human health or the environment. Various sections of the plan address:

- Personnel/tasks
- Emergency response procedures
- Control procedures
- Post-emergency procedures
- Incident reporting
- Emergency equipment
- Evacuation Plan

The plans identify at least two emergency coordinators who are authorized to commit resources necessary to expediently and effectively implement the plans. The following public assistance facilities/agencies have been identified and are an integral part of the emergency plan:

- National Response Center
- EPA
- State Regulatory Agencies
- Local Fire Department
- Local Police Department
- Local Hospital

Fire/evacuation drills are conducted at random times throughout the year. Copies of VES's contingency and SPCC plans can be provided to prospective customers upon request.

VI. Risk Management

A. Environmental Information

Permit Information

Veolia ES Technical Solutions, L.L.C. operates (4) four fully permitted lamp and ballast recycling facilities across country. Facilities are located in Arizona, Wisconsin, Massachusetts and Florida.

Facility Permits and Licenses

Facility Name Address Telephone Site Contact	Part B Permit or Solid Waste Permit Number, Date of Issuance, and Expiration Date	Air Permit Number, Date of Issuance, and Expiration Date	NPDES Permit Number, Date of Issuance, and Expiration Date	Wastewater Discharge Permit Number, Date of Issuance, and Expiration Date	TSCA Permit Number, Date of Issuance, and Expiration Date	EPA Id Number
Veolia ES Technical Solutions, L.L.C. 5752 West Jefferson Street Phoenix, Arizona 85043 Contact: Heath Hildebrand 602-233-2955 or 800-368-9095	ADEQ RCRA Part B Permit Submitted 10/14/98 ADEQ Compliance Agreement issued 9/02. No Expiration Date	Air Quality Permit from Maricopa County, AZ #000139 Expires: 3/31/06 Under renewal	NPDES Permit AZMSG-12840 1/3/10	City of Phoenix 0306-10963-ZCD 2/28/09	TSCA Permit AZD983473539 Issued: 12/15/94 Expires: 12/31/99- Written request for renewal submitted 180 prior to expiration Alternate Disposal Technology issued by EPA Region IX 12/15/98 (40 CFR 761.60 (e)	AZ0000337360
Veolia ES Technical Solutions, L.L.C. 1275 Mineral Springs Drive Port Washington, WI 53074 Contact: Kevin Shaver 262-284-6855	RCRA Permit: WID988566543 Issued:10/1/99 Under renewal WDNR License #6008 Issued 10/1/06 Expires: 9/30/07 SW License: 03870 Issued 10/1/06 Expires 9/30/07	Air Permit #01-DJH-339 Iss:3/01/05 Expires: 2/28/10	NA	NA	Meets Exemption Criteria	WID988566543
Veolia ES Technical Solutions, L.L.C. 230 Canton Street Stoughton, MA 02072 Contact: Paul Conca 781-341-6080	Class C Recycling Permit 1RC/2005 Issued 5/20/05 Expires 5/20/10	NA	NA	NA	TSCA Permit MA5000004713 Issued: 1/20/99 Expires: 1/31/09	MA5000004713
Veolia ES Technical Solutions, L.L.C. 342 Marpan Lane Tallahassee, FL 32305 Contact: Linda Dunwoody 850-877-8299	Permit Number HO 37-82472-004 Issued 9/26/01 Expires 9/26/06 Under renewal	0730094-05-AG Issued: 5/27/98 Expires 5/27/08	FLR05F873 Expires: 6/11/2009	NA	NA	FL0000207449

Transportation Permits and Licenses

Jurisdiction	Permit Name	Number
Alabama	Hazardous Waste	NJD080631369
Arkansas	DOT	H-986
Arkansas	DEP	PC-1562
Arizona		NJD080631369
Boston	Fire Department	7026
Broward County	Hazardous Materials	HMT –01-16993
California	Hazardous Materials	CA - 76443
California	Hazardous Waste	3424
California	Motor Carrier Authority	0076443
Colorado	Hazardous Materials	HMP-02581
Connecticut	Hazardous Waste	CT-HW-663
Connecticut	Biomedical Waste	CT-BMW-012
Dade County, FL	Liquid Waste Hauler	LW-HW2000-0001-000
Delaware	Solid Waste Transporter	DE-SW-463
Delaware	Hazardous Waste	DE-HW-463
Florida	Hazardous Waste	NJD-080631369
Florida	Mercury Containing Lamps & Devices	NJD080631369
Florida	Used Oil Transporter	NJD080631369
Georgia	Hazardous Materials	10444-10451
ICC	Motor Carrier Authority	MC295758
Idaho	Hazardous Waste	1001043
Idaho	Hazardous Material	1001043
IFTA	Fuel Tax – Illinois base	IL36428799801
Illinois		
Illinois ICC	Single State Registration	112609
Indiana		NJD080631369
Iowa		NJD080631369
Kansas	Hazardous Waste	NJD080631369
Kentucky		NJD080631369
Louisiana		NJD080361369
Maine	Hazardous Waste	ME-HWT 400 ME-WOT-425
Maryland	Hazardous Waste	HWH599
Massachusetts	Hazardous Waste	452
Michigan	Liquid Industrial Waste Uniform Program	LIW 0609181 MI
Mississippi		NJD080631369
Missouri	Hazardous Waste	H-2146
Montana		NJD080631369
Nebraska		NJD080631369
New Hampshire	Hazardous Waste	TNH-0227
New Jersey	Hazardous Waste	50160
New Jersey	Solid Waste	20071
New Mexico	Hazardous Material	00000835744
New Mexico	Tax ID	0835744
New York	Waste Transporter	NJ-410
New York	Highway Use Tax	Varies
New York City	Fire Department	
New York City	Dept. of Consumer Affairs	Transfer
North Carolina		NJD080631369
North Dakota		WH-586
Oklahoma		3883
Oregon	PUC	217942
Pennsylvania	Hazardous Waste	PA-AH0500

Jurisdiction	Permit Name	Number
Pennsylvania	PUC Authority	A-00112479
Pennsylvania	Turnpike Commission	1571
Rhode Island	Hazardous Waste	RI-748
Rhode Island	Medical Waste	RI-410
South Carolina	Hazardous Waste NJD080631369	NJD080631369
South Carolina Used Oil Reg	Used Oil Registration	UOT – NJD080631369
South Dakota		NJD080631369
Tampa	Solid Waste-recycling	02-002356-PRS
Tennessee	Hazardous	NJD080631369
Tennessee	Radioactive	T-NJ011-L01
Texas	Hazardous Materials	00504177OC
USDOT	Motor Carrier ID	609181
USDOT	RSPA Registration	061103015031L
USEPA	Hazardous Waste	NJD080631369
USEPA	TSCA-PCB Transporter	NJD080631369
Utah	Davis Co. Scavenger & Salvage	Varies Per vehicle
Vermont	Waste Transporter	54013
Virginia	Hazardous	NJD080631369
Washington	Interstate Common Carrier Permit	CC-58568
Wisconsin	Hazardous Waste	16139
Wisconsin	Solid Waste	13800
Wisconsin	Infectious Waste	14520
Wyoming		NJD080631369
OH, OK, IL, NV, WV, MI, MN	Uniform Program Registration	UPW-0609181-OH

Copies of all permits available upon request.

Compliance Record

VES maintains an excellent record of compliance with regulations governing health and safety and the environment. This record is ready for inspection at any time. A culture of compliance is a way of life at VES, where we manage lighting and electronic waste with the utmost care. We follow procedures meticulously with our on-site teams, and continue to focus on the details throughout transportation, treatment, recycling and disposal. Compliance records appear following for each facility, based upon that last five years

NOV- Notice of violation
NON- Notice of Non Compliance

All regulatory inspections are available for review on site.

Phoenix, AZ

VES maintains an excellent record of compliance with regulations governing health and safety and the environment. This record is ready for inspection at any time. A culture of compliance is a way of life at VES, where we manage lighting and electronic waste with the utmost care. We follow procedures meticulously with our on-site teams, and continue to focus on the details throughout transportation, treatment, recycling and disposal. A compliance record is shown below for our Phoenix, AZ facility based upon that last five years. The VES Phoenix, AZ facility is permitted to store hazardous waste. Associated with this permit, VES is inspected approximately yearly by the Arizona Department of Environmental Quality (ADEQ). VES is approved to store PCB waste. Associated with this approval, inspections occur approximately biannually by US EPA Region IX.

Date	Agency	Program	Description	Penalty Accessed
4/3/2001	US EPA Region IX	RCRA	NOV issued for containers not properly marked Universal Waste, Failure to submit one time BIF exemption notification	Monetary Penalty of 18,150.00 to US EPA Closed 10/3/2002
5/3/2001	ADEQ	RCRA	NOV issued for exceeding storage capacity, improper recording keeping, unmarked containers of Hazardous Waste	Monetary Penalty of $125,000.00 and a SEP with Phoenix Union High School District for $125,000.00. Closed 10/03/2002
5/10/2001	City of Phoenix	Fire	Routine Fire Occupancy Inspection. Facility was required to put up HMIS signs on outside of buildings and gates to facility.	Closed- No Penalty
4/24/2002	City of Phoenix	Zoning	NOV issued for treating hazardous waste, processing PCB's greater than 50 ppm, and treating or disposing of hazardous waste outside of an enclosed building, non conforming use in accordance with City Ordinance 648.	Zoning Waiver Application approved by City Council on May 5, 2004.
4/16/2002	ADEQ	RCRA	NOV issued for container not having a spill proof lid, and LDR violation that was withdrawn upon documenting compliance	Closed- No Penalty
4/24/2003	Federal Motor Carrier Safety	DOT	Terminal Hazardous Materials Shippers review. No issues at time of inspection.	Closed- No Penalty
5/12/2003	Maricopa County	Air	No Issues at time of inspection	Closed- No Penalty
3/31/2004	US EPA Region IX	TSCA	No Issues at time of inspection, Samples of decontaminated metals taken for analytical at US EPA Lab. Provided 15 months of inbound and outbound manifests to EPA	Pending
6/22/2004	ADEQ	RCRA	Satellite Accumulation Container lid not closed and Accumulation Start date on container did not match on two labels on same container	Closed- No Penalty
10/27/2004	US EPA Region IX	RCRA	Universal Waste pallets must be labeled while in process or storage areas. Fixed on the spot and No Violations. CERCLA Off Site Approved	Closed-No Penalty

Date	Agency	Program	Description	Penalty Accessed
6/28/2005	ADEQ	RCRA	Facility not submitting copies of signed Outbound Shipment Manifest to ADEQ- Provided copies of all 2002,2003,2004 and YTD 2005 manifests during inspection	NOV Issued for generator failing to provide signed copies of site generated waste manifests to ADEQ. NOV closed with no penalties.
12/14/2005	Maricopa County Air Quality	Air	Routine Compliance Inspection.	Closed- No violations
4/26/2006	ADEQ	RCRA	Universal Waste lamps must be stored in properly closed containers. Drywell on the north east side of site must have asphalt repaired around the drywell. Barbwire on top of fence must be repaired as it is loose.	Pending written inspection report

Port Washington, WI

VES maintains an excellent record of compliance with regulations governing health and safety and the environment. This record is ready for inspection at any time. A culture of compliance is a way of life at VES, where we manage lighting and electronic waste with the utmost care. We follow procedures meticulously with our on-site teams, and continue to focus on the details throughout transportation, treatment, recycling and disposal. VES is permitted to store hazardous waste. Associated with this permit, VES is inspected approximately twice per year by the Wisconsin Department of Natural Resources (WDNR).

Date	Agency	Program	Description of Violations	Corrective Actions	Status of Corrective Actions	Penalty Assessed
6/15/2000	WDNR	RCRA	No Violations	None	None	None
12/2/2000	US EPA	RCRA	NOV failure to submit an un-manifested waste report, the report was submitted within the time frame allowed. Inadequate inspection records, inspection logs updated. Transfer facility logs were incomplete. Training for two employees not completed, training had been performed within the one-year time frame but summary page had not been updated.	Un-manifested waste report filed within time frame allowed by regulation, no corrective action required. Update training summary page. Update inspection forms to include additional items, and update transfer logs.	Complete, Acknowledgement Letter received from US EPA May 1, 2001	None
5/24/2001	WDNR	RCRA	NON one container not fitted with a proper lid	Replace lid with an undamaged lid	Complete	None
12/6/2001	WDNR	RCRA	NON damaged fence and tracking of phosphor powder generated	Repair fence and implement updated tracking system	Complete	None
5/21/2002	WDNR	RCRA	NON one drum on loading dock without a lid.	Put lid on drum	Complete	None
12/19/2002	WDNR	RCRA	No Violations noted, one area of concern identified regarding the storage of mixed batteries.	None required	None	None
6/17/2003	WDNR	RCRA	NON inadequate security measures	Developed program for keeping doors locked at all times	Complete	None
11/14/03	WDNR	RCRA	NON container labels, storage space, container height, security measures, inventory tracking	Relabeled containers, relocated containers, updated security and inventory	Complete	None
6/25/04	WDNR	RCRA	No violations noted	None required	None	None
12/16/04	WDNR	RCRA	No violations noted	None required	None	None
6/15/05	WDNR	RCRA	No violations noted	None required	None	None

Stoughton, MA

VES maintains an excellent record of compliance with regulations governing health and safety and the environment. This record is ready for inspection at any time. A culture of compliance is a way of life at VES, where we manage lighting and electronic waste with the utmost care. We follow procedures meticulously with our on-site teams, and continue to focus on the details throughout transportation, treatment, recycling and disposal. VES is permitted to operate al amp recycling and mercury reclamation processes under a “Class C” Commercial Recycling Permit issued by the Massachusetts Department of Environmental Protection (MADEP).

Date	Agency	Description of Violations	Corrective Actions	Status of Corrective Actions	Penalty Assessed
7/25/96	US EPA Region I	No violations noted	None	None	None
7/23/96	MA DEP	No violations noted	None	None	None
8/21/96	MA DEP	No violations noted	None	None	None
11/26/96	MA DEP	No violations noted	None	None	None
1/16/97	MA DEP	No violations noted	None	None	None
8/15/97	US EPA Region I	No violations noted	None	None	None
10/15/97	MA DEP	No violations noted	None	None	None
10/15/97	Town of Stoughton Board of Health	No violations noted	None	None	None
7/15/98	MA DEP	No violations noted	None	None	None
11/16/00	US OSHA	5 violations noted, 3 relating to respiratory protection program, 1 for an inoperative interlock device on a baler and 1 for an electrical box that was exposed to moisture when it rained.	Update respiratory program, fix baler, repair roof	Complete	$3,562.50
2/21/01	US EPA Region I	No violations noted	None	None	None
4/2/01	MA DEP	No violations noted	None	None	None
1/8/02	US EPA Region I	No violations noted	None	None	None
11/18/02	US EPA Region I	NON, 1 container missing a PCB label, 1 container missing an out of service date, two bench grinders located outside the ballast processing room	Containers labeled and dated during inspection, grinders move into processing room later same day.	Complete	None
8/22/02	MA DEP	No report received	None	None	None
1/6/04	US EPA Region I	No Violations	None	None	None
11/23/04	US OSHA	Defective eye wash station.	Repaired same day	Complete	$725.00
12/7/04	US OSHA	2 violations - improperly guarded shear, improperly guarded conveyor belt, damaged forklift tires	Shears retrofitted with guards and conveyor guarded, forklift tires replaced.	Complete	$1325.00

Tallahassee, FL

Veolia ES Technical Solutions, L.L.C. (OES) is permitted to store hazardous waste. Associated with this permit, OES is inspected approximately yearly by the Florida Department of Environmental Protection (DEP).

VES maintains an excellent record of compliance with regulations governing health and safety and the environment. This record is ready for inspection at any time. A culture of compliance is a way of life at VES, where we manage lighting and electronic waste with the utmost care. We follow procedures meticulously with our on-site teams, and continue to focus on the details throughout transportation, treatment, recycling and disposal.

VES is permitted to store hazardous waste. Associated with this permit, VES is inspected approximately yearly by the Florida Department of Environmental Protection (DEP).

Date	Agency	Program	Description of Violations	Corrective Actions	Status of Corrective Actions	Penalty Assessed
3/6/2000	FL DEP	Solid Waste	No violations noted	None	None	None
11/16/2000	FL DEP	Solid Waste	No violations noted	None	None	None
1/17/2001	FL DEP	RCRA	NOV - exceeding permitted capacity, achieving <99% recovery, and not submitting samples in a timely manner	Process materials or ship to off-site facility to reduce volume to permitted limit. Obtain a variance from the percent recovery requirement and submit samples in a timely manner.	Complete	$6,600.00
3/9/2001	FL DEP	Solid Waste	No violations noted	None	None	None
8/30/2001	FL DEP	Air Resources	No violations noted	None	None	None
2/13/2002	FL DEP	Solid Waste	No violations noted	None	None	None
5/22/2002	FL DEP & U.S. EPA	RCRA	NOV - inadequate aisle space, one drum with no lid and one drum with a lid not properly secured, training records not complete, one employee had been trained but log and summary had not been updated.	Rearrange drums to ensure adequate aisle space, cover or process open containers, update training logs and summary.	Complete	$2,937.00
3/6/2003	FL DEP	Air Resources	No violations noted	None	None	None
5/15/2003	FL DEP	Air Resources	No violations noted	None	None	None
6/3/2003	FL DEP	RCRA	No violations noted	None	None	None
8/19/2004	FL DEP	RCRA	No violations noted	None	None	None
1/6/2005	FL DEP	Air Resources	No violations noted	None	None	None
4/1/2005	FL DEP	Storm water	No violations noted	None	None	None
5/10/2005	FL DEP	RCRA	No violations noted	None	None	None
1/30/2006	FL DEP	Air Resources	No violations noted	None	None	None

Regulatory Agency Contact Information

Veolia ES Technical Solutions, L.L.C. remains in compliance with all facility permits. Regulatory contacts appear below.

Phoenix, AZ

Chris Rollins
Toxics Office
US EPA, Region IX
75 Hawthorne Street (CMD-4)
San Francisco, CA 94105-3920
(415) 947-4166

Steve Miller
Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, Arizona 85007
(602) 771-4579

Sean Riley
Air Quality Inspector
Maricopa County Environmental Services Department
1001 North Central Avenue, Suite 200
Phoenix, Arizona 85004-1942
(602) 525-0470

Port Washington, WI

Dolores R. Hayden
Hazardous Waste Management Specialist
Wisconsin Department of Natural Resources
2300 N. Martin Luther King Jr. Drive
PO Box 12436
Milwaukee, WI 53212-0436
(414) 263-8580

Mark Stohl
Solid Waste Management Engineer
Wisconsin Department of Natural Resources
9531 Rayne Road, Suite IV
Sturtevant, WI 53177
(262) 884-2340

Dan Hellenberg
Air Emission Environmental Engineer
Wisconsin Department of Natural Resources
4041 North Richards Street
PO Box 12436
Milwaukee, WI 53212
(414) 229-0837

Stoughton, MA

Jim Miller MADEP
1 Winter Street, Boston, MA 02108
(617) 292-5574

Joe Leary MADEP, SE Region Office
20 Riverside Drive, Lakeville, MA 02347
(508) 946-2831

Marianne Millette USEPA, Region I
TSCA JFK Federal Building, Boston, MA 02202-0001
(617) 918-1854

Tallahassee, FL

Jim Byer
Florida Department of Environmental Protection
160 Government Center, Pensacola, FL 32501-5794
(850) 595-8360 ext 1264

B. Indemnification

VES will agrees to defend, indemnify, and hold harmless our customers, its affiliates and subsidiary entities, and it and their officers, directors, employees and representatives in any action arising out of the services provided by VES or any of its employees or agents (including but not limited to any subcontractors), or any breach of contract, including, but not limited to any and all claims, fines, penalties, suits, causes of action, liabilities, losses and expenses (including attorneys' fees and costs of litigation) arising out of or resulting from the handling and disposal of the materials.

It's important to note that any company can provide indemnification. What's important when measuring indemnification is whether or not a company can meet those expectations? VES offers true indemnification protection through our unmatched insurance coverage, fully funded facility-closure plans, as well as our financial strength and stability.

Insurance

Veolia ES Technical Solutions, L.L.C. carries all applicable insurance as part of the policy provided by VES North America Corp.

The current program in place has been designed in conjunction with VES North America Corp. by Marsh, Inc., the world's largest insurance broker and a leader in environmental insurance. Environmental coverage are placed with the American International Group (AIG), the largest insurer in the United States and the largest underwriters of environmental risks; Discover RE, Zurich, Liberty International, and Commonwealth. The program was specifically structured for VES North America Corp. and incorporates the most recent coverage available.

Workers Compensation / Employers Liability

The WC/EL policy provides coverage that conforms to the statutory requirements for each state in which employees of VES North America Corp. perform operations. The policy is further endorsed to provide coverage for the United States Longshoremen and Harbor workers Act and for Maritime Employers Liability including Transportation, Wages, and Cure.

Commercial Motor Vehicle Liability

Providing limits of a $5,000,000 combined single limit ($1,000,000 Veolia ES Waste to Energy, Inc. and subsidiaries), this policy protects VES North America Corp. for claims from third parties for bodily injury and property damage arising out the use of any owned, non-owned, or hired motor vehicle. Where hazardous waste requirements are present, the policy has been endorsed to address such areas as MCS 90 endorsement mandated by the Motor Carrier Act of 1980 and protects us from pollution liability resulting from the use of motor vehicles. Contractors without an MCS 90 endorsement on their auto policy provide no protection for accidents that occur over the road. We believe the MCS-90 endorsement is a necessity in order to protect our customers. VES subcontractors carry this endorsement.

Commercial General Liability (CGL)

The CGL policy provides occurrence based coverage for bodily injury, property damage and personal injury of third parties arising from the negligence of VES North America Corp.'s facilities, premises, operations, and products. A primary limit of liability of $5,000,000 per occurrence/$5,000,000 aggregate is provided. It is further supplemented by Excess Environmental Umbrella coverage, which will be addressed later.

Pollution Legal Liability (PLL)

Pollution Legal Liability (PLL) insurance is an essential asset management tool for businesses that have environmental exposures. Whether hazardous or not, sudden or gradual, practically any substance can cause pollution, given the right circumstances. It includes coverage for third party claims of off-site bodily injury and property damage including legal defense costs and the cost of cleaning up the off-site contamination. A limit of liability of $5,000,000 per occurrence and in the aggregate ($20,000,000 for Veolia ES Waste to Energy, Inc and subsidiaries) is provided and includes coverage for such exposures to on-site third party bodily injury, and pollution related transportation risk exposures. This policy satisfies the financial responsibility requirement under the Resource Conservation and Recovery Act (RCRA).

Contractors Operations & Professional Services (COPS)

The COPS program meets the needs of the “hands-on” operations and professional services contracting arm of VES North America Corp. It insures against pollution claims that may arise from working at others' sites or claims that may arise out of acts, errors or omissions in rendering professional services. Limits of coverage are $5,000,000 each occurrence/total all claims ($25,000,000 for Veolia ES Waste to Energy, Inc and subsidiaries). COPS policy coverage is very important because this coverage protects customers from claims as a result of a contractor's error, while on customers’ property.

Environmental Umbrella Liability (Excess Liability)

This policy substantially extends the limits of the primary General Liability, Motor Vehicle Liability, and Employers Liability to $5,000,000 per occurence/$50,000,000 aggregate. This coverage also supplements the Pollution Legal Liability for claims that are sudden and accidental and are discovered and reported within policy parameters. Coverage is designed for environmental risks and specific limits of insurance coverage will be addressed on an as needed basis or may be noted on a certificate of insurance.

Property Coverage

Liberty International and Commonwealth partner to provide VES North America with a $100,000,000 of all risk property insurance program. The program contains boiler and machinery, business interruption, and earthquake/flood coverage.

We have dedicated significant resources to the proper implementation and administration of a high quality insurance program. Where applicable and within the parameters of the insurance contracts, coverage can be extended to VES North America Corp.'s customers as may be required by various contracts. VES North America Corp. has established a record of providing exemplary insurance coverage and risk management practices, which offer the prospect of stable and long-term relationships with their clients and customers.

Sample certificates can be forwarded upon request.

Funded Closure Plans

VES has made provisions for the proper closure of the company's facilities in the unlikely event that VES ceases operations. All closure plans are fully funded. These agreements to pay the costs associated with proper and complete closing of these facilities in accordance with the applicable state and federal environmental regulations. A brief description of each closure plan follows.

Phoenix, AZ

The VES facility in Phoenix, AZ has two closure plans in place. VES maintains trust funds agreements for both RCRA and TSCA operations.

Port Washington, WI

The Port Washington, WI has a single closure plan, approved by the Wisconsin Department of Natural Resources, which is funded by a letter of credit.

Stoughton, MA

At the Stoughton, MA facility, VES has in place two (2) Facility Closure Plans that have been approved by the MA DEP (mercury operations) and the US EPA Region I (ballast operations). These plans are funded through trust fund agreements.

Tallahassee, FL

The VES facility in Tallahassee, FL has one closure plan in place, approved by the Florida Department of Environmental Protection. This plan is funded through a performance bond.

Financial Strength and Stability

Veolia ES Technical Solutions, L.L.C. is a part of $1.6 Billion VES North America and part of $30 Billion Veolia Environnement. Veolia is a publicly owned company with 150 years of experience delivering environmental solutions and is the international leader in waste management as well as water and energy services. Veolia is the largest environmental services-company in the world and is committed to expanding its presence in North America. Financial strength and stability are key determinants of meeting indemnification contractual obligations. Audited financials for the parent company of Veolia ES Technical Solutions, L.L.C., can be forwarded upon request.

C. Experience

Summary

The final element of VES's risk management offering is the professional experience of the Electronics Recycling Team and the Team's commitment to protecting our customers from financial/legal liability and negative publicity. For several years, members of this Team have successfully fulfilled this most important of commitments. We would like very much to continue in this serious responsibility for your company.

The VES Team represents many years of experience in environmental and customer service. We have a proven track record of providing safe, reliable, and cost-effective environmental services to some of the nation's largest corporations and institutions. We have successfully managed recycling programs for lighting projects as large and the US Capitol Complex and Johnson Space Center retrofit projects, and as small as single box "mail-in " lamp recycling programs for the US Postal Service in the Northeast. We offer the same serious commitment to service and risk management to our "largest" and "smallest" customers.

Below, we have listed some of the customers we are currently servicing.

References

JC Penney Procurement, LP
P. O. Box 10001
Dallas, TX 75301-2107
Ms. Lisa Monnig
972-431-4375

Sears Roebuck and Co.
3333 Beverly Road, D824C
Hoffman Estates, IL 60179
Ms. Dawn Jess
847-286-8616

National Grid
55 Bearfoot Road
Northborough, MA 01532-1555
Ms. Anita Hagspiel
508-421-7721

State of New York
Office of General Services- Procurement Services Group
Corning Tower Building
Empire State Plaza
Albany, NY 12242
Gary Snay
(518) 473-5721

W. W. Grainger, Inc.
100 Grainger Parkway
Lake Forest, IL 60045-5201
Mr. Richard Cole
847-535-4278

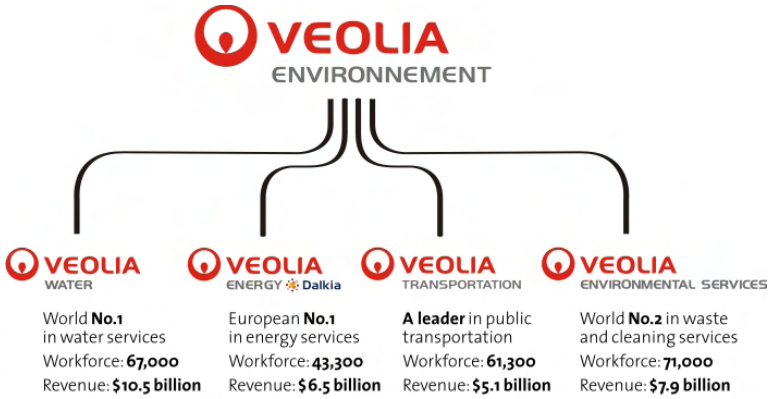
Gillette
1 Gillette Park
South Boston, MA 02127
Mr. Steven Fradkoff
617-463-2351

NSTAR Services Company
One NSTAR Way, Suite 360
Westwood, MA
Augustine Pimentel
(781) 441-8705

PSEG
243 West Jefferson
Gibbstown NJ 08027
Tom Costantino
856 224-1637

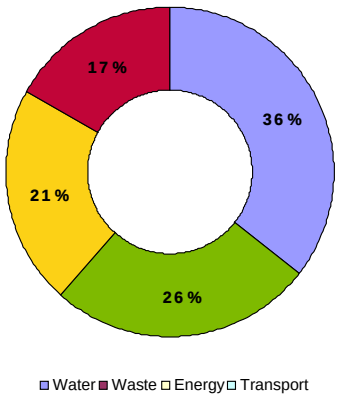
VIII. Company Background / Description

A. Veolia Environnement



Veolia Environnement operates the environmental services business, with operations in more than 80 countries on six continents. Veolia Environnement provides environmental management services, including water treatment and system operation, waste management, energy services and power generation, and transportation services, to a wide range of public authorities and industrial, commercial and residential customers. Veolia Environment is the only company to provide total integrated environmental services including:

- Water
- Waste Management
- Energy Services
- Transportation

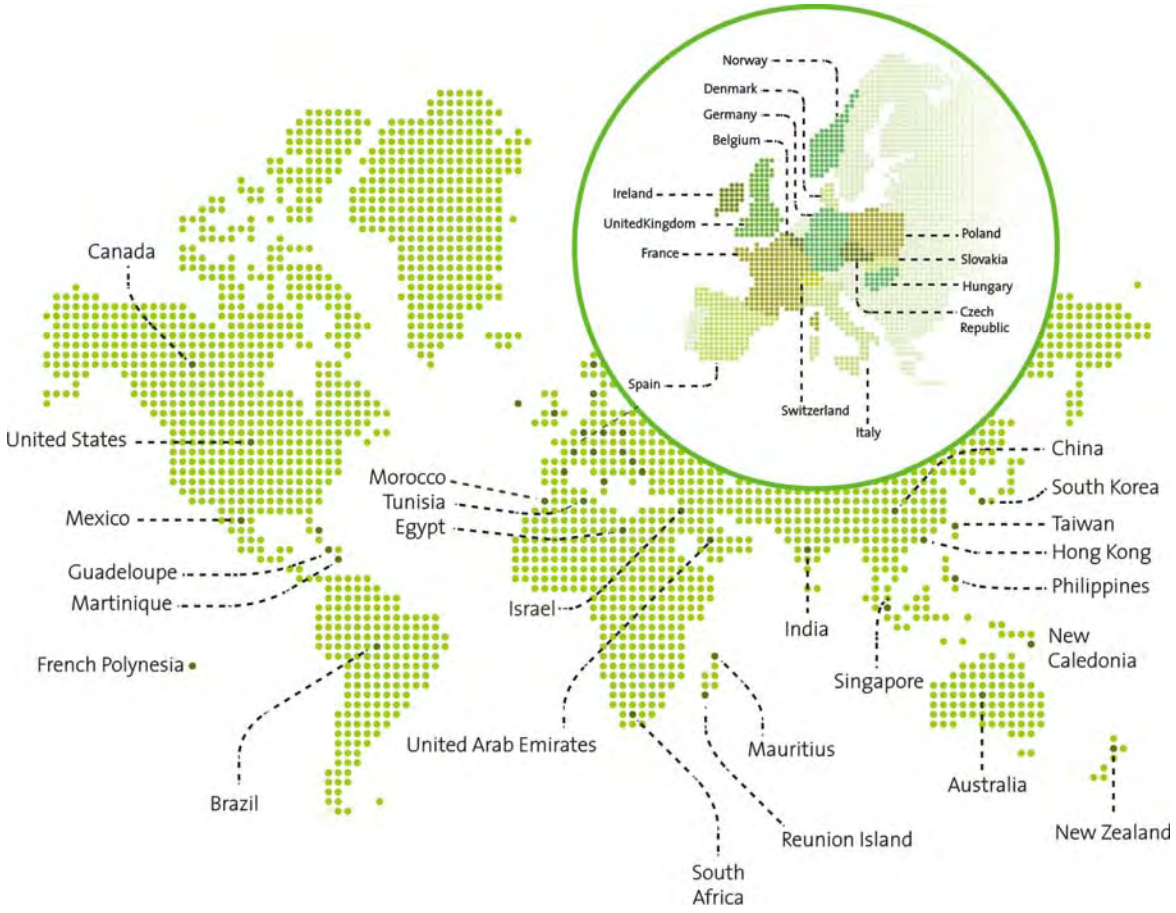


Key Facts

- # 1 Worldwide in Environmental Services
- Net sales 2005 of $30 Billion
- Water: 36% of Revenue
- Waste: 26% of Revenue
- Energy: 21% of Revenue
- Transport: 17% of Revenue
- 250,000+ employees
- Operations in over 80 countries & on 6 continents

Web site: http://www.veoliaenvironnement.com

B. VES Worldwide



Veolia Environmental Services, the waste management division of Veolia Environnement, is the world's second largest waste management company, with 80,000 employees in 35 countries. We generated revenues of 7.8 billion in 2005.

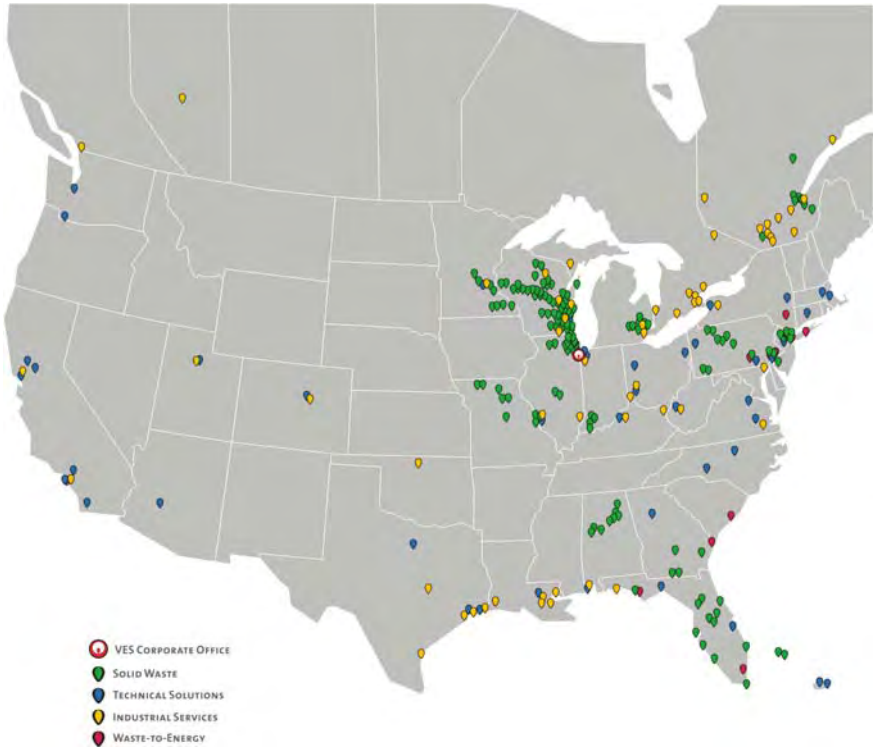
Veolia Environmental Services is the only company that handles all forms of waste, at every step in the waste management process. We manage liquid and solid, non-hazardous and hazardous waste, from collection to disposal and recycling, for both the public and private sectors.

Key Facts

- No 2. Worldwide in waste management and world leader in hazardous industrial waste management.
- 2005 Revenues Exceeded $7.8 billion
- Established in 35 countries
- 50 million people served worldwide;
- 80,000 employees

Web Site: http://www.veolia-proprete.com

C. VES North America



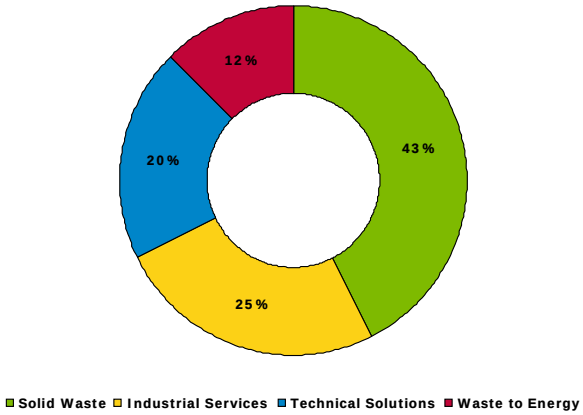
With $1.6 billion in revenues in 2005, Veolia Environmental Service s North America continues to innovate in order to maintain leadership in its ever-expanding business sector. The main components of our strategy are to treat waste and turn it into usable resources, to promote sustainable development through our work, to communicate and participate in public strategy, and to extend our presence around the world. Our services to industrial, commercial, municipal and residential customers include:

- Technical solutions (hazardous waste management)
- Industrial maintenance & cleaning
- Solid waste management
- Waste-to-Energy

Key Facts

- 2005 Revenues of $1.6 Billion
- Hazardous Waste 19%
- Industrial Services 24%
- Waste-to-Energy 12%
- Solid Waste 44%
- 250+ Facility and Service Locations
- Serving US, Canada and Puerto Rico
- 10,000 Employees

Web Site: http:www.VeoliaES.com



D. VES Family of Companies

Solid Waste

As a solid waste provider, we are one of the largest solid waste management organizations in North America, providing a full range of services to more than 128,000 commercial and industrial firms and 1,200,000 residences in 11 states, the Bahamas, and Canada. We operate 49 collection facilities and 26 solid waste sanitary landfill facilities in the United States. By working in partnership with communities, we aim to preserve valuable resources and extend landfill capacity by focusing on waste reduction, curbside collection, sorting and the processing and marketing of recyclables.

More information can be found at http://veoliaes-sw.com

Technical Solutions

Technical Solutions provides a complete range of services for industrial and municipal customers needing to dispose of hazardous and non-hazardous waste. With more than 45 sales, service, treatment and disposal facilities, our locations are convenient to most industrial facilities throughout the U.S. Services provided include thermal destruction, fuels blending, solvent recovery, electronics recycling and on-site technical services.

More information can be found at http://veoliaes-ts.com

Industrial Services

For more than 30 years, Industrial Services has worked as a business partner with its customers. Through continuing to combine the best technological capabilities and services expertise with a focused, business-plan approach, we provide a depth and breadth of industrial services focused on delivering cost-effective solutions. We address the short and long-term economic, environmental and performance needs of customers by working faster, smarter, and safer. Combined with best-in-class equipment, this approach reduces cost, risk, and production downtime.

More information can be found at http://veoliaes-is.com

Waste-to-Energy

Waste-to-Energy (WTE) operates and maintains plants under long-term contracts in cities throughout North America. WTE recovery provides communities with a safe and environmentally sound method of solid waste disposal, while helping North America decrease its dependency on fossil fuels. Our WTE plants generate enough electrical energy to meet the needs of three hundred thousand households. State-of-the-art air quality control systems enable our facilities to easily meet rigorous Clean Air standards. WTE also facilitates the design, construction, and financing of integrated solid waste management projects.

More information can be found at http://veoliaes-wte.com

E. Veolia ES Technical Solutions, L.L.C.

Electronics Recycling Branch

Veolia ES Technical Solutions, L.L.C.

The Electronics Recycling Branch of Veolia ES Technical Solutions, L.L.C. dates back to 1983, when our founding company was formed. Today, our company provides environmental services to a diverse customer base across the country. Purchased by Veolia Environment in July 1999, VES-TS is a wholly owned subsidiary of VESNA. The electronics recycling branch is managed through Veolia ES Technical Solutions, L.L.C. and began recycling electronic waste in 1992.

Key Facts:

Company Legal Name:	Veolia ES Technical Solutions, L.L.C. Previous names were Onyx Environmental Services, L.L.C. and Onyx Special Services, Inc.
Branch Headquarters:	Veolia ES Technical Solutions, L.L.C. Electronics Recycling 1275 Mineral Springs Drive Port Washington, WI 53074 T: (262) 243-8900 F: (262) 284-3775
Headquarters:	Veolia ES Technical Solutions, L.L.C. 700 East Butterfield Road Suite 201 Lombard, IL 60148 T: (630) 218-1500 F: (630) 627-2983
Duns #:	08-218-4156
FEIN#:	36-4287998
Date of Incorporation:	State of Delaware 03/24/99
Locations:	45
Employees:	1400
2005 Revenues:	$321M
President:	Philippe J. Martin
Insurance Brokers:	Marsh, Inc.
Insurance Company:	American International Group
Toll Free Number:	(800) 556-5267
Web site:	http://www.VeoliaES.com

Electronics Recycling Timeline

- **Jan. 1983- Founding company incorporated in State of WI**
- **Feb. 1993- Superior Services is formed through the consolidation of 22 companies**
- **Feb. 1993- Superior offers lamp recycling services**
- **Feb. 1994- Superior offers mercury retort services**
- **Dec. 1997- Superior acquires Dynex, Inc. Greendale, WI St. Paul, MN**
- **July 1999- Vivendi Environment Acquires Superior**
- **Oct. 1999- Superior acquires Recyclights, Inc. Bloomington, MN Columbus, OH, Lakeland and Tallahassee, FL**
- **Oct. 1999- Superior acquires P3, Inc. Plant City, FL**
- **Nov. 1999- Superior acquires Quick Silver, Inc., Tampa, FL**
- **April 2000- Superior acquires Global Recycling Technologies, Inc. Stoughton, Massachusetts**
- **May 2000- Superior acquires Salesco Systems USA, Inc. Phoenix, Arizona**
- **Jan. 2003- Superior Special Services changes name to Onyx Special Services, Inc. The Electronics Recycling Division is the largest lamp recycler in the country.**
- **Jan. 2005- The Electronics Recycling Division becomes legally Onyx Environmental Services, L.L.C.**
- **July 2006- Onyx Environmental Services, L.L.C. becomes Veolia ES Technical Solutions, L.L.C.**

F. Electronics Recycling Services

Veolia Environmental Services (VES) offers solutions for both large and small quantities of lighting and electronic waste. Whether customers participate in our "Bulk" recycling or "OnyxPak®" prepaid recycling program, both are assured environmental compliance, liability protection and timely and responsive service. Our turnkey recycling programs include packaging, transportation, tracking documents, and waste processing, and recycling certificates for customers throughout the United States.

Mercury-Bearing Lamps	
Straight fluorescent	U-tubes
Circular lamps	Compacts
HIDs	Neons
Shielded/coated	Ultra violets
Mercury Waste	
Thermometers	Thermostats
Relays	Manometers
Ignitron tubes	Flow meters
Rectifiers	Gas pressure regulators
PCB and Non-PCB Lamp Ballast	
Magnetic and Dimmable Fluorescent Ballasts	CFL Ballasts
Pulse Start Metal Halide Ballasts	Mercury Lamp Ballasts
Standard Metal Halide Ballasts	Electronic HID Ballasts
High and Low Pressure Sodium Ballasts	PCB and Non-PCB Ballasts
Batteries	
Alkaline	Nickel metal hydride
Mercury	Zinc carbonaire
Lithium	Nickel cadmium
Carbon zinc	Silver oxide
Magnesium	Lead acid/gel cell
PCB and Non-PCB Electronic Waste	
Transformers	Capacitors
Switches	Debris and oil
Cable	Bushings
Computers and Electronic Equipment	
Cathode ray tubes (CRTs)	PCs, mainframes, peripherals
Telephone systems	Generators
Medical equipment	Wire
Office equipment	Motors

VES also offers a full range of packaging for smaller quantities of lighting and electronic waste. Our RECYCLEPAK program was designed was designed to handle small quantities of lamps, TSCA-exempt PCB and Non-PCB lamp ballast, dry cell batteries, mercury thermostats and computer CRTs. Contact your customer service or sales representative for additional details or visit www.prepaidrecycling.com for more information.

IX. Value to You: A Summary

As stated in the previous section, the employees of VES take very seriously our responsibility to protect the environment and public health through the proper management of our customers' wastes. We understand that protecting the environment also protects our customers from financial and regulatory liability and the resulting negative publicity.

This proposal represents our commitment that we will deliver the highest possible value in a recycling program for lighting waste from your facilities across the nation. The value we bring consists of three elements: risk management, responsive service, and reasonable pricing.

Risk Management

Environmental and Operational Safeguards

- Legitimate recycling and materials recovery and management
- Strict operating permits, that include training, contingency plans, health monitoring, and other protections
- Regulatory compliance and responsibilities
- Nationwide emergency response capabilities
- Experienced team of professionals

Financial Strength

- Meaningful indemnification backed by the best and most complete insurance coverage available in our industry
- Fully-funded, state-approved facility closure plans
- Financial resources of a large, profitable environmental services company

Responsive Service

- eFax ordering system
- Team of regional customer service representatives
- Minimal transport distances
- Ongoing service monitoring
- Convenient RECYCLEPAK recycling "kit" service
- Senior management commitment and oversight

Reasonable Pricing

We have developed pricing based on a careful review of the market, our operations and service options, our costs, and opportunities for savings – without sacrificing risk management and service. We believe that, based on our understanding of current market conditions, the pricing that is offered in this proposal is competitive and reasonable for the services offered.

We believe that the value we incorporate into this proposal from not only a service and pricing standpoint, but also the marketing support will maintain and strengthen a mutually beneficial relationship between your company and VES.

Pricing to be presented at a later date.