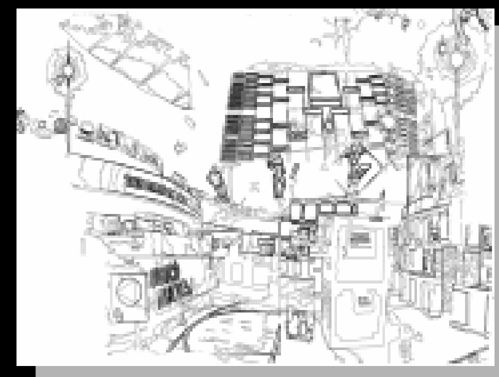
Dynamics of the NCAA Hall of Champions Gallery Transition Sequence

A Study of Lighting Effectiveness in Relation to Visual Comfort

Hall of Champions

NCAA Headquarters



Indianapolis, Indiana

Lew Beyers **Josh Deyer**

Vital Signs VI

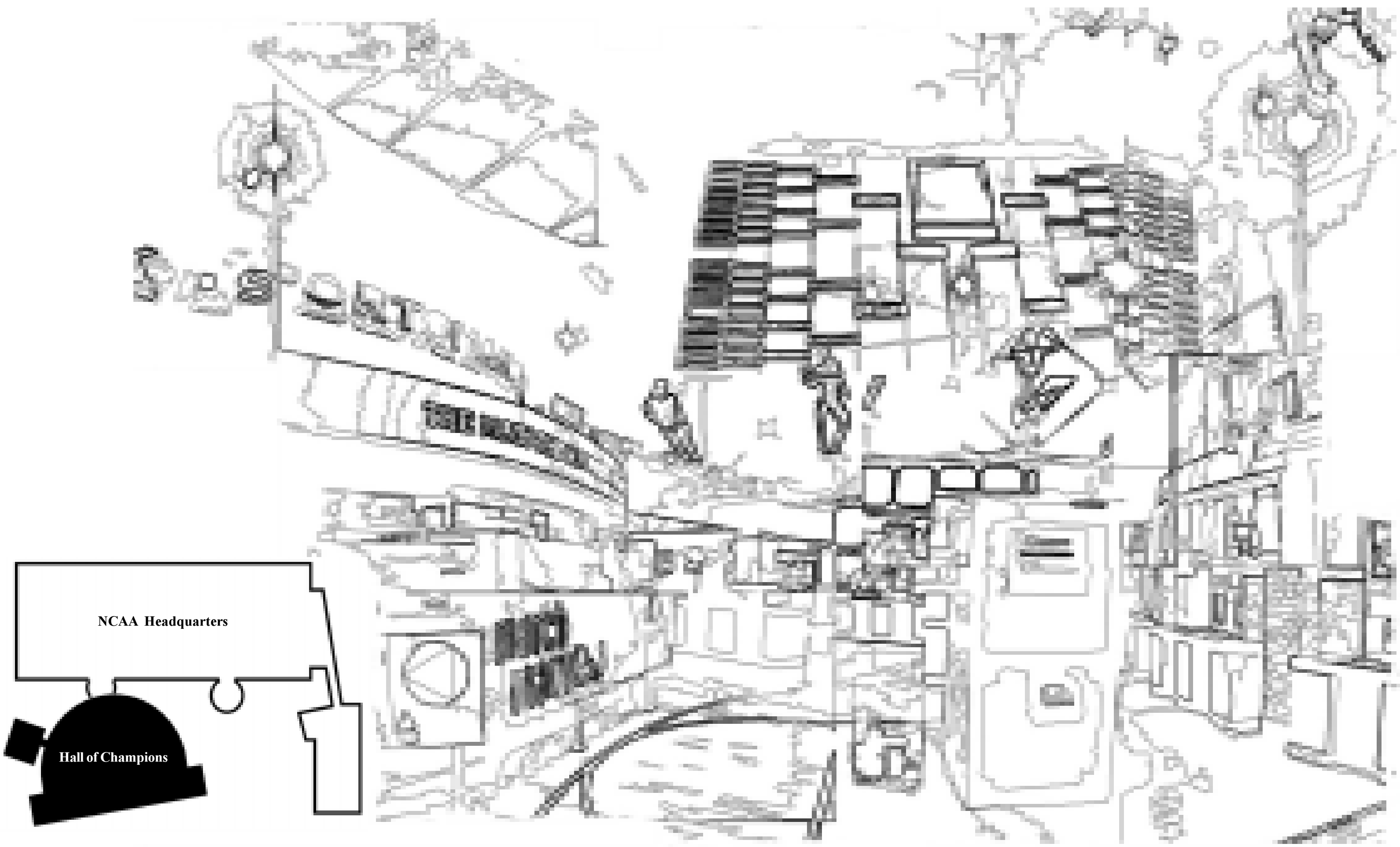
Center for Energy Research, Education, and Service

Ball State University
Fall of 2001

Dynamics of the NCAA Hall of Champions Gallery Transition Sequence

A Study of the Lighting Effectiveness in Relation to Visual Comfort

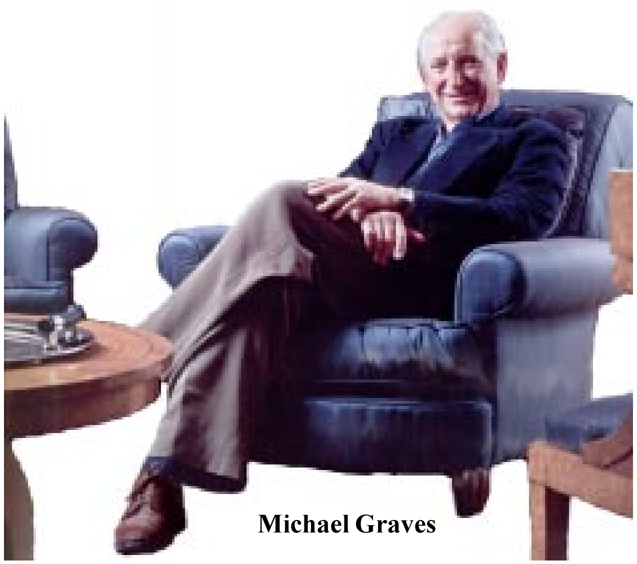
An Investigation which Focuses on the Second Floor Gallery Hall



The Architect

Michael Graves, a native of Indianapolis, Indiana, received his architectural education at the University of Cincinnati and at Harvard Univeristy. Among his many completed projects are the Portland Building, the Humana Building, the Clos Pegase Winery in the Napa Valley, and the Walt Disney World Swan and Dolphin Hotels, Graves is the winner of fifteen Progressive Architecture Design Awards, nine American Institute of Architects National Honor Awards, and thirty-eight New Jersey Society of Architects, AIA Awards as well as the National Medal of the Arts.

Michael Graves was recently awarded the 2001 AIA Gold Medal



Michael Graves

Dynamics of the NCAA Hall of Champions Gallery Transition Sequence
A Study of the Lighting Effectiveness in Relation to Visual Comfort

Investigation Focuses on the Second Floor Gallery Hall

Case Study Participants

Lew Beyers - Second year Graduate - Architecture
Josh Deyer - Fifth Year - Architecture

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Jeff Culp - Operations Manager
Robert A. Fisher - Resident Fellow, Professor of Architecture

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Nick Rajkovich - Graduate Teaching Fellow, Oregon

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A very special thanks to Wayne Leonard, CEO of Entergy Corporation for his company's endowment of the Ball State University Vital Signs Program which has helped finance the student scholarship documented in this report.

Also a thanks to Stacy Stinson for all of the time, assistance and great discussions on lighting.

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A Study of the Lighting Effectiveness in Relation to Visual Comfort

Abstract

This semester-long instrumented field study of the Hall of Champions at the NCAA Headquarters focuses on the lighting effectiveness and visual comfort of the second floor gallery hall.

The transition sequence was examined to determine the effect of the lighting conditions on the visitor. We discovered the lighting conditions change significantly when transitioning through the gallery hall. The high contrasts between lighting and color palette causes visual discomfort for the visitor.

In our research, we determined the key factors that have an effect on visual comfort, including: adaptation of the eyes, field of view, brightness / contrast, contrast grading and material reflectiveness.

In touring the second floor gallery hall and exhibits visual discomfort was experienced by visitors due to the current lighting layout. This discomfort stemmed primarily from direct glare caused by the spot-lights, used to light the sporting statues, located within the visitors field of view. The apparent attempt to reinforce a sense of the heroic by the placement of fixtures at dramatic angles of incidence caused substantial direct glare. Reflected glare, specular reflections, diffuse reflections, veiling reflections, and contrast grading; all of which contribute to the discomfort experienced in the second floor gallery, but this was minimal compared to the direct glare experienced.

An initial visit was conducted to gather general illuminance and spot readings within the gallery hall and pin-point the specific areas for further investigation. For the purpose of framing and testing our hypothesis, the second floor gallery hall was subdivided into three segments (A-C) for in-depth study.

After the formulation of our hypothesis, several additional visits were conducted to collect additional specific data including: instantaneous spot illuminance readings, long-term and overnight illuminance data, luminance measurements, and photographs necessary to test our hypothesis.

In order to interpret the collected data, we constructed comparative line graphs, section line graphs, isolux grid maps and grayscale visual field maps using excel and photoshop. In analyzing the data we discovered, that testing our hypothesis required a balance between empirical and subjective analysis techniques.

As a result of our investigation and analysis of the current lighting illumination levels, fixture layout geometries, and lamp types we discovered visual discomfort is experience by visitors in the NCAA Hall of Champions second floor gallery hall.

Introduction

The Vital Signs VI course, offered during the fall semester of 2001 at Ball State University, is a field-based research course that focused on interior illuminance, daylight control and occupant response. To gain a greater understanding of the course's subject matter, a comprehensive project was formulated by the Vital Signs VI director, Robert J. Koester under the auspices of the Vital Signs Project, a national curriculum transformation initiative developed by Cris Benton at the University of California, Berkeley which is funded by The Energy Foundation, Pacific Gas and Electric and the National Science Foundation. The signature architecture chosen to be investigated and analyzed in Vital Signs VI was the NCAA Headquarters and Hall of Champions in Indianapolis, Indiana.

The NCAA Headquarters and Hall of Champions was completed in the spring of 2000 and was designed by Princeton-based architect Michael Graves in concert with Schmidt Associates, the Architect of Record.

The Hall of Champions portion of the building serves to showcase past and present events in collegiate sports history. It is a top tourist attraction located in the White River State Park in Indianapolis, Indiana and hosts a national audience of visitors year round.

For the purpose of our investigation, an initial site visit was scheduled, in early September, as a means to familiarize ourselves with the NCAA campus complex. A guided tour was provided by NCAA operations and REI facility management staff members. These individuals included David Clendinin of the NCAA organization and Milt Grissom, the senior facility manager. Our main objective during the site visit was to look for indicators and locate problem zones or nodes within the lighting design. With the indicators in mind we then developed an assessment of the lighting conditions within these spaces.

Upon our return to Ball State University, the Vital Signs class was divided into six teams composed of two or three individuals. The individual teams then decided which zones in the NCAA Headquarters and Hall of Champions they would use to focus their comprehensive investigation pertaining to interior illuminance, daylight control and occupant response. Our group chose to focus our investigation on the second floor exhibit hall in the Hall of Champions. This zone was selected because the visual comfort we experienced was not that of the other zones of the NCAA complex.

Figure 7.1
Key plan highlighting the building which is the main focus of our field research.

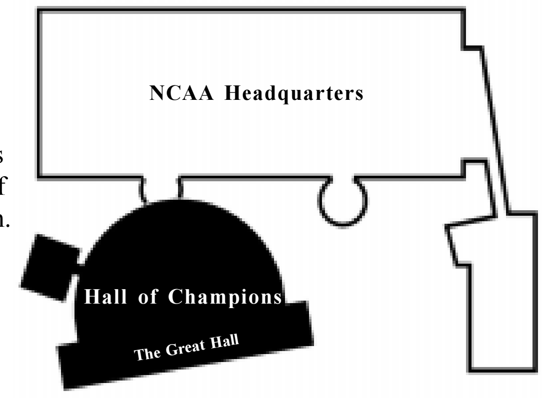
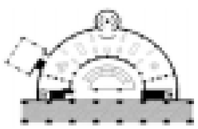
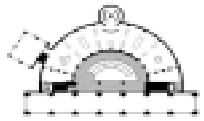


Figure 7.2
The "Great Hall" is flooded with daylight during the day and becomes a "Lantern" for White River State Park at night.



NCAA Hall of Champions- The "Great Hall"

Figure 8.1
View of the video screens on the second floor mezzanine.



Hall of Champions second floor "Wall of Champions"

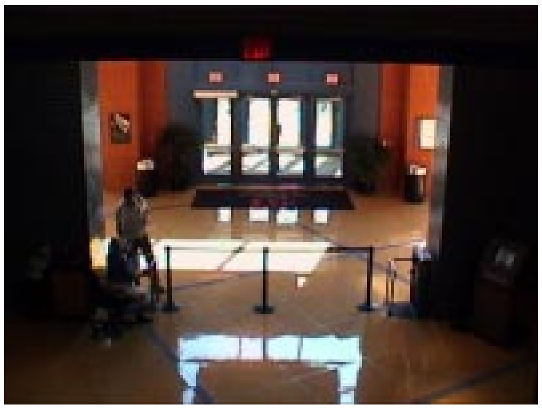
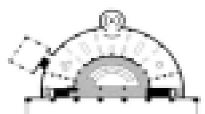
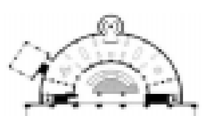


Figure 8.2
View from stair landing looking into "The Great Hall".



Main Entrance into the Gallery Hall

Figure 8.3
View into "The Great Hall" at eye level.



"The Flying-V" - Bronze Sculpture

Introduction

The investigation prescribed in Vital Signs VI was a post occupancy evaluation methodology developed by Wolf Prieser. The process is threefold: Indicative, Investigative, and Diagnostic. Through our indicative investigation, the initial phase, we gained a greater understanding of the present environmental conditions. This was achieved through our initial site visit and walk-through in which we documented the indicators of direct glare and brightness contrast within the environment through photography and narrative writing. Once this audit was completed a list of issues pertaining to visual comfort was compiled. The list included adaptation of the eyes, field of view, brightness/contrast ratios, contrast grading and material reflectiveness. These issues are the driving force behind our investigation.

Once the audit was completed, we developed a list and rated the issues in order of significance as they pertained to visual comfort in the space. We found that direct glare and brightness contrast were the two most prevalent issues in terms of visual comfort in the second floor gallery in the Hall of Champions. Our hypothesis was formulated under the assumption that architects and designers attempt to create museum/exhibition spaces in which the visual comfort of the visitors is optimal. A museum will not be successful in terms of attendance numbers, if visitors are unable to experience the displays and exhibits in comfort. It is human nature for an individual to remove oneself from a physically uncomfortable space. Following the formation of our hypothesis we moved onto investigative research.

Investigative data gathering used hand held instrumentation, i.e. light meters, to measure overall illuminance levels in the space. Location and quantity of spot-lighting were documented in an attempt to gain a greater understanding of the problem areas within the second floor gallery hall. Once this information was obtained we moved on to diagnostic investigation.

Diagnostic investigation, was the final phase in this methodology. In-depth examination of collected data sets occured in this phase. Comparative line graphs, section line graphs, isolux grid maps and grayscale/visual field maps are the means by which we will illustrate and communicate our findings.

Upon completion of this investigation into the second floor gallery hall, our assessment of findings and recommendations are to be handed over to the NCAA organization and they will hopefully implement a few, if not all, of our recommendations in an attempt to improve the illumination environment of the NCAA Headquarters and Hall of Champions.
Get numbers on visitors per year from mike.

Hypothesis

Our hypothesis was formulated under the assumption that architects and designers attempt to create museum/exhibition spaces in which the visual comfort of the visitors is optimal. A museum or gallery will not be successful in terms of displaying art or conveying the intended message, if visitors are unable to experience the displays and exhibits in comfort. It is human nature for an individual to remove oneself from a physically uncomfortable space.

Visual discomfort does not occur while viewing the exhibits located in the second floor gallery hall.

Visual discomfort, in this case study, pertains to:

Visual Comfort

Visual comfort in the investigation refers to the absence of the sensation of physiological pain, irritarion or distraction. Visual discomfort within a space is directly related to contrast levels and luminance variations across the space. In lighting design, glare is the key cause of visual discomfort. Glare resulting from extreme contrast within a given field of view prompts us to turn away or squint our eyes. In essence, we are protecting our eyes.

For optimum comfort, the brightness of the task should be graded from that of the general environment, to a local area of intermediate brightness, i.e. contrast grading. Visual comfort limits for glare depend on the relationship of brightness and size of the source, position of the object in the visual field and the eye adaptation of the viewer.

Adaptation of the eyes

The eyes are astoundingly adaptive in range. They can adjust from levels below 1fc to levels over 10,000fc in just seconds. They have the ability to detect brightness over a range of 1012fc to 1fc. Eyes are only stressed or damaged when the change is too rapid or most of the background is dark, but one spot is intensely bright. Glare results from such extreme contrasts.

If the eyes are kept in low light for some time they grow more sensitive, and as a result a given quantity of light will seem brighter. This "dark adaptation" is rapid for the first few seconds, then slows down. The cone (color) and rod (monochromatic) receptor cells adapt at different rates. Cone adaptation is normally completed in seven minutes where rod adaptation continues for an hour or more. As the eyes become adapted to the darkness, they lose acuity while gaining sensitivity. With a decrease of luminance and the compensation of dark adaptation, the ability of the eyes to make out fine detail is lost.

Figure 9.1
Types of glare related to visual comfort. i.e. Direct and Reflected Glare (MEEB).

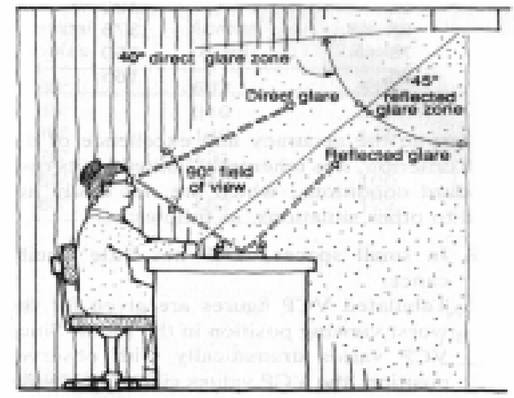
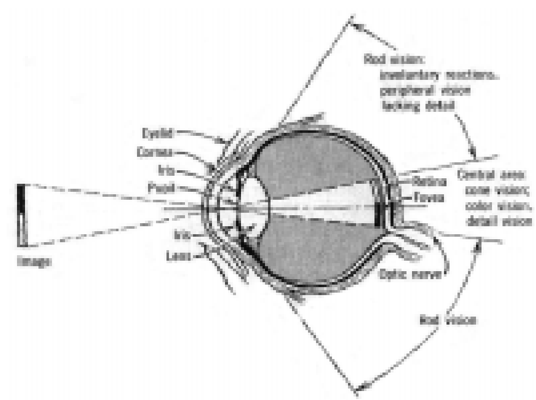


Figure 9.2
Anotomy of the human eye (MEEB).



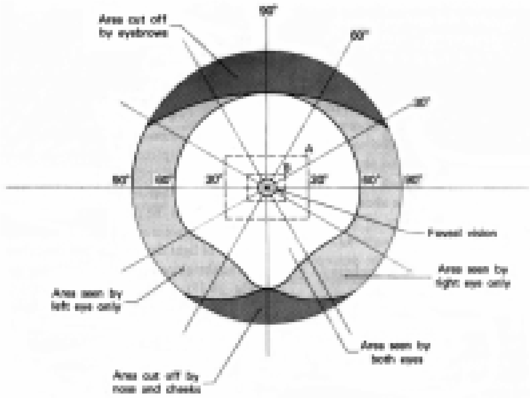


Figure 10.1
Field of view with subtended angles (MEEB).

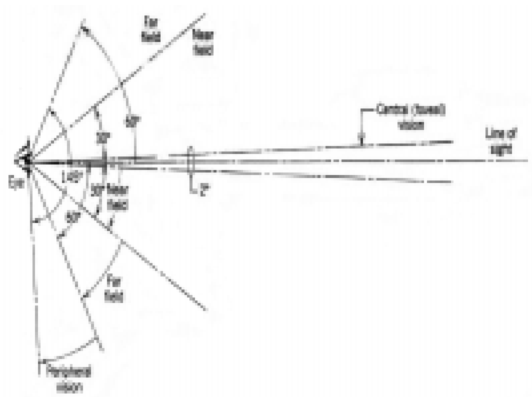


Figure 10.2
Field of vision of a normal pair of human eyes (MEEB).

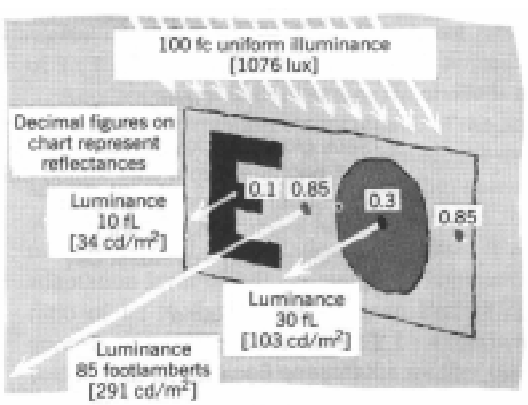


Figure 10.3
Brightness contrast, the sensation of luminance difference between two visual proximate surfaces (MEEB).

Hypothesis

Eye strain

The eyes are strained when there is a great demand placed on them. The eyes become overexerted when they are forced to adapt to quickly to extreme contrasts in the visual field.

Eye fatigue

The eyes become exhausted in cases of extreme contrast when they are overexerted for an extended period of time. In essence, the eyes are overworked by continually distinguishing complex visible information, thus attempting to adapt to the environment.

Field of Vision

The field of vision of a normal pair of human eyes consists of the central (foveal) vision, cone of binocular vision, and the cone of monocular vision. The foveal vision consists of a 2 degree cone, along the line of sight, in which acute perception of detail takes place. This area of vision is the most sensitive to extreme contrasts or glare. The binocular vision or near field consists of a 60° overlaping cone, which consists of a 30° half-angle central vision area where most of the coarser sight information is gathered. The monocular or far field consists of a 120° cone in which subjective and ambience-type information is gathered. The peripheral vision consists of a 145° cone where visual imformation is collected by each eye separately.

Brightness contrast

When light falls on a surface, spreading luminous flux over it, and when this luminous flux is reflected back to the eye, by virtue of the reflecting power of the surface, the luminous sensation which we perceive is called brightness. Contrast is the sensation of luminance difference between two visual proximate objects or surfaces. It is the brightness difference between the object being viewed and the immediate surroundings. Contrast is a vital element in visual perception. Therefore, visual performance increases with contrast depending on the eye adaptation.

Hypothesis

Contrast Grading

The surrounds of a surface have a significant effect on the quality of the light within a space. High levels of surrounding brightness in the field of view causes the eyes to adjust by reducing the amount of light entering the eye and hence sensitivity to contrast is lost. Unfavorable contrast of this kind makes the room look gloomy and glary. A grading of brightness between the source and surrounds is called contrast grading, and should be incorporated into any design , to reduce glare.

Material reflectivity

If light is bounced off a material, the material is said to be reflective. If the reflected image is maintained (in the case of a mirror) the surface is called specular, but if the image is not maintained (in the case of a matte finish) the surface is called diffusing. Reflectivity or reflectance is usually expressed as a percentage of the incoming light energy that is bounced back from a surface.

Design Intent - Second floor gallery hall

According to Ron Fisher, the Architect of Record for the NCAA Headquarters and Hall of Champions complex, the actual lighting within the Hall of Champions galleries became very specific to each exhibit with the intent of using lighting to reinforce the actual design of the exhibits and the experience that one would have with them. Two lighting consultants, Seventeen - Seventeen and Fisher, Morantz, Renthrow and Stone, worked closely with Michael Graves on the concept of the exhibits. The concept of the exhibits, interactive video screens, and the music scores were all specifically developed for this facility.

In the second floor gallery hall, the exhibit spaces are, in concept, to be reminiscent of sports areas, i.e. field houses or arenas, which are composed of high-tech or industrial types of materials. The feeling of being inside of a stadium is evoked by these types of materials.

The design intent of lighting the sculptures, within the second floor gallery hall, was to portray or display the sports figures heroically. This was done by intense side-lighting to create sharp highlights and dark shadows.

Figure 11.1 Contrast grading, source against background, alone. Source with surround added (Vital Signs, course manual).

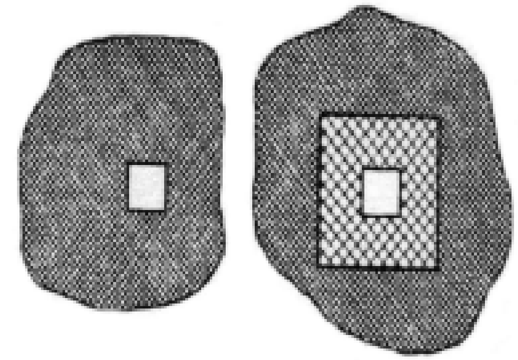


Figure 11.2 Illustrates the importance of contrast which enhances visual acuity (MEEB).

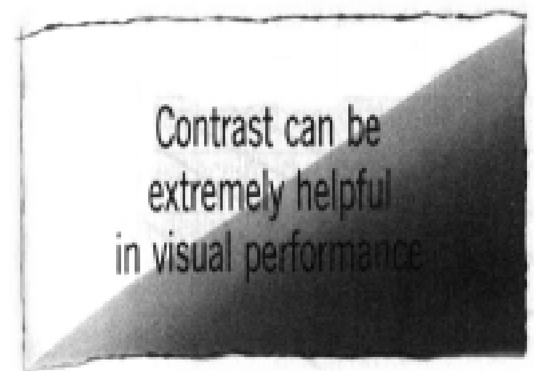
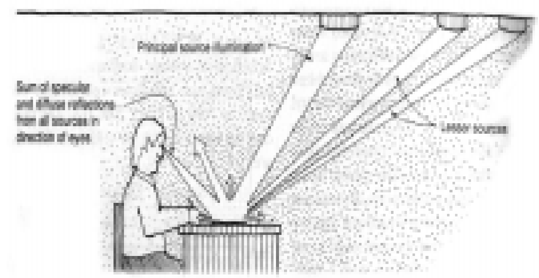
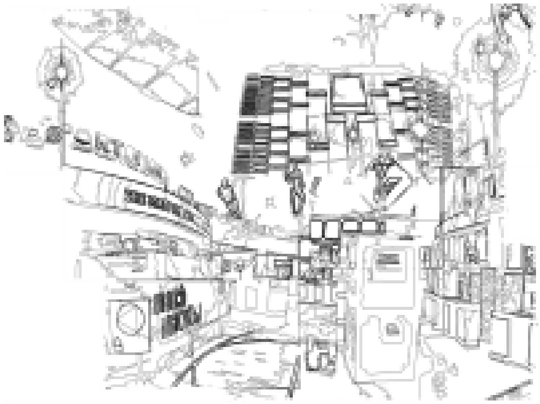


Figure 11.3 Material reflectance, illustrating the sum of specular and diffuse reflections (MEEB).





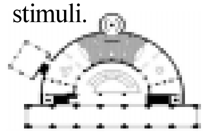


Figure 12.1 Graphic illustrates the visual complexity within the space. Visual clarity is reduced as a result of many visual stimuli.

(See section- for detailed description)

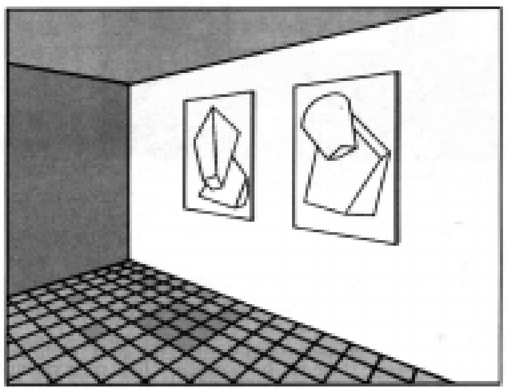


Figure 12.2 Diagram illustrates uniform illumination for art work(Gordon and Nuckolls).

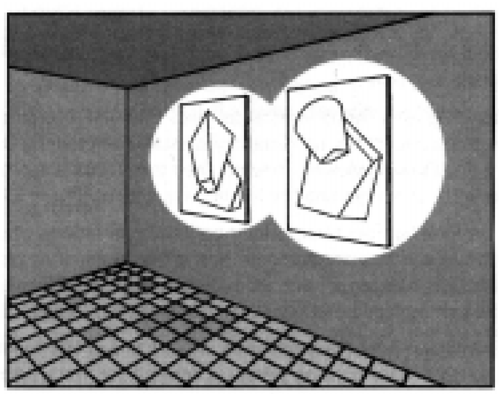


Figure 12.3 Diagram illustrates nonuniform illumination for art work(Gordon and Nuckolls).

Background Research

Design Guidelines for Gallery / Exhibit Space

Lighting design is a process. More specifically, it is the process of integrating light into the fabric of the architecture.

According to Gordon and Nuckolls, successful lighting is integrated into both the architectural concept and the physical structure. The lighting concept can be integrated into the architecture in two ways; one, by reinforcing the activity of the space and two, by highlighting areas to be more prominent and deemphasizing areas to be subdued.

Lighting equipment can be integrated into the physical structure of a building in one of three ways; one, by selecting visible elements that harmonize with the design motif, two, by incorporating hidden elements within the architectural forms and surfaces, and three, by coordinating electrical systems with other mechanical systems of the building.

People search for simplification, i.e. visual clarity, within their visual fields when faced with demanding tasks and activities. Too many visual stimuli or patterns placed in an environment used for complex activities such as viewing an exhibit results in an overload condition. The visitor becomes tense and frustrated causing a diminished ability to perform complex tasks. An excellent example of this visual noise as stated by Gordon and Nuckolls, “When reading with music playing nearby, the sound competes yet allows comprehension of simpler passages. At a complex portion of the material where the reading task becomes more absorbing, one instinctively turns the volume down or off. In doing so, the amount of information that is competing for attention is reduced”.[1] Therefore, meaningless or confusing luminances in a space are similarly distracting. In essence, the brain becomes overstimulated, having to spend additional time and energy discerning the conflicting information. As an activity becomes more complex, thus more loaded, visual clutter becomes a design issue.

Humans define their environment through a process of additive perception. By scanning the boundaries of a space, information is gathered to form a concept of direction and spatial limits. In order for people to maintain a sense of direction and spatial understanding, with minimal distraction from the surrounding environment, the lighting system must establish the physical boundaries of the space.

[1]Gordon, Gary and James L. Nuckolls, Interior Lighting for Designers, John Wiley and Sons Inc., New York, (1995).

Background Research

Also according to Gordon and Nuckolls, dark-colored, low-reflectance finishes absorb much of the light that strikes them, reflecting only a small amount back toward the eyes. This gives an impression of a dark, high-contrast space regardless of the amount of illumination.

Illumination of Art

According to Gordon and Nuckolls, there are two principal methods for lighting art, uniform and nonuniform illumination.

Uniform lighting for all vertical surfaces that will receive art gives prominence to the architecture. No hierarchy is established allowing viewers to select their own focus among the individual works of art.

Nonuniform lighting, on the other hand, does establish a hierarchy by focusing light on individual objects while leaving the surround / background in comparative darkness. This gives permanence to the art over the architecture, thus creating a dramatic environment. Therefore adding visual interest. The only drawback to nonuniform lighting is that when the art changes, the lighting equipment needs to be adjusted.

A gallery designed to have frequently changing artwork or exhibits coupled with nonuniform illumination, must incorporate a flexible lighting system. A track system is the most appropriate and often selected because it is relatively easy to relocate and aim the track luminaires as specified. Another added feature, the track itself serves as the wire raceway which provides a simple method for power distribution.

Either method is appropriate for illuminating a gallery or exhibit space. Although the designer must consider the types of art pieces on display along with keeping the design intent of the space in mind.

The optimum placement for a light source, for flat works of art, is usually at an angle of 30^{o} from nadir (straight down) to eye level (5'-6" AFF, average eye level). An aiming angle of less than 30^{o} causes disturbing shadows and an aiming angle of more than 30^{o} results in reflected glare from the surface of the object, thus washing out the detail. A greater angle will also cause, in some cases, the viewers to cast their shadow onto the art work and the luminaire can become a source for direct and reflected glare for others moving through the space.

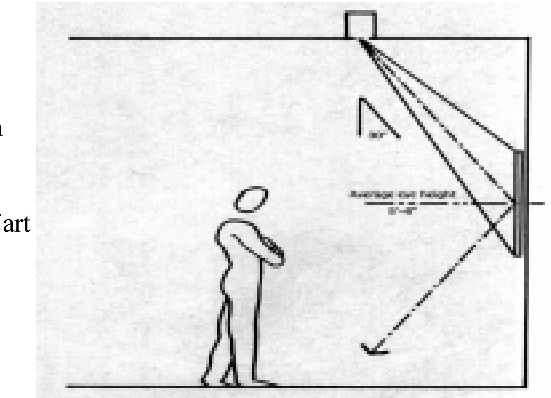


Figure 13.1
Diagram illustrates optimum luminaire placement for illumination of art (Gordon and Nuckolls).

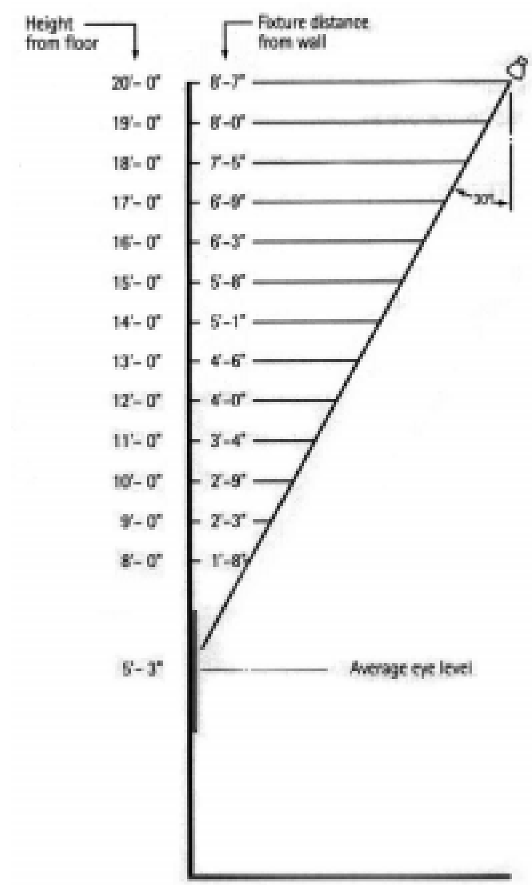


Figure 13.2
Typical luminaire mounting locations with a 30^{0} aiming angle (Gordon and Nuckolls).

Figure 14.1
Sculpture lit with concentrated direct lighting from below (Gordon and Nuckolls).

Figure 14.2
Sculpture lit with diffuse lighting from above (Gordon and Nuckolls).

Background Research

Illumination of Sculpture

All three-dimensional forms are seen as a complex pattern of luminance contrasts, often consisting of highlights and shadows. By making changes to the direction and distribution of light our visual impressions of a form or surface is altered.

Three dimensional objects, such a sculpture, are lit in ways which affects or alters the viewer's perception of the piece. To emphasize form and texture a concentrated light beams create higher contrast and deeper shadows. The best manner in which to replicate sunlight, according to Gordon and Nuckolls, frontal lighting should be between 30^{o} to 45^{o} from horizontal and between 30^{o} to 45^{o} from vertical. Another method used to emphasize sculpture is to light a vertical surface behind the object which provides a luminous backdrop that separates the object visually from its background. Also lighting the object from the side as well as from above provides added dimension and visual interest to the piece.

According to Gordon and Nuckolls, in practice, objects being exhibited are often lit from two sides to reduce excessive shadows. One side has a concentrated beam-spread to enhance drama and function as the sun's direct beam radiation; the other side receives diffuse illumination to soften shadows and replicate the sky's diffusing quality. The background may also be lit separately to distinguish the object from its surround and to add visual depth and interest. Therefore, sharp highlights and dark shadows create a dramatic setting by strengthening the impressions of depth, form, and texture. Gordon and Nuckolls states, Sometimes highlights and shadow are desirable in an interior space, just as the highlights and shadows of a sunny day are emotionally stimulating. Essentially, carefully placed highlights and shadows in an interior can provide visual relief and interest.

On the other hand, concentrated direct lighting on objects produces powerful drama and emotional excitement. Although, the same sharp distinct shadows contribute to the dramatic impact of the piece it diminishes the visibility of detail.

Perception is disturbed by reversing the expected relationship of highlight and shadow by lighting an object from a less conventional angle. In worst cases uplighting can create / cause an ominous, ghoulish impression. Backlighting is appropriate for viewing objects in silhouette.

Background Research

IES General Illumination Guidelines for Museum and Gallery Spaces[1]

Area / Activity	*Illuminance Category*	*Ranges of Illuminances Footcandles*	*Reference to Work-Plane*
Museums / Gallery spaces			
Lobbies, general gallery areas, and corridors	C	10-15-20	General lighting throughout spaces
Displays of nonsensitive materials	D_2	20-30-50	Illuminance on task
Displays of sensitive materials	D_2	20-30-50	Illuminance on task

[2] Specific limits are provided to minimize deterioration effects.

Visual Attention

Visual attention is drawn by high brightness. In point of fact, this technique is used most frequently in displaying merchandise or art. The following are the usual psychological reactions to specific luminace or brightness ratios.

3 to 1 - luminance ratio between object and surround will be noticed, but will typically not affect behavior or draw attention.

10 to1 - luminance ratio will attract attention and, if interesting, will hold it.

50 to 1 - luminance ratio or larger will highlight the object to be illuminated, practically to the exclusion of all other objects within the visual field.

[1]Schiler, Marc, Simplified Design of Building Lighting, John Wiley and Sons, Inc., New York, (1992).

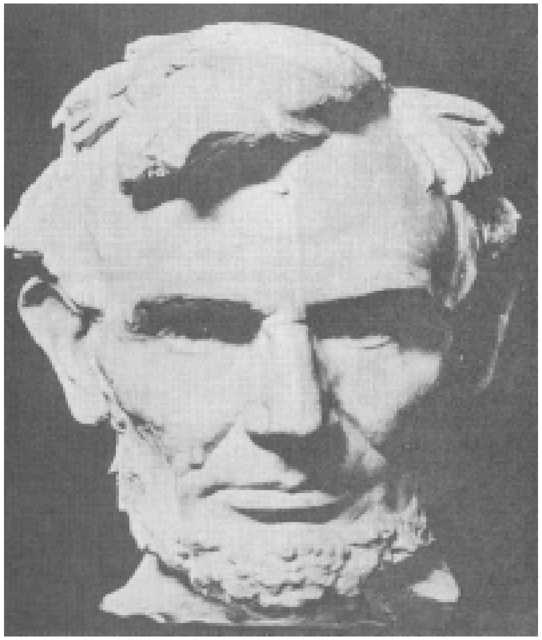


Figure 15.1
Bust of Lincoln lit by direct source from above (Gordon and Nuckolls).

Figure 15.2
Bust of Lincoln lit by direct source from below (Gordon and Nuckolls).

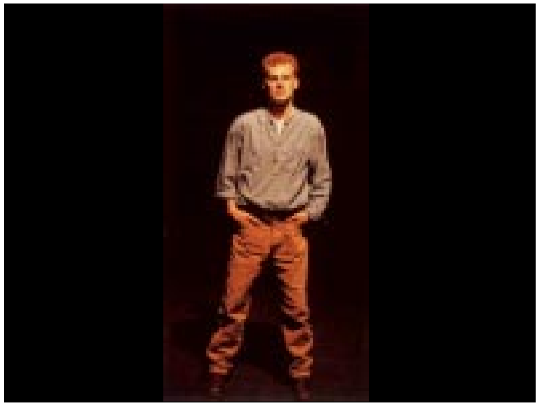
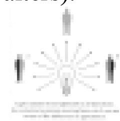


Figure 16.1
The angle at which the actor or sculpture is lit can dramatically alter how the audience perceives him (Walters).



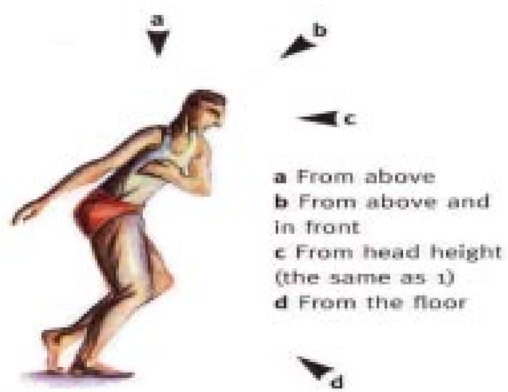


Figure 16.2
Graphic illustrates the four possible positions of luminaires in the vertical plane (Walters).

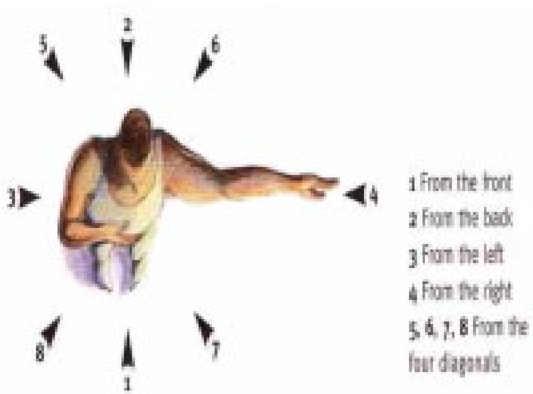


Figure 16.3
Graphic illustrates the eight possible positions of luminaires in the horizontal plane (Walters).

Background Research

Painting with Light

Lighting Angles[1]

Here we look at lighting performer or sculpture as well as at the possible options open to the lighting designer when positioning the lights. It is very useful to divide the three-dimensional object area into a number of directions in the horizontal and vertical planes.

The Twelve Directions[1]

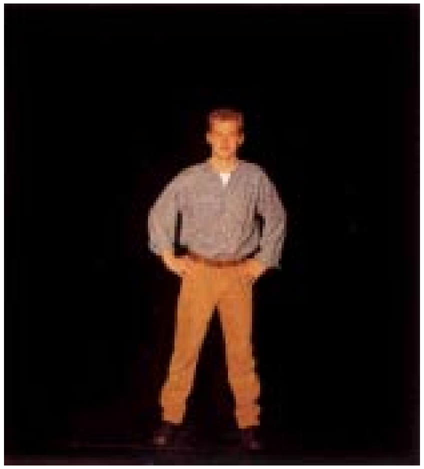
This is an expansion of up, down, back, front and so on. Starting with the horizontal plane, imagine the object that is to be lit in its location then we were able to divide the directions from which it can be lit into eight directions. Although there is a multitude of angles between these positions (keeping in mind the lighting angles of 30° to 45° from horizontal and vertical) it is simpler to start using these broad categories. In the vertical plane (i.e. up and down) the lighting can come from four directions. Using these four divisions, we were able to describe all the possible ways to light the object/sculpture.

Directions and Combinations[1]

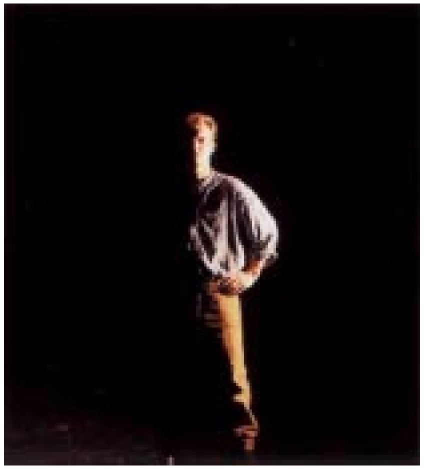
The way the light falls upon the sculpture can alter its structure profoundly, and the manner in which these lighting structures can alter the appearance of the sculpture or object means that the lighting can be considered a modeling or even a sculptural art.

[1] Walters, Graham, Stage Lighting: Step-By-Step, Quarto Inc., Cincinnati, Ohio, (1995).

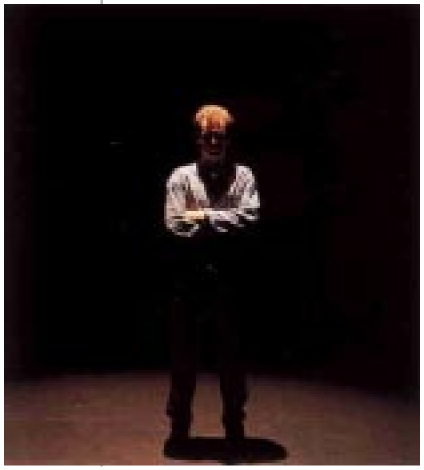
Background Research



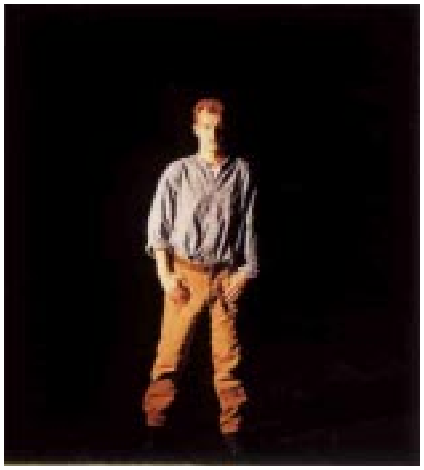
Lighting from the Front
A flat front light will shine directly into the actor's face and tends to flatten the features and look quite bland. It can be usful as a filler light to eliminate deep shadows cast on the face by an intense light from a higher angle (Walters).



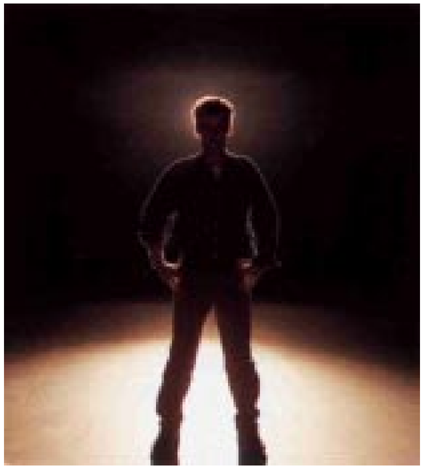
Lighting from the Sides
Side light helps to mold the actor's form. The effect of side light is to provide a dramatic modeling effect on the performer (Walters).



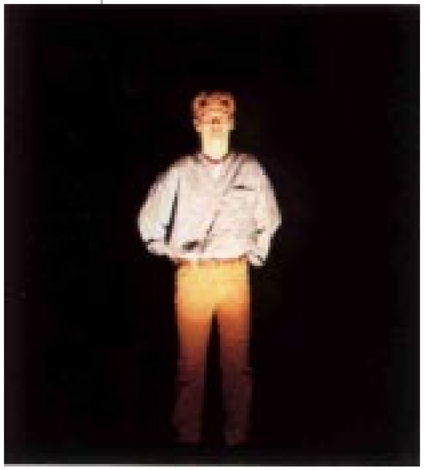
Lighting from the Top
Here light is shone directly down onto the subject, creating a very dramatic effect as the light strikes the most protuberant parts of the subject while leaving the others unlit (Walters).



Lighting from the Front at 45 degrees
This creates some shadow and brings the actor's features or the contours of the object into sharper relief. If lit at 45 degrees to the side, this modeling effect is doubled and the subject becomes three-dimensional. By using both, all harsh shadows can be avoided (Walters).



Lighting from the Back
Shining a light from behind the actor or object and down onto his or its head and shoulders produces a kind of halo that helps separate the actor or object from the background (Walters).



Lighting from the Ground
This is not considered to be a very natural form of lighting, but can be very useful and dramatic since it distorts the actor's features in a most interesting way. Although, it is most commonly used in horror films (Walters).

Figure 18.1
Data collection instrument: Sylvania OSRAM instantaneous light meter.

Figure 18.2
Data collection instrument: Stow-Away light intensity logger. Collection of data over time.

Figure 18.3
Data collection instrument: Minolta, LS-100 Direct-reading, narrow-angle spot-type luminance meter.

Research Methodology[1]

The following research methodology was used as the means to test our hypothesis. The protocol for this field research, developed by Wolf Priesers, among others, dictates the following phases:

Indicative phase reflected preparatory visits to the NCAA Hall of Champions by which indicators were identified and general assessments of the space were made.

Investigative phase involved more detailed fact finding. Collecting and recording of instantaneous light instrument sampling, reflectance of materials and light intensities, i.e. lumination levels, within the visual field to gain a broader understanding of the lighting and design technologies. It also involved longer-term data collection and a more in-depth examination of collected information. Data collection was made over a period of several days to gain insight on the behavior of light in the second floor gallery hall.

Diagnostic phase involved examining the sets of data collected in the investigative phase to make more informed assessments to support or refute our hypothesis.

[1]Vital Signs, Spring 1996, Lighting Study, Cleo Rogers Memorial Library, Columbus, Indiana

Indicative Research

On the first visit to the NCAA Headquarters and the Hall of Champions, our intent was to familiarize ourselves with both facilities.

In our meeting with Michael King, David Clendenin, and Milt Grissom, we covered the specifics of business hours, security, and protocol for future site visits. We were then briefed on the building program and the activities that occur on a typical business day. We were then given a guided tour by Milt Grissom, Senior Property Manager of REI, a real estate services firm. During this tour, we were encouraged to keep in mind the need to identify spaces for which we would be interested in exploring and researching the lighting characteristics in greater detail.

The first space we earmarked for possible in-depth exploration was the south facing barrel vaulted atrium in the NCAA Headquarters building. It was flooded with a warm natural light. The light reflecting off the cantaloupe colored paint radiated a warm glow. The incandescent can-lighting, mounted in the vault, produced very strong "spot-lights". Direct beam daylight, however, flooded the space causing us to squint our eyes. This space caused some eye fatigue, but overall the atrium was comfortable. The second and third floor offices where lit with energy efficient fluorescent lighting and ambient daylighting. In addition, ambient light was coupled with compact fluorescent task-lighting to insure Illuminance Engineering Society (IES) standards. (This was discovered to be the case on subsequent visits in which intstantaneous illumination readings were performed with Sylvania OSRAM meters). The space was uniformly lit with electric light and daylighting. These spaces were lit quite well causing no eye fatigue.

The fourth floor office space was another candidate under consideration for our research project. This space was barrel vaulted as well, and beautifully lit with indirect compact flourescent lighting. The uplighting fixtures bathed the ceiling with light. Daylight penetrates into the space through the north facing wall. This space was also comfortable.

Figure 19.1
View into atrium illustrating the light quality within the space.

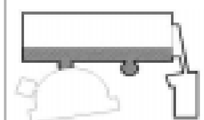


Figure 19.2
View of the NCAA,fourth floor barrel vault beautifully lit with indirect uplighting.

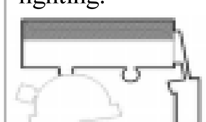


Figure 20.1
View of the Hall of Champions "Great Hall" which illustrates the intensity of the direct beam daylighting entering the space.

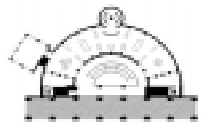
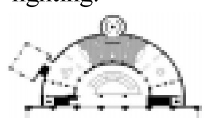


Figure 20.2
Photograph illustrating direct glare caused by ceiling mounted adjustable track lighting.



Indicative Research

The final spaces under consideration for this comprehensive lighting study were located in the Hall of Champions. Upon entering the Hall of Champions, we noticed the south wall allowed a tremendous amount of direct beam daylighting into the "great hall." This caused instant eye strain and a few individuals on the tour were so bothered by the amount of daylighting they put on sunglasses. The high level of light washed out the illuminated displays in some of the exhibits in this space. Also as a result of this overpowering light and glare the video screens were difficult to read.

In the gallery spaces, the lighting was very dim. The darkness of the first floor gallery was noticeable, but our eyes adapted with no discomfort. The second floor gallery hall was lit by ceiling mounted adjustable track lighting, compact flourescent can-lighting, and flourescent tube task-lighting. The spot lights used to illuminate the ceiling-mounted sculpture, in some cases, entered into the field of vision resulting in eye fatigue and pain. The after image caused by the track lighting was irritating while viewing the exhibits. Some of the free-standing exhibits where top lit to provide more light, but we discovered the wall exhibits were not. Direct reflections and reflected glare occurred on most of the video exhibits within the space. It seemed to have high brightness and contrast in both the lighting and the colors of the second floor exhibit hall material palette.

The abundant indicators of direct glare and high contrast between light and dark sources and material surfaces, a result of the position, direction and location of the ceiling mounted track lighting within the field of view, in the NCAA Hall of Champions led us to focus our investigation on the lighting conditions in the second floor gallery hall.

Investigative Research

On the second visit to the NCAA Hall of Champions, we toured the second floor gallery hall carefully observing the electric lighting and its effect on our visual comfort. We began our documentation of the gallery hall through the collection of a number of digital photographs illustrating direct glare, reflected glare, specular reflections, diffuse reflections, veiling reflections, brightness contrast and contrast grading.

For the purpose of our investigation the gallery hall was subdivided into segments A, B, and C. The overall illumination upon entering the gallery hall was uniform, but illumination levels seemed low. While we observed the space no visual discomfort was noted in Segment A of the gallery. As we transitioned in Segment B, the main exhibit hall, we immediately noticed a significant illumination change.

Instantaneous light measurements were taken to document the illumination levels in the second floor gallery hall. The entrance at Segment A was recorded at 8Fc, which is within the IES range of illumination for simple orientation for short temporary visits. The freestanding exhibits were brightly top-lit causing them to be unevenly lit. Due to the contrast of brightness, visual discomfort occurred. We collected another meter reading on an exhibit kiosk (96Fc at the top, and 20Fc at the bottom). A contrast ratio of 4.8 to 1 was calculated. For recommended maximum luminance ratios (see figure 39.1).

The space was uncomfortable due to spot lights mounted in the dark ceiling zone. The spot-lights are used to illuminate sculpture located near the ceiling. The brightness and positioning of lighting caused, in some instances, direct glare. Two other factors that related to visual comfort are the size of the brightness area and the placement of bright spots. The contrast grading appeared harsh because the floor and exhibits are of a neutral color place against a dark navy blue colored ceiling. In most of the free-standing exhibits visual discomfort was caused by direct glare entering the visual field from the spot-lights.

Our observations, collection of illumination data and documentation of the gallery hall led us to a further and more systematic study of the lighting effectiveness in relation to visual comfort.

Figure 21.1
View of segment-A of the second floor gallery hall.

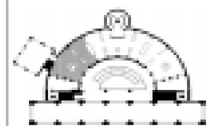


Figure 21.2
View of segment-B of the second floor gallery hall.

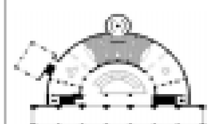
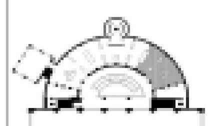


Figure 21.3
View of segment-C of the second floor gallery hall.



Investigative Research

The following is an inventory made through observation of the second floor gallery hall.

Furnishings
1- couch, 2- end tables, 1- chair, 1- coffee table, 1- television and stand, 14- wall mounted exhibits, and 11- free-standing exhibits.

Finishes
The floors vary in contrast, brightness and color from dark green astroturf, glossy hard wood, and reddish brown rubber.

The structural columns are clad in a neutral peach colored brick with matching base molding.

The ceiling is a dark navy blue.

Coloration of light and materials
With the exception of the flooring, the gallery hall consists of neutral colors with black metal trim and details. The gallery is divided into three zones or cavities.

- Zone one- floor cavity- 55% reflective.
- Zone two- room cavity- 30% reflective.
- Zone three- ceiling cavity- 25% reflective.

Zones two and three are separated by an off-white colored cornice.

Lighting sources
Ceiling mounted can-lighting for general illumination.
Ceiling mounted track spot-lighting for illumination of sculpture.
Task-lighting for illumination of free-standing exhibits.

Lighting controls
Standard manual switching, no motion or daylight sensors.

Space function
Interactive exhibit space, second floor gallery hall.

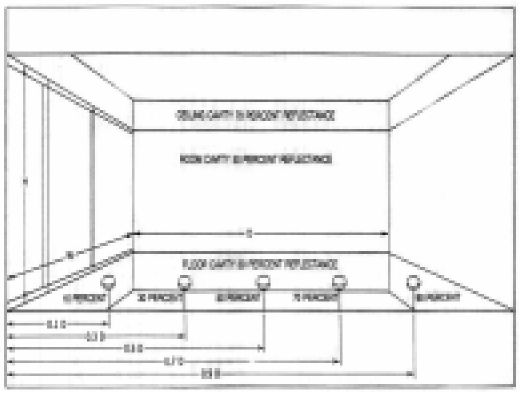
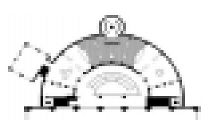


Figure 22.1
Diagram illustrating optimum reflectances within space cavities (MEEB).

Figure 22.2
Image illustrating location and type of lighting sources.



Investigative Research

Subdivision of space

The second floor gallery space is subdivided into three segments (A-C)
Segment A- Football theme.
Segment B- Basketball theme.
Segment C- Track and Field theme.

In passing through and viewing the exhibits, visual discomfort was experienced. This is due to:

Glare

Good lighting demands not just adequate amounts of illumination but also a uniform light distribution within the space. Glare is the result of unwanted light in the visual field, and is caused by the presence of one or more sources of bright light in the field of view. The eye functions well only when the object upon which attention should be concentrated is the brightest in the visual field and is worse when extraneous objects are much brighter than the visual task itself.

Direct glare

Direct glare is defined as excessive light misdirected toward the eye and is caused by the lighting system. Direct glare within the visual field is a distracting influence in the environment

Reflected glare

When light from a source is reflected off specular surfaces into the eye or field of view. In order to determine on a scientific basis, the necessary standards of lighting in a building, it is necessary to break down the characteristics of visual comfort, visual acuity and task, and express these relationships in terms of brightness, contrast ratios and adaptation levels. These particular characteristics have been the basis for the methods of glare evaluation to date.

Specular reflections

A reflection that retains the original image being reflected.

Veiling reflections

A reflection superimposed on a surface that interferes with the perception of the information on or behind that surface.

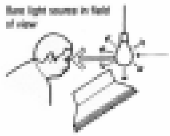


Figure 23.1
Photograph and diagram illustrates direct glare (Schiler).

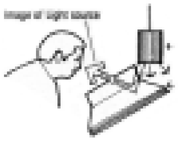


Figure 23.2
Photograph and diagram illustrates reflected glare (Schiler).

Figure 23.3
Photograph and diagram illustrates veiling reflections (Schiler).

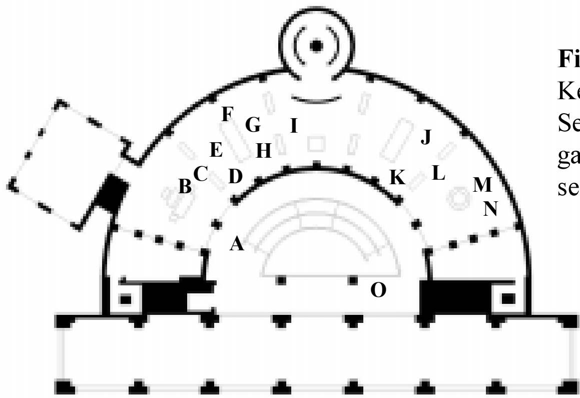


Figure 16.1
Key plan.
Second floor gallery hall sequence.

Dynamics of Gallery Transition Sequence

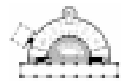
The visual arts require movement and choice on the part of the spectator / visitor. Galleries must be designed to help the viewer organize the experience of looking at and considering a sequence of art work and objects.

The entry and lobby areas should serve to direct visitors to the galleries, where they should be able to survey what there is to see, select a starting point, and move to it as easily as possible. Here the space should be arranged in such a way to yield a continually unfolding experience, which allows for the visitor's attention to be drawn easily from object to object and gallery to gallery.

Factors for designing gallery spaces

- Viewers should be able to move through the space without being forced to walk past objects they have already experienced.
- There must be adequate circulation space for visitors to move at differing speeds.
- A viewer tends to turn to the right upon entering a gallery. Circulation patterns should take this into consideration.
- The ability to survey the gallery area in one visual sweep will help viewers understand what is on display and decide what they want to see.

The curved stair deposits the visitor at the entry of exhibit hall. Upon entering the hall, there is no prescribed path that one must follow when viewing the exhibits. The exhibit kiosks are situated in a manner that allows for adequate movement throughout. The viewer is able to meander through the exhibits and decide what they want to see.



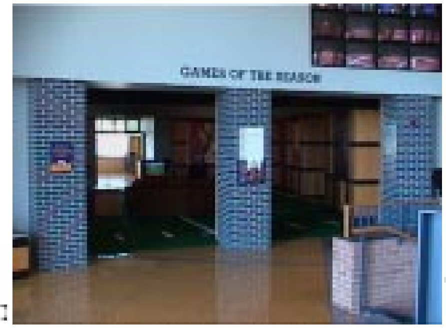


Figure A
View at the entry.

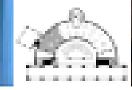


Figure B
View of **Segment A** of the second floor gallery hall.

Figure F
View transitioning into **Segment B** of the gallery hall. Viewing distance approximately 6'-0" from exhibit.

Figure G
View at the center of **Segment B** of the gallery hall.

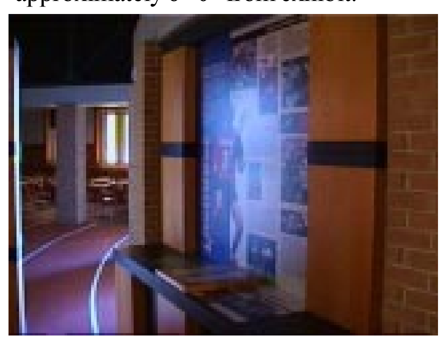


Figure K
Specular reflection occurs at this wall exhibit in **Segment C** of the gallery hall.

Figure L
View into main space, **Segment C** of the gallery hall.

Investigative Research

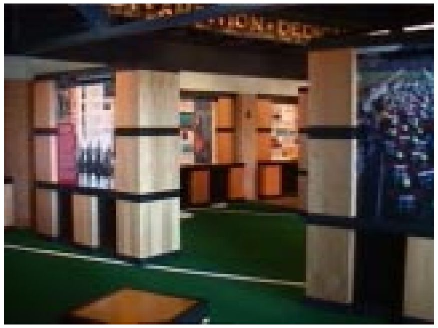


Figure C
View at the entry, transitioning into the main exhibit space.

Figure D
Contrasting bright and dark sources create high glare conditions, causing visual discomfort to the viewer.

Figure E
Specular reflection from natural daylighting is problematic when viewing this exhibit.

Figure H
View of **Segment B** of the gallery hall.

Figure I
View of the users occupying the space.

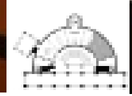


Figure J
View of **Segment C** of the gallery hall.

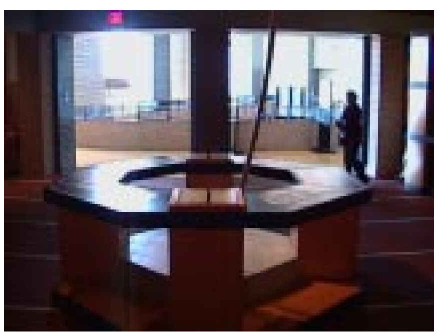


Figure M
View at the exit looking into **Segment C** of the gallery hall.

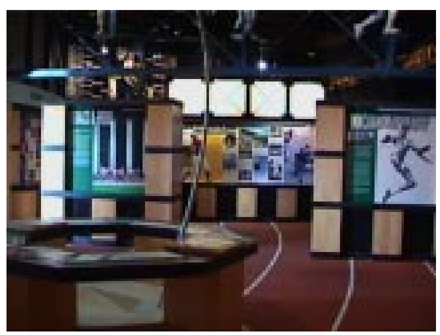
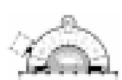


Figure N
View looking back into main exhibit space, **Segment C** of the gallery hall.



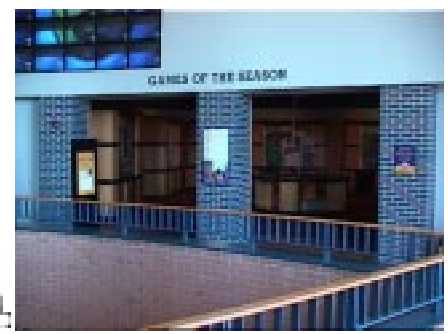


Figure O
View at the exit looking into **Segment C** of the gallery hall.

Figure 26.1 Collection of instantaneous spot illuminance. Readings taken in this manner to insure accuracy.

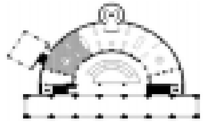
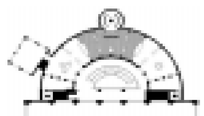


Figure 26.2



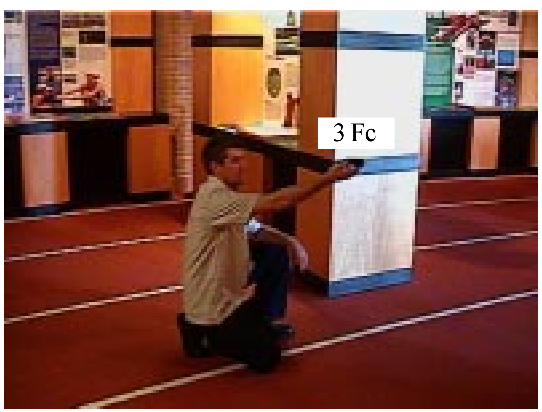
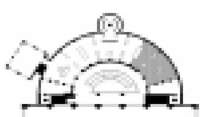


Figure 26.3



Investigative Research

The third visit to the NCAA Hall of Champions was more systematic. It was 10:00 am on October 17, a sunny day, with a tempature of 40 degrees. The sky luminance levels were recorded at 390Fc (at the start) and immediately following an intantaneous light meter reading was taken outside the entry to the second floor gallery hall. It was recorded as 45Fc. The D.F. (daylight factor) was calculated to be (45Fc/390Fc)*100= 11.5%. The recomended daylight factor for gallery and exhibit displays at a 40° latitude is between 2-6%.

Upon entrance, the light in Segment A of the gallery hall seemed to be uniformly distributed. Although, the space was dimly lit no visual discomfort was perceived. The color palette, in this area of the gallery, included dark green astroturf representing a football field, natural wood grain panels on the exhibits accented with black metal trim and detailing. The dark navy blue ceiling is consistent throughout the second floor gallery hall which results in a high contrast space regardless of the amount of illumination. We continued to walk about this segment of the gallery taking intantaneous light meter readings to get a better understanding of the overall light level distribution within the space. The readings ranged from 5Fc (minimum) to 15Fc (maximum) with most of the values reading between 7-9Fc. We then calculated the brightness ratio from outside to inside the gallery to be (2,834 to 1), which is significantly above environmental comfort and causes a noticable difference. But our eyes adjusted with no discomfort. We also took instantaneous illumination and luminance readings at the NCAA football exhibit kiosk in this space. This particular exhibit was illuminated by the general lighting within the space. No task lighting was provided. The readings ranged from 8Fc (top), 11Fc (middle), to 13Fc (bottom). This is well below the IES standards for performance of tasks of medium contrast or small size. The illumination levels were recorded at 2Fc.

Transitioning into the galleries main exhibit space is where the most noticable discomfort in the visual field occured.
When viewing the elevated sculptures the direct spot-lighting , in most cases, was positioned within the visual field causing extreme discomfort. The intensity of the light caused members of our team to squint. We proceeded to shield our eyes from the glare. As a result, the elaborate detailing of the sculptures are not visible. It also created a problem when viewing other exhibits because of the after image caused by the bright point(s) of light.

In essence, our eyes needed time to adjust and adapt to the general lighting levels.

Next, we took note of the color palatte. Again, the same colors were used on the exhibits and ceiling, but the flooring was a highly polished hardwood as used for a basketball court. Some glare and reflections occur as a result of this material selection. It is noticable, but did not cause any visual discomfort.

We then recorded the overall distribution of light in Segment B of the gallery hall. We walked through this space, on an arbitrary grid, taking instantaneous light meter readings. The readings ranged from 4Fc (minimum) to 15Fc (maximum) with most of the readings being between 8-10Fc.

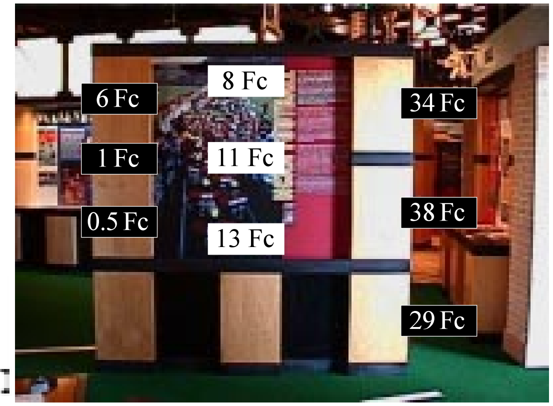
The task-lit exhibits were difficult to read because the illumination at the top was brighter than at the bottom. As a result the vertical surface was not uniformly lit. When viewing art uniformity of illumination is necessary. We selected four exhibits within this segment of the gallery space and recorded instantaneous illumination measurements.

	Illumination Levels			IES Recommended Illumination levels
	Top	Middle	Bottom	
1st Exhibit	98Fc	63Fc	28Fc	20-30-50
2nd Exhibit	149Fc	68Fc	39Fc	20-30-50
3rd Exhibit	111Fc	54Fc	31Fc	20-30-50

Luminance values were also recorded at these exhibits.

	Luminance Levels		
	Top	Middle	Bottom
1st Exhibit	6 Lf	1 Lf	0.5 Lf
2nd Exhibit	11 Lf	5 Lf	9 Lf
3rd Exhibit	22 Lf	10 Lf	6 Lf

Exhibit three is interactive with three video screens communicating



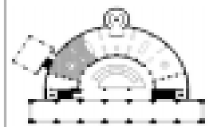


Figure 27.1
Selected as exhibit one.

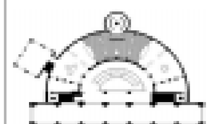


Figure 27.2
Selected as exhibit two.

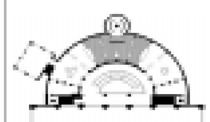


Figure 27.3
Selected as exhibit three.

Figure 28.1 Selected as exhibit four.

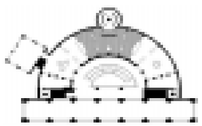


Figure 28.2 Selected as exhibit five.

Figure 28.3 High constrast and brightness resulted from the bright spot-lighting mounted in the ceiling zone.

information. The illumination reading at the center monitor was recorded at 36 Fc and the luminance level was 26Fc. The monitor is 72.2% reflective. When viewing and interacting with this exhibit, direct glare (from the ceiling spot-lights) and reflected glare on the monitors causes some viewing difficulty. The fourth exhibit consisted of a free-standing single interactive video screen. An illumination reading was taken and recorded at 8Fc and a luminance level at 2Fc. Reflected glare caused difficulty when viewing the information presented at this exhibit, but the most noticeable discomfort was from the ceiling mounted spot-lights.

The next segment, Segment C, of the gallery hall consisted of the same as the preceding segments with the exception of the floor, which is a reddish-brown rubber used for a running track. Overall illumination distribution readings were taken and recorded at 1Fc to 10Fc with most of the readings being 4Fc. This is the darkest segment within the gallery hall. Illumination readings taken at the main octagonal ranged from 6-11Fc. Luminance readings were recorded at 10Fc. This exhibit displayed high levels of specular glare resulting in viewing difficulty and discomfort. An intantaneous meter reading taken outside the exit of the gallery hall measured 46Fc. The brightness ratio was caculated to be (3,218 to 1 see figure 36.3), which created an extreme contrast.

In our opinion, when viewing these types of exhibits, which mainly consist of text and video information, they should be uniformly illuminated. Also, some of the free-standing exhibits displayed direct glare from the ceiling mounted spot-lights. In extreme cases up to four spot-lights were within the cone of vision. Also, the non-task-lit exhibits were difficult to read at times because the general lighting in the gallery hall cast shadows of the viewer onto the viewing surface. This caused some brighness contrast differences. Specular glare was also noticed near the top of the exhibit.

In summary, the general illumination levels were quite low with higher levels of task-lighting occuring at the free-standing exhibits. No task-lighting was placed at the wall mounted exhibits. High contrast and brightness resulted from the bright spot-lighting mounted in the ceiling. This led us to our hypothesis and the development of the investigative phase of the field study

Investigative Research

Collection of instantaneous light measurements were taken in this manner to insure accuracy.

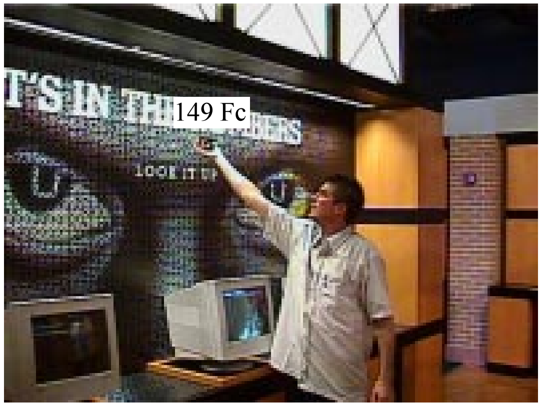
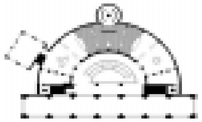


Figure 29.1
Instantaneous light measurement read 149Fc at 7'-0" above finished floor.

Figure 29.2
Instantaneous light measurement read 68Fc at 5'-0" above finished floor.

Figure 29.3
Instantaneous light measurement read 39Fc at 2'-6" above finished floor.



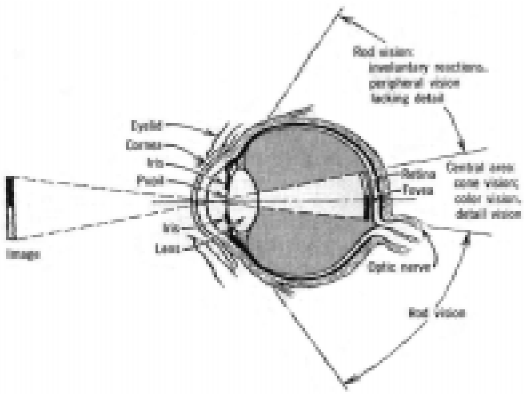


Figure 30.1
Anatomy of the human eye (MEEB).

Hall of Champions second floor "Wall of Champions"

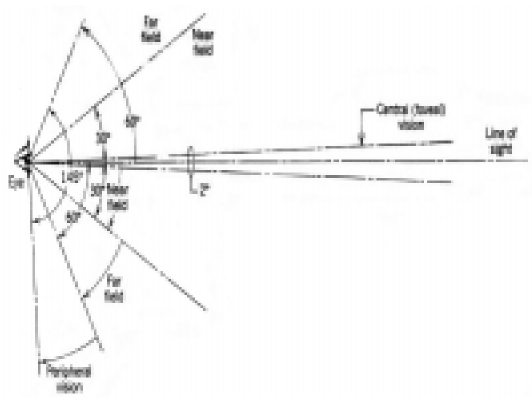


Figure 30.2
Field of vision for a normal pair of eyes (MEEB).

Main Entrance into the Gallery Hall

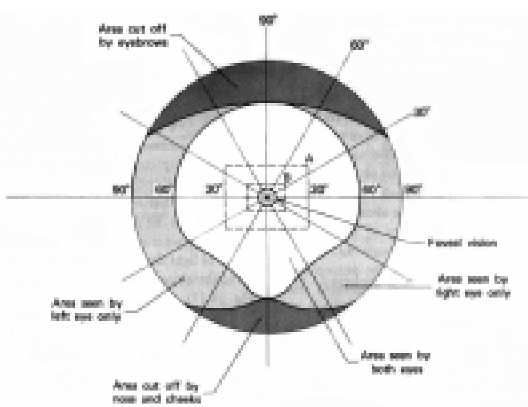


Figure 30.3
Field of view with subtended angles (MEEB).

"The Flying-V" - Bronze Sculpture

Investigative Research

Grayscale / Visual Field Mapping

The visual field maps were constructed using a thorough understanding of the anatomy of the eye and the field of vision.

The foveal vision lies within only 1° of the 180° field of view. The eyes acute ability to distinguish fine detail is achieved when the ratio between the immediate background and the central task is 1:1 to 4:1. The near surround lies within 60° of the field of vision and allows for contrast ratios of 10:1. While the 120° far surround , which accounts for the rest of the visual field, allows for contrast ratios of 100:1.

With the aid of Photoshop, the images produced from the digital camera form collage in order to fully represent the true visual field see through the human eyes.

The complexity of the images were then reduce to eight scales of gray. In order to properly and accurately take and record luminance values the manipulated gray scale image was reduce to a edge diagram.

The image was then inserted into the field of view to accurately represent the portion of the image seen by the human eyes in the NCAA Hall of Champions, second floor gallery hall.

The brightness ratios where then calculated and the results prove that the space displays high contrasts, extreme brightness ratios, and direct glare discomfort.

Grayscale / Visual Field Map

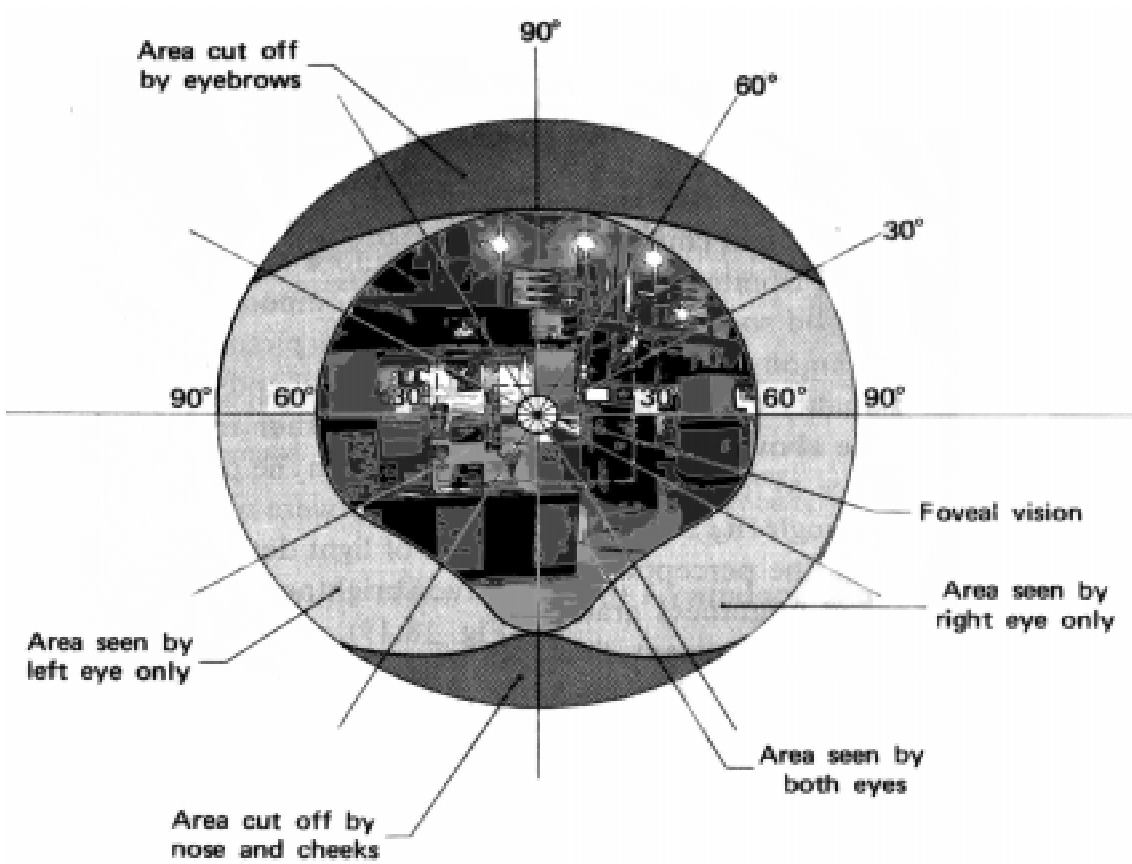


Figure 31.1
Original greyscale image.

Figure 31.2
Manipulated greyscale image.

Figure 31.3
Spot luminance meter readings taken with Minolta LS-100.

Brightness ratio 32,440 to 1.

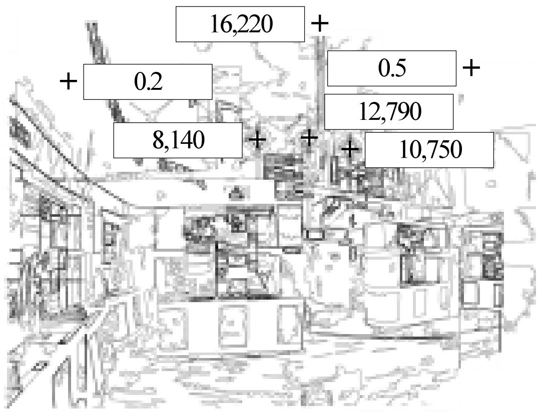


Figure 32.1
Original greyscale image.

Figure 32.2
Manipulated greyscale image.

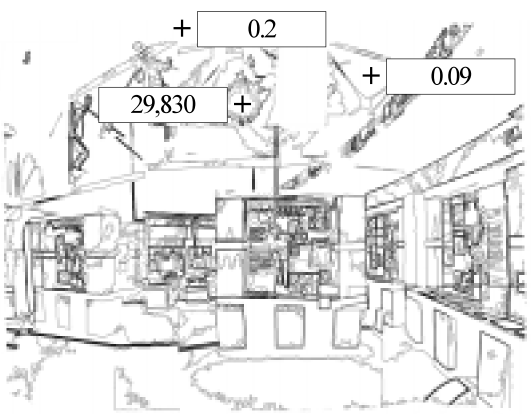
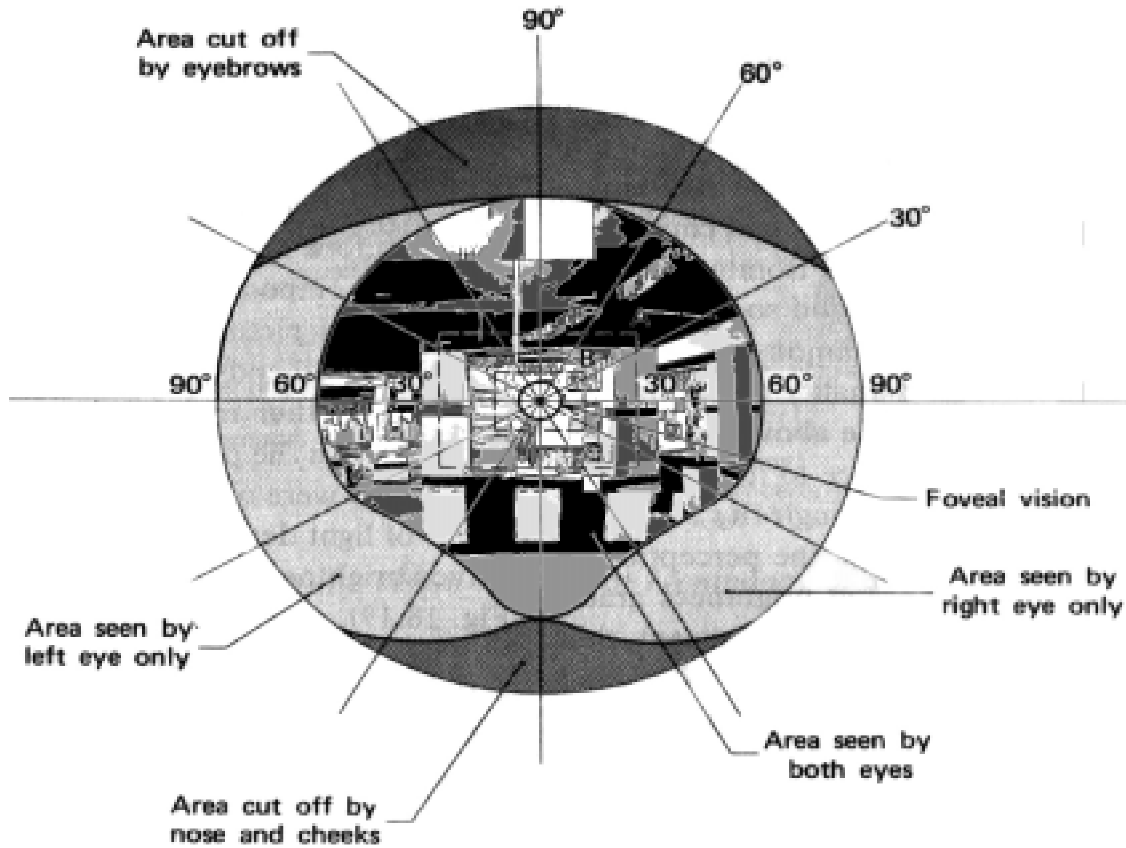


Figure 32.3
Spot luminance meter readings taken with Minolta LS-100.

Brightness ratio 149,150 to 1.

Grayscale / Visual Field Map



Grayscale / Visual Field Map

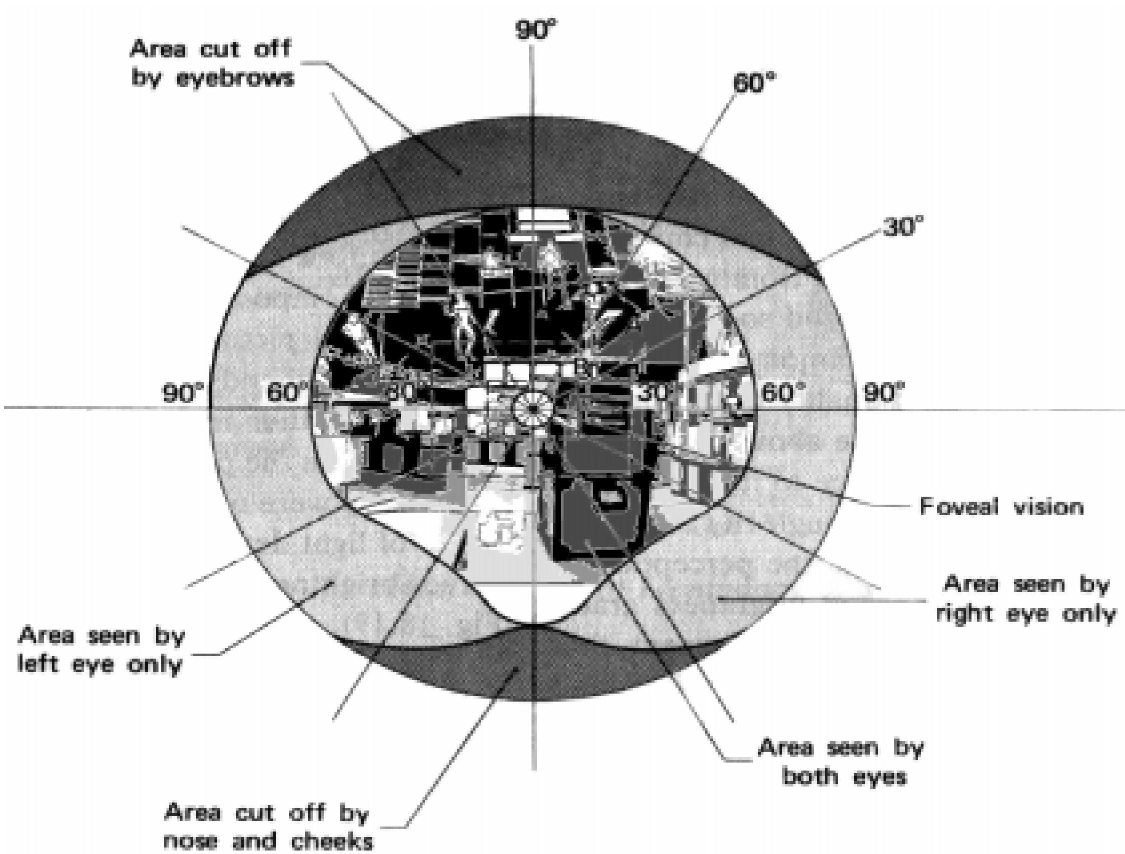


Figure 33.1
Original greyscale image.

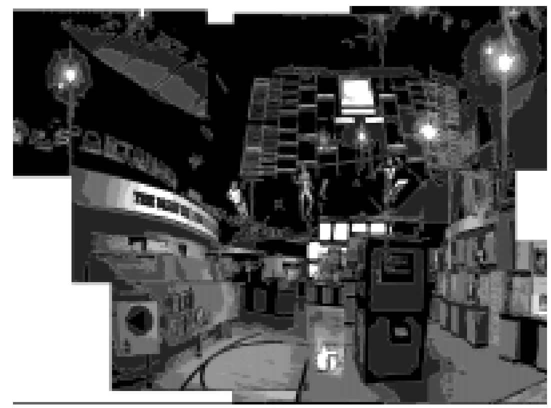


Figure 33.2
Manipulated greyscale image.

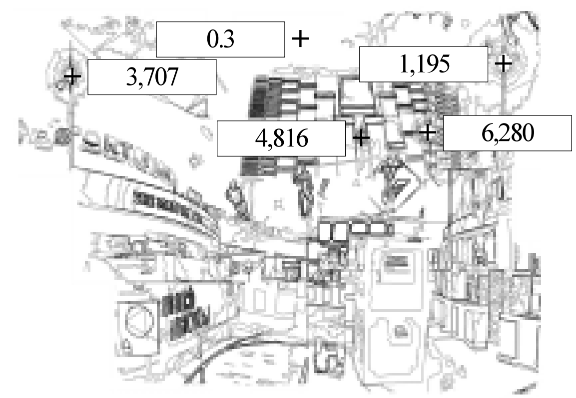


Figure 33.3
Spot luminance meter readings taken with Minolta LS-100. Brightness ratio 12,357 to 1.

Note: all luminance values in L/ft

Visual field images were created using Photoshop (find edges effect). Collection of instantaneous luminance measurements were taken with Minolta, LS-100, digital luminance spot meter to insure accuracy.

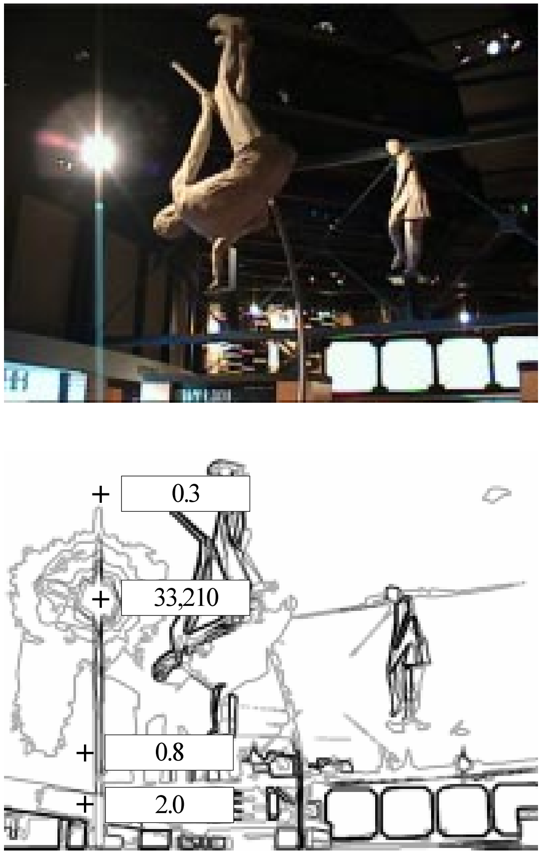
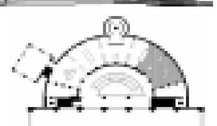


Figure 34.1
The spot-lights in Segment C of the gallery hall produce direct glare, which caused discomfort in the visual field. Brightness ratio is 33,210(source) / 0.3 (surround) = 110,700 to 1.



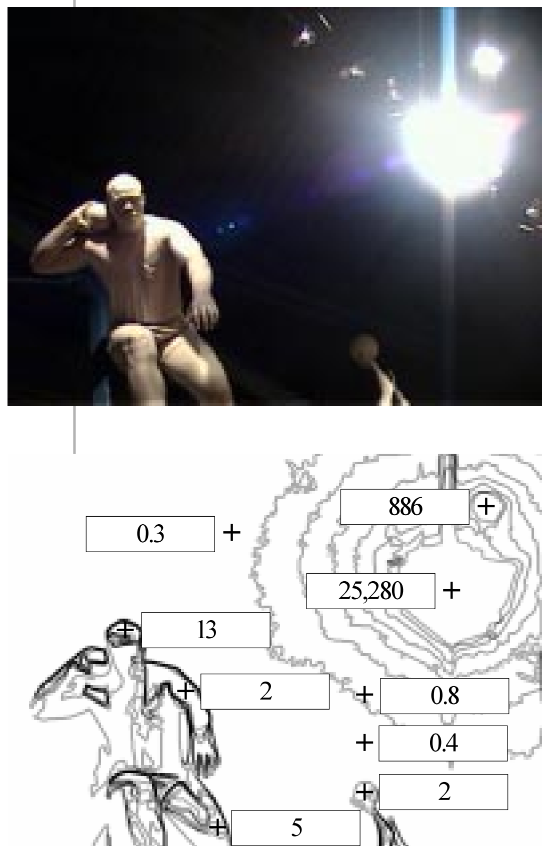
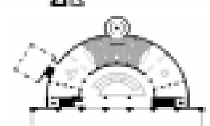


Figure 34.2
Direct glare is very problematic and causes severe visual discomfort when viewing the sculpture exhibits. Brightness ratio is 25,280(source) / 0.3 (surround) = 84,267 to 1.



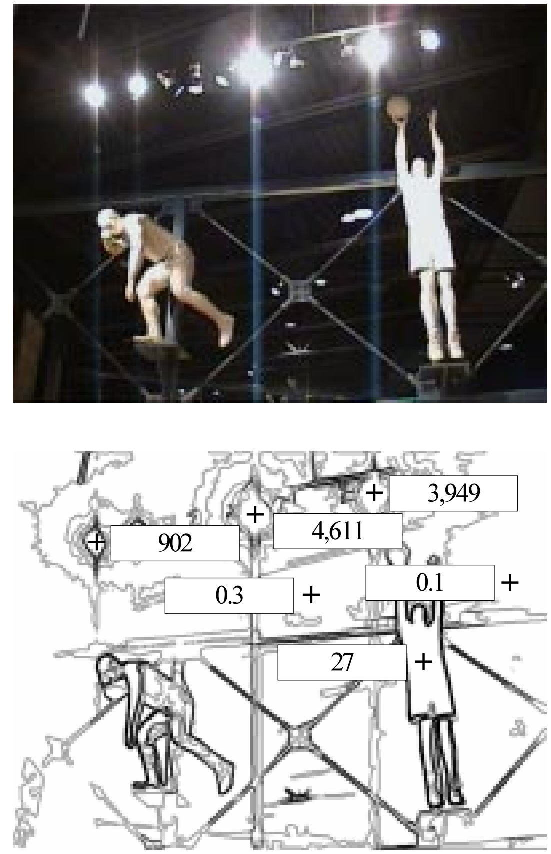


Figure 34.3
Direct glare is very problematic and causes eye squinting, shielding and severe visual discomfort when viewing the exhibits. Brightness ratio is 4,611(source) / 0.3(surround) = 15,370 to 1.

Investigative Research

Assessment of images taken within the second floor gallery hall.

Figure 35.1
The spot-lights in Secment B of the gallery hall produce direct glare, which caused discomfort in the visual field.

Figure 35.2
Direct glare is very problematic and causes severe visual discomfort when viewing the interactive video exhibits. Brightness ratio is 21,050(source) / 0.3(surround) = 70,167 to 1.

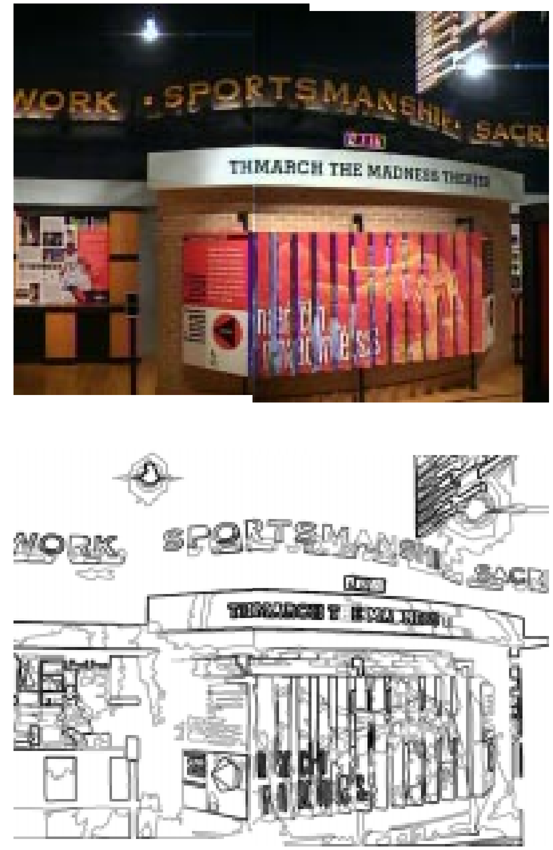
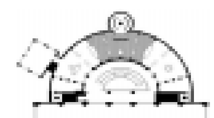


Figure 35.3
Brightness constrast is caused by bright sources placed against or within a dark surface or field.



Note: all luminance values in L/ft

Collection of instantaneous luminance measurements were taken with Minolta, LS-100, digital luminance spot meter to insure accuracy.

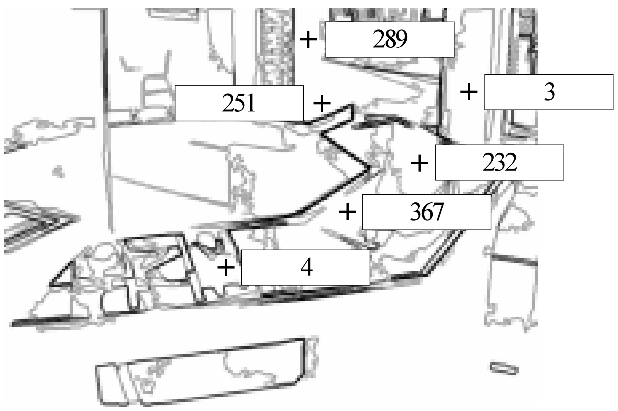


Figure 36.1
Specular reflection is problematic in viewing this exhibit.

Figure 36.2
Spot-lighting and natural daylighting produces veiling reflections, making it difficult to view exhibit.

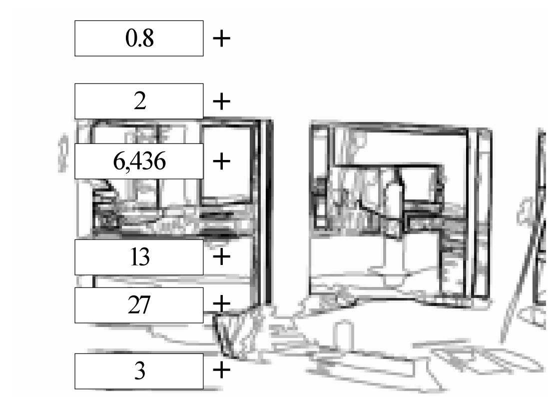
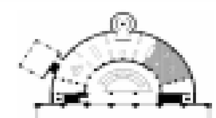


Figure 36.3
Contrast grading. Brightness ratio is 6,436(source) / 0.8(surround) = 3,218 to 1.



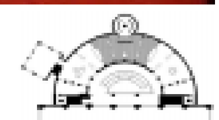
Investigative Research

Assessment of images taken within the second floor gallery hall.

Figure 37.1
The glossy finish on the gallery floor, in Segment B, causes some reflected glare and direct reflections.

Figure 37.2
Reflected glare as a result of ceiling spot-lighting. Monitor has a (26/36)x100 =72.2% reflectance.

Figure 37.3
Veiling reflection occurs on the interactive video screens making them difficult to view video footage.



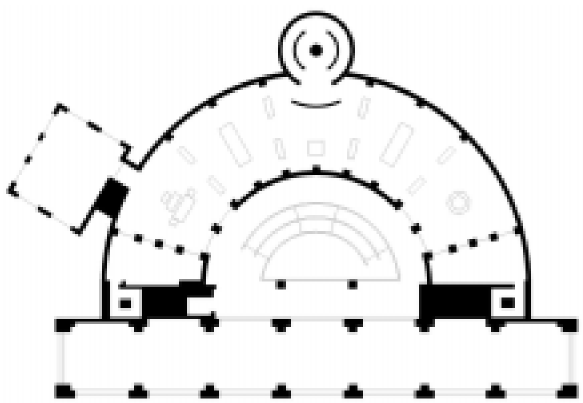
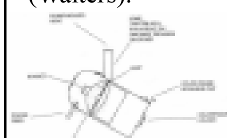
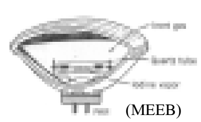


Figure 38.1
A parcan provides an intense, fixed, virtually parallel beam of light (Walters).



(Cunningham)

Figure 38.2
The 120v par 38, 90 watt, bulb is a sealed unit containing a bulb, lens, and reflector (Walers).



(MEEB)

Investigative Research

Second Floor Gallery Hall Dimensions
Due to the shape complexity of the space the dimensions were interpolated to be 28'x108'.
The exact area of the space used for energy density was calculated in AutoCAD using the area tool.

Illumination Specs.

Geometry of fixture layout-

Geometry of fixture type- The parcan is a member of the parallel beam family in most common use. Parcans are cheap, lightweight, and quick to hang and focus. It consists of a sealed lamp unit which produces an intense oval shaped beam, like an old-fashioned car headlight, which has a lens and a reflector built into it. The reflector is slightly asymmetric so that the intense near parallel beam is slightly extended in one plane. Pars are ideal for a strong bright beam, which might be needed for sunlight effects or dramatic key light. Its oval shape can be rotated to be used either at portrait or a landscape oval.

Geometry of lamp type- spot-light (Philips PAR 38-flood, 90 Watt), can-fixture (Philips PL-t 4 pin high performance compact fluorescent, 42 Watt), and task-light (General Electric ,4'-fluorescent tube, 32 Watt).

PAR 38 lamp- 7½"x7½" color frame, diameter of instrument 7¾" length 9", weight with lamp 4½ lbs.

Energy Density Calculation-

73-PAR 38 lamps (90watts) = 6,570 watts
43-High performance compact fluorescent lamps (60watts) = 2,580 watts
28-Fluorescent tube lamps (32watts) = 896 watts

(6,570 watts + 2,580 watts + 896 watts) / 4,878 sq.ft. = **2.1 watts/sq.ft.**

ASHREA/IES Standard 90.1-1989: Electric Lighting and Power Estimating recommends 1.9 watts/sq.ft. for a Gallery-General Exhibition and 2.6 watts/sq.ft. for a Exhibition Hall (MEEB). The calculated 2.1watts/sq.ft. for the second floor gallery hall is approximately between the recommended ranges.

IES Lighting Standards[1]
Chart represents current illumination ranges recorded within the NCAA Hall of Champions second floor gallery hall.

Type of Activity	*Illuminance Category*	*Ranges of Illuminances Footcandles*
Public spaces with dark surroundings	A	2-3-5
Simple orientation for short temporary visits	B	5-7.5-10
Working Tasks where visual tasks are only occasionally performed	C	10-15-20
Illuminanace on Task		
Performance of visual task of high contrast or large size	D	20-30-50

[1]Stein, Benjamin and John S. Reynolds, Mechanical and Electrical Equiment for Buildings, John Wiley and Sons, Inc., New York, (1992).

Figure 39.1 Recommended maximum luminance ratios (MEEB).

To achieve a comfortable brightness balance, it is desirable to limit luminance ratios between areas *of appreciable size* as seen from normal viewing positions as follows:

1 to $\frac{1}{3}$	Between task and adjacent surroundings
1 to $\frac{1}{10}$	Between task and more remote darker surfaces
1 to 10	Between task and more remote lighter surfaces
20 to 1	Between luminaires (or fenestration) and surfaces adjacent to them
40 to 1	Anywhere within the normal field of view

These ratios are recommended as maximums; reductions are generally beneficial.

Blank Page

Investigative Research

The investigative research was carried out in the following steps.

First, the overall illuminance levels of the space were recorded. This was done by taking instantaneous readings using the Sylvania OSRAN light meter. An accurate plan and section of the space was drawn and an appropriate testing grid or path was overlaid. By recording illuminance levels at these specific points on the grid or path, the data needed to produce an overall distribution of illuminance within the space or along a path will be provided.

Second, instantaneous light levels will be taken with the Sylvania OSRAM data collectors at strategic exhibits (exhibits that experience any of the indentified problematic areas) to record the intensity of light at the task surface. The overall distribution of illuminance on the task surface of each exhibit will be collected. Also the reflectance or luminance levels will provide data to understand the intensity of light bouncing off each surface. The reflectance levels of each surface were recorded and calculated.

Third, the gallery transition sequence will then be represented on the plan in graphic form. The viewing locations of each exhibit will then be mapped to the sequence. At these particular locations digital field maps were created using Photoshop to further develop, pin-point, and illustrate our assessment of the problematic areas.

Fourth, the location and direction of the spot-lighting will be studied and recorded. An assessment of the problematic areas were made. A study of each problematic area resulted in a collection of light intensity data. This data pin-pointed areas of direct glare and contrast grading within the space.

Figure 41.1 Setting-up the measurement grid in 4' increments.

Figure 41.2 Taking measurement.

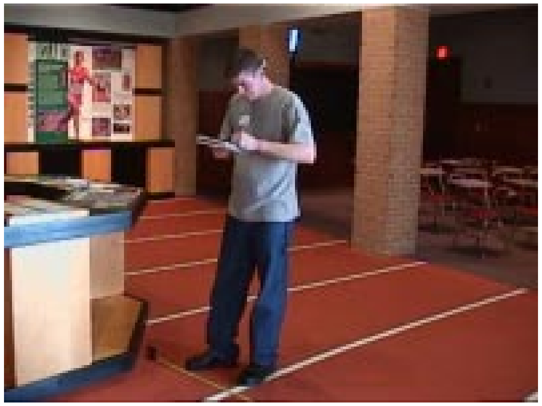


Figure 41.3 Recording measurement.

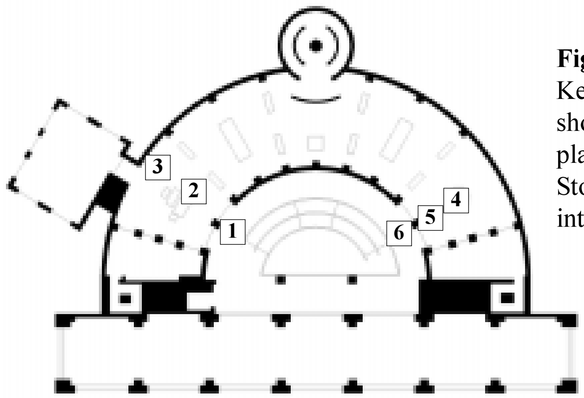


Figure 42.1
Key plan showing the placement of the Stow-Away light intensity loggers.

Figure 42.2
1. Stow-Away meter location 2'-0" outside gallery entrance, 30" AFF.

Figure 42.3
6. Stow-Away meter location 2'-0" outside gallery exit, 30" AFF.

Diagnostic

Comparative Line Graphs- Long-Term Data Collection

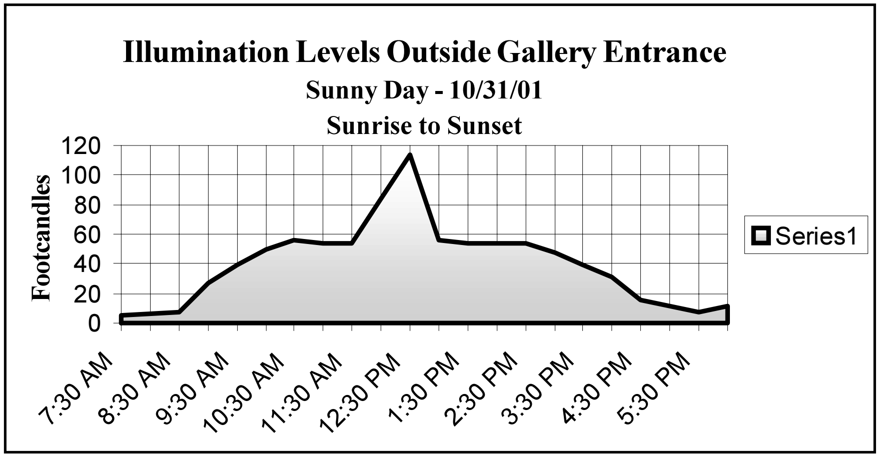
Long-term illumination levels were collected at six stratigic locations. The Stow-Away instantaneous light loggers were placed as follows:

1- placed 2'-0" outside the second floor gallery hall entry at 30" AFF.
2- placed on the end-table at the center of Segment-A.
3- placed on the horizontal task surface of a wall exhibit, Segment-A.
4- placed on the horizontal task surface of the pole-vault exhibit, Segment-C.
5- placed 5'-0" inside Segment-C, near exit.
6- placed 2'-0" outside the second floor gallery hall exit at 30" AFF.

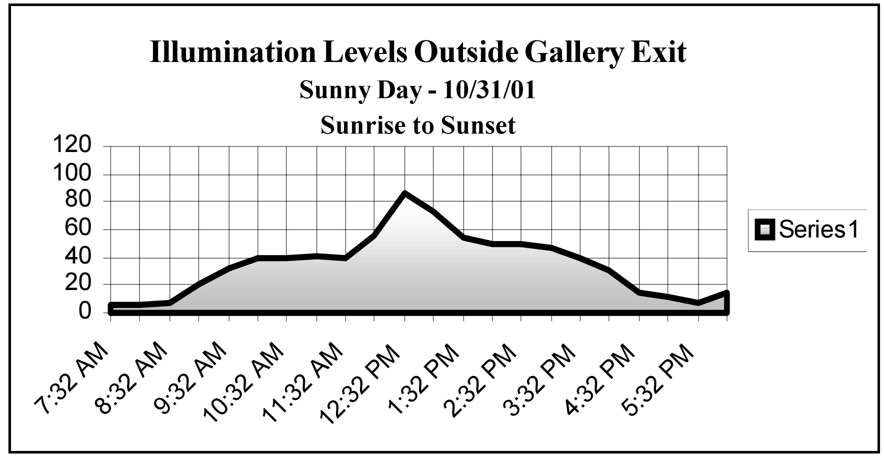
Each logger was programmed to record on 30 minute intervals. We collected illumination data for sunny and overcast sky conditions as well as overnight readings. The loggers were place at these specific points within the second floor gallery hall and second floor mezzinine to determine the percentage of natural daylight that is contributed to the selected spaces.

We later determined, due to the narrow scope of study, this information had no direct bearing on the outcome of our investigation. We elected to include here, thecollected graphic illumination data of Stow-Away locations (1and 6) to illustrate the footcandle intensity of daylight reaching the entry and exit points of the second floor gallery hall as well as the related overnight readings.

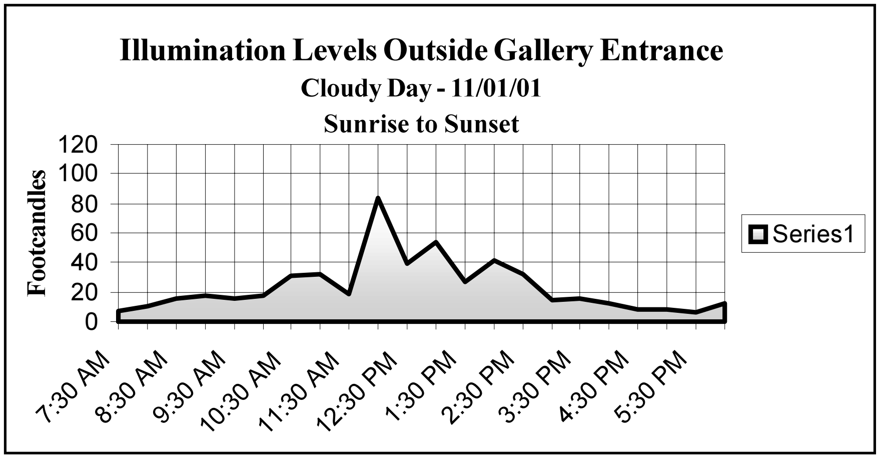
The data for the other Stow-Away locations is located in Appendix A-2.



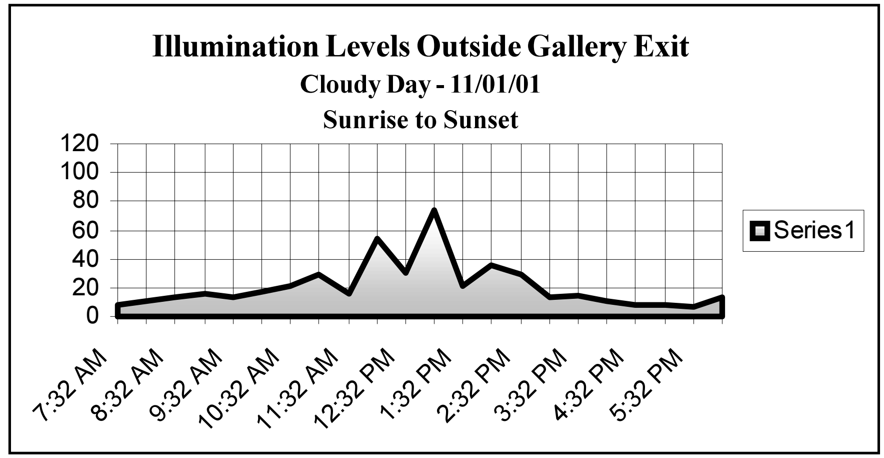
Illumination Levels Outside Gallery Entrance
Sunny Day - 10/31/01
Sunrise to Sunset
Footcandles
120
100
80
60
40
20
0
7:30 AM
8:30 AM
9:30 AM
10:30 AM
11:30 AM
12:30 PM
1:30 PM
2:30 PM
3:30 PM
4:30 PM
5:30 PM
Series1



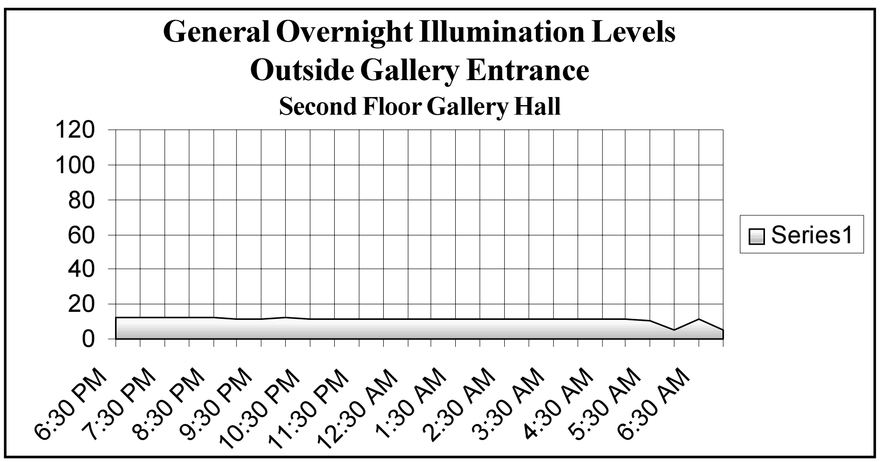
Illumination Levels Outside Gallery Exit
Sunny Day - 10/31/01
Sunrise to Sunset
120
100
80
60
40
20
0
7:32 AM
8:32 AM
9:32 AM
10:32 AM
11:32 AM
12:32 PM
1:32 PM
2:32 PM
3:32 PM
4:32 PM
5:32 PM
Series1



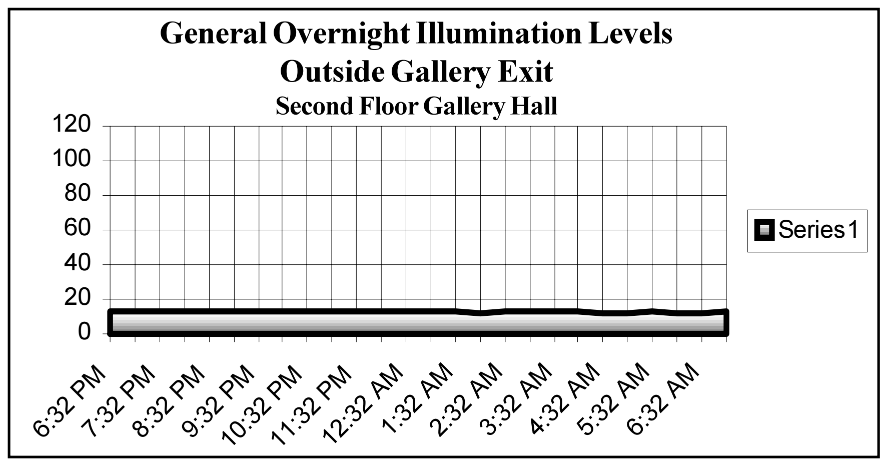
Illumination Levels Outside Gallery Entrance
Cloudy Day - 11/01/01
Sunrise to Sunset
Footcandles
120
100
80
60
40
20
0
7:30 AM
8:30 AM
9:30 AM
10:30 AM
11:30 AM
12:30 PM
1:30 PM
2:30 PM
3:30 PM
4:30 PM
5:30 PM
Series1



Illumination Levels Outside Gallery Exit
Cloudy Day - 11/01/01
Sunrise to Sunset
120
100
80
60
40
20
0
7:32 AM
8:32 AM
9:32 AM
10:32 AM
11:32 AM
12:32 PM
1:32 PM
2:32 PM
3:32 PM
4:32 PM
5:32 PM
Series1



General Overnight Illumination Levels
Outside Gallery Entrance
Second Floor Gallery Hall
120
100
80
60
40
20
0
6:30 PM
7:30 PM
8:30 PM
9:30 PM
10:30 PM
11:30 PM
12:30 AM
1:30 AM
2:30 AM
3:30 AM
4:30 AM
5:30 AM
6:30 AM
Series1



General Overnight Illumination Levels
Outside Gallery Exit
Second Floor Gallery Hall
120
100
80
60
40
20
0
6:32 PM
7:32 PM
8:32 PM
9:32 PM
10:32 PM
11:32 PM
12:32 AM
1:32 AM
2:32 AM
3:32 AM
4:32 AM
5:32 AM
6:32 AM
Series1

Diagnostic

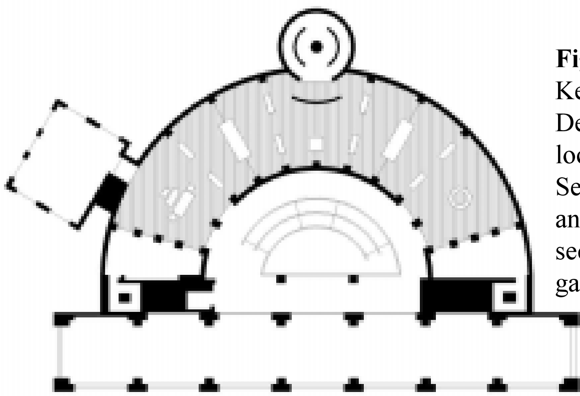


Figure 1
Key plan. Denotes location of Segments- A,B and C within the second floor gallery hall.

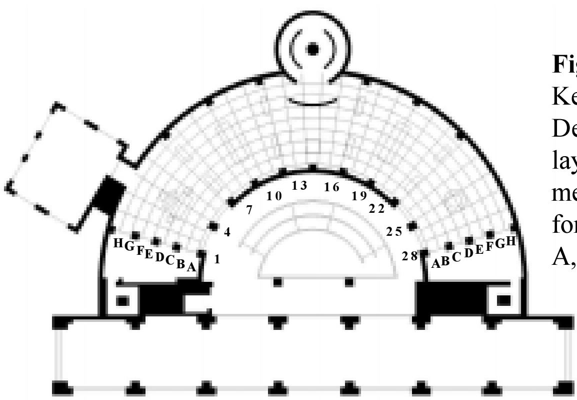


Figure 2
Key plan. Denotes layout of measurement grid for Segments- A,B and C.

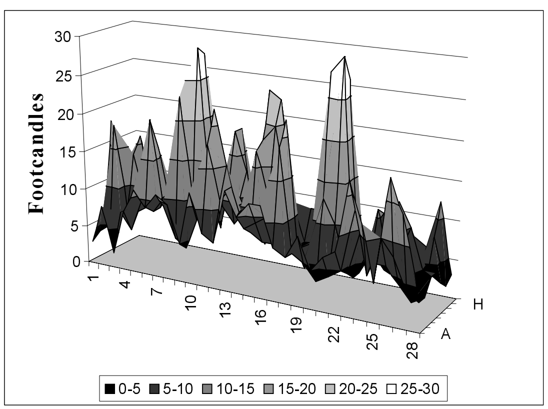


Figure 3
Three dimensional surface chart illustrating the variations in the overall illuminance distribution.

Isolux Grid Mapping

The data collection began November, 14 on a sunny day at 2:30pm and ended at 4:00pm. We collected a series of instantaneous illuminance measurements in 4'-0" increments.

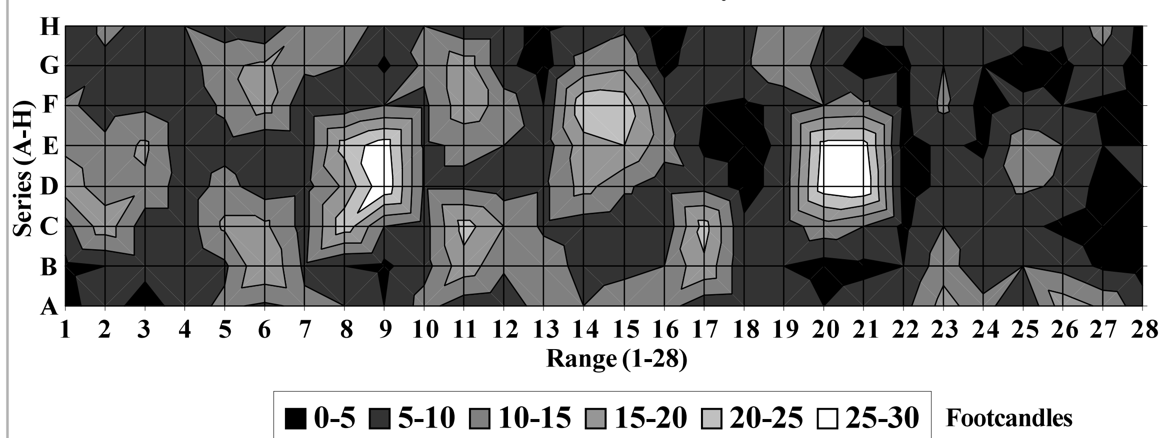
IES recommends an illumination range between 10 and 20 footcandles for general lighting throughout general gallery areas. The graph clearly illustrates that the recorded illumination measurements range from 1 to 30 footcandles. The higher readings occur near the task-lit exhibits, which creates bright spots or focal points within the space. In order to relate the graph to IES recommendations an average of illumination was calculated. The total illumination values were calculated from 224 measurement recordings, which equalled 2101 fc.

Average Calculation

2101 fc / 224 recordings = 9.37 fc Avg.

The average overall illumination level is just below IES recommendations.

Overall Distribution of Illuminance
NCAA Hall of Champions
Second Floor Gallery Hall

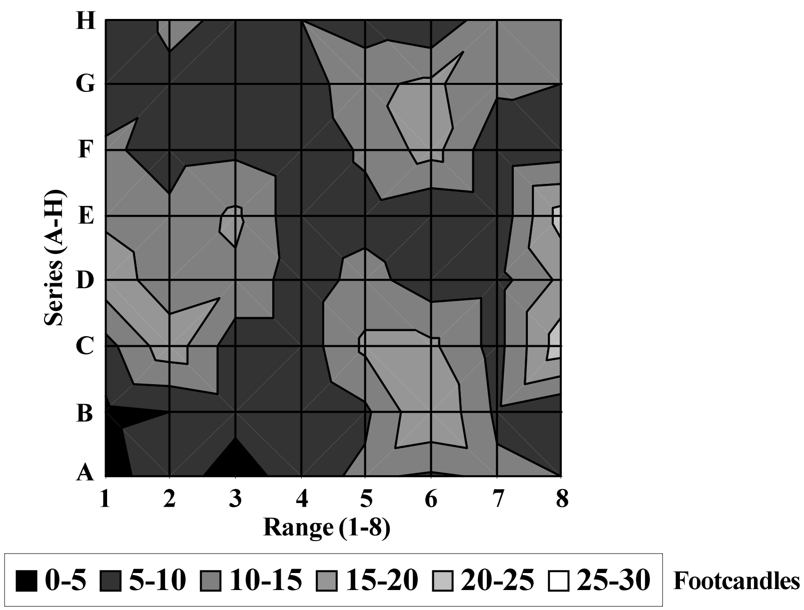


Diagnostic

The recorded illumination levels within Segment-A of NCAA, Hall of Champions second floor gallery hall range from 2fc (A2) to 23fc (C8). 56% of the recorded illumination values within this space are below the minimum 10fc IES recommendation.

Series (A-H)								
H	6	11	9	10	7	5	14	13
G	6	9	6	7	14	16	11	10
F	11	8	9	6	11	17	6	7
E	14	11	16	6	8	5	6	22
D	18	12	14	7	12	7	8	16
C	8	18	7	7	16	16	8	23
B	4	5	7	5	9	20	9	5
A	3	8	2	8	11	9	11	10
	1	2	3	4	5	6	7	8

Range (1-8)



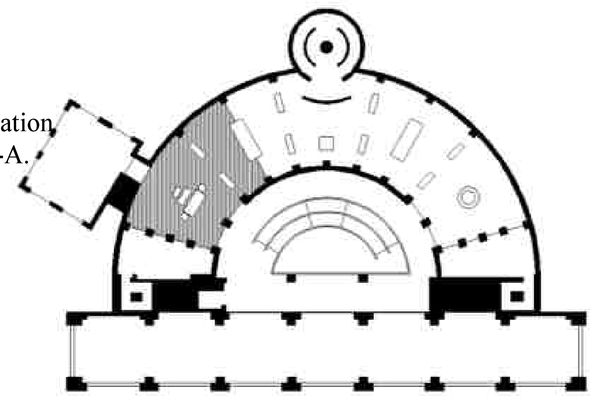


Figure 1
Key plan.
Denotes location of Segment-A.

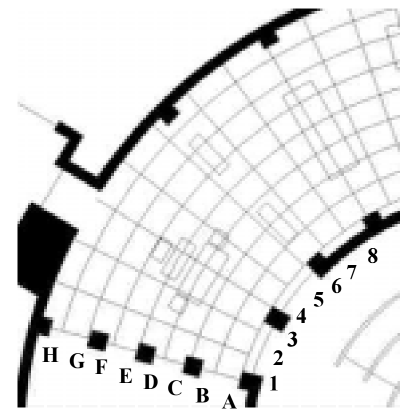


Figure 2
Enlarged plan of Segment-A showing measurement grid.

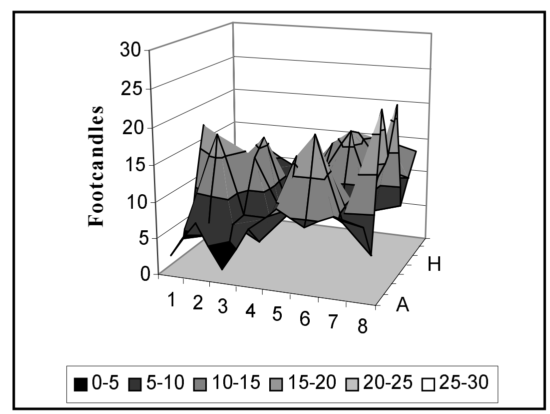


Figure 3
Three dimensional surface chart illustrating the variations in the overall illuminance distribution within Segment-A.

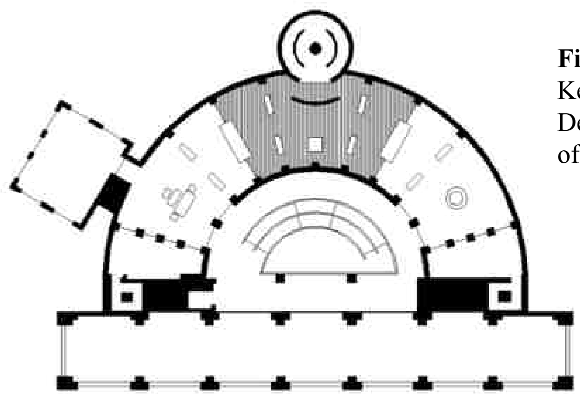


Figure 1
Key plan. Denotes location of Segment-B.

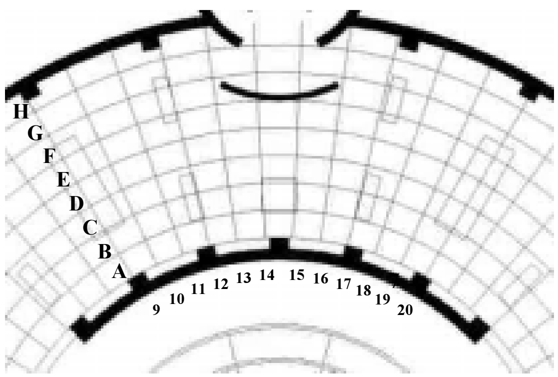


Figure 2
Enlarged plan of Segment-B showing measurement grid.

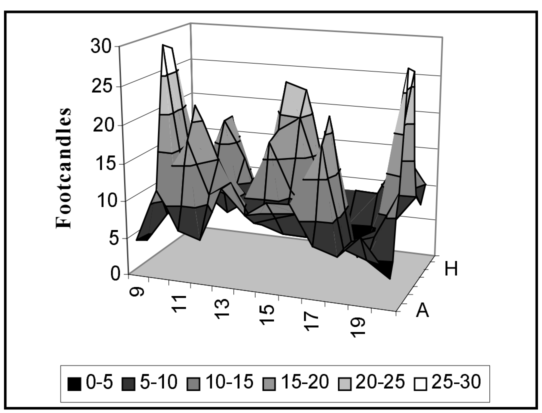
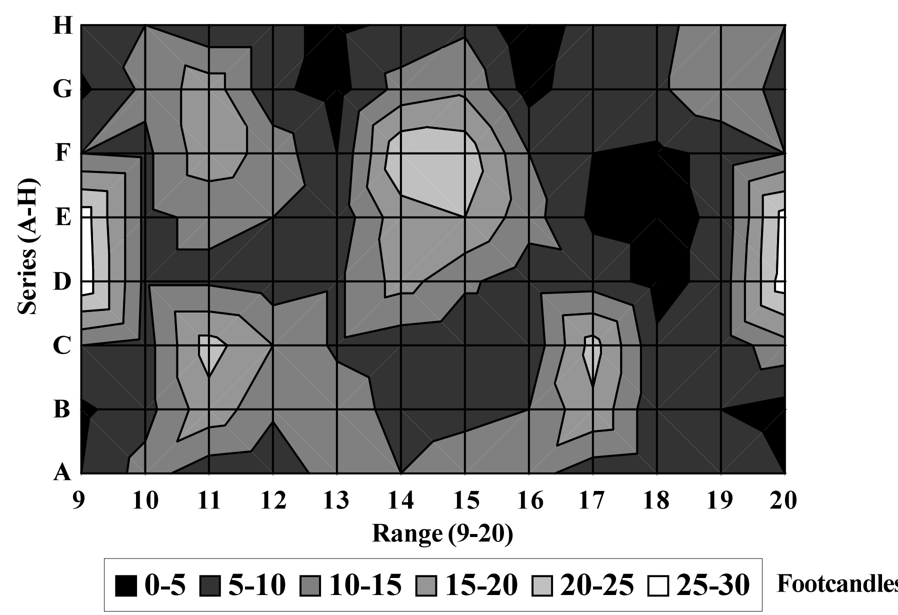


Figure 3
Three dimensional surface chart illustrating the variations in the overall illuminance distribution within Segment-B.

Diagnostic

The recorded illumination levels within Segment-B of NCAA, Hall of Champions second floor gallery hall range from 1fc (H16) to 29fc (D9). 57% of the recorded illumination values within this space are below the minimum 10fc IES recommendation.

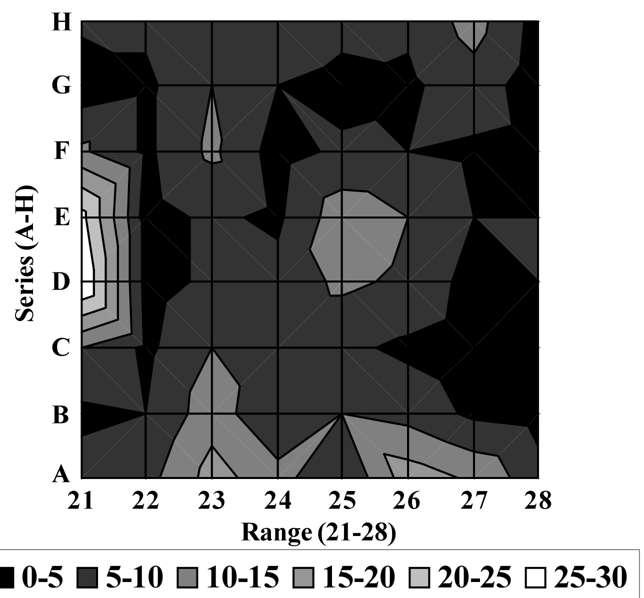
Series (A-H) \ Range (9-20)	9	10	11	12	13	14	15	16	17	18	19	20
H	8	10	6	6	4	6	9	1	8	8	14	10
G	4	11	18	6	3	12	14	3	9	9	14	8
F	10	9	18	13	5	24	23	10	5	4	6	10
E	28	9	11	10	7	18	20	12	4	3	6	27
D	29	9	9	7	9	17	11	7	8	3	7	28
C	10	8	22	15	9	7	6	6	22	6	7	13
B	4	8	18	11	13	8	9	10	19	6	5	3
A	5	12	7	6	13	10	12	12	7	6	9	5



Diagnostic

The recorded illumination levels within Segment-C of NCAA, Hall of Champions second floor gallery hall range from 2fc (C27) to 31fc (D21). 72% of the recorded illumination values within this space are below the minimum 10fc IES recommendation.

Series (A-H) \ Range (21-28)	21	22	23	24	25	26	27	28
H	6	6	7	10	7	6	12	3
G	2	4	10	5	3	4	8	2
F	11	4	11	3	6	5	4	3
E	27	3	6	4	13	10	5	5
D	31	3	6	7	11	9	3	5
C	10	4	10	6	6	4	2	3
B	4	5	13	5	10	8	4	3
A	7	8	17	12	5	18	14	7



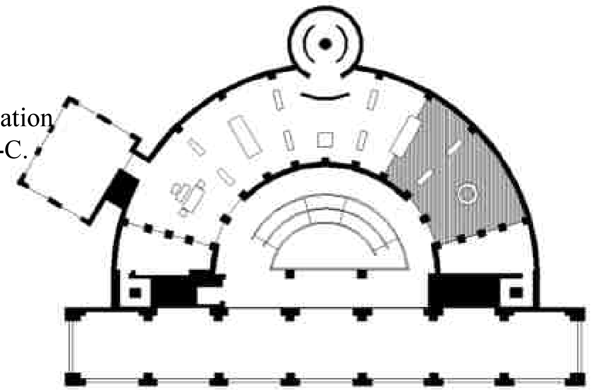


Figure 1
Key plan.
Denotes location of Segment-C.

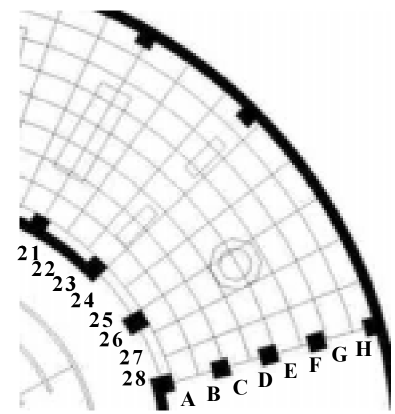


Figure 2
Enlarged plan of Segment-C showing measurement grid.

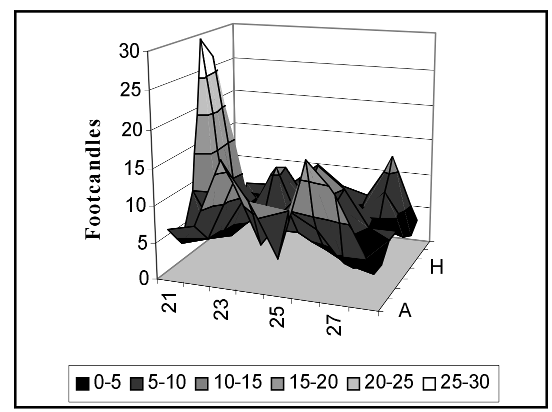


Figure 3
Three dimensional surface chart illustrating the variations in the overall illuminance distribution within Segment-C.

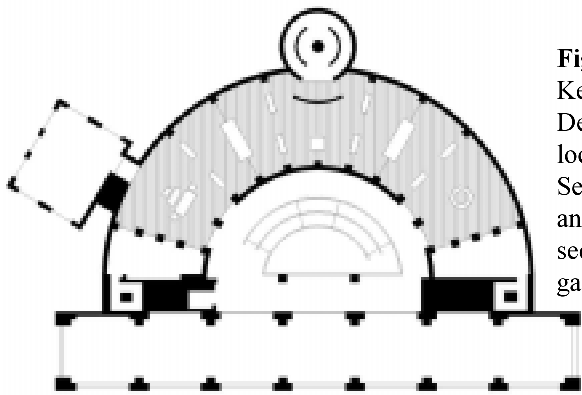


Figure 1
Key plan. Denotes location of Segments- A,B and C within the second floor gallery hall.

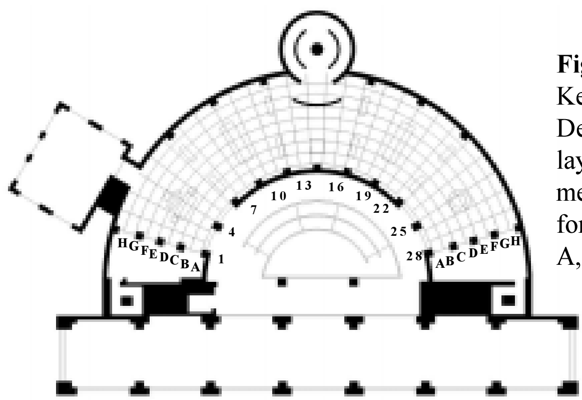


Figure 2
Key plan. Denotes layout of measurement grid for Segments- A,B and C.

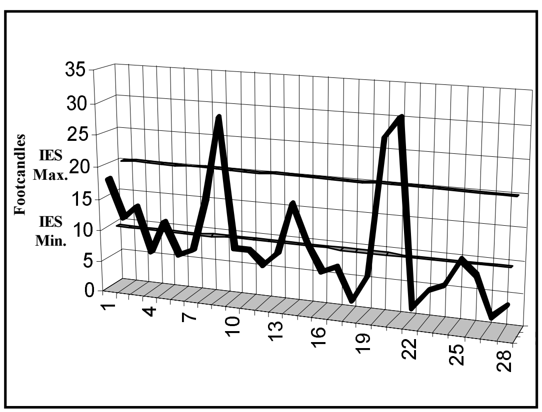


Figure 3
Graph illustrates illumination levels of Series E in relation to IES recommendations.

Diagnostic

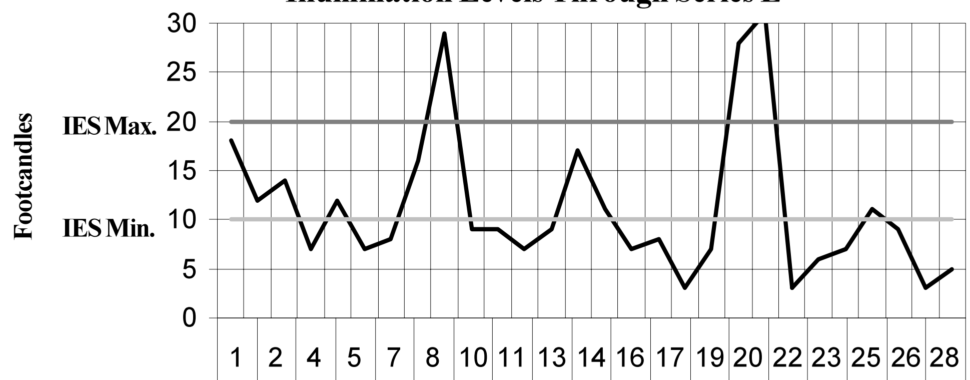
Section Line Graphs

The section line graph represents a general cross-section through the second floor gallery hall which contains the highest illumination values. Here the IES recommended 10 fc (Min.) and 20 fc (Max.) levels for general gallery areas are superimposed on the graph.

More specifically, the graph illustrates the current illumination levels through Series-E and the relationship to IES recommended illumination levels.

Illumination Levels Through Series-E
Represented in Longitudinal Section

Illumination Levels Through Series E

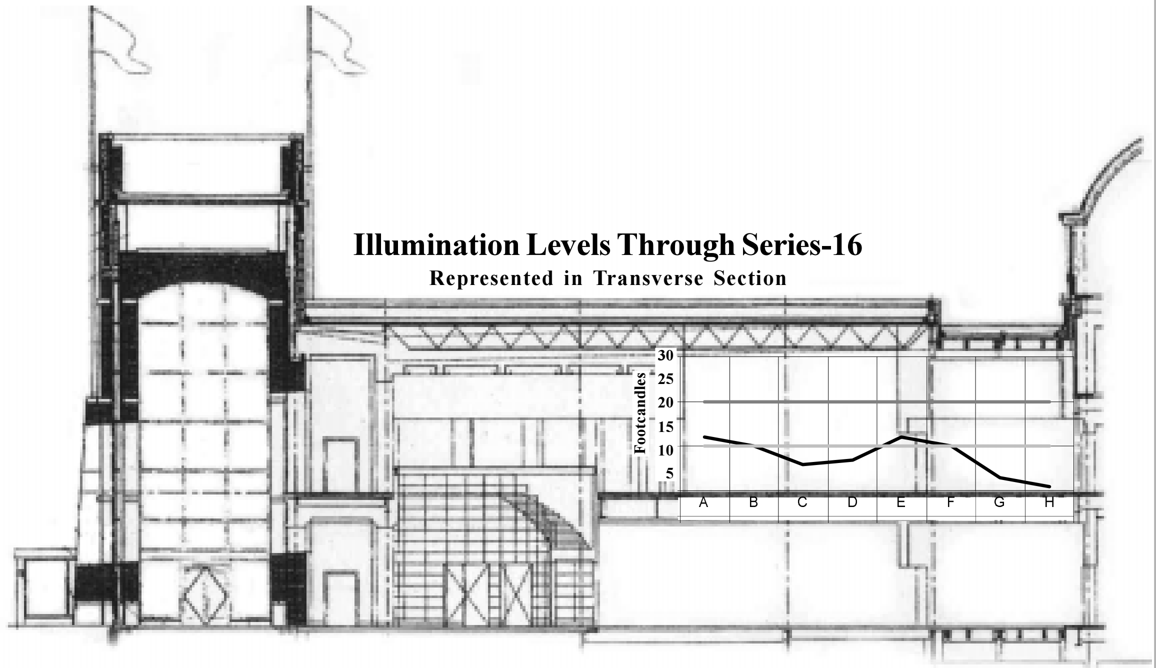


	1	2	4	5	7	8	10	11	13	14	16	17	19	20	22	23	25	26	28
Series E	18	12	7	12	8	16	9	9	9	17	7	8	7	28	3	6	11	9	5
IES Min.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
IES Max.	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

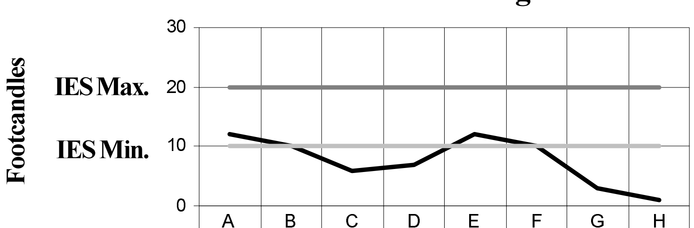
Diagnostic

The section line graph represents a general cross-section through the second floor gallery hall which contains the lowest illumination values. Here the IES recommended 10 fc (Min.) and 20 fc (Max.) levels for general gallery areas are superimposed on the graph.

More specifically, the graph illustrates the current illumination levels through Series 16 and the relationship to IES recommended illumination levels.



Illumination Levels Through Series 16



	A	B	C	D	E	F	G	H
Series 16	12	10	6	7	12	10	3	1
IES Min.	10	10	10	10	10	10	10	10
IES Max.	20	20	20	20	20	20	20	20

Figure 1
Key plan. Denotes location of Segments-B within the second floor gallery hall.

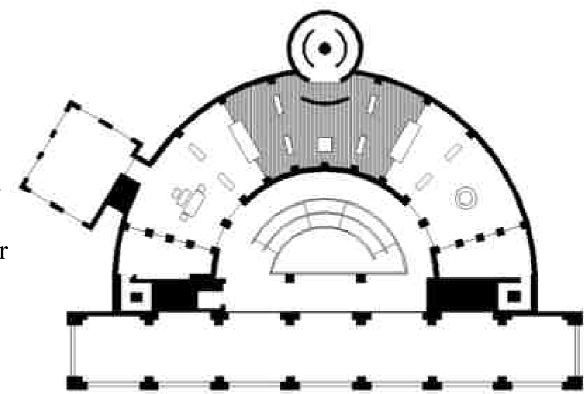


Figure 2
Key plan. Denotes layout of measurement grid for Segments- A,B and C.

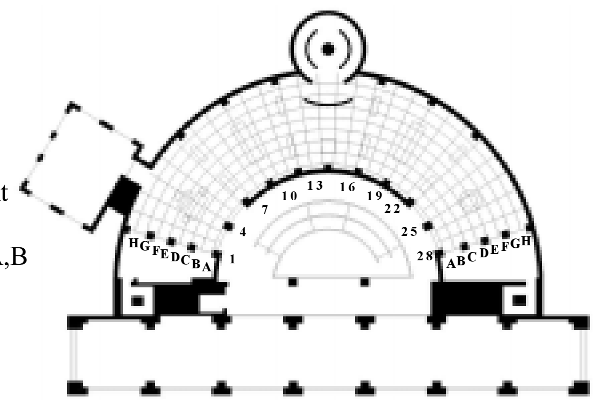


Figure 3
Graph illustrates illumination levels of Series 16 in relation to IES recommendations.

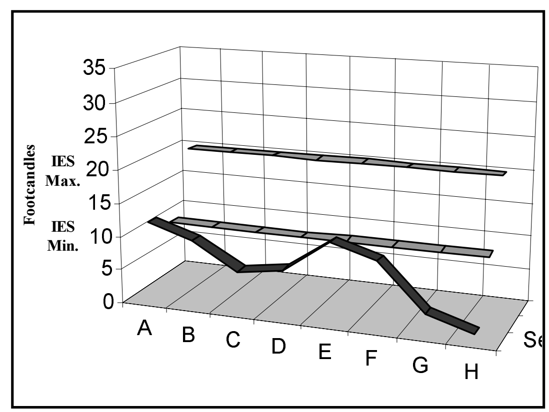


Figure 50.1
Observing visitors viewing an exhibit, approximately 6'-0" away.

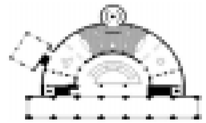
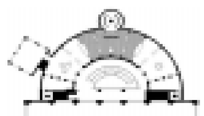


Figure 50.2
Observing visitors viewing a videoexhibit, approximately 4'-0" away.



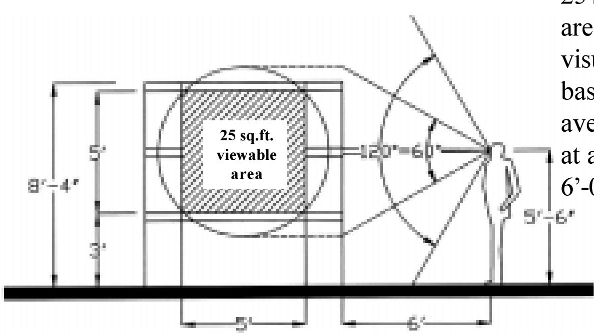


Figure 50.3
25 sq.ft. viewable area, of the near visual field, based on 5'-6" average eye level at a distance of 6'-0".

Diagnostic

Design of the Lighting Scenarios

Six lighting scenarios were selected as potential candidates for further analysis and investigation. The dimensions of each exhibit and display area was collected and recorded. Sections of the selected areas were then drawn for the purpose of locating the position and angles of the current luminaires in relationship to the exhibit, display, and the viewer. The viewable display area in the exhibits under analysis measured 5'-0"x5'-0" or 25sq.ft. Next, a tape measure was placed on the floor at the center of the exhibit. We then moved toward the exhibit until the display area filled our near visual field. We discovered the optimal viewing distance to be 6'-0". At this distance the information such as text and images on the display area were still legible. But in the selected cases under investigation, it was at this 6'-0" viewing distance that direct glare from the PAR 38 flood luminaires became an issue. Although, once we were enticed to take closer look at the exhibits' display area, the direct glare experienced at the 6'-0" viewing distance was shielded by the exhibit itself. Therefore, direct glare is only problematic at a 6'-0" or greater distance. After making these discoveries, we observed people within the space and noticed that they stood approximately 6'-0" away from the exhibits while viewing them. This information was crucial for making thorough analytical assessments and recommendations for each exhibit.

Due to the time constraints of this semester long field investigation, one scenario was selected for further investigation. More specifically, we chose to analyze the pole vault exhibit, which is located in Segment-C of the second floor gallery hall, in greater detail. A subjective and critical assessment was made which ultimately lead to the development of an engineering and architectural design solution.

The remaining scenarios are offered (see Appendix A-1) for future analysis and development by us or others interested in this area of research.

Diagnostic

Design of the Lighting Scenarios

This particular sculptural exhibit was chosen for further analysis and development because it displayed the most glare discomfort within the visual field. The glare discomfort experienced in this lighting scenario stemmed from direct glare which resulted in extremely high brightness ratios. In point of fact, the brightness ratio from this particular point of view is 110,700 to 1 (see figure 51.3 and 53.3). Essentially, the dark-colored, low-reflectance finish, used on the ceiling cavity, absorbs most of the light that strikes it. This creates a high contrast space regardless of the amount of illumination.

This exhibit was particularly interesting because it is designed for a 360° viewing angle which adds to the complexity of the design solution. In an attempt to heroically portray this exhibit through the use of artificial light, the sculpture is in some cases, dramatically over lit by a series of PAR 38, 90 watt, flood type luminaries (see figure 51.1).

In setting up the experiment, we walked around the exhibit in an attempt to find the most comfortable viewing angle which still displayed the sculpture in a dramatic light and direct glare discomfort. In selecting this particular point of view, we discovered that our most comfortable viewing distance was 10'-0" from the outside edge of the octagonal portion of the exhibit, which required minimal head tilt. We then measured 24'-0", along our line of sight, to locate the position of the luminaire. Next, the angle of declination for the fixture was discovered to be 26° from horizontal to nadir. At this angle, the nadir is directed at the center of the sculptural piece (see figure 52.1 and 52.2). As a result, it causes extreme discomfort glare within the near visual field which is seen by both eyes.

Figure 51.1
Direct glare occurs in within the 360° viewing angle of this sculptural exhibit.

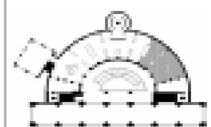
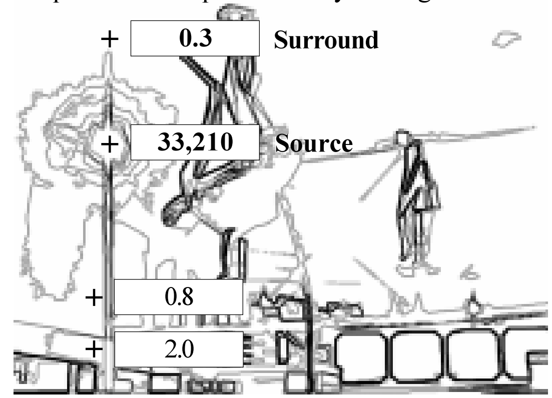


Figure 51.2
The spot-lights in Segment C of the gallery hall produce direct glare, which caused discomfort in the visual field.

The see the effects of direct glare in relation to visual comfort, view sculpture by covering the left portion of the picture with your finger.

Figure 51.3
Brightness ratio is 33,210(source) / 0.3 (surround) = **110,700 to 1**.

Spot luminance meter readings taken with Minolta LS-100.



Note: luminance values measured in L/ft

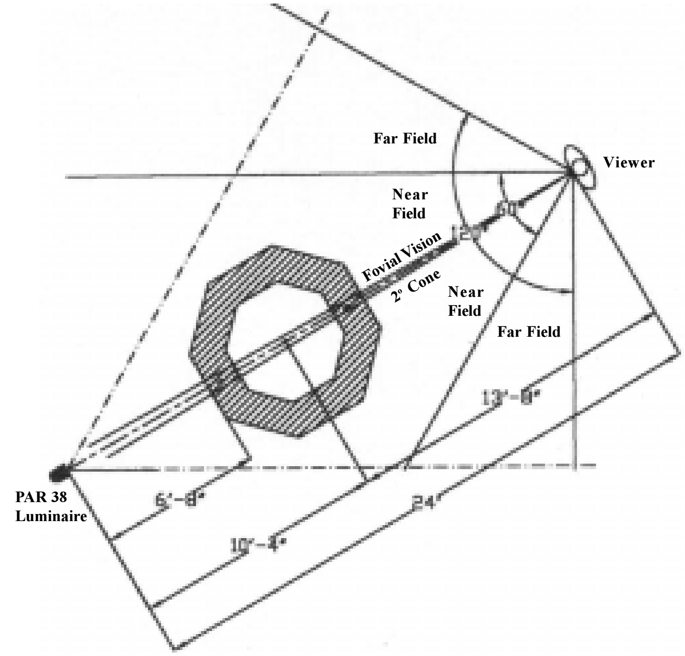


Figure 52.1- Plan Diagram of Current Layout

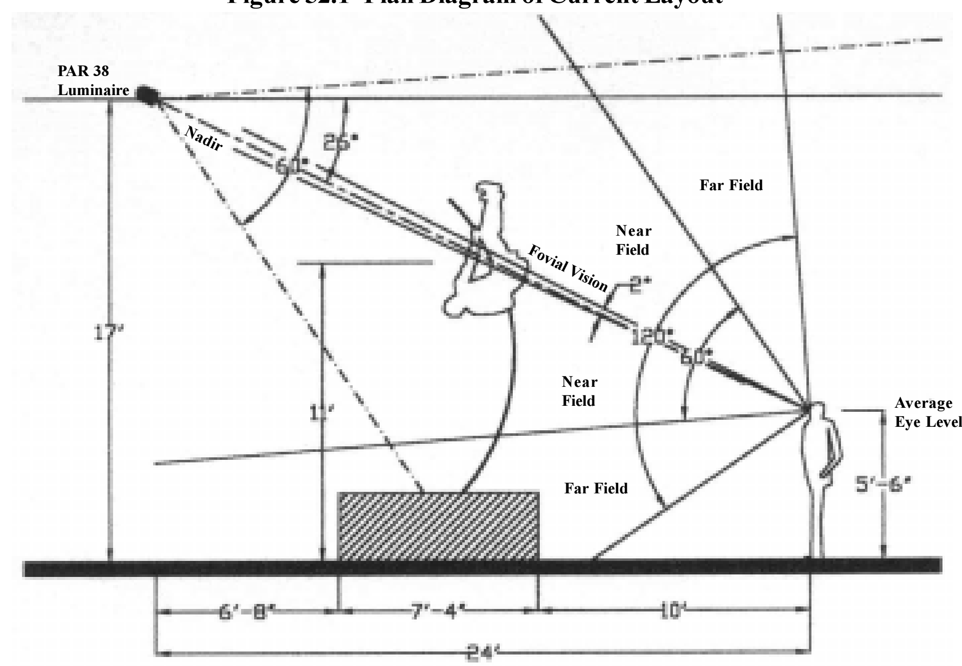


Figure 52.2- Section Diagram of Current Layout

Diagnostic

The relationship between the brightness zone (source) and the sculptural exhibit within the visual field is illustrated using a visual field map (see figure 53.4).

According to the lighting guidelines for illuminating sculpture the luminaire should be positioned between 30° and 45° from horizontal and between 30° and 45° from vertical. After the construction of the section diagram, it was discovered that the current luminaire is positioned 26° from horizontal which is outside Gordon and Nuckolls illumination guidelines for sculpture.

Using the geometry of the near visual field with a line of sight parallel to the floor plane, we were curious to see if the visitor was permitted space to back far enough away from the sculptural object to comprehend it. Basically, placing the 30° half angle of the near visual field at the top of the object being viewed sets up the geometry for optimal viewing distance. By using this technique, we calculated the optimal viewing distance for this scenario to be 14'-5". We discovered in most cases, this exhibit can be viewed from this distance (see revised plan diagram).

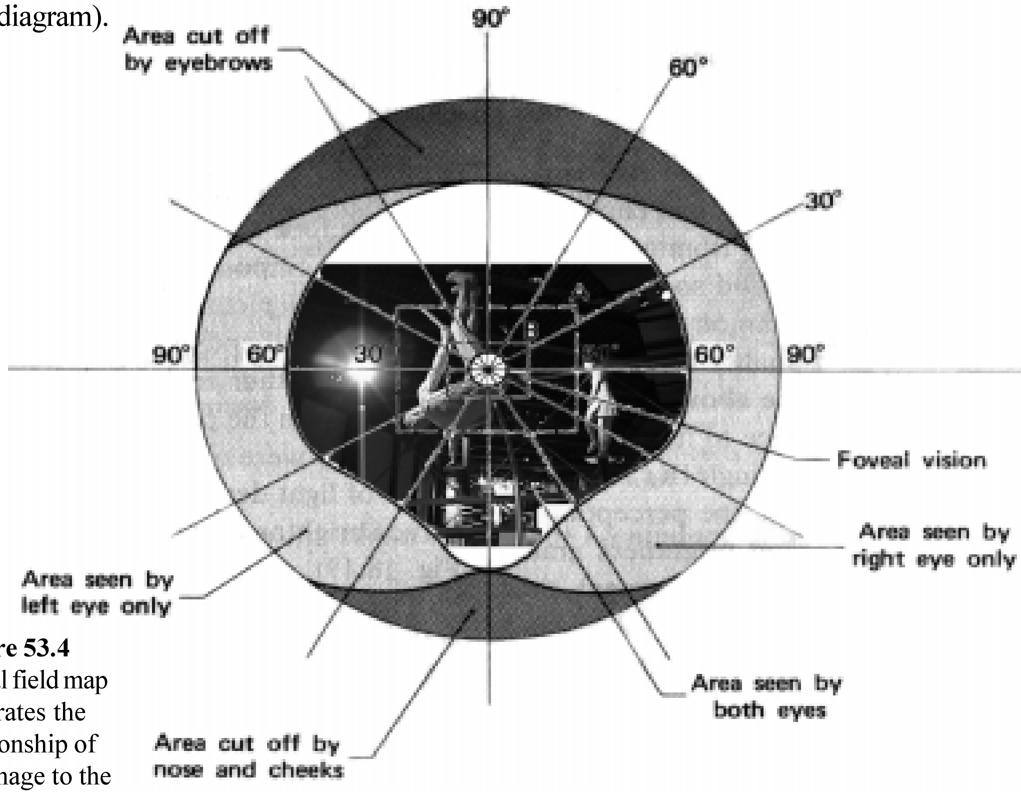


Figure 53.4
Visual field map illustrates the relationship of the image to the field of view.

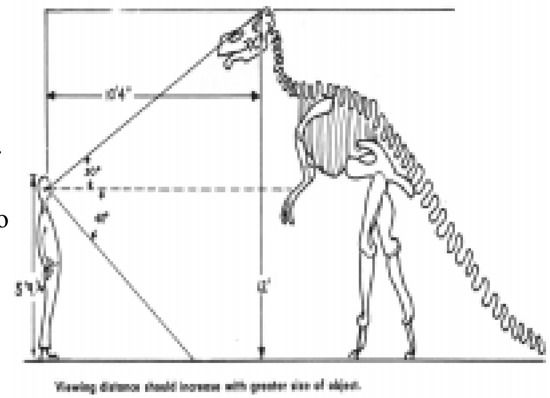


Figure 53.1
The visitor must be permitted space to back far enough away from the object to comprehend it (Chiara and Callender).

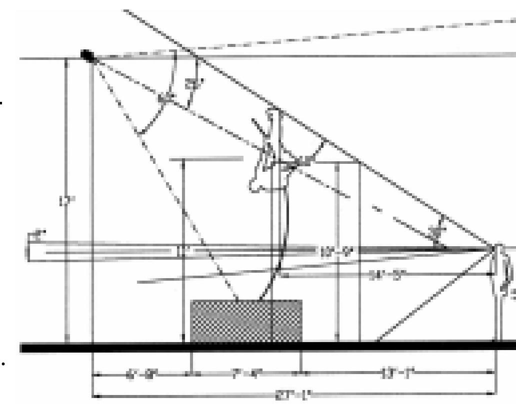


Figure 53.2
Diagram illustrating optimal viewing distance to be 14'-5" from exhibit. Also illustrates the optimum height for the light screening device.

Figure 53.3
Brightness ratios (Flynn).

	Vector to Background Brightness Ratio
Barely significant contrast Low contrast environment	2:1
Minimum meaningful contrast in the sense of spatial vector influence	10:1
Dominating contrast High contrast environment	Approaching 100:1

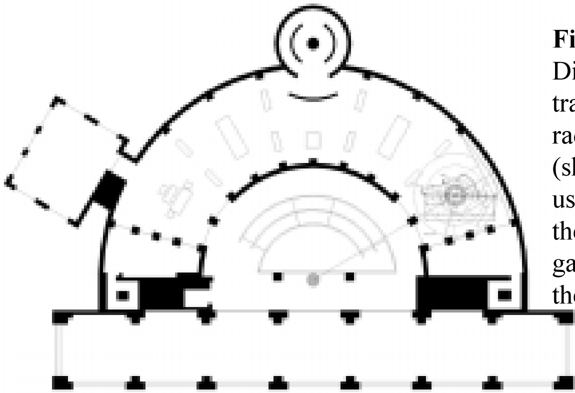


Figure 54.1 Diagram illustrates central radius point (shaded circle) used to generate the second floor gallery portion of the building.

Diagnostic

Design Methodology for Revised Lighting Arrangement

In practice, sculptural objects being exhibited are usually lit from two sides to reduce excessive shadows. One side typically has a concentrated beam-spread to enhance drama and function as the sun's direct beam radiation; the other side receives diffuse illumination to soften harsh shadows and replicate the sky's diffusing qualities. Using this rationale and applying Gordon and Nuckolls design guidelines for illuminating sculpture and the appropriate lighting studies for dramatically lighting an actor / object, we chose to radically simplify the complexity of the current lighting layout, yet attempt to reproduce the same heroic lighting qualities while eliminating direct glare.

We determined, through further analysis of the section diagram, the focal point to be 11'-0" AFF at the center of the sculptural exhibit. By keeping the current track lighting system height of 17'-0" AFF, the focal point of the exhibit was discovered to be 6'-0" below the track lighting height. In order to replicate the sun's concentrated direct beam, we fixed (luminaire A) at a 45^{o} angle from vertical. Using this geometry, we then calculated that the exact placement of (luminaire A) had to be 6'-0" horizontally away from the focal point of the exhibit. Now, in order to create the diffuse illumination to soften the sharp shadows created by (luminaire A), we fixed (luminaire B) at a 30^{o} angle from horizontal. Using the same geometries, we calculated that the exact placement of luminaire B had to be 10'-5" horizontally away from the focal point of the exhibit (see figure 55.1). Now that both (luminaires A and B) have been located in three-dimensional space, they essentially can be rotated 360^{o} around the focal point (see figure 56.1). Keeping the dynamics of the gallery sequencing in mind, the luminaires were arranged accordingly. We took into account, Segment C can be entered from two points i.e. Segment B and the exiting area which opens onto the second floor mezzanine (see figure 56.1). Through the investigation of these points of entry, we discovered that the current lighting geometry when entering Segment C from Segment B and the exiting area of the gallery space results in extreme direct glare (figure 51.1). In an attempt to eliminate the resulting direct glare at the points of entry, (luminaire A) was rotated 102^{o} and (luminaire B) was rotated 31^{o} from the central radius point used to generate the second floor gallery hall portion of the building (see figure 54.1 and).

Design Recommendations

Now that the luminaires are configured in accordance with the illumination guidelines and in relationship to the sculptural exhibit, we analyzed the revised section to evaluate the revised lighting geometries. By doing so, we discovered the direct beam light from (luminaire B) could potentially cause glare discomfort. In essence, strictly using the illumination guidelines and geometries can not ensure direct glare will be eliminated. The guidelines assume a fixed point of view, which in this particular exhibit is not the case. Here is where the development and design of the lighting scenario became very exciting and challenging.

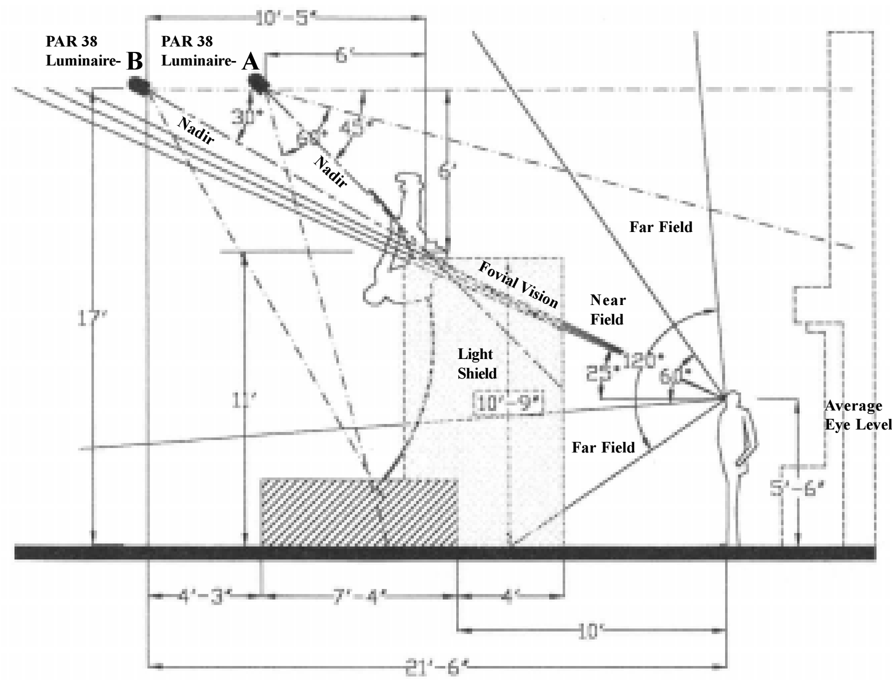


Figure 55.1- Section Diagram of Revised Layout

Figure 55.1
Revised section diagram illustrates locations of optimal viewing distance, location of sculptural focal point, luminaires A and B, and light shield dimensions.

Design Recommendations

Figure 56.1
Revised plan diagram illustrates optimal viewing distance, placement of luminaires A and B, and light shield.

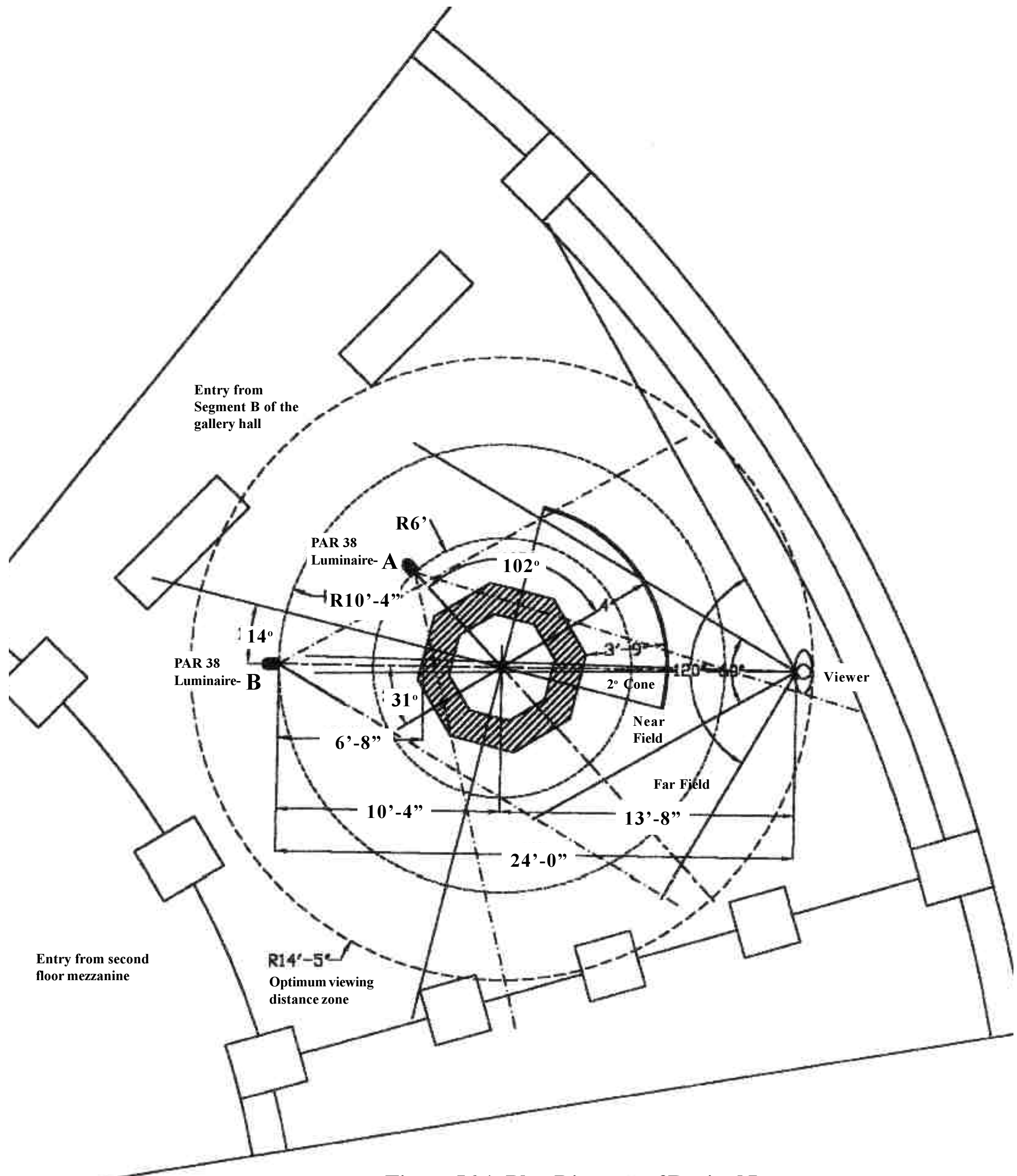


Figure 56.1- Plan Diagram of Revised Layout

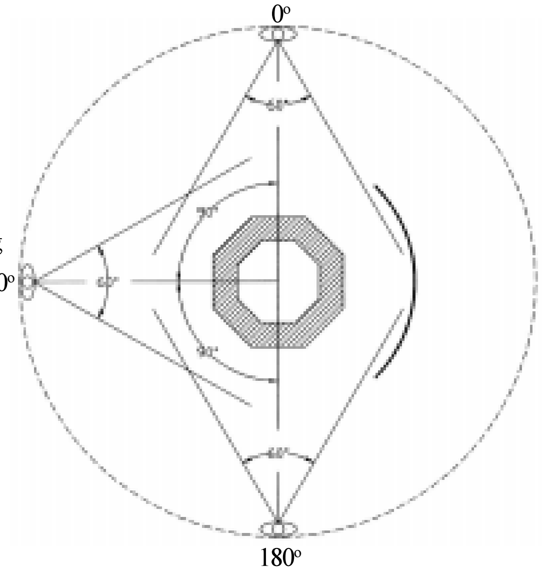
Design Recommendations

We elected to provide a simple architectural design solution to a complex engineering problem. Now wearing our architectural design hat, one possible solution would be to install a translucent material to shield the direct beam light of (luminaire B) from the viewer. This led to a design discussion about how the installation of a light shield / object could serve a dual purpose and effectively eliminate direct glare as well as serve to reinforce the heroic or epic drama of the exhibit. The architectural design concept for this light shield is that it become symbolic of the bar that the champion is attempting to vault over. This symbology would enhance the perception of the heroic struggles that challenge a true champion. It was also discussed, that the shield also become a celebration of milestones. To reinforce this concept, the translucent material should be engraved with a chronological listing of the past and present record holders, the date the record was set, and the vaulting height achieved. These conceptual ideas would strongly reinforce the heroic qualities of a champion. The light shield should also be lit from the floor. This would produce a lit background for the sculpture which would reinforce the drama ever further by distinguishing it from the surround as well as add visual depth and interest. We determined that the shield should be concentric to the octagon, arranged and positioned along the back wall of segment C's exhibit space. This arrangement sets-up and defines clearer viewing locations of the sculpture on a 180° degree viewing arc (see figure 57.1), while continuing to allow for 360° viewing of the octagonal portion of the exhibit and light shield exhibit. Therefore creating a most powerful focal point within this portion of the second floor gallery hall.

Now, we must look at the technical aspects of designing the wall. First, we acknowledged that the octagonal portion of the exhibit displays information on all sides. So, the lighting shield must allow adequate circulation around this exhibit. In order to serve all patrons, the light shield was placed 44" (requirement for handicap accessibility) from the octagon. Next, referring to the diagram (see figure 53.2) for optimal viewing distance and the relationship of the shield to the octagon, we calculated that the optimum height of the light shield needed to be 10'-9".

In essence, the integration of lighting and architectural design for the pole vaulting sculptural exhibit forms a synthesis that alters the viewers perception of the sculptural piece and evokes the ambiance of an epic champion.

Figure 57.1 Diagram illustrates the clearly defined viewing locations of the sculptural exhibit on a 180° viewing arc.



Conclusion

By participating in this semester long post occupancy review, we gained broad and specific knowledge of the complex issues designers confront in lighting design. We also discovered lighting design is not just an engineering challenge but an architectural one as well. We have concluded at the completion of our indicative, investigative, and diagnostic research that, in some cases, visual discomfort is experienced by the user as he or she transitions through the second floor gallery space. The visual discomfort experienced is a result of direct discomfort glare and occasionally disabling glare. In essence, we disproved our hypothesis.

The direct glare discomfort and disablig glare discovered in the NCAA Hall of Champions second floor gallery hall stemmed from a combination of conditions related to:

- Overall distribution of illumination levels
- Adaptation of the eyes
- Dark, low reflective ceiling cavity
- Extreme brightness contrast ratios within the field of view

Overall distribution of illumination levels

As a result of our investigation and analysis, we discovered the overall distribution of illumination within Segments A, B and C ranged from 56% to 72% below the IES minimum 10fc recommended illumination level for gallery spaces. The instantaneous light meter readings we recorded ranged from 1fc (low) to 31fc (high). Although, at best 44% of the recorded illumination levels are above the 10fc recommendation, the overall illumination levels in the space, according to IES recommendations, are less than adequate for its intended use.

Adaptation of the eyes

The eye adapts to the brightness level of the overall scene and sees each object within that scene in the framework of that adaptation level. In a dimly light space, such as the NCAA Hall of Champions second floor gallery hall, the adaptation level of the eyes is much slower, in some cases an hour or more is needed to fully adapt. Here, the pupil becomes much larger or dilated and the rod based (scotopic) vision takes over, which causes the eyes to be more sensitive to relative brightness. The rods sense black and white or simply the presence of any light available. Scotopic vision works very efficiently at low light levels within a building. In low light conditions, visual acuity is hindered or, in worse cases, lost completely. In essence, once the eyes have become completely adapted to the darkness, they lose acuity while gaining sensitivity. Another important point to mention is that with a decreased level of illuminance along with the compensation of dark adaptation, the ability of the eyes to make out fine detail is lost.

Dark, low reflective ceiling cavity

We also discovered that extreme brightness ratios were a result of a dark, low reflective ceiling cavity together with the PAR 38 flood type luminaires located within the field of view. It can be argued that the rationale for choosing such a dark color was simply to mask or conceal the mechanical equipment located in the ceiling cavity. However, in a gallery space, the ceiling cavity is typically a light, medium to high reflective color. This would also reinforce the design intent, as stated by Ron Fisher of Schmidt Associates, the architect of record. “In the Hall of Champions second floor gallery hall, the exhibit spaces are, in concept, to be reminiscent of sports areas, i.e. field houses or arenas, which are typically composed of high-tech or industrial types of materials.” Again, most sports arenas or field houses are typically rendered with a light, medium to high reflective color. It could also be argued that the color choice was made to create the contrasting background for the off-white sculptures. If this was the design intention, the color was an appropriate choice. The dark background effectively serves to magnify the perception of the sculptures. However, the recommended 70% ceiling cavity, 50 % room cavity, and 30% floor cavity more closely emulates the reflectiveness perceived in nature. The current material reflectiveness in the second floor gallery hall where calculated at 25% ceiling cavity, 30% room cavity, and 55% floor cavity. Comparing the recommended and the current reflectiveness, we find that the cavity reflectiveness of the current design are in reverse order.

Conclusion

Extreme brightness contrast ratios within the field of view

People search for simplification, i.e. visual clarity, within their visual fields when faced with demanding tasks or activities. As a result, too many visual stimuli or patterns placed in an environment used for complex activities such as viewing an exhibit can potentially create an overload condition.

The design intent for the lighting of sculptures was to portray or display the sports figures heroically, which was done by intense side-lighting to create sharp highlights and dark shadows.

Through further investigation of the selected lighting scenario we discovered the arrangement of the PAR 38 flood type luminaires resulted in direct discomfort glare and high brightness ratios (110,700 to 1) when viewing the pole vault sculptural exhibit. According to Stein and Reynolds, a 50 to 1 luminance ratio or greater will highlight the object practically to the exclusion of all else in the visual field. In this case, brightness draw's our attention causing us to look at the source, thus affecting visual comfort. Here the eyes have adjusted to the illumination levels of the scene which cause them to be more sensitive to brighter light. The eyes are forced to radically adjust resulting in eye fatigue and discomfort. Also bright light in a dark surround causes an after image, i.e. disabling glare, of the source to be burned into the retina. As a result the eyes continually need time to readjust to the scene. The eye becomes exhausted in this case of extreme contrast or brightness when they are overexerted for an extended period of time. In essence, the eyes are strained due to the great demand placed on which results in eye fatigue and ultimately visual discomfort.

Further lighting scenario studies would investigate each of the factors previously mentioned more closely in order to arrive at a more complete quantitative and qualitative evaluation of the NCAA Hall of Champions second floor gallery hall.

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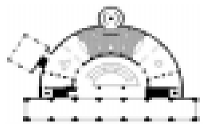
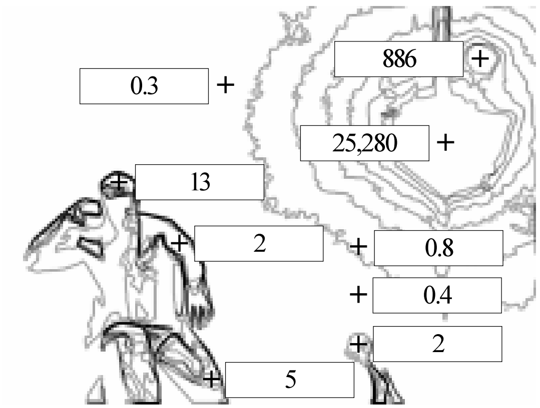
Figure 62.1 Lighting contditions documented at the shot-put sculptural exhibit.





Direct glare is very problematic and causes severe visual discomfort when viewing the sculpture exhibits. Brightness ratio is 25,280(source) / 0.3 (surround) = 84,267 to 1.

Appendix A-1

Lighting Scenarios offered for further investigation and analysis

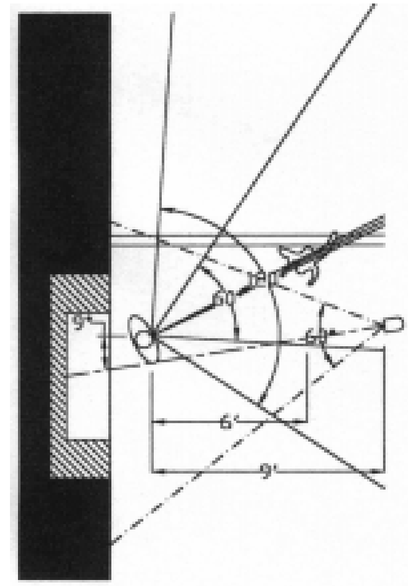


Figure 62.2- Plan Diagram of Current Layout

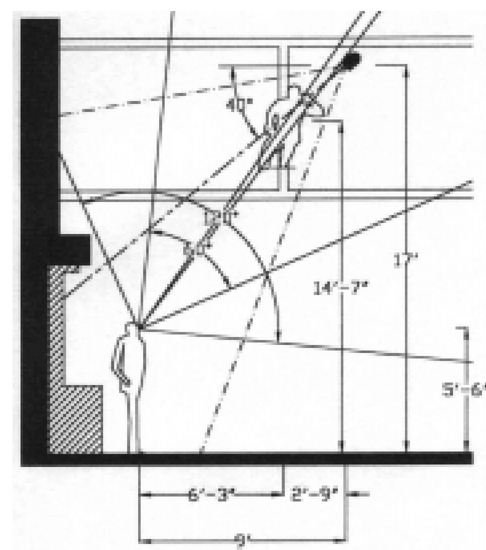


Figure 62.3- Section Diagram of Current Layout

Appendix A-1

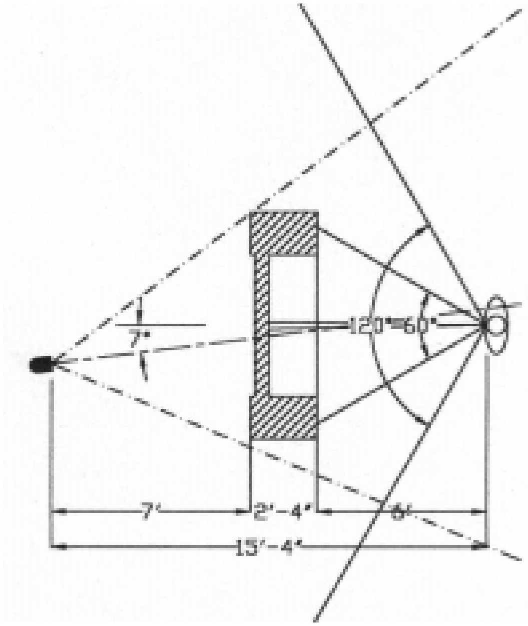


Figure 63.2- Plan Diagram of Current Layout

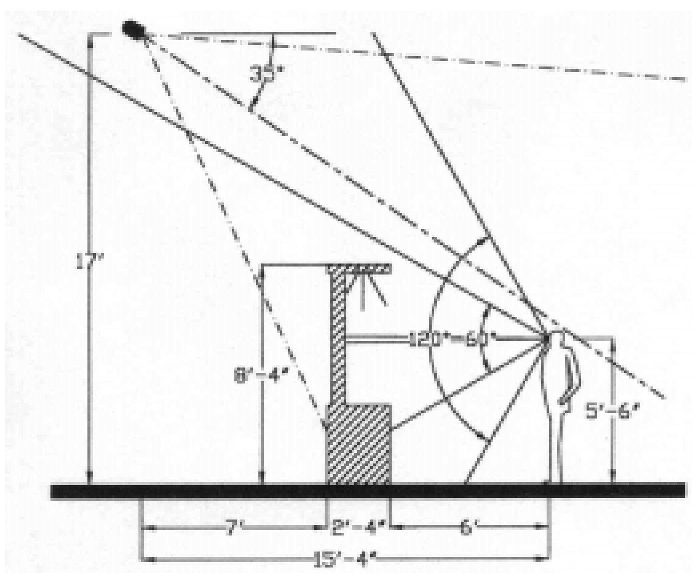


Figure 63.3- Section Diagram of Current Layout

Figure 63.1
Lighting contditions documented at the soccer exhibit.

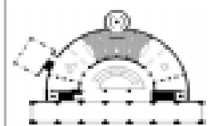
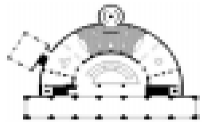


Figure 64.1 Lighting contditions documented at the gymnastics exhibit.



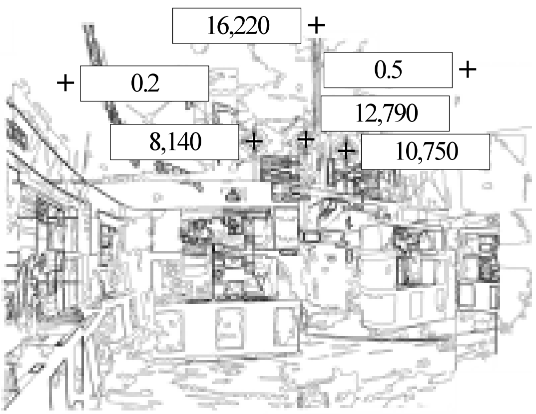


Figure 64.2 Spot luminance meter readings taken with Minolta LS-100.

Brightness ratio is 16,220(source) / 0.2 (surround) = 32,440 to 1.

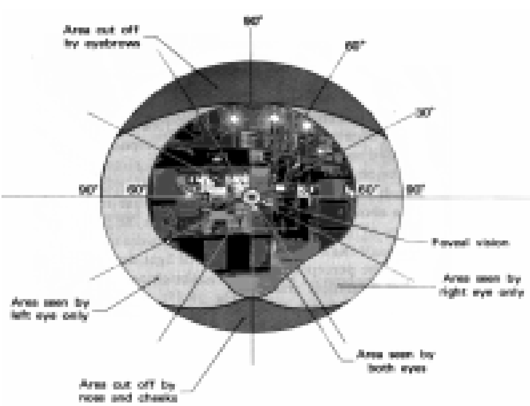


Figure 64.3 Scene in relation to visual field.

Appendix A-1

Lighting Scenarios offered for further investigation and analysis

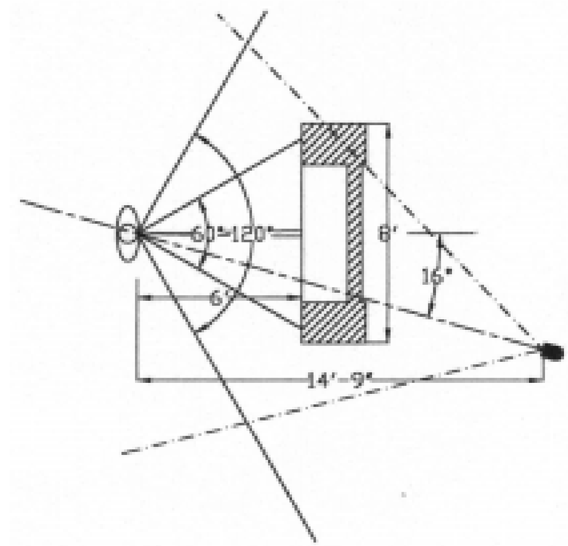


Figure 64.4- Plan Diagram of Current Layout

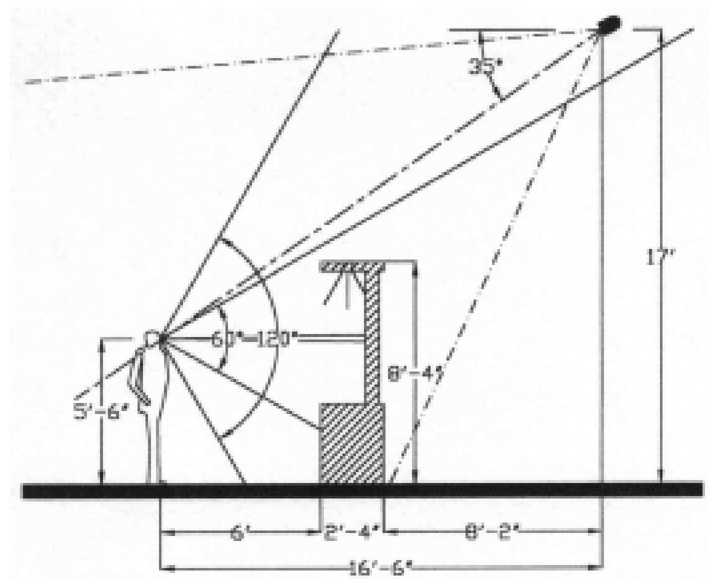


Figure 64.5- Section Diagram of Current Layout

Appendix A-1

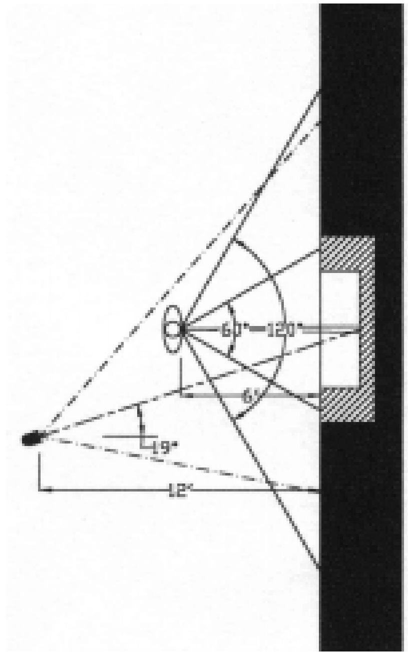


Figure 65.4- Plan Diagram of Current Layout

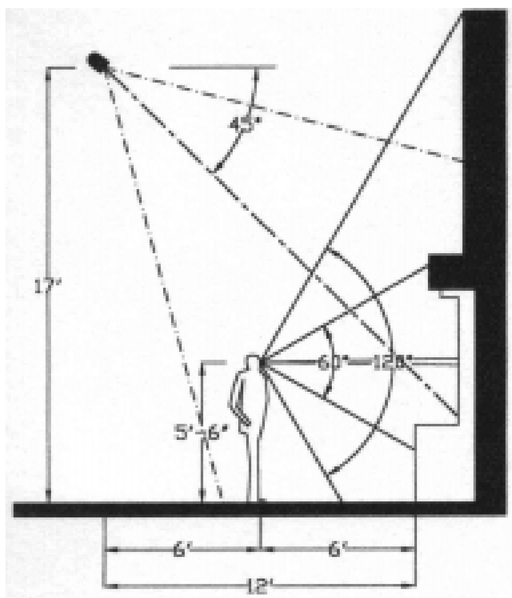


Figure 65.5- Section Diagram of Current Layout

Figure 65.1
Lighting contditions documented at the field hockey exhibit.

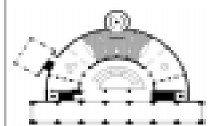


Figure 65.2
Shadows cast on task surface due to placement of luminaire lighting the exhibit.

Figure 65.3
Shadows cast on task surface due to placement of luminaire lighting the exhibit.

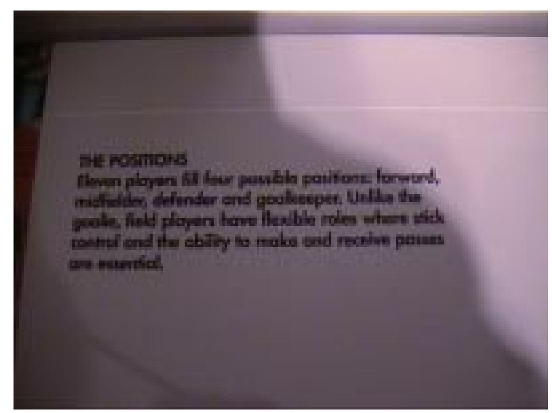
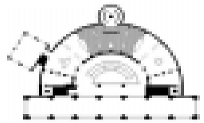


Figure 66.1 Lighting contditions documented at the free-standing interactive video exhibit.



Appendix A-1

Lighting Scenarios offered for further investigation and analysis

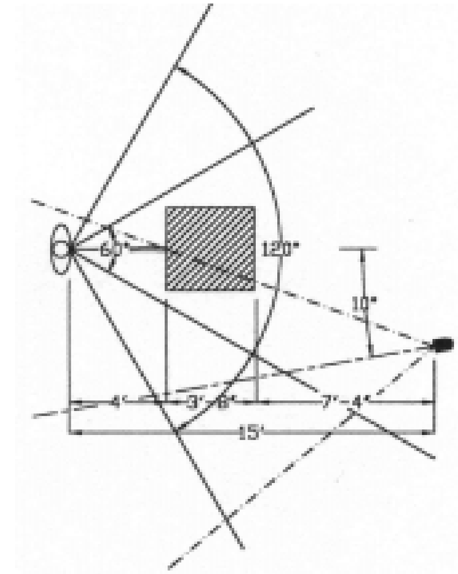


Figure 66.2- Plan Diagram of Current Layout

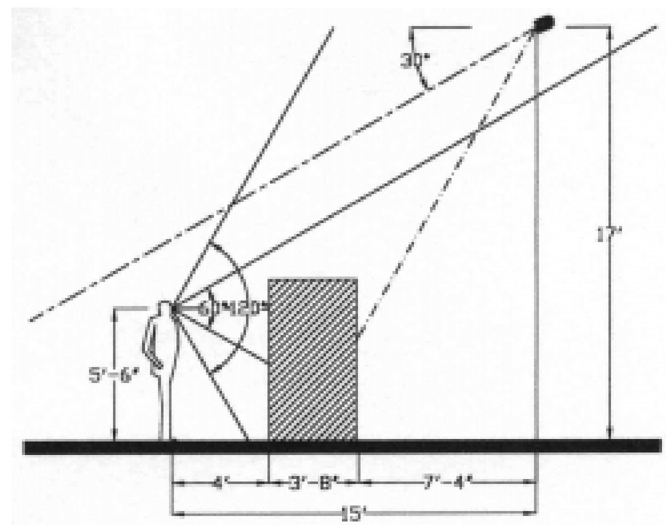
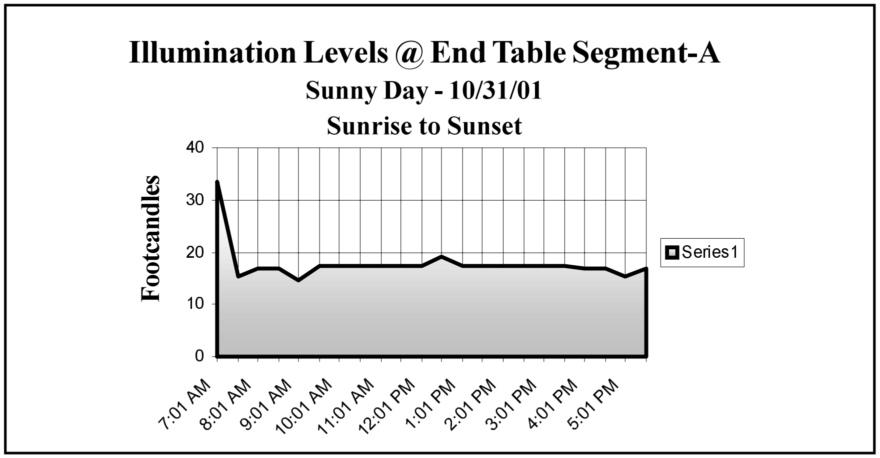


Figure 66.3- Section Diagram of Current Layout

Appendix A-2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Sunrise to Sunset
Footcandles
0
10
20
30
40
Series1
7:01 AM
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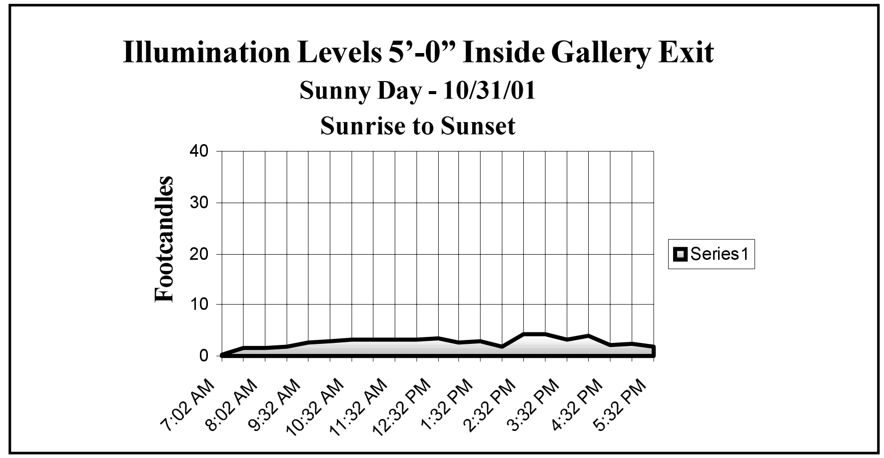
Illumination Levels 5’-0” Inside Gallery Exit
Sunny Day - 10/31/01
Sunrise to Sunset
Footcandles
0
10
20
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Series1
7:02 AM
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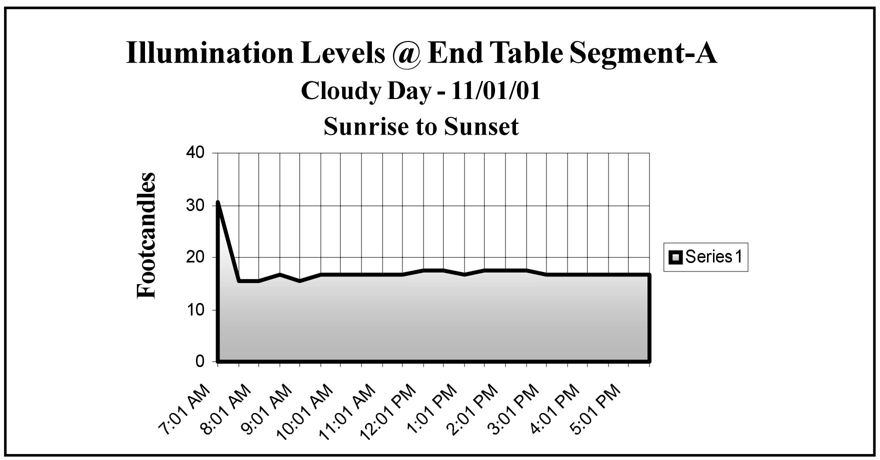
Illumination Levels @ End Table Segment-A
Cloudy Day - 11/01/01
Sunrise to Sunset
Footcandles
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10
20
30
40
Series1
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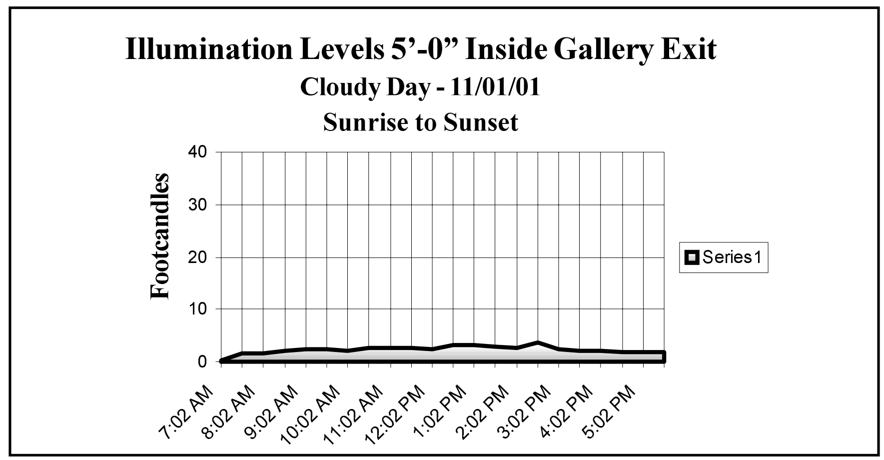
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Cloudy Day - 11/01/01
Sunrise to Sunset
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Notes