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FORRESTAL BUILDING LIGHTING RETROFIT SECOND LIVE TEST DEMONSTRATION (LTD)

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Preface

The goal of the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) is to facilitate energy efficiency improvements at federal facilities. This is accomplished by a balanced program of technology development, facility assessment, and use of cost-sharing procurement mechanisms. Technology development focuses upon the tools and procedures used to identify and evaluate energy-efficiency improvements, such as the ASEAM simulation model and the Federal Life Cycle Costing procedures. For facility assessment, FEMP provides metering equipment and trained analysts to federal agencies exhibiting a commitment to improve energy use efficiency. To assist in procurement of energy-efficiency measures, FEMP helps federal agencies devise and implement shared energy savings and utility demand-side management projects.

Pacific Northwest Laboratory (PNL)[a] supports the FEMP mission as the lead laboratory for energy systems modernization. Under this charter, the Laboratory and its contractors work with federal facility energy managers to assess and implement energy-efficiency improvements at federal facilities nationwide.

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

Executive Summary

This report describes and summarizes the Forrestal Building Lighting Retrofit Live Test Demonstration (LTD) performed by Pacific Northwest Laboratory (PNL) in Room 5E-080 of the DOE Forrestal Building in Washington, D.C. The purpose of the LTD was to evaluate proposed lighting retrofits for compliance with the requirements laid out in the request for proposal (RFP) for the Shared Energy Savings (SES) Lighting Retrofit Project for the Forrestal Building, Washington, D.C.[a]

Testing was conducted from March 9 through March 18, 1992, and again on August 3 through August 6, 1992. Four contractors were initially tested in March. Then, two contractors were retested in August due to changes in the rebate schedule for electronic ballasts being offered by the Potomac Electric Power Company (PEPCO), the utility servicing the Forrestal Building. The two contractors tested in March were retested with different ballasts, tubes, and reflectors. The results from these new tests are reported here and compared with those from the earlier tests.

The technical requirements of the LTD are briefly summarized as follows:

- The power consumption of each retrofit must be at least 20% lower than the baseline power consumption in the room when configured as described in the RFP.
- The lighting levels for each retrofit must be at least 50 footcandles on work surfaces at least 18 inches from the wall and at least 30 footcandles in the other areas of the room as measured at 30 inches above the floor.
- The retrofit may not degrade any aspect of building performance below the current levels. This requirement is related primarily to total harmonic distortion (THD) of the current drawn by levels associated with the lighting system.

The contractors were allowed to install their proposed retrofit in the test room. Lighting level, power consumption, and THD measurements were then taken for the proposed retrofit. The test room was returned to baseline conditions after the contractors had removed their retrofits. Measurements were taken for each proposed retrofit and for the baseline of the room. An additional series of measurements was taken in the test room for a configuration representing the best available technology to the building maintenance staff.

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In the March tests, all four proposed retrofits met the minimum technical requirements of the RFP. In the August tests, the two contractors retested also met all the minimum technical requirements. Total room lighting energy savings for the four contractors ranged from 57 to 70% over the baseline levels while meeting the lighting level requirements. The THD levels also showed a decrease from the baseline levels for all four contractors.

The configuration representing the best technology available to building maintenance staff resulted in improved lighting levels and a reduction in THD, but only a 12% reduction in total room lighting energy consumption.

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1.0 Introduction

This report describes and summarizes the Forrestal Building Lighting Retrofit Live Test Demonstration (LTD) performed by Pacific Northwest Laboratory (PNL) August 3 through August 6, 1992, in Room 5E-080 of the Forrestal Building in Washington, D.C. The purpose of the LTD was to evaluate proposed lighting retrofits for compliance with the requirements laid out in the request for proposal (RFP) for the Shared Energy Savings (SES) Lighting Retrofit Project on the Forrestal Building, Washington, D.C. Four contractors submitted proposals for the project.

The four contractors proposing on the lighting retrofit project were tested in March 1992, and a letter report[a] was written on those tests. Changes to the Potomic Electric Power Company (PEPCO) ballast rebate schedule effective June 1992 led to two of the four contractors requesting additional tests with different products, and the retests took place in August of 1992. In this report, the March test results (Contractors "A" and "B") are compared with those from the August retest (Contractors "C" and "D").

The technical requirements of the LTD are summarized as follows:

- The power consumption of each retrofit must be at least 20% lower than the baseline power consumption in the room when configured as described in the RFP.

- The lighting levels measured at 30 inches above the floor must be at least 50 footcandles on the part of the work surface that is at least 18 inches from the wall and at least 30 footcandles in the other areas of the room.

- The retrofit may not degrade any aspect of building performance below the current levels. This requirement is related primarily to total harmonic distortion (THD) levels associated with the lighting system.

Evaluations were made of the baseline performance of the room as configured in the RFP, each of the four proposed retrofits, and on a configuration representing the best technology currently available to building maintenance staff. During the test period, the room was unoccupied but contained office furniture.

Evaluations included measurement of power consumption for the room lighting as a whole and for each lighting fixture in the room, lighting levels at five locations on the work surface and 18 locations in the rest of the room, and power quality measurements taken

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(a) Halverson, M. A., J. R. Schmelzer, and G. B. Parker. May 1992. *Forrestal Building Lighting Retrofit Live Test Demonstration (Letter Report).* Richland, Washington.

on the room lighting system as a whole. Power consumption and lighting level (illuminance) are called out as direct requirements of the RFP. Power quality measurements were taken to ensure that the retrofits do not degrade the THD below current levels.

2.0 Lighting Configurations

The office used for testing was arranged with furniture as shown in Figure 2.1. The selected office contained six 2-foot by 4-foot drop-in light fixtures in a suspended acoustic tile ceiling. The following is used to identify the fixtures:

Fixture 1 - front of room near instrumentation panel.
Fixture 2 - middle of room beside desk.
Fixture 3 - back of room beside desk.
Fixture 4 - back of room over desk seat.
Fixture 5 - middle of room over desk.
Fixture 6 - front of room near door.

Tests were performed on six lighting technologies (configurations) in the office. The six configurations included the baseline configuration as specified above (and in the RFP), four proposed retrofits - one by each contractor - and a configuration representing the best technology currently available to the building maintenance staff.

2.1 Baseline Configuration

The baseline configuration was specified in the RFP and was included in packages sent to prospective bidders. The configuration was designed to represent the range and approximate mix of lighting fixture configurations currently found in the Forrestal Building. The lighting system configuration is given below.

Fixture	Lamps	Ballast	Reflector
1	none	none	none
2	1 34W T12 1 40W T12	yes	none
3	2 40W T12	yes	none
4	2 34W T12	yes	none
5	2 34W T12	yes (ES)	none
6	none	yes	none

Fixture - typically dusty and paint-spattered
Lamps - mixture of Sylvania, Phillips, and GE; 34 and 40-watt (W)
Ballast - Advance Mark III and Advance Mark III Energy Saver (ES)

Note that there are fixtures with mixed 34W and 40W type T12 lamps, fixtures with energy saving ballasts, and fixtures with ballasts but no tubes, as well as fixtures with no lamps or tubes. All these configurations are currently found in the Forrestal Building. The

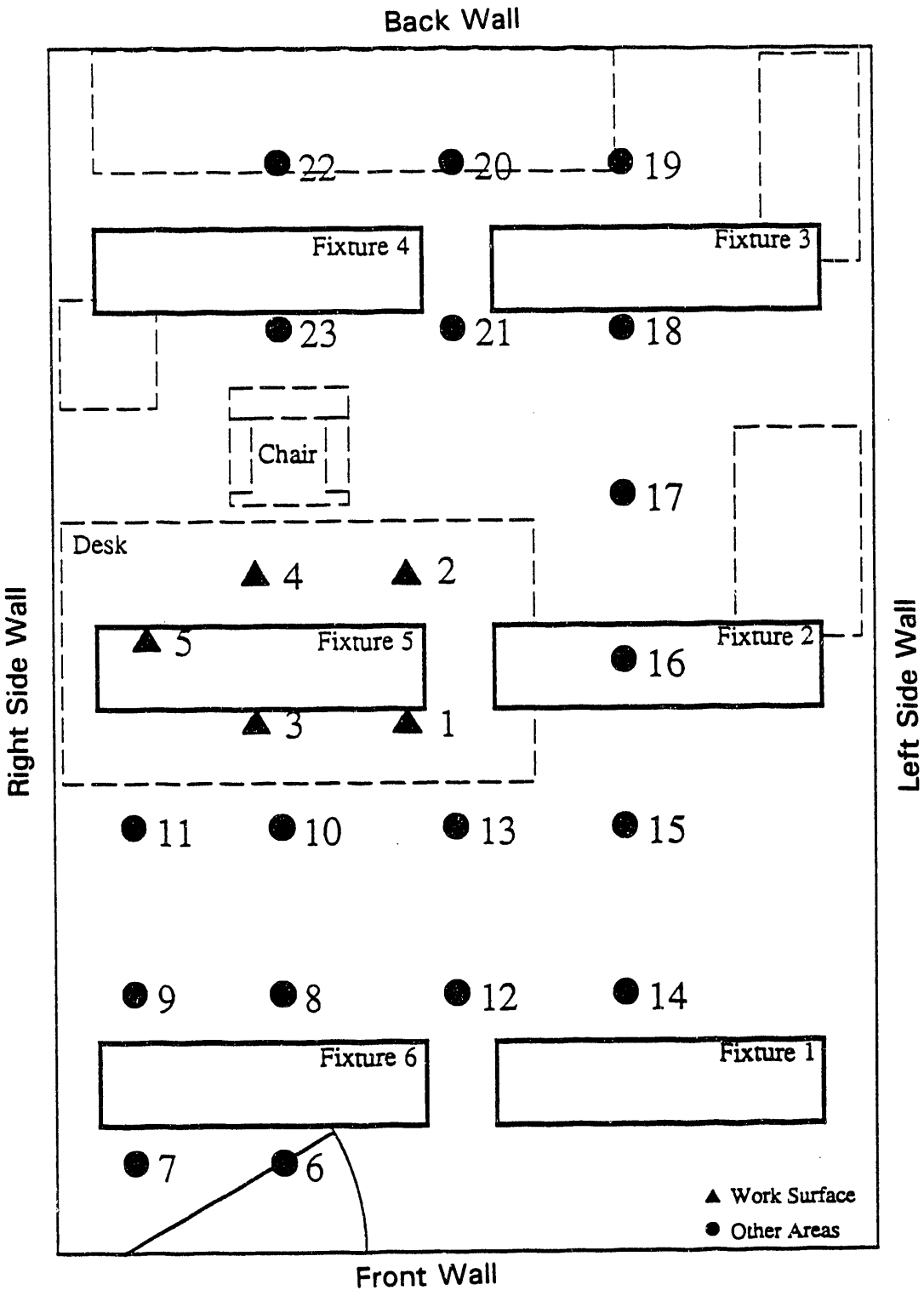

Figure 2.1. Test Room Layout, Fixtures and Measurement Points

baseline configuration was tested during the March measurement period but was not restored for the August testing period. All comparisons and energy saving calculations are based on the baseline measured in March.

2.2 Proposed Contractor Retrofits

Four contractors submitted proposals for relighting the Forrestal Building and participated in the testing. The general retrofit strategy for the contractors was to clean the fixtures, relamp the fixture with a single T8 tube, install a reflector, and tandem-wire two or more fixtures with a single ballast. The combinations of lamps, ballasts, and reflectors for each contractor are given below. The first two contractors (A and B) were tested only in March 1992; the second two contractors (C and D) were tested in March and again in August 1992 after changes were made in the PEPCO rebate schedule. The March testing results are presented for contractors A and B, and the August testing results are presented for contractors C and D. These results are to be used by each contractor in preparing their final proposals.

2.2.1 Proposed Retrofit of Contractor A--March 1992

The following configuration was proposed by Contractor A:

Fixture	Lamps	Ballast	Reflector
1	none	none	none
2	1 32W T8	yes	yes
3	none	none	none
4	1 32W T8	none	yes
5	1 32W T8	none	yes
6	1 32W T8	yes	yes

Fixtures - cleaned
Ballasts - Osram Qt2x32/27715
Reflectors - Easco Custom
Lamps - Osram F032W/30k T8

2.2.2 Proposed Retrofit of Contractor B--March 1992

The following configuration was proposed by Contractor B:

Fixture	Lamps	Ballast	Reflector
1	none	none	none
2	1 32W T8	none	yes
3	1 32W T8	yes	yes
4	1 32W T8	none	yes
5	1 32W T8	yes	yes
6	none	none	none

Fixtures - cleaned
Ballasts - Triad B2321277L
Reflectors - Silverlight Sterling
Lamps - Sylvania F032/41k

2.2.3 Proposed Retrofit of Contractor C--August 1992

The following configuration was proposed by Contractor C:

Fixture	Lamps	Ballast	Reflector
1	none	none	none
2	1 32W T8	yes	yes
3	none	none	none
4	1 32W T8	none	yes
5	1 32W T8	none	yes
6	1 32W T8	none	yes

Fixtures - cleaned
Lamps - Phillips TL80 F32/T8/TL841
Ballasts - Advance VEL-4P32-RH-TP
Reflectors - Parrish #3506

2.2.4 Proposed Retrofit of Contractor D--August 1992

The following configuration was proposed by Contractor D:

Fixture	Lamps	Ballast	Reflector
1	1 32W T8	yes	yes
2	1 32W T8	none	yes
3	1 32W T8	none	yes
4	1 32W T8	yes	yes
5	1 32W T8	none	yes
6	1 32W T8	none	yes

Fixtures - cleaned
Lamps - Phillips TL80 F32/T8/TL841
Ballasts - Magnetek Triad B4321277L & B2321277L
Reflectors - Metal Optics #4105

2.2.5 Best Technology Available to Maintenance Staff--March, August 1992

At the conclusion of the March measurements, the room was equipped with new lamps and ballasts from existing maintenance supplies. This combination represents the best lighting technology available to the maintenance staff. Measurements for this technology were taken during both the March and August testing.

Fixture	Lamps	Ballast	Reflector
1	none	none	none
2	2 34W T12	yes	none
3	2 34W T12	yes	none
4	2 34W T12	yes	none
5	2 34W T12	yes	none
6	none	none	none

Fixtures - cleaned
Lamps - mixture of Sylvania, Phillips, and GE 34W T12
Ballasts - Advance Mark III Energy Saver

3.0 Test Equipment

The test equipment used for each series of measurements in the LTD is described in this section.

3.1 Power Consumption

Power consumption was measured with a Synergistics C180 Survey Meter[a] (Serial No. 1132 for the March tests, Serial No. 90 for the August tests). The power consumption was determined through the use of 1%-tolerance, 5-amp current transformers (CTs) connected directly to the lighting circuit wiring in the room.

The accuracy of the CTs is influenced by the magnitude of the current flowing through the current transformer. To increase the current and accuracy of the measurements, the wire carrying power for each individual fixture was looped through the CT five times. The current flowing in the wire to measure the total lighting power (of all six fixtures) was sufficient without looping through the CT. Due to expected measurement errors, the sum of the six individual circuit measurements is not identical to the single power consumption measurement of the total lighting power. The single total lighting power measurement is the most accurate description of the total lighting power in the room.

Additional power consumption measurements were provided by a Basic Measurement Instruments (BMI) 3060 Power Profiler[b] Serial No. 30992 - March tests only) and by a Synergistics C180E Survey Meter (Serial No. 948 - August tests only). These instruments provided backup measurements of the total power consumption in the room.

3.2 Illuminance Levels

Illuminance (lighting level) was measured with a Photo Research LiteMate III® light meter (Serial No. 2535).[c] The instrument was calibrated to within 1% of National Bureau of Standards (NBS) traceable standards over the range of lighting levels found in the room (0 to 60 footcandles). This calibration was performed on March 9, 1992, by the Westinghouse Hanford Company Standards Laboratory, Richland, Washington. Additional lighting level measurements during the March tests were provided by a second Photo

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(a) Synergistics Control Systems Inc., New Orleans, Louisiana.
(b) BMI Inc, Foster City, California.
(c) Kollmorgen Instruments Corp., Chatsworth, California.

Research LiteMate III® light meter (Serial No. 2342) loaned to PNL by Hayden McKay Lighting Design, New York. This second light meter was used to provide a spot check of the measurements taken with the primary light meter.

3.3 Power Harmonics

Power harmonic measurements during the March tests were provided by a BMI 3060 Power Profiler (Serial No. 30992) equipped with a BMI A-115 Probe (Serial No. 1894). The instrument was calibrated by BMI to factory specifications using NBS traceable standards. Additional power harmonic measurements during the March tests (only) were provided by a Synergistics C180E Survey Meter (Serial No. 948). Based on comparisons between this instrument and the BMI during the March tests, the C180E was used both as the redundant power and the only THD measurement instrument for the August tests.

4.0 Test Procedures

The overall procedure of the test was to allow the contractors to install their proposed retrofit in the test room, conduct the tests outlined below, and then have the contractors restore the room to its original condition. Installation of the retrofit was typically concluded in a single morning, with testing and restoration occurring in the afternoon. All testing was conducted during normal operating hours of the building.

4.1 Power Consumption

Power consumption was taken continuously throughout the period of testing with a C180 data logger connected directly to the power for room lighting using 1%-tolerance CTs. The test room was specially wired so that all six lighting fixtures were controlled by individual switches. Each fixture was monitored independently and a seventh measurement was taken of all six fixtures at once.

Data were collected, read and recorded in real time prior to and during the testing and stored for future analysis on a portable computer. Data analysis was conducted shortly after each test to examine for reasonableness of the test results.

4.2 Illuminance Levels

The LTD test procedure as expressed in Attachment 8 of the RFP (reproduced here in the Appendix), while reasonably descriptive of the testing and evaluation, was not explicit enough to ensure repeatable results. For example, the procedure refers to the Illuminating Engineering Society (IES) Lighting Handbook (IES 1984) chapter on field measurements but does not specify which measurements are to be made. The procedure also lists illumination level requirements but does not specify whether these are to be minimum or average values.

The fundamental illuminance measurement prescribed in the IES Lighting Handbook is a light level measurement taken in a 2-foot square. There are numerous statistical sampling procedures listed in the Handbook for reducing the number of measurements that must be taken in a large room, but these procedures are used in determining the average illuminance in a room. Since the LTD requirements called for one illuminance level on the work surface and another in the rest of the room, an average room illuminance was not appropriate.

To meet the requirements of the Handbook, the work surface and other areas of the room were laid out in grids of approximately 2 feet (see Figure 4.1). Grids on the work surface (defined in discussion with DOE staff as the desktop only) were 25 inches by 19 inches and excluded the 18 inches closest to the wall (as required by the LTD). Grids laid out on the floor were 24 inches by 24 inches with the exception of the six points in the entryway near the door. These points were on a 21-inch by 24-inch grid due to the proximity of the door. Grid points were chosen to exclude locations deep in corners or in between pieces of office furniture. The decision to exclude deep corners was consciously made after discussion with DOE staff. The resulting grid represents the areas of the room where occupant activity can be reasonably expected, other than the work surface. A map of all lighting level measurement locations is shown in Figure 1.1.

Discussions with DOE staff led to a decision to interpret the lighting level requirements as averages for the appropriate areas. Thus, the 30-footcandle requirement for the other areas of the room was taken as the average of the 18 light level measurements in the other areas. The 50-footcandle requirement for the work surface was taken as the average of the four desktop measurements that were at least 18 inches from the wall. All lighting retrofits were allowed to warm up for 1 hour prior to measurement.

4.3 Power Harmonics

Power harmonic measurements in the August test were taken continuously throughout the period of testing with a C180E data logger equipped with 1%-tolerance CTs. Additional power harmonics measurements in the March tests (only) were provided by a BMI Power Profiler equipped with calibrated probes. The main interest in this measurement is the total harmonic distortion.

Data were collected, read and recorded in real time prior to and during the testing and stored for future analysis on a portable computer. Data analysis was conducted shortly after each test to examine for reasonableness of the test results.

5.0 Results

The results of the LTD are summarized below in Tables 1 through 4 comparing the four proposed retrofits (Contractors A, B, C and D), the baseline configuration of the room as described in the RFP (Base), and a baseline representing the best technology currently available to the building maintenance staff (energy saving baseline [ESBase]).

5.1 Illuminance Levels

Illuminance levels for each of the 23 locations in the room are shown in Table 5.1. Table 5.2 shows a number of statistics related to average illumination in various areas of the room. (See Figure 1.1 for locations of each measurement.) Note that the lamps used during the August testing of contractors C and D were not burned-in for the required 100 hours prior to testing (see Appendix). This will result in illuminance measurements for these two contractors somewhat higher than what would be measured if the protocols in the LTD were followed (as they were in the March testing). Therefore, a "derating" factor of approximately 1 to 2% should be applied to these illuminance measurements. Applying this derating factor results in lamps that, under the LTD test conditions, should produce at least 51 footcandles on the desktop and at least 31 footcandles in the rest of the room.

All proposed retrofits met the illuminance requirements of the LTD. Both the 50 footcandles on the work surface and the 30 footcandles in the other areas of the office were easily achieved by all proposed retrofits. This indicates that it should be possible to specify higher lighting levels in future RFPs and still achieve desired power reductions.

It is interesting to note that the baseline (Base) illumination almost met the LTD requirements for the work surface and met the other room illumination requirements, while the energy saving baseline (ESBase) met all illumination requirements of the LTD. Merely cleaning the lenses for the baseline case would likely have provided about 4 to 5 additional footcandles of illumination and would have allowed the baseline to meet the requirements of the LTD. There was no requirement in the LTD that the baseline illumination levels would in fact meet the LTD requirements.

Table 5.1. Illuminance Measurements, Footcandles

		Contractor					
	Location	A	B[a]	C[b]	D[b]	Base	ESBase[c]
	1	61.4	54.4	55.3	60.2	47.2	55.2
Desktop	2	61.2	58.3	55.0	60.1	53.1	62.0
	3	60.7	50.3	54.3	56.1	44.3	51.4
	4	60.5	53.7	53.6	55.7	51.7	57.8
	5	55.0	45.6	48.3	47.7	41.7	47.3
	6	39.4	18.3	39.9	44.4	20.0	23.0
	7	36.1	13.7	34.3	36.2	16.1	18.8
	8	49.9	20.2	44.6	49.5	23.2	27.4
	9	46.2	17.4	41.5	43.2	19.9	23.3
	10	50.8	31.9	46.7	57.1	35.7	40.3
	11	47.4	29.1	43.5	50.6	30.9	35.4
Floor	12	44.3	21.5	41.6	53.6	25.7	30.1
	13	48.8	35.3	44.4	60.4	38.2	44.2
	14	36.7	24.2	33.0	51.7	24.0	29.2
	15	44.2	35.2	39.6	58.0	36.5	42.3
	16	56.6	53.6	31.6	58.1	46.4	54.5
	17	46.6	51.1	43.9	57.4	51.8	60.2
	18	37.9	54.3	33.8	54.4	51.1	59.2
	19	31.3	57.5	27.4	45.3	46.0	54.0
	20	41.1	62.6	35.9	47.3	50.3	57.9
	21	47.8	58.1	40.9	56.2	55.6	62.9
	22	47.7	59.9	40.7	46.3	50.3	56.0
	23	52.5	56.4	45.9	53.8	54.7	60.9

(a) Contractor B chose not to clean fixtures for the March LTD. This would have likely increased the measured lighting levels by an estimated 4 to 5 footcandles.

(b) Contractors C and D did not use tubes with 100 hours of burn-in during August; measurements should be reduced approximately 2% to account for this.

(c) ESBase measurements were taken in both March and August but only March measurements (taken on new lamps) are presented here. August measurements were about 2% lower due to the extended period of use.

Table 5.2. Illuminance Statistics, Footcandles

Statistic	Contractor A	B[a]	C	D	Base	ESBase
Work Area[b] Average	61.0	54.2	54.6	58.0	49.1	56.6
Other Area[c] Average	44.7	38.9	40.5	51.3	37.6	43.3
Seating Area[d] Average	43.6	57.1	38.4	51.5	51.4	58.7
Entry Area[e] Average	45.0	21.8	41.8	46.8	24.3	28.0
Computer Area[f] Average	43.5	29.1	39.7	55.9	31.1	36.5
Work Min	60.5	50.3	53.6	55.7	44.3	51.4
Work Max	61.4	58.3	55.3	60.2	53.1	62.0
Other Min	31.3	13.7	27.4	36.2	16.1	18.8
Other Max	56.6	62.6	51.6	60.4	55.6	62.9
Work Ratio[g]	0.99	0.86	0.97	0.93	0.83	0.83
Other Ratio	0.55	0.22	0.53	0.60	0.29	0.30

(a) Contractor B chose not to clean fixtures for the March LTD, although this would have increased the measured lighting levels by an estimated 4 to 5 footcandles.
(b) *Work Area* is defined as locations 1 through 4 (see Figure 1). Location 5, while still on the desktop, is within 18 inches of the wall.
(c) *Other Area* is defined as locations 6 through 23.
(d) *Seating Area* is defined as locations 17 through 23.
(e) *Entry Area* is defined as locations 6 through 11.
(f) *Computer Area* is defined as locations 12 through 15.
(g) *Ratio* is defined as the area minimum divided by the area maximum.

In terms of uniformity of illumination on the work surface (as measured by the ratio of the minimum to maximum illuminance values on the work surface), all proposed retrofits exceed both the baseline (Base) and the energy saving baseline (ESBase). In the other areas of the room, only contractor B failed to improve the uniformity of illumination over baseline values. Uniformity of illumination is not a requirement of the LTD, however, so this calculation is for information purposes only.

5.2 Power Consumption

The average load for each of the six fixtures in the room, the sum of the individual fixture loads, the measured total load, and the room total lighting power density (in watts/ft² of floor space) are given for each of the four retrofits, the baseline (Base), and the energy saving baseline (ESBase) in Table 5.3.

Lighting loads and total harmonic distortion (THD) for the Base and ESBase configurations were measured only during the March testing. Individual fixture loads were recorded only for those fixtures with ballasts (see Section 2.1), and therefore some of the fixtures in the configurations will have no load listed as is noted in Table 5.3.

When contractor A was tested in March 1992, the power to the fixtures was metered on fixtures 5 and 6, rather than fixtures 2 and 6 as would be indicated by the location of the ballasts (see Section 2.2.1). This indicates either an unusual wiring configuration of the fixtures or mismarked current transformers in the metering system. This problem is not serious since the retrofit consisted of two pairs of tandem-wired fixtures. Neither the fixture loads nor the total load of this particular retrofit is in question.

Table 5.3. Power Consumption, Watts

	Contractor					
Fixture	A	B	C	D	Base	ESBase
1	0.0	0.0	0.0	50.8	0.0	0.0
2	0.0	0.0	108.0	0.0	86.0	77.4
3	0.0	52.6	0.0	0.0	95.0	70.0
4	0.0	0.0	0.0	94.8	80.8	75.6
5	59.0	51.6	0.0	0.0	69.6	78.8
6	56.6	0.0	0.0	0.0	9.0	0.0
Sum	115.6	104.2	108.0	145.6	340.4	301.8
Measured Total	113	101	108	144	335	295
Lighting Power Density (watts/ft²)	0.75	0.67	0.72	0.96	2.23	1.97

Comparing the measured total power consumption for each retrofit to the baseline (Base) power consumption of 335 watts gives the percent reduction in power consumption. This is shown below ranked in order of decreasing percent reduction.

	Percent Power Consumption Reduction
Contractor B	69.9%
Contractor C	67.8%
Contractor A	66.3%
Contractor D	57.0%
ESBase	11.9%

All proposed retrofits (in both the March and August tests) exceeded the requirement of at least 20% reduction in the power consumption of the test room. The best technology currently available to building maintenance staff (ESBase) gives about a 12% savings. Note that all of the proposed retrofits also provide at least 20% savings over the energy savings baseline (ESBase).

Contractor D chose to lamp all six fixtures (contractors A, B, and C chose to lamp only four) to achieve uniform lighting levels even though the LTD did not require all fixtures to be lit and there was no requirement for uniform lighting levels in the room. The addition of two extra lamps significantly increased the measured total power consumption of this configuration compared with the other three contractors' retrofits. Therefore, to better compare the results among the contractors, Table 5.4 shows a comparison of the retrofits on a "per lit fixture basis."

Table 5.4. Retrofit Strategy Comparison

	Contractor					
Statistic	A	B	C	D	Base	ESBase
Measured Total Watts	113	101	108	144	335	295
Number of Lit Fixtures	4	4	4	6	4	4
Watts per Lit Fixture	28	25	27	24	84	74
Percent Power Saved/Fixture Over Base	67%	70%	68%	71%	--	12%

On a per-lit-fixture basis, the energy savings are almost identical among the four contractors.

5.3 Power Harmonics

Power harmonic measurements for each of the four proposed contractor retrofits plus the baseline and the energy saving baseline are shown below ranked in order of increasing percent distortion.

Total Harmonic Distortion (THD) of Current Waveform

ESBase	12.6%
Contractor A	17.5%
Contractor B	19.3%
Contractor C	19.3%
Contractor D	19.6%
Base	21.5%

All contractors met the requirement that THD be held to no more than current levels in the test room.

These results are expected due to the age and nature of the ballasts involved. The baseline (Base) configuration contains older inductive ballasts originally installed in the building in 1968. The energy saving baseline (ESBase) configuration contains much newer inductive ballasts with a lower THD. All four contractors installed electronic ballasts, which are known to have higher THD than inductive ballasts.

6.0 References

IES Lighting Handbook - Reference Volume - 1984. Edited by J. E. Kaufman and J. F. Christensen. Published by Illuminating Engineering Society of North America, New York.

Appendix

Request for Proposal
Attachment 8
Live Test Demonstration Procedures

Attachment 8

LIVE TEST DEMONSTRATION PROCEDURES

General:

Live test demonstration of offeror's energy saving improvements will be conducted as follows:

(a) All offerors that are accepted in the competitive range will be required to perform a Live Test Demonstration (LTD). Each demonstrating offeror will be assigned a specific period to install, test, and remove their lighting modifications. All LTDs will be given in a room that contains fixtures that are representative of the fixtures within the building. This room will consist of six fixtures, of which four are lamped and two are delamped. The lamped fixtures have five 34 watt tubes and three 40 watt tubes. One of the delamped fixtures will have a ballast which is energized. Each LTD will be made in the same room.

(b) Before the date of the LTD, a preliminary inspection of the space will be arranged to allow offerors an opportunity to see the space prior to the design and installation phase. Each offeror will be given 24 hours before the scheduled beginning of the LTD to install their proposed energy improvements within the test room.

(c) Testing shall be performed with the assistance of Pacific Northwest Laboratories (PNL). With the aid of this DOE contractor, tests shall encompass electrical power consumption measurements and verification of footcandle levels. Each demonstrator is encouraged to verify the Government's measurements (both before and after retrofit) with their own equipment. DOE shall have final authority if discrepancies arise and DOE's decision as to pass or fail shall be final.

(d) All test results will then be used to determine if the offeror can meet the minimum energy consumption reduction requirement while maintaining the minimum footcandle levels specified below. Offerors participating in the LTD will know power consumption and footcandle conditions of the test room in advance.

Offeror's Responsibilities:

The responsibilities of the offeror are as follows:

(a) All costs incurred by the offeror in preparing for and performing the LTD in accordance with the provisions of this RFP will be borne by the offeror. No portion of these costs will be underwritten by the Government.

(b) Offerors will be required to return the test room to its original condition within 24 hours once the test is complete.

(c) The offeror must utilize a licensed electrician to install all energy improvements for use during the course of the LTD.

DOE Responsibilities:

The responsibilities of DOE are as follows:

(a) DOE will notify the Offeror of the LTD date at least 10 days ahead of the date. Efforts will be made to establish a date and time which is mutually agreeable to the parties.

(a) DOE will provide an opportunity for a single site visit to see the test room not less than 7 calendar days before the LTD.

(c) DOE will provide the same test room to all offerors designated to provide LTDs. DOE will furnish necessary electrical power and will make an electrician available to answer questions concerning the building. However, the electrician will provide no direct "hands-on" assistance to the offeror.

Design Constraints and Technical Information:

Room 5E-080
Length: 15'
Width: 10'
Ceiling Height: 9'
Windows: None
Wall Finish: Painted - Off White
Floor Coverings: Carpeted - Blue
Ceiling Finish: Painted - Off White

See attached sheet for existing furniture location and lighting layout.

- Minimum electrical power consumption reduction shall be 20% of existing electrical power consumption;

- Minimum footcandle (FC) levels shall be as follows:

  50 FC - At any work (desktop) plane location >18" from wall or any wall furniture at 30" above floor.

  30 FC - At any other location at 30" above floor level.

Test Procedure:

(a) After the offeror has installed the proposed lighting modifications, PNL will make a series of lighting-level measurements according to accepted Illuminating Engineering Society procedures. Concurrently, for evaluation of power consumption, PNL will measure:

(1) Total electrical power consumption (steady state KW and KVA) over a 1 hour period;

(2) Power harmonics for the general office lighting in this space. This will be done at a single point at the switch location or common location controlling all the lights in the room.

(b) This measurement will then be compared to the one-time measurement of power consumption and power harmonics taken by PNL prior to any lighting modifications. The minimum energy consumption reduction criteria will be determined and evaluated from this data. Power harmonics measurements will be taken to evaluate the power quality effects of the proposed lighting retrofit, but will not be used in meeting the energy consumption reduction criteria.

(c) For assured accuracy, this test will be performed sequentially with two separate and individually calibrated sets of test instruments.

(d) The offeror will be advised promptly of the results of the LTD.

Test Equipment:

(a) PNL will use industry standard electrical consumption, power harmonics and light-level measurement devices, each calibrated immediately before the Forrestal Building testing.

(b) The test will not include testing of any control options. Evaluation of contractor-recommended control options as part of a lighting retrofit will be based on calculations. All calculation procedures and assumptions will be available to offerors for review.

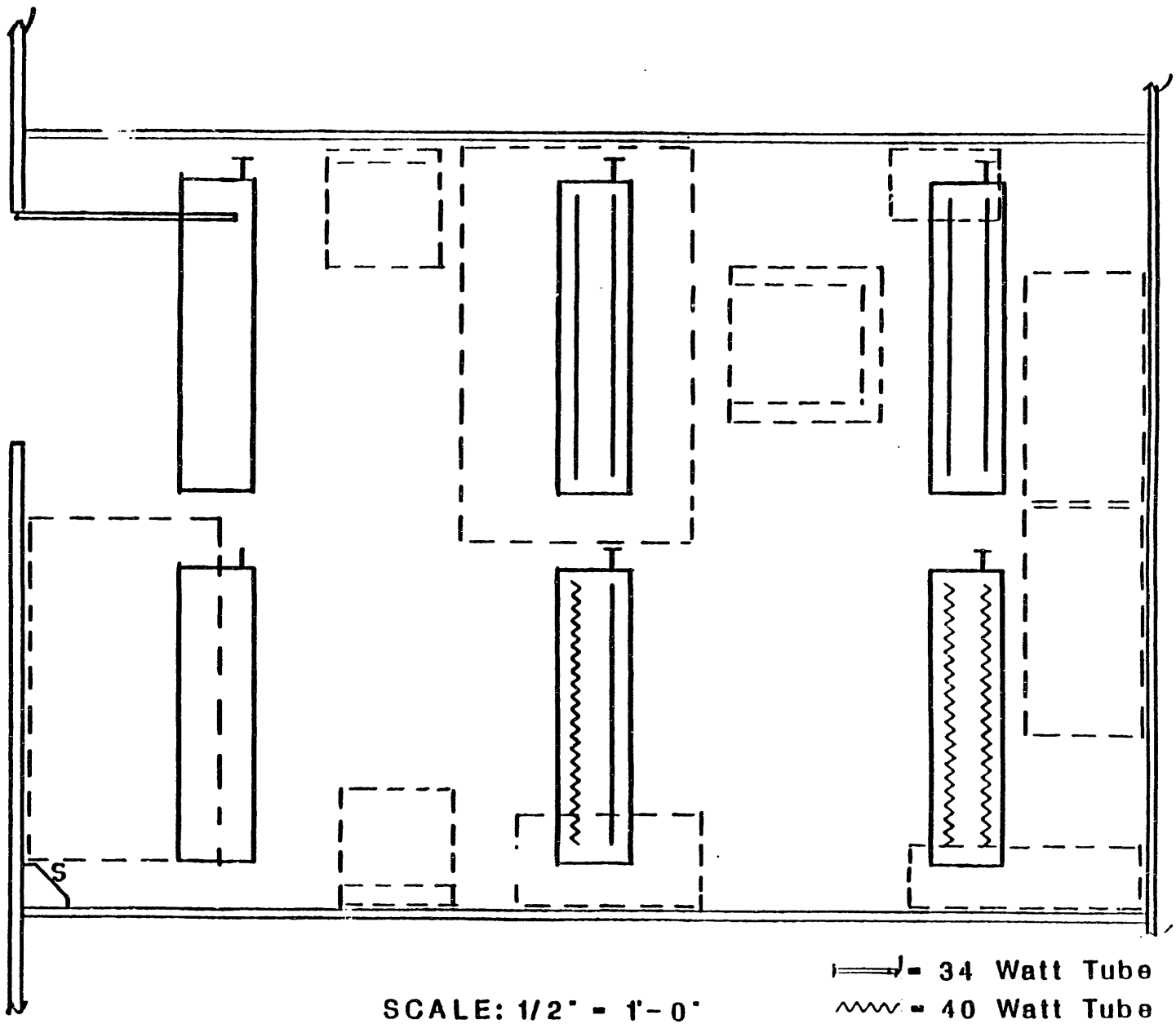
Room Layout:

Exhibit 1 - Lighting Layout for Room 5E-080

LIGHTING AND FURNITURE LAYOUT

ROOM 5E-080

A.4



SCALE: 1/2" = 1'-0"

= 34 Watt Tube
= 40 Watt Tube
= Connected Ballast
= Disconnected Ballast

Exhibit 1

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