

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
DENVER SERVICE CENTER
DENVER, COLORADO

RENOVATION OF
STATUE LIGHTING
STATUE OF LIBERTY NATIONAL MONUMENT
NEW YORK AND NEW JERSEY

FINAL NARRATIVE REPORT
COMPREHENSIVE DESIGN
(TITLE I SERVICES)

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U. S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
BASIC AGREEMENT CX-2000-4-0002
WORK DIRECTIVE 4-0002-74-2
STATUE OF LIBERTY NATIONAL MONUMENT
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FINAL NARRATIVE REPORT (March 1975)

This final narrative report is a composite of modifications of the Narrative Report of April 1974, the Supplemental Narrative Report of August 1974 and the Lighting Test Report of December 1974.

Statue Lighting - Existing Equipment & Relamping

When the Statue of Liberty was dedicated on 28 October 1886 the only exterior illumination on it was the torch which was lighted by a flare. An electric lighting system was inaugurated in 1916, and in 1931 that system was replaced by 96 floodlight units which are currently in use. In 1967 16 mercury floodlights were added. Thus, as of April 1974, exterior lighting of the Statue is accomplished by 112 lighting units distributed in groups of 8 and 16 among the 11 points of the Fort at the base of the Statue.

The 96 floodlights installed in 1931 were manufactured by Westinghouse. Similar units are no longer manufactured, and the manufacturer was unable to supply us with photometric or other data pertaining to the units. Each unit was intended to accommodate a 1000 watt incandescent lamp. As the latter burn out they are being replaced by 500 watt self-ballasted mercury lamps. The bodies of the lighting units are of bronze alloy, and they are in fair condition.

The 16 units added in 1967 were also manufactured by Westinghouse. Each accommodates a 400 watt externally ballasted lamp. The bodies of these floodlight units are of aluminum alloy, and they are in fair condition. Corrosion of the fasteners is noted.

Aforesaid lighting units are supplemented by the following lighting units for illuminating the Statue's exterior surfaces:

- A. Two lighting units mounted on the Statue's left shoulder. Each of these accomodates a 500 watt

self-ballasted mercury lamp. These units add local illumination to the neck and shoulder areas.

- B. Fifteen small lighting units mounted inside the base of the Statue. These units project light vertically up. Their location and orientation does not permit effective impingement of light on the Statue, and access to the units is difficult through a congested crawl space.

Statue Lighting - Effectiveness of Existing Illumination

Observations were made of the exterior illumination effects on the Statue by members of the engineering firm under contract, specifically A. Colabella, P.E.; H. Reuter, P.E.; and V. Serpikov, P.E. Observations were made jointly at night from a boat circumnavigating Liberty Island at distances ranging from 300 to 500 yards from the Island seawall. At the onset of the observation period, 15% of the lighting units were on. This is the number of lighting units which are planned to be normally operated during the present energy crisis. Additional lighting units were gradually turned on during the observation period which lasted for about 1-1/2 hours until a maximum of 85% of the lighting units were on. 40% of the total number of lamps turned on at the end of the observation period were mercury. The consensus of opinion of the three observers is summarized as follows:

Judging by present day criteria the general illumination effect of the exterior surfaces of the Statue is mediocre to sub-mediocre. Illumination intensity is not uniform. The highest intensity is at the Statue pedestal; the lowest intensity is at the top of the Statue. There are excessively pronounced shaded areas at the folds in the garment, at the tablet and part of the neck. Approximately 50% of the lighting energy is wasted due to scattering. This latter appears to be due to poor beam control and excessive beam spread.

Statue Lighting - Discussion Regarding Present Relamping

The 96 lighting units installed in 1931 were intended to be lamped with 1000 watt incandescent lamps. Because of the very short life (1000 hours) of these lamps they are being replaced by 500 watt self-ballasted mercury lamps. The latter very conveniently require no revision to wiring because of load or ballast nor is any adaptation of the mogul lamp socket required. The mercury self-ballasted lamps

recommendation is that high intensity discharge lamps of the metal halide type be used. This type lamp has high luminous efficiency, long useful life, compact size (allows the lighting units to be as inconspicuous as possible), and has color rendering properties which approach that of natural daylight. The following tabulation contains comparative data for the metal halide lamp and the various lamp types currently in use at the Statue.

Lamp Type	Watts Consumed	Lumens Output Initial	Life Hours	Cost Net	Remarks
Incandescent	1000*	23,000	1,000	\$4	Short Life, Original equipment
Mercury External Ballast	400*	24,000	24,000	\$11	Long Life, used in 16 floodlights
Mercury Self Ballast	500*	11,800	20,000	\$44	Presently used as a mercury replacement for incandescent lamps
Metal Halide	1000*	100,000	10,000	\$40	Highest output per watt

*Currently in use.

**Proposed replacement.

The lumens required to provide 50 foot candles on the surfaces of the Statue are calculated as follows:

$$L_s = \frac{F_s \times A_s}{CU_s \times MF}$$

where:

L_s = Lumens for Statue

F_s = Footcandles at Statue surfaces = 50

A_s = Statue area, sq. ft.

CU_s = Coefficient of Utilization for lighting unit with 1000 watt metal halide lamp operated at 90,000 lumens, 11° x 16° required beam, 26° x 25° ltg unit beam.

N_s = Number of lighting units required.

for Statue = $\frac{L_s}{\text{Beam lumens/unit}}$

MF = Maintenance Factor for enclosed lighting unit = 0.70.

Area to be illuminated:

A prism 35' x 25' x 111' is estimated to approximate the Statue surface Dwg No. 356/41018 Sheet 03

$A_s = 35 \times 111 \times 4 = 15,540$ sq. ft.

Coefficient of Utilization:

$$CU_s = \frac{\text{Utilized Lumens}}{\text{Beam Lumens}} = \frac{21,410}{38,140} = 0.56$$

Utilized Lumens for 11° horizontal x 16" vertical beam spread = 21,410 (obtained from G.E. photometric data sheet 35-174686-00, rev 02).

Beam Lumens for 26° horizontal x 25° vertical beam spread = 38,140 (obtained from G.E. photometric data sheet 35-174686-00, rev 02).

$$L_s = \frac{50 \times 15,540}{0.56 \times 0.70} = 1,982,000$$

$$N_s = \frac{1,982,000}{38,140} = 52$$

The lumens required to provide 9 foot candles on the surfaces of the pedestal are calculated as follows:

$$L_p = \frac{F_p \times A_p}{CU_p \times MF}$$

where:

L_p = Lumens for pedestal

F_p = Footcandles at pedestal surfaces = 9

A_p = Pedestal area, sq. ft.

CU_p = Coefficient of Utilization for lighting unit with 1000 watt metal halide lamp operated at 90,000 lumens, 46° x 45" required beam, 62° x 64° lighting unit beam.

N_p = Number of lighting units required for pedestal = $\frac{L_p}{\text{Beam lumens per unit}}$

MF = Maintenance factor for enclosed lighting unit = 0.70

Area to be illuminated:

A prism 66' x 66' x 116' is estimated to approximate the pedestal surface Dwg No. 356/41018 Sheet 03.

$A_p = 66 \times 116 \times 5 = 30,624$ sq. ft.

- A. The harbor location with frequent mist and the generally remote viewing distance.
- B. Having the capability to provide 50 foot candles allows more flexibility for illumination technique in the final adjustments.
- C. The 10 additional lighting units to provide 50 foot candle capability would not constitute severe increase in construction cost since the required electrical feeders are existing.
- C. After the final adjustments, any excess lighting units which are deemed not be normally illuminated may be maintained in stand-by service.

Statue Lighting - 3D Effect

We agree with the importance to avoid creating through illumination a "washed-out" look. Our comment, made earlier in this report that the lighting must enhance the artistic accomplishment and render inspiration to the observers, emphasizes our awareness of this aspect of the lighting task. The point we wish to make is that with the existing illumination where there are shadows and poorly illuminated areas on the Statue which are considered objectionable. It is these objectionable features of the existing illumination that we see need to improve. The recommendation that there be a concentration of lighting units at five of the eleven points of the base of the Statue is well taken. Following is a comparative tabulation indicating the number of lighting units for Statue lighting at each of the eleven points. The columns I, II and III represent the following distribution of lighting units. Column I places 67% of the lighting units at five points; average illumination is 40 foot candles. Column II places 69% of the lighting units at five points; average illumination is 50 foot candles. Column III is the Crouse-Hinds recommendation. It places 100% of the lighting units at five points; average illumination exceeds 50 foot candles. As noted earlier in this report we are inclined to favor the illumination indicated in column II which results in an average of 50 foot candles, but we will, unless otherwise directed, prepare final construction documents based on Column I.

Point Location	Quantity of Lighting Units		
	I	II	III
A	6	8	15
B	3	3	0
C	5	7	10
D	2	3	0
E	6	7	15
F	2	2	0
G	2	2	0
H	6	7	15
I	2	3	0
J	5	7	10
K	<u>3</u>	<u>3</u>	<u>0</u>
Totals	42	52	65

Following is a similar tabulation indicating the distribution of lighting units for pedestal lighting. Column I places 63% of the lighting units at five points; average illumination is 9 foot candles. Column II is the Crouse-Hinds recommendation. It places 100% of the lighting units at five points; average illumination is less than 9 foot candles. We are preparing final construction documents based on Column I. Column III indicates the addition of high pressure sodium lighting units to blend yellow light to the base illumination. Both 1000 and 500 watt sodium lamps are utilized.

Point Location	Quantity of Lighting Units		
	I	II	III
A	2	2	1
B	1	0	0
C	2	2	1
D	1	0	0
E	2	2	1*
F	1	0	1*
G	1	0	0
H	2	2	0
I	1	0	1
J	2	2	0
K	<u>1</u>	<u>0</u>	<u>—</u>
Totals	16	10	5

* 500 Watt

H. The observation group was comprised of:

Lawrence F. Kotecki	NPS, DSC
D. Roy Johanningsmeir	NPS, DSC
Lawrence B. Coryell	NPS, Phila
Don Hovland	NPS
Alfred V. Colabella, Jr.,	A. V. Colabella, Engineers
Herman H. Reuter	A. V. Colabella, Engineers

also present were:

James H. David	Crouse-Hinds Company
Bob Stark	Westron Corporation

I. The weather was clear without rain at the start of the tests. During the course of the tests it rained intermittently but remained clear. This proved advantageous in that it also permitted observations with the Statue surface wetted. There is a change in the hue of the Statue patina when wet.

At the beginning it was obvious to all observers that the illumination level on the Statue from the three 1000 watt metal halide lamps was uncomparingly superior to that resulting from the three 1000 watt DX mercury lamps. The higher lumen output (about 1.7 to 1) of the metal halide is, of course a factor, but moreover a distinct beam was evident with the metal halide lamps whereas no beam effect was achieved with the DX mercury lamps. The beam explanation is that the phosphor coating on the DX mercury lamp diffuses the light emanating from the source and also creates a larger globular source of light than the quasi point-source of light with uncoated, high intensity discharge lamps. The lighting fixture reflector transmits more of the lamp output in the form of parallel rays of light the smaller (dimensionally, not lumens) the source of light and the closer the source is to the reflector focal point. An increased amount of the lamp output is transmitted as scattered light rays as the light source increases (dimensionally, not lumens) in size and as the light source becomes farther removed from the reflector focal point.

The difference in illumination effect was so overwhelming, even when only one of the metal halide lamps was on and compared with three of the DX mercury lamps, that it was concurred by all present that in order to get enough mercury light on the Statue to make a comparison that the three DX mercury lamps should be replaced with clear mercury lamps.

This was done, and it did result in more light on the Statue but still significantly less (estimated at about 1/3) than that from the metal halide lamps. A brief demonstration was also made of several self-ballasted mercury lamps manufactured by Westron Corp. Two of these lamps were 750 watt rating each, without built-in reflector; two were 500 watt rating each, with built-in reflector; and two were 750 watt rating each, with built-in reflector. These six lamps resulted in more light on the Statue than the three 1000 watt DX mercury externally ballasted lamps but less light than the three 1000 watt externally ballasted clear mercury lamps.

The remaining test observations were then made comparing clear mercury with halide. The close-up observations as well as the distant observations proved the color rendition and illumination qualities achieved with the metal halide lamps to be superior to that using the mercury lamps. Slight color variations were noted in the metal halide lamps when they were lit, but this color variation at the lamps resulted in no apparent difference in the light reflected from the Statue. The large amount of blue light from the mercury lamps gave a displeasing effect on the Statue patina, wet or dry, whereas the effect was quite purifying and pleasing with the light from the metal halide lamps. The difference in illumination effect on the Statue pedestal was not as marked as the effect on the Statue itself. No advantage was seen in blending mercury and halide lamps. Warming the white light of metal halide lamps lighting the pedestal by introduction of some fraction of yellow light, as might be obtained from high pressure sodium lamps, was discussed. These opinions represented the consensus opinions expressed at a convening of all observers in the Administration Building Conference room following the test observations.

Security Lighting - General

The requirements for security lighting are threefold. First, there is the need to illuminate the area around the three doors from the Mall to the entrance at the rear of the Statue. Second, there is the need to illuminate the stairs from the Mall to the mezzanine entrance at the rear of the Statue. Third, there is the requirement to provide complete flood-light coverage around the base of the Statue at ground level. The outside visitors area, we understand, will be provided with illumination under a separate project.

Security Lighting - Doors at Statue Entrance from Mall

To avoid an "add-on" appearance to the proposed lighting over

the entry doors, the lighting fixture bodies shall be of aluminum with dark bronze anodic finish matching that of the doors. The fixture body shall extend the full width of the masonry opening. Lens shall be flat and of obscure plastic. Lens shall permit down light only. With regard to switching control for these lights we suggest that they be operable with a radio operated relay controllable from a portable transmitter as well as with 3-way key switch override. The latter to be located at the doorway; one switch inside and one outside.

Security Lighting - Stairway from Mall to Statue Mezzanine Entrance

Handrail lighting for this stairway shall be provided. The handrail shall be of extruded aluminum, rectangular, with flat plastic lens permitting down light only. Handrail shall be wall mounted. Lamp ballasts shall be remotely located in the space above the suspended ceiling of the lower lobby. Switching is proposed to be identical to that proposed for security lighting at the doors at the Statue entrance from the Mall.

Security Lighting - Grounds Surrounding Base of Statue

This need will be achieved by having twenty 500 watt incandescent floodlights mounted on grade at the base of the Statue. Incandescent lamps will be provided because of the instant response without warm-up delay. Also, the infrequent use of these floodlights will make relamping insignificant. These floodlights may be supplied from existing main switchboard "A" which has adequate spare capacity. Wiring to the floodlights will be in direct burial. The floodlights will be wired as two groups, one group serving the east side, the other the west side. Switching control may be operable with a radio operated relay for each group controllable from a portable transmitter as well as with two 3-way post-mounted key-switches for each group.

