



**spertus**

יהי אור

| Institute of Jewish Studies | 610 S Michigan Ave Chicago, IL

# TECHNICAL REPORT 1

9.29.08



Consultant: Dr. Kevin Houser

**kanis glaewketgarn** | lighting/electrical | 2009 senior thesis

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Lighting/Electrical Option  
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Spertus Institute of Jewish Studies  
610 S Michigan Ave Chicago, IL  
September 29, 2008

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## Executive Summary

This report provides a detailed analysis of existing lighting design and systems of the Spertus, Institute of Jewish Studies in Chicago. The analysis focuses in four spaces that offer different tasks and purposes. Each space is broken down into three parts including existing condition, design criteria/consideration, and evaluation/critique.

Lighting design of Spertus compliments the architectural concept of the building by featuring and highlighted many design elements in the subtle way. General lighting layout designed around grid system to provide consistent appearance while maintaining quality of light. IESNA lighting design guideline and criteria were implemented to create appropriate visual performance and environment. Lighting design and systems were designed to meet ASHRAE/IESNA Standard 90.1 Energy code requirement using space-by-space method.

Although lighting design system provides quality of light in the areas studied, visual impression can be developed in many areas to create more aesthetic pleasing, dramatic, comfortable space, yet stimulate learning and working environment. Calculations show the existing design has achieved most of design recommendation provided by IESNA, there are some areas that quantity of light can be improved to enhance the overall quality of light.

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## General Building Statistics:

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Building name: **Spertus**

Location and site: **610 South Michigan Ave Chicago, IL 60605**

Building occupant name: **Institute of Jewish Studies**

Occupancy / function types: Institutional facility that includes the following space types:

- **Museum**
- **College**
- **Library**

Size: **155,000 Sq.ft.**

Number of stories above grade: **10 (total levels: 11)**

Primary projects team:

- **Owner: Spertus Institute of Jewish Studies**
- **Architects: Krueck+Sexton Architects**
- **MEP/FP & Tel/Data: Environmental Systems Design**
- **Structural Engineer: Tylk Gustafson Reckers Wilson Andrews**
- **Lighting Design: SPI Design Inc. / Schuler Shook**
- **General Contractor: W.E. O'Neil Construction Co.**
- **Theater Consultant: Schuler Shook**

Dates of construction: **September 2007 – September 2009**

Actual cost information: **\$59 million (actual construction cost)**

Project delivery method: **Design-bid-build – GPM**

## Building Façade

## Existing Conditions

### Description:

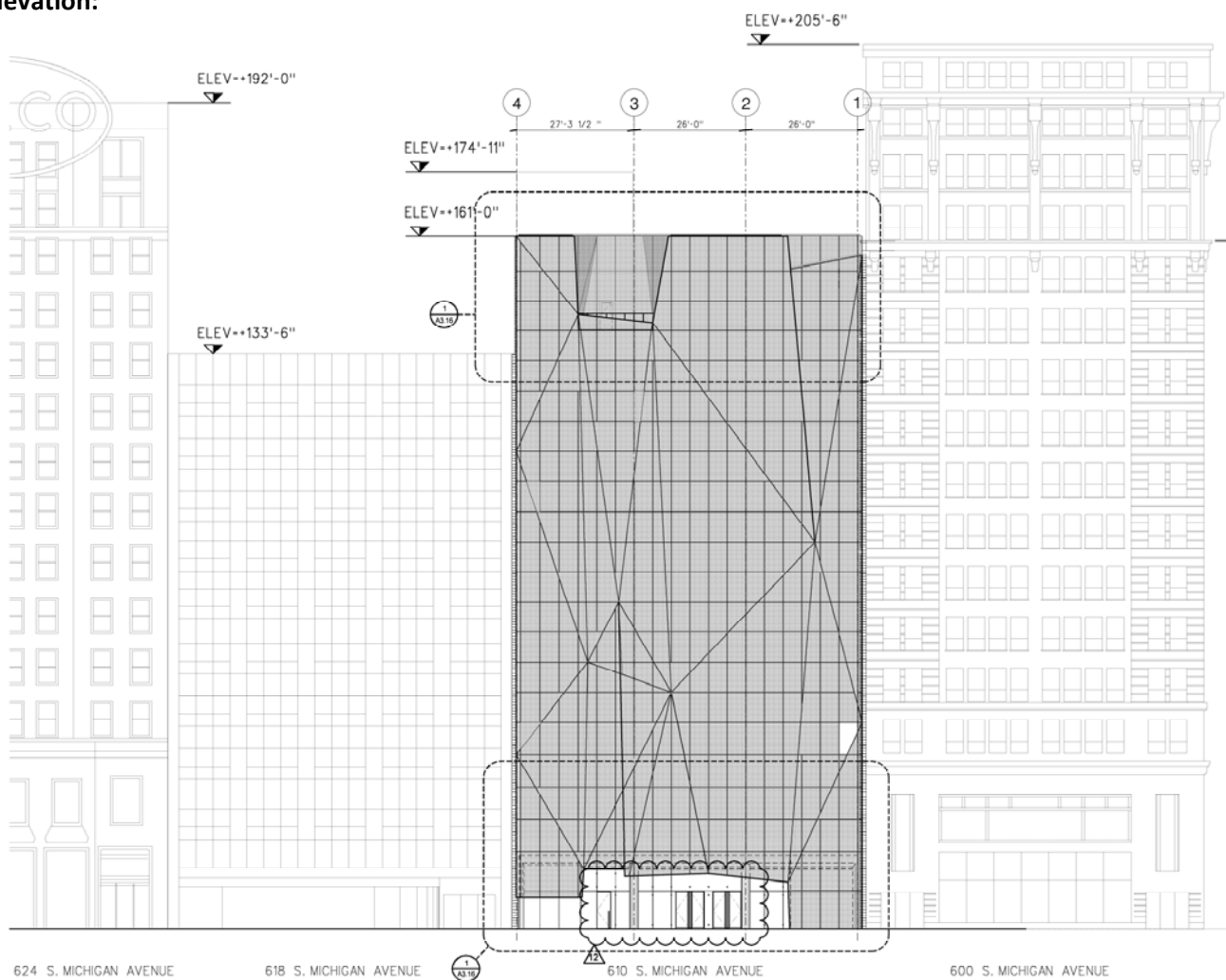
The geometry of the façade is unique because the surface is constantly tilting in three dimensions. There are a total of 720 individual pieces of 250 different shapes of laminated fritted glass assembly with a typical size of 4'-4" x 7'-0". Glass pieces are held by custom aluminum extrusion spanning 14' on floors 1 through 8 and 21' on floors 9 and 10. 1" silicone joint is used to insulate glass and keeping wind and moisture from entering the building.

**Space Category:** An outdoor space or building façade

**Area:** approx. 12,700 Sq.ft. (vertical projected area)

**Dimension:** 79'-0" x 161'-0"

### Elevation:



**Photographs:**



Spertus façade facing East



View from Michigan Ave.

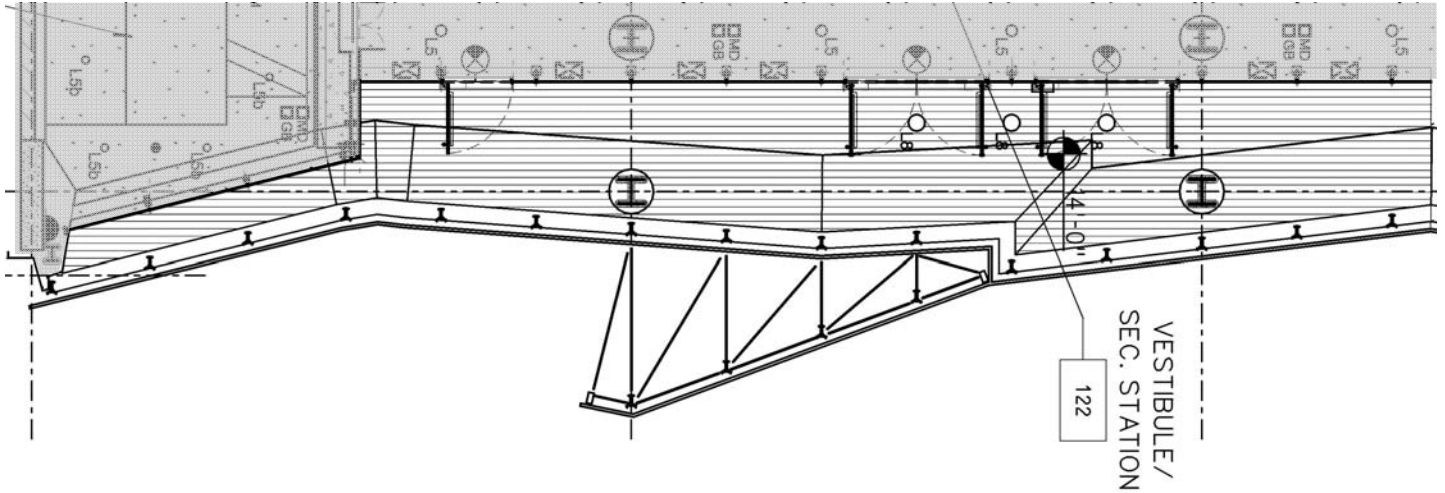
**Surface Materials:**

Surface	Material	Reflectance
Glass Façade	Interior surface of the outer lite of glass has a low-E (low emissivity) coating and a 40% ceramic frit pattern made up of 0.125" white dots.	.1
Channel Set Glazing	Aluminum extrusion frame, bright silver finish	.3
Solar Shade	NYSAN Green screen fabric with 3% light transmission	.5

**Activities/Tasks:**

- Entrance to building
- The expression of warm welcoming through the transparency of the façade.

**Reflected Ceiling Plan:**



**Lighting Equipment:**

There is currently no lighting illuminating the building facade. The appearance of the facade is somewhat transparent during night time. Interior lighting especially recessed linear fluorescent fixture (TYPE L22) and recessed low voltage downlight (TYPE L5) are visible from the outside. The only exterior lighting is recessed exterior downlight lighting (TYPE L8) at the exterior canopy below the glass facade, which provide general ambient light at the entrance of the building.

**Lighting Equipment Schedule:**

Type	Fixture Description	Mounting	Manufacturer	Catalog Number	Lamp(s)	Watts	Volt.
L8	Wet location recessed PAR30 downlight for harsh environment with nominal 8 in. aperture, trim is silver double powder coated clear specular anodized aluminum 30 degree cut-off reflector with white flange, and rated for Chicago plenum.	Ceiling Recessed	Erco	81028.023	75PAR30/CAP/SPL/FL40 lamp by Osram Sylvania	75	120

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**Building Façade****Design Consideration / Criteria**

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**Design Consideration:**

- Reinforcement of Architectural concept
  - Façade lighting should convey the concept of ‘The energy inside the building’ and the idea of ‘The animated façade that spells out what is going on inside’.
  - During the day, the glass façade refracts and reflects the image of the clouds moving across the sky. The idea of dynamic and movement of light is also very important in this design. Lighting can be used to mimic this natural effect during night time.
- Reinforcement of Architecture Features
  - The dynamic glass façade that compels the folding and movement of materials is the most important design element of the Spertus building.
  - Such design element should be emphasized during nighttime using lighting as a tool.
- Color Dynamics
  - The idea of the energy inside the building can be conveyed through shades of color
  - The perception of color is related to individual psychological interpretation. Most of them are commonly interpreted. That means colors can be used to express emotional feeling and relate people to this piece of art. For example, colors can be used for seasonal expression.
  - To emphasize dynamic apparent of the glass façade, the use of color could be implement to reinforce architectural feature.
- Constructability
  - The shape of glass façade is irregular and asymmetric. Depending on the design and location of fixtures, constructability may be an issue and may dictate many locations of the fixtures.
  - Small linear fixture may be appropriated for easy fitting or recessing.
- Glare Issue
  - Depending on the orientation and location of the façade lighting, direct glare could potentially be a problem for both building occupants and people on the street.
  - Smaller light source can be utilized to reduce discomfort glare.
- Glass Transmittance/ Opaqueness/ Material Properties
  - In order to make glowing effect, it requires surface with some reflectance or level of opaqueness to interact with light.
  - This may be an issue because frosted or opaque glass may minimize the outside views from the interior spaces.
  - Fritted glass with certain percentage of fritted dots maybe a good compromise for viewing and façade lighting purpose.



- Energy Considerations
  - Energy Code Requirements – ASHRAE 90.1-2004 – Lighting Power Densities for Building Exteriors
    - **1.25w/sq ft.** for attached canopies and overhangs
    - Exterior Building Grounds Lighting – All exterior building grounds luminaires that operate at greater than 100watts shall contain lamps having minimum efficacy of 60lm/w unless the luminaire is controlled by a motion sensor.
- Exterior lighting (below glass façade)
  - Visual Environment
    - Welcoming mat should be created by lighting to anchor the building and invite people into the building.
    - The area is right in front of the vestibule. It should act as a transitional space before people enter the building. (illuminance levels gradually increase as progressing inside the building)
  - Visual Performance
    - **5 fc** on Horizontal workplane (ground) (Active pedestrian/conveyance – Entrances – Building Exteriors – IESNA Lighting design guide)
    - **3 fc** on Vertical surfaces (Active pedestrian/conveyance – Entrances – Building Exteriors – IESNA Lighting design guide)

## Building Façade

## Evaluation and Critique

There is currently no façade lighting except the exterior lighting underneath the glass canopy. There are three fixtures recessed right above the entrance. Perhaps there should be more fixtures that would provide general ambient in this area. However the entrance should have the highest light level to define the hierarchy of the entry. The current fixture utilize halogen PAR30 light source. Although halogen sources offer good color rendering and good directional distribution for entry, other light source that offers higher efficacy could be employed to save some energy while maintaining quality of light. Metal Halide sources have higher efficacy than halogen sources and have color rendering index in the range of 80-90, which is slightly lower than halogen sources. The current light level at the entry below the canopy is average of 4.53 fc (data provided by ISP Design Inc.) which is very close to IESNA recommended value for Active pedestrian/conveyance Entrances for Building Exteriors.

The glass canopy extended from the façade is an interesting architectural design element that should be highlighted (refer image1 below). Perhaps in-grade up light could be used to not only provide ambient to this area, but also illuminate the underside of the canopy.

During the night time the crinkled dynamic glass façade loses its three-dimensional perception. A higher illuminance level from the interior spaces make the façade seems transparent. The appearance of linear light fixtures and recessed halogen downlights are visible consistently for many levels.



Image 1 – Building Entry and Canopy

**Foyer / Elevator Lobby**

**Existing Conditions**

**Description:**

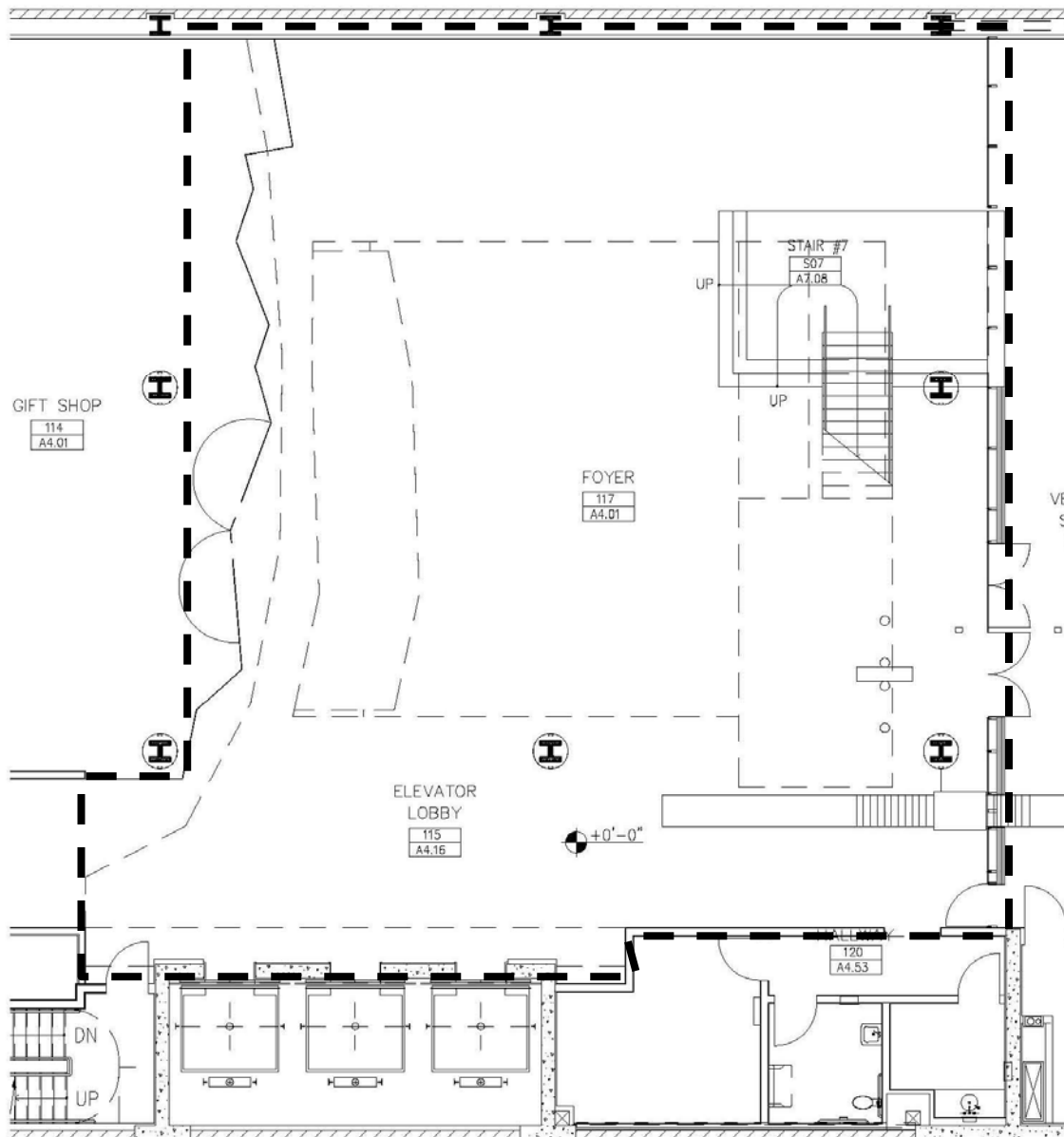
A magnificent atrium extends three-stories, with a unique sculptural wall treatment echoing the facets of the building's glass front. A grand glass and terrazzo staircase extends down from the Spertus Café and the Feinberg Theater.

**Requirement met:** A circulation space

**Area:** 3400 Sq.ft. (projected area)

**Dimension:** Approx 56'-0" x 64'-0"

**Plan:**



— — — Proposed Space

**Photographs:**



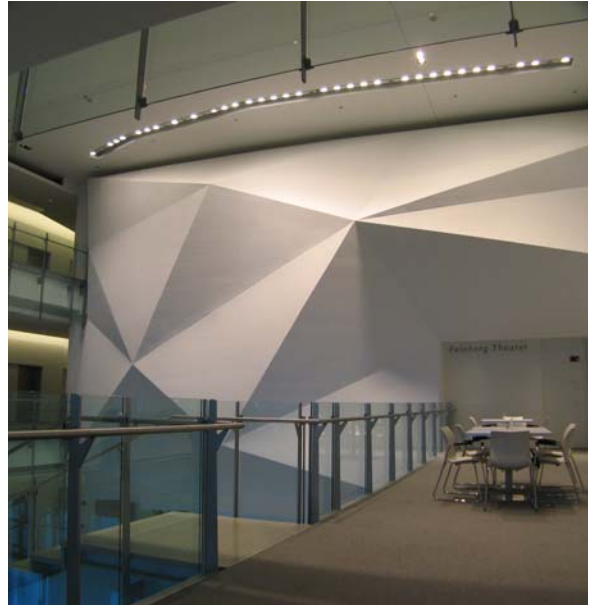
Looking to entry and visitor services desk



Looking from 2<sup>nd</sup> floor mezzanine



Looking to elevator lobby



Looking to sculptural wall

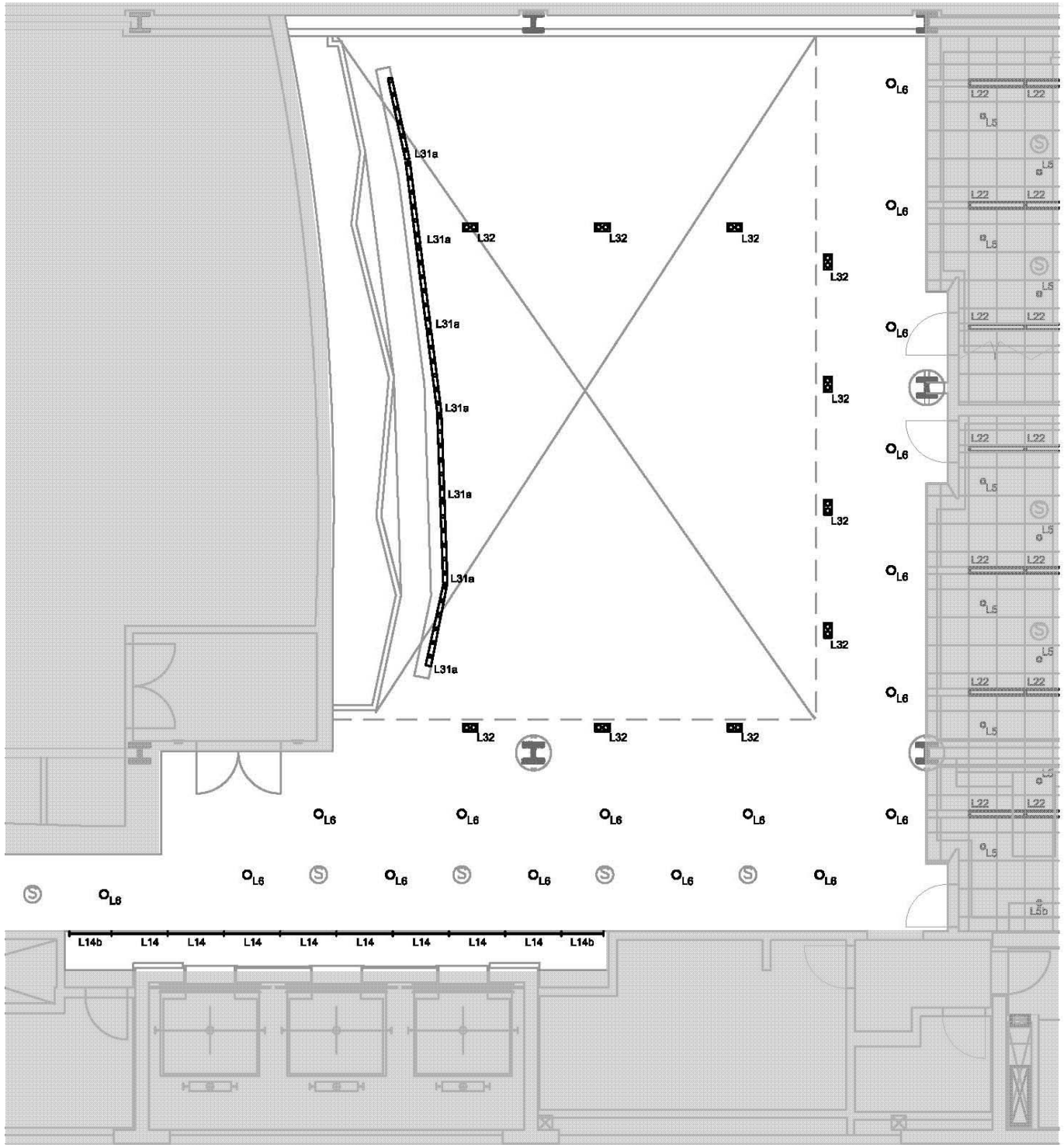
**Surface Materials:**

Surface	Material	Reflectance
Floor	Concrete slab	.3
Ceiling	White painted gypsum wall board	.8
Wall	White painted gypsum wall board	.7
Sculpture Wall	White painted gypsum wall board	.7
Stairs (Railing)	Clear glass railing	n/a
Stairs (Steps/Platform)	Terrazzo, light gray finish with glass railing	.3

**Activities/Tasks:**

- Visitor services desk
- Congregation
- Circulation ( to elevators, stairs, gift shop, and theater)
- Private events
- Wall of names of supporters

**Reflected Ceiling Plan: (3<sup>rd</sup> floor RCP)**



**Lighting Equipment:**

- General ambient light in the atrium space is provided by series of 2-head recessed Metal Halide adjustable fixture. In the elevator lobby area, there is an architectural cove with Fluorescent strips on level one to three in front of the elevator wall. General ambient light in the elevator lobby area is provided by recessed compact fluorescent downlight. The sculpture wall is illuminated by series of 7-lamp Metal Halide recessed adjustable fixture.

**Lighting Equipment Schedule:**

Type	Fixture Description	Mounting	Manufacturer	Catalog Number	Lamp(s)	Watts	Volt.
L2	Low voltage floor recessed ingrade uplight. Fixture is constructed die-cast anodized aluminum with powder coated paint finish. The top plate is stainless steel with tempered glass.	Recessed Floor	Louis Poulsen	WEEBEE-1/20W/MR11 GU4-12V-ST.STEEL-FROSTED STRAIGHT	20MR11/SP10(FTB) lamp by Osram Sylvania	20	120
	a Frosted		Louis Poulsen	Frosted			
	b Straight		Louis Poulsen	Straight			
L5	Halogen MR16 low voltage downlight with nominal 4 in. aperture, clear specular Alzak reflector with white flange, integral magnetic transformer, and rated for Chicago plenum.	Ceiling Floor	Portfolio	HA3MRCP-DR50-3450-HB26-L110N	50MR16/IR/FL40/C lamp by Osram Sylvania	50	120
L5b	Halogen MR16 low voltage adjustable downlight with nominal 4 in. aperture, clear specular Alzak reflector with white flange, integral magnetic transformer, and rated for Chicago plenum.	Ceiling Floor	Portfolio	HA3MRCP-DR50-3470-HB26-L110N	50MR16/IR/FL40/C lamp by Osram Sylvania	50	120
L14	Linear fluorescent T8 strip with nominal 4 ft. length, one (1) lamp in cross section, and integral electronic ballast	Surface In cove	Metalux	SN-132-UNV-EB81	FO32/830/XP/ECO lamp by Osram Sylvania	32	120-277
L14b	Linear fluorescent T8 strip with nominal 3 ft. length, one (1) lamp in cross section, and integral electronic ballast	Surface In cove	Metalux	SN-125-UNV-EB81	FO17/830/XP/ECO lamp by Osram Sylvania	25	120-277
L31	Ceramic metal halide PAR30 borderstrip with lamp sockets and integral, accessible, electronic ballasts mounted at 12 in. centers, two circuits to separately switch alternate lamps, positive locking for tilt, 36 in. long white cord, and white finish for fixture and trunion	Surface Cove	TIMES SQUARE	LB70-xxx-W-MOD (two circuits to switch alternating lamps separately)	MCP70/PAR30LN/U/830/SP lamp by Osram Sylvania	70	120
	a Trunion set		TIMES SQUARE	SBB			
	b Asymmetric spread lens with 5° by 55° distribution		TIMES SQUARE	GF16-600			
L32	Ceramic metal halide accent light with two (2) adjustable PAR30 lamps, individual integral electronic ballasts, positive locking in both tilt and rotation, minimum of 360° rotation and 45° tilt for each lamp, interior finish in black, flangeless plaster trim, aperture of 14 in. by 6.5 in. and rated for Chicago Plenum	Recessed Ceiling	RSA	CO320MHTR-BK-70-YK-xxx-CP	MCP70/PAR30LN/U/830/SP lamp by Osram Sylvania	70	120
	a Accessory holder with black finish		RSA	COAR30-B			
	b Glare snoot with black finish		RSA	SNP30-B			
	c Soft focus lens		RSA	LN31COAR			

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**Foyer / Elevator Lobby****Design Consideration / Criteria**

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**IESNA Lighting Design Guide**

- **Office – Lobby, Lounge, and Reception Area**

**Appearance of Space and Luminaires**

- According to IESNA design guide, this topic is a very important issue. The interior architecture of the space speaks for itself through clean lines and the use of modern materials including glass, metal, and terrazzo floor. Although the sculpture wall, which is a focal point of the space, has a very interesting geometrical form, it is painted with a very neutral white finish. The appearance of the luminaires should implement the interior architecture by being simple and not interrupting the focal point of the space.

**Color Appearance (and color contrast)**

- Color Appearance is an important design issue (IESNA). Color appearance of the space should provide warm and welcoming atmosphere. Color correlated temperature should be around 3500 K to provide somewhat warm to neutral color appearance. Good color rendering light source should be implemented to compliment people skin tones. Since all the material surfaces other than glass railing are painted in white, the use of color light should be considered to create visual interest and flexibility for private events that may occur in the space.

**Daylight integration and control**

- The daylight integration issue is somewhat important in this space (IESNA). Although the space is not directly adjacent to the exterior curtain wall, there is some daylight contribution from level one and two. Since the façade is east facing, the space may gained some direct sunlight penetration in the morning depending on time of year. Photocensor and dimming control system may be useful to help adjust light output accordingly.

**Direct Glare**

- Direct glare from the light sources and luminaires is an important issue in this space (IESNA) because it can potentially causes discomfort glare. In order to reduce direct glare from a single high intensity light source, multiple smaller light source that provide less light intensity should be substituted. To reduce direct glare from the luminaire, comfort diffused reflector and glare shield should be specified.

**Light Distribution on Surfaces**

- In order to illuminate the sculpture wall while maintaining its three dimensional appearance, faces adjacent to one another should have different luminance level to create higher contrast level. The faces that are lit should be uniformly illuminated to enhance the contour lines of the sculpture.
- Since all wall surfaces are painted in white, unwanted beam distributions or patterns are noticeable if not properly aimed or located.

#### Light Distribution on Task Plane (Uniformity)

- The task plane of the space is the floor of the main lobby or atrium. Lighting level on these areas should be fairly uniform to avoid hot spots or distract people's attention from the architecture features of the space. Light level on terrazzo steps should also be fairly uniform, and perhaps higher light level in this area to emphasize and highlight the stairs.

#### Luminances of Room Surfaces

- Luminances of room surfaces are important to create visual hierarchy in the space. Although the sculpture wall is the focal point of the space and required to produce higher luminance level, the north wall of the space should be illuminated as well. Luminance level on north wall does not only create a scene of spaciousness, but also define the perimeter of the space.

#### Modeling of Faces and Objects

- Facial modeling is an important issue (IESNA) because of activities conducted in the space. To provide good facial modeling, it requires a combination of key light and fill light (direct and indirect components light). Since all the wall surfaces are white, reflected light may be bouncing off these surfaces as fill light. Good color rendering light sources should be specified to compliment people skin tones.

#### Points of Interest

- Point of Interest should be highlighted by lighting to create a focal point of the space and also to prevent boredom. The sculpture wall must be illuminated with highest luminance level.
- The other point of interest in this space is Spertus logo behind the information desk. These sign should be uniformly illuminated. They also act as a backdrop for people in front of them.

#### Shadows

- As mentioned before, in order to create three-dimensional look for the sculpture. Different luminance levels on adjacent surfaces should be appearance. In this particular case, if the sculpture is lit from above, soft shadows are created automatically because surfaces are not on the same plane.

#### Surface Characteristics

- All wall surfaces are gypsum wall board painted in white eggshell finish. Due to its high reflectance property of selected paint, high luminance level can be easily achieved. The space may seem brighter than it actually is.

#### System Control and Flexibility

- Flexibility in control system is not critical in this space because it is mainly used for lobby and circulation. The space occasionally used for private social events; thus, control system should allow some level of flexibility.



### Special Considerations

- Task light should be provided for the visitor service desk for adequate light level for reading and writing.
- Energy consideration is important because the space is the main circulation of the building. Efficient light source that has high efficacy like Metal Halide should be considered.
- Long lamp life is also an important issue from maintenance perspective for such a high ceiling space.
- The elevator lobby is opened up to the atrium and can be seen from all levels. Lighting in this area should provide directional circulation especially in vertical direction.

### Energy Considerations

- Energy Code Requirements – ASHRAE 90.1-2004 – Space by space method
  - **1.3w/sq ft.** for lobby

### Illuminance (Horizontal)

- 10 fc (IESNA Offices – Lobby, lounges, and reception areas)

### Illuminance (Vertical)

- 3 fc (IESNA Offices – Lobby, lounges, and reception areas)

## Foyer / Elevator Lobby

## Evaluation and Critique

In general, lighting system of the lobby offers warm and welcoming atmosphere to the space by providing adequate light levels and featuring many architectural features.. The sculpture wall was highlighted as a focal point of the space. The top faces of the terrazzo stairs were also highlighted to provide the sense of movement and circulation. The elevator walls on level one to three were grazed by light to indicate the vertical circulation of the building. Refer to table 1 for light level summary prepared by ISP Design Inc.

**Table 1 – Photometric results compiled by ISP Design Inc.**

Room Description	IESNA Recc. Level	Avg	Max/Min
Elevator Lobby	10	19.7	7.69
Foyer (atrium)	10	20.64	26.07

Metal Halide adjustable recessed fixtures were specified to provide general ambient in the space. It worked well in such high ceiling because Metal Halide offers high luminance intensity. It also allowed for minimal number of fixture and a clean layout.

The sculpture wall was well illuminated. The irregular line of light that follows the contour line of the sculpture allowed maximum light intensity to reach top faces of the sculpture. Three-dimensional modeling was created by differences in luminance level between top and bottom faces. A minor comment from the site visit was that many lamps were burnt out creating visual disorder on the ceiling (refer to image 1).



Image 1 – Fixture TYPE L31 and Sculpture wall

A minor detailing issue I found during the site visit (Aug 11, 2008) was the conflict of linear fluorescent strip in the architectural cove at the elevator lobby (refer to image 2). The cove was designed and constructed with no lip to prevent direct light from spilling to wall surfaces. Thus a sharp cutoff ray of light was created (refer to image 3) resulting in an imperfection of light effect on both the elevator wall and the side walls. Another reason could be the distance from the cove to the wall was too large.

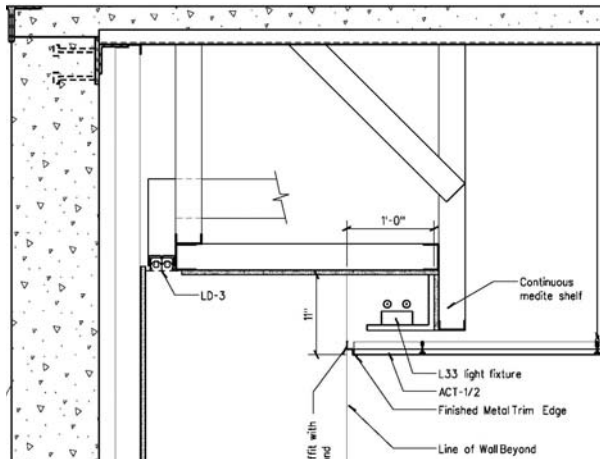


Image 2 – Elevator cove detail



Image 3 – Spill light from Elevator cove

Fixture TYPE L5 is recessed halogen downlight with 50 watts MR16 in it. They are located at the same location as fixture TYPE L6 but on the first and second level. When I was in the space during the day, I felt these fixtures were not contributing much at all comparing to daylight contribution. It was such a waste of energy to keep them on all day. Perhaps, compact fluorescent downlight (TYPE L6) with dimming ballast could replace fixture TYPE L5 to save energy and better match the color temperature of daylight contribution.

## Feinberg Theater

## Existing Conditions

### Description:

Feinberg Theater is specially designed for lectures, live performances, and film, with a proscenium stage, viewer-friendly tiered seating, a wrap-around mezzanine and balcony, and state-of-the-art acoustics. It can seat up to 400 people. Possible breadth topic for this space is a study of acoustics system.

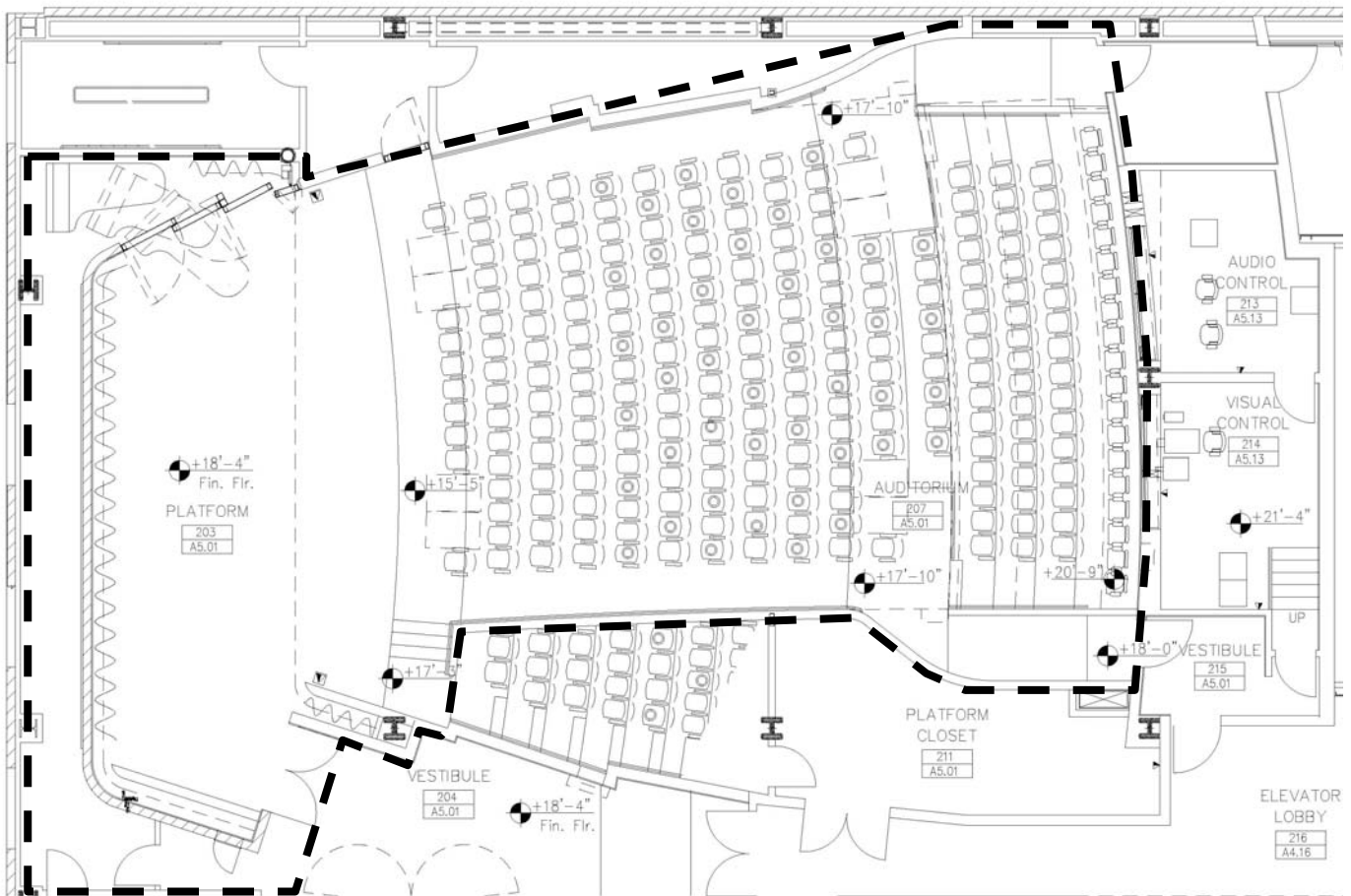
**Requirement met:** A special purpose space

**Area:** approx. 4,700 Sq.ft. (total of both levels)

**Dimension:** Approx 58'-0" x 82'-0"

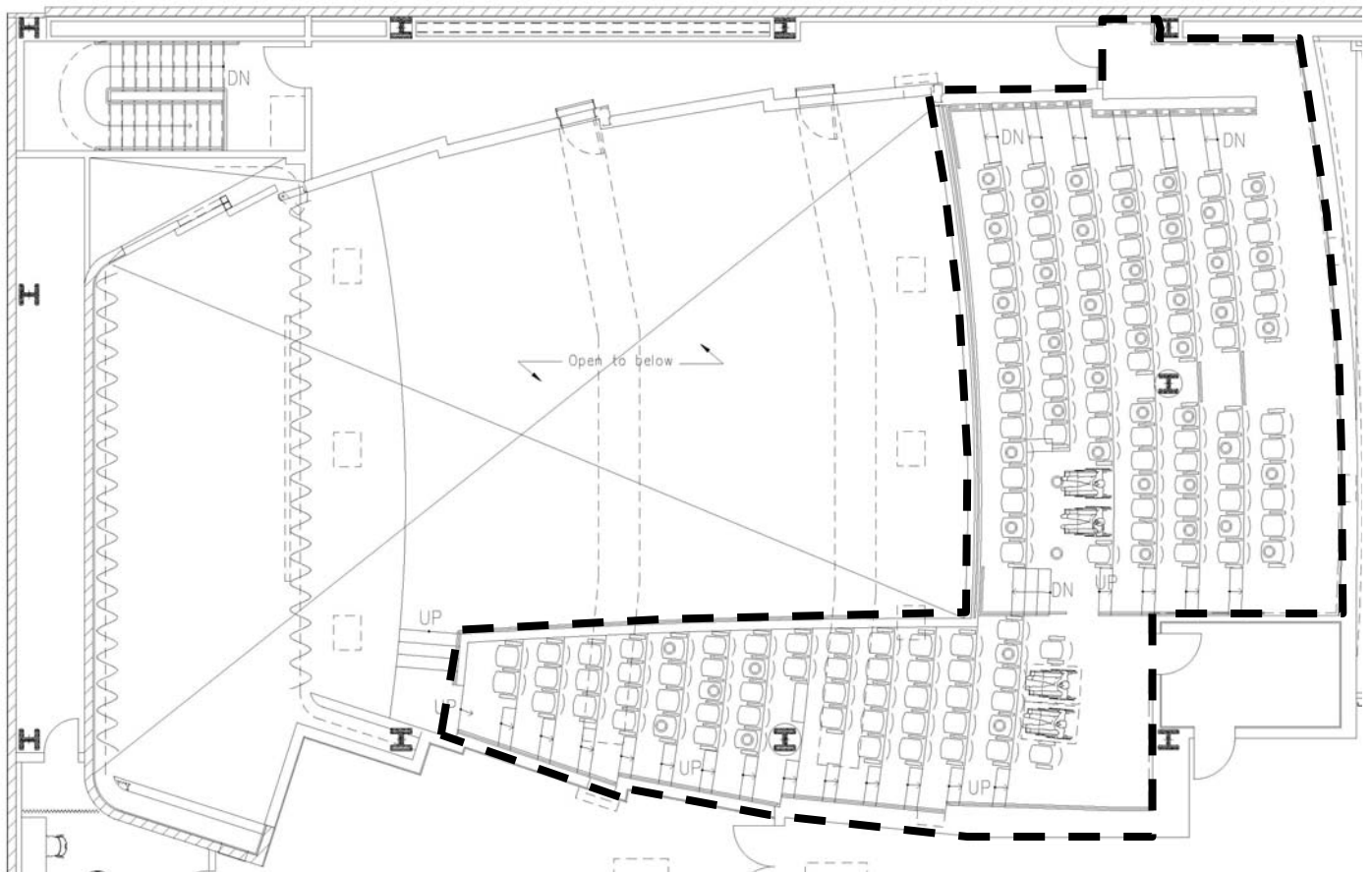
### Plan:

Main level



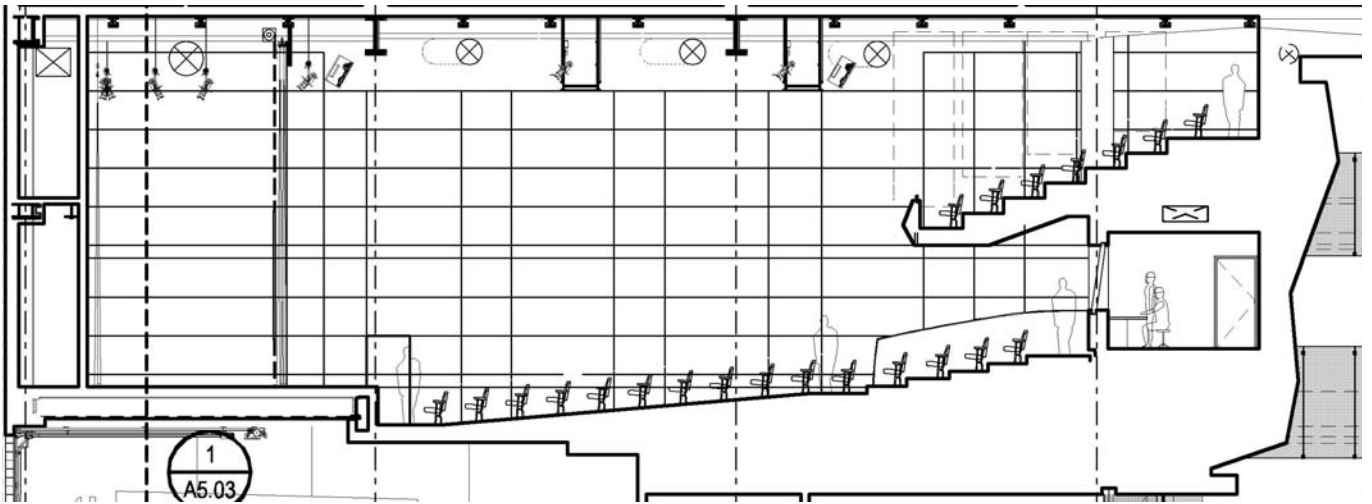
--- Proposed Space

Balcony level



--- Proposed Space

Section:



**Photograph:**

View from the stage

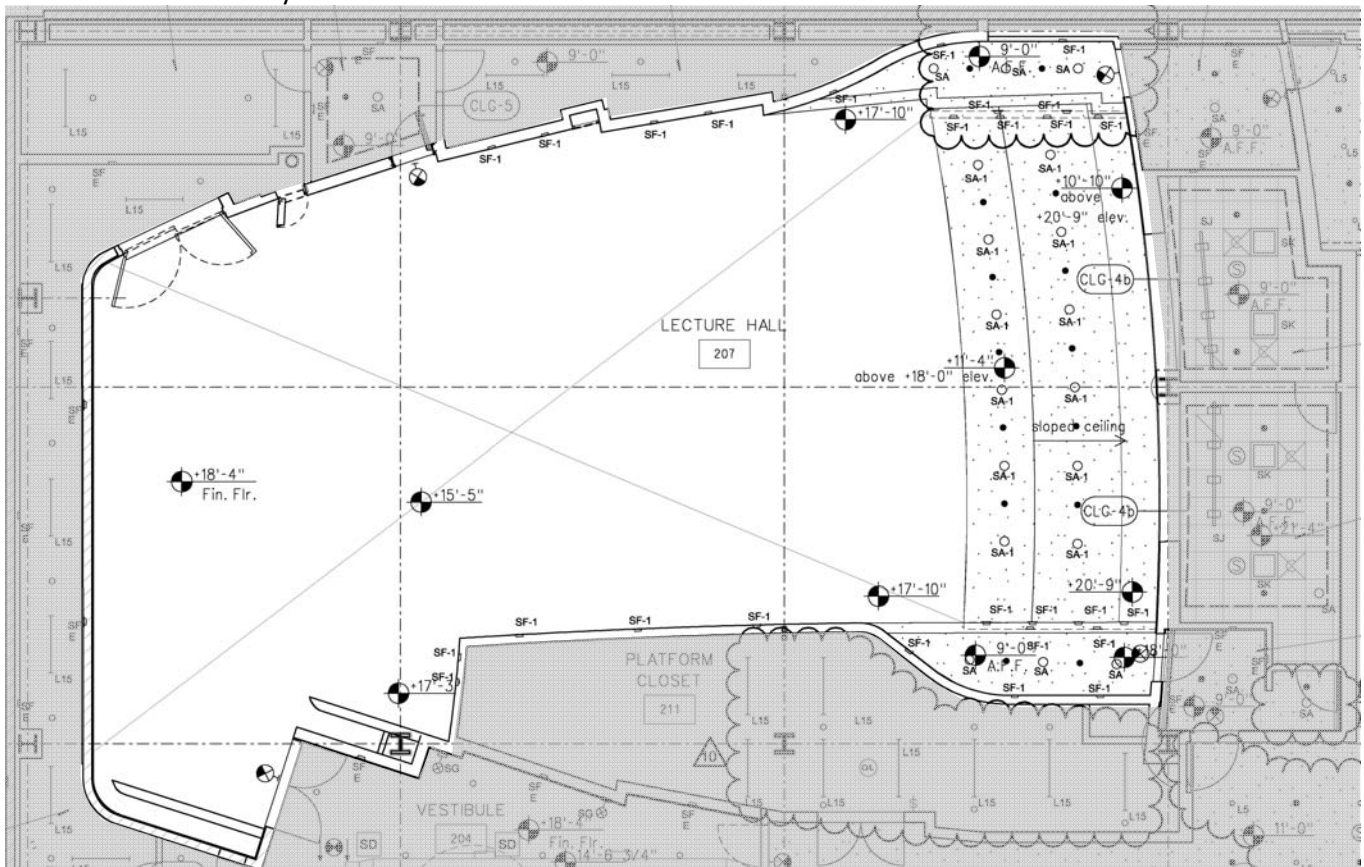
**Materials:**

Surface	Material	Reflectance
<b>Floor</b>	Carpet Broadloom, color Dove Gray	.4
<b>Stage Floor</b>	Resilient wood floor assembly (Northern hard maple tongue and groove flooring)	.4
<b>Ceiling</b>	Exposed Ceiling	.6
<b>Wall (side wall, front portion)</b>	Grey painted gypsum wall board	.5
<b>Acoustic Wall (side wall, rear portion)</b>	Medium density fiberboard with perforated 5/8" fire retardant treated MDF	.5
<b>Acoustic Wall (back wall)</b>	1" thick fiberglass panels	.5
<b>Stage Curtain (side)</b>	Dark red curtain	.3
<b>Stage Curtain (back)</b>	Medium Gray curtain	.4
<b>Seating</b>	Yellow (Ochre) fabric with light colored natural wood back	.7

**Activities/Tasks:**

- Lectures
- Live performances
- Films

**Reflected Ceiling Plan:**  
RCP underneath balcony



**Auditorium RCP**



**Lighting Equipment:**

General ambient light is provided by house lighting system which consists of Halogen Source Four PAR fixture (TYPE SC) and recessed incandescent downlight (TYPE SA) for area underneath the balcony. Fixture TYPE SC offers different beam distributions (TYPE SC – medium floor distribution, TYPE SC-1 – extra wide flood distribution, and TYPE SC-2 – narrow spot distribution) depending on the distance from the luminaire to the workplane. Fixture Halogen steplight located along the perimeter of the auditorium to illuminate walk way and steps to the balcony level. Stage lighting consists of two systems which are front lighting and top lighting. Halogen Source Four 36° ellipsoidal fixture (TYPE SL) pipe mounted along the cat walk serves as front lighting. Top lighting consists of Halogen Source Four PAR fixture (TYPE SC) and Ceramic Metal Halide surface mounted floodlight luminaire.

**Lighting Equipment Schedule:**

Type	Fixture Description	Mounting	Manufacturer	Catalog Number	Lamp(s)	Watts	Volt.
SA	Incandescent A lamp downlight with nominal 4 in. aperture, clear semi specular Alzak reflector with white flange, and rated for Chicago plenum	Recessed Ceiling	Portfolio	HD6-6701-LI	100A A-19 IF	100	120
SA-1	Incandescent A lamp downlight with nominal 4 in. aperture, clear semi specular Alzak reflector with white flange, and rated for Chicago plenum	Recessed Ceiling	Kramer Lighting	KL6200A21-XF-SCA	150W A-21 IF	150	120
SC SC-1/2	Halogen Source Four PAR fixture with four heat resistant, molded borosilicate glass lens, cold mirror reflector, and finish in black	Unistrut Pipe Monopoint Canopy	ETC	PAR-MCM	HPL-575/115X	575	120
	a Safety Cable		ETC	400SC			
	b Grounded, 20 amp, twistlock connector		ETC	C			
	c Color Frame		ETC	407CF			
	d C-Clamp		The Light Source	MABS			
SF	Halogen steplight with 9 in. x 2 in. rectangular aluminum faceplate in black finish and horizontal louvers.	Recessed Wall	FC Lighting	FCSL106-120V-9PL-E-CC-SLH	9W PL	9	120
SF-1	Halogen steplight with 9 in. x 2 in. rectangular aluminum faceplate in black finish and horizontal louvers.	Recessed Wall	FC Lighting	FCSL106-120V-25W-T10-CC-SLH	25W T10	25	120
SG	Compact fluorescent "jelly jar" fixture with grey thermoplastic housing with guard, low glare clear prismatic globe standard, wall mount canopy, and integral electronic ballast	Surface Wall	Stonco	VVXL32-HFL	28 PL/SPX 27	28	120
SH	Ceramic metal halide surface mounted floodlight luminaire with intergral electronic ballast.	Surface Ceiling	Times Square	MC420-PC9M-SC-B	CDM70/TD/830	70	120
SL	Halogen Source Four 36° ellipsoidal with cold mirror reflector, and finish in black	Unistrut Pipe Monopoint Canopy	ETC	S4 - 436-B	HPL-575/115X	575	115
	a Safety Cable		ETC	400SC			
	b Grounded, 20 amp, twistlock connector		ETC	C			
	c Color Frame		ETC	407CF			
	d C-Clamp		The Light Source	MABS			
SL-1	Halogen Source Four PAR fixture with 36° medium flood lens, cold mirror reflector, and finish in black	Unistrut Pipe Monopoint Canopy	ETC	S4 - 450-B	HPL-575/115X	575	115
	a Safety Cable		ETC	400SC			
	b Grounded, 20 amp, twistlock connector		ETC	C			
	c Color Frame		ETC	407CF			
	d Safety Cable		ETC	400SC			
	e C-Clamp		The Light Source	MABS			
SL-2	Halogen Source Four PAR fixture with 36° medium flood lens, cold mirror reflector, and finish in black	Unistrut Pipe Monopoint Canopy	ETC	S4 - 426-B	HPL-575/115X	575	115
	a Safety Cable		ETC	400SC			
	b Grounded, 20 amp, twistlock connector		ETC	C			
	c Color Frame		ETC	407CF			
	d Safety Cable		ETC	400SC			
	e C-Clamp		The Light Source	MABS			
L15	Linear fluorescent T8 strip with nominal 4 ft. length, one (1) lamp in cross section, and integral electronic ballast	Chain Hung	Metalux	SN-232-UNV-EB81	FO32/830/XP/ECO lamp by Osram Sylvania	32	120
	a Chain Hung		Metalux	AYC-CHAIN/SET-U			



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**Feinberg Theater****Design Consideration / Criteria**

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**Appearance of Space and Luminaires**

- Since the ceiling is exposed and

**Color Appearance (and color contrast)**

- Color Appearance is an important design issue. Good color rendering light source should be implemented to compliment people skin tones for house lighting. Color correlation temperature should be warm to neutral (3000-3500 K) to complement with golden yellow color of seating fabric.

**Direct Glare**

- Direct glare from light sources is an important design issue in a theater space. Direct glare does not only create discomfort glare, but also can distract the audience's attention. To reduce direct glare from the luminaire, comfort diffused reflector and glare shield should be specified especially for steplight.

**Light Distribution on Task Plane (Uniformity)**

- Task plane for house lighting is seating area. The seating area should have diffuse, uniform, and comfortable illumination.
- Luminaire should provide medium - wide distribution to provide uniform lighting and avoid hot spots depending on the mounting height.

**Luminances of Room Surfaces**

- Although the focal point of the space is the stage, side walls should be uniformly illuminated to define the perimeter and promote the scene of spaciousness.

**Modeling of Faces and Objects**

- Facial modeling is particularly important for the performer or speaker on the stage. Good modeling of faces can be done by providing lighting from multiple directions.

**Points of Interest**

- The focal point of this space is the stage. Curtains around and behind the stage can be created as a point of interest.

**Shadows**

- Shadows on performers should be avoided by providing key light from different angles and locations.

**System Control and Flexibility**

- The general house lighting should be under dimmer control, preferably from several stations, such as the stage lighting control board, the projection booth, and the staff entrance. There should be transfer capabilities, however, so that the lighting is not accidentally turned on during performances (IESNA Ch.15-8).
- Selected lighting system circuits may be dedicated for cleaning and rehearsals.
- "Panic" switches independent of dimmers and switches should be provided to allow an operator to bring on selected lights on the house in case of emergency (IESNA Ch.15-8).

### Special Considerations

- Foyer area (IESNA Ch.15-8)
  - Restful, subdued atmosphere is desirable.
  - Wall lighting and accents on statuary, paintings, posters, and plants are important in developing atmosphere.
  - Lighting must not spill into the auditorium
  - Before and after performances, the following levels are recommended:
    - 5 fc for motion picture theater
    - 15 fc for live production theatres
    - Since this particular theatre will be used for both purposes, 10 fc should be provided to compromise the differences.
- Seating area (IESNA Ch.15-8)
  - Diffuse, comfortable illumination is desirable.
- Stage Lighting (IESNA Ch.15-9)
  - Intensity of light
    - Precise, consistent dimmer control is essential for establishing and maintaining various intensity levels.
    - Vertical illuminances of 200 fc or higher are required to highlight selected performances.
  - Distribution of light
    - Stage lighting calls for wide variety of luminaire types and mounting positions.
    - Luminance ratios on the stage should not exceed 100:1
  - Color
    - Color is used to accent, enhance, distort, and motivate the scene.
    - Color should be controlled means of lamp selection, dimmers, and filters.
    - A tonal quality can be obtained by the additive mixture of two or more sources
    - Color rendering index used in stage lighting should not be less than 80.
  - Lighting location
    - Two basic locations are:
      - In front of the proscenium opening, including the auditorium ceiling and side walls.
      - Behind the proscenium opening, including pipes for attaching tormentor (side) lights, overhead cyclorama or top lights
    - A typical multipurpose stage can be divided into smaller lighting areas (10-12 ft. in diameter). In this particular theater, we have approximate 40'x20' stage. Therefore, we can have two rows of four lighting areas, for a total of 8 lighting areas. Each lighting area should have four sets of luminaires

### Lamp maintenance consideration

- Location of luminaires has to be accessible for the purpose of lamp replacement
- Long lamp life should be specified

#### Energy Consideration

- Energy Code Requirements – ASHRAE 90.1-2004 – Space by space method
  - **2.6w/sq ft.** for audience/seating area in performing arts theater

#### Illuminance (Horizontal)

- Seating area: 10-20 fc when performances are not taking place (IESNA recommendation – Ch.15-8)
- 30 fc (IESNA Reading – Handwritten tasks - #2 pencil and softer leads)
- Although IESNA design guide recommends 10-20 fc on horizontal workplane for theater seating areas, 30fc should be able to achieve by the system to provide adequate light level for reading and writing.

#### Illuminance (Vertical)

- 3 fc (IESNA Offices – Lobby, lounges, and reception areas)

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**Feinberg Theater****Evaluation and Critique**

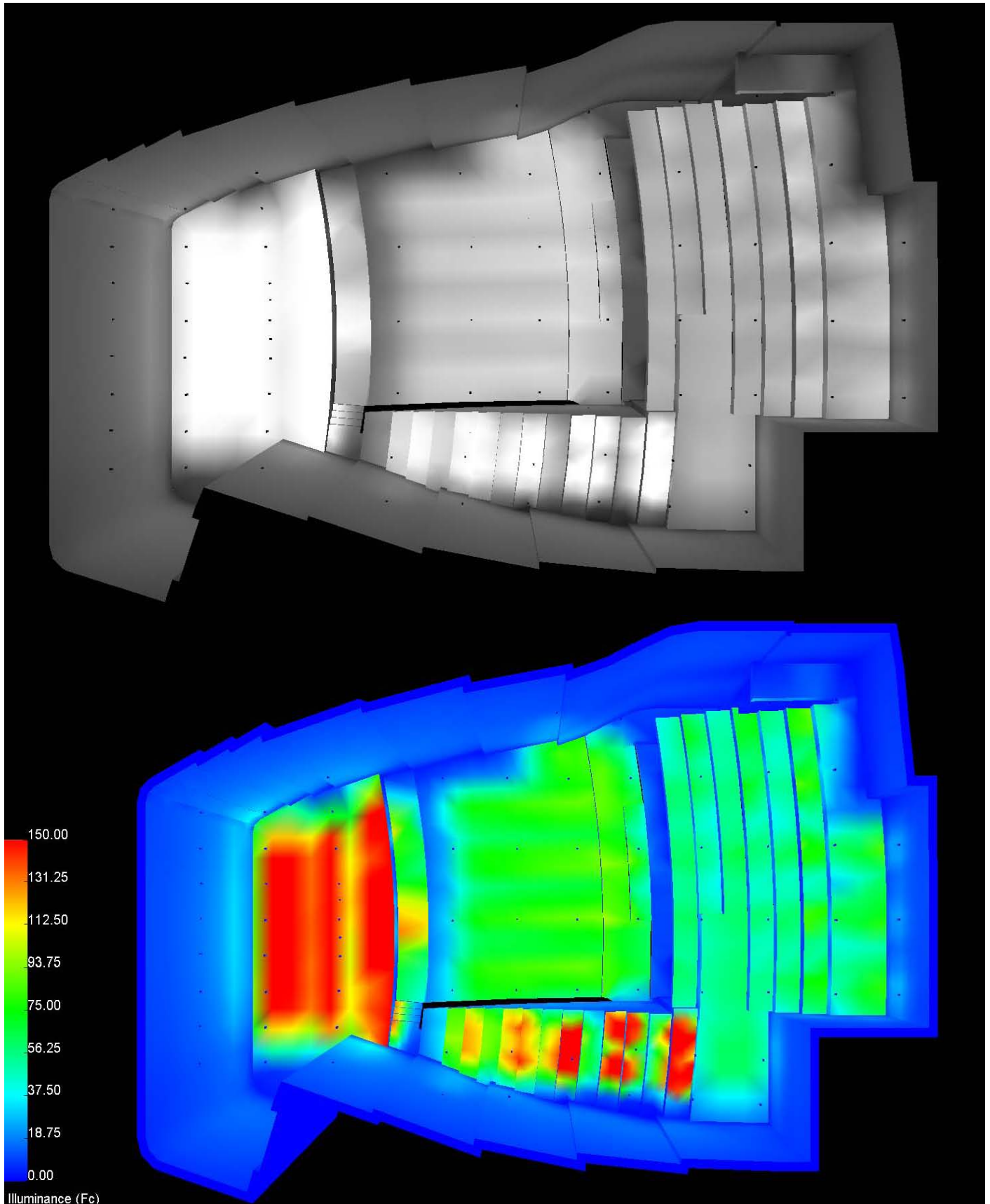
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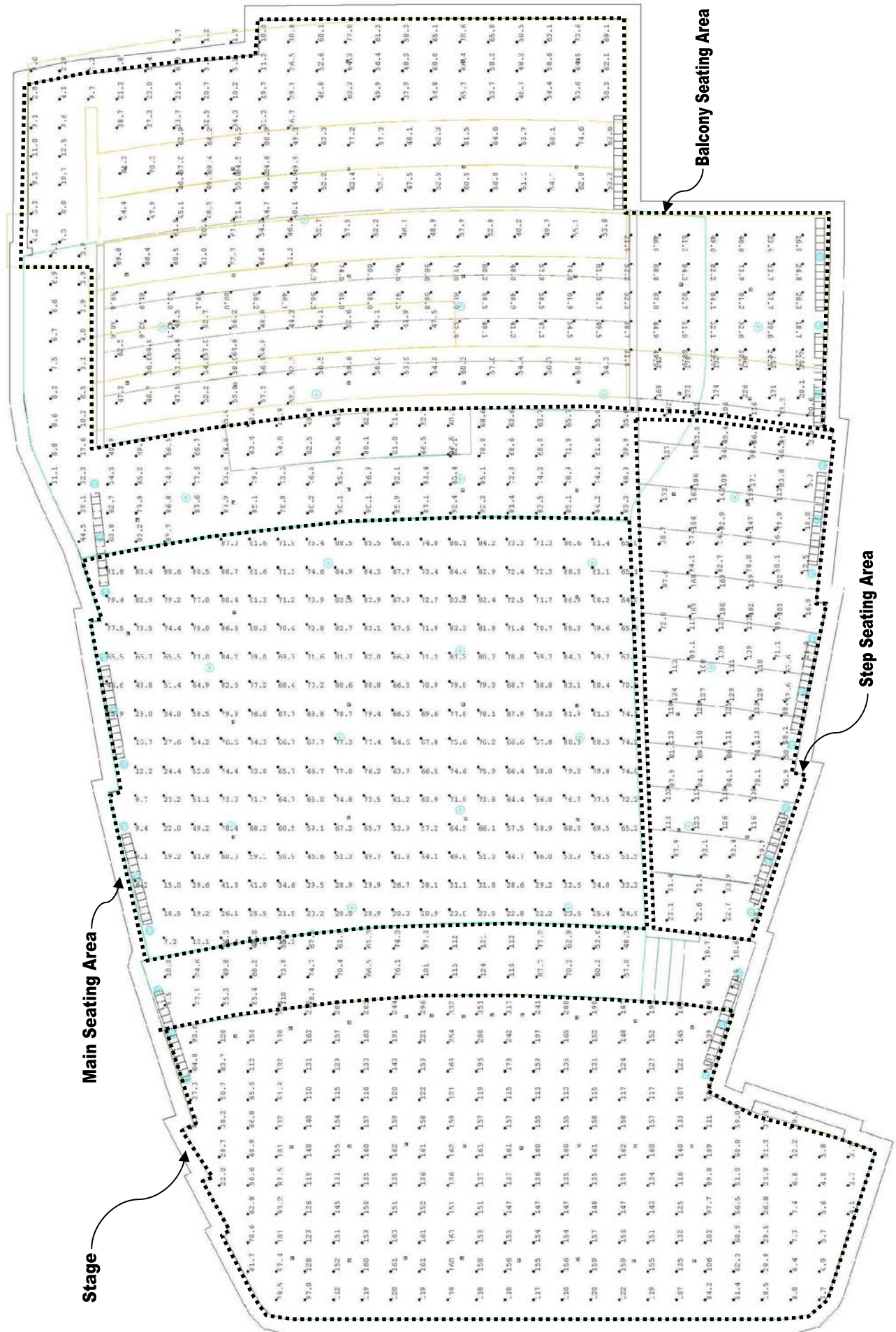
General house lighting in the theater is provided by 575 watts Halogen Source Four PAR fixture. After conducting lighting calculation and light level analysis, it is clear that the space is over lit. The average illuminance on the ground at the main seating area is 61.59 fc, which is a lot higher than IESNA recommended value (10-20 fc). The system may be dimmed in reality; however, lamp life for halogen sources may be reduced tremendously because halogen cycle is unable to properly operate.

Illuminance levels in main seating area and balcony seating area (refer to light level summary) are fairly uniform. Different distributions are utilized depending on distance between the luminaire and the workplane to provide uniform lighting. However, around the step seating area, light levels are quite high and not uniform due to alterations of workplane height but mounting height stays the same.

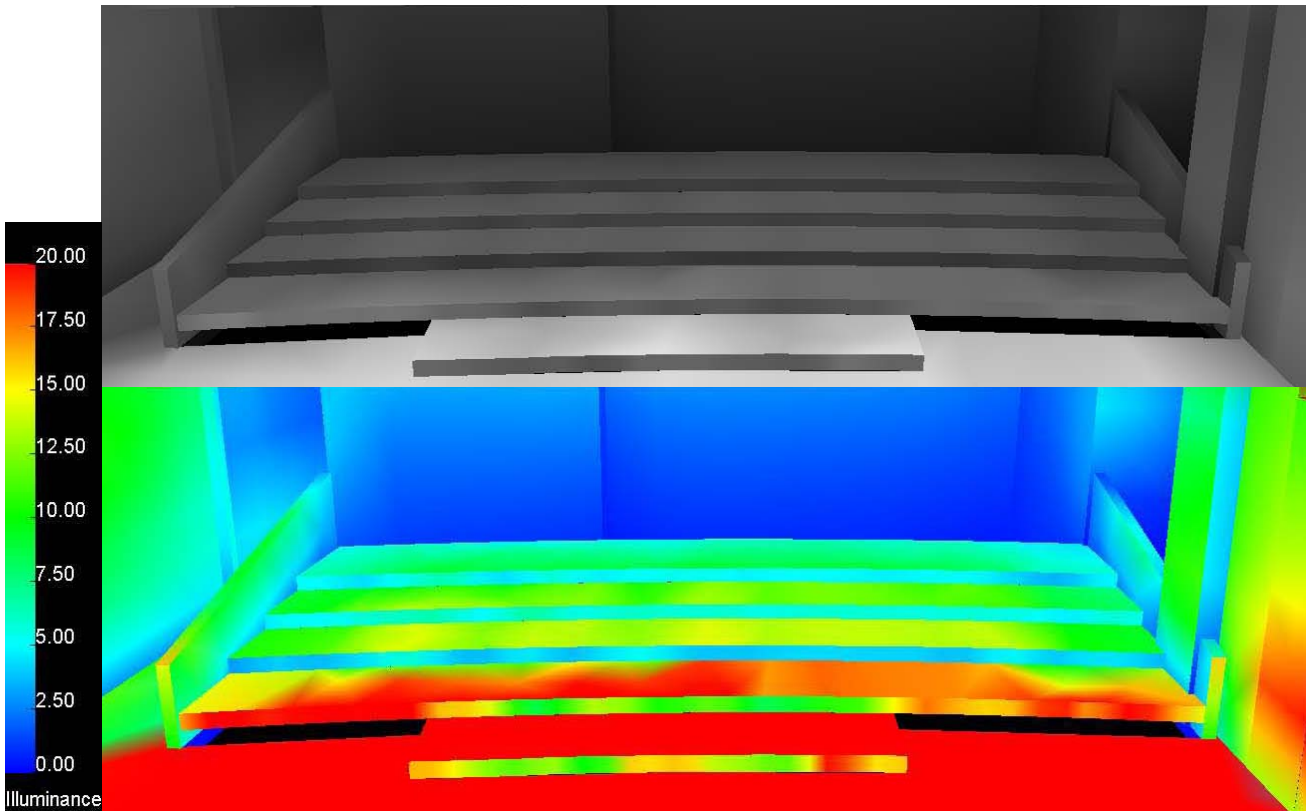
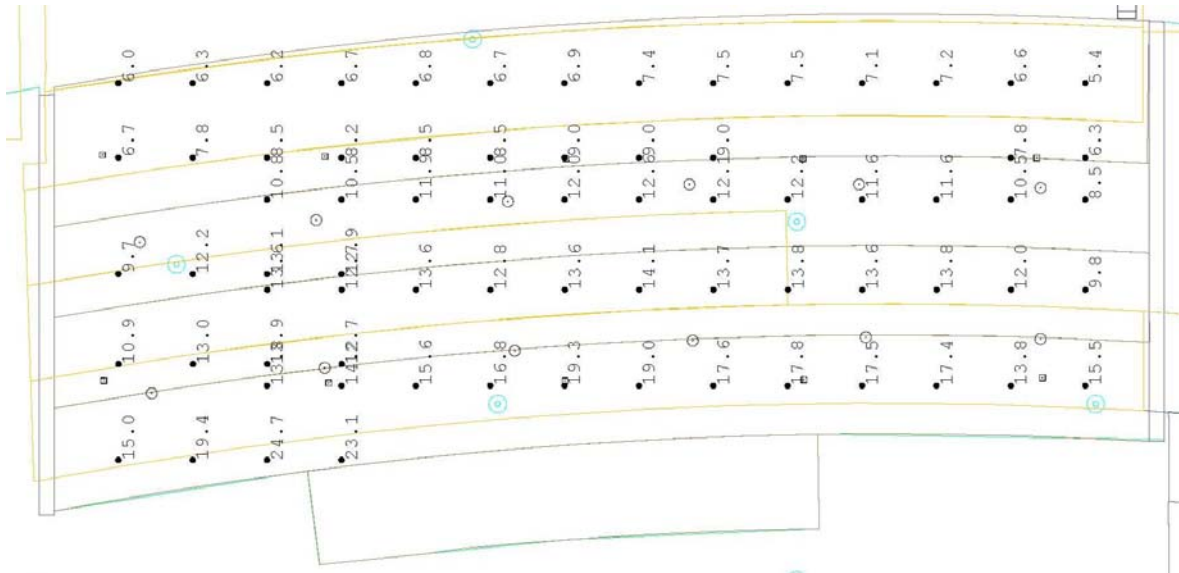
Illuminance level on the stage is quite high and uniform. Although the stage is already a focal point itself, high illuminance level also helps reinforce the level of hierarchy. Narrow spot distribution from Source Four PAR performs well in given mounting height and luminaire spacing.

Area underneath the balcony is illuminated by 100 watts incandescent recessed fixture. The illuminance level in this area is not quite as high. It may not provide adequate light level for reading and writing (refer to Under balcony seating area calculation).





**Under Balcony Seating Area Calculation**



Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Under Balcony Seating_Under Balc	Illuminance	Fc	17.53	24.7	13.8	1.27	1.79
Under Balcony Seating_Under Balc	Illuminance	Fc	12.98	14.1	9.8	1.32	1.44
Under Balcony Seating_Under Balc	Illuminance	Fc	11.45	13.1	8.5	1.35	1.54
Under Balcony Seating_Under Balc	Illuminance	Fc	7.34	9.0	5.4	1.36	1.67

**Calculation Summary**

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
QT-FLOOR_5	Illuminance	Fc	35.98	80.1	10.6	3.39	7.56
QT-FLOOR_7	Illuminance	Fc	88.53	93.4	79.7	1.11	1.17
QT-FLOOR_17	Illuminance	Fc	61.71	86.5	42.9	1.44	2.02
QT-FLOOR_25	Illuminance	Fc	154.10	273	28.1	5.48	9.70
QT-FLOOR BALC_15	Illuminance	Fc	53.24	64.8	43.9	1.21	1.48
QT-FLOOR STEP_24	Illuminance	Fc	65.76	116	3.6	18.27	32.28
QT-FLOOR STEP_23	Illuminance	Fc	100.38	186	5.3	18.94	35.09
QT-FLOOR STEP_22	Illuminance	Fc	122.09	199	10.0	12.21	19.85
QT-FLOOR STEP_21_1	Illuminance	Fc	56.09	94.1	12.5	4.49	7.53
QT-FLOOR STEP_21	Illuminance	Fc	136.47	186	16.0	8.53	11.63
QT-FLOOR STEP_20	Illuminance	Fc	92.17	133	21.9	4.21	6.05
QT-FLOOR STEP_19	Illuminance	Fc	108.23	134	63.6	1.70	2.10
QT-FLOOR STEP_18	Illuminance	Fc	109.82	133	58.1	1.89	2.29
QT-FLOOR STEP_17_1	Illuminance	Fc	78.25	94.1	45.9	1.70	2.05
QT-FLOOR STEP_8_1	Illuminance	Fc	111.20	126	74.2	1.50	1.70
QT-FLOOR STEP_6	Illuminance	Fc	27.14	33.9	20.7	1.31	1.64
STAGE_1_X	Illuminance	Fc	125.63	351	3.7	33.95	94.84
MAIN SEATING_1	Illuminance	Fc	61.59	88.7	6.2	9.93	14.31
MIDDLE BACK SEATING_2	Illuminance	Fc	58.74	92.4	3.9	15.06	23.69
FRONT_4	Illuminance	Fc	71.08	124	8.5	8.36	14.59
QT-FLOOR BALC_12	Illuminance	Fc	52.44	84.3	11.2	4.68	7.53
QT-FLOOR BALC_8	Illuminance	Fc	33.88	77.0	0.6	56.47	128.33
QT-FLOOR BALC_10	Illuminance	Fc	51.32	62.4	40.1	1.28	1.56
QT-FLOOR BALC_14_1	Illuminance	Fc	56.92	72.3	46.0	1.24	1.57
QT-FLOOR BALC_9	Illuminance	Fc	65.27	84.5	48.1	1.36	1.76
QT-FLOOR BALC_13	Illuminance	Fc	54.98	60.3	46.7	1.18	1.29

**Light Loss Factor Calculation**

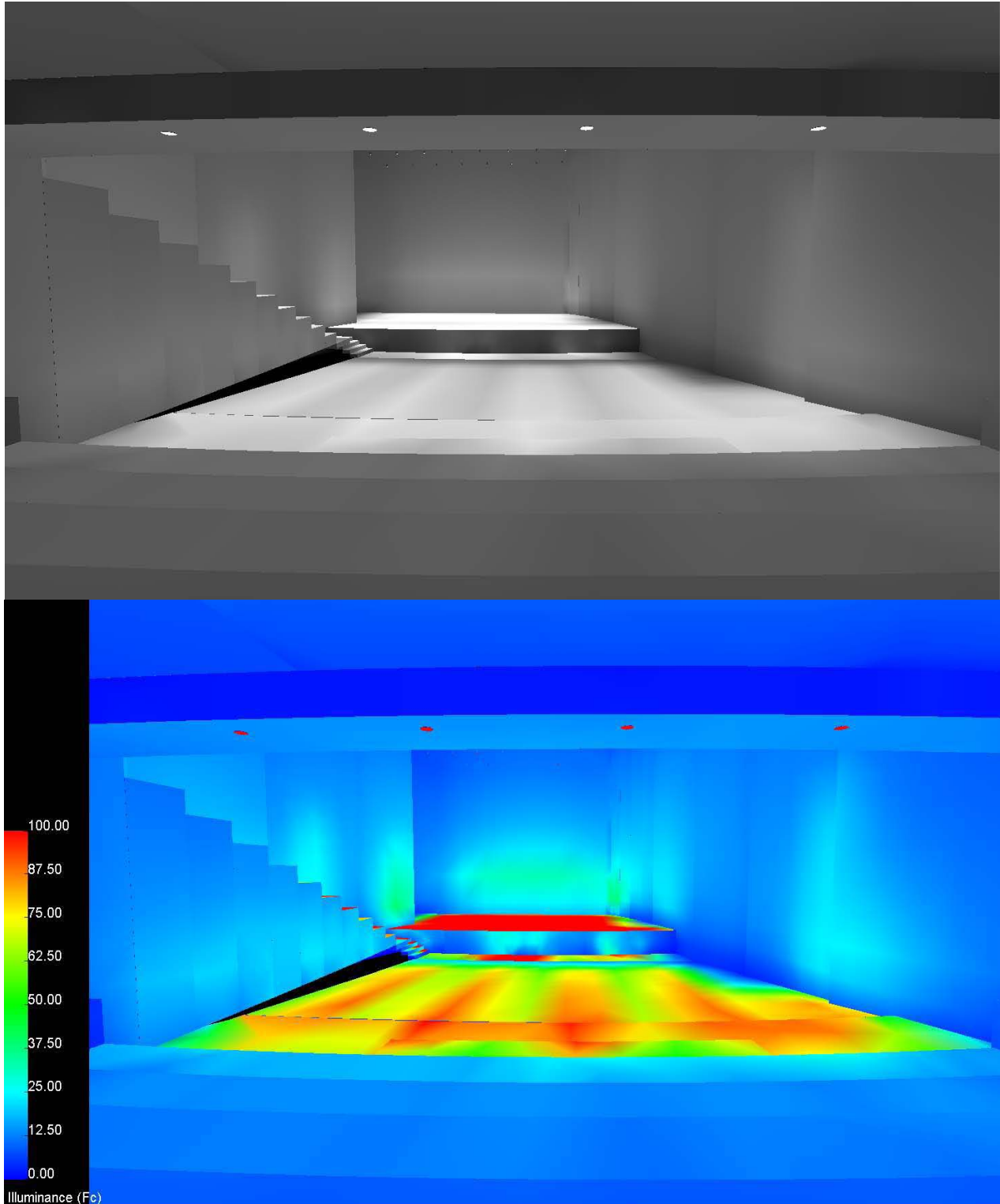
Source Four PAR Fixture

- Lamp Lumen Depreciation – HPL-575/155X (lamp not found in lighting catalog, initial lumen provided in ies file from ETC)
  - LLD = maintained / initial = XXXXX / 12,360 = **.85** (assumption)
- Luminaire Dirt Depreciation
  - Maintain category – V
  - Degree of dirt condition – Clean
  - Cleaning cycle – 24 months
  - LDD = **.89**
- Room Surface Dirt Depreciation
  - Room cavity ratio =  $5 \times 22.5 \times (53.5 + 46) / (53.5 \times 46) = 4.55$
  - Degree of dirt condition – Clean
  - Cleaning cycle – 24 months
  - Expected dirt depreciation = 17%
  - Luminaire distribution type = Direct
  - RSDD = **.95**

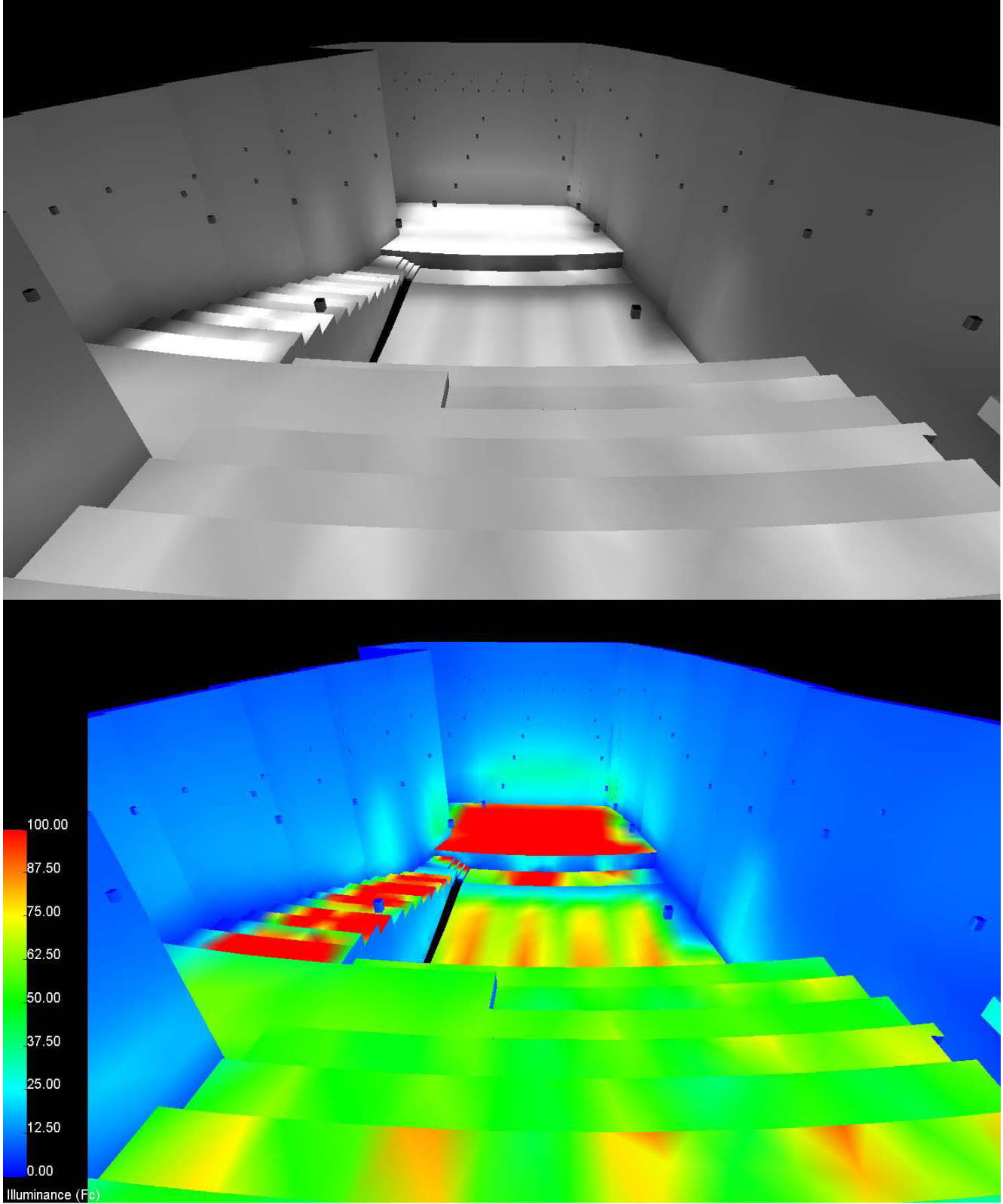
<b>LLF = .85 X .89 X .95 = .72</b>
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Under Balcony Seating Area – Looking to the Stage



Balcony Seating Area – Looking to the Stage



**Open Office Area**

**Existing Conditions**

**Description:**

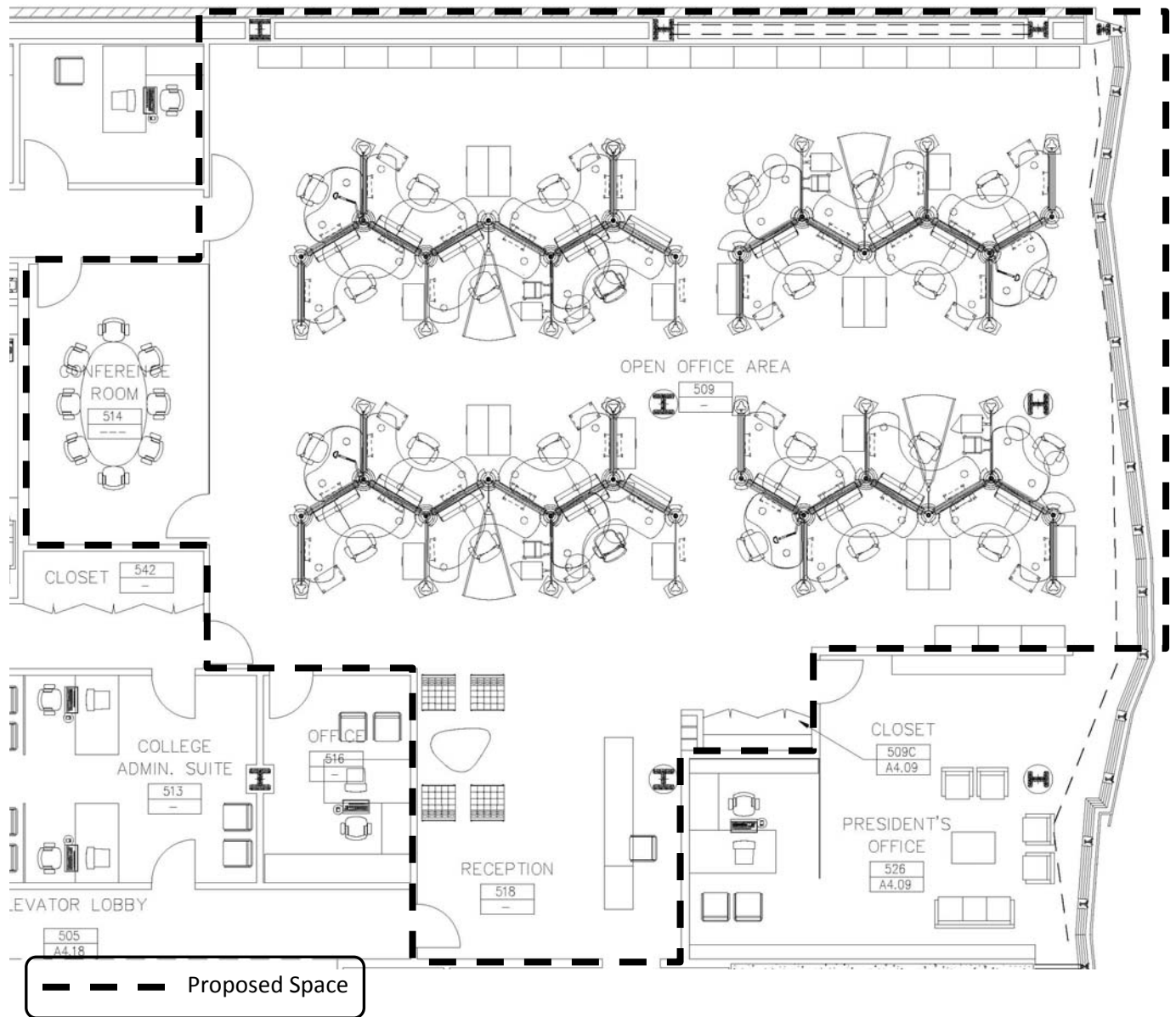
Open office area on 5<sup>th</sup> floor of Spertus College consists of an open space predominately for computer usage, a small conference room, and a reception area. Daylighting breadth could potentially implement in this space.

**Requirement met:** A large work space

**Area:** 3,450 Sq.ft.

**Dimension:** Approx 43'-0" x 63'-0"

**Plan:**



**Materials:**

Surface	Material	Reflectance
<b>Floor</b>	Concrete slab	.3
<b>Ceiling</b>	Acoustical ceiling tile: Armstrong Optima open plan, 2'x2' panels with Square Tegular edge profile. Ceiling system consists of E-W running 6" nominal slots spaced 8'-8" o.c. for light fixtures and air supply diffusers.	.8
<b>Wall</b>	White painted gypsum wall board	.7
<b>Conference Room wall (adjacent to open office)</b>	Full height interior glass wall set into recessed aluminum channels top and bottom. All vertical glass to glass joints to be sealed with Rhoda clear silicones	n/a

**Activities/Tasks:**

- Reception and waiting area
- Open space for computer usage
- Small conference room
- Circulation to President's Office

**Reflected Ceiling Plan:****Lighting Equipment:**

The main lighting system for the open office is narrow direct louvered fluorescent fixture (TYPE L22) recessed in grid ceiling. The fixtures are running alternate with linear bar diffusers. Halogen recessed downlight is predominantly used to provide ambient light in reception area. They are also scatter throughout both open office area and conference room.

**Lighting Equipment Schedule:**

Type	Fixture Description	Mounting	Manufacturer	Catalog Number	Lamp(s)	Watts	Volt.
L5	Halogen MR16 low voltage downlight with nominal 4 in. aperture, clear specular Alzak reflector with white flange, integral magnetic transformer, and rated for Chicago plenum.	Ceiling Floor	Portfolio	HA3MRCP-DR50-3450-HB26-L110N	50MR16/IR/FL40/C lamp by Osram Sylvania	50	120
L5b	Halogen MR16 low voltage adjustable downlight with nominal 4 in. aperture, clear specular Alzak reflector with white flange, integral magnetic transformer, and rated for Chicago plenum.	Ceiling Floor	Portfolio	HA3MRCP-DR50-3470-HB26-L110N	50MR16/IR/FL40/C lamp by Osram Sylvania	50	120
L22	4' Recessed Narrow Direct Louvered Fluorescent of 20-gauge steel housing. Finish of low gloss white powder coat. Shielding of arceylic diffuser and parabolic louvers, which locks in place without hardware. Trim in rigid "U" shaped, doubled formed with a 3/8" regress soft lit edge. Fixture has intergral ballast and rated for Chicago plenum.	Recessed in grid ceiling	Neroray	81-R-2-T8-ETG-1-EB-CP-S79	(2) F032/B30/XP/ECO lamp by Osram Sylvania	64	120

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**Open Office Area****Design Consideration / Criteria**

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**Appearance of Space and Luminaires**

- Since the glass curtain wall is one of the walls for the open office area, the lighting system on the ceiling can be seen from the street level. It is important to ensure the consistency of luminaires' appearances with other spaces attached to the curtain wall.

**Color Appearance (and color contrast)**

- Color Appearance is an important design issue (IESNA). Good Color rendering light source should be implemented to compliment people skin tones. Color correlation temperature (CCT) produced by light source should be neutral (3500 K) to transition daylight contribution into the space. It also helps stimulate work activities and environment.

**Daylight integration and control**

- It is important to integrate daylight into the space due to large area of glazing. Direct glare and direct sun penetration could potentially be a problem in the morning depending on time of year. Dimming control system should be integrated to save energy. Shading devices or blinds with different transmittance levels should be considered to prevent direct sunlight penetration.

**Direct Glare**

- This design issue is considered very important by IESNA design guide.
- In term of sun light direct glare, this is an important issue and can be avoided by shading devices. Direct glare from the luminaires could potentially be a problem. It can cause visual discomfort and reflected glare on the computer screen.
- One of the ways to reduce direct glare in the intensive VDT space is to employ direct/indirect or indirect fixture. To reduce direct glare from the luminaire, comfort diffused reflector, louvers, or glare shield should be specified.

**Reflected Glare**

- This design issue is considered very important by IESNA design guide.
- Reflected glare can be reduced by the use of matte surfaces and by carrying out the procedures for reducing veiling reflections on the task
- Large area low-luminance luminaires or indirect luminaires can be used when specular surfaces cannot be avoided.

**Light Distribution on Surfaces**

- The north and south wall of the space should be uniformly illuminated. It does not only help create the sense of spaciousness, but also reduce contrast level between the curtain wall and side walls.

**Light Distribution on Task Plane (Uniformity)**

- In order create the impression of visual clarity, high uniform light level should be provided, mostly overhead (direct) lighting.
- Non-uniform perimeter lighting is crucial to allow the eyes to stretch and prevent fatigue.

### Luminances of Room Surfaces

- This design issue is considered very important by IESNA design guide.
- Luminances near each task and in other parts of the office interior within the field of view should be balance with the task luminance.

Tasks	Luminance Ratio
Between paper task and adjacent VDT screen	3:1
Between task and adjacent dark surrounding	3:1
Between task and remote (non adjacent) Surface	10:1

- The maximum allowable ceiling luminance should not exceed 850 cd/m<sup>2</sup>.
- The smooth gradient should be provided between the high and low luminance level.

### Modeling of Faces and Objects

- Facial modeling is an important issue (IESNA). To provide good facial modeling, a combination of key light and fill light is required (direct and indirect components light).

### Points of Interest

- There is currently no point of interest in the space. However it can be created by providing lighting that exceeds recommended luminance ratio stated above in some area.
- Another possibility is to provide different lighting system for the adjacent areas (reception and conference). Since both areas are transparent and connected the open office. Creating interesting and innovative lighting system for these two areas would help an open office from being uninteresting.

### Shadows

- Shadows are minimized if the light arrives at the task from many directions, helped by high-reflectance matte finishes on room surfaces.

### Source/Task/Eye/Geometry

- Luminaires should be located at the appropriate distance and angle from the VDT screens.

### Sparkle/Desirable Reflected Highlights

- Sparkle/Desirable Reflected Highlights can be created in reception area to provide visual interest to the space.

### Surface Characteristics

- All wall surfaces are gypsum wall board painted in white eggshell finish. Due to its high reflectance property of selected paint, high luminance level can be easily achieved. The space may seem brighter than it actually is.

### Task lighting

- Task lighting integrated to the furniture system should be considered to reduce level of ambient in the space and save some energy.

### Illuminance (Horizontal)

- 30 fc (IESNA Offices – Open plan office – Intensive VDT use)

### Illuminance (Vertical)

- 5 fc (IESNA Offices – Open plan office – Intensive VDT use)



## Special Considerations by Areas

### Reception Area

- Visual Environment
  - The lighting should be restful and yet provide enough illumination for reading
  - Relaxation impression (Steffy)
    - Create a less formal setting and more casual space
    - Relaxation impression is best enhanced with non-uniform luminance and peripheral emphasis through accent of selective walls, wallslots, consistent accent lighting, and sconces.
- Visual Performance
  - Task
    - **10fc** on horizontal surfaces for general ambient and **3fc** on vertical surfaces (offices – lobbies, lounges, and reception areas – IESNA lighting design guide)
    - **30fc** on horizontal tasks at seating area for reading (reading – glossy magazines – IESNA lighting design guide)
    - **30fc** on horizontal workplane at reception desk (reading – printed tasks – 8 and 10 point style – IESNA lighting design guide)

### Conference Room

- Visual Environment
  - Visual Clarity (Steffy) to provide occupants ability to perceive distinctions of architecture, interior detail, features, objects, and other people's features.
  - Spaciousness Impression (Steffy) to provide perception of spatial volume.
  - Two or more lighting systems should be planned to provide flexibility for this range:
    - A general lighting system in which the control of illuminance is provided by switches or dimmers.
    - A supplement lighting system consisting of downlighting with dimmer controls for slide projection and other low-level illumination requirements.
    - A perimeter or wall-wash lighting system controlled with dimmers for better visual appeal and for wall-mounted presentations.
    - The use of color to provide a point of interest to the open office area when the conference room is unoccupied.
- Visual Performance
  - Video Presentation
    - Less than **5fc** on front screen projection systems (DG-17)
    - **10fc** for writing on work plane (Category C – Working spaces where simple visual tasks are performed – IESNA ch.10)
  - Face to Face Conference
    - **5fc** average vertical illuminance on faces (IESNA design guide for meeting in the conference room)
    - **20-40fc** average illuminance on 60% reflectance walls (target 30fc at eye height) (DG-17)
    - **1.5:1** max:min uniformity ratio across all faces (DG-17)
    - **30-50fc** for writing on work plane (IESNA)

### Energy Considerations

- Energy Code Requirements – ASHRAE 90.1-2004 – Space by space method
  - Open Office Area
    - Standard 90.1 – **1.1w/sq ft.** for open plan office
    - Additional **1.0w/sq ft.** for decorative
    - Additional **.35w/sq ft.** for VDT compliance fixtures
  - Conference Room
    - Standard 90.1 – **1.3w/sq ft.** for conference room
    - Additional **1.0w/sq ft.** for decorative
    - Additional **.35w/sq ft.** for VDT compliance fixtures
  - Reception Area
    - Standard 90.1 – **1.2w/sq ft.** for lounge/recreation

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## Open Office Area

## Evaluation and Critique

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Although the impression of visual clarity is being performed, the lighting system is very uniform and can lead to boredom if no other visual interest is in the space. Illuminance levels on the workplane and part of the circulation traffic are on the high end of the spectrum (50-70 fc). Perhaps two-lamp fixture can be replaced with one-lamp fixture to produce illuminance in the range of 30s fc as recommended in IESNA for intensive VDT use space. Light level on the workplane is quite uniform. The vertical walls are uniformly illuminated with appropriate illuminance level to create a sense of spaciousness. Due to excessive amount of light in the open office area, perhaps Fixture TYPE L5 can be eliminated or reduced to the minimal. One of the reasons fixture TYPE L5 is there is because they are specified near the curtain wall on every level. Consistency of fixture appearances from the exterior perspective is important.

General lighting in reception area is provided by recessed halogen downlight. Illuminance levels around the seating area and on the reception desk are adequate for reading and writing. However, the impression of relaxation is not implemented in the lighting design of the space.

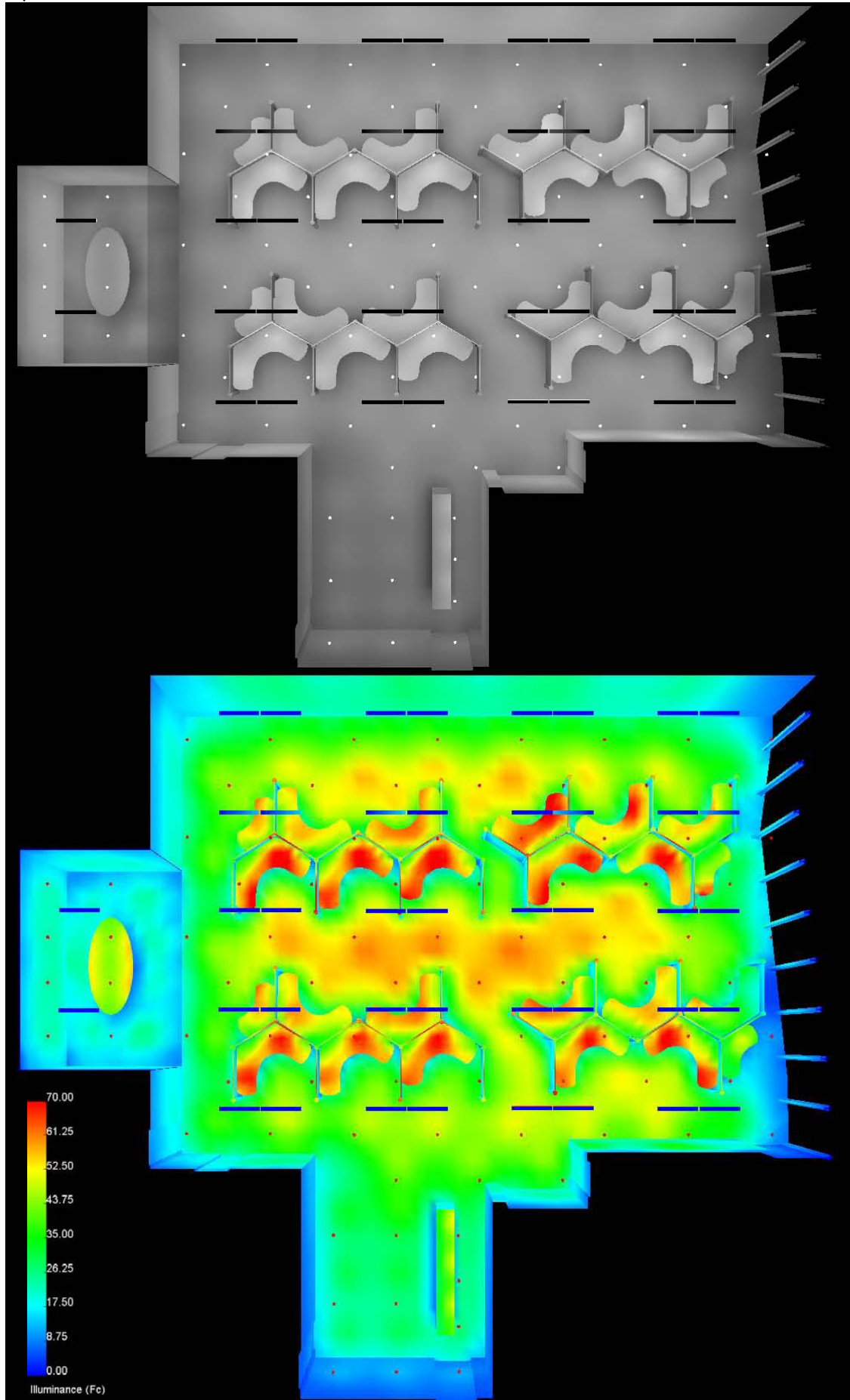
Adequate illuminance level is provided on the conference room table for meeting, reading, and writing. All lighting system in the conference room is overhead system. Facial modeling may not be as good due to lack of fill light (however fill light may be supplemented from reflected light off the walls).

The linear fluorescent fixture (TYPE 22) and recessed halogen downlight (TYPE L5) are visible from the outside as shown in image below. Due to simple layout and spacing of these fixtures, the exterior appearance is quite clean and organized.

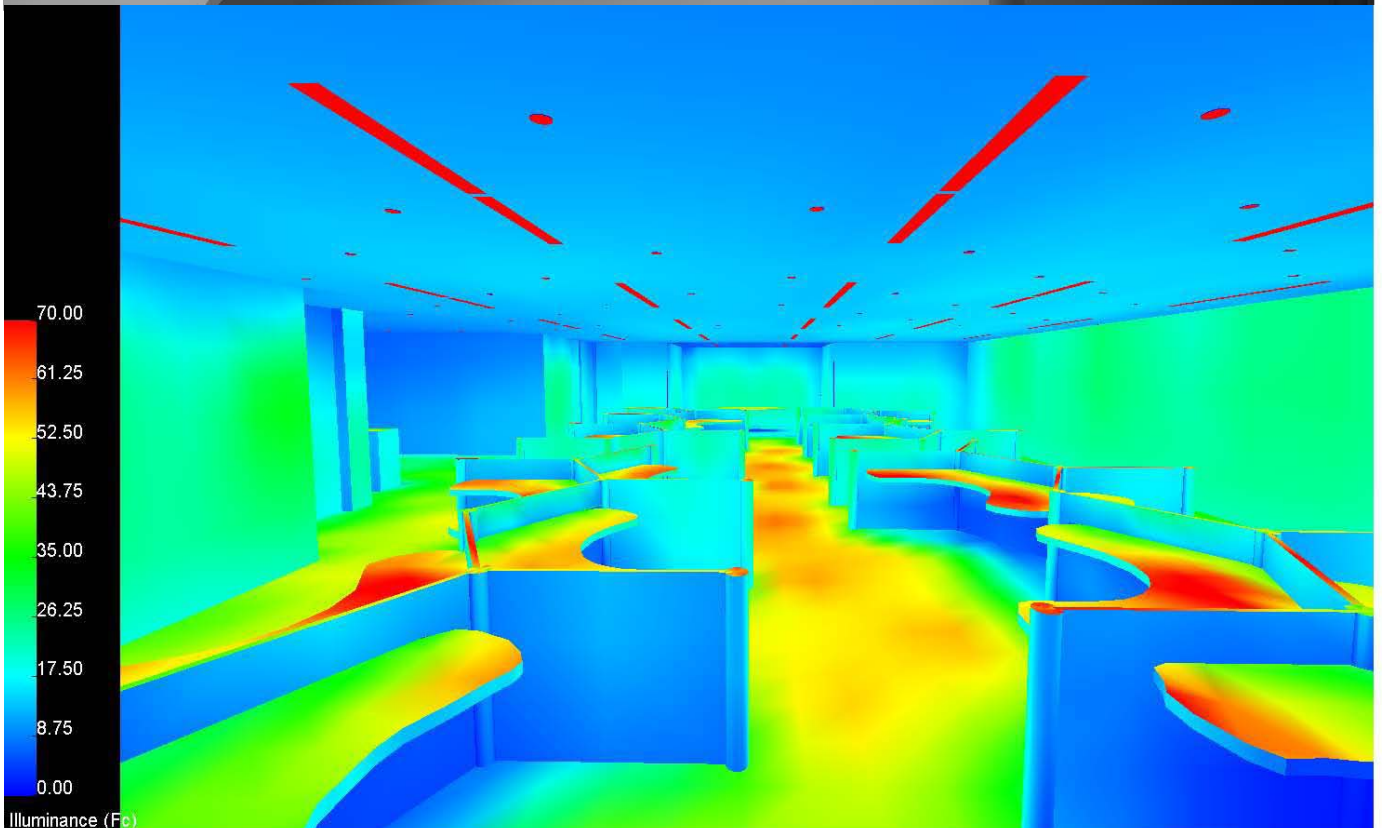


Exterior View – Open Office

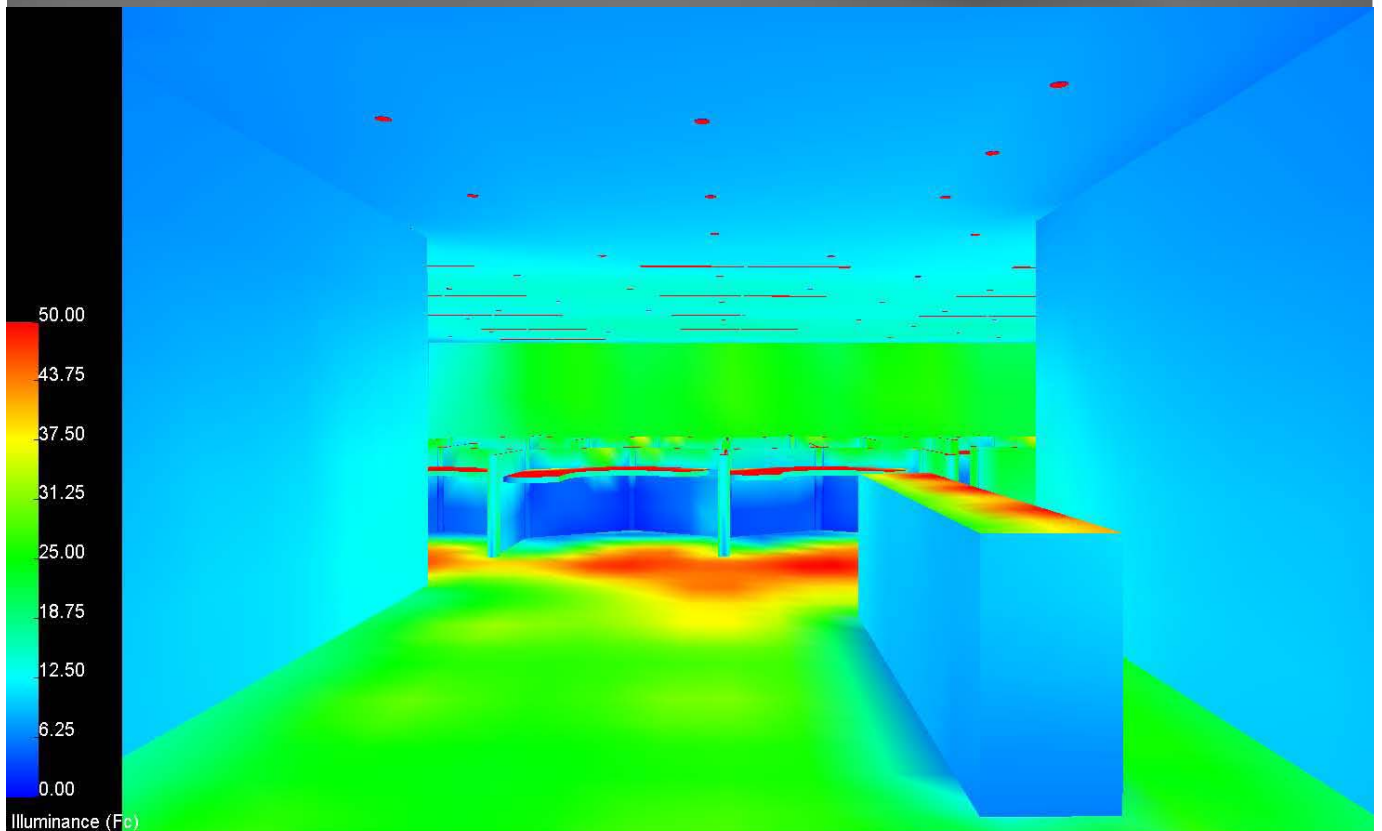
Open Office

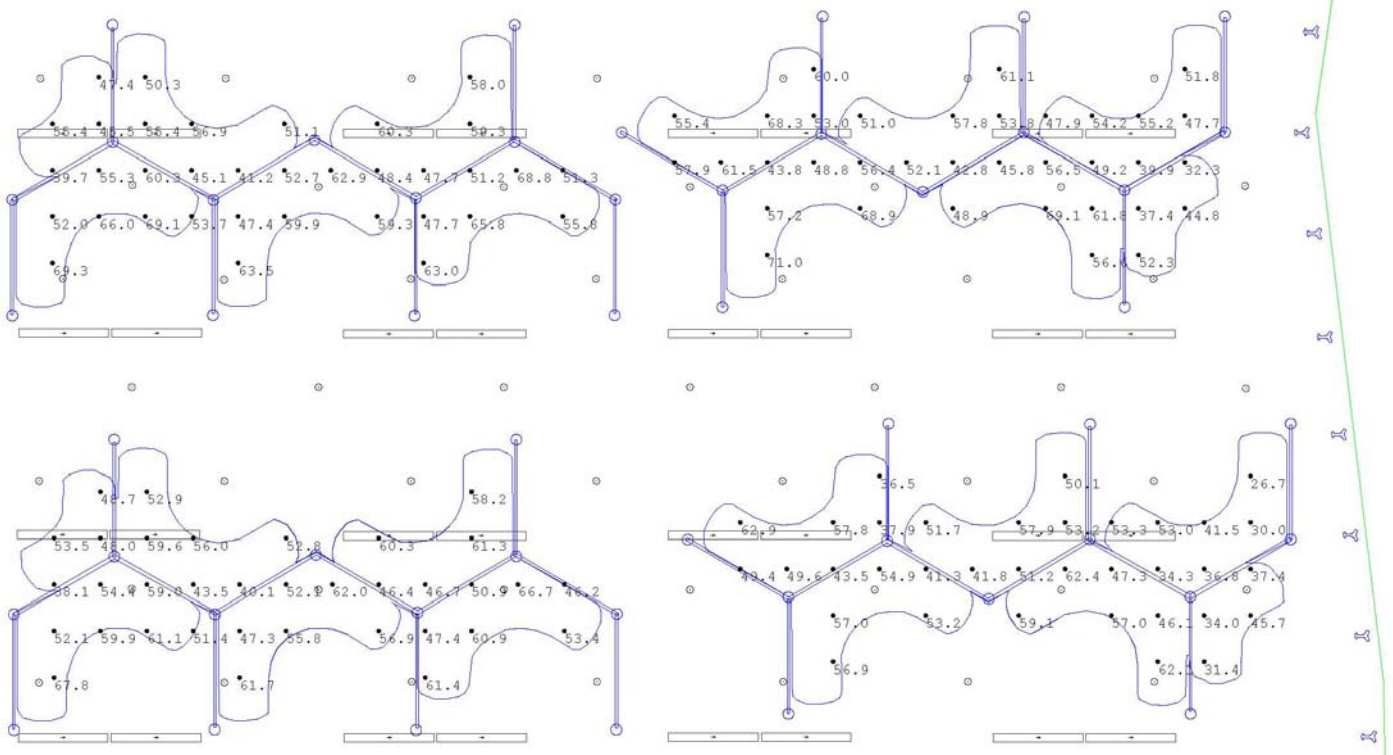


Open Office – Looking to the Conference Room in the back

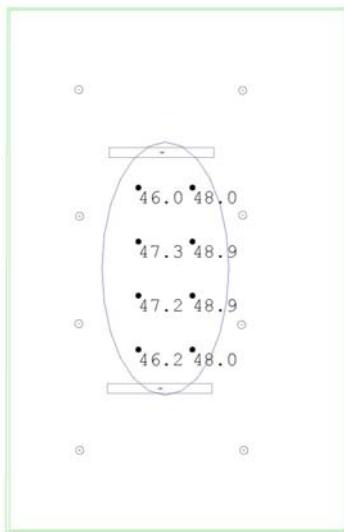


Reception Area – Looking to the Open Office Area

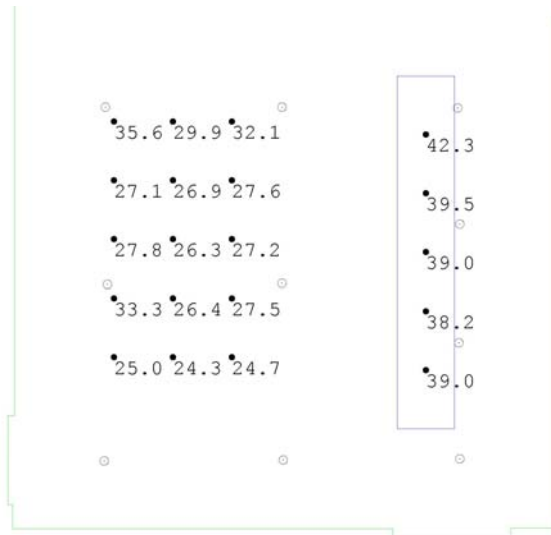




Open Office – Workplane (2’-6”)



Conference Room – Conference table (2’-6”)



Reception Area – Reception desk (3’-6”)  
– Seating area (2’-0”)

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Conference Table_Top_1	Illuminance	Fc	47.56	48.9	46.0	1.03	1.06
Reception Counter_Top_Top_1	Illuminance	Fc	39.60	42.3	38.2	1.04	1.11
Reception Seating Area	Illuminance	Fc	28.11	35.6	24.3	1.16	1.47
Room_Floor	Illuminance	Fc	32.04	60.5	2.6	12.32	23.27
Workplane_Top	Illuminance	Fc	53.49	71.0	32.3	1.66	2.20
Workplane_Top_1	Illuminance	Fc	55.33	69.3	39.7	1.39	1.75
Workplane_Top	Illuminance	Fc	47.57	62.9	26.7	1.78	2.36
Workplane_2_Top	Illuminance	Fc	54.13	67.8	38.1	1.42	1.78

Light Loss Factor Calculation

## 4' Recessed Narrow Direct Louvers Fluorescent Fixture

- Lamp Lumen Depreciation – F032/830/XP/ECO
  - LLD = maintained / initial = 2,800 / 2,950 = **.95**
- Luminaire Dirt Depreciation
  - Maintain category – IV
  - Degree of dirt condition – Clean
  - Cleaning cycle – 12 months
  - LDD = **.88**
- Room Surface Dirt Depreciation
  - Room cavity ratio =  $5 \times 7.5 \times (48.5 + 42) / (48.5 \times 42) = 1.6$
  - Degree of dirt condition – Clean
  - Cleaning cycle – 12 months
  - Expected dirt depreciation = 12%
  - Luminaire distribution type = Direct
  - RSDD = **.98**
- Ballast Factor = **.94**

$$\text{LLF} = .95 \times .88 \times .98 \times .94 = .77$$

## 4' Recessed Halogen Downlight

- Lamp Lumen Depreciation – F032/830/XP/ECO
  - LLD = maintained / initial = 2,800 / 2,950 = **.95**
- Luminaire Dirt Depreciation
  - Maintain category – V
  - Degree of dirt condition – Clean
  - Cleaning cycle – 12 months
  - LDD = **.88**
- Room Surface Dirt Depreciation
  - Room cavity ratio =  $5 \times 7.5 \times (48.5 + 42) / (48.5 \times 42) = 1.6$
  - Degree of dirt condition – Clean
  - Cleaning cycle – 12 months
  - Expected dirt depreciation = 12%
  - Luminaire distribution type = Direct
  - RSDD = **.98**

$$\text{LLF} = .95 \times .88 \times .98 = .82$$