

LED STREET LIGHTING RESEARCH PROJECT June 8, 2011

TECHNICAL AND AESTHETIC PERFORMANCE FOR BUSINESS DISTRICT LED LIGHTING

The performance of new LED street lighting luminaires is intended to be superior to the performance of the HID luminaires they are replacing. This is true in terms of more accurate color rendering, but is also true in terms of visibility, glare, and energy consumption. Within the standards that are noted below, the intent of this lighting is to only see the effects of the lighting on the ground, sidewalks, streets, and parts of building facades, but to not see the light sources from most angles of view.

Although LED lighting can be very even, it is the intent of these recommendations to comply with the noted lighting regulations at the lowest acceptable evenness ratio in order to control for glare and visual clarity.

General Criteria:

1. Luminaires for LED replacement are existing business district shoebox, cobra head, teardrop, and acorn luminaires.
2. The entire luminaire *head* is to be replaced, not just the HID lamps. The luminaire is to attach to existing pendants or poles similar to existing shoebox, cobra head, teardrop, and acorn luminaires. Manufacturers are responsible for this coordination between existing pendants or poles and new lighting heads.
3. Light color is to be white within a required temperature range noted below.
4. Under good street lighting conditions, the LED light source should not be visible to drivers or pedestrians, unless they are looking directly up into the light source.
5. Lighting that is non-uniformly distributed is better than lighting that is uniform in terms of glare, as evenness requires higher power for lighting toward the edges of the distribution pattern. This high angle glare is not acceptable.
6. The current acorn luminaire will be discontinued because of glare issues and dark sky considerations and replaced with an LED equivalent luminaire for mounting atop 15' high poles with either down-firing or up-firing LED cells.
7. Imaging photometry will be used to benchmark glare by measuring luminance at high resolution. Measurements will be both photopic and scotopic.
8. LED luminaires must be guaranteed for a minimum 10-year life span, defined as no more than a 30% deterioration of LED cells in each luminaire and continuous maintenance of the minimum FC illuminance within a 10 year period
9. LED luminaires are intended to meet current City of Pittsburgh Lighting Ordinance requirements for business district lighting.

Base Criteria: Photometrics

1. Illuminance must meet a minimum of 1.5 FC as a maintained value on the roadway and a uniformity ratio of 4:1 per City of Pittsburgh Lighting Ordinance requirements for street lighting in business districts.
2. It is preferable to use lower power LEDs and higher source quantity to correct brightness.
3. The preferable lighting pattern is overlapping ovals, with adjustable cutoff angles to minimize glare. Typical 25' high street lighting (existing cobra head and teardrop luminaires) is typically spaced at 85 to 150 feet apart. Typical 30' high street lighting (existing shoebox luminaires at Downtown intersections only) is located atop signal light poles at all four corners of intersections. Typical 15' high sidewalk lighting (existing acorn luminaires) is typically spaced at 80 feet apart; however in some instances luminaires are spaced closer together and in some instances, particularly in Downtown, this is the only street lighting in mid-block locations. Typical sidewalk width is 8 feet. The vendor will be responsible for calculating spacing and angular photometric distribution as well as illuminance.
4. To control lighting brightness, luminaires should favor center brightness over edge brightness. Side shielding of optics should be considered to control side angle glare.
5. In business districts, the sidewalk backlighting should not exceed 6" (inches) in height on adjacent building facades. The manufacturer will be responsible for calculating backlighting.

Base Criteria: Color

1. The color temperature range must be within 2800 to 5000 Kelvin, preferably 3500 Kelvin.
2. Color Rendering Index (CRI) must be 80 or greater.

Base Criteria: Controls

1. All luminaires are to be control ready: have the ability to be individually controlled (addressed) remotely by either RF, Wi Fi, or hard-wired systems.
2. (Option) The luminaire must be capable of dimming from 6 FC to 1.5 FC (code). Provide a separate price for this feature.
3. (Option) The luminaire must be capable of adjusting the color temperature range between 2800 and 5000 Kelvin. Provide a separate price for this feature.

Anticipated future controls for each luminaire include: monitor real-time power consumption; diagnose luminaire problems and issues; monitor age/LED life; serve as a warning signal, such as strobe, or flash, or chasing; integration with police, fire, and 911 service; networked connectivity; 256-bit encryption or better; control accessory wayfinding and/or sidewalk fixtures attached to the same pole.

Base Criteria: Design

1. Contemporary luminaire design is preferred. The attached illustrations of luminaires are examples of acceptable luminaire design and are included to provide design guidance to lighting manufacturers and vendors. They are not definitive of acceptable luminaire design and hopefully will encourage design experimentation.
2. Teardrop and acorn equivalents should be compatible with the streetscape in a historic context.
3. Manufacturers are encouraged to submit an optic that addresses the technical performance items with a variety of luminaire head designs. Provide a separate price for each head design.

EVALUATION PROCEDURE FOR BUSINESS DISTRICT LED LIGHTING

This process is intended to provide the City of Pittsburgh the opportunity to consider actual luminaires and their performance in a laboratory setting and “in place” on a Pittsburgh business district street in order to consider different luminaire embodiments (replacement of shoebox, cobra head, teardrop, and acorn luminaires with LED equivalents) and to qualify those luminaires to be considered for purchase and installation for the City’s business district LED lighting program.

The evaluation procedure will consist of a two-part, simultaneous testing process for each luminaire submitted, consisting of:

- (1) Laboratory testing and observation of each luminaire using photometry at Orfield Laboratories in Minneapolis, MN for the luminaire’s compliance with the recommended performance.
- (2) Field testing and observation of each luminaire by the City of Pittsburgh and the Remaking Cities Institute for the luminaire’s compliance with the recommended performance and aesthetics criteria.

Manufacturers will fund the testing and install each luminaire for evaluation. Each manufacturer, or their representatives, will be responsible for installing all luminaires at Orfield Labs and on existing street lighting pendants or poles in Pittsburgh and certify that they are working properly. The cost for the laboratory testing and evaluation program will be \$10,000 per luminaire, per manufacturer. The cost for field testing will be \$2,500 per luminaire, per manufacturer. Each manufacturer will have the option of sending additional LED “breadboard” optics for evaluation of the same luminaire at an additional cost of \$2,500 per breadboard, per manufacturer for laboratory testing and at an additional cost of \$500 per breadboard, per manufacturer for field testing. Manufacturers requesting testing of additional LED breadboard optics should send multiple luminaires with different breadboards rather than change out LED arrays within the same fixture. Exact costs will depend on the number of products that each manufacturer submits and the testing regimen of each part.

For field testing, each luminaire is to be provided with adequate control mechanisms to test variable



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color temperature and intensity (dimming), including the ability to individually address the luminaire. Manufacturers will be responsible for providing the control mechanism within each luminaire and remote control mechanism(s) for testing within 100' of the installed luminaire(s).

LED testing results will be submitted to the City of Pittsburgh, who will make the determination of each luminaire's qualification for the business district LED lighting program. The City of Pittsburgh is under no obligation to qualify any of the luminaires submitted. At their discretion, the City of Pittsburgh reserves the right to qualify fixtures that do not meet all performance specifications and evaluative criteria.

Orfield Laboratories will be available to manufacturers for consultation during this process. Any findings that would modify the preferred performance will be shared with each participating manufacturer. The City of Pittsburgh is aware that this may be one of the first LED applications to approach a large LED project based on optics and urban qualities, rather than simply approaching the selection based on energy and life cycle cost savings claims.

LABORATORY TESTING EVALUATION

The intent of this luminance measuring process is to evaluate glare at a set of fixed viewing angles.

1. The testing at Orfield Laboratories will be in two planes at 10 degree angles from 0 degrees to 90 degrees.
2. Each image capture will be photopic and scotopic.

FIELD TESTING EVALUATION

Evaluation Criteria:

Each luminaire will be observed and rated for the following characteristics:

1. Beam spread on the street based on luminaire type and typical height and spacing measurements: The beam spread on the street should meet code requirements for coverage and intensity.
2. Beam spread on the sidewalks based on luminaire type and typical height and spacing measurements: The beam spread on the sidewalk should meet code requirements for coverage and intensity.
3. Beam spread on vertical building surfaces based on luminaire type and typical height and spacing measurements: The beam spread on the vertical building surfaces should not be blinding to occupants inside the building.
4. Flexibility of color temperature control: Flexibility of dual color temperature should range between 2800K and 5000K to accommodate color preference in business districts and other

commercial locations. This also allows each business district or location the ability to create a warmer environment in winter and a cooler one in the summer. Varying color temperature specifically integrates the street lighting to the surrounding landscape.

5. Light intensity: Light intensity will meet all code requirements. Dimming the light during periods of time with low activity can create additional energy savings. Varying intensity will also allow preference of brightness in business districts and quickly identify emergency areas for police and medical personnel.
6. Light clarity: The light should be broad spectrum for accurate color rendition and provide good visibility without glare.
7. Elimination of glare: Glare should be eliminated from most viewing angles with the exception of looking straight up.
8. Integration with the surrounding context: The total effect of intensity, color temperature, clarity of light, beam spreads, and luminaire design in a business district and pedestrian streetscape context where 25' high pendent-mounted and/or 15' high pole-mounted luminaires are installed.
9. Visual experience: The total effect of intensity, color temperature, clarity of light, and beam spreads should enhance the safety and aesthetic beauty of the landscape and be a place where people want to be.
10. Luminaire design: The design of the luminaire should not only house the specified LED breadboards, but should be aesthetically pleasing to the surrounding architecture and streetscape.

Rating scale: 1-to-5, with 5 being excellent and 1 being unacceptable.