SAN FRANCISCO BEAUTIFUL's
Position Paper On Streetlighting and Outdoor Lighting Issues

5 February 1997 by Daniel J. P. Weaver

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STREETLIGHTING AND OUTDOOR LIGHTING ISSUES

Policy 11 of the San Francisco Master Plan Urban Design Element requires the development of a citywide plan for streetlighting. San Francisco Beautiful advocates preparation of a comprehensive streetlighting and outdoor lighting plan based on the standards outlined in this paper.

INTRODUCTION: CURRENT CONDITIONS

San Francisco's nighttime street environment can be fairly characterized at this time as a visible demonstration of bad outdoor lighting. The majority of San Francisco's street lights have been changed from blue to orange-yellow spectrum light sources; traditional historic poles and fixtures (many with good optical controls) have been replaced with inappropriate poles and cobrahead fixtures with poor optical controls.

Glare conditions are a significant part of the city's current lighting problem. Glare is defined as:

The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort or loss in visual performance and visibility (Lighting Handbook. Illuminating Engineering Society of North America. 8th Edition. 1993).

If the light source itself is more noticeable than the objects it is illuminating, then the source is likely producing glare.

Glare is one of the most common outdoor lighting condition in San Francisco. Yellow-orange-pink glare, light trespass into buildings, and uplighting to the sky are the chief characteristics of our degraded nighttime environment. Glare is mitigated only on the few streets where previous generations of blue spectrum light source incandescent or mercury lamps are still intact, where cobras on 30-foot poles either diffuse the light into trees, or where almost all of the light shines directly onto the tree canopy tops thereby keeping the ground under the trees in deep and perhaps dangerous shadow.

To see well at night, we need to minimize glare. A proper nighttime environment for a pedestrian-oriented city requires the even distribution of appropriate amounts of light or lumens along the sidewalk pedestrian areas and pavement particularly at corners where motor vehicles and pedestrians meet. The proper distribution of light means eliminating both dark areas and overly lit glare areas. Minimizing glare always results in a more attractive nighttime environment.

Recommendations:
San Francisco Beautiful proposes that a comprehensive streetlighting plan be adopted based on the following considerations: requiring that the remaining 50 percent of overhead utility wires be undergrounded; establishing new streetlight pole height standards; specifying criteria for lamp fixture choice; adopting lamp technology, color rendering and light spectrum criteria; reevaluating light level standard; establishing ongoing streetlight planning; and reconsidering nighttime safety criteria.

UNDERGROUNDING

Undergrounding overhead utility wires is a key prerequisite to achieving adequate streetlighting. Today about 50 percent of San Francisco blocks have undergrounded utility wires and 50 percent have overhead street wires with streetlight fixtures attached. It is estimated that at the current rate it will take 100 years or more to underground the remaining overhead wires. San Francisco Beautiful and the Bureau of Street-Use and Mapping want to expedite this process so that the remaining overhead wires can be undergrounded in 25-50 years.

San Francisco Beautiful strongly supports all efforts to expand utility wire undergrounding including expansion of the local assessment district program. This position is based on the recognition that undergrounding is a prerequisite to achieving adequate streetlighting; eliminating overhead utility wires is becoming increasingly attractive to San Franciscans; and overhead wires are a significant hindrance to a beautiful city. Some neighborhood groups have recently been told they might have to wait 8 to 10 years for undergrounding. Homeowners in Dolores Heights stated they waited nearly 30 years.

Undergrounding utility wires has been required for new developments in California since 1968. (Overhead wires in older cities place those areas at a competitive disadvantage.) Under the Rule 20A program of the California Public Utilities Commission, about 90 percent of the public space undergrounding costs are paid for by utility company funds collected from rate payers, and the 10 percent local share plus building hook-up costs is paid for by property owners in the undergrounding assessment districts.

The city should develop a program for pole and/or fixture replacement for streets and neighborhoods already undergrounded that require new streetlight poles and fixtures, and for neighborhoods wanting to upgrade from cobrahead or other inadequate light fixtures to full optical control fixtures. A streetlight upgrade program should allow for neighborhood decision making within the available choices and, if required, an efficient method to pass on capital costs to property owners without having to form local assessment districts. City responsibility for lighting major and transit preferential streets should be specified. A process to set aside funds for purchasing reserve poles and fixtures to replace damaged units should also be a part of this program.

Recommendations:
The city should underground the remaining 50 percent of overhead utility wires within 25-50 years or less; and Develop a city program to replace or upgrade utility poles and fixtures in areas where undergrounding has occurred.

STREETLIGHT POLE HEIGHT AND FINISH

Full optical control lamp fixtures are designed to control all light, thereby minimizing energy waste and light pollution. Full optical control fixtures with side shields eliminate the problems of light trespass, and help to minimize the problem of glare; the light that is conserved is put down on the ground where it is needed: Therefore there is no need to use 30-feet high poles with inefficient, optical control, fixtures (such as the commonly used cobrahead without a full cut-off device that can waste 50 percent or more of the light generated) but rather the preferable use of full optical control lamp fixtures at 18 feet utilizing the same standard 140 feet on center spacing, or closer where additional pedestrian lighting is appropriate.

Full optical control lamp fixtures allow San Francisco's existing streetlighting standard of 0.4 footcandles to be achieved with poles at 18-feet height and with streetlight pole spacing of 140 feet on center. This means that 30-foot pole heights are not necessary and should not be promoted by city agencies. The acorn lamp fixtures that allow for this height and spacing standard to be achieved are those that allow 8 percent on average of the light to escape to the sky, onto building sides or into windows and onto the pavement or sidewalk; they also have shields to minimize side glare as required.

A streetlight pole is too high if it extends over the tops of buildings on a street and allows light intrusion into surrounding streets, buildings, and roofs, and onto the tops of tree canopies, thereby keeping sections of the street and sidewalk in deep shadow. A streetlight pole at 18-feet should be standard because 140 feet on center spacing can be achieved, and the pole is scaled to pedestrian and automobile traffic, no matter how tall the buildings are along the street. Where buildings are lower than 18 feet, where tree canopies are extensive and darken sidewalks or on commercial streets where additional pedestrian lighting is advantageous, 14 foot poles may be appropriate.

This position paper assumes undergrounding of all overhead wires except for Municipal Railway (MUNI) strain wire and overhead electric lines. These lines can be tied to streetlight poles that would be higher than 18-feet, but the lights should be placed under the strain wires at 14 or 18 feet as appropriate. New F-Line wire poles in Eureka Valley of unpainted metal towering over historic houses and streetlight poles are the wrong way to add overhead MUNI lines. Van Ness Avenue, Union Street and parts of McAllister Street where MUNI overhead wires attached to the streetlight/strain wire poles and the streetlights are underneath the strain wires are the proper way to do it. At these locations, excellent pedestrian scale night time urban environments have been established. Transit streets are also major pedestrian streets and therefore require good pedestrian lighting.

Poles can be of painted metal or aggregate concrete (marbelite) if pre-treated for graffiti removal. Unfinished metal poles should not be used without painting in residential or commercial areas. The pole design and detailing should be appropriate to the lamp fixture selected and the character of the street, buildings and neighborhood.

Recommendations:
Limit streetlight pole heights to 18 feet or alternatively to 14 feet where buildings are lower than 18 feet or in commercial areas where tree canopies block light from 18-foot poles or where additional pedestrian lighting is appropriate.
Select streetlight poles and fixtures that are appropriate to the street and neighborhood character.
On MUNI overhead wire streets, place streetlights under MUNI strain wires

LAMP FIXTURE CHOICE

Lamp fixtures with full optical controls and side shield options should be used exclusively in San Francisco because they minimize uplight, light trespass into buildings, energy waste and glare. The capital cost difference between full optical control fixtures and poor optical control fixtures can be as little as $250. In an undergrounding assessment district, this amounts to about $25 over the life of the fixture per 25-foot parcel. Energy cost savings can more than cover the capital cost differences.

With high intensity discharge (HID) light technologies such as High Pressure Sodium (HPS) and Metal Halide (MH), lighting professionals point out that use of optical controls including side shield panels is a necessary tool to fully control glare. This is because the brightness of high intensity lamps necessary to cover long distances will produce glare unless full optical protection is available as necessary to protect windows that are close to the lamp. HID lamps are quite different from incandescent lamps, candlelight and gas lamps because their light output (lumens) allows for spacing of 100 feet or more, whereas gas lamps need to be placed at 10 to 20 feet intervals. Notwithstanding, cities such as Boston have recently opted to reinstall gas lamp lighting at 10 to 20 feet intervals in some historic districts, with general approval of the change.

San Francisco's Master Plan urban design element calls for distinguishing city districts and neighborhoods by utilizing different types of streetlights and streetlight poles. Currently, the skyward-facing acorn lamp fixture is the only approved alternative to cobrahead lamp fixtures for underground assessment districts (see streetlight fixture figure). The downward-facing tear drop or boulevard fixture that is being utilized along the Embarcadero is an even better fixture selection because it recesses the lamp into the fixture so as to minimize glare. [Along the Embarcadero, compare the acorn (sidewalk) to the teardrop (median).] These tear drop fixtures, however, are 34 inches long and are suitable, as the name implies, for wider boulevard type streets. Smaller teardrop fixtures are needed for narrower streets. An older version of a smaller teardrop fixture is commonly found in many areas west of Twin Peaks as well as along Howard Street from 5th to 10th streets. An updated version of this fixture is necessary for residential streets.

Cobrahead fixtures with full cut-off designs allow less than one percent of the light to go above the horizontal plane of the fixture into the sky. This meets the goal of controlling uplight but these full cut-off cobras may not have enough precision to light urban streets consistently and keep light off of buildings and out of windows. Cobrahead fixtures without full cut-offs extend the bulb out of the fixture and create substantial uplight, light intrusion and glare that is not acceptable for an urban street lined with buildings close to the sidewalk. Christopher Ripman, a streetlight planner and lighting designer, concludes that cobrahead fixtures combined with the new generation of high intensity lamps such as HPS and MH are unacceptable choices for this reason ("New Concepts in Streetlighting" by Christopher Ripman. Architectural Record Lighting. 2/1995, p. 12).

A radial wave reflector with a bishop's crook pole configuration would be a fine addition to the residential street light fixture and pole options, particularly for Victorian neighborhoods (see Ripman, 1995). A lantern type fixture has a good design that eliminates uplight like the teardrop fixture; it would be most appropriate for very narrow streets or outdoor staircases. Destination Downtown: Streetscape Investments for a Walkable City includes a discussion about streetlights and the excellent Golden Triangle pole and double fixture that merits expanded use on the downtown streets (San Francisco City and County Planning Department. 1995).

All outdoor area lighting should be designed to minimize glare, uplight and light trespass. As with public streetlighting, more light does not necessarily equate with more security. At places such as ATM machines, schools and houses, wall or roof installations that direct poorly shielded HID lights at people creates glare and wastes energy. Glare does not enhance security; it makes night vision more difficult, places less attractive and therefore less safe at night.

Recommendation:
Select lamp fixtures with full optical controls and side shields that light the street and sidewalk, not the sky, building interiors or building sides and roofs. Cobrahead fixtures do not provide adequate optical controls. Fixture replacements should have full optical controls and be appropriate to the street and neighborhood.

LAMP TECHNOLOGY CHOICE

Under low light and off-axis conditions the human retina is more responsive in the scotopic or short wavelength of the visible spectrum. HPS yellow-orange light sources have relatively little energy in this short wavelength. The incandescent, mercury and MH blue-white light sources have higher energy in this short wavelength. While this fact is easily demonstrated experimentally, yet no standards of luminous efficacy under low light conditions have been established by lighting professionals. The lighting industry has not been able to establish the superiority of MH over HPS for street lighting. Lighting professionals are only now starting to address this problem, although they have a good idea of what is the best nighttime lighting (Terry McGowan and Mark Rea. "Visibility and Spectral Composition." Proceedings of the C. I. E. Symposium on Advances in Photometry, December 1-3, 1994. International Commission on Illumination, Vienna, Austria).

Because of its blue spectrum light sources and good Color Rendering Index (CRI) number, MH is the current lamp technology of choice among lighting design professionals. But, it is not the choice of streetlighting engineers at utility companies and city streetlight agencies. MH is the technological successor to the mercury blue light source lamps still gracing some of our streets today.

HPS lamps have a life span up to 24,000 hours (GE Lighting Lamp Catalog; see Comparison of Lamp Technologies table in this report). The 70-watt and 100-watt MH lamps now available with a 15,000 hour rated life are an appropriate replacement for San Francisco streets. Lighting companies are fully aware of the need for a smaller wattage longer life MH lamp for residential street uses, and are working on the problem. When a 50-watt MH lamp with a rated life of 15,000 hours or more is developed, it would be an appropriate residential street lamp choice to replace the 70-watt HPS lamp. Currently available 15,000-hour MH lamps will probably have to be replaced two to three years before HPS lamps, but continuing progress in extending MH lamp life and lowering costs can be expected because lamp companies are focusing their research on MH, not HPS.

COLOR RENDERING INDEX AND NIGHT VISION

The color rendering index (CRI) describes "how well or poorly the colors of objects will appear 'familiar' or 'natural' under the light source being selected" ("A Guide to Lamps and Controls" by Joseph Knisely. Architectural Record Lighting. August 1990). The higher the CRI number the more natural objects appear at night. Incandescent bulbs have the highest CRI rating at 100. The mercury lamps fast disappearing from our streets have a CRI of 50. The HPS lamps have a CRI of about 20. HPS, for example, changes vibrant green plant materials to a dead-brown color. HPS color corrected lamps improve the CRI number up to 65, and MH has a CRI number of 65-80. Good color rendering allows for discerning color differences well at night and thereby makes the street safer and more attractive to pedestrians and to people looking at the street from indoors. Street attractiveness does not equate with poor color rendering, glare, light trespass or light pollution.

CRI is difficult to use as a comparison between light technologies, but can be used as a screening device to determine appropriateness. Lamps with a CRI below 50 should not be utilized on San Francisco streets. CRI, however, doesn't allow for a meaningful choice between blue source MH lamps and yellow-orange source color corrected HPS lamps. Today, light spectrum source has come to be more important than CRI as a tool for evaluating outdoor lighting (Ric Barton, GE Lighting, Personal Communication). Because of its blue-white spectrum light source, MH is a better choice than HPS or color corrected HPS (see comparison table at end of text) for streetlight lamps in San Francisco. MH and other blue light source technologies allow people to see better at night with lower wattage and lumens because of its higher energy at the shorter wave length.

With a photopic lumen measurement basis, HPS produces 125 lumens per watt; with a scotopic or low light measurement basis, HPS produces 80 lumens per watt. With a photopic yellow-orange spectrum basis, MH produces 90 lumens per watt; with a scotopic blue spectrum basis, MH produces 140 lumens per watt.(Mark Rea. "In the Dark About the Lumen." Lighting Magazine. February 1996. pp.16-17). The definition of lumens for scotopic or low light vision conditions is expected to be revised by the lighting industry to recognize the fact that the scotopic or blue spectrum is the proper spectrum to measure human night vision. In the blue spectrum, MH "is 125 percent more effective than HPS at producing the same visual effect" (Rea, 1996, p. 17). Therefore, much lower lumens and wattage are needed for good night vision.

Recommendations:
Use light bulbs with CRI rating above 50; good color rendering is a critical safety and urban design criteria for urban streets where encouraging pedestrian activity is important.

Use lamp technologies producing a blue spectrum light sources such as metal MH or mercury for outdoor lighting; people see twice as efficiently at night with blue light, and these blue light source technologies have a CRI above 50.

Adopt MH lamp technology for street lighting; it provides a good blue light source, a good color rendering index (CRI) rating, and an acceptable life span up to 15,000 hours. Mercury lamps are poor in lumen maintenance and are not likely to improve because lamp companies are not working to develop mercury lamp technology; they are focusing their attention on MH lamps.

LIGHT LEVEL STANDARD

San Francisco currently has a streetlight standard of 0.4 footcandles. Full moonlight ranges from 0.025-0.03 footcandles of superb blue-white light; residential streetlighting has been effective at a level as low as 0.05 footcandles ("An Historical Note About Recommended Lighting Levels." International Dark-Sky Association. Newsletter No. 22. October 1994). Residential sidewalk lighting can be effective at 0.02 footcandles if the light is consistent and there are no blackout areas.

Upgrading from Mercury to HPS, the city has gained 25 percent more photopic lumens for the same or slightly less wattage expended. Cobrahead fixtures generally have become glare bombs with this 25 percent lumens increase; glare has become the pervasive condition on San Francisco streets. Even 18-foot poles with acorn fixtures having full optical controls can cause glare conditions because the light fixtures often cannot control the additional light generated. That extra 25 percent lumens simply are not needed for most streets and cannot be controlled by the fixtures. (HPS lumens are also inferior for human night vision as explained above.)

The use of lower wattage MH lamps and 18-foot poles with full optical control lamp fixtures can successfully address this situation. The current city standard of 0.4 footcandles street coverage should be revised downward 25 percent to 0.3 footcandles, at least for residential streets.

Recommendations:
Develop a hierarchy of light levels for different land uses and urban design situations such as commercial, intermediate or small scale commercial, and residential. Dangerous areas should have higher light level standards. Higher light levels require reevaluations of the light fixture optical control capacity.

Consider lowering the light standard for residential streetlighting from 0.40 footcandles to 0.30 footcandles. The current high pressure sodium (HPS) lamps provide 25% more lumens for less wattage compared to the mercury lamps. That additional 25% is not needed on San Francisco streets: it is one of the basic reasons for the glare that has become a pervasive nighttime condition. Adopting MH could allow even more reduction of light because its blue light source is 125 percent more effective for night vision than the HPS yellow-orange light source.

PURPOSE OF STREETLIGHTING IN A PEDESTRIAN ORIENTED CITY

Lighting of sidewalks more carefully than roadway areas should also be a part of the overall street lighting design program for San Francisco. In places such as San Francisco where pedestrian activity is important and encouraged, streetlighting should primarily illuminate sidewalks and street crossing areas; in rural and auto suburb areas, roadbeds and intersections should be the primary focus of streetlighting. San Francisco's Transit First policy requires that proper sidewalk and crosswalk lighting be provided on transit streets and in all areas of the city where people walk to and from transit stops or neighborhood commercial places.

Recommendation:
Establish the objective of lighting sidewalks and crosswalk areas as the primary purpose of streetlighting for San Francisco because it seeks to be a pedestrian and transit oriented city. All streetlighting designs should satisfy this objective.

OUTDOOR SAFETY

For many people the bottom line on streetlighting is safety. Some people interested in outdoor lighting have been told or have concluded that the yellow-orange-pink glow of HPS bulbs allows for greater security on San Francisco streets. (Some even suggest that the pinkish glow has been created to make them feel better, and to achieve a more positive outlook on night life.) There seems to be a myth that the police prefer HPS because it facilitates their job of patrolling the streets, perhaps because yellow-orange is a safety color. Safety, and even security, however, depends on being able to see colors accurately with minimum glare. Generally, the higher the CRI, the more accurately people can discern colors. The blue light source of MH is also twice as efficient for night vision as HPS, thus allowing better night vision while minimizing glare and other over-lighting conditions. Good color rendering allows for discerning color differences well at night and thereby for safety. Street safety does not equate with poor color rendering, glare, light trespass or light pollution.

Night street and outdoor safety will be enhanced with blue spectrum light sources having a CRI of 50 or above. The current standard HPS lamps do not have the blue spectrum light and have an unacceptably low CRI of 22. The 25 percent additional lumens for the same watts as mercury lamps have resulted in substantial additional light pollution and glare. Overlighting and glare detract from a safe nighttime environment.

STREETLIGHT PLANNING IN SAN FRANCISCO

Streetlight planning and design is always changing because of new developments in lighting technologies and lamp fixtures due to ongoing research in the physiology of night vision. Therefore, streetlight and outdoor lighting plans and programs should be reviewed and updated on a biannual basis.

Recommendations:
San Francisco should develop a comprehensive streetlighting and outdoor master lighting plan and ordinance to guide ongoing public and private streetlighting efforts.

The Department of Streetlighting and Hetch Hetchy Water & Power should form a Citizens Streetlight Advisory Committee to advise city streetlighting authorities on a regular basis. This advisory committee should be involved in the development of the Streetlighting Master Plan.

Educate electrical engineers and planners who design streetlights and make purchasing decisions for San Francisco periodically about the ever-changing technologies available for streetlighting so that the city maintains an efficient and cost effective lighting program.

Seek development and adoption of outdoor lighting plans based on these guidelines by San Francisco Recreation and Park Department, the San Francisco MUNI, The San Francisco Housing Authority, the San Francisco School District, the San Francisco Community College District, and the San Francisco Redevelopment Agency.

Finally, San Francisco Beautiful asks the Department of Streetlighting and/or Pacific Gas & Electric to maintain the remaining blue spectrum mercury or incandescent streetlights rather than replacing them; further it requests that they stop replacing historical streetlight fixtures/poles with cobra head fixtures until a streetlighting plan can be completed.

COMPARISON OF LAMP TECHNOLOGIES

Average Initial Photopic Lumens At 10 hours/start

Incandescent

327 Watts	100 CRI	4000 Lumens	6,000 Hours

Mercury

100 Watts	50 CRI	4200 Lumens	24,000 Hours

High Pressure Sodium

50 Watts	22 CRI	4000 Lumens	24,000 Hours
70 Watts	22 CRI	6400 Lumens	24,000 Hours
100 Watts	22 CRI	9500 Lumens	24,000 Hours

Color Corrected High Pressure Sodium

70 Watts	65 CRI	3800 Lumens	10,000 Hours

Metal Halide

50 Watts	65 CRI	3500 Lumens	5,000 Hours
70 Watts	65 CRI	5300 Lumens	15,000 Hours
100 Watts	65 CRI	7600-9000 Lumens	15,000 Hours
400 Watts	65 CRI	36,000 Lumens	20,000 Hours
70 Watts (Ceramic)	80 CRI	5000 Lumens	7,500 Hours

Source: GE Lighting

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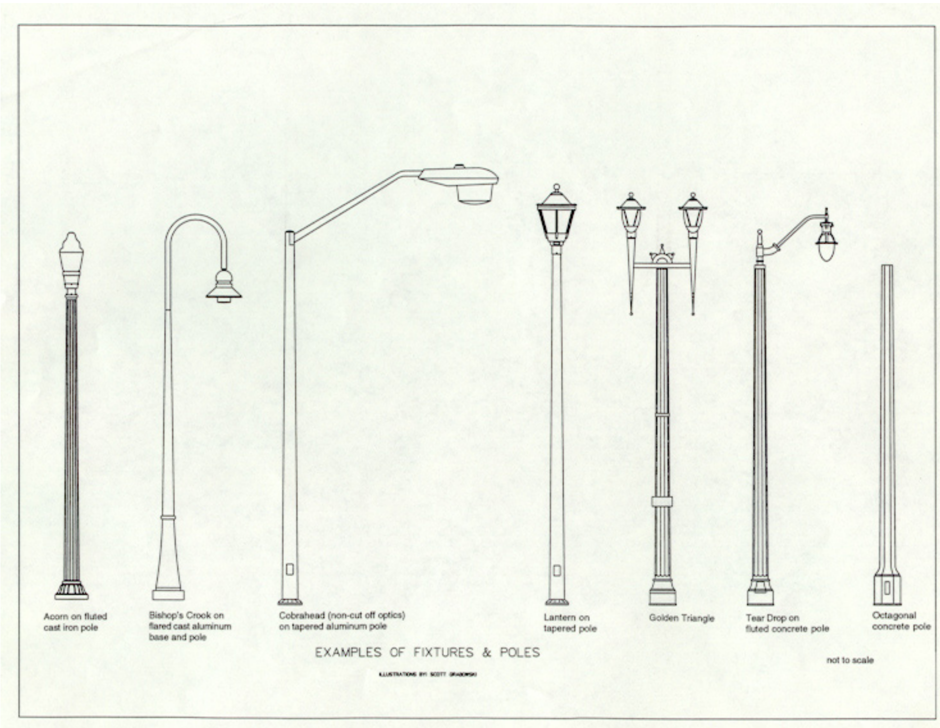
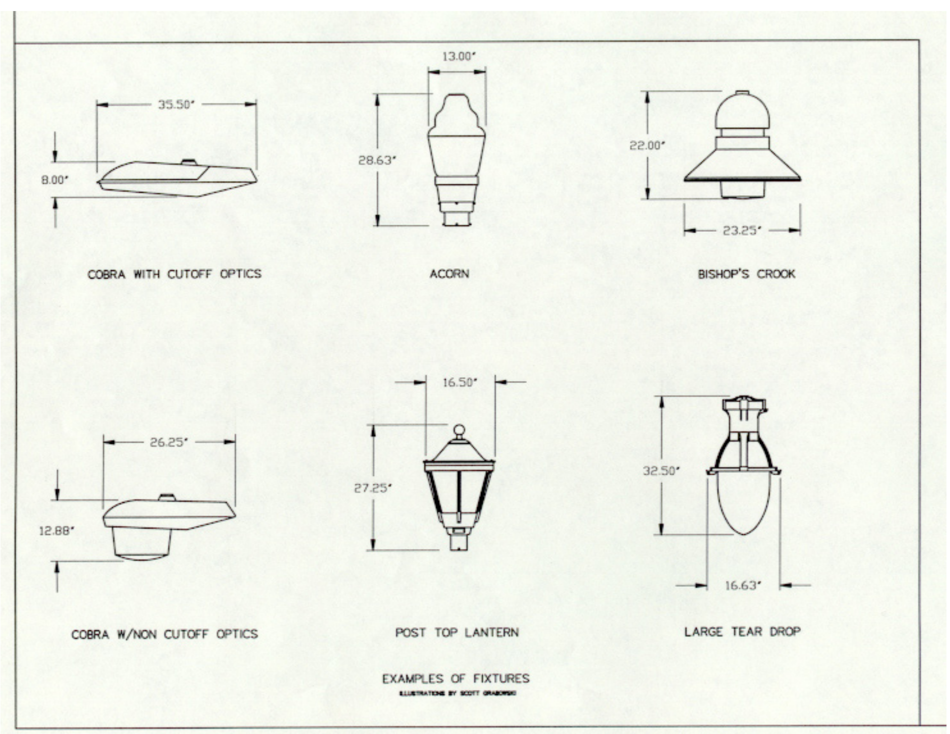
San Francisco Beautiful's is a non-profit organization whose mission is "Creating, Enhancing and Protecting the Unique Beauty and Livability of San Francisco."

Examples of Fixtures on Poles and Details of Fixtures

Top box from left to right: Acorn on fluted cast iron pole; Bishop's Crook on flared cast aluminium base and pole; Cobrahead (non-cut off optis) on tapered aluminium pole; Latern on tapered pole; Golden Triangle; Tear Drop on fluted concrete pole; Octagonal concrete pole.



Bottom Box left to right: (top line) Cobra with Cutoff Optics; Acorn; Bishoop's Crook; (bottom line) Cobra W/Non Cutoff Optics; Post Top Lantern; Large Tear Drop



Graphic by Scott Grabowski.