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Vision 2001:
Energy & Environmental Engineering

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18th World Energy Engineering Congress
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A Prescription for Quality Lighting In Hospitals

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Abstract

The Sun produces a full spectrum of electromagnetic waves, from cosmic rays to radio waves. Visible light is only a very small segment of the electromagnetic spectrum that the human eye can perceive. Good quality lighting is of great importance to all of us, whether in the work place or at home. Light can have a positive effect on our behavior, productivity and health. It influences our health, how we feel, think, learn and work. Light is used beneficially in the treatment of disease, disorders and may even influence recovery times for patient care. Lighting is also a major consumer of energy, and as such, offers a unique opportunity to improve energy efficiency while enhancing the environment. It is therefore essential in the development of a system approach toward quality lighting that you promote good health and a sense of well being while concurrently optimizing energy efficiency.

Health Care Facilities

Kaiser Permanente is the nation's largest prepaid health maintenance organization. The Southern California Region consists of about 200 buildings representing 16 million square feet. Our facilities include numerous acute care hospitals, medical office buildings, office buildings, warehouses, data centers, records centers, call centers, laboratories and parking structures.

Hospitals are complex institutions that have a variety number of tasks being carried out by doctor's nurses, administrators, maintenance and other personnel. Lighting considerations for the many different areas are as varied as their functions. Providing illumination for general and task lighting in these varied environments requires special skills. Attention to spatial distribution visual comfort, glare, color rendition, efficacy and conservation become part of the prescription for quality lighting in health care facilities. Lighting quality and quantity optimization is difficult at best. The challenge is to balance energy conservation without compromising quality lighting for the specific visual task.

Care must also be given to avoid overexposure of the patient's retina. The retina of the human eye is most sensitive to light between 400 and 1400 nanometers (nm).

Lighting in all areas, including patient care areas, must enhance chromaticity (colors) and provide high visual comfort probability (VCP) (reduced direct glare). The spectral distribution from a light source and color rendition affects visual fatigue. It also affects the way the eye focuses, as well as the accuracy and speed with which certain tasks are performed. With proper lighting, eye fatigue can be reduced and human performance be improved. In addition, some people believe that proper lighting and decor can have a soothing effect in the promotion of the healing process.

The Power of Light

The Sun produces a full life-giving spectrum of electromagnetic waves shown in Figure 1. Light is only a very small segment of the electromagnetic spectrum that we can see. Radio, television and light waves travel at the same speed of 186,000 miles per second. Of particular interest for this discussion is the ultraviolet, visible and infrared spectrum. The human eye can see only a very narrow part of the electromagnetic spectrum, in the range between 380 and 770 nm.

Proper lighting in the work place and at home can have a positive effect on human behavior, productivity and health. The photobiological responses of light influence our health, including how we feel, think, learn and work. Lighting is also a major consumer of energy. In the medical care community, quality lighting offers a challenging opportunity to enhance environmental quality while balancing energy efficiency. Our objective is to develop lighting systems that illuminate appropriately, provide aesthetic quality, promote better health, less absenteeism and a sense of well-being while concurrently optimizing energy efficiency. Lighting can be a robust resource for a facility or a powerful detriment to productivity.

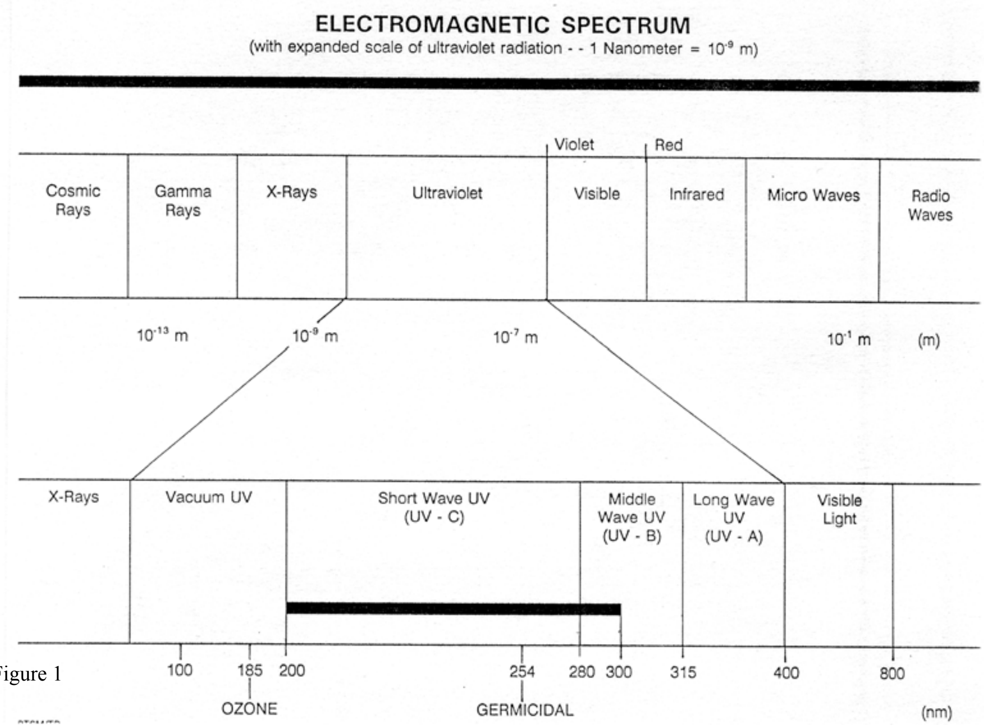


Figure 1

Natural light is an obvious human preference as compared to artificial lighting. Our inherent affinity for sunlight can lead to an overstimulation that will lead to fatigue and declining performance. Too little natural light will also lead to declining performance. Therefore, the challenge is to find a delicate balance between too much and too little natural light when designing lighting systems.

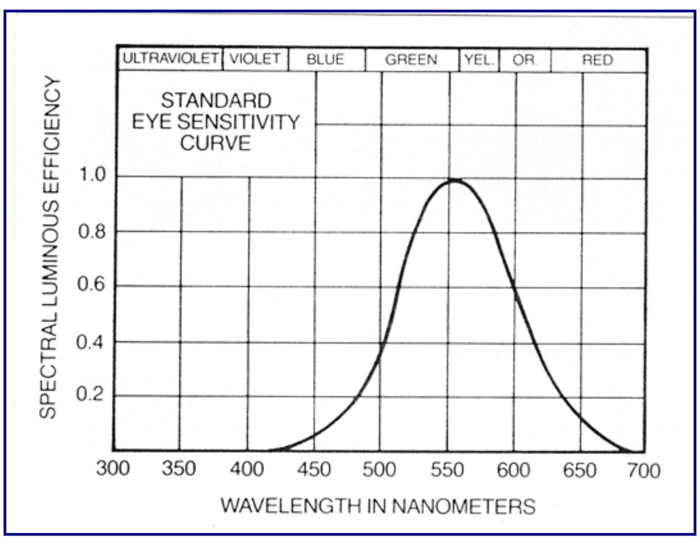


Figure 2

Generally, chronic eye fatigue can be reduced or eliminated by controlling direct glare (from lights, windows, etc.) and reflected glare from task lighting. The latter can be annoying, and it often reduces contrast making it difficult to perform a visual task.

Sensitivity of the human eye across all wavelengths of colors is not equally distributed. Psychophysical research lead to a spectral luminous efficiency curve that shows the relative brightness sensitivity of the eye at various wavelengths. Physiological response of the human eye for peak spectral sensitivity is at about 555 nm, or more commonly called the yellow green wavelength (Figure 2). Conversely, red and blue responses are very low in comparison. When performing a lighting retrofit in a facility some individuals either complain or complement the changes depending on their particular sensitivity to a color change, brightness or color rendering of objects. Others may not even notice a change.

THE BIOLOGICAL RESPONSE

The biological effects of light on the human body are known in several areas. For instance, light stimulates production of vitamin D when the skin is exposed to light. Important as it is, this beneficial effect is more important with the elderly and the ailing, whose exposure to natural light is limited. Phototherapy (light therapy) is also commonly used therapeutically to treat effects caused by

Seasonal Affective Disorder (SAD), psoriasis, neonatal jaundice and dentistry. Systematic exposure to bright light can overcome certain disabling effects caused by SAD as well as a myriad of other maladies. Studies of light on laboratory animals established significant positive impacts on the physical activity level, growth, production of a precursor of vitamin D, life spans and reproductive responses.

Skin is stimulated by light to produce a precursor of Vitamin D. Light is also known for its role in the deposition of calcium, can be an effective aid in promoting the soundness of teeth and bones, and may even prevent rickets. The region of light spectrum where these human physical responses occur is in the 280-320 nm range.

Clearly there is a need for more research, not necessarily concerning just energy savings. The need is for research on the effective application of light to maintain or enhance human performance.

ULTRAVIOLET LIGHT

Ultraviolet light is primarily the invisible part of the spectrum whose wavelengths are shorter than those of the violet end of the visible spectrum. It is longer than those of X-rays. The UV spectrum is usually considered to extend from about 50 to 400 nm. The UV spectrum is divided into three regions, which are designated as UV-A, UV-B and UV-C. Both UV-A and UV-B are of interest when considering lighting within a building in terms of photosensitive lupus patients. Literature generally indicates that adverse reaction and photosensitivity for lupus patients is mostly in the UV-B range.

> UV-A (long-wave) generally occurs between 315 to 400 nm band and is considered the black light region.
>
> UV-B (middle-wave) generally occurs between 280 to 315 nm and is commonly known for its use erythemally for tanning.
>
> UV-C (short wave) generally occurs between 100 to 280 nm and is in the ozone-producing spectrum (185 nm). UV-C is typically screened out by the Earth's atmosphere and is rarely found in a natural state on Earth.

THE FLUORESCENT LAMP

The principle of producing light using a fluorescent lamp was first developed about 1938 with the introduction of the 18-inch T-8 lamp. The fluorescent lamp is an electric discharge device, which utilizes a low-pressure mercury vapor arc to generate UV energy. This is a form of plasma energy, which by definition, is a highly ionized gas that is electrically conductive. The UV energy produced in this process is absorbed by a phosphor coat on the inside of the glass tube and converted by the phosphor to visible wavelengths. This phenomenon is known as fluorescence. The distribution of multiple wavelengths of light is determined by the phosphor composition. This in turn determines the color appearance of the light and the color rendering properties of the lamp.

How do fluorescent lamps work? Simply stated, fluorescent lamps have electrodes coated with emissive material that emits electrons. The voltage accelerates these electrons between the electrodes until they collide with mercury atoms. A collision excites the outer orbital electrons in the atom. For example, the collision raises the electrons to higher energy levels and knocks them out of the atom. These electrons radiate power when they return to the unexcited state. While some light is radiated, the principal radiation is at 254 nm in the UV spectrum. The UV is absorbed by the phosphor coating on the inside of the glass shell where it is converted to visible light as shown in Figure 3.

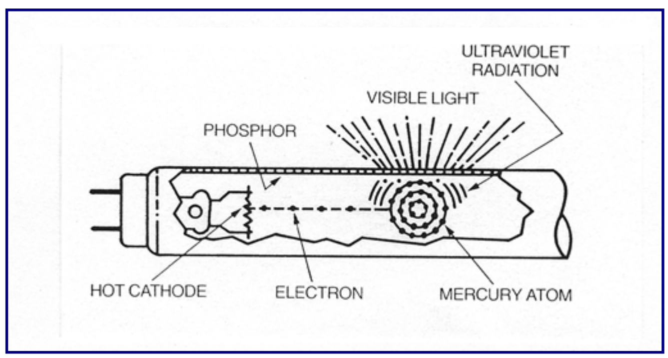


Figure 3

FLUORESCENT LIGHT AND UV EMISSIONS

The toxic effects of sunlight on lupus patients are well known. There was some concern about UV emission from fluorescent lamps, especially those patients with systemic lupus erythematosus (SLE). A small percentage of lupus patients that are particularly photosensitive to UV.

To verify that we are nor exacerbating the problem for the SLE patient with our fluorescent fixtures, we contracted with ETL Testing Laboratories, Inc., of New York to conduct a series of UV tests. The purpose was to determine if our patient care areas were being subjected to elevated levels of UV emissions from the fluorescent fixtures.

Spectral flux tests of the fluorescent fixtures with and without acrylic lenses were conducted with an Optronics Spectroradiometer with ultraviolet region gratings and ETL Integrating Sphere Photometer. The fixture was measured spectrally with the acrylic lens installed in the sunbed and then without the acrylic lens in place. The two series of spectral measurements were taken at one nm intervals. Measurements were taken with the fixture suspended at the center of the ETL Sphere Photometer. The electronic ballast in the fixture was operated at 277 volts. It powered three 4-foot T-8 fluorescent lamps for the series of tests.

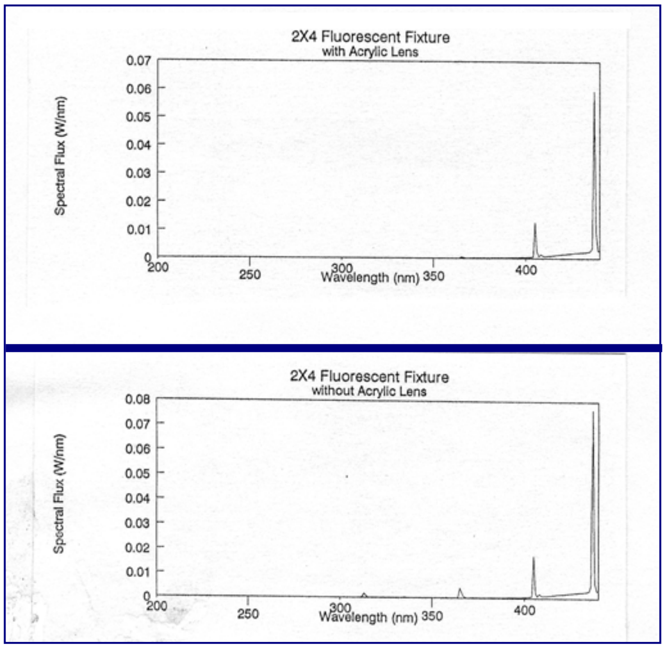


Figure 4

The UV-C integration values were obtained by the summations of the spectral irradiance values from 200 to 260 nm for each test. UV-B integration values were obtained by the summations of the spectral irradiance values from 260 to 320 nm for each test. UV-A integration values were obtained by the summations of the spectral irradiance values from 320 to 400 nm for each test. UV-C to UV-B ratio was computed from the UV-C and UV-B integration values for each test. UV-B to UV-A ratio was computed from the UV-B and UV-A integration values for each test.

The first test was conducted using a three-lamp fixture with Magnetek electronic ballast with acrylic lens, and the second test was performed without acrylic lens as shown in Figure 4. Results indicate that there appears to be no significant ultraviolet emissions produced by fluorescent fixtures typically used in an office or medical environment. Therefore, there is no potential for adverse effects for lupus patients, or health risks for the general public.

Light; A Medical Treatment

In July 1993 a scientific study was conducted by Dr. Hugh McGrath, Section of Rheumatology, Department of Medicine, Louisiana State University Medical Center in New Orleans. That study involved fifteen patients with SLE. Results using special fluorescent lamps to obtain only UV-A1 (340-400 nm) and visible light emissions, produced significantly diminished clinical disease activity and autoantibodies. Four patients selected for long term therapy (8-months) improved further over time.

Joint pain, fatigue, morning stiffness, malaise, headache, disturbed sleep pattern, impaired activity level and need for pain medication all decreased dramatically with treatment. There were no side effects. Since exposure was in the UV-A1 range there was no observed tanning. Two of these patients had a positive noteworthy response. One had a rash over the entire upper torso that was resistant to several months of extensive corticosteroid therapy. Using UV-A therapy for three days eliminated the pruritic (relating to itching) symptoms. A resolution of up to 70 percent of the symptoms was realized after three weeks of therapy. The rash reestablished itself after the phototherapy was discontinued.

A Prescriptive Control of Light

There are several ways to control light in a given application. Light fixtures can be designed to control light distribution for a variety of applications. Manufacturers employ one or more of the following in the design elements of a lighting fixture:

- absorption
- diffraction
- diffusion
- polarization
- reflection
- refraction

Painted reflectors produce a diffuse light and are typically found in standard off-the-shelf fluorescent fixtures. They use multiple lamps to produce enough lumens (if properly applied) to illuminate the work surface. Painted surface reflectors and other similar materials reflects at all angles while exhibiting little directional control. Pigment in the paint is composed of minute pigment particles, which tend to reflect diffuse light as illustrated in Figure 5. Some of this light is lost in the fixture.

The highly reflective specular surface of a fluorescent reflector is typically made of a polished aluminum, silver film or dielectric film. Proper design will control light reducing light loss within the fixture. Energy gains are achieved by removing one-half of the lamps and repositioning the remaining lamps in the center of each side of the fixture. The reflector produces multiple images of the relocated lamps, making the fixture appear to have all the lamps still inside. Without image (light) control, additional lights must be added to make-up for light loss within the fixture.

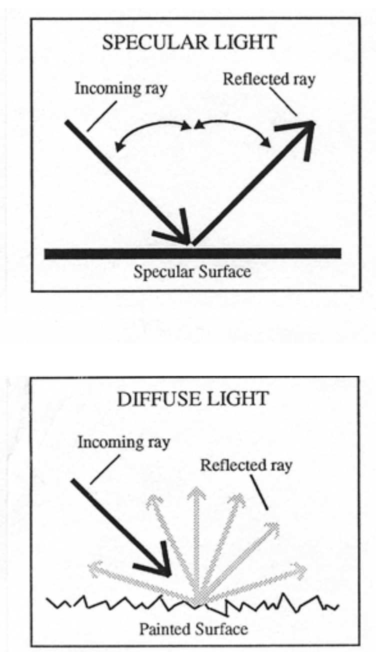


Figure 5

Fluorescent fixtures are inherently inefficient at getting the light out of the fixture, (no optical control). Light typically bounces around inside the fixture. Using the specular optical reflector allows for control of light and therefore reduction in a total number of lamps and ballasts. Maintenance costs are reduced as well as energy consumption.

The success of a lighting project incorporating specular optical reflectors totally depends on design by the manufacturer. Reflectors cannot be a single universal design but must be designed for each specific application. The goal is to reflect light directly out of the fixture and create a spread (horizontal luminance) of light necessary for the particular application. It should create multiple reflections without directing the light back onto the lamp. In some cases, this can shorten the life of the lamp. Our requirements are that the design includes a curved profile with a series of bends for multiple images.

Long-term performance of the reflector material is of utmost importance. Any degradation of the specular surface material during the life of the system will affect the long-term performance of the fixture. This is understandable when the material is oxidized, improperly applied or scratched either before, during or after the manufacturing process. Most manufacturers do not guarantee their product beyond a few years (generally five years or less). Some manufacturers guarantee the reflector material will not degrade over a 25-year period.

As of October 1994, the Southern California Region has removed over 31,000 fluorescent lights and 19,000 ballasts from operation. Savings are realized by not having to own, operate and maintain these lamps and ballasts. The ultimate goal is to remove 100,000 fluorescent lamps from operation through the application of specular optical reflectors. All lamps removed during lighting retrofit projects are recycled.

Additionally, lighting systems impacts the heating loads too. Therefore, another advantage of removing lights and ballasts results in air-conditioning costs decrease. This is due to less heat being generated within the building envelope.

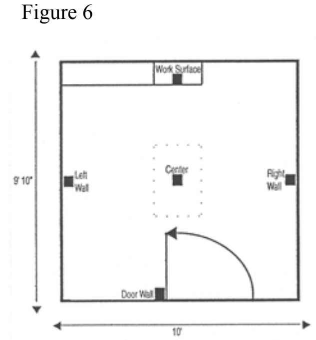
THE FONTANA CASE STUDY

I. Introduction

To test the efficacy of our prescriptive measures for lighting, we randomly selected a patient care room in a medical office building located in Fontana, California. The following case study is the results of our investigation.

Date of Test: August 26, 1994
Measurement Equipment: Sylvania DS-2000 Calibrated Light Meter (in foot-candles)
Room: 3032 - Phase 5
Room Size: 10' X 9'10"
Ceiling Height: 9'
Windows: No -- no ambient light
Work surface height: 36"
Room Layout (not to scale) with 5 testing points indicated:

Figure 6



The lighting test of a typical 2x4 fixture was conducted in 1994. Figure 6 shows the room and testing information. It also gives further specific detail including the testing criteria sheet that gives specific testing protocol followed during the test. One additional test, designated B-1, was included at the time of test. Room 3032 in Phase 5, an exam room, was chosen because it had one 4-lamp 2x4 lay in troffer with A12 diffuser and no ambient light. Phase 5 of the hospital was opened in 1989, making the fixture about 4 to 5 years old.

II. Purpose

The purpose of the test was to demonstrate:

- Washing fixtures does not increase efficiency of the fixture significantly in a typical hospital setting. Further, fixture washing alone is not justified as the sole method for delamping fixtures during lighting retrofit projects.

- Ballast and lamp change outs (BLO) (after washing the fixture) are valid in some configurations.

- Whether or not delamping fixtures and adding specular optical reflectors is the most viable option for the majority of 2x4 fixture retrofits in terms of providing equivalent or better light while providing maximum value to the organization.

III. Existing Condition (Test A)

As tested, the fixture in the exam room did not produce adequate light at the work surface (36 inches) to meet the Illuminating Engineering Society (IES) "E" standard (50-75-100 foot-candles) for exam rooms (local). The fixture had 4 Sylvania F40LWSS 34 Watt lamps and two Velmont 861038W Maxi Miser II 277 volt ballasts. The test measured 44 foot-candles at the work surface. Test A was used as the baseline for comparison.

IV. Fixture Washing (Test B, B-1, C and D)

Test B was conducted in the same configuration as test A. The fixture was washed, the 4 original 34-watt lamps were placed back in the fixture and measurements taken. The efficiency of the fixture increased at the work surface by 4.3% and overall by 3.0%. This increase still did not bring the light levels up to the IES standard for an exam room. Washing the fixture alone is not effective for retrofit projects because the cost to wash the fixture is not offset by any energy/cost savings.

Test C and D further demonstrate that washing and reducing lamps and replacing existing 34-watt lamps is not applicable. The average efficiency of the fixtures decreased by 36.4% for a washed fixture delamped to 3 lamps (Test C) and by 80.9% for a washed fixture delamped to 2 lamps (Test D).

Test B-1 was done with 4 new Sylvania F40T12/D35 40 watt lamps and the original Velmont ballasts from Test A after the fixture was washed. The average efficiency increase was 38.5%. The reading at the work surface was 71 foot-candles and meets the IES standard for an exam room. The significant factor was the lamp change, not the fixture washing. It should be noted that 40 watt fluorescent lamps were probably the original lamps installed in the fixtures in that room.

V. Ballast and Lamp Only (BLO) Change outs (Tests E, F and G)

Test E was conducted with the washed fixture and installing 4 Sylvania Octron FO32835 32 watt 3500K T8 lamps and two Magnetek B232I277RH electronic ballasts. The results of this change out were almost identical to Test B-1 where 4 new 40-watt T12 lamps were installed. This shows that a 4 lamp BLO with 4 T8 lamps and electronic ballasts is effective for retrofits in exam rooms, offices, acute care patient areas and other areas requiring an "E" IES luminance category (50-75-100 foot-candles). There are some energy savings for this retrofit due to the reduced wattage of the lamps from 34 watts to 32 watts and the reduced load of electronic ballasts.

Test F reduced the 4 T8 lamps to 3 T8 lamps in the washed fixture using the two Magnetek ballasts from Test E. The test fixture used had a very shallow ballast cover so the light was evenly distributed throughout the exam room. In most cases, the ballast cover is deeper (2" to 3") and the light will be unevenly distributed in the room. One half of the room will be underlit. This is not an acceptable BLO application for retrofits.

Test G went from 4 T8s to 2 T8s in the washed fixture using one Magnetek electronic ballast from Test E. This configuration does not come close to the original baseline fixture (Test A). The average efficiency reduction was 22.9%. Foot-candles at the work surface were 36, compared to 44 from the baseline fixture. It would be useful only in areas that are overlit such as storage or corridors. Our experience shows that 2-lamp T8 BLOs have very limited application, but can be used for retrofits. The energy savings are about 50% for these change outs.

VI. Ballast and Lamp Change outs with Specular Optical Reflectors (Tests H and I)

Test H was conducted with 3 of the T8 lamps and the Magnetek ballasts from Test E, with an electropolished aluminum specular optical reflector installed. This configuration compares favorably with Test B-1 and E. It outperforms the 4-lamp T8 32-watt configuration at the center, with a 1% increase. Both 4-lamp configurations (40 and 32 watt) at the work surface measured 71 foot-candles. The 3-lamp T8 with reflector configuration measured 67 foot-candles, or a difference of 3.7% at the work surface. All three meet the IES standard for an exam room. The 3-lamp T8 with reflector retrofit is one recommended configuration because it provides acceptable light level while realizing an additional 25% energy cost savings over the 4 lamp T8 BLO.

Test I measured the efficiency of having half the lamps of the 4-lamp T8 BLO and a specular optical reflector. The 2-lamp T8 with reflector configuration was closest to achieving the light levels of the baseline fixture (Test A). It would not be adequate to meet IES standards for exam rooms, offices and acute care patient areas needing between 50 to 100 foot-candles. It would be adequate for general service are as such as stairways, corridors, appointment areas, lobbies, waiting areas and dining areas for example. These areas need between 10 and 50 foot-candles. The energy savings are about 50% for these change outs.

VII. Conclusion and Cost Comparison - BLO Change outs Compared to Ballast and Lamp Change outs with Reflectors

The actual retrofit cost from the Kaiser Permanente Riverside Park Sierra MOB lighting retrofit project completed in July 1994 was used as the basis for this comparison. At issue is whether lighting retrofits with reflectors work and provide value to the organization. The results of the testing show that reflectors work and the attached cost comparisons show the following:

- The actual increased installed cost per fixture for a 3-lamp T8 with reflector retrofit change out instead of a 4-lamp T8 BLO is $8.01. This incremental increased cost is recovered in energy and life cycle costs in 8.6 months.
- The estimated incremental additional savings from using reflectors in 2x4 fixtures for the Fontana Lighting Project is $123,000+ a year. Over 10 years this adds up to additional savings of $1.23 million dollars. This provided ample justification for installation of specular optical reflectors in retrofit applications.

ANAHEIM RESULTS

The lighting retrofit project at our Anaheim Medical Center was completed in December 1993. The annual average kWh usage per square foot for 1990 through 1992 was 41.0827 kWh per square foot and it decreased to 31.2827 kWh per square foot after the project in 1994 (Figure 9). This was a 23.85 percent reduction in kWh per square foot.

Last year we returned to take additional light meter readings on selected rooms. Figure 10 are the results of those readings.

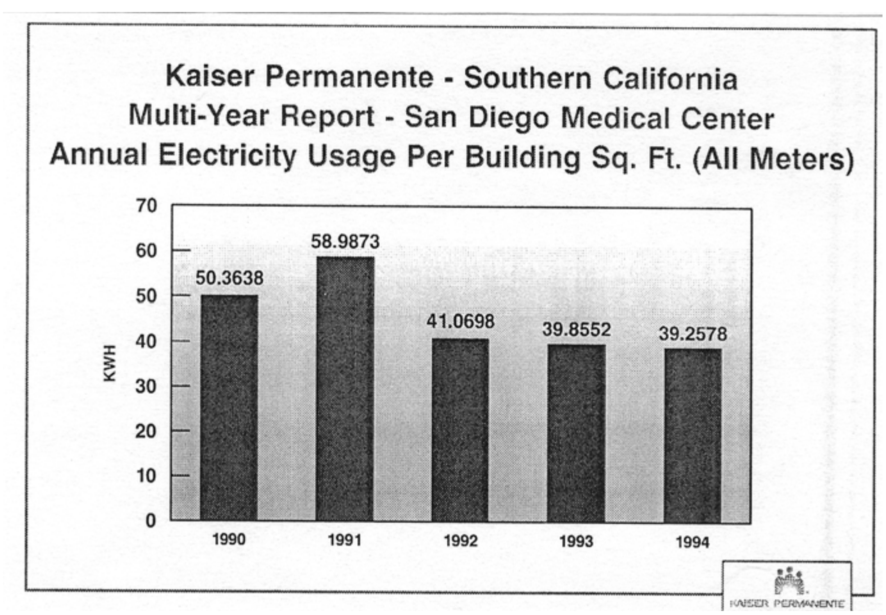


Figure 7

SAN DIEGO; TWO YEARS LATER

The lighting project in San Diego includes 13 buildings and a medical center was completed at the end of December 1992. Figure 7 is a five-year report showing the kWh consumption per building square foot since 1990. The kilowatt-hour (kWh) usage per square foot dropped 27 percent in 1993 and 28 percent in 1994 from previous years. It is interesting to note that the San Diego area had record-breaking high temperatures and humidity during the summer of 1992.

Two years after completing the project, we returned to take light meter readings. Figure 8 are the results of those readings.

KAISER PERMANENTE ENERGY SERVICES
FOOTCANDLE COMPARISON REPORT

BEFORE LIGHTING RETROFIT AND TWO YEARS AFTER RETROFIT

SITE: SAN DIEGO MEDICAL CENTER, 4647 ZION AVE.
USING: CALIBRATED SYLVANIA IDS-2000 LIGHT METER
READ DATE: AUGUST 1, 1994
BY: VIRGINIA PRUE, CEM
JENNY FLACK, IL&S

ROOM NO.	AREA	FIXTURE TYPE	REFLECTOR (YES OR NO)	PREV. READ DATE	IES STANDARD (FC)	PREVIOUS FC READING	CURRENT FC READING
5319	PANTRY	A	YES	6-25-92	D (20-30-50)	91	60
5300	NURSES STATION	X-A2K	NO	6-25-92	E (50-75-100)	70	74
5228	OFFICE (NO TASK LIGHTING INCL.)	X-A5	YES	6-25-92	D (20-30-50)	41-53	48-51
4404	SPEC. CARE NURSERY (DIMMER)	A	YES	6-25-92	C (10-15-20)	18-38	44-80
	IN INDIVIDUAL BASSINETS:						
	WITH EXAM LIGHTING				E (50-75-100)		165
	WITH TASK LIGHTING				H (500-750-1000)		1800
3228	CHAPLAIN'S OFFICE	X-A4	YES	6-23-92	D (20-30-50)	65	58-64
2426	SATELLITE PHARMACY (HOME IV)	X-A2K	NO	6-30-92	E (50-75-100)	69-86	68-99
2102	PATIENT ROOM (ACUTE CARE) ONCOLOGY 2-WEST	X-A4K	YES	6-30-92	E (50-75-100)	114	154
2128	PATIENT ROOM (ACUTE CARE ONCOLOGY 2-WEST	X-A4K	YES	7-9-92	E (50-75-100)	132	142
2128	PATIENT ROOM BATHROOM ONCOLOGY 2-WEST	X-BB	YES	7-9-92	D (20-30-50)	34	37
3103	CRITICAL CARE CNICU	X-A4KD	YES	7-9-92	E (50-75-100)	142	156

* SEE ATTACHED FIXTURE SCHEDULE FOR DEFINITION (BEFORE AND AFTER)

Figure 8

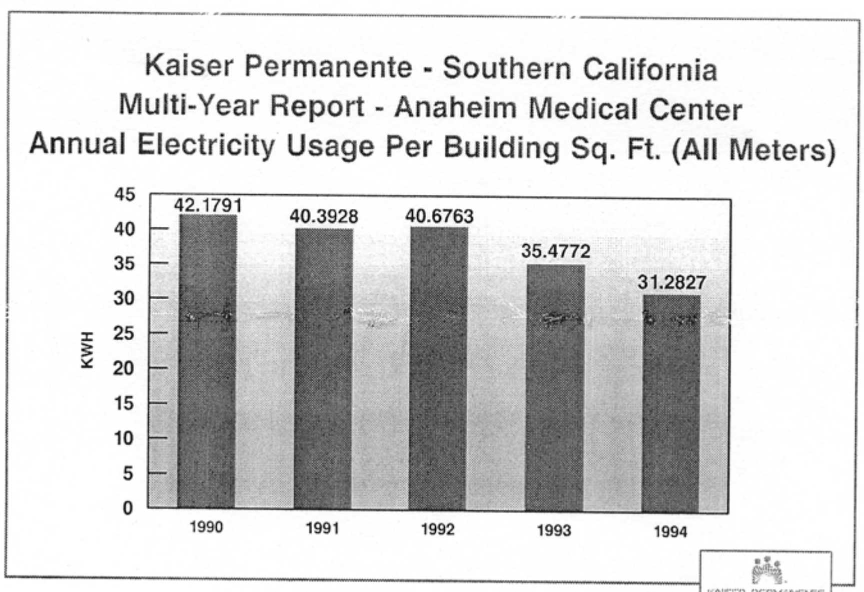


Figure 9

KAISER PERMANENTE ENERGY SERVICES

FOOTCANDLE COMPARISON REPORT
BEFORE LIGHTING RETROFIT AND TWO YEARS AFTER RETROFIT

SITE: ANAHEIM MEDICAL CENTER, 441 N. LAKEVIEW AVE.
USING: CALIBRATED SYLVANIA DS-2000 LIGHT METER

READ DATE: SEP. 9, 1994 & (APR. 13, 1995, OR ROOM)
BY: VIRGINIA PRUE, CEM
JENNY FLACK, IL&S

ROOM NO.	AREA	FIXTURE TYPE	REFLECTOR (YES OR NO)	PREV. READ DATE	IES STANDARD (FC)	PREVIOUS FC READING	CURRENT FC READING
B01	FOOD PREP	A/3	YES	3-19-93	50	77,122,108	E(50-75-100)
B06	OFFICE (NO TASK LIGHTING INCL.)	A/2	NO	3-19-93	77	77	D(20-30-50)
SPD	PREP AREA-CTRL STERILE SUPPLY	A/3	YES	3-19-93	53	107,124	E(50-75-100) F(100-150-200)
W108	CHART ROOM-MEDICAL RECORDS IES NOT COMPARABLE, READS AT FLOOR, NOT TASK HEIGHT	A/3	YES	3-19-93	14	24,.25,23	E(50-75-100) SEE NOTE AT LEFT
ER	NURSES STATION	A/3	YES	3-19-93	73	111	E(50-75-100)
ICU SO.	NURSES STATION	A	YES	3-23-93	66-71	98,103,134	E(50-75-100)
WAS 122 NEW 1322	OFFICE (NO TASK LIGHTING INCL.)	A/3	YES	3-23-93	50	72-79	D(20-30-50)
WAS 120 NEW 1320	OFFICE (NO TASK LIGHTING INCL.)	A/3	YES	3-23-93	51	61,70	D(20-30-50)
2ND FLR	IV AREA LITE-INPATIENT PHARM	A/3	YES	3-23-93	68-100	73-107	E(50-75-100)
2ND FLR	INPATIENT PHARMACY	A/3	YES				
	FLOOR				39	51,54,58	
	COUNTER				65	80,93	E(50-75-100)
OR4	OPERATING ROOM-GENERAL	A6/L	YES	3-19-93	133-241	151-241	F(100-150-200)

* SEE ATTACHED FIXTURE SCHEDULE FOR DEFINITION (BEFORE AND AFTER)

Figure 10

THE ENVIRONMENTAL BENEFITS

Traditionally, a combustion process produces electrical and thermal energy. Coal, fuel oil and natural gas are common fuels used for electrical generation at central power plants.

Health risks from polluted air are starting to be accepted as an actual cost for energy. Some of these costs are starting to manifest themselves in the form of higher energy costs. Air pollution, higher maintenance and energy costs are the driving forces behind Kaiser Permanente's switch to more energy-efficient lighting. Energy-efficient lighting makes good economic sense.

According to the California Energy Commission and the Environmental Protection Agency, our greatest resource is energy conservation.

In our resource planning, we are removing 1/3 to 1/2 of the lamps used in our facilities by using specular optical reflectors. Removal of over 31,000 fluorescent lamps and 19,000 ballasts from operation also meant a reduction of source emissions. Based on contemporary natural gas combustion technologies, this translates into an annual reduction of emissions by:

- 5,430 Tons of CO_2
- 13 Tons of SO_2
- 18 Tons NO_X
- 17,370 Barrels of oil

With a $40 million dollar energy budget, performing a lighting project in Southern California will reduce our cost of operation by almost $10 million dollars. Generally speaking, the cost of lighting of our hospitals exceeds 40% of the total cost of electricity. Reducing those cost by 50% yields about a 20% reduction in electric consumption for that facility, generating substantial incremental revenue from energy savings.

CONCLUSION

After extensive testing and actual results from our comprehensive lighting retrofit projects, we have developed a successful systems approach for our medical centers. The evidence supports our belief that quality lighting and energy efficiency can be successfully prescribed together, while also being environmentally responsible.

REFERENCES

Figure 1 Energy Services, Kaiser Permanente, Southern California Region

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