CATHEDRAL PLACE

MILWAUKEE, WI

Steven T. Puchek **Lighting/Electrical** **10 April 2006**

The Pennsylvania State University - Senior Thesis - Architectural Engineering

Cathedral Place

Milwaukee, Wisconsin

Project Team

Owner:	Van Buren Management, Inc.
CM:	Comerford Development Resources
Architect:	Solomon, Cordwell, Buenz & Associates, Inc.
GC:	KBS Construction, Inc.
Structural:	Skilling Ward Magnusson Barkshire
MEP:	Arnold & O'Sheridan, Inc.
Civil:	National Survey & Engineering

Architecture

- 17 story mixed-use building south of Cathedral Park
- Concrete parking deck molded into glass curtain wall structure, which houses condominiums (1-9), tenant office spaces (10-17), and retail at ground level
- Facade curvature unique among office buildings in area
- Tallest in immediate area generates beautiful views of downtown, city (to the west), and Lake Michigan

Structural

- 6" and 8" post-tensioned concrete slabs on long-span concrete beams (floors B1-9)
- Building sectioned into two structural entities
- Simple footings support concrete columns
- Steel moment frame structure integrated and supported by 9th floor concrete columns (floors 9-17)
- 4" concrete slab floor on composite steel deck.
- Steel frame structural entity ties together two lower structural entities

Construction

Project Size:	649,000 sq.ft. - 373,000 sq.ft. parking
Total Levels:	18 floors (17 above grade)
Project Cost:	$53,040,000
Delivery Method:	GMP - Cost plus Fee
Construction Dates:	March 2002 - March 2004

Electrical

- 13.2kV 3ø parallel service entrance to switchgear
- 4 main switchboards serve Office, Residential, Parking, and Retail with 480/277V and 208/120V distribution from tenant/condo panels
- 350kW diesel emergency generator for house only
- 2500A bus duct to office spaces, 1200A bus duct to residential, tapped at each floor respectively

Lighting

- Lobby luminaire artwork for ambient, fluorescent strip and downlight for general purpose lighting
- Vast daylighting throughout building via curtainwall
- Ceramic Metal Halide for parking and facade lighting

Mechanical

- Packaged Terminal Air Conditioning units serve tenant offices and retail spaces
- Water Source Heat Pumps serve condominiums
- PTAC and HP hot water supplied by water-steam heat exchanger, steam provided as utility
- 1 Evaporative Fluid Cooler serves condo heat pump condensed water loop.
- 2 Cooling towers serve office and retail CW loops

Steven Puchek - Lighting/Electrical - Thesis Abstract

Thesis ePortfolio - http://www.arche.psu.edu/thesis/eportfolio/current/portfolios/stp140/

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Executive Summary

The Senior Thesis Project is the culmination of the past 5 years in the Architectural Engineering Program. The thesis is a highlight of a particular building, unique to each individual, from which thorough analysis and redesign are completed over the course of the 5th year. Existing systems are investigated, new designs are proposed, and then those designs are tested for feasibility and compared to the initial design with hopes of implementing the new design as a more efficient and oftentimes cost effective alternative.

The thesis project in this document focuses on Cathedral Place in Milwaukee, Wisconsin. Cathedral Place is a multi-use building completed in 2004. The analysis of this building comes as a particular interest given the author's thorough knowledge of the area and easy accessibility between semesters. Cathedral Place, like most buildings, has its share of design flaws and successes and the thesis proposal investigated some of those flaws and analyzed a number of alternatives – many of which were theoretical.

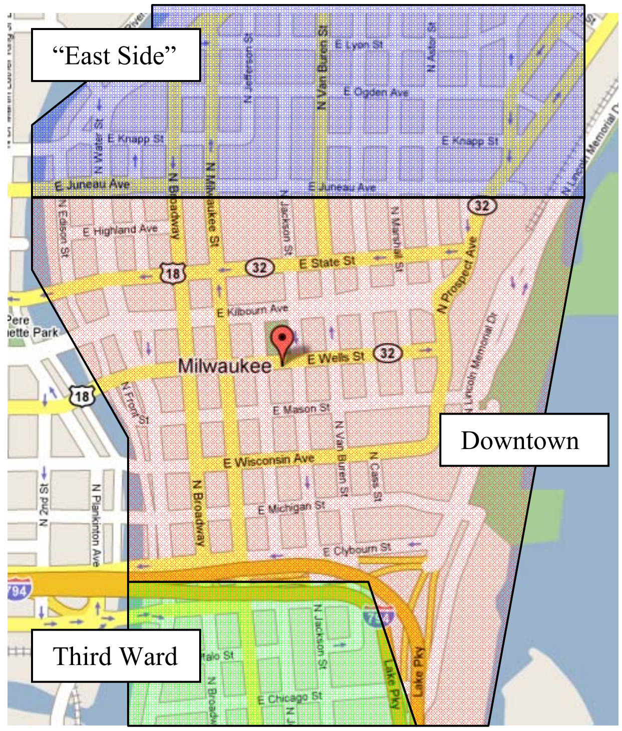
Cathedral Place was analyzed mainly for its Electrical system, Architectural designs and methodologies, and the application of Lighting design to those architectural forms and absences. Furthering the investigation of the building's systems and the use of 5-years worth of knowledge, a brief Structural system breadth (as a result of certain Lighting design elements), and minor Mechanical breadth were also completed. All of the preceding analyses were somehow interconnected and relationships between them could not be ignored, much the same way it would have to be done on a real project.

This thesis focused on a number of theoretical lighting design elements, co-operational electrical and mechanical system components, analysis of external factors (utility company regulation, services, and rate structures), and complimentary architectural forms and functions. These many topics, brought together in as comprehensive a manuscript as possible, is the result of the pursuit of as many building system interests as could be applicable to the building.

Complexity in the designs and sheer volume of information prevent all of the acquired knowledge from being presented. The knowledge obtained from this thesis project far surpasses what can all be illustrated or described below. While the end-result of this thesis – this report – is mainly for the author's benefit and use, anyone having interest in topics that have been researched here have an excellent base from which to further their knowledge.

Project Background

Location



Cathedral Place is located in Milwaukee, WI just north of inner downtown. Its construction was the first of many new projects in the downtown area designed to develop residential revitalization and growth as well as stunt the suburbanization of the surrounding rural-based cities and counties.

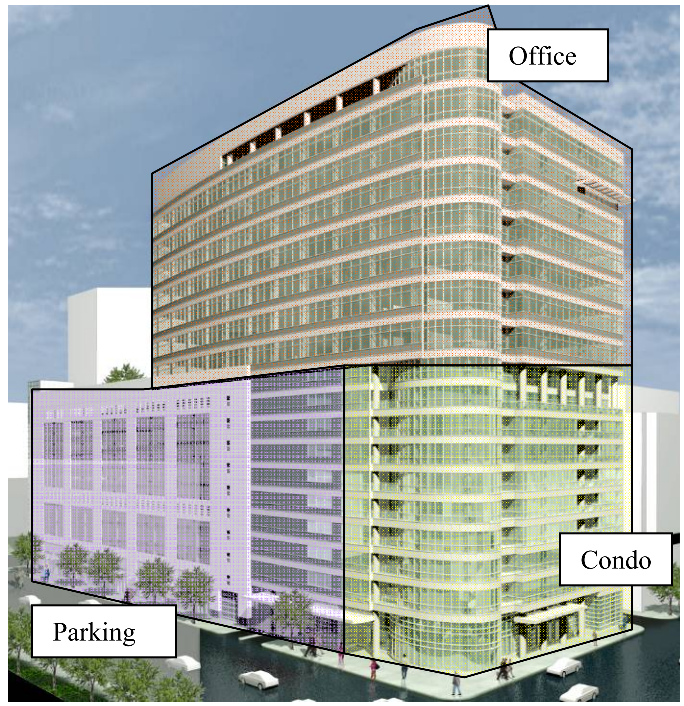
Milwaukee is also primary location for many large industry headquarters including Harley Davidson, US Bank Corp., Masterlock, Miller Brewing Company, and Northwestern Mutual, and a commercial locale for many of Wisconsin's larger businesses. As such, the compact downtown area has been well developed over the decades and only benefits from the construction of a new, high-rise office and residential tower.

The actual site of the Cathedral Place is immediately south of Cathedral Park, one of the few remaining Milwaukee County Parks in the downtown area. Cathedral Park is the location of many smaller downtown music and ethnic festivals, as well as a centerpiece for the many surrounding upscale restaurants. The building occupies half of the block between Jefferson St. and Jackson St and is bordered to the north and south by Wells St. and Mason St. Sharing the block with a parking deck and surrounded by other 10+ story office and residential buildings with ground level restaurants, Cathedral Place is a "bird of a feather" and very well molded into the area.

The city was founded based on its access to Lake Michigan and the Milwaukee River similar to Chicago and its foundation on the waterways and access to great lakes shipping routes. As such, the city focuses much of its personality on the lake, shipping, and other "coastal" traits. It is this "persona" that governed the form of the building's architecture, and in this thesis, much of the lighting design.

For more information on Milwaukee and the surrounding areas please visit www.ci.mil.wi.us or www.onmilwaukee.com. As an often misunderstood urban and suburban area of the Midwest, it allows one to better appreciate the lighting proposals and architecture of the building itself.

Building Uses



Cathedral Place as a building entity does not conform to the status quo of buildings in its immediate vicinity. It is a mixed-use building serving Commercial/Office, Residential Condominium, Retail and Restaurant, and has an integrated Parking Garage.

As can be seen from the Building Abstract, the percentage floor area of the construction is heavily weighted toward the Parking Garage, but the percentage of the occupied structure is focused more toward the Office tenants. The condominiums occupy 8% of the total structure area, but 16% of the tenant space. As a contrast, the office tower spans 42% of the total structure and accounts for over 78% of the tenant space. The restaurant and retail spaces are allocated only a small section of the ground floor.

Because of this varied use, the systems of the building were divided prior to construction to reflect this separation of space usage. This includes the electrical, mechanical, and even the structural components of the building. While the architecture and layout of the building suggest a complete segregation of space, the internal workings of the building are all connected at some level. At the street level, this gives greater appeal to the retail and restaurants, as well as a delineation of the residential spaces from commercial spaces.

All of this begs the question, for what purpose other than the architecturally psychological would one choose such a complex nature for a simple building. The answer is related to both the systems within the building as well as the owners and funding sources for its construction.

Owners and Management

Cathedral Place was constructed at a cost of over $50 million. The controlling owner of this project, Van Buren Management, was not enticed to construct a building of this magnitude without the accessible income to supplement the intended commercial development – and subsequent residential development. Residential development was added as an extra and immediate source of income to offset the construction costs while the commercial development's payback came to fruition.

The parcel of land purchased allowed, while city demand necessitated, the development of a parking structure. Occupying over 50% of the available land and gross building floor area, the Redevelopment Authority of Milwaukee authorized the allocation of supplemental funds for the construction of the Parking Garage.

As an additional layer of division for the project, Van Buren Management does not manage office tenants, condominium tenants, retail tenants or in-house affairs related to their developments. Pentagon Management LLC was chosen as the entity to manage the building's affairs. For this reason, previous division had to be mended well enough to allow for the successful and easy management of half of the building's tenants.

The internal workings of the building as well as the structural and architectural segregation of the building is directly related to the three "owning" entities – Van Buren's Commercial and Retail, Individual's Condominiums (bought outright), and the Redevelopment Authority's Parking and Retail. The electrical system illustrates this fact quite clearly as will be seen in the Electrical Depth.

Construction and Occupancy

The building was constructed between January 2002 and March 2004. Office fit-out and occupancy was allowed in November of 2004 and Anchor tenants occupied by March. All but 2 of the condominiums have been filled as of this writing (26 of the 28) and office tenants have fitted out all of the floors from 11 to 17, and half of the 10^{th}. Retail entities have moved in with relative permanence, including 2 restaurants, as can be seen from the Thesis Abstract. As of this writing, occupancy has been unchanged for one full year – a fundamental basis for many of the systems' designs.

Existing Conditions

Architecture

Form and Layout

The architecture of the building is simple in form on the outside, and slightly more complex in design for the façade and interior. The building retains a stepped shape form its two masses, the elongated rectangular parking garage, and the tall tubular glass tower of the same width. The glass façade and its curvature reflect a large amount of the sky toward street level as other high-rise building located to the North, Northeast and Northwest are relatively distant.

The entire façade of the tubular occupied space is a glass curtainwall, framed vertically and horizontally on the East North, and West sides, with only horizontal framing in the elliptical form at the Northeast corner of the building. To accentuate this cylindrical form, the exterior canopies over the two entrances to the Office lobby (as well as the entrance to the residential lobby) are sectioned to allow the glass curtainwall to extend from street level to the 17th floor uninterrupted.

The main entrance lobby serves only the upper office floors (10th through 17th) via 4 general purpose elevators located at the north end of the building. The residences are served by 2 separate elevators connected to an immediately adjacent, but physically separate, entrance lobby. The parking structure is accessible via hallway from any of the condominiums, and by two separate elevator banks located at the Northeast and Southeast corners of the Parking Garage.

The Parking Garage, spanning 300' of the Basement through 9th floors from north to south, is congruent in layout and space allocation for every floor except the ground level where street access points, parking booths, and Retail spaces fill the area. The implication here is that no architectural "support" space was allocated on the Parking Garage end of the building for the first 9 floors. All of the mechanical, electrical, in-house support (trash removal, loading docks, etc.) are located within a 60'-80' section of the North end of the building. While this works for the first 9 floors where the condominiums only occupy this section of the floor plate, at the 10th level diversion of all systems is to the core of the office tower, but with as little space allocated for mechanical and electrical equipment as possible.

Materials

Materials used throughout the building vary dependent on the space. The Parking Garage is made entirely of concrete, save the columns which are composite beams (which are about 80% concrete themselves). The exterior is constructed mainly of polished cut-white-stone precast concrete paneling while the interior is a rough broom-finished concrete floor with exposed concrete columns. Of architectural note are the large "window" spaces on the exterior façade of the parking garage. The windows are over 30' high and over 20' wide spanning multiple stories. These spaces, whether developed for an architectural appeal, or for required, yet un-powered, ventilation of the structure is much larger in scale, but comparable to the mullion-framed curtainwall of the remainder of the building. In these massive spaces are placed square wire-mesh elements which act as negative windows, with the remaining open spaces acting as the negative framing. This architectural element was used to maximum extent in the lighting redesign, as will be shown in later sections.

The Office tower is architecturally incomplete to be designed by whatever tenant moves into a given floor space. The only architectural elements are the exterior façade, to be mentioned shortly.

The Office Lobby is the only non-residential space with specific architectural materials including 4 different marble floors (a bluish-black, a royal blue, a brick red, and a sandy white), wood finishes on particular wall elements, translucent glass framed in the same architectural aluminum mullion as the exterior (to be mentioned), chrome-plated knit-mesh accents, and polished aluminum metal framing for elevator openings. The Residential Lobby is the remaining space that the architect chose to have specific design control over. The walls are laden with a rough-quarried green and grey stone, tan carpeting and lighter mocha-brown painted walls. The flooring inside the residential elevator lobby becomes a blue-grey square foot quarried tile with white painted walls.

While much of the architecture wasn't developed specifically within the scope of the initial project, spaces analyzed, developed and further designed within this thesis either make distinct use of the current materiality or add to the space to modify the overtone and/or theme of individual spaces. All of this is done without drastically altering the form and current impression the building gives the surrounding area and residents.

Existing Lighting Systems

Façade

Current lighting systems vary, again, with the space. On the exterior, individual fluorescent tube fixtures are used under the canopies and overhangs, while metal halide fixtures are used to accentuate the precast panels of the Parking Garage.

Architecturally, and from a fundamental lighting standpoint, the Parking Garage is the only portion of the building capable of façade illumination. At the ground level and around the building were placed ground-recessed luminaires capable of uplighting the columns at the base, but ignoring the rest of the building. The only lighting element preventing the impression that the structure bleeds away into nothingness is the linear illumination of the 17th floor balcony with column uplighting and considerable linear fluorescent ceiling washing reflecting back down toward the ground level. Other than these few elements, the building glows from the inside relative to office lights being used late at night, or left on due to poor building automation.

Parking

The interior of the Parking Garage has a very simple lighting solution developed for a maximum light level without the overuse of electricity. Fixtures within the parking garage were 175W metal halide vandal-resistant surface-mounted luminaires used for general illumination of the travel lanes, while the each floor's elevator lobbies contained recessed linear fluorescent fixtures for simple, all-purpose (and cheap) illumination. This very general space gets just about as complex as possible without unnecessary cost and over-design.

Lobby

The Office Lobby is the only space throughout the project that was intricately designed for lighting. The lobby itself has many "volumes" requiring separate lighting conditions and solutions. The first volume is the entrance from Jackson St. to the east. This small alcove of the entire U-shaped space has as its main architectural feature, the translucent glass grid framing the entrance to the Parking Garage Elevator lobby and the mid-height plaster wall with a wood-panel background full-height wall. This space contains two rows of recessed fluorescent downlights over the main travel path, and wall-mounted metal halide uplights on the "backside" of the mid-height wall.

Immediately to the north is the lobby's main open "court" currently void of all vegetation, furniture, and oftentimes, people. This elliptical open area is well-lit in the mornings from the daylight penetration, and otherwise lit by the sculptured art-piece luminaires hanging from the 16' ceiling.

To the west is the main entrance lobby from Wells St. to the North containing the security and check-in desk. This space, fluid with the elliptical area benefits from a number of the sculptured luminaires, but has suspended linear fluorescent luminaires, architecturally recessed into the ceiling by the suspended ceiling. (For all intents and purposes, these luminaires are 8" wide and 4' long recessed linear fluorescents) On the white-translucent glass wall behind the security desk track-light MR16s illuminate the upper ¼ of the wall (rather ineffectively).

The third volume extends from the western border of the previous volume south into the office elevator lobby with full-height walls beginning 20' from the northern border. Architecturally, the space has the same grid pattern translucent glass on the west wall as the east alcove, and the same wood paneling on the east wall in the same alcove. Similar sculptured art-piece luminaires hang in a line through the elevator lobby, and recessed downlights add greater illumination to the floor and walls. This space has somewhat limited illuminance due to the few number of luminaires in the space.

Remaining Spaces

Again, due to the lack of tenant fit-out description, office tower existing conditions do not exist. Similarly, under separate contract, the condominium units were developed with lighting relative to an individual buyer's preferences, without regard to power density, appearance of space, or consideration of façade. These spaces are not considered in the existing conditions, and only individual spaces in a faux tenant fit-out are used for the lighting thesis proposal.

Existing Electrical Systems

Office Tower

The existing electrical system distribution to the Office spaces is dependent on the office tenant fit-out for all electrical systems beyond the bus-tapped disconnect. It is assumed that all office low-voltage loads will be subfed from the low-voltage panel, which is fed through the high voltage panel connected to the bus duct. For this reason, a single disconnect has been illustrated for office load panel. All of the office floors are served by a single 2500A, 480/277Y V, 3Φ, 4-wire, bus duct. All office PTAC units (see Existing Mechanical) are served individually by the bus duct and not tied to the office power supply directly. The bus duct rises from the basement to the 17th floor through an initial bus duct riser adjacent to the Condominium riser, which angles and turns down-hall to the electrical rooms of each office floor from 10-17. This bus duct serves only the office tenants. The only office-specific loads not connected to the bus duct are the cooling towers which are served by the house panels for the 10th through 17th floors.

All other house electrical loads are served by house panels or standby panels connected directly to the Main switchboard or through automatic transfer switches to the Main switchboard. Low-voltage requirements for the house loads and emergency loads are supplied by low-voltage panels fed from each high-voltage panel though the appropriately sized transformer. Motors located on the roof including the 5-elevator office bank are all connected to the house standby panels. Emergency panels are connected indirectly to the Main switchboard through automatic transfer switches. Please see the Existing Electrical Riser in Appendix D for more specific details.

Also connected to the Main switchboard, but separate from the rest of the building, is the Retail distribution panel. This panel serves all of the retail locations simultaneously and is not redundant at all. This includes the absence of emergency and standby panels where the standbys are not required by law because of the single floor height.

Condominiums

The condominiums are served by a separate 1200A, 208/120Y V, 3Φ, 4-wire, bus duct extending from the basement through a separate bus duct riser passing through the electrical room on each floor from 1 through 9-Mezzanine. Each condominium is metered in the electrical room on each floor for individual consumption provided to each condominium loadcenter. The condominium house and standby panels are connected to a separately metered section of the condominium switchboard. There are no high voltage panels on the house or emergency branch circuits. The lone standby panel feeds the condominium elevators and therefore needs to feed through a transformer on the panel-side of the automatic transfer switch increasing the provided switchboard voltage to the required 480/277Y voltage for the elevators. During an emergency condition, the generated 480/277Y voltage meets the elevator’s requirement and therefore bypasses the transformer. The emergency panels are connected indirectly to the condominium switchboard through a separate automatic transfer switch. Please see the Existing Electrical Riser in Appendix D for more specific details.

Parking Garage

The Parking Garage electrical distribution is fed entirely through panel P / HA and not any specific distribution switchboard as was the case in the other two occupancy types. This panel is sized large enough to subfeed the two additional Parking distribution panels, which in turn feed the low-voltage panels. The two elevator banks within the parking structure are fed from this panel, and the single emergency panel for the entire structure is indirectly fed from this panel through an automatic transfer switch connected to the emergency power distribution panel.

Building Electrical Utility Distribution

From these three individual systems, the utility provides a number of individual cable pulls and service entrance locations and voltages. These three systems are fed through their single main distribution points – the Main switchboard for the office tower and office-related mechanical equipment and elevators; the Condo switchboard for all of the condominium loads including the two elevators and condo mechanical loads, and the Parking distribution panel P / HA for all of the parking garage loads including the 4 elevators and all parking-related mechanical loads.

The Main switchboard is a double-ended, redundant transformer breaker-tied bus fed from the utility's 13.8kV Δ service entrance in the electrical vault. This is a building-owned transformer system with the advantage of reduced utility costs associated with quantity usage and service voltage. This also has the advantage of requiring thinner gauge high-voltage feeders eliminating the need for electrical bussing or large-radius cable angles.

The Condo switchboard is a single-service bussed switchboard with a sectioned metering and breaker separating the house loads from the individual condominium loads. This system sees no redundancy, and is fed from a utility-owner transformer in the electrical vault at a service voltage of 208/120Y V. This system has the advantage of being completely separate from the office tower for better isolation and non-contingency on failure of a single high-voltage service. The disadvantage is the increased service cost associated with the utility-provided transformer and lower service-voltage.

The Parking distribution panel is a simple distribution panelboard fed from a utility-owned transformer in the electrical vault providing a service voltage of 480/277Y V. This system can be metered completely separately by the utility company and is also completely isolated from the high-voltage service. The advantage again, is the separation for the owner entities that do exist, but the disadvantages are the costs associated with the utility installation of a transformer and the lower service voltage.

While, from the utility's standpoint, all of these services may be fed from probably two transformers within the electrical vault and there is less separation of the systems in actuality, the cost associated with buying transformers in excess of 3000kVA becomes an annoyance for the utility which gets passed down monetarily to the customer.

Existing Mechanical Systems

Office

The mechanical system for the office tower is specific to each floor. Each floor is serviced by a single Packaged Terminal Air Conditioning unit (PTAC). The mechanical layout of each floor is specific to the tenant fit-out, but each tenant can tie back to the PTAC system for all of their heating and cooling needs.

All of the PTACs are served by a single hot-water loop for heating and a single, but separate, condensate water loop for cooling. All PTACs are connected to this loop in parallel and all of them are sized equally except for the 17th floor which has a smaller serviced floor area.

The hot water (henceforth referred to as "heating loop") runs from the basement office steam-to-water heat exchangers at 190˚F to the heating loop pumps and up through an 8" diameter pipe (tapered as height increases) to the PTACs and is returned through a single 8" diameter pipe back at 178˚F to the heat exchangers.

The condensate water ("cooling loop") runs from the basement to the cooling loop pumps and up through 10" diameter pipe to each of the PTACs connected in parallel at 85˚F. From the PTACs, the 95˚F runs up to the 17th floor. At this point, a bypass valve allows up to 1000gpm to bypass the cooling towers based on a temperature of 40˚F or less (assumed to prevent freezing). All other cooling loop water is run through one of two cooling towers and then dropped back to the basement through a 10" diameter pipe back to the pumps.

For all retail and house heating or cooling loads the same office loops are used, run in the same parallel loop/circuit, where the loads are connected a second time in parallel. This gives the system the impression of just another large PTAC instead of many smaller mechanical heating and cooling elements.

Condominiums

The condominium heating and cooling solutions are very similar to the office tower, but with a slight difference. The heating loop is, again, begun in the basement at the condominium steam-to-water heat exchangers, pumped through the combined heating and cooling pumps at 81˚F (around the bypass valve depending on necessary capacity for heating or cooling), and up through a parallel circuit to each floor serving each of the water source heat pumps in the condominium units connected in a second parallel circuit. All of the fluid used in the heating and cooling loops in the condominium is a 40% ethylene glycol solution, however. The heating loop then returns the 75˚F water via bypass valve to the heat exchangers in the basement.

In the case of a cooling load, the same loop is utilized, except the initial bypass valve prevents the heat exchangers from seeing the loop. From the heating/cooling pumps, the 85˚F water flows up through the same parallel circuit into the same floor parallel-connected circuit of heat pumps, and up to the Evaporative Fluid Cooler on the roof. This closed system cooler reduces the temperature of the water from 95˚F to the initial 85˚F and returns it to the basement pumps. This single-pipe system with bypass is very logical for the condominium and it is questioned why it was not used in the office tower loops. The main reason assumed is the difference in entering and leaving water temperature for heating and cooling in the PTACs.

Parking Garage

The parking garage is served by simple hot water unit heaters at the 9-Mezzanine floor under the office structure (aka, not the 10th floor deck or open ceiling). This is to prevent excessive heat loss from the office tower's 10th floor slab. The only other mechanical systems above grade are located in the elevator lobbies and are simple electric cabinet unit heaters. Below grade and at ground level are the air handling units and fans specifically designed to supply outside air to the basement to remove carbon monoxide and additional air handling unit systems for the retail spaces mentioned previously (i.e. outdoor air supplies and ducting, air cooled condensing units, etc.)

Existing Structural System

Foundation, Parking Garage and Condominiums

Due to the architect's preference to limit the number of structural drawings made available for this thesis, information regarding the structural system is based on the 3 drawings provided and the verbal information gathered over the course of the thesis.

The building rests on simple concrete foundations 8' square and a building footing along the perimeter. The main structural system of the Parking Garage are composite steel columns on footers every 20' North and South and in two adjacent (2'8" separated) "rows" with 56'8" spacing between columns East and West. The 6" unbonded post tensioned floor slab rests upon post-tensioned beams only spanning between columns. Due to the difference in grade for the slabs at the parking garage midpoint, the slabs were split into two sections. The southernmost section is a one-way post-tensioned slab, while the northernmost section is a two-way post tensioned slab.

The condominium structural system, completely separated from the Parking Garage structural system from the footings to floor 9-Mezzanine, is made up of an irregularly patterned "grid" of columns spaced much closer together than the parking garage (read, "about every 15'") with a concrete wall supports for the southern third of the condominium section. The floor for the condominium section is an 8" thick unbonded two-way post-tensioned slab.

Office Tower

At floor 9-Mezzanine, the structural system of the building changes from a composite column and post-tensioned floor slab design to a composite steel moment frame with concrete on form deck for the floor system. The frame is connected directly to the column grid structural system developed in the lower 9 floors, and connects the Parking Garage and Condominium concrete sections. This steel frame continues up through the roof and the slab on deck flooring is consistent through the upper floors.

The entire structural system is, in essence an upside-down horseshoe as far as system interconnection is concerned. Based on the drawings, only this information could be obtained and no further explanation could be obtained for this system (and certainly no assumptions were going to be made).

Orientation, Daylight, and Environment

The orientation of the building is directly north and south. The "long" sides of the building face east toward the lake and west toward the rest of Milwaukee. The main office tower is located at the northernmost point. At a latitude of 43.03˚N and 87.99˚W longitude, the building receives a great deal of southern direct sun exposure. The building in essence "faces" north.

Daylight in the building is all relative to the altitude of the sun and the azimuth toward the surrounding, taller buildings. The US Bank Corp building, the largest in Milwaukee, is much taller than Cathedral Place, with the closer, Wisconsin Gas building also reaching well above Cathedral Place's roof line. For this reason sunlight comes in and out throughout the day depending on the time of year.

The environment in Milwaukee is moderate with cold brisk winters, and mild, moderately humid summers. The average winter low temperature is 18.9˚F with the average summer high being 71˚F. Over the course of the year, 25% of the days are clear, 25% are partly cloudy and 50% are cloudy. These weather conditions factor into the development of the building systems considerably.

Utility Services

Cathedral Place has a considerable electrical service for all of the power requirements and for cooling, but not for any heating. The heating systems utilize the grid steam utility provided to the downtown area for heating of water for the heating systems and potable hot water needs. Cathedral Place also has a small Natural Gas utility provided for the condominium and restaurant units as none of the heating systems require natural gas. All of the above utilities are provided by WE Energies Corp., a recent union of Wisconsin Electric Power Co. and Wisconsin Gas Co.

Architectural Breadth

Architectural Breadth

An architectural breadth was chosen early in the thesis project due to the lack of information provided for tenant spaces throughout the building. Not wanting to invent lighting spaces for the Lighting Depth, it was decided to create the architectural spaces under the tutelage of an Architectural Professor – Scott Wing, AIA – for the architectural development of a single tenant area. From the development of the entire area of this space, a few areas of interest could be chosen to use in the Lighting Depth. In doing so, this also made available the types of areas of specific interest for this thesis.

Relationship with Thesis Project

This architectural breadth, as was previously mentioned, concerns three main spaces used in the Lighting Depth, and impacts the Structural Breadth as well. Developing the upper three floors of the building for interior design, impacts the following areas: existing skylights for the Reception area, a new skylight in the Reception and Conference Lobby areas; the structural impact of cutting a skylight into the floor slab of the elevator machine room; and the structural impact of cutting a stairwell hole into the 17 and 16th floor slabs.

Design Program

The design program was provided by Gensler Architects as a "wiped" version of the current tenant assumed to be Deloitte & Touche (or Deloitte. as a member of Deloitte Touche Tohmatsu). The program itself can be found with Appendix A .

From the program, three floors were developed and integrated with "architectural freedom" from which the existing systems, if necessary, would have to be amended. Since all of this took place in the fall semester, the resulting design of all the systems for this thesis resulted from this development.

For a better idea of the end result of the breadth, hand-drawn floor plans have been included in the same Appendix. A CD containing the Final Submittal has been included.

Chosen Spaces – Foci

Reception

The architecture of the Reception area was based on an obvious layout of space for the Penthouse (17th) floor. When occupying the most expensive spaces, especially those with roof/skylight access, the space should be immediately impressive as soon as one steps off the elevator. A desk modeled after the existing security desk in the lobby was used as the front desk, with an impressive display of the skylights and front desk drawing the visitor's eye immediately.

The program for design called for a number of conference rooms for regular meetings with clients. Given that a client's access is only by elevator to the 15th-17th floors, and that these clients need to be comfortable and impressed, the reception as a dedicated appealing space was chosen. At the south end of the elevator lobby at the reception level is the translucent glass door for access by employees and for security purposes. This way, the reception area is "reserved" for the high-profile clients only.

Moving toward the idea that the clients need quick access to conference facilities, and the fact that those facilities would not fit on the 17th floor, an easier method would have to be developed to bring the clients to the meeting rooms without sending them "back where they came from" – the elevators. Also considering the considerable space needs for the directors and managers, access should be easy for them as well. The idea came together that the conference rooms would be located directly beneath the reception area and a stairwell would connect the two with as much immediate adjacency as possible. This stairwell could also not serve as the fire escape, since the high-profile impression would soon wear off in a concrete and CMU stairwell.

The choice was made to put the stairwell behind the elevator bank. While this seems a contradiction in transportation, given the fact that these stairs are only used by Deloitte & Touche, and more specifically for their clients, an air of exclusivity is given, impressing the client even more. In the case that the visitor was not a client, but visiting personnel on the 17th floor, the area immediately north of the stairwell was made into a sitting/waiting area. Likewise the area immediately east of the reception desk was given a few chairs for the same purpose.

Conference Lobby

Working with the stairwell idea and the "shortest travel path possible" mentality for impressing and providing comfort for clients, the Conference Lobby was naturally developed. Given a single main entry point, the entire space focuses (quite literally) at the base of the stairs. The curvature of the walls give a fuller, more volumetric look to the space and give the client equal options to travel to a given conference room. This option, while oftentimes not an "option" in the traditional sense, psychologically affects the individual who is traveling the shortest path possible – not adding to their comfort, but instead preventing their discomfort.

The stairwell as a main element of the space had to be developed in detail. Corresponding directly with an analogy made for the choice of wood paneling on the curved wall surface, the stairs were "floated" as best as structure would allow. The wood panel, as mentioned, was raised off of the floor and brought forward from the actual wall to give the impression that this massive volume was being floated. This is furthered by the transparent glass area at the top of the wall, where it appears as though the wall is supported only at its base. The transition spaces at the to 45˚ angles from the base of the stairs to the "back conference rooms" were given a wood paneling on their initial 4'-6' of wall space to further the notion of this massive wood volume.

The intermediate space between the actual Conference Lobby and the Entrance to the Open Offices was developed to seal the void between the three spaces and create better continuity. Following the architectural plans (altered in minor detail), this space was the reception area for the service elevator through which all deliveries would pass. This area was also the entrance to the sealed open office area (so as to separate the business from the everyday facilities activities and mail area.

Open Office

The Open Office area came as a development of the need for general purpose office space. An idea for a thesis project early on came to fruition in this space (as can be seen in the Lighting Depth). The idea was to create a truly open space without any ceiling mounted fixtures and to maximize the daylight penetration of the curtainwall to the west (or east/south as the open office has been implemented on the East and South faces as well).

The space was intended to delineate areas as hierarchy within the business. The open office was utilized by the general employees in a row-and-column fashion, while the individual or paired open office desks were given to the administrative assistants. The open cubicles were intended as a pointer toward the management and clustered to better provide for interaction among the managers as necessary. The full-height translucent glass offices were to increase the hierarchical awareness considerably as they maintained relative privacy as they saw fit. These directors (highest in the program's food chain) were given windows as much as possible, were given doors for importance and confidentiality, and were located generally near the administrative assistants and managers and away from the general employees and facilities operations. They were also located as near the "inter-office" conference rooms as well.

The use of the translucent glass for daylight penetration was to attempt to provide an area source lighting that would not hinder work through any glare elements. The translucent glass at the top 2.5' of the offices also allowed as much light to pass through as possible and reflect off of the ceiling for better daylight illumination.

Additional Architectural Adjustments

Lobby Façade Canopy

A major concern of the owner's was the daylight penetration into the ground-floor main lobby. The specular finish of the floor gave rise to a very glary condition. As developed in the Lighting Depth, an additional canopy extending from the existing canopies (such that it maintains the form and characteristic of the original canopy) was placed at the same height and "revolved" around the elliptical façade to maintain the shape and contour of the main façade.

As was mentioned in the Existing Conditions, the elliptical cylinder would no longer extend from street level to roof-line. Upon consideration of the impact this new canopy would have on the building, it was observed that on all street-accessible façades canopies, of varying height, existed on 75% of their total length. Therefore, this canopy was deemed to not as much impose upon the tubular nature of the ellipse, but provide a base, or low "skirt" for the entire building – an idea developed considerably in the Lighting Depth proposal for the faced lighting.

The main difference with the new canopy design in relation to the current canopies over the two entrances is the use of tension cables to resist deflection at the end and support stability (see Structural Breadth for details). These cables, while different from the immediately adjacent canopies, mimic exactly the remaining canopies used on the eastern and southern facades. In addition to this, the cables themselves would

Skylight stair-Well

First and foremost, function of the stairwell had to be possible. After analysis of the structural system of the upper floors was completed, (and luckily the easier-to-work-with steel frame) it was determined that the new skylight stair-well would cut into the elevator machine room at the roof level. The elevator machine room is a closed space, with a lot of unused floor area. When compared to the location of the elevator motors and fire control equipment, it was found that more than sufficient space was available to "open" the roof and erect two additional, non-load-bearing walls into the elevator machine room. This opened the skylight to the sky without taking away from the architectural form of the building as seen from anywhere except above it (a very unlikely circumstance in Milwaukee).

The skylight stair-well had to be architecturally pleasing as well as functional. For this reason, and through a bit of luck, the 17th story grid was offset slightly inside the wall limits. This allowed the 17th floor to have a small "plant balcony" at the first horizontal surface inside the skylight.

As was mentioned in the Reception description, an attempt to make the stairs "float" was furthered by the use of transparent glass walls and railings preventing people from falling into the stairwell's "hole". This would indeed be a problem, as the column of space allocated for the stairwell was greater than the designed area of the stairwell. This open space would allow better daylight penetration to fall into the Conference Lobby and into the 15th floor as well.

The last remaining architectural characteristic of the stairs was the choice in material. Given the stairwell was to act as a stairwell and lightpipe (although rather "inefficient" as a lightpipe), and it was to maintain a certain comfort and high-profile with those who frequented it most, white and grey marble was chosen as its tiling material. Because of the abusive weight of an entire stairwell of marble (not to mention the cost), the stairs were, as stated, simply tiled. Matching the white plaster walls of the stairwell, ascent and descent of these stairs was likened to "walking on clouds".

Conclusions

The architecture of the space spanned an entire semester. It was well thought out and conferred upon with a professor of architecture – one who teaches courses on interior materials and is familiar with interior layouts and rationale. The program was the exact program provided to Gensler Architects by Deloitte & Touche, so the architecture is a very feasible design solution that, under proper direction and with greater experience could have seen its way into design development for the actual space.

The better part of the breadth was the development of spaces and the simultaneous brainstorming of ideas to be used within the Lighting Depth for, what was then, the following semester. While all of the space was laid out in plan, only a limited amount of it was brought into 3 dimensions and even less was utilized in photorealistic rendering. While other architectural elements such as the canopy will have a more significant impact on the look of the building, the breadth study provided a very accurate representation of how a tenant fit-out can be designed, and the effects architectural changes can have on the designed structural, electrical and mechanical systems of the building.

Structural Breadth

Structural Breadth

The structural breadth for this thesis was chosen late in development as a response to the use of a seemingly exorbitant cantilever at the ground floor of the building's lobby. Fully aware of the questions this canopy would produce in its effectiveness and/or constructability, it was decided that a structural breadth analyzing the canopy would serve better purpose for the overall thesis project. Additionally, following the choice of a structural breadth altogether, the analysis of all architectural modifications was chosen. Therefore a small breadth relative to the skylight wells cut into the roof floor slab, and the stairwells cut into lower floor slabs should also be analyzed for implementation. Note: the analysis was not completed on the entirety of the structure, as the elements chosen do not affect the structure on the whole by relative comparison, but also that modeling of this building is, as peers have deemed it, very difficult.

Relationship with Thesis Project

The canopy being designed as the major focus of the structural breadth would be constructed between the two existing canopies at the north and east entrances to the main lobby at the northeast corner. This canopy's intention is to block out direct sunlight and glare resulting from early morning direct sun. Modeling the new canopy off of the current canopy design and following the architectural form of that section of building, a longer, broader, and curved canopy had to be developed to maintain the architectural form of the northeastern corner.

Façade Canopy

The façade canopy in plan is shown in Appendix B. The canopy has the elliptical shape as described previously and this makes it relatively hard to model through a single representation or at the expense of modeling the entire structure to detail. Based on the largest dimension found for the canopy, a single "bay" type of model was developed for a section of the canopy that can be applied equally too all sections of the model including an additional factor of safety built in by the "worst-case scenario" analysis.

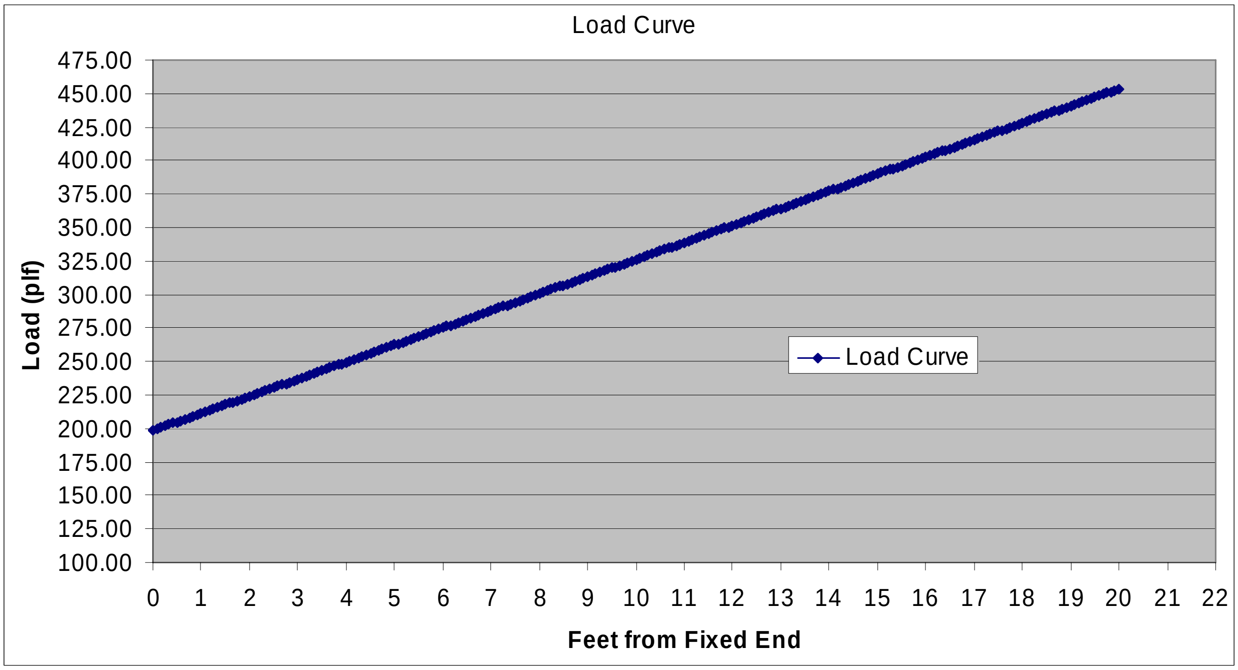
Based on the section of the existing canopy and its dimensions similar shapes were used for the cantilevered members and a similar shape was intended to be used for the cantilever's support members. The following design loads were applied to the structure to be analyzed:

Dead Load –	MEP – 10psf	
	Deck Wt – 3psf	
	Insulation – 2 psf	
	Collateral – 5 psf	TOTAL = 18psf
Live Load –	Snow – 30psf	TOTAL = 30psf
Self Wt –	Wt. – 8.7psf *	TOTAL = 8.7psf

TOTAL LOAD = 56.7psf

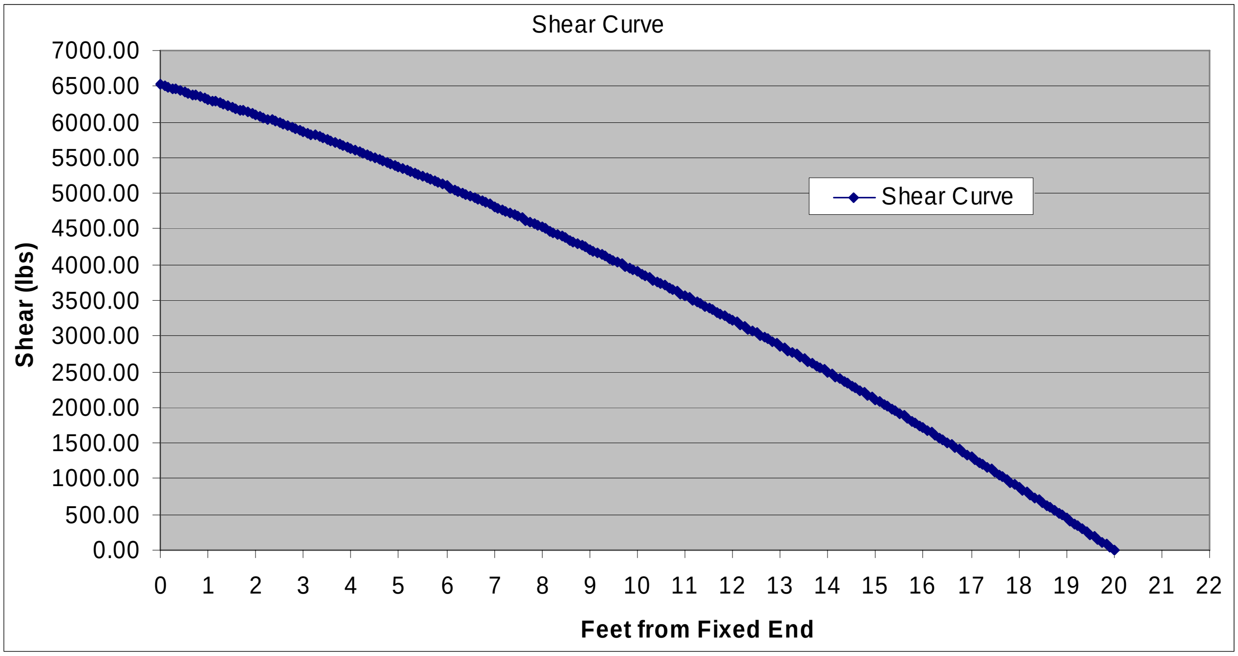
* Calculated from 50plf member (conservative) averaged over the wedge area

Because the shape is a curve, the tributary area at the "base" will be less than the tributary area at the "head". From the dimensions, the average end dimension was 3'6" and the average cantilevered dimension was 8'. This resulted in a load diagram as seen below.

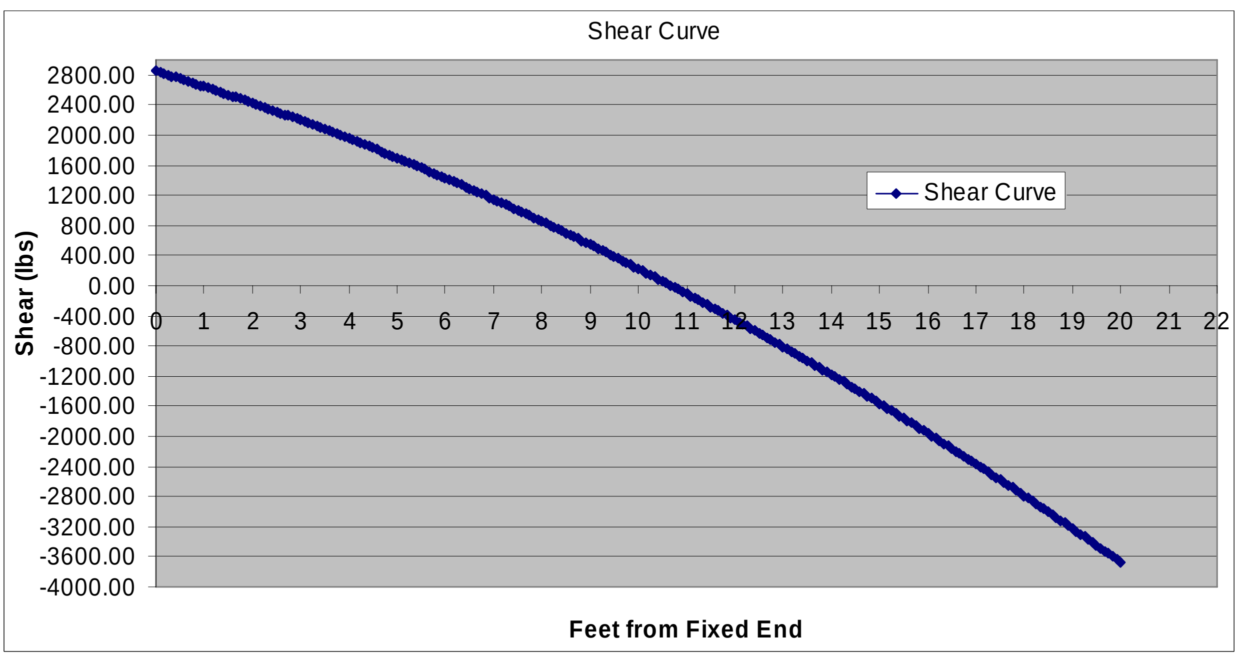


From this, the reaction forces were found for two conditions. First, the condition where the cantilever was purely cantilevered and only supported at the base member was considered. For a second analysis (to be explained), a cantilever with a tension cable was considered. Based on the reactions found, the tension in the cable for the second condition could be calculated. The resulting shear and moment diagrams were found for the two conditions and are shown below.

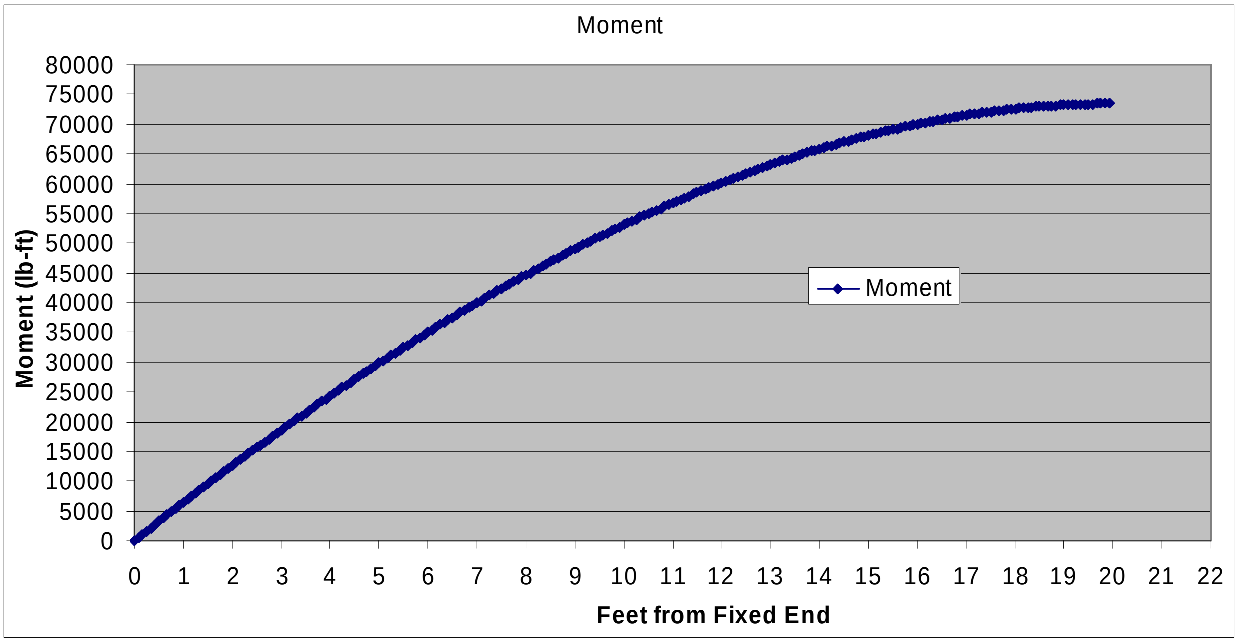
Cantilever Option – Shear Maximum = 6521 lbs At Base = 6521 lbs



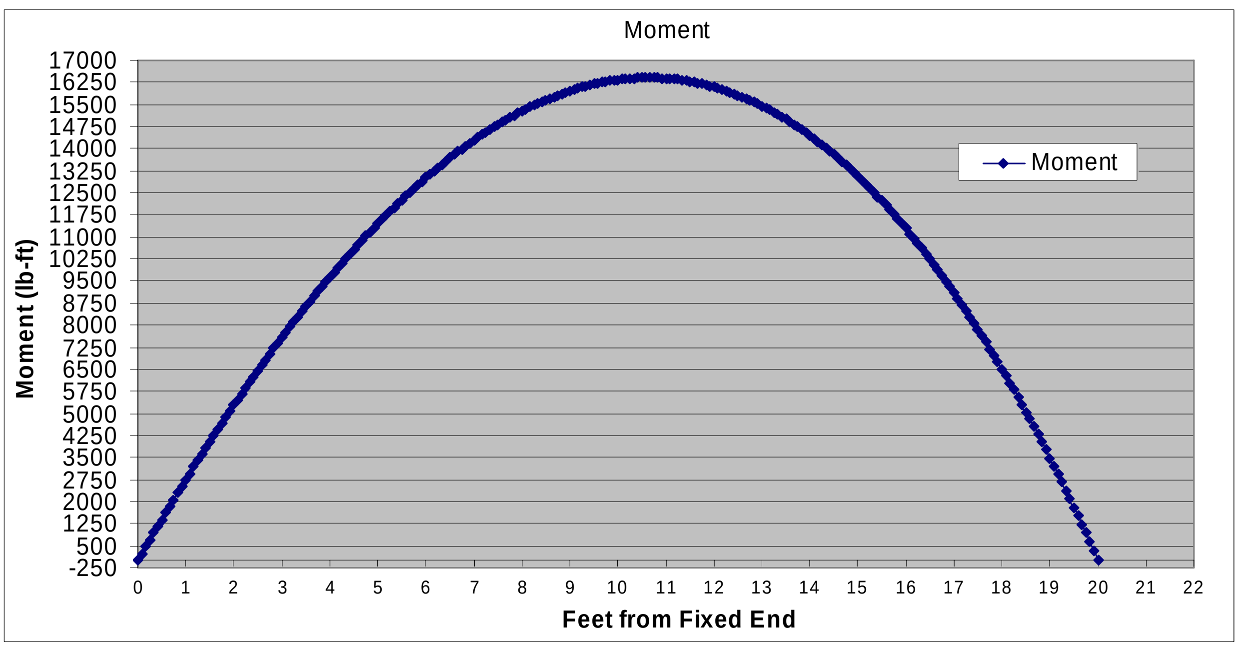
Tension Cable Option – Shear Maximum = -3619 lbs At Base = 2850 lbs



Cantilever Option – Moment Max = 73.4 ft-k At Base = 73.4 ft-k



Tension Cable – Moment Max = 16.4 ft-k At Base = 0 ft-k



Based on these diagrams and the maximum moment found for each condition, a member was chosen using the 2005 AISC Steel Manual. The maximum moment at an unbraced length of 20' was used for both the cantilever and tension cable options. These calculations and the resulting member chosen assumes that the base end of the cantilevered beam is purely fixed, with no base member rotation – a point found to be of great importance for a full cantilever option. The chosen members are as follows:

Full Cantilever Option	-	MC12x50
Tension Cable Option	-	MC8x21.4

These diagrams and the associated members were checked using STAAD Pro. Based on the moments and shear values matching, the maximum deflection was found using the program to save time.

STAAD output Cantilever Base	-	Moment = 72.4 ft-k	Shear = 6518 lbs
STAAD output Tension Cable Base	-	Moment = 5.7 ft-k	Shear = 2327 lbs
Deflection Cantilever	-	-1.675"	
Deflection Tension Cable	-	2.610"	

Because of the extreme positive deflection in the smaller, tension cable member (due to the assumed self weight of 50plf and actual self weight of 21.4plf), the load was adjusted in STAAD to determine the resultant vertical cable tension. The goal was to produce 0 ft-k moment at the base of the cantilever such that the supporting member would only see column-axial load.

Full Cantilever Option

With the full cantilever option, the initial cantilever member must be a very large channel, with a significant self-weight. Additionally, the member deflects at the end -1.675" even when considering the supporting member to be a perfectly fixed end. In reality, the supporting member will rotate and a considerable torsion of 72.4 ft-k will be placed on it at every connection point.

The results of attempting to size the supporting member to match the current canopy detail for the cantilever resulted in the following:

Max Moment (Torsion)	= 144.75 ft-k
Max Moment (Bending)	= 47.11 ft-k
Max Deflection (Cantilever end)	= 7.5"
Max Shear (Column End)	= 13.5 k

As one can see, the torsion placed on the member at the connection point with the columns is considerable compared to the bending moment. Due to the lack of knowledge in torsional failure (especially for HSS Round or HSS Rectangular shapes currently employed in the canopy section), further analysis of the Cantilever Option was deemed unnecessary. The deflection seen by the Cantilever is also considerable when considering a simple cantilever, and this results in a rotation of the supporting member of 1.79˚. Additionally, comparison to the tension cable member shows that one could purchase about 3 of the tension cable members for the equivalent weight and size of the cantilever member. At this point, it was decided that the Cantilever might be a better choice.

Tension Cable Option

With the tension cable, the resulting necessary cable force needed for a 0 ft-k moment at the supporting member end was 3333.3 lbs upward. This results in a 1.871in upward deflection. The goal was to add these elements to the proposed cantilever design for a single supporting member. Using STAAD Pro, it was decided that two analyses could be completed. One where the maximum deflection of the entire structure was 0" total, and one where the moment at the column was 0 ft-k.

Using the upward force of 3333.3 lbs and resolving the axial force in the cantilever produced by the angle of the tension cable (3897.4 lbs) the following results were obtained for the cantilever:

Max Moment x-axis (torsion)	= 0 ft-k
Max Moment y-axis (bending)	= 19.8 ft-k
Max Moment z-axis (lateral bending)	= 27.3 ft-k
Max Deflection	= 1.83" (upward)
Max Shear at Column (lateral)	= 7.8 k

All of these numbers fall well within the limits of the available bending moment of any HSS10x10 thickness. Therefore, from the steel framing standpoint, the canopy works beautifully. The supporting member could even be downsized to meet the new loading requirements; however, given the current canopies size, it would be more difficult to introduce a new size and possibly cost prohibitive.

The second analysis takes the cable system and is only concerned with the maximum deflection the cantilever can take by code – L/360 or 0.67". By adjusting the forces in STAAD to obtain a deflection that does not exceed 0.67" the following results are obtained.

Max Moment x-axis (torsion)	= 23.7 ft-k
Max Moment y-axis (bending)	= 23.9 ft-k
Max Moment z-axis (lateral bending)	= 22.5 ft-k
Max Deflection	= 0.656" (upward)
Max Shear at Column (lateral)	= 6.9 k

The concern that arises with this steel design is the implementation of the cable system into the current concrete column structure. Each of these cables would be tied to one of the four exterior columns either inside, or immediately outside of the façade. The four columns have been shown with cabling in Appendix B. Each of these columns requires a maximum lateral force of 3.9 k per cable for the 0-moment design and 3.3 k for the 0.66"-deflection design. The largest number of cable applied to a single column would be 5 under this design resulting in either 19.5 k shear or a 16 k shear. Whether or not the column would be able to withstand a shear force of this magnitude is uncertain for two reasons. First, analysis of the column would require more information about the column, and given the lack of structural drawings and information, one cannot determine the properties of the column to make any valid design. Second, this analysis begins to fall outside the scope of the breadth work which was to analyze whether or not such a canopy could exist. Since it can be constructed, can take the appropriate loading, and requires only a shear connection to the columns, it is reasonable to assume the canopy can be easily constructed.

Cable System

The cable system is relatively easy to design. Based on the maximum required vertical component (for the 0-moment design) of 3897 lbs, the tension in the cable is 5127.6 lbs. Based on the maximum required vertical component (for the 0.66" deflection design) of 2825 lbs, the tension in the cable is 4342.1lbs.

Using the yield strength of A36 steel as a relative minimum for typical steel elements, and the required tension force, the thickness of the steel cable can be computed. The calculation also includes a 0.6 safety factor since the structure would collapse in the case of a cable failure. This also accounts for excessive stresses built up over the course of many varying load conditions (read "winter seasons"). Based on these two facts, the 0-moment design requires a cable of 0.237 sq in and the 0.66" deflection design requires a cable of 0.201 sq in. This equates to a 0.55" diameter cable and a 0.506" diameter cable respectively. Given the difference and the probable standardization of cables, the 5/8" diameter cable would suffice for both designs.

Skylight stair-Well

Stair-Well

The skylight stair-well was the other structural entity that required analysis in the redesign of the architectural spaces relative to the Lighting Depth. Using the single bay of the steel frame at the 17th and 16th floors for the skylight and stairs respectively, the analysis had to account for any change in the weight distribution over the floor area.

At the time of design, completely unaware of the impact, the stairwell was cut into the entire bay. (See the Lighting renderings under "Reception" for a better view). This bay would allow excess light from the 17th floor to spill into the 16th and 15th floors – as was the design intention and goal. Because the stairwell "hole" was cut along the steel frame members, no actual design of supporting beams was needed. This part of the skylight stair-well design was, suffice to say, quite easy.

Skylight

The actual skylight was a little different, and did require the design of 4 separate members placed off-center. Each of these members had differing tributary areas and, therefore, had differing calculated uniform loads. The loads applied to the floor area of interest to each member are as follows:

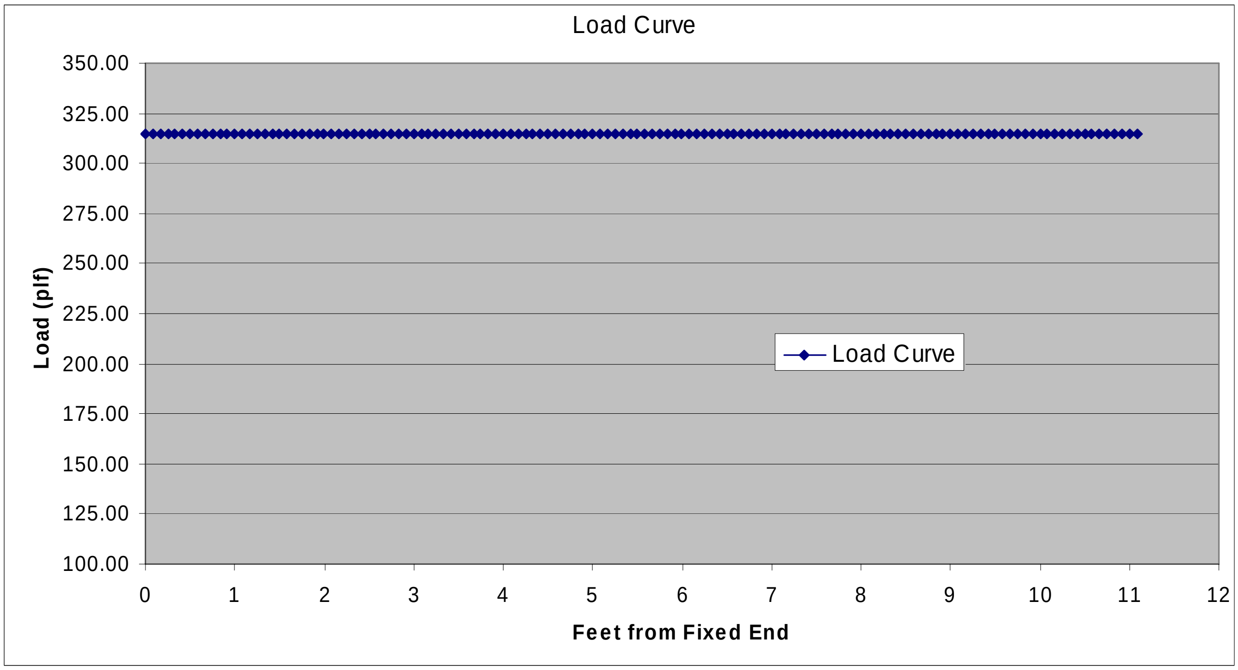
Dead Load –	SDL – 25psf	
	Deck + Concrete – 48psf	
	Finishes and MEP – 5 psf	
	Collateral – 5 psf	TOTAL = 83psf
Live Load –	Live – 80psf	TOTAL = 80psf
Self Wt –	Wt. – 20psf	TOTAL = 20psf

TOTAL LOAD = 103psf

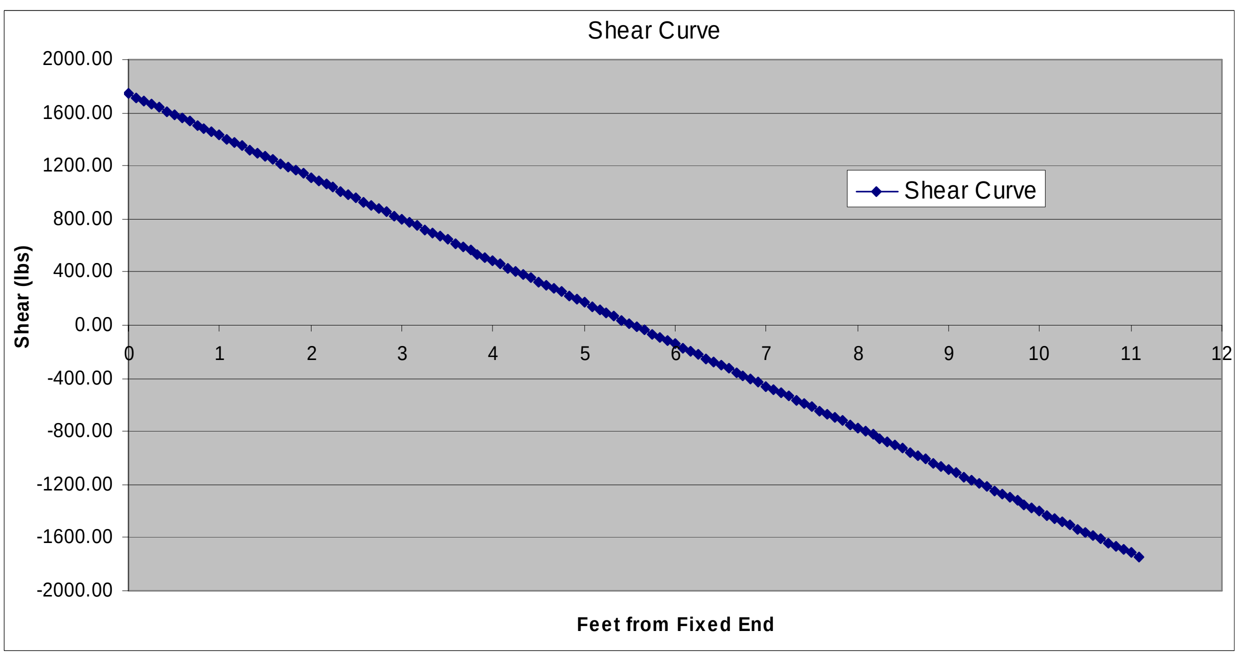
The loading, shear, and moment diagrams for the 4 members are shown below.

Member A

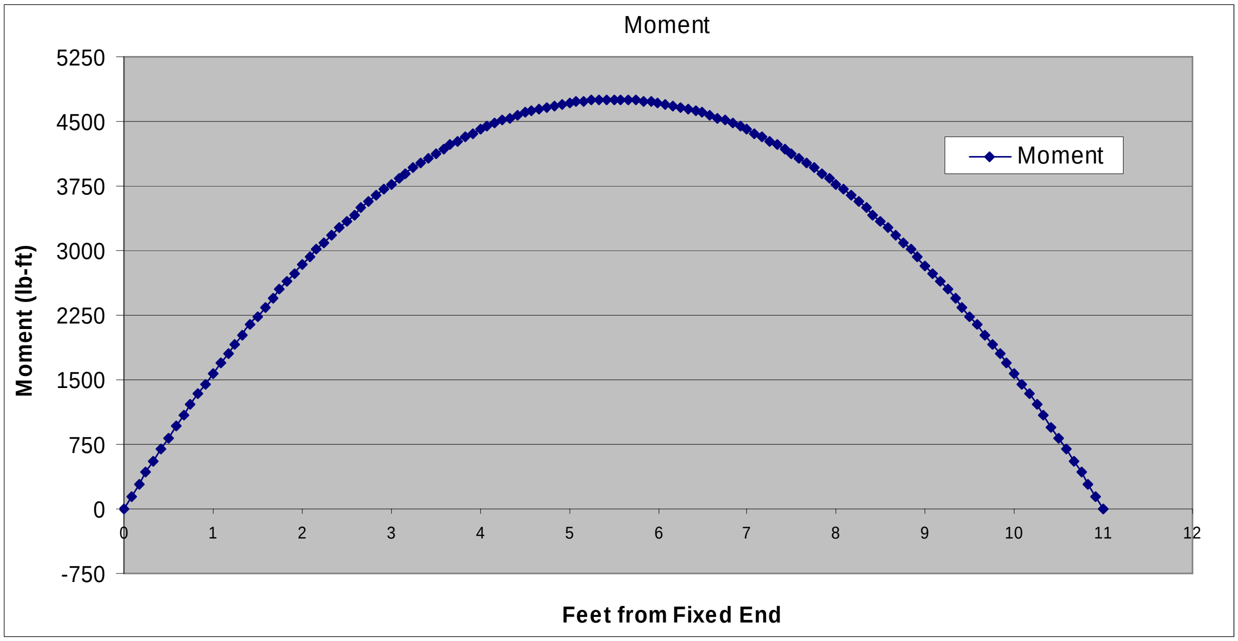
Loading



Shear Max = 1742.8 lbs

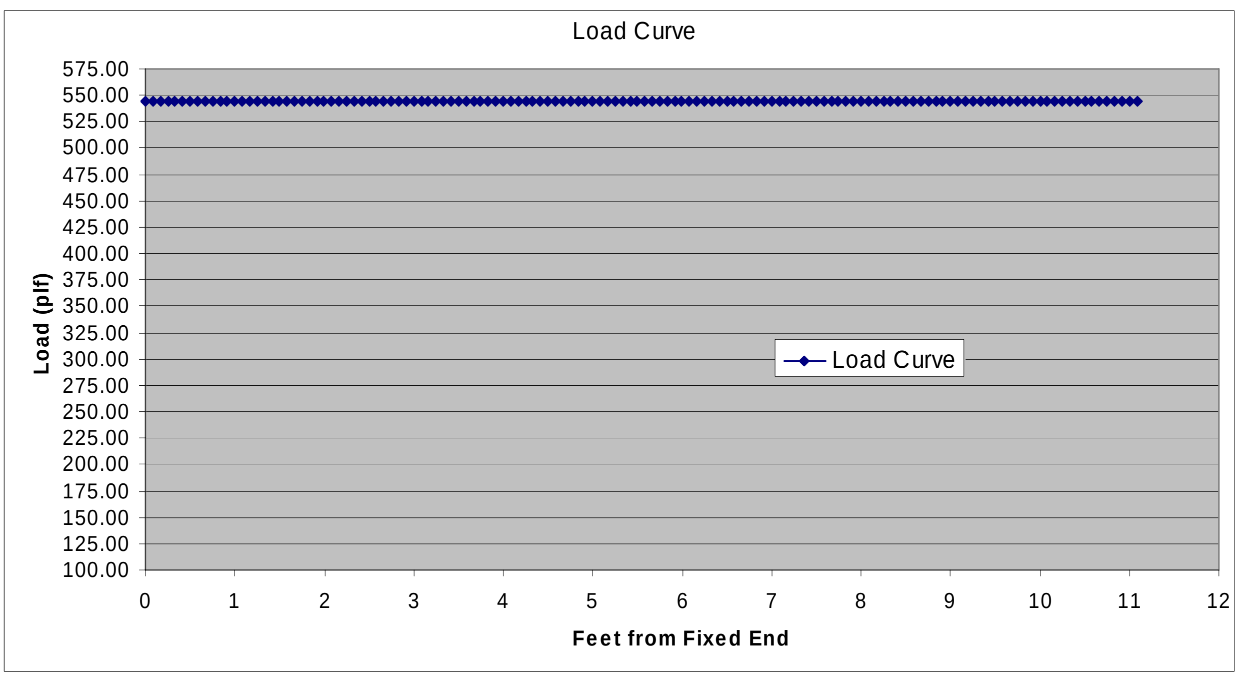


Moment Max = 4.76 ft-k

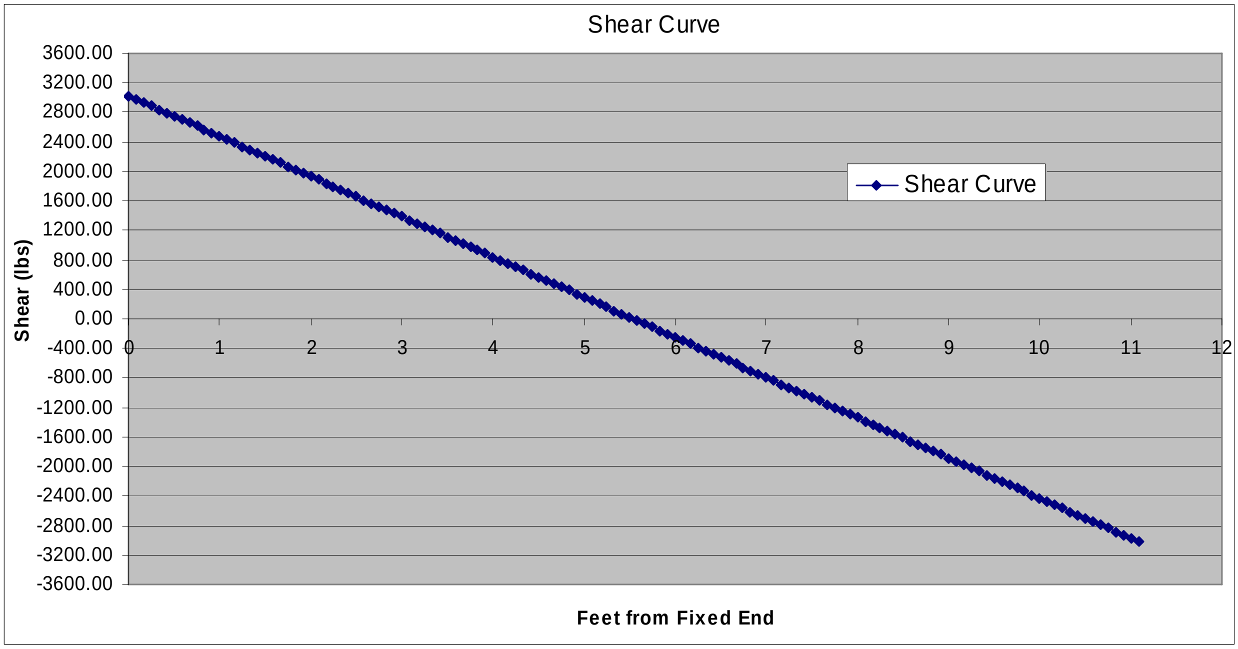


Member B

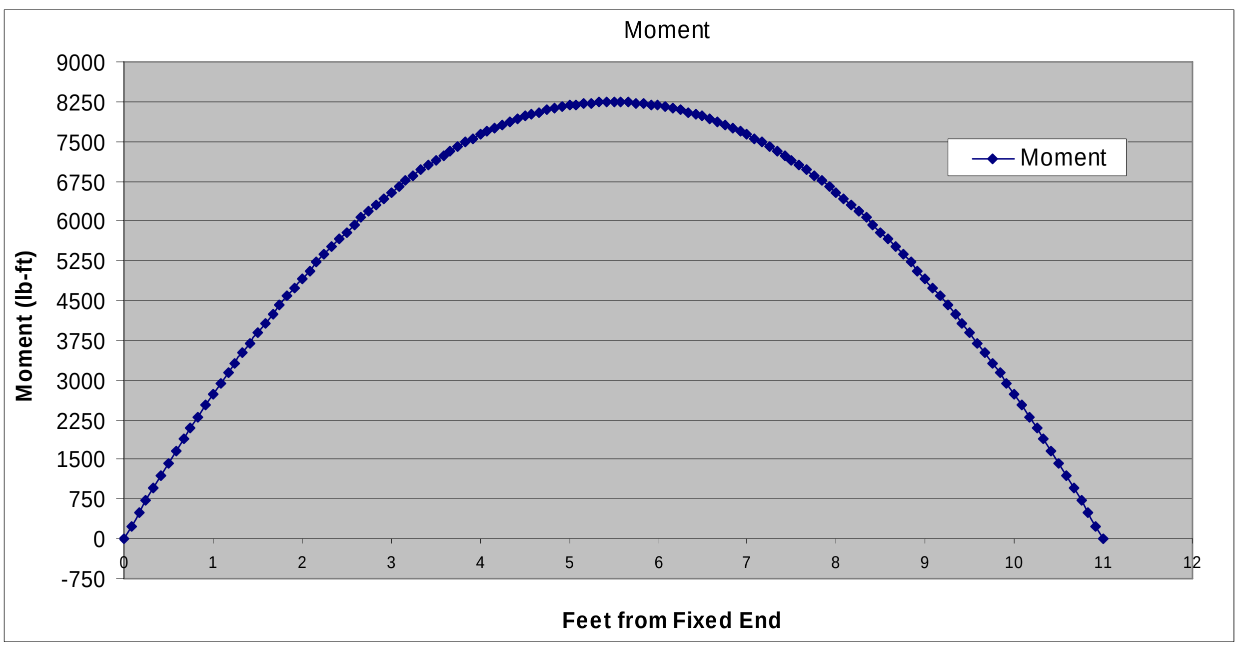
Loading



Shear Max = 3020.7 lbs

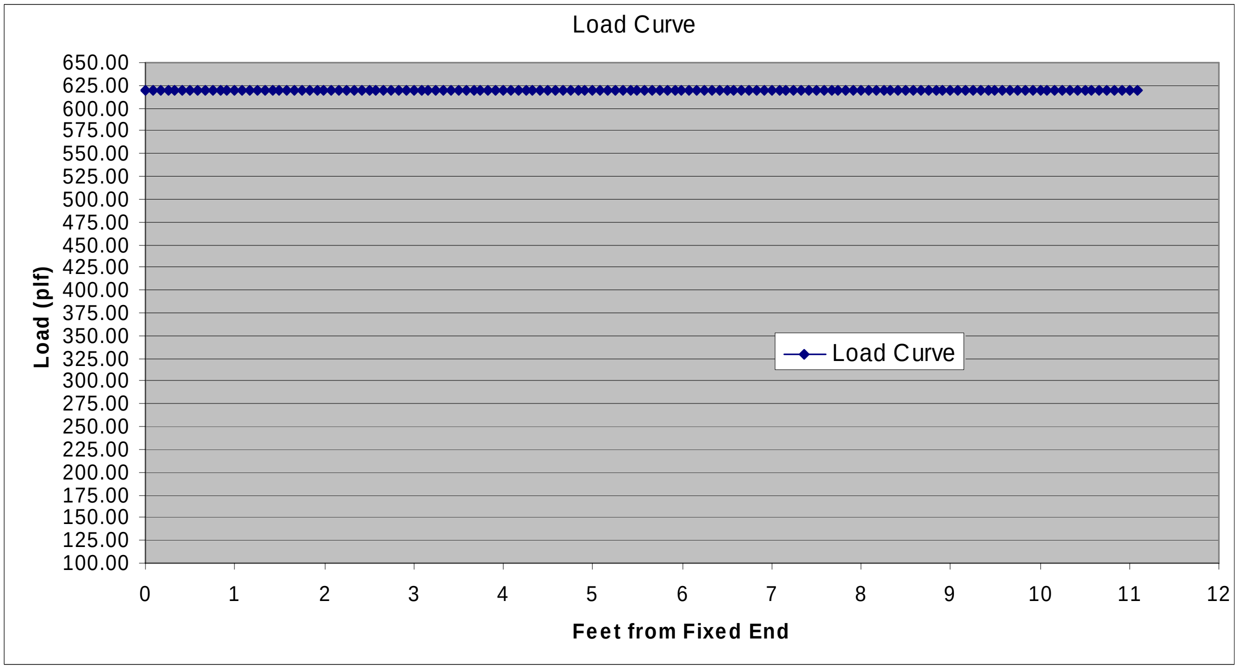


Moment Max = 8.24 ft-k

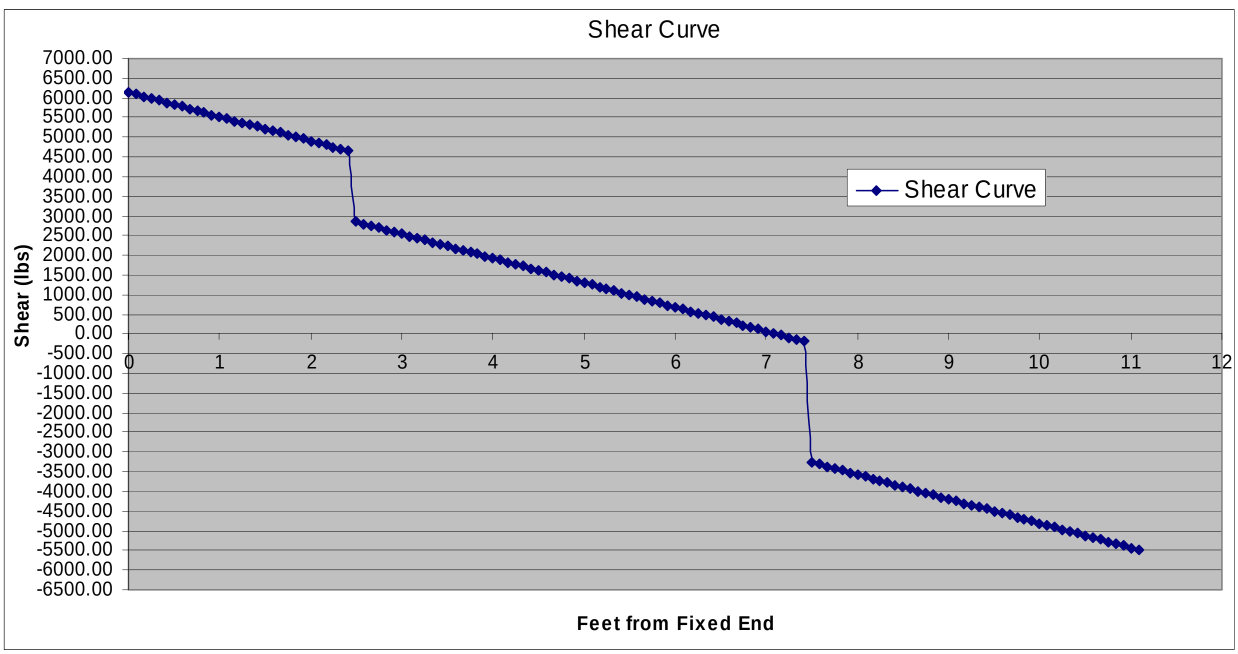


Member C

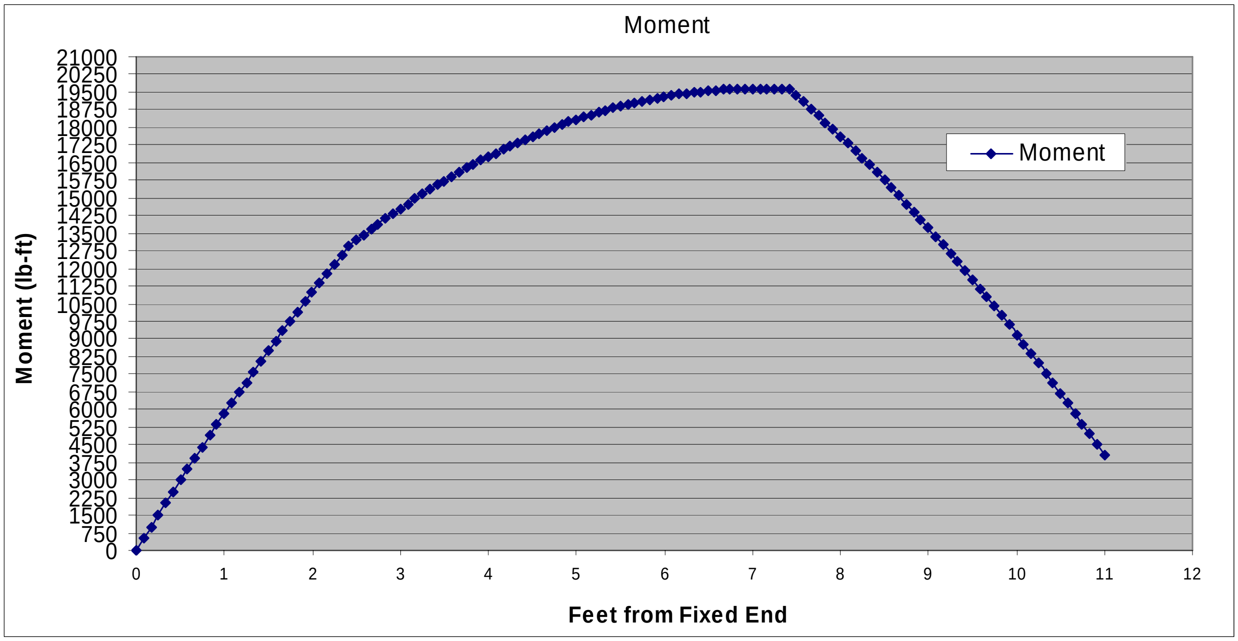
Loading



Shear Max = 6141.2 lbs

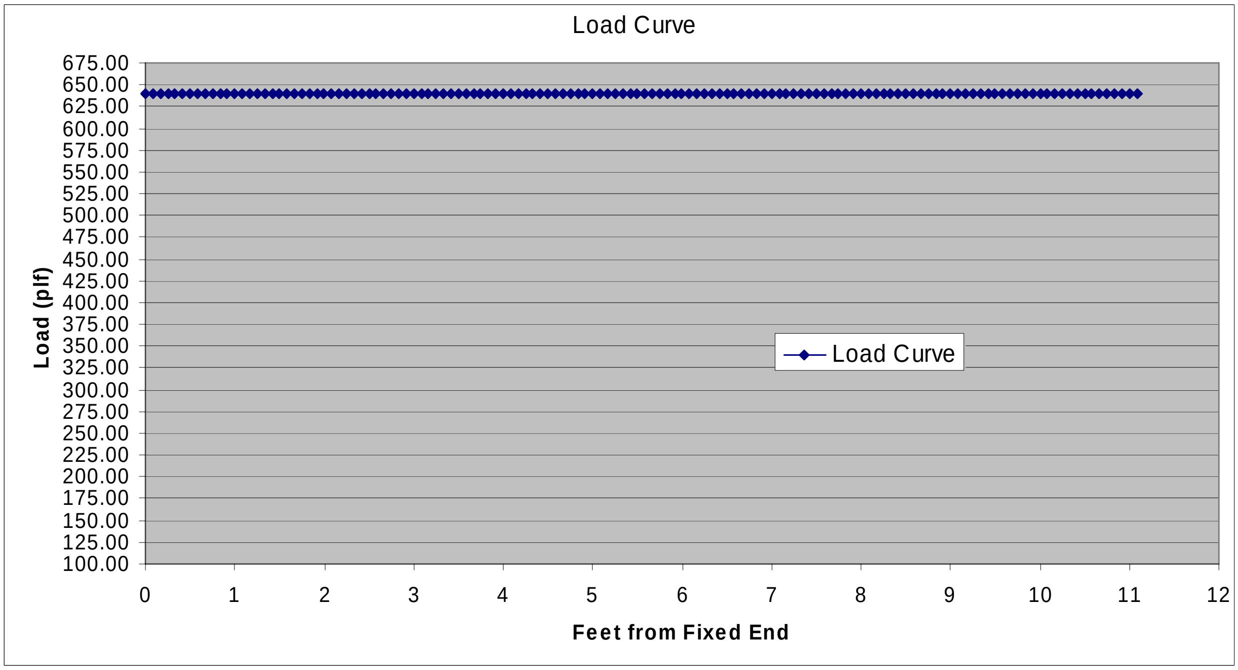


Moment Max = 19.66 ft-k

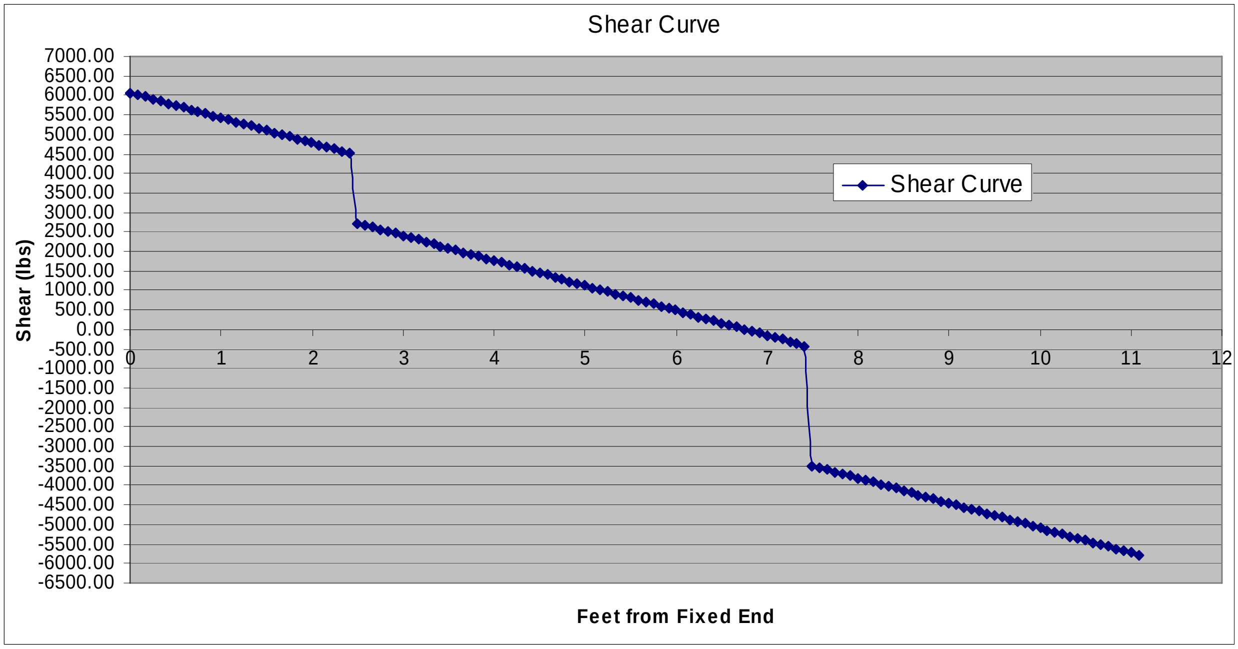


Member D

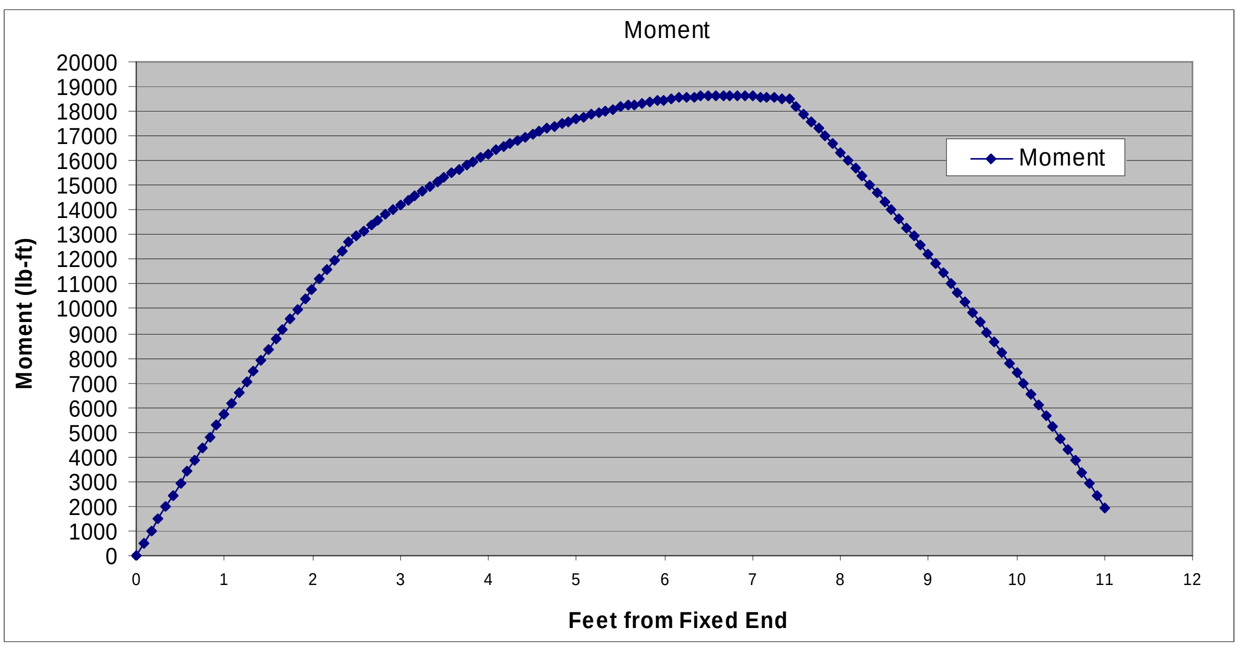
Loading



Shear Max = 6063.6 lbs



Moment Max = 18.64 ft-k



Using the maximum bending stress equation $Fy / 1.67 = M_{max} / S$ with $F_y = 36$ ksi and the maximum moments found from the graphs, an appropriate angle was sized based on the section modulus. The following section modulus values and corresponding angle sizes are used for the appropriate members (based on building orientation):

Member A (East) :	$M_{max} = 4.76$ ft-k	$S = 2.65$ in^3	Size = ∠5x3x1/2
Member B (West):	$M_{max} = 8.42$ ft-k	$S = 4.69$ in^3	Size = ∠7x4x7/16
Member C (South):	$M_{max} = 19.66$ ft-k	$S = 10.95$ in^3	Size = ∠8x4x7/8
Member D (North):	$M_{max} = 18.64$ ft-k	$S = 10.4$ in^3	Size = ∠8x4x3/4

For the sake of cost efficiency and installation ease, one would simply choose the largest angle and use it to frame the entire skylight into the slab.

Conclusions

The structural breadth has proven that both systems required for the completion of the Lighting Depth and envisioned in the Architectural Breadth of the fall semester are both feasible from a structural point of view. Without considering the results obtained from the Lighting Depth the skylight will allow a vast amount of light to penetrate deep into the north core of the 15^{th} through 17^{th} floors. The canopy, acting as both a direct sunlight shade and prominent architectural element, can be implemented into the structural design of the northeast corner without causing too many headaches with the already complex design.

Lighting Depth

Lighting Depth

Introduction

The Lighting Depth for this thesis proposal is the starting point from which much of the integration of the remaining thesis topics are derived. Based on the desired lighting scheme, the structure had to be modified (if only slightly), the electrical system was affected in its layout, and the architecture of certain spaces had to be developed altogether. Based on the architectural work put into the project, it only made sense to light the newly created spaces to get an idea of how they would actually appear under a realistic lighting condition.

The Lighting Depth analyzes 6 distinct spaces: the Façade, a Parking Level and Parking Lobby, the Entrance Lobby, an Office Reception, an Office Conference Lobby, and an Open Office space. Each of these areas had their own distinct criteria and each of them resulted in a differing lighting design. Based on an ideal that the building was to be completely owner-created, the lighting in all of the spaces attempted to make use of as many of the same luminaires as possible.

The overall theme for the general building (notice, this theme does not apply to the office tenant spaces) was one that compliments the city and its lake-oriented personality as well as the architecture of the building.

Research

A great deal of research went into the Lighting Depth and became the focus of the depth itself+. Such design aspects as control issues, dimming systems (DALI, GrafikEye, etc.), and building management systems fell out of the scope for this particular thesis. Instead research was conducted on the digital modeling of ray-trace modeling of materials, luminaire distributions for illuminated works of art, basic luminaire reflector design, LED systems, and integration of lighting into desk systems. The research was directly implemented in its entirety into the spaces design for the Lighting Depth.

Ray-Trace Modeling of a Diffuse Glass

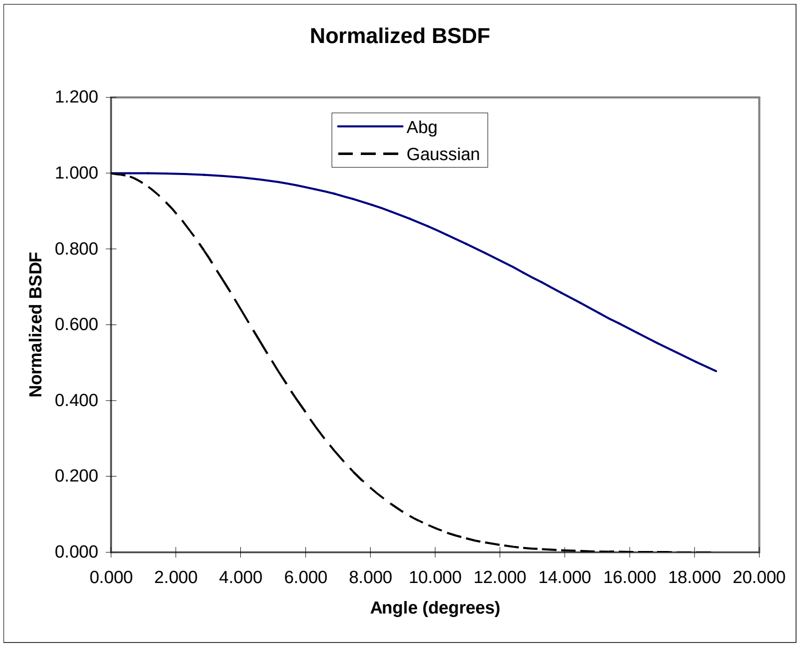
The ray tracing modeling of a diffuse glass was the basic need for the design of two of the additional researched luminaires. To appropriately model the diffuse characteristics of the artwork pendants hanging in the Entrance Lobby space, a surface characteristics was needed that would both transmit and reflect light similar to a sand-blasted glass design. TracePro was used to determine the light distribution for these lamps, but an appropriate model could not be obtained with the standard transmissive glass or opaque reflector materials provided. This necessitated the calculation and modeling of my own surface. While this endeavor was undertaken specifically from the ideas provided by TracePro consultants, it nonetheless was required of me to fine-tune the material to account for absorption within the glass and the appropriate levels of specularity and diffusivity provided by the glass.

Lambda Research provides a spreadsheet and instructions for creating a surface of "ground glass" based on the A, B and g values defining the BRDF and BTDF properties of a material. Per the instructions, a variable value of B and g was changed altering the Normalized plot of the BSDF in the spreadsheet. A number of calculations were used altering the Absorptance between 0.05 and 0.08, the Specular Reflectance between 0, 0.05, and 0.1, the B value between 0.01, 0.03, and 0.1, and the g value between 0.5, 1 and 3. The final distribution that was thought to approximate the glass type that coincided with the artwork (and subsequently the diffuse glass desired for the desk system) used an Absorptance of 0.08, a Specular Reflectance of 0.05, a B value of 0.03, and a g value of 3. The Normalized graph for the BSDF of this material according to the Lambda Research spreadsheet is below.

ABg model coefficients

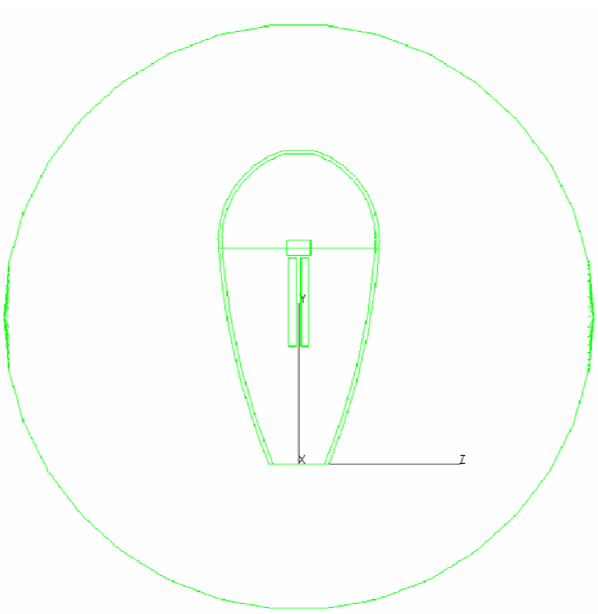
A	0.03		
B	0.03	Gaussian	
g	3	1sigma =	6 degrees

b-b0	Abg	Gaussian	degrees
0.000	1.000	1.000	0.000
0.010	1.000	0.991	0.573
0.020	1.000	0.964	1.146
0.030	0.999	0.921	1.719
0.040	0.998	0.864	2.292
0.050	0.996	0.795	2.866
0.060	0.993	0.719	3.440
0.070	0.989	0.639	4.014
0.080	0.983	0.557	4.589
0.090	0.976	0.476	5.164
0.100	0.968	0.400	5.739
0.110	0.958	0.330	6.315
0.120	0.946	0.268	6.892
0.130	0.932	0.213	7.470
0.140	0.916	0.166	8.048
0.150	0.899	0.128	8.627
0.160	0.880	0.096	9.207
0.170	0.859	0.071	9.788
0.180	0.837	0.052	10.370
0.190	0.814	0.037	10.953
0.200	0.789	0.026	11.537
0.210	0.764	0.018	12.122
0.220	0.738	0.012	12.709
0.230	0.711	0.008	13.297
0.240	0.685	0.005	13.887
0.250	0.658	0.003	14.478
0.260	0.631	0.002	15.070
0.270	0.604	0.001	15.664
0.280	0.577	0.001	16.260
0.290	0.552	0.000	16.858
0.300	0.526	0.000	17.458
0.310	0.502	0.000	18.059
0.320	0.478	0.000	18.663

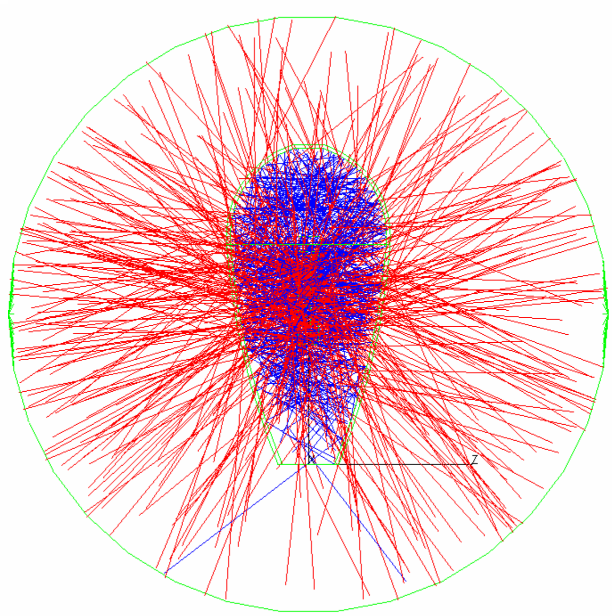


Using this material and solving for the BRDF function and BTDF function in the Surface Properties editor the resulting distribution when applied to one of the luminaires results in this raytrace.

Original Luminaire and Lamp
In integrating sphere



Raytraced Luminaire and Lamp
in integrating sphere



As one can see, a large portion of the light is allowed to escape, and the remaining portion reflects around in the luminaire. This material was chosen because the distribution (shown below) seemed to be the most likely based on acquired knowledge of luminaire distribution.

While not an overly complex research project, and with limited knowledge of the functions associated with the Lambda Research spreadsheet, a basic knowledge of BRDF and BTDF functions as acquired in the Graduate courses allowed me to make a fair judgment on values I should use. Through trial and error, the final values were decided upon through experimentation with TracePro.

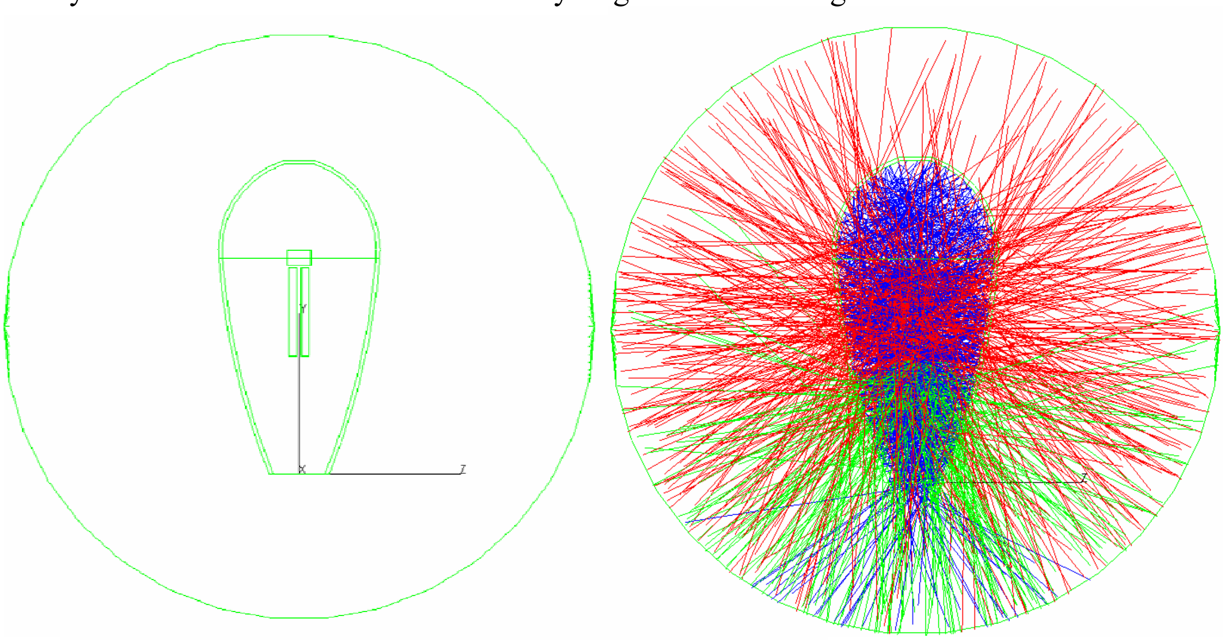
Light Distribution for Luminous Works of Art

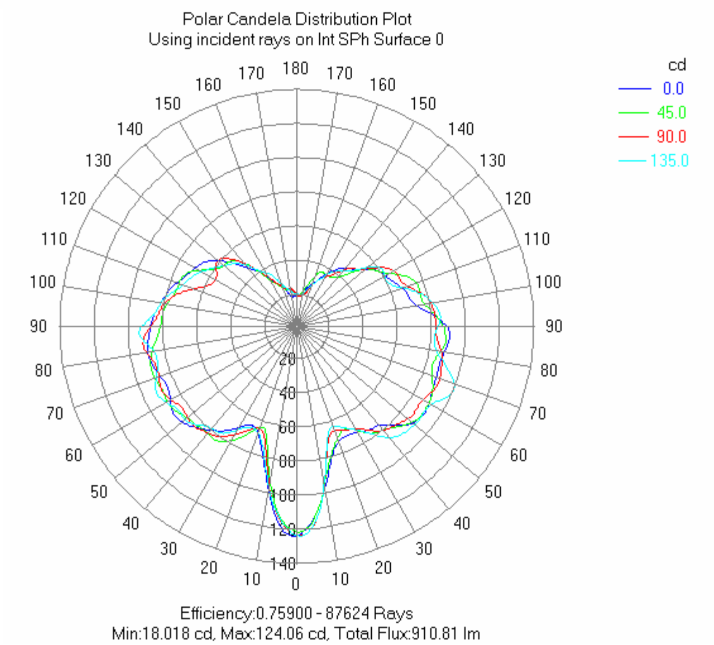
For the glass-sculptured luminaires throughout the Entrance Lobby, an appropriate distribution was necessary to accurately model the space as much as possible. The sculptured pendants comprise a considerable portion of the lighting within certain volumes of the space.

Each of these sculptured luminaires was modeled in AutoCAD 2006 and exported as an ACIS file (3D solid required). These solids were then imported into TracePro and an approximation to a compact fluorescent lamp was built from Primitive Solids. The values for an 18W compact fluorescent were obtained from Sylvania.com and applied to the 4 luminous tubes of the faux-CFL in TracePro.

Using some 84,500 rays, an approximation to the distribution was constructed for each of the three luminaires. The Monte-Carlo based raytrace solutions with a 1% ray sorting parameter and resulting candela distributions are shown below.

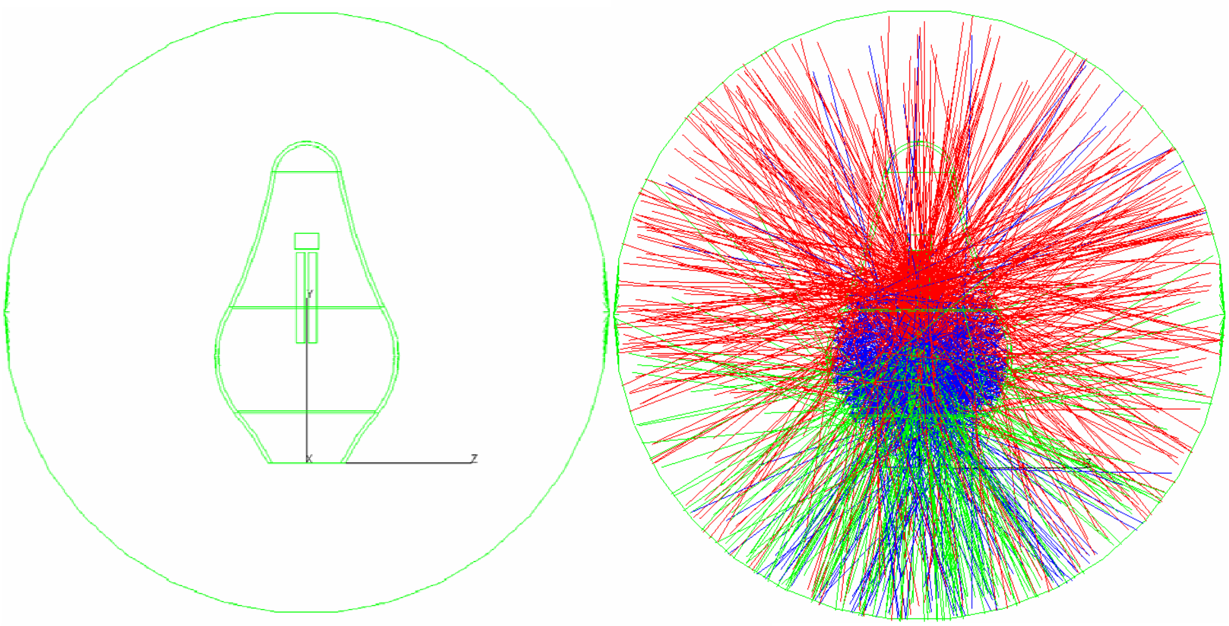
"Tuby" – assumed to be a flower in its early stages of blossoming – 18W CFL

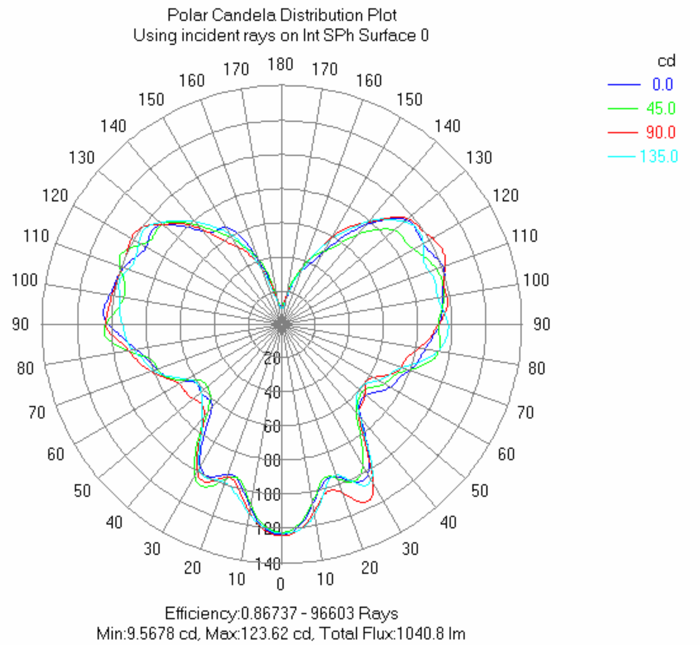




As one can tell from the raytrace and the distribution, a large amount of diffuse light is cast mainly to the sides with the highest intensity exiting the open bottom of the luminaire. Also, the efficiency of the luminaire is cited as 76%, a reasonable approximation for an absorbing glass luminaire.

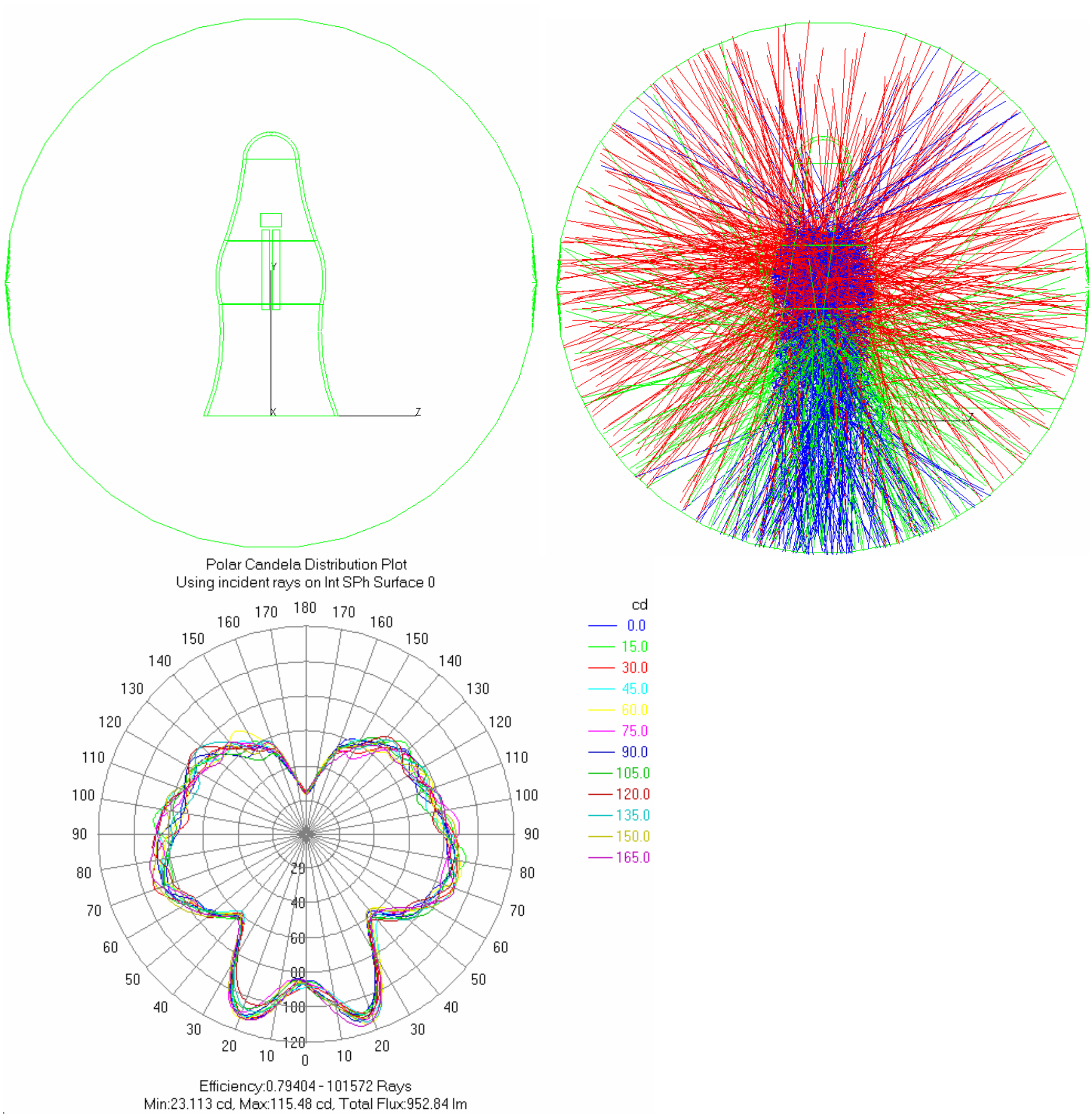
"Bulbous" – assumed to be a flower in its mid stage of blossoming – 18W CFL





From the raytrace and the distribution, a considerable amount of diffuse light is cast upward and less is cast to the sides. The highest intensity still exits the open bottom of the luminaire. The efficiency of this luminaire is cited as 86.7%, a reasonable approximation for an absorbing glass luminaire with a larger open bottom.

"Ghosty" – assumed to be the same flower in full bloom – 18W CFL



From the raytrace and the distribution, a large amount of diffuse light is cast upward and to the sides. The highest intensity still exits the open bottom of the luminaire, but at 20˚ angles. The efficiency of this luminaire is cited as 79.4%, a reasonable approximation for an absorbing glass luminaire with a bottleneck in the middle and a wide opening at the bottom.

These distributions seem to fit the luminaires fairly well based on previous experience modeling luminaires. TracePro will have accounted for any inaccuracies that would arise from simply "estimating" the luminaires as a Louis Poulsen fixture, and the space will have a more accurate radiosity solution. All of these candela distributions were converted into IES files and the luminaires used specifically in the Entrance Lobby Space.

Basic Reflector Design for an Area Source Ceiling

The basic reflector design for the Entrance Lobby "wave ceiling" was developed and eventually altered completely negating the main impetus of this research project. While the ceiling changed significantly, the luminaire was still used because an area source was needed to achieve a similar effect.

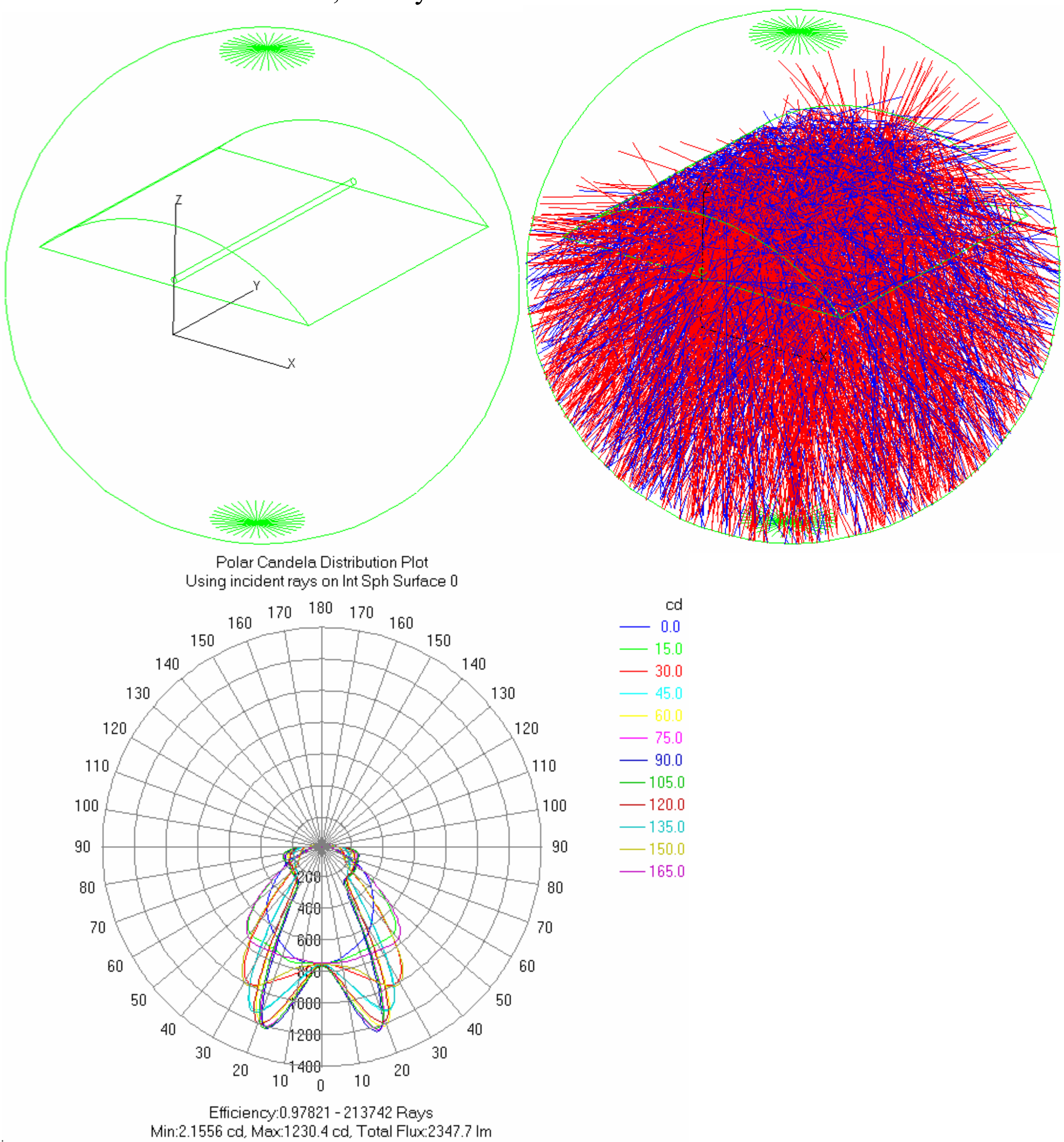
Initially the wave ceiling was designed as a combination of laminated translucent strips of varying width, and oriented broad-side down. As can be seen from the rendering of the Entrance Lobby space, the orientation of the same strips is now edge-side down. The broadside was to transmit a large amount of colored light down into the space wherein the variance in width would simulate a three-dimensional wave pattern. Because of the low transmittance value, the necessarily high lumen output of the lamps, the exorbitant power density, and the realization that only blue and green hued light would be illuminating the space, the original design was scrapped for the current one. The current design still required an area source, however – except one that was more efficient and provided white light to the space.

The luminaire was constructed in AutoCAD of 3D solids and imported to TracePro in an ACIS file just as before. The intention was to use a T8 lamp across the bottom of the "barrel" reflector to get as better approximation of parallel rays of light a slight emphasis on increased illuminance at the center to offset the larger-than-anticipated transmissive gradient of the colored strips. For constructability and installation which would keep the cost of such a luminaire low, the reflector was modeled as a large-radius cylinder (as compared to the requisite parabola for parallel light rays). The lamp position was then adjusted from center until the final illuminance distribution on an area plane coincided with the needed illuminance to produce the "wave" effect.

Realizing that the full-size barrel luminaire would be centered at the "openings" of the strip-sets and not at the middle of the strip-sets as was originally intended, a "half-barrel" luminaire was also calculated from the same form and shape, but with a reflecting block placed at the extreme edge where the luminaire would meet the ceiling plenum wall.

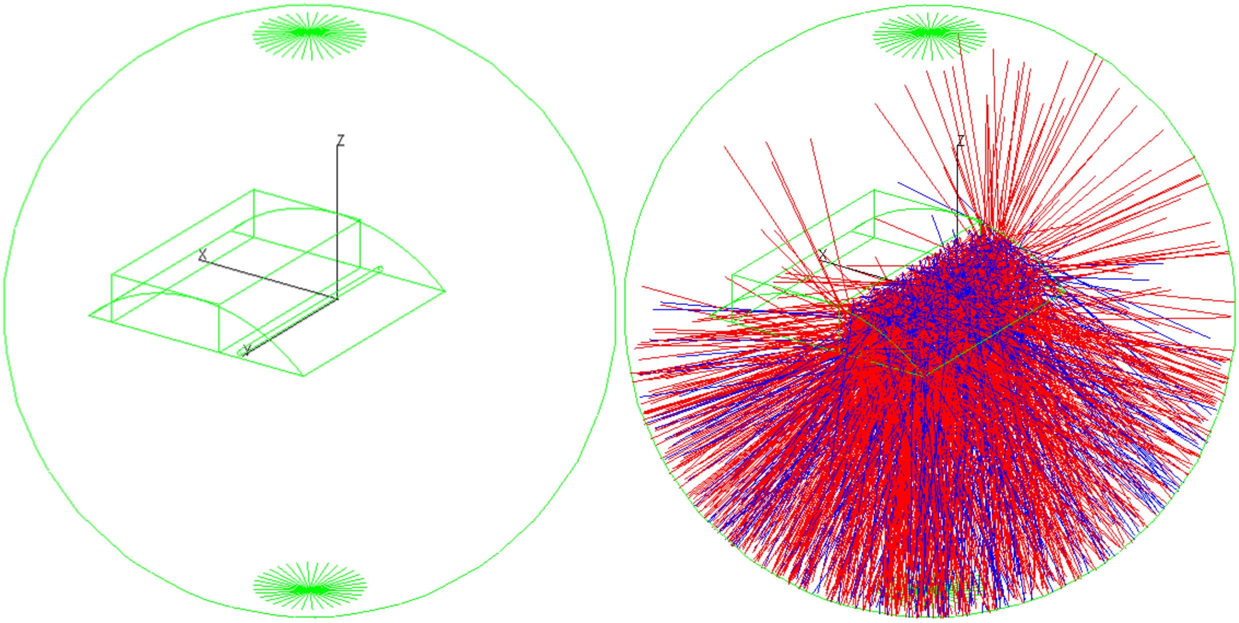
The ray trace is shown below with the chosen design, and the candela distribution follows.

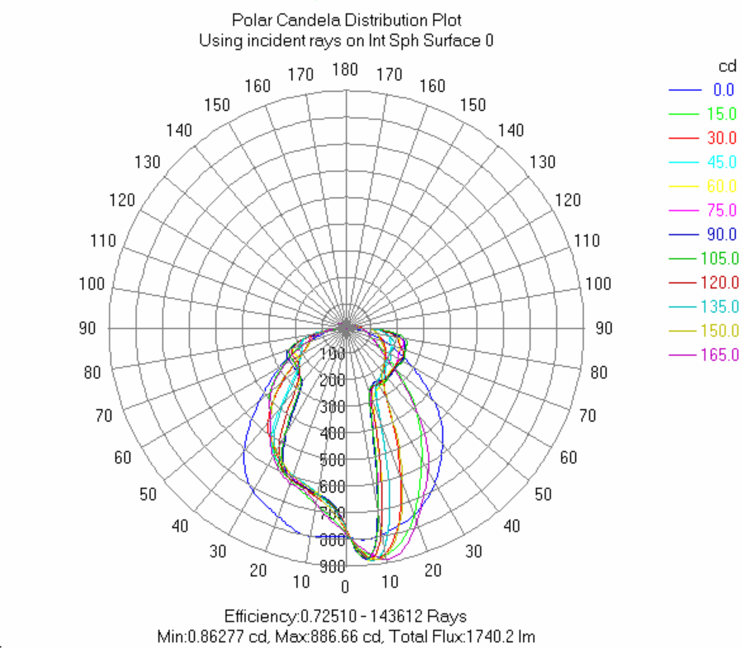
Full Barrel – 32W T8 – 150,000 rays



The distribution has a little more angle than would be preferable, but with the placement of a highly transmissive translucent plastic sheet on the back to avoid direct glare issues with the bare lamps being exposed, the peaks will join closer together. The important fact here is that all of the light is reflected downward at a 97.8% efficiency.

Half Barrel – 32W T8 – 150,000 rays



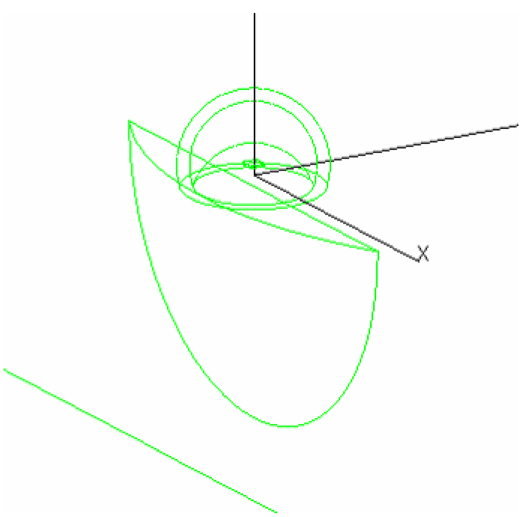


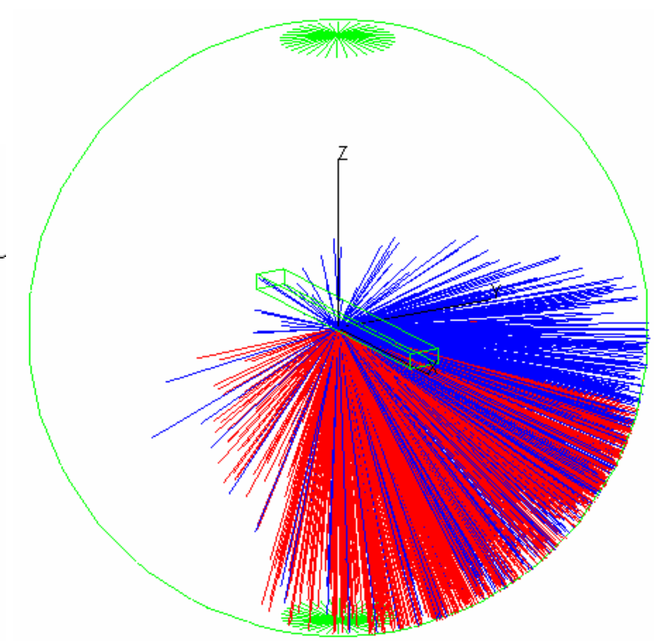
The distribution has a fairly significant downward peak which was desired to maintain the wave appearance, and the falloff toward the uninhibited side is smooth enough to accurately play into the area source model (via the same glare-reducing translucent backing).

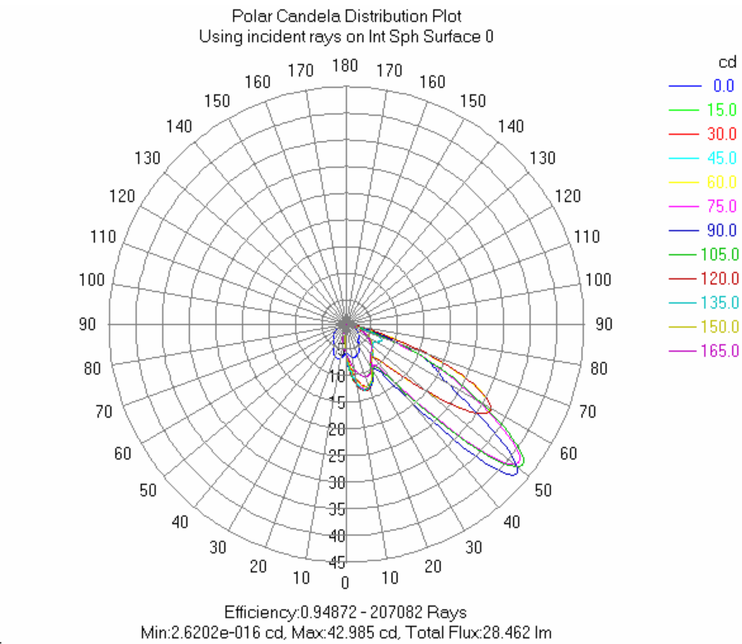
LED Emitter Use in a Linear Luminaire System

There were two research concepts that went into the development of the LED system used on the façade. First the distributions of all LEDs by themselves are either Lambertian or Batwing for the purposes and at the light output levels this thesis is concerned with. It is possible to purchase narrow "spot" LEDs but they are used for extremely low light output levels. The LEDs chosen for the design of the façade lighting were the Philips/Lumileds Luxeon emitters and/or stars. The overall LED chosen was the Luxeon K2 emitters because of their tremendous light output, low power consumption, and many available colors (required for the lighting design as described later).

The only problem is that the LED comes as a lone emitter, or as part of a tape of emitters and it only distributes light in a Lambertian distribution. The needed distribution was a wall-wash type and thus a reflector system had to be designed for it. Using the same modeling procedures as for the previous two research concepts, the LED was modeled as a point source and a small reflector placed around it. This reflector was not of congruent circular radius as the point source itself so as to broaden the distribution in along the wall, but curtail any distribution that was beyond 0˚ in the direction away from the wall. After applying the raytrace, the following results were obtained.







From the distribution, it is easily seen that the reflector was effective in redirecting all of the light toward a single wall. The light has a considerable distribution toward the 45˚ and 50˚ vertical angle, but this was assumed to be fine. The higher the luminance at a given point, the more that point will stand out, and for a 17-story building the linearly distributed "hot spots" will seem to form a nice line.

The actual installation of the LED module and the typical concerns of heat dissipation, lumen maintenance, and light output as a function of temperature was also researched thoroughly using the technical data provided on the Lumileds website.

From the LED cut sheets, the typical luminous flux for an example white LED used in the design is 60 lumens at a junction temperature of 25˚C, which is relatively low for the junction temperature of any electrical component. The corresponding drive current with this test method was 350mA and under the 3.6V forward voltage, corresponding to a wattage of 2.4W at full output and full driving current. This type of LED at this driving current would be used as it provides more light than any other system searched for otherwise.

Of first concern is the relative light output for a given junction temperature. From the Lumileds datasheets, the following graph was obtained.

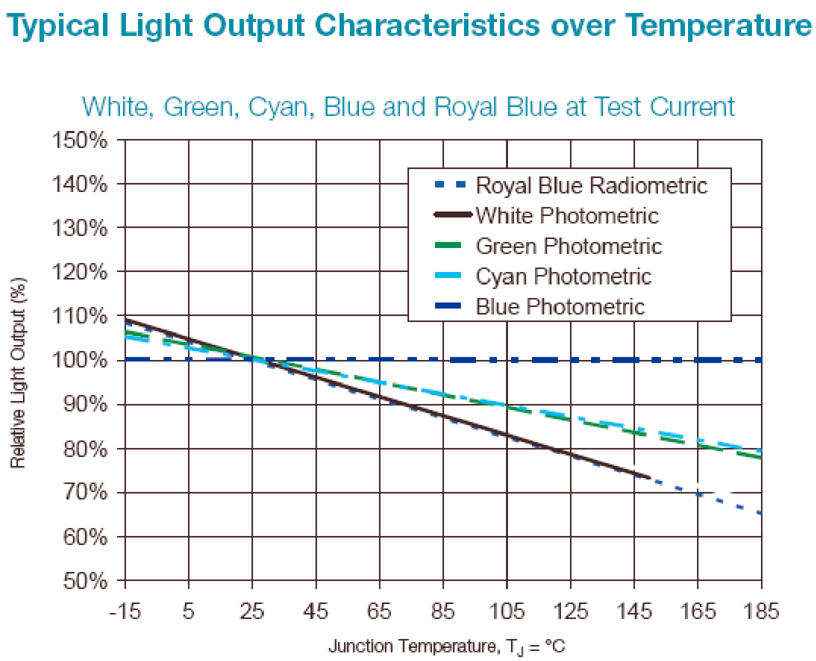
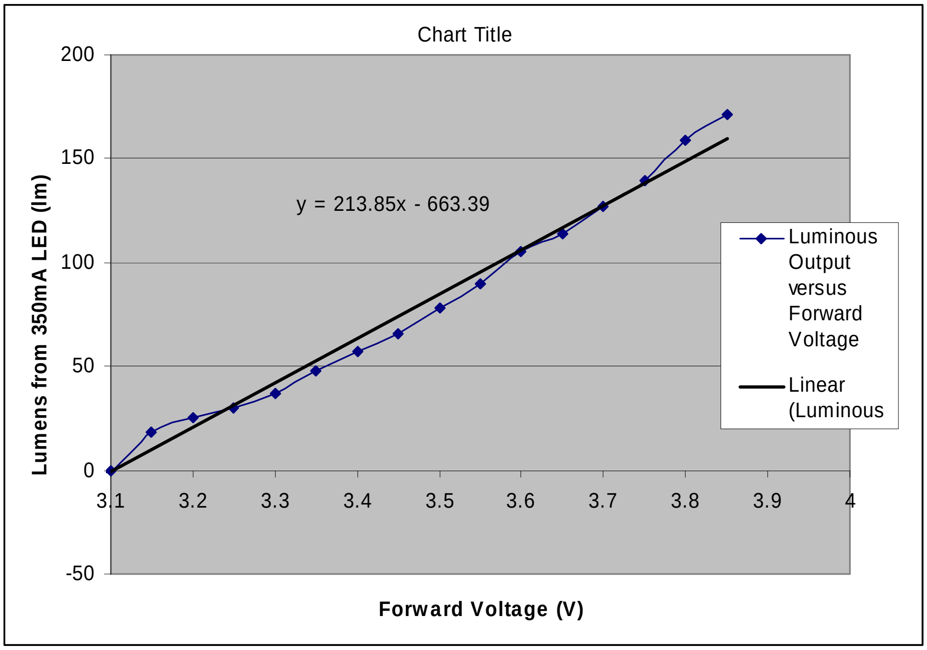
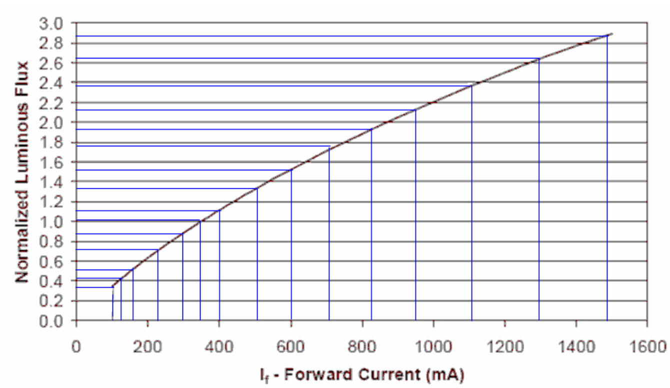


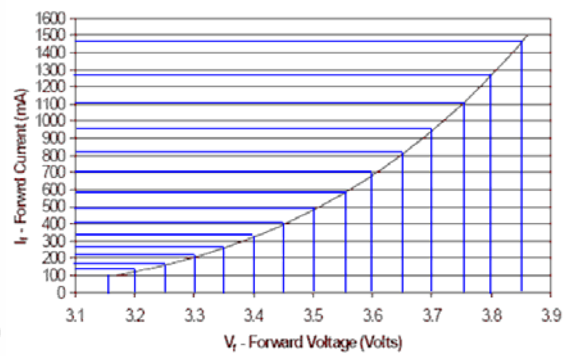
Figure 7. Relative light output vs. junction temperature for white, green, cyan, blue and royal blue.

One can see that the light output decreases dependent on both junction temperature and color of the LED. Assuming the worst conditions (White and Royal Blue LEDs), the maximum relative light output factor can be assumed to be around 85% for the worst case <u>realistic</u> scenario. This output corresponds with a junction temperature of 95˚C – just below the boiling point of water. The lighting design implementation of these LEDs is limited to the blue, green and white ranges, so the light output of red-hue LEDs is not considered (although it can be noted that their performance at higher junction temperatures is much worse). The typical junction temperature for an Intel Pentium Processor (the worst thermal processors on the market) is specified as 90˚C. It can be assumed that the junction temperature for the LED can be modeled with this gauge. Considering the heat source is much smaller for an LED, it may even be considered a conservative estimate. The processor analogy is also applied to heat dissipation of the LED and will be described shortly.

The light output is also reduced by the driving voltage and the driving currents. Two graphs were specified in the datasheet relating drive current with forward voltage, and drive current with luminous output. The two graphs were taken out further charted, and the data plotted against one another to relate the forward voltage to the luminous output. Considering current is a function of forward voltage, and light output as a function of current, the only variable affecting luminous output directly is forward voltage. The resulting graph from relating the two is given below.







Following the junction temperature analysis, consultation of the Lumileds datasheets produced a few additional factors that must be taken into consideration when powering and installing the LED emitters. To better understand the light output relative to the driving voltages and currents, as well as with respect to the ambient temperatures, the thermal design of the actual LED emitter was also researched.

From the Lumileds datasheets, a linear range of R-theta thermal resistances for board-to-ambient conditions was given. Each LED emitter has an R-theta junction-to-board value of 17˚C/W. This basis allows one to simply analyze the board to ambient conditions to understand the thermal heat dissipation characteristics of the LED. Within the datasheet a number of control experiments were conducted which are only fairly

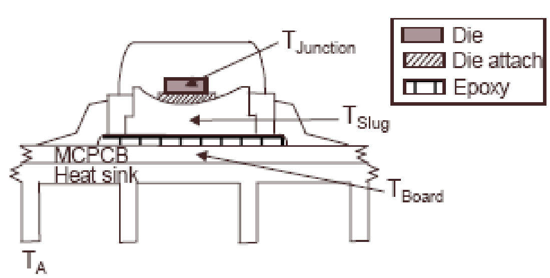


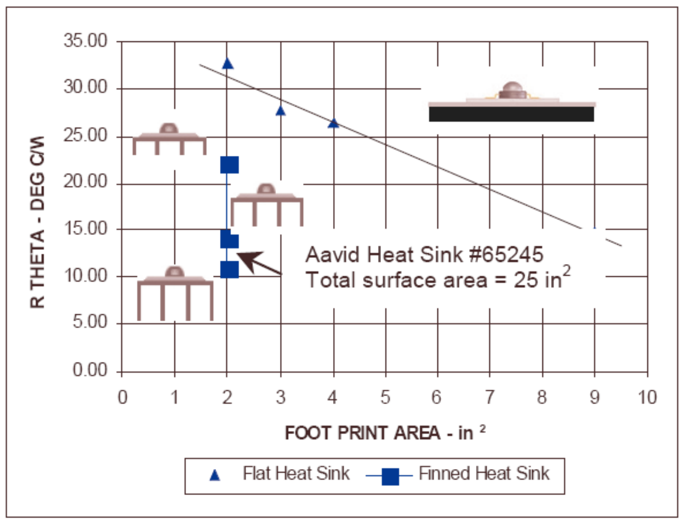
Figure 1B. Emitter Cut-Away

Equation 2. Thermal Resistance Model

$$R\Theta_{Junction\text{-}Ambient} = R\Theta_{Junction\text{-}Slug} + R\Theta_{Slug\text{-}Board} + R\Theta_{Board\text{-}Ambient}$$

applicable (for the level of accuracy this thesis desires to retain). Certain negative factors stated in the text include: a) the lack of thermal grease in the connection of heatsinks; b) the lower quality of the heatsinks (compared to the high polish finish and flatness applied to computer processor heatsinks); c) the use of fixed footprint heatsinks with and without fins; and d) the design emphasis on natural convection within a closed space.

The results of the experiments show that the finned heatsinks have a much lower R-theta value than the flat heatsinks. Because of the nature of the design implemented on the façade, a "poor" average of the finned and flat heatsinks could be used conservatively with a resulting R-theta board-to-ambient of about 25˚C/W. This means each emitter has a total R-theta of 42˚C/W. This value, while still conservative, will be used in the further analyses of light output versus ambient temperature.



It should be noted at this time, the use of a thermal grease (anything as simple as the most common heatsink binding paste up to the highly conductive Arctic Silver used by computer enthusiasts) will also decrease this thermal resistance. Also, in the proposed design of the LED system, the spacing of the emitters is much further apart than the technical datasheet specifies is necessary to treat every LED as a discrete thermal source. Couple this with the fact that the mounting for each LED is the underside of an aluminum mullion and the effective footprint of the "heatsink" is increased considerably.

After the thermal characteristics had been analyzed, and the installation "approved" for realistic application, further analyses of the light output degradation were conducted. The first analysis was the current derating based on the ambient temperatures and a maximum junction temperature of 150˚C. The curve for 350mA white LEDs is shown below. A very similar graph is also contained within the datasheet for the Blue/Green/Cyan LEDs as well, and differs only in the fact that they can withstand greater ambient temperatures before current is derated.

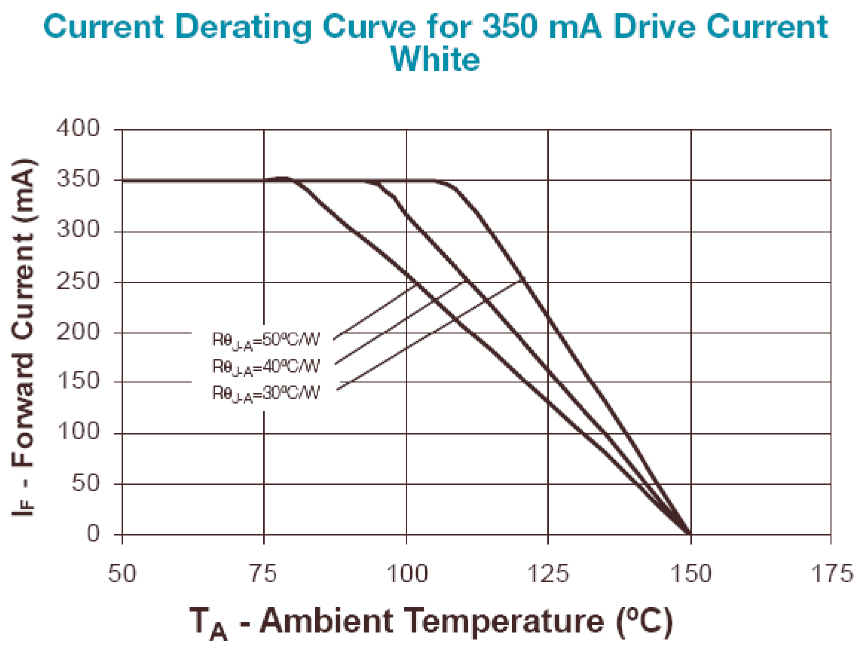


Figure 14: Maximum forward current vs. ambient temperature, based on T_{JMAX} = 150°C.

Note that the curve in question for the "worst-case scenario" developed during the research is to 40˚C/W curve, allowing the ambient temperature to reach 80˚C before derating must occur. This ambient temperature should not be reached within the design even if a 1" convection-less bubble was considered around the luminaire installation site. Within the design proposed one will also make note of the outdoor location, where free convection only occurs on a select few days a year, if at all. Wind will always be present thus forced convection can be considered the norm, thus further reducing the heat dissipation requirements. Add to the fact that the luminaire system will only be used at night when the temperature is lower than the recorded high, and also that the highest recorded temperature in Milwaukee was 105˚F, or 40.5˚C – considerably lower than all of the previous data considers a limit.

All of the heat characteristics have been taken into consideration, and the only remaining factor requiring attention is the length of time the luminaires will be used, or the lumen maintenance. From yet another datasheet provided by Lumileds, the lumen maintenance curve for an ongoing experiment involving the life of the LED has been provided. Two distinct graphs shown below show very interesting results obtained through direct experimentation. For an LED driven at 350mA (as in the installation proposed), having a case temperature of 25˚C and junction temperature around 45˚C, the lumen output actually increased over the course of 4000 hours of operation. This condition may seem a bit "aggressive" if it were to be applied to the thesis proposal, as it makes use of an obviously well designed condition. Contrasting this, an experiment conducted with a case temperature of 85˚C and junction temperature of 105˚C and the lumen maintenance decreases by 7.5% over the course of 2000 hours. Placing the proposed design conditions in-between the two would suffice as an accurate approximation and the lumen maintenance over a 10,000 hour life could be estimated at 0.9. This would correspond to almost

3.5 years of operation at 8 hrs/day with relative light output remaining constant. The lumen maintenance graphs are shown below.

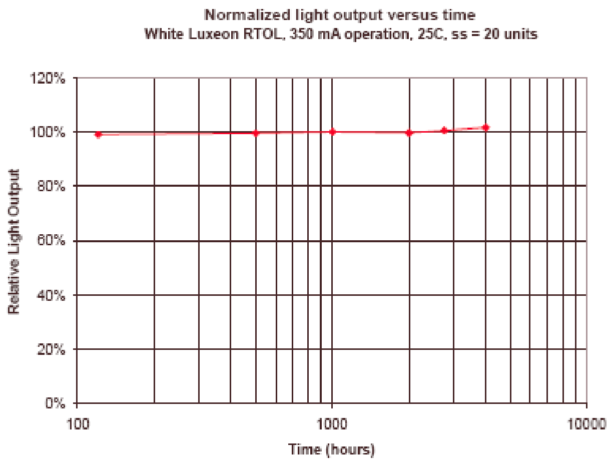


Figure 4. Relative light output for white Luxeon Power Light Sources driven at 0.35A, 25°C case temperature ($T_J \cong 45°C$).

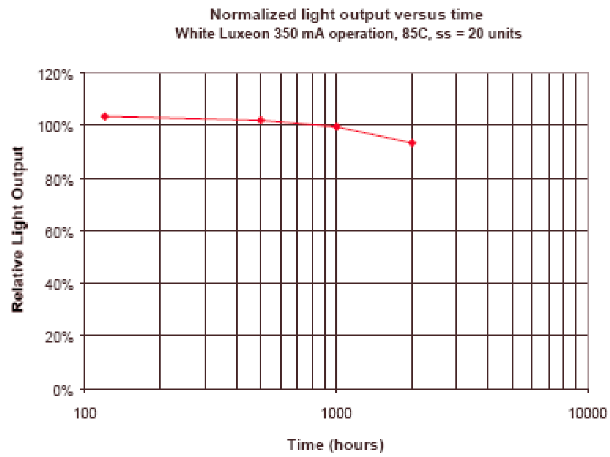


Figure 5. Relative light output for white Luxeon Power Light Sources driven at 0.35A, 85°C case temperature ($T_J \cong 105°C$).

Overall, the LED system seems quite feasible as an architectural façade lighting design solution. Even considering all of this "positive" data, a "safety" factor was also included to account for all remaining luminaire degradation issues.

For the dimensioning and detailing of the proposed LED system please see Appendix C

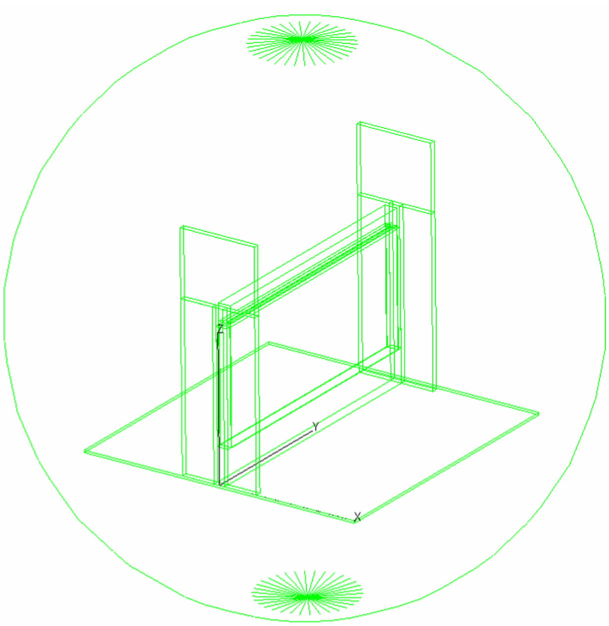
Integration of Luminaires into Desk Systems

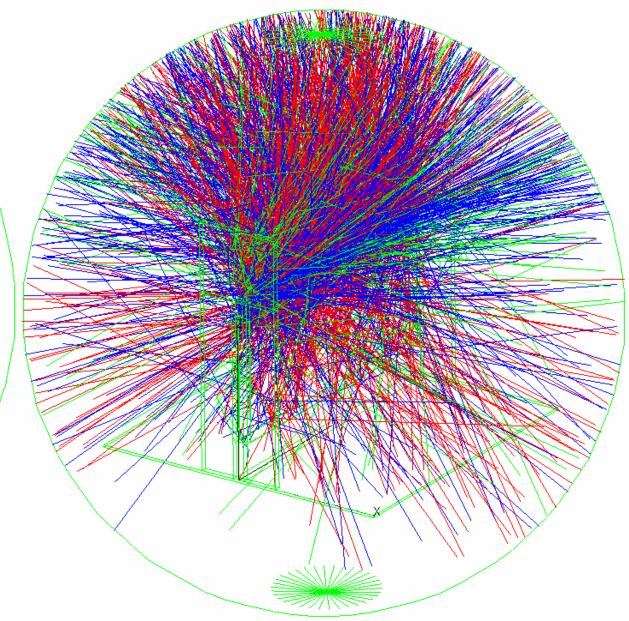
The Open Office design focused on a system that conceptualized to investigate the alternative to typical open office lighting design. After the architecture of the space was laid out, the desk systems was modeled and laid out in the space relative to the available space requirements. What was needed was the distribution for the light source through the top opening and through the translucent glass panels on the sides.

Using the same modeling method as all of the previous research, the desk system was devised, appropriate glare angles calculated (based on an eye height of 6' – the equivalent of a 6'4" person on the low-end) and brought into TracePro. All of the surfaces within the "luminaire" – closest to the lamp and receiving the highest number of rays – were assigned a specular Miro surface. The glass walls were given the same glass properties that were used in the sculpted luminaires to approximate a diffusing glass surface. The lower half of the "glass trough" was also given a specular Miro surface to reflect any light back up toward the lamp or around and out through the glass of the desk system.

Once the rays were traced, individual sections of the luminaire's surfaces, namely the top, and each individual side, was used as the candela distribution surface and the appropriate candela distributions were applied. The top and the side distributions were saved as IES files separately to better model the effect of the luminaire in AGI32. The raytraces and the candela distributions are shown below.

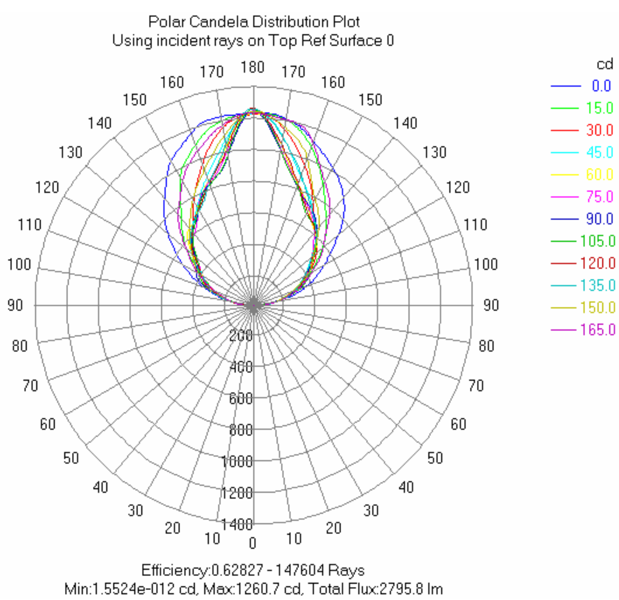
Full Distribution Desk System – 54W T5 – 100,000 rays

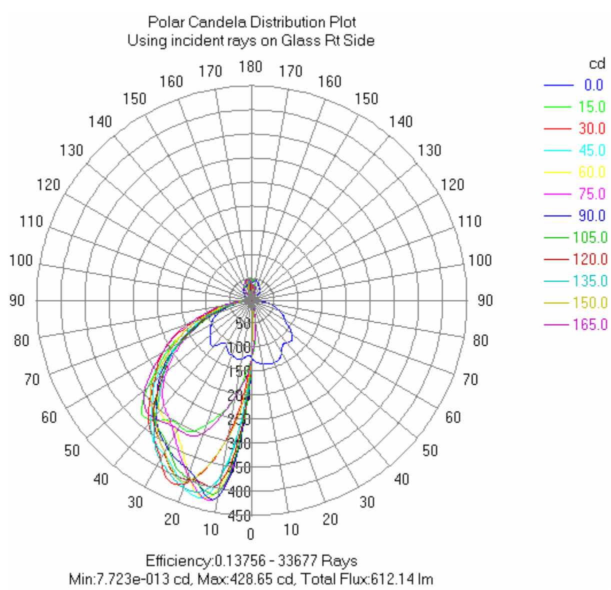




Top Exiting Surface Candela Distribution

(Symmetrical) Side Candela Distribution

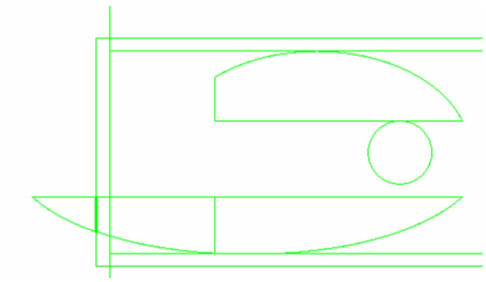




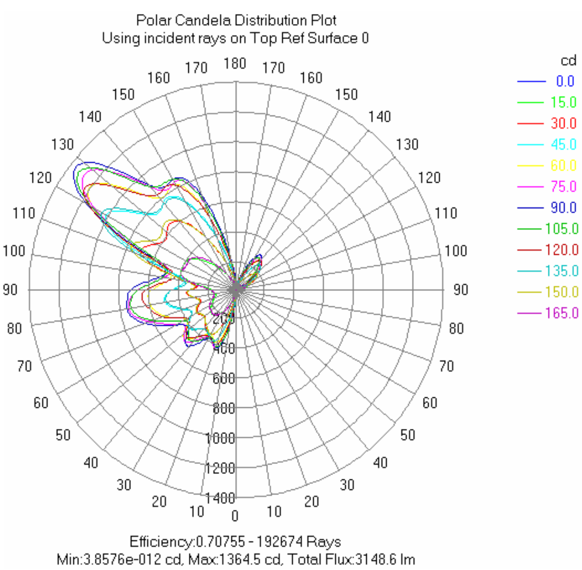
As can be seen from the distributions, the candela value for the single T5 lamp distributing upward was considerable, especially since there was nothing to prevent its distribution (like luminaire housing or lenses and other transmissive surfaces. The side distribution on the other hand has a nice high immediate downward component and a very smooth falloff distribution at higher angles. This implies that the luminance directly affecting the desk occupant will not blind them. The luminance is highest toward the desk surface and falls off gradually, but quickly. The efficiency of each component is listed, and the efficiency of the overall system is 89% which seems very reasonable for such an open upward aperture and low component downlight.

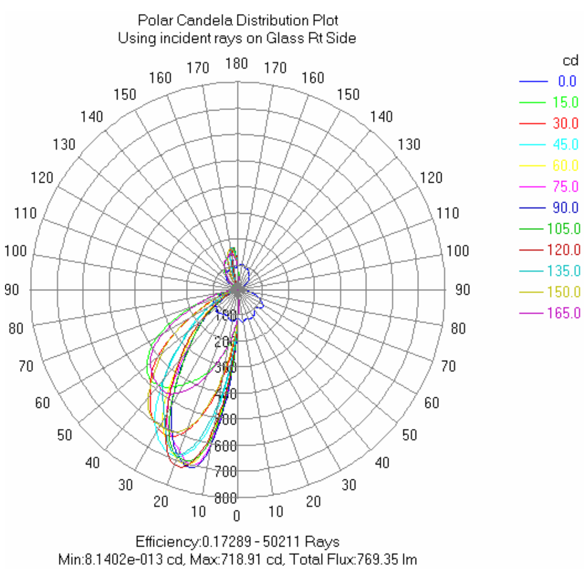
The half distribution system was also developed for those desks that abutted walls and not another desk. Instead of wasting the light and creating a very heavy shallow scallop on the wall, the light is attempted to be redirected into the space and above the desk user. One side of the glass partition is also given a specular Miro surface such that a lower lamp wattage can be used. Using an extra-long reflector at the top and an additional reflector in the glass, the lower wattage lamp should produce a similar luminance for the upward component and a similar luminance through the glass as well. The section showing the new reflector and the associated top and side candela distributions are illustrated below.

Half Distribution Desk System – 28W T5 – 100,000 rays



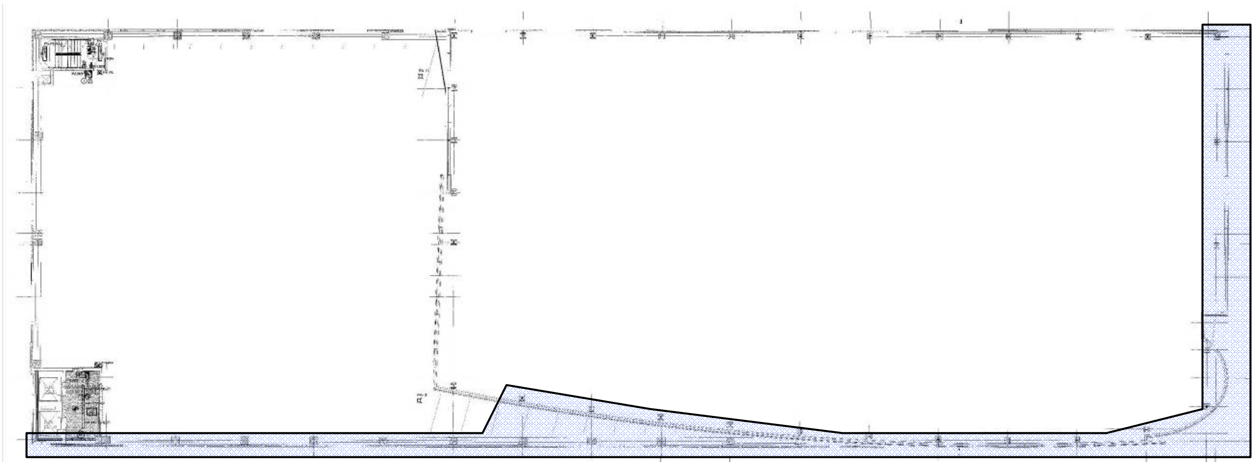
** A similar raytrace is produced, but will not be shown.





Based on these two systems, the Open Office plan was constructed and these luminaires used as the primary lighting elements of the space. Based on the TracePro output for the luminaires, they seem to be an extremely useful alternative to suspended fixtures if one wishes to keep the ceiling open and clear. This could also be a viable system to use when the ceiling height is extremely high or "non-existent" as might be the case where a glass atrium ceiling is used.

Façade



Special Luminaires

The façade lighting design makes use of two types of fixtures. The Erco Beamer IV is used as the only long-throw metal halide and can be found in the cut sheets in Appendix C . The other luminaire is of a design created specifically for this thesis project. The LED fixture researched and modeled specifically to be install on the mullions of the building (and underside the canopies) is detailed in Appendix C. Please refer to these drawings for the design dimensions and parameters. One will note that while two “differing fixtures” are used to model the space, the installation is almost identical – one with the reflector, and one without.

Thematic Description

The theme of the façade arose from the architectural form itself, as well as a conceptualized view of the proposed lighting scheme, was based around a water fountain or free-flowing water. The concrete parking garage forms the “basin” of this fountain, or the rock face from which the water freely flows. The entire glass façade reflects the blue skies and lake in the distance giving it a bluish-green “tint” from an outside on-looker’s perspective. Since it is relatively reflective, but still see-through, it gives the impression of water in a deep lake – the observer knows it is transparent, but cannot always see to the bottom. The goal of the façade lighting design was to accentuate this point at night through the use of variable colored light sources, and create a “free-flowing” form in a spatial dimension that complimented the building’s curved façade.

As a compliment to the free-flowing water, the concrete “basin” needs to be accentuated as well. The building also required the illumination of the building’s limits such that the water and basin didn’t seem to appear to fade into bleak nothingness. The linear accentuation across the top of the building is complimented as well by a light cast at a very low grazing angle down at the edges of the parking structure.

Surface Materials

The roof façade is composed almost entirely of aluminum paneling. The aluminum shown here is from a large section of the roof paneling, but is typical of all of the aluminum used throughout the 17th floor and roof façades.

Reflectance: 0.6

The aluminum shown here is typical of the entire façade. It is a little bit lighter than the roof façade but a little duller. There is no specularity associated with this aluminum façade paneling at all which accounts for its slightly increased reflectance compared to the aluminum above.

Reflectance: 0.59

The granite base material shown here is only located at the ground floor, on and around column lines, between retail facades, and no higher than 3 feet off of the ground. The granite is used as an accent piece to the lower façade.

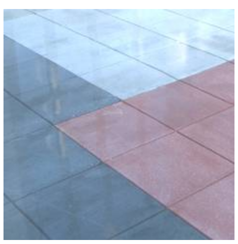
Reflectance: 0.31

The green glass shown here accent outdoor entrances and garage entrances, as well as the accent glass around the retail facades. It is purely opaque, and therefore has no transmittance.

Reflectance: 0.57

The major component to the façade, on the parking structure side, but the majority surface material nonetheless is the concrete precast panels. The precast panels are not just concrete, but have been infused with small specks of black glass to give it a more stone-like or marble look.

Reflectance: 0.68



The sidewalk pattern shown here is more for informative purposes and is important to the façade lighting. Not a whole lot of downlighting should be used to avoid mixing and bleeding the colors up against the building or against any adjacent building.

Reflectance: 0.42

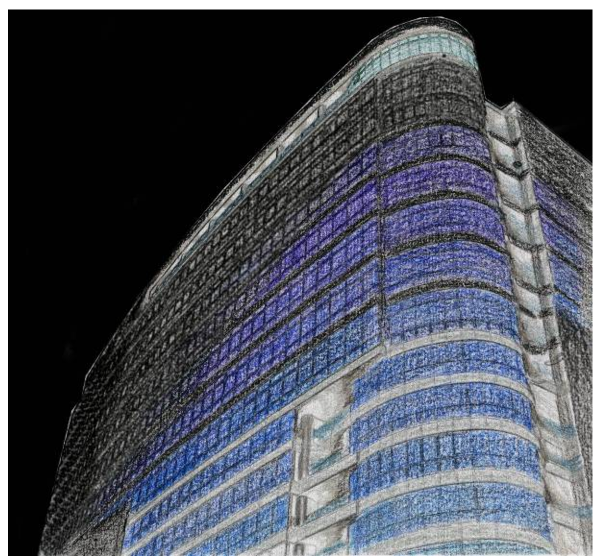
Glazing Specifications – Transmittance and Reflectance

The glass on the exterior, shown to the left, has a slight reflectance and a high transmittance. Because of the viewing angle, a considerable amount of the street can be seen. It is a light hue of blue, but not to the contrast that the picture shows (combination of daylighting and camera quality).

Further information on the glazing is shown below.

Type:	Insulating Glass - Surface #2 Coating – NP-61
Reflectance Outdoors:	0.21
Transmittance Visible:	0.61
Solar Heat Gain Coefficient:	0.4
U-Value:	0.31 (winter and summer)
Light to Solar Gain Ratio:	1.53
Thickness and # panes:	(2) 6mm panes with ½" airspace between

Design Concept



The design concept for the building as developed in the fall semester is illustrated below. The design hinges on the use of LED point sources located at a standard distance from one another to give the impression of a soft, continuous light source that spans the given length for each floor's layout. The use of LEDs was chosen because of their thermal characteristics – namely their resistance to light loss with decreased temperature. The use of LEDs was also useful in determining whether or not their efficiency was greater or less than that of standard lighting solutions and could provide the owner with a viable, long-term solution.

One will note that the design concept as used in the fall semester was altered in significant detail at the parking garage façade. This was to eliminate light pollution and trespass problems arising from the uplighting solution initially proposed.

Design Criteria

Appearance of Space and Luminaires – Rating: 10

The appearance of the façade is of dire importance. Not only does it proclaim the materials used on the building's exterior but it presents the building as a showpiece to the surrounding area and the city given its appropriate size and visibility. Functionally, lighting the façade also accents the skyline. It gives a form to the building at night and distinguishes its boundaries when the interiors are dark.

At ground level, the façade lighting can also act as a highlight to the retail and restaurant spaces that otherwise have no verticality to their advertising, signage, or landmark accentuation. Façade lighting draws an individual to it both spatially and psychologically, and therefore acts as an advertisement for the building – not only at ground level, but in its entirety.

Luminaires should not be as prominent in the lighting solution and their goal is to be not seen at all. Façade lighting should seem mystifying, if not magical. To view the luminaires that illuminate the façade takes away from the mystery and wonder, and then detracts from the landmark status of the building.

Color Appearance and Contrast – Rating: 7

Because the majority of the building is glass, it is hard to illuminate (save from the inside), and the color scheme of the building at night would seem to be rather plain. Highlighting the aluminum paneling or the precast concrete walls of the parking structure by themselves becomes no daunting task as the color variety does not exist. Nonetheless, for a nighttime scenario, one does not wish to light the building façade with a warm light and impress upon it a reddish tone when the nighttime sky reflects well of black and dark hues of blue.

Direct Glare – Rating: 7

In-ground fixtures are a cause for concern for direct glare. Additional façade lighting results in direct glare of particular concern considering vehicular traffic. Given the building's proximity to the street on three of four sides, façade lighting intended for sidewalk illumination and side-building illumination can become major direct glare issues as well. Sharp cut-off angles are required for fixtures installed outside such that they do not distract or, worst-case scenario, blind passing drivers.

Light Distribution on Surfaces – Rating: 8

Harsh scallops on the façade will alter the linearity of the building and create an unpleasant wave-effect on the lower portions of the building. Depending on the lighting design intentions, spots should be aimed to accent certain areas, but narrow beams should not be used to reach a large number of floors simultaneously unless highlighting a specific linearity.

Luminance of Surfaces – Rating: 6

Surface luminance is not of great concern because of the obvious characteristic of the surfaces. The bright white precast concrete walls will have a great luminance, while the glass panels will have very little. Balancing these light levels or creating an appropriate gradient will be very important to the design scheme.

Light Pollution and Trespass– Rating: 9

Light pollution from the glass façade may be considerable. Without appropriate lighting (not currently utilized) dark sky recommendations cannot be met. Light trespass to adjacent properties is also of concern due to the variety of zoning in the immediate vicinity. With residential areas to the north and east of Cathedral Place, light trespass will not be tolerated by current residents. Light pollution and trespass should be minimized as an example to future new construction and as a courtesy to those neighboring properties and their current occupants.

Modeling of Faces and Objects – Rating: 6

The modeling of faces and objects is important at ground level for easy and accurate facial recognition and general safety concerns. Bollards, curbs, wall extensions or protrusions, and spatial awareness are a necessity at ground level when considering façade lighting for the safety of the pedestrian, and passer-by, as well as for vehicular access and awareness.

Points of Interest – Rating: 8

Façade lighting, when not independent to the tenant space such as a restaurant or retail shop, is important to identify the entrance(s) and exit(s) to a building. Considering this building's use, the entrances and exits to the parking garages (and the differentiation between them) is extremely important as points of interest. These areas should have a higher illuminance than the adjacent spaces.

Shadows – Rating: 8

Shadows at the ground level should be avoided as a general safety concern as well as vehicular-pedestrian safety. A poorly located shadow could make a pedestrian all but invisible to a car entering the parking structure, which would be a great safety concern.

Surface Characteristics – Rating: 6

As previously noted, the surfaces of the building do not vary considerably, but they do have architectural appeal. For this reason, it would be in poor design taste to neglect these elements (such as the dark marble at the base of the columns between retail entrances, or the aluminum canopies over each retail and the main entrances).

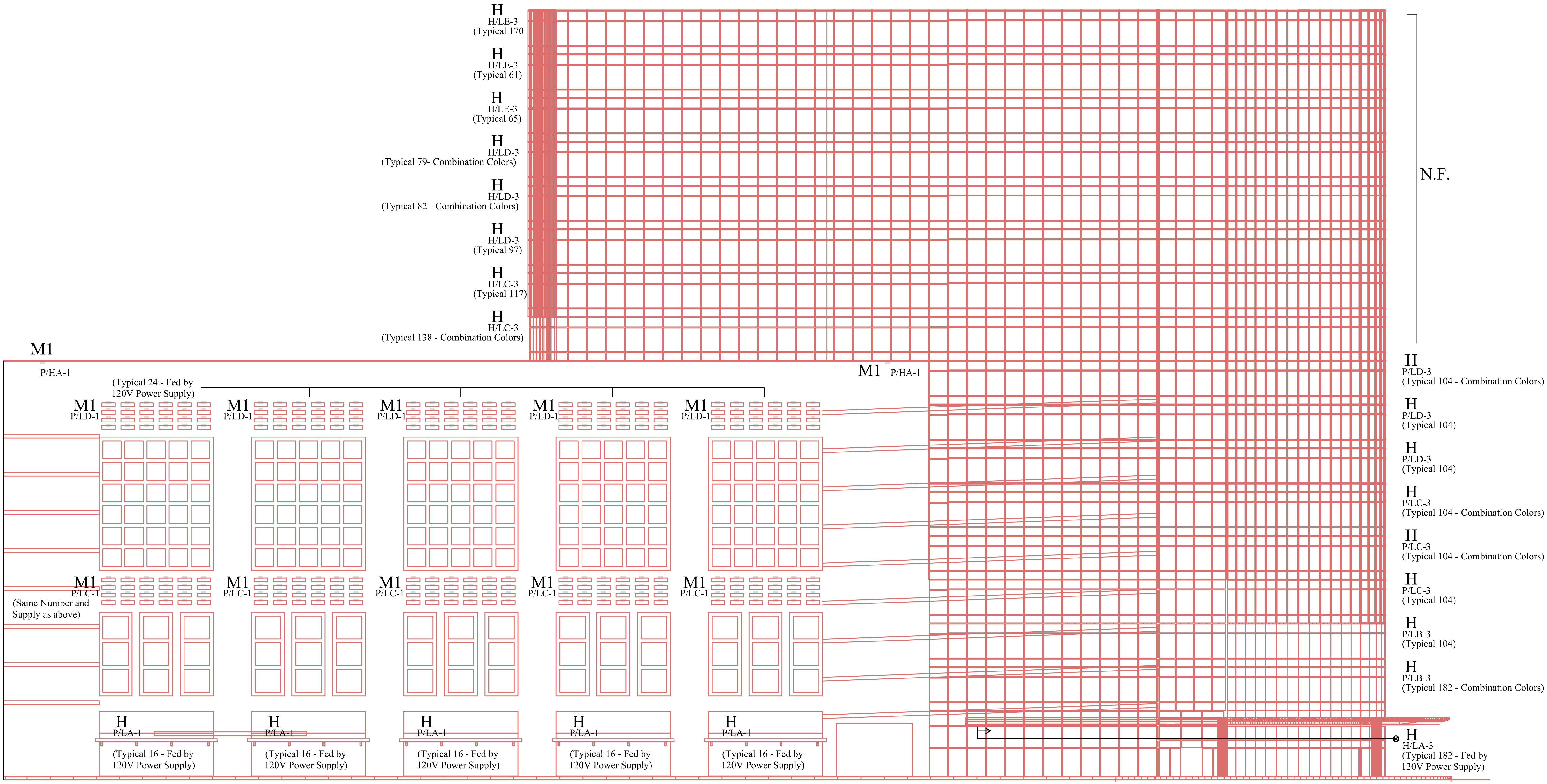
Horizontal Illuminance – Rating: 8

The horizontal illuminance on the façade is extremely variable. Horizontal illuminance occurs mainly at ground level, and those values should range from 10 to 50 lux depending on the security condition and the proximity to a major building entrance. Under the canopies, illuminances should attempt to maintain 20 lux and increase in response to the "point of interest" criteria.

Vertical Illuminance – Rating: 6

Vertical illuminances of the façade are extremely variable dependent on the location of measurement. The vertical illuminances at the ground level should be the most uniform with an illuminance similar to that of a parking structure condition – 10 to 30 lux for facial recognition and general safety and spatial awareness concerns.

Layout and Circuiting



Facade Profile, Lighting Layout and Circuiting Diagram
Luminaires on the Northern Facade (labelled N.F.)
are included in the numbers listed for this profile.

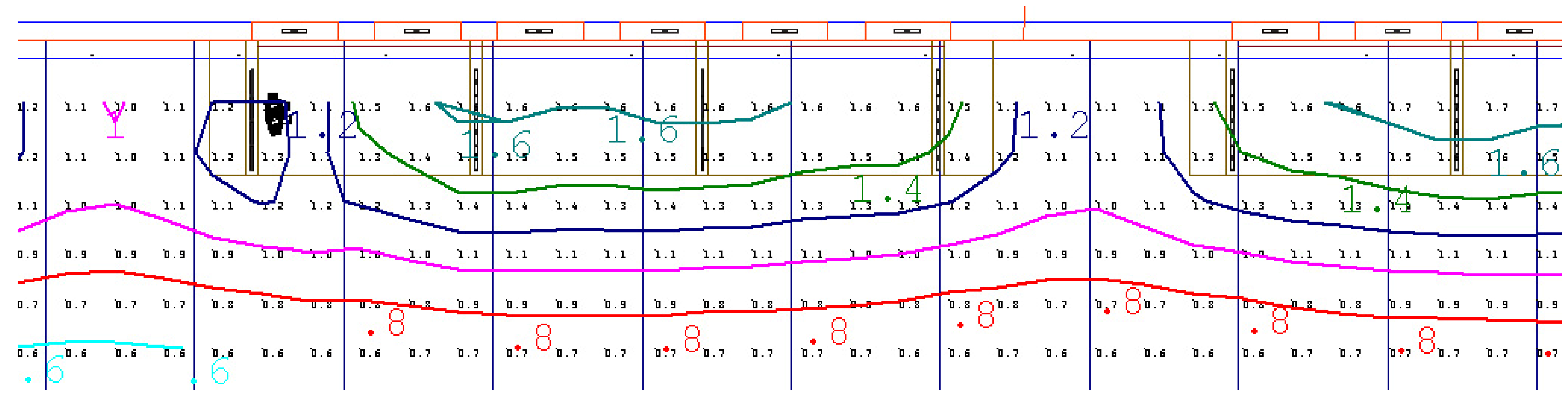
All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

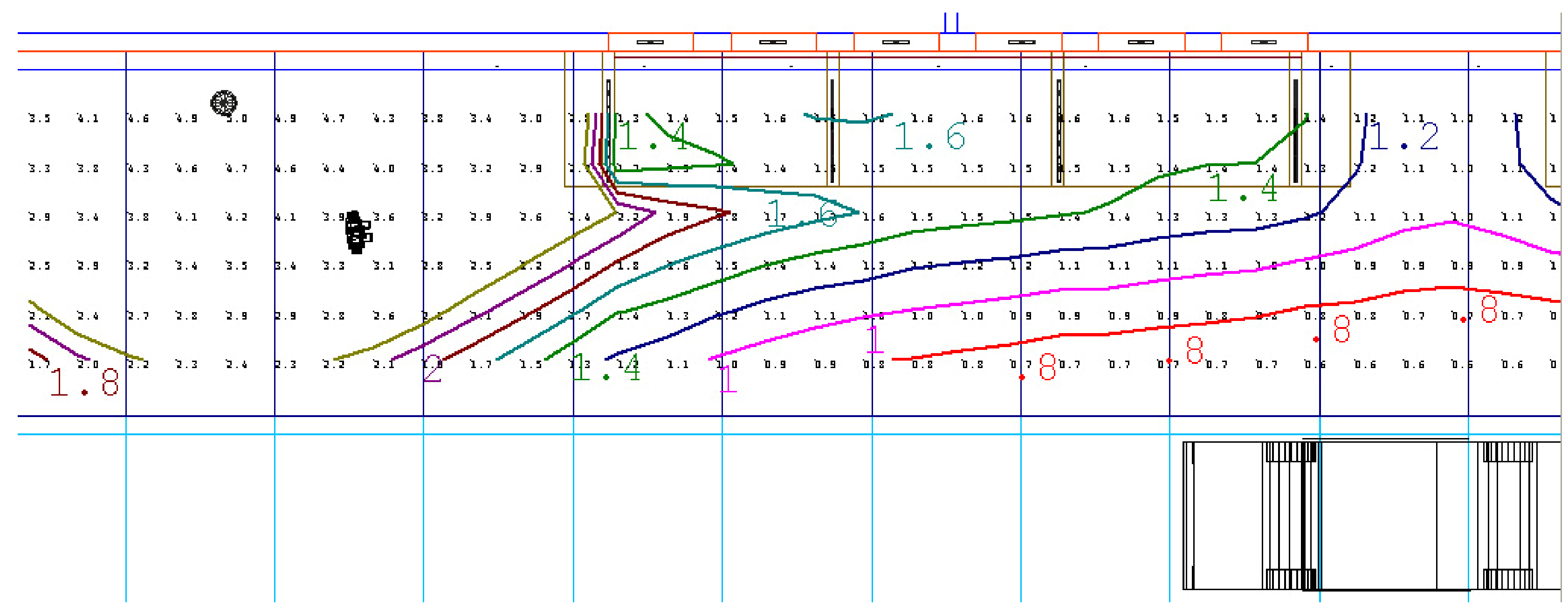
Performance

Sidewalk
Illuminance Values
(Fc)
Average=1.62
Maximum=5.8
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

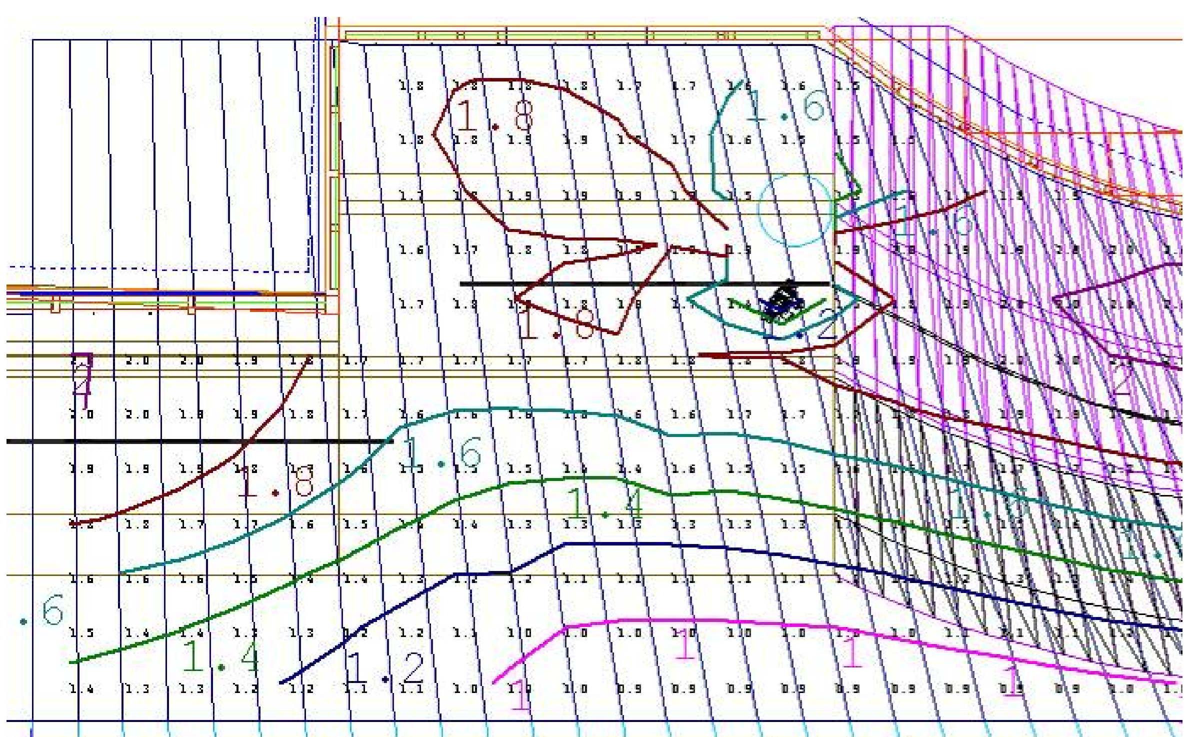
Main Canopy
Illuminance Values
(Fc)
Average=1.52
Maximum=2.0
Minimum=0.6
Avg/Min=2.53
Max/Min=3.33



Mid Sidewalk Portion



Far South Sidewalk Portion



Entrance to Lobby

ASHRAE Power Density Calculation

ASHRAE Power Density Allowance for Facade – Exterior Lighting: 0.25 W/sf façade lit

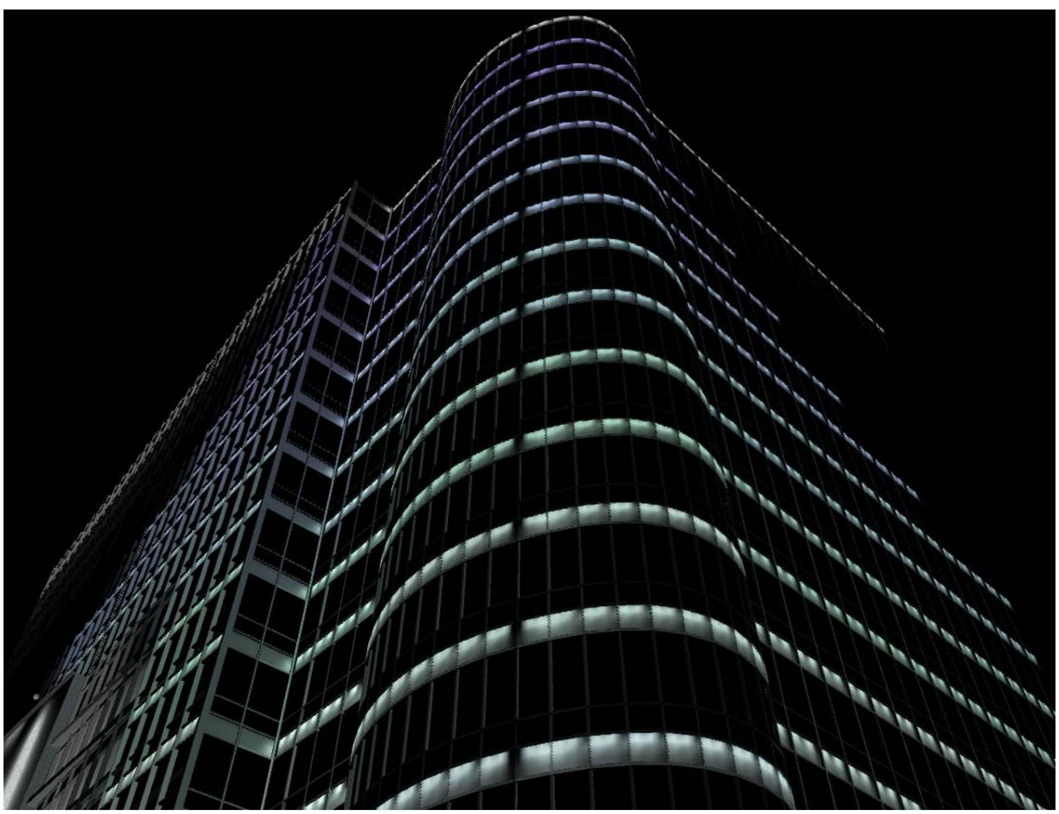
Façade square footage: 9700 sf(485' "perimeter" * 40' vertical illumination area)
ASHRAE allowance : 4850 W
Existing Power Density: 0.28 W/sf Does NOT meet ASHRAE 90.1

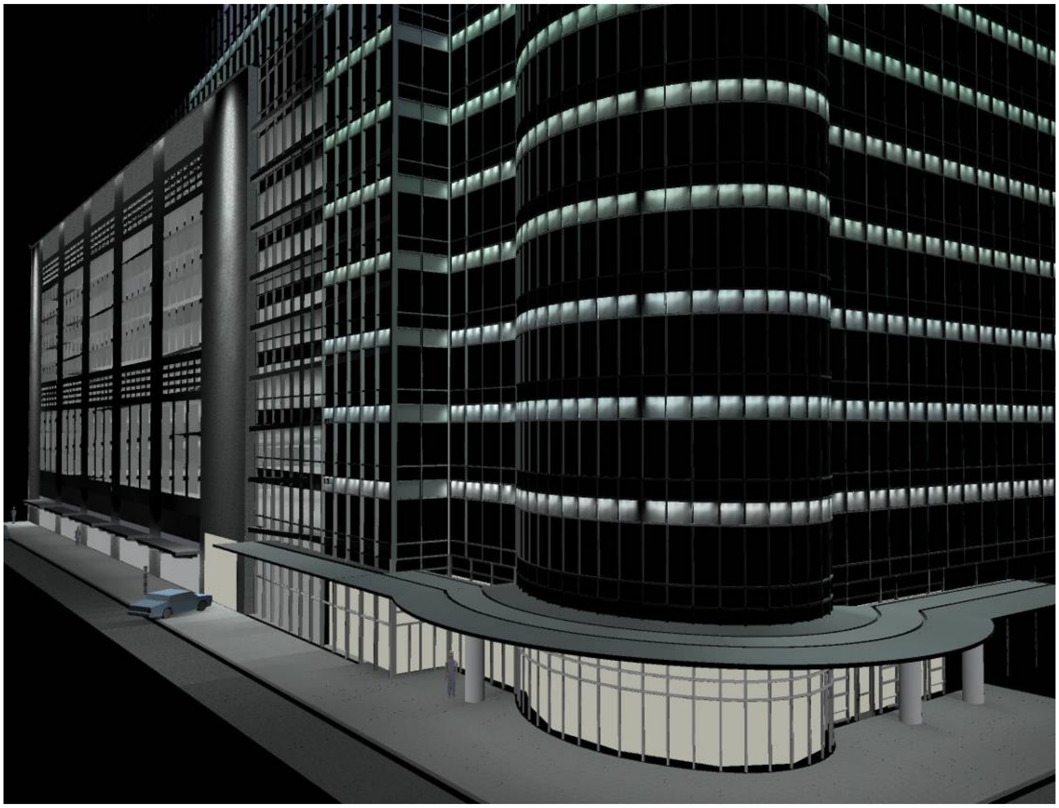
Façade	H	H1	H2	H3	H4	M1			
Luminaire	781	165	312	312	456	2			Power Density
Wattage	1	1	1	1	1	191	SUM (VA)	Area (sf)	
Total Power	1172	248	468	468	684	573	3612	9700	**0.372 W/sf**

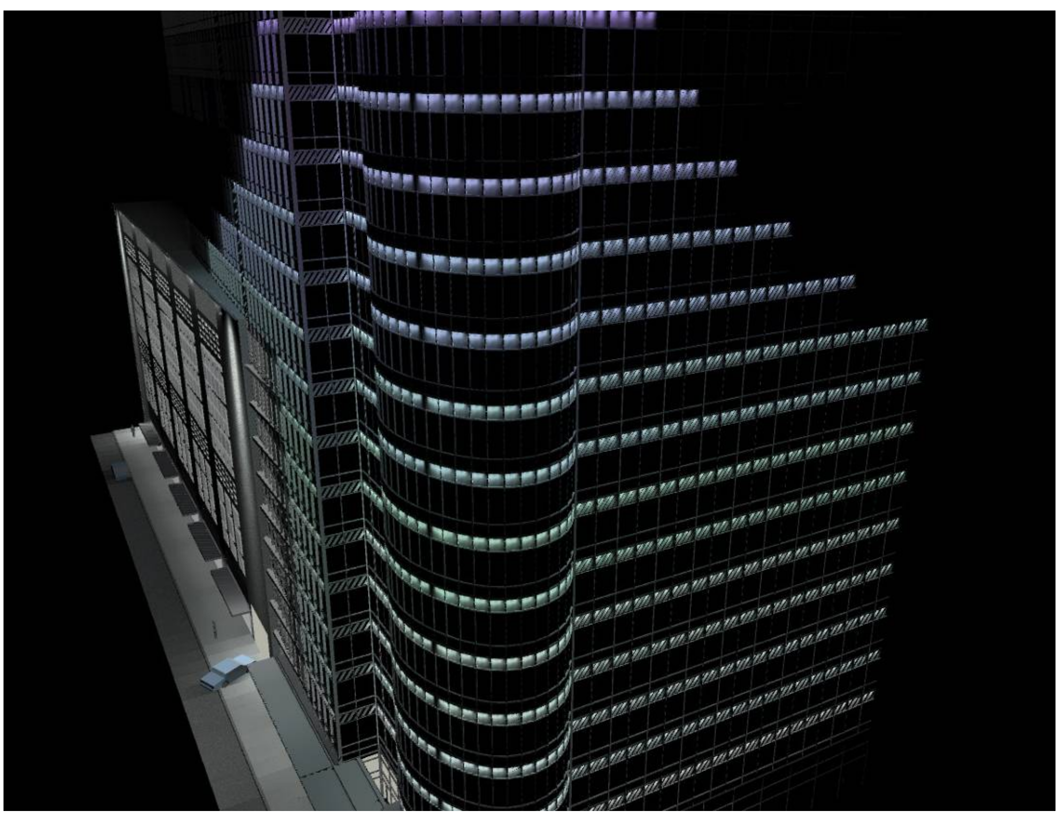
New design meets ASHRAE 90.1 Standard

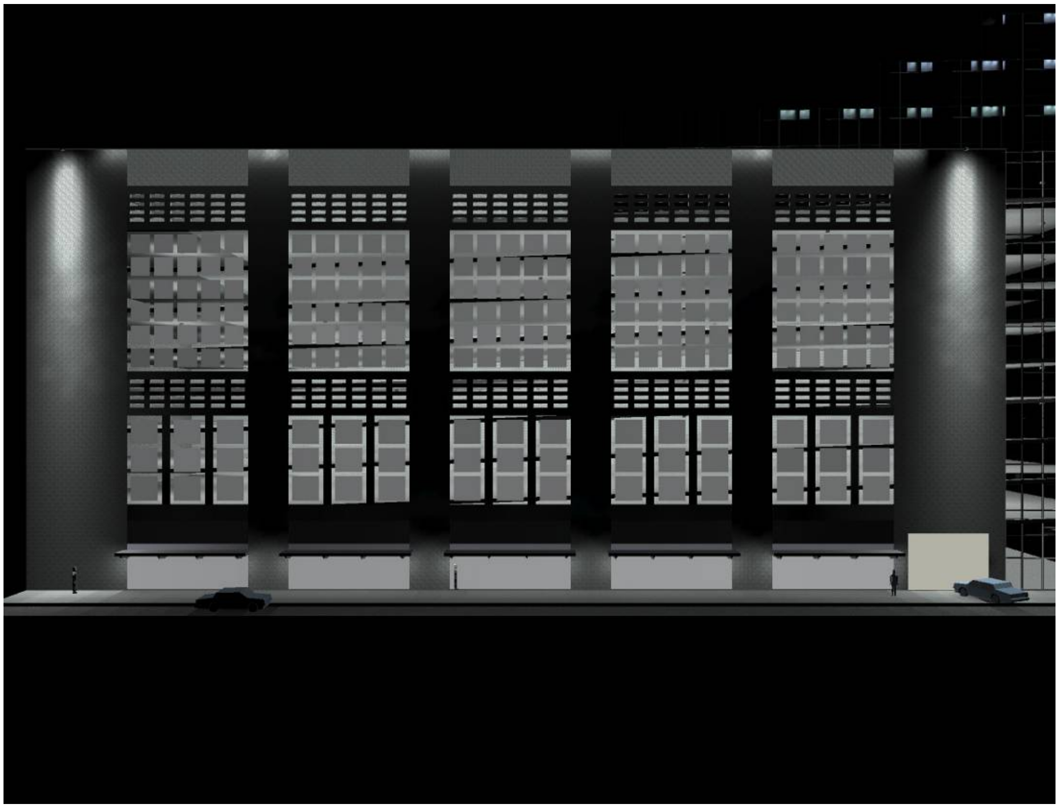
**It should be noted that the area used was calculated from the "per square foot of façade being lit" calculation. And the area determined above is a conservative estimate of the area actually being lit by all sources.

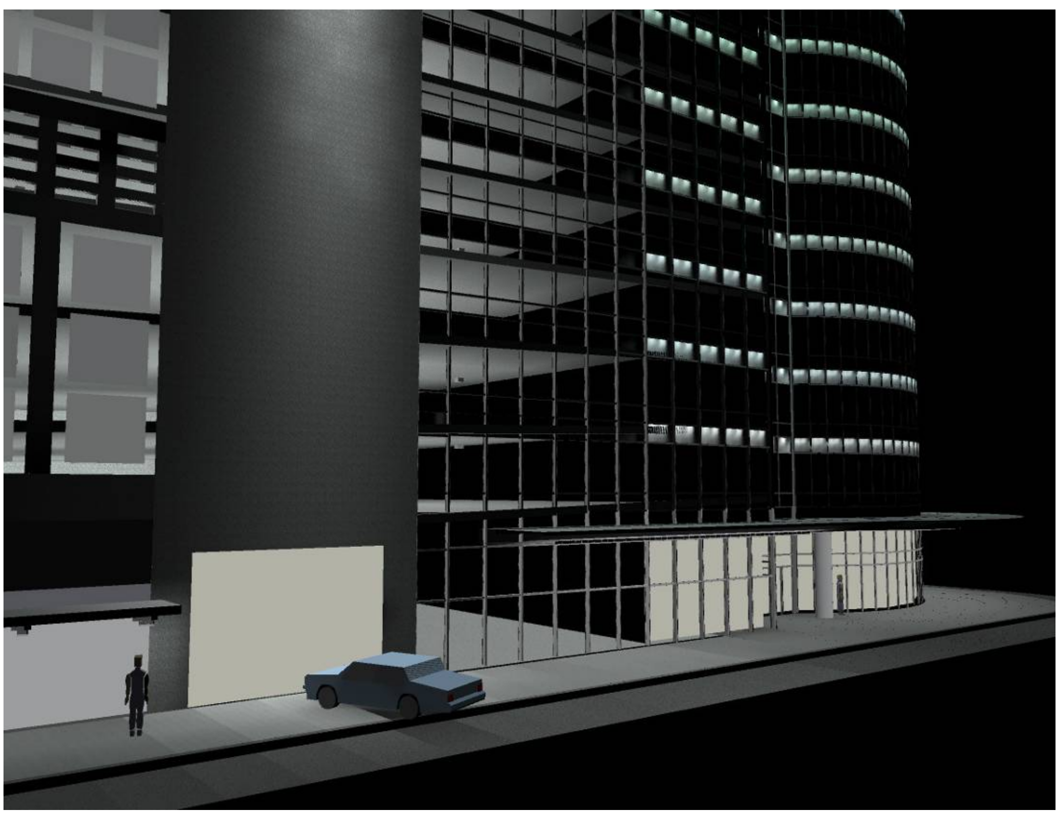
Renderings

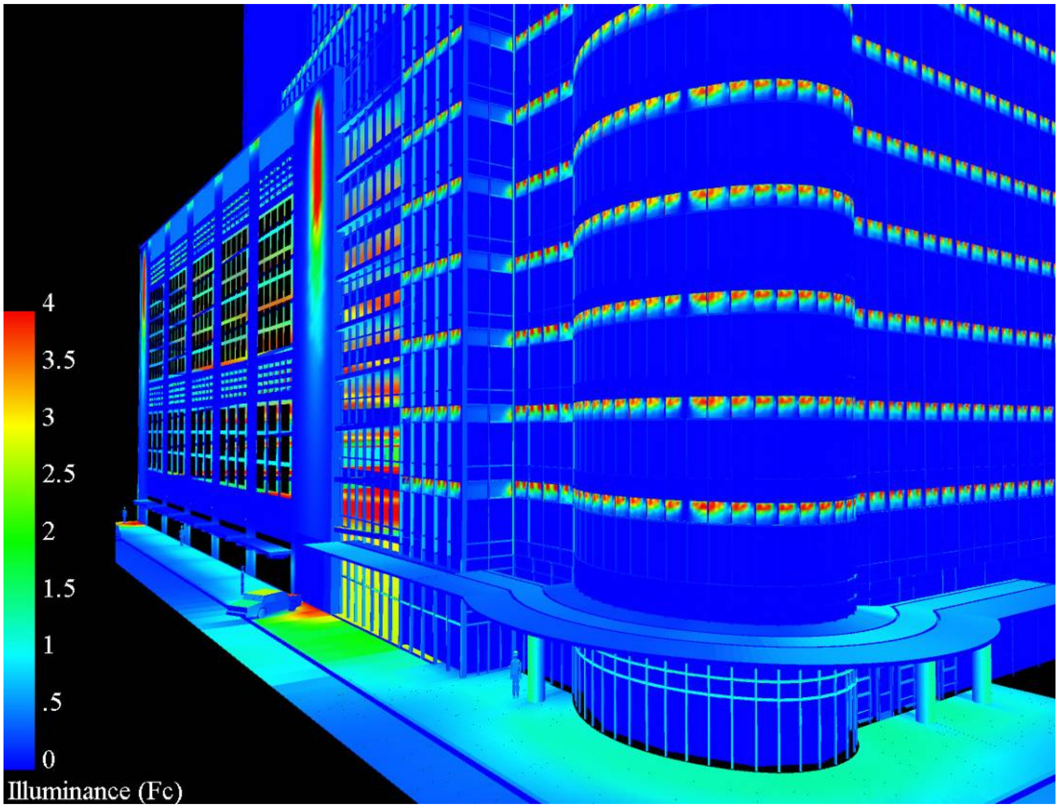


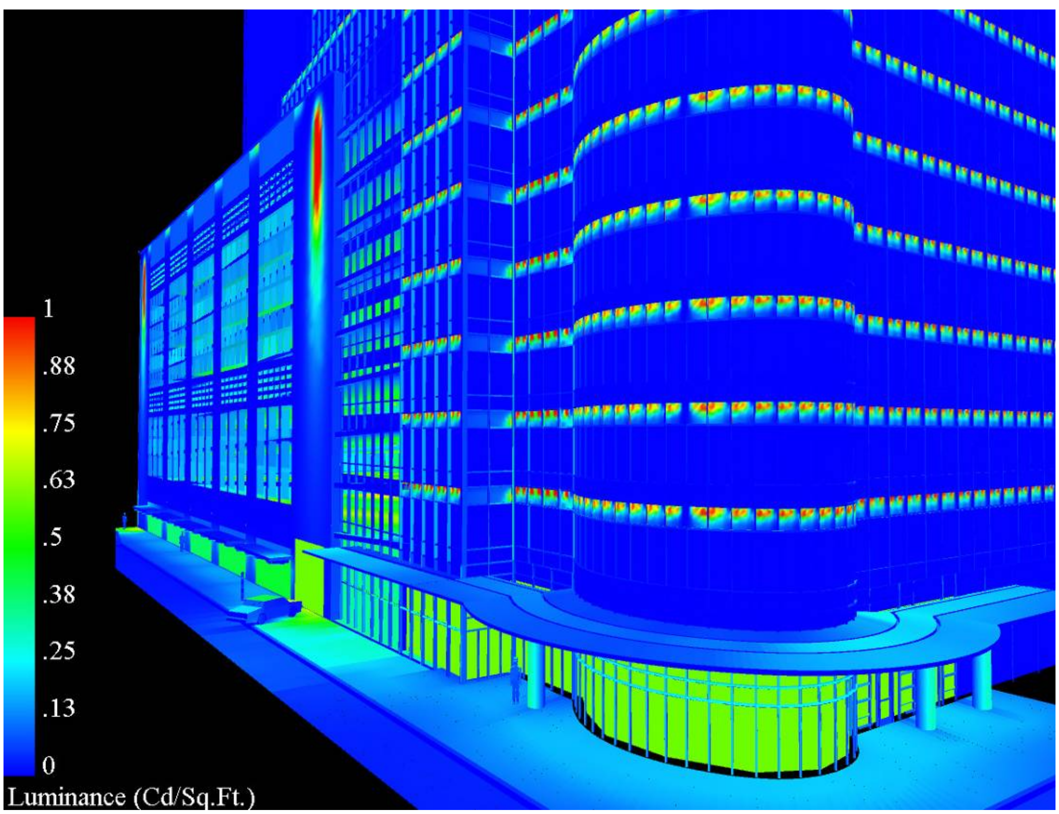


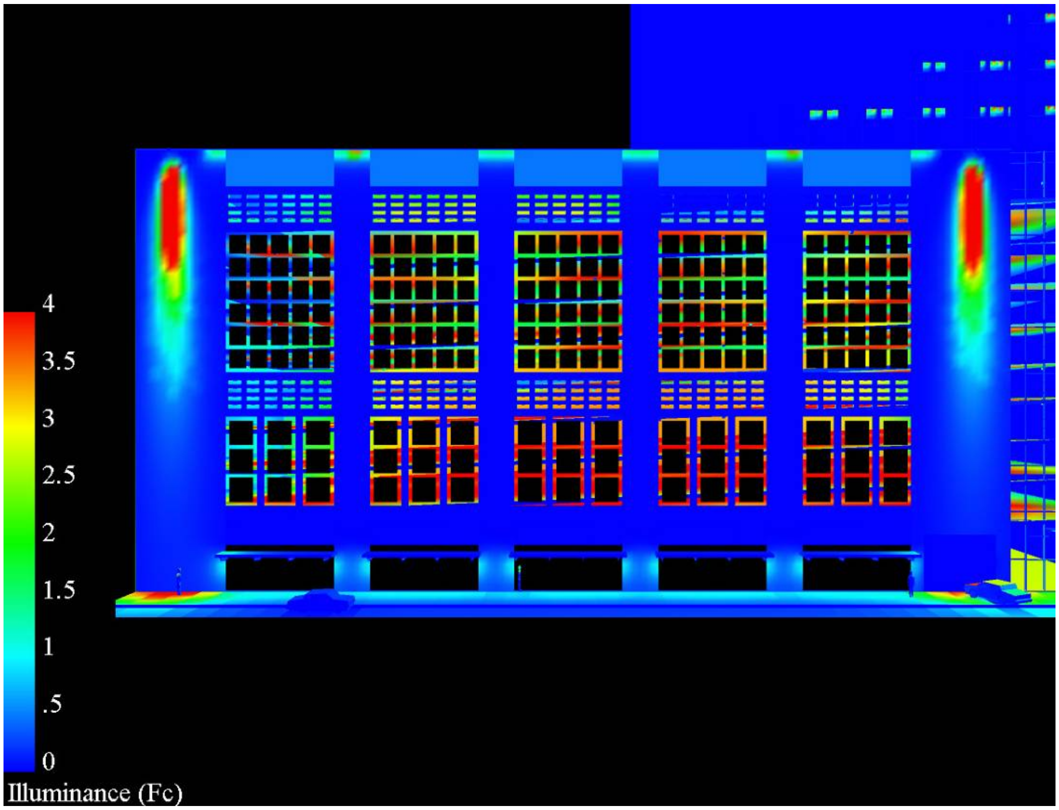




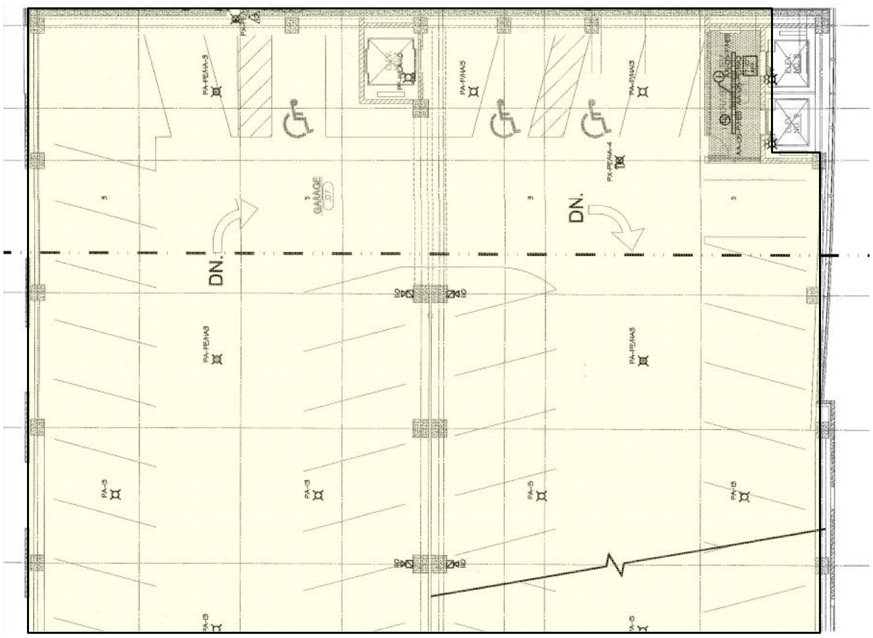



4
3.5
3
2.5
2
1.5
1
.5
0
Illuminance (Fc)


1
.88
.75
.63
.5
.38
.25
.13
0
Luminance (Cd/Sq.Ft.)


4
3.5
3
2.5
2
1.5
1
.5
0
Illuminance (Fc)

Parking and Parking Lobby



Thematic Description

The parking level and lobby theme was not as profound as the façade, and was never intended to be. The overall “water” theme was touched upon in the Parking Lobby where the materials of the space were changed to include a bluish tint, giving the vague impression that the individual was underwater. Considering the surrounding space is completely concrete, it was hard to bring any theme to fruition when a simple exterior glace would force the occupant to dismiss any vague notion.

Surface Materials

One of the main surface materials is the wall material, which, on interior load-bearing elements are cinderblock masonry walls. These concrete blocks with similar concrete mortar are all of the relatively same color and reflectance. They are a medium grey on average.

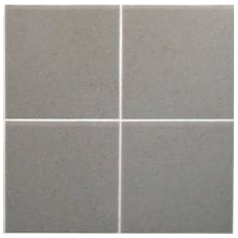
Reflectance: 0.41

The floor of the parking structure is uniform except for the elevator lobbies. The surface is a smooth concrete with a similar color and reflectance as the cinderblock walls. It, while dirtier and discolored more often, is an average medium grey.

Reflectance: 0.37

The walls and ceiling of the lobby are a simple white painted drywall. It is highly reflective when compared to the rest of the structure, and as such, stands out as a point of interest.

Reflectance: 0.81



The tile in the lobby on the floor and on the lower few feet of the walls (kick-guard tiling) is a deep grey with white grout. This dark surface requires little cleaning, and if so, it is very easy. It also complements the grey color of the structure and doesn't give a "color-bomb" appearance to the lobby.

Reflectance: 0.30

Glazing Specifications – Transmittance and Reflectance

While there is no technical glazing on the walls, there are any number of open portholes, and as shown to the left, large expansive openings with metal mesh inlays acting as "window screens". This metal mesh surrounded by open air is approximated with diffuse windows and transparent windows respectively.

Transmittance (screen): 0.33
Reflectance (screen): 0.66

Design Concept

The design concept for the parking garage was based on two specific goals – to maintain the illuminance in the parking garage at levels appropriate for a parking garage, and to decrease the number of luminaires used and therefore decrease the interior power density of the garage. A subsequent advantage of the alteration of the lighting design was the glowing appearance the parking garage will create throughout the precast structural area of the façade.

Design Criteria

Appearance of Space and Luminaires – Rating: 6

The appearance of the parking deck and the luminaires is not of great concern. A general attempt to deviate from the typical parking structure look and feel should be attempted. The appearance of the space from the exterior however, is a bit more important. To have a blue/white façade get drowned out by light pollution and trespass from an orange high-pressure sodium within the garage would not be prudent. Exterior appearance of the garage's interior is relatively important.

Appearance of the luminaires themselves is not very important either. While an attempt to furnish a more aesthetically pleasing luminaire should be made, the greatest importance lies in the efficiency of the luminaire, not its aesthetic pleasantness.

Color Appearance and Contrast – Rating: 8

Color appearance and contrast should be regarded as a more important to the design. The lighting design should attempt to use lamps with high CRIs as well as high efficacies. The lacking appearance of color and accurate rendering would be a significant safety concern. Additionally, the color appearance is important to the general façade lighting as mentioned previously. They must be intertwined.

Direct Glare – Rating: 5

Appropriate fixtures with adequate diffusing lenses should be used to eliminate the direct glare that can accompany low-ceiling parking structure lighting. Reduction of glare in typical parking structures is completed by placing the luminaires off-center of the driving aisle. However, in this building, the post tensioned concrete beams drop down so far below the ceiling level, direct glare is almost entirely masked.

Light Distribution on Surfaces – Rating: 5

Distribution of light should be uniform for all surfaces with as slight a gradient as possible. Harsh shadows from vehicles may impede this uniformity, but driving lanes and pedestrian walkways should maintain a consistent uniformity. Ceiling brightness is not of great concern, and scalloping on walls can be nearly neglected based on the positioning of the luminaires nearest the aisles.

Luminance of Surfaces – Rating: 2

Considering the entire structure to be concrete, luminance of surfaces only concerns the space itself, and the cars parked within it. The luminance of the walls, floor, and ceiling will be equal in ratios to their illuminances, and concern for spatial depth problems is nullified. Since the specularities of cars cannot be accounted for either, it too is neglected.

Light Pollution and Trespass– Rating: 9

Light pollution and trespass (one and the same at level 3) should be accounted for as previously noted in the space and color appearance sections. Pollution and trespass through the many openings in the precast concrete walls should be controlled as much as possible through appropriate luminaire placement and selection of appropriate IESNA type fixtures.

Modeling of Faces and Objects – Rating: 6

Similar to the façade ground-level reasoning for safety concerns and vehicular awareness, face and object modeling is relatively important and a higher light level should be maintained to account for these conditions. Given the exposed internal structure, the bollards around the exposed upper structure, and the precast panel walls, spatial and depth cues should be easily identifiable for all vehicles.

Points of Interest – Rating: 8

Higher illuminances at the elevator lobbies and pedestrian paths to said lobbies should be maintained as the only point of interest for a given floor. Exit stairs in the case of emergencies should also be highlighted points of interest in the parking structure.

Shadows – Rating: 7

Shadows, for safety concerns, should be minimized as much as possible and their existence should start at the center of the aisle (none) and become harshest at the head of a parking stall. Shadows created between cars from long throws of light in far fixtures should be minimized to maintain a certain safety factor.

Horizontal Illuminance – Rating: 6

The horizontal illuminance varies for points within the parking structure. As noted in chapter 22 of the IESNA Handbook, they should follow this schedule:

	Day	Night
Basic	10 lux	10 lux
Ramps	20 lux	10 lux
Stairs	20 lux	20 lux
Entrance	500 lux (incl. daylight)	10 lux

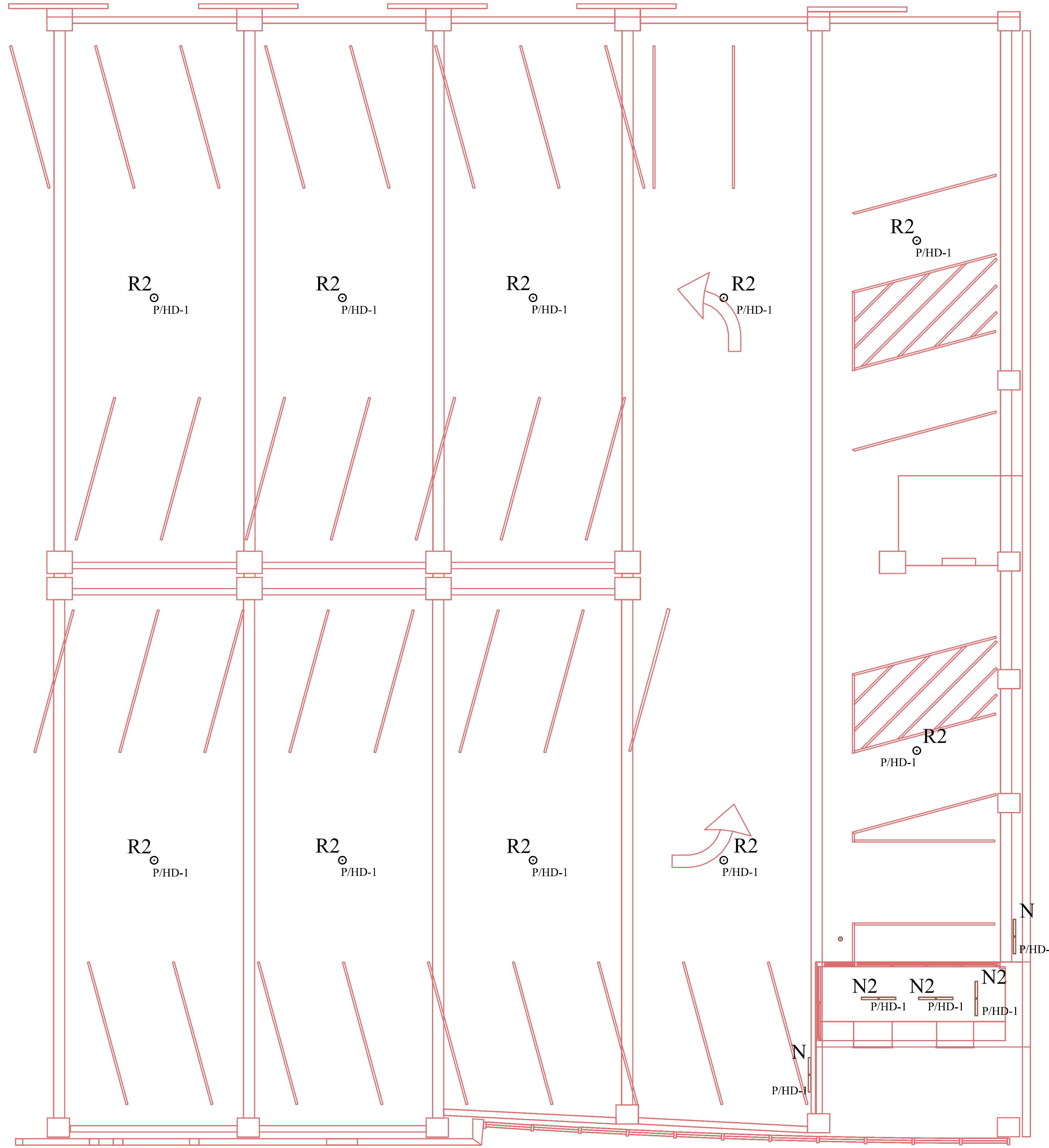
Vertical Illuminance – Rating: 6

The vertical illuminance varies for points within the parking structure. As noted in chapter 22 of the IESNA Handbook, they should follow this schedule:

	Day	Night
Basic	5 lux	5 lux
Ramps	10 lux	5 lux
Stairs	10 lux	10 lux
Entrance	250 lux (incl. daylight)	5 lux

Layout and Circuiting

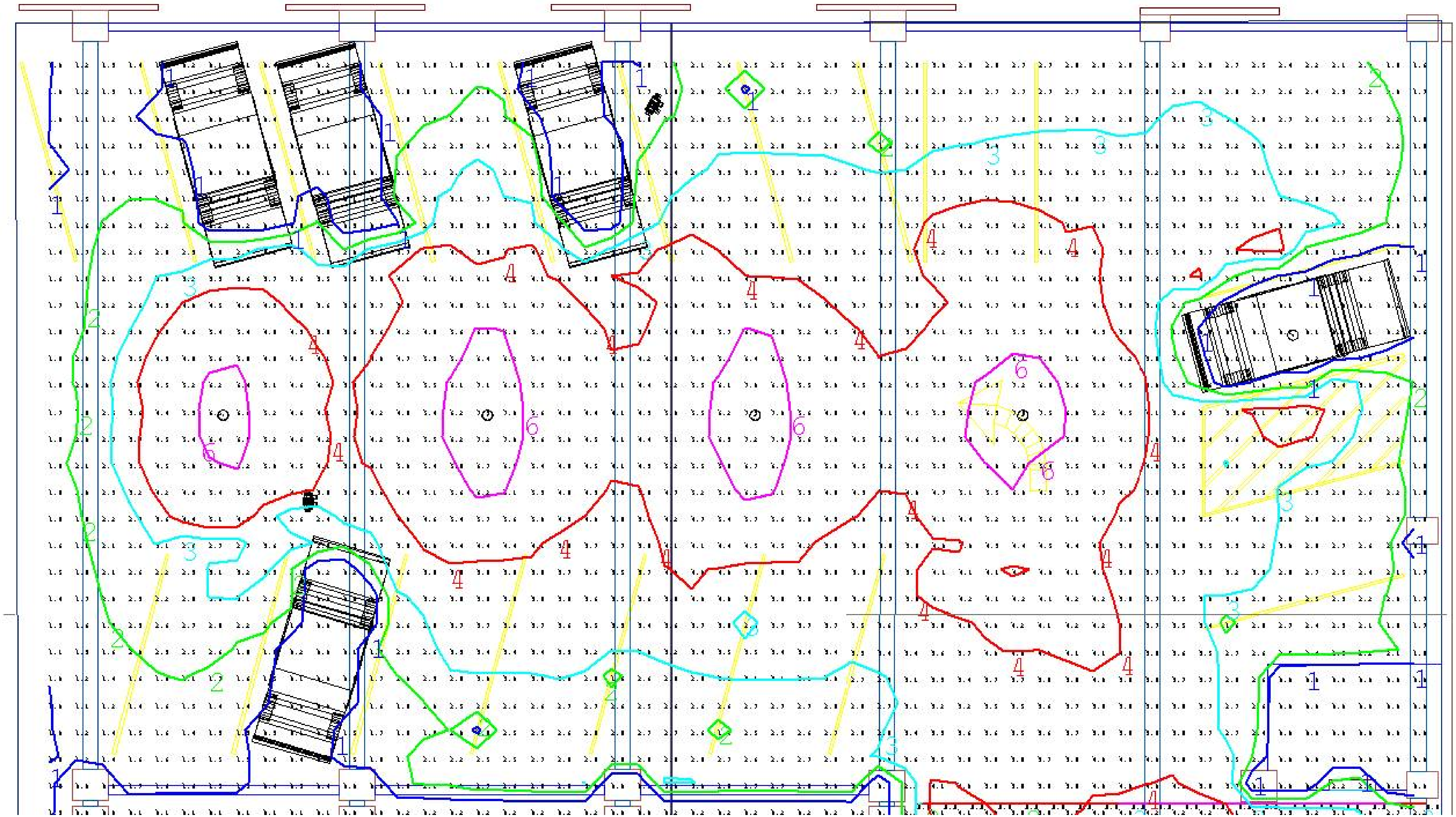
Parking Garage Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D) or Occupancy ("O") Sensor

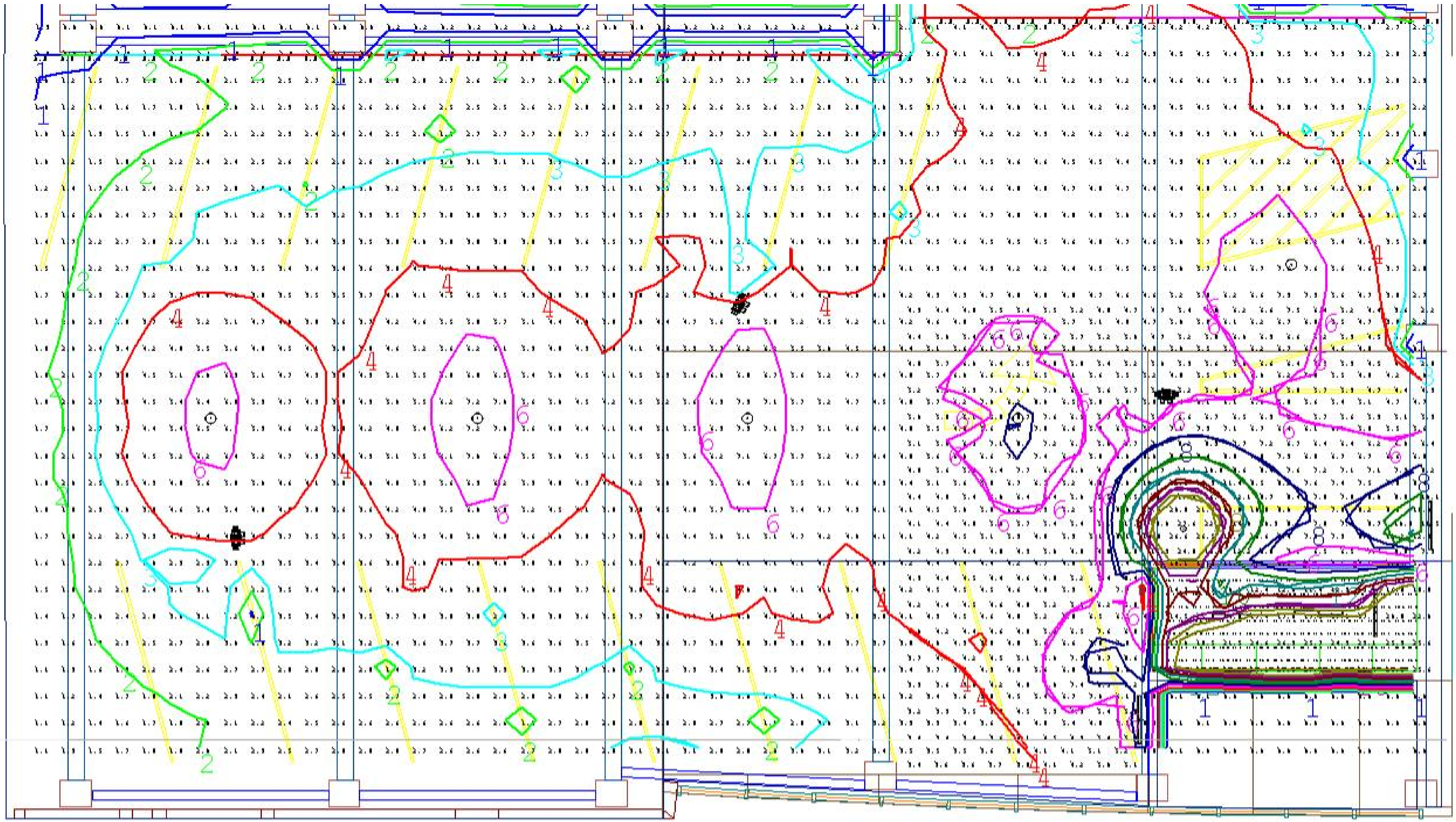


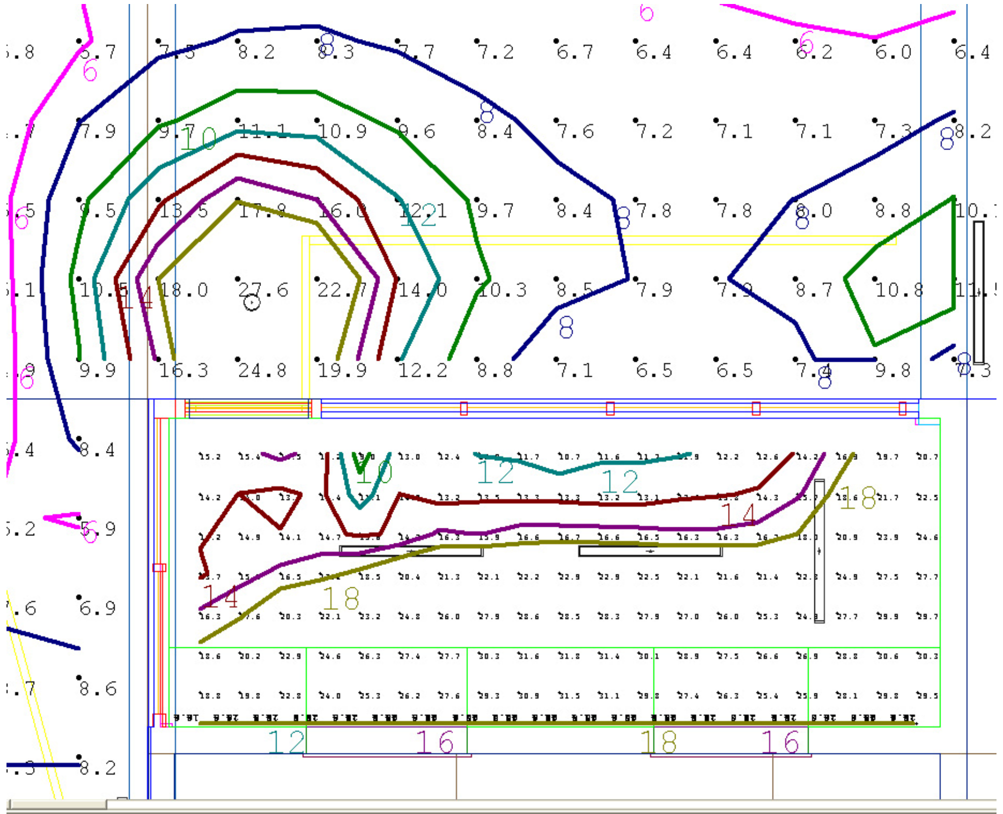
All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

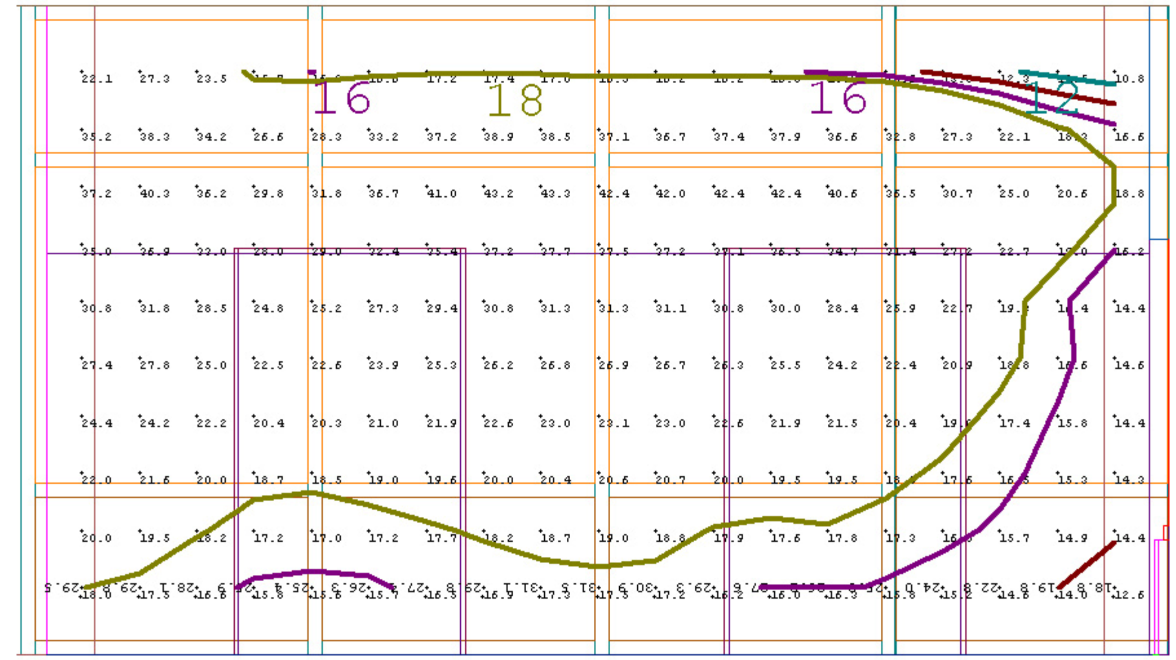
Performance



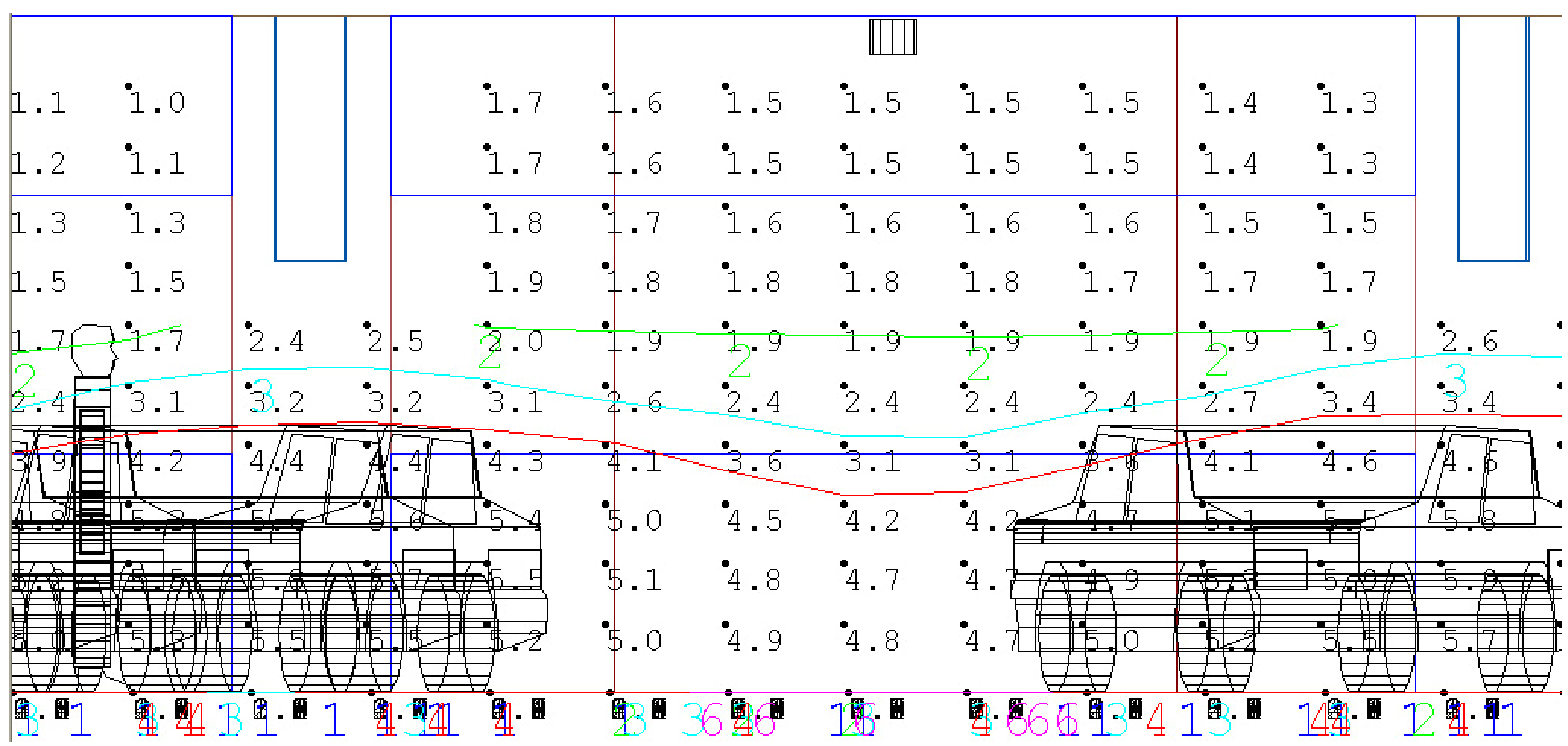




Close-up of Elevator Lobby



Elevator Wall Illuminance



Vertical Plane Illuminance

Project_1

Calc Pts

Lobby
Illuminance Values (Fc)
Average=20.91
Maximum=31.8
Minimum=9.0
Avg/Min=2.32
Max/Min=3.53

Lobby Elev Wall
Illuminance Values (Fc)
Average=24.09
Maximum=43.3
Minimum=10.8
Avg/Min=2.23
Max/Min=4.01

Outside Lobby
Illuminance Values (Fc)
Average=6.42
Maximum=27.6
Minimum=2.2
Avg/Min=2.92
Max/Min=12.55

Parking Vert Mid
Illuminance Values (Fc)
Average=2.92
Maximum=6.2
Minimum=0.1
Avg/Min=29.20
Max/Min=62.00

Parking Vert Turn
Illuminance Values (Fc)
Average=4.15
Maximum=7.8
Minimum=1.6
Avg/Min=2.59
Max/Min=4.88

Parking
Illuminance Values (Fc)
Average=3.76
Maximum=27.6
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

ASHRAE Power Density Calculation

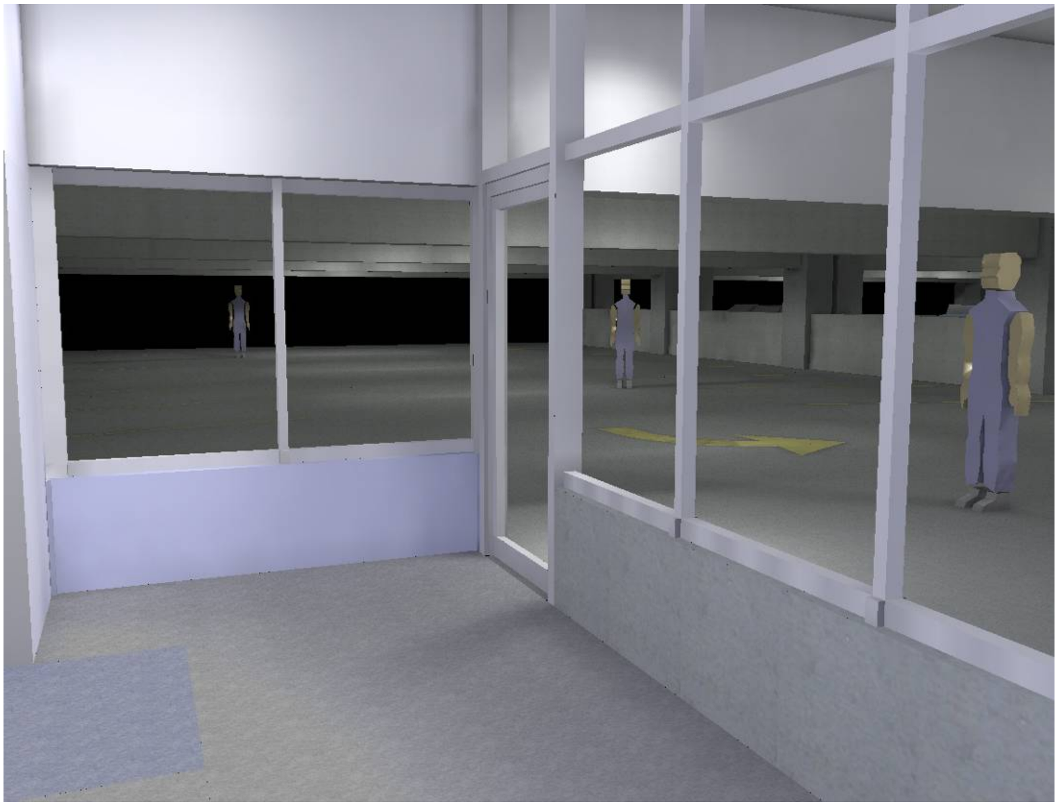
ASHRAE Power Density Allowance for Parking Garage: 0.3 W/sf

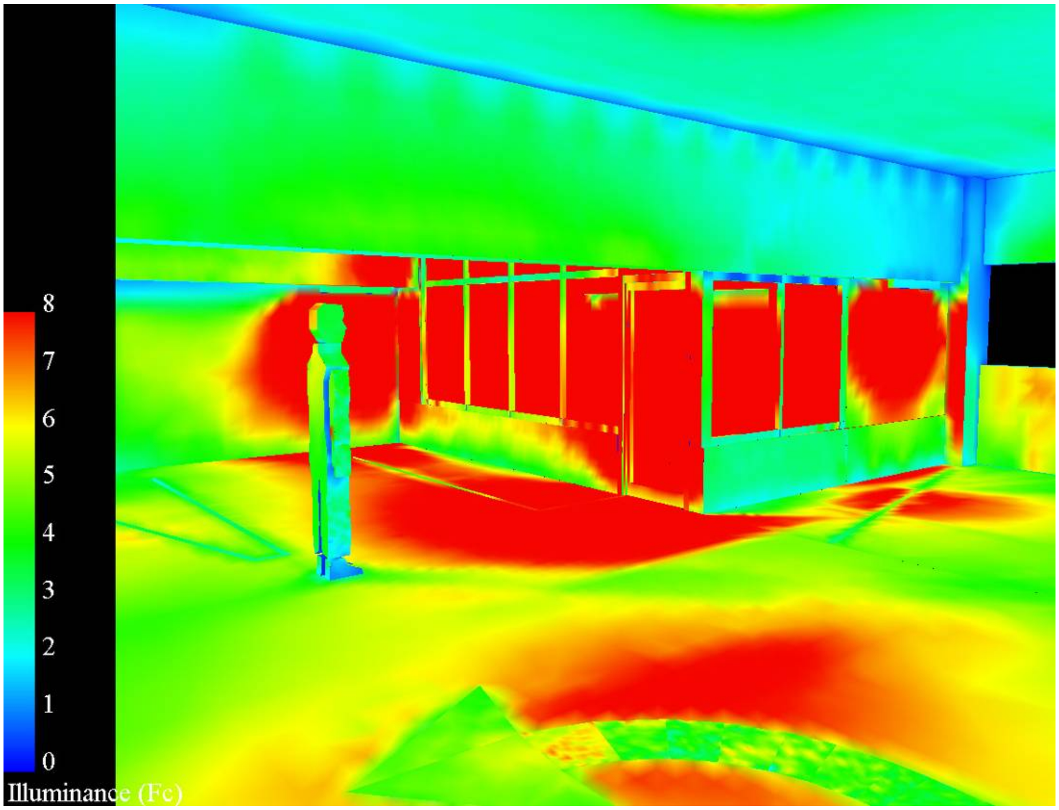
Parking square footage BA:	11600 sf	
ASHRAE allowance BA:	3480 W	
Existing Power Density BA:	0.255 W/sf	Meets ASHRAE 90.1

Parking Garage (Section)	N	N2	R2			
Luminaire	2	3	10			Power Density
Wattage	32	59	191	SUM (VA)	Area (sf)	
Total Power	63	176	1910	2148.5	11600	**0.185 W/sf**

New design meets ASHRAE 90.1 Standard

Renderings




8
7
6
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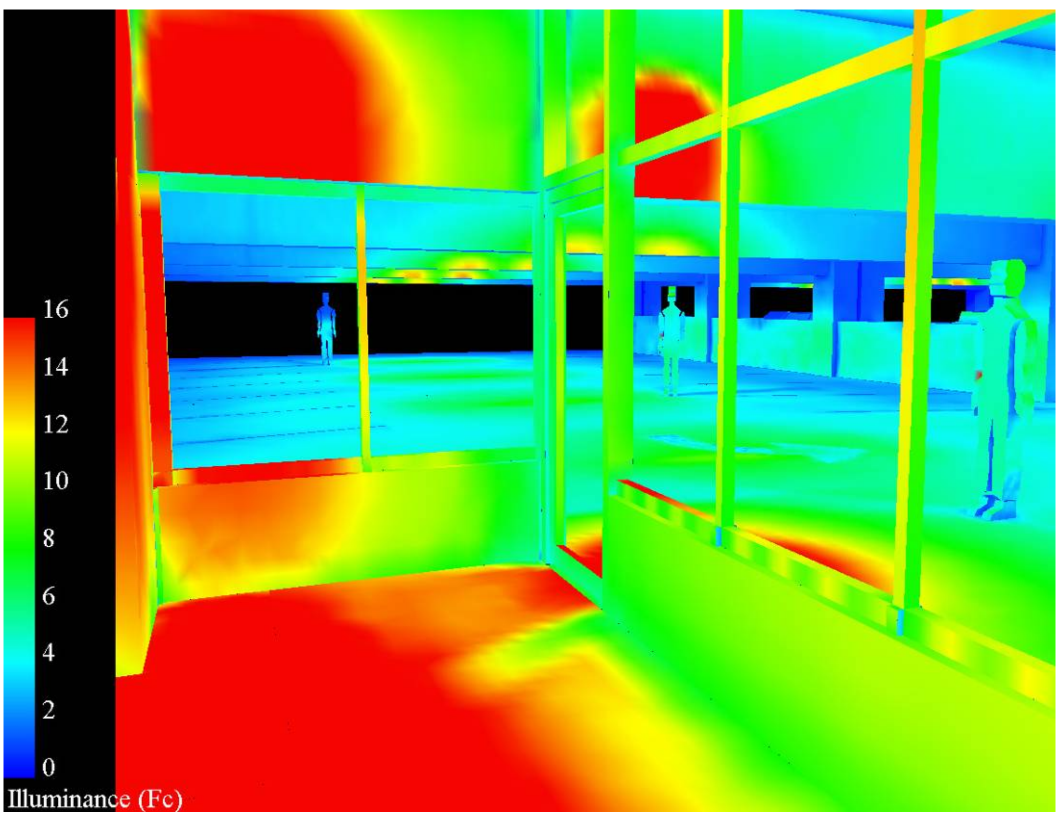
Illuminance (Fc)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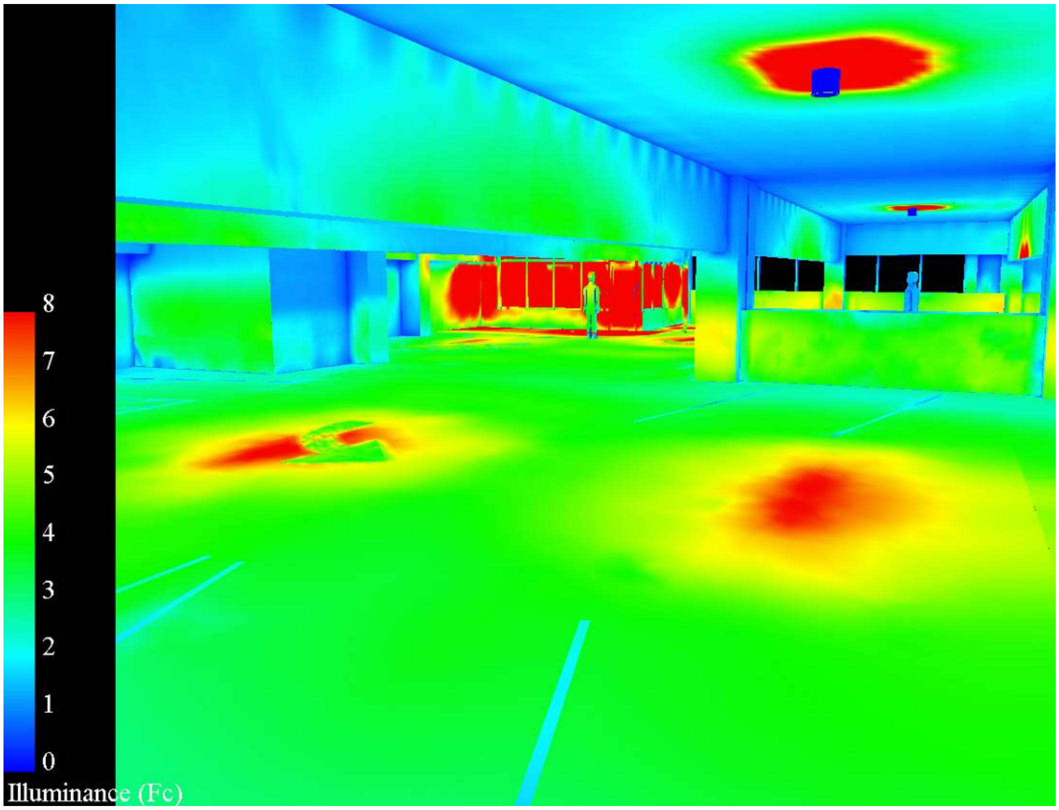
Illuminance (Fc)


8
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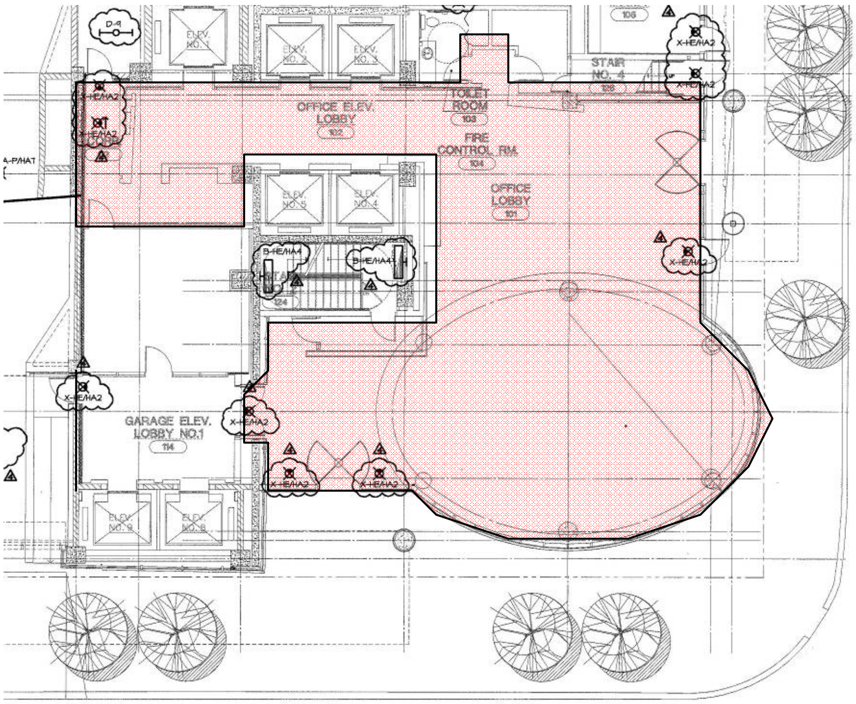
Illuminance (Fc)

Lobby



Special Luminaires

The Lobby has a few special luminaires that should be mentioned prior to viewing of the spaces. First, the same LED system used on the façade of the building is used on the aluminum mullion elements where the green translucent glass walls are located. The only difference between the façade LEDs and the Lobby LEDs is the orientation. The façade aims upward while the Lobby has the LEDs aiming upward.

The second of the special luminaires are the sculptured art pieces which were researched for the candela distribution (described above). These pieces are only located within the space and do not have any special orientation or function beyond simply existing.

The third special luminaire is the "barrel" luminaire used as an area source for the translucent "wave" pattern on the ceiling. These luminaires were also modeled as part of the lighting research and are described above as well.

All of these luminaires are detailed in Appendix C

Thematic Description

The theme of the exterior façade complimented by the vast, screened "windows" of the parking garage is exemplified, and even magnified in detail, within the Entrance Lobby. The water theme of the exterior would have to remain on the exterior and could not extend into the Lobby without logically altering the impression. Upon entering the building, one, in theory, enters the water fountain. This would put them underwater in all technicality and this idea was the basis for the lighting design within the space.

Considering the architectural elements already used, metaphors were developed for each of the materials and the lighting design appropriately adjusted. For example, the translucent walls, both white and green tinted, were underwater "bubbling" elements of the scene. The wood paneling seen on a select few of the walls, and accentuated by differing materials, implies a sunken ship, or underwater view of piers. All of the marble elements and white painted walls were considered stone, or the "bottom of the sea" where the individual would be walking. The glass and ceiling would then naturally be the limit of the water, as implied by the façade's appearance. Because the limit of the water is naturally oriented upward, the ceiling needed special significant design to achieve this impression. For this reason, a barrel-downlighting solution was applied and plastic highly translucent strips of varying width hung from the ceiling. These strips were tinted with a color gradient varying from light coral green to blue. The light output through these materials would vary, the dimensions of the strips themselves vary, and the varying color all give rise to a "wave" impression with peaks and valleys – a distinct indicator of the water's limit.

Surface Materials

Material and finish schedules could not be obtained in detail from the architects, and thus the reflectances have been determined using a small patch of the material gleaned from photographs and applied as surface materials in AGI which calculates an overall reflectance based on the materials colors and patterns.

The aluminum for the interior spaces has a higher specularity than the aluminum on the façade. The aluminum as is seen on the left side (non-daylight) is grey colored with a high sheen clear glazing giving it the specular look.

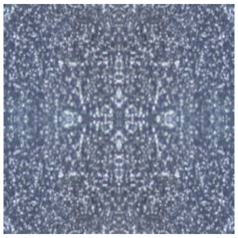
Reflectance: 0.7 (based off façade aluminum)

The blue glass interior wall is a deep panel system with the aluminum mullions extruded out 3 inches past the glass. The glass is colored blue to complement the coral green tones seen on other elements and in other glass framing.

Reflectance: 0.27 overall

The ceiling is a whitened grey tone with a high reflectance value. The soft grey was used to complement the other soft colors and not provide a stark bleak background to the otherwise colorful space.

Reflectance: 0.77



The black/blue marble shown here is the pattern seen on half of the floor in the lobby space. It is closest to the eastern façade and accounts for roughly 20% of the floor area.

Reflectance: 0.22

The white marble is the majority floor covering for the lobby space. The white marble does not sit adjacent to any façade, but is continuous through the main lobby, around the security station and into the main elevator lobby. It is similar to the black/blue marble, but obviously a different shade

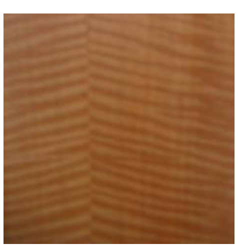
Reflectance: 0.69

The red mosaic tile is the only different material used on the floor. Between the black/blue marble and the white marble is a rectangular area (oval atrium) or thin 6” strip of tile extending to each wall. The mosaic pieces are glazed over to match the specularity and smoothness of the marble floor area.

Reflectance: 0.36

The green glass wall complements the blue glass wall, and is of the same construction. While the blue glass wall is on the western side of the room, the green glass wall is on the southern wall leading to the parking elevator lobby.

Reflectance: 0.50



The wood paneling throughout the space has a very light hue with a slightly darker contrast in the “veins”. The wood paneling is located on the western wall as an accent piece to the blue-glass, and at the south end of the elevator lobby. It is also featured behind the east entrance stair-wall.

Reflectance: 0.14

This metal mesh is featured on the desk area and is complimented on the walls in thin strips between light green colored glass paneling (same as the material shown, without the mullions). It is not prominent by surface area, but by location and accentuation.

Reflectance: 0.16

This wood featured mainly on the security desk as well, is a lighter version of the wood paneling seen on the walls, but complements it very well.

Reflectance: 0.56

Glazing Specifications – Transmittance and Reflectance

The glass on the exterior, shown to the left, has a slight reflectance and a high transmittance. Because of the viewing angle, a considerable amount of the street can be seen. It is a light hue of blue, but not to the contrast that the picture shows (combination of daylighting and camera quality).

Further information on the glazing is shown below.

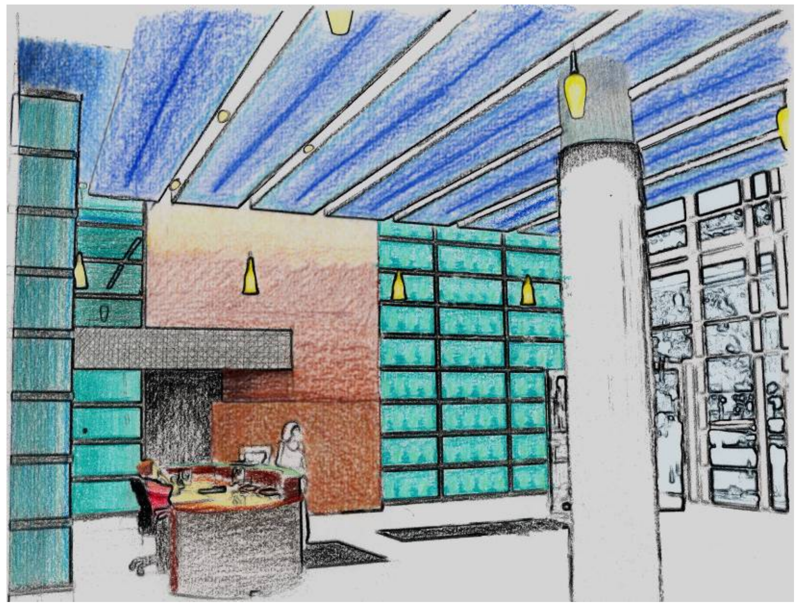
Typical Glazing:

Type:	Insulating Glass - Surface #2 Coating – NP-61
Reflectance Outdoors:	0.21
Transmittance Visible:	0.61
Solar Heat Gain Coefficient:	0.4
U-Value:	0.31 (winter and summer)
Light to Solar Gain Ratio:	1.53
Thickness and # panes:	(2) 6mm panes with ½" airspace between

Laminated Glazing:	Insulating Glass with Lami Board – Surface #2 Coating – NP-61
Reflectance Outdoors:	0.21
Transmittance Visible:	0.59
Shading Coefficient:	0.46
Solar Heat Gain Coefficient:	0.39
U-Value:	0.30, 0.31 (winter, summer)
Light to Solar Gain Ratio:	1.51
Thickness and # panes:	(2) 3mm panes, ½" airspace, and (1) 6mm pane
PVB thickness:	0.030"

Design Concept

The design concept for the Lobby space focused on the "water" theme as described in the thematic description. It will not be further detailed here, but the fall semester concept sketches have been included.



Design Criteria

Appearance of Space and Luminaires – Rating: 10

The appearance of the main entrance lobby to the office tower is of utmost importance. Business clientele as well as the employees of the offices require a pleasant and calm, yet sophisticated and professional appearance. The space itself should not scream at the occupants what the most unique or particular aspects of its design are, but should calmly present itself and its intricacies only through the occupant's consideration. The appearance of the luminaires and overall aesthetics must conform to the activities to which this lobby will lead, and only enhance the "psychological advantage" of the office tenants.

Color Appearance and Contrast – Rating: 9

The architectural materials of the space are not to be taken for granted. The translucent glass banding, the fine metal mesh banding, the wood veneers, and aluminum accent pieces all require accurate color rendering for the space to result as the architect had intended. To forego this quality undermines the architect and causes the space to quickly lose appeal. Additionally, the colors of the lobby's terrazzo flooring must also be accented and appropriately viewed. The three differing patterns and color schemes would not seem so brilliant under a poorly color-rendered lighting system.

Daylighting Integration and Control – Rating: 9

Daylighting control within this space is absolutely necessary. The daylighting, at times, borders on "severe penetration" due to the extreme specularity of the terrazzo floor, the glare resultant from the floor at early morning hours (times of high use at the start of business day), and the direct glare due to such high ceilings. The entire east and north façades are 20'6" high, 3' wide glass paneling with diffuse aluminum mullions. During the day on clear days, and especially in the morning hours, daylight penetration is considerable. In an attempt to counteract the current system's daylight penetration, a large canopy was added as a shadowing lightshelf to around the most offensive areas of the curtainwall.

Direct Glare – Rating: 7

As a calm and comfortable atmosphere, direct glare will result in immediate discomfort and reflect poorly on the space, the building, and especially of its occupants. Due to such a vast ceiling height, current direct glare is relatively non-existent for most of the luminaires. The sculpted luminaires' lamps cannot be viewed unless the individual is within 10d of nadir. Similarly, the lamps of the recessed downlights and linear fluorescents cannot be seen easily without extending one's view angle greater than 70d from horizontal.

Light Distribution on Surfaces – Rating: 5

A differing ratio of distribution can be used as a means of leading an individual from entrance to destination or exit. Contrary, an even distribution can give the occupant a feeling of spaciousness and openness with which they have the freedom to move around. The lack of constraint may prove misleading to points of interest (entrances, exits, elevators, etc.) but would increase the overall immediate comfort level the person has upon entry or while waiting.

Luminance of Surfaces – Rating: 8

Complimentary of the appearance and color appearance, the luminance of surfaces will be important in further distribution of diffuse light, and will enhance the depth and relativity aspects of locations in the lobby. Highlighting the dark woods, and decreasing the illumination levels on the aluminums, white surfaces, and translucent glass may even out the depth appearance of some walls and an even greater contrast in brightness on these darker elements may reverse the spatiality of the space.

Modeling of Faces and Objects– Rating: 6

Facial modeling is not a distinctly important quality of the lobby. While initial face-to-face contacts may be made, and close personal conversation between individuals is typical, they do not create a great necessity for substantially well modeled faces. Likewise, the space itself has few objects that would cause confusion or be completely neglected due to poor modeling.

Points of Interest – Rating: 7

Points of interest are quite necessary in differentiating lounge and waiting areas from information and reception areas. There is no standard waiting area within the space, and the only locus of information is centered on the security desk. The three remaining points of interest are the entrances and exits, the information panel at the west wall, and the elevator area. Higher illumination in these areas is necessary for differentiation.

Surface Characteristics – Rating: 7

As has been mentioned, the surfaces used throughout this lobby vary in their reflectances, specularities, colors, and textures. To bring out the greatest aesthetic appeal in the architect's design, these characteristics should be accentuated if the design allows. At most, one wishes to make the occupant or visitor aware of the specular, and therefore smooth, slippery nature of the floor as a safety concern. All other accentuation of materials is purely aesthetic and will only be relative to the overall lighting theme.

System Control – Rating: 10

Because of the considerable daylight penetration, the vast spectrum of illuminance levels over the course of the day, and for better energy savings, system control in the lobby should be considerable. It is very important to make the most use of the natural light and to minimize the energy consumption of the lobby. This is especially true since the lobby operates over the longest time period throughout the day.

Horizontal Illuminance – Rating: 8

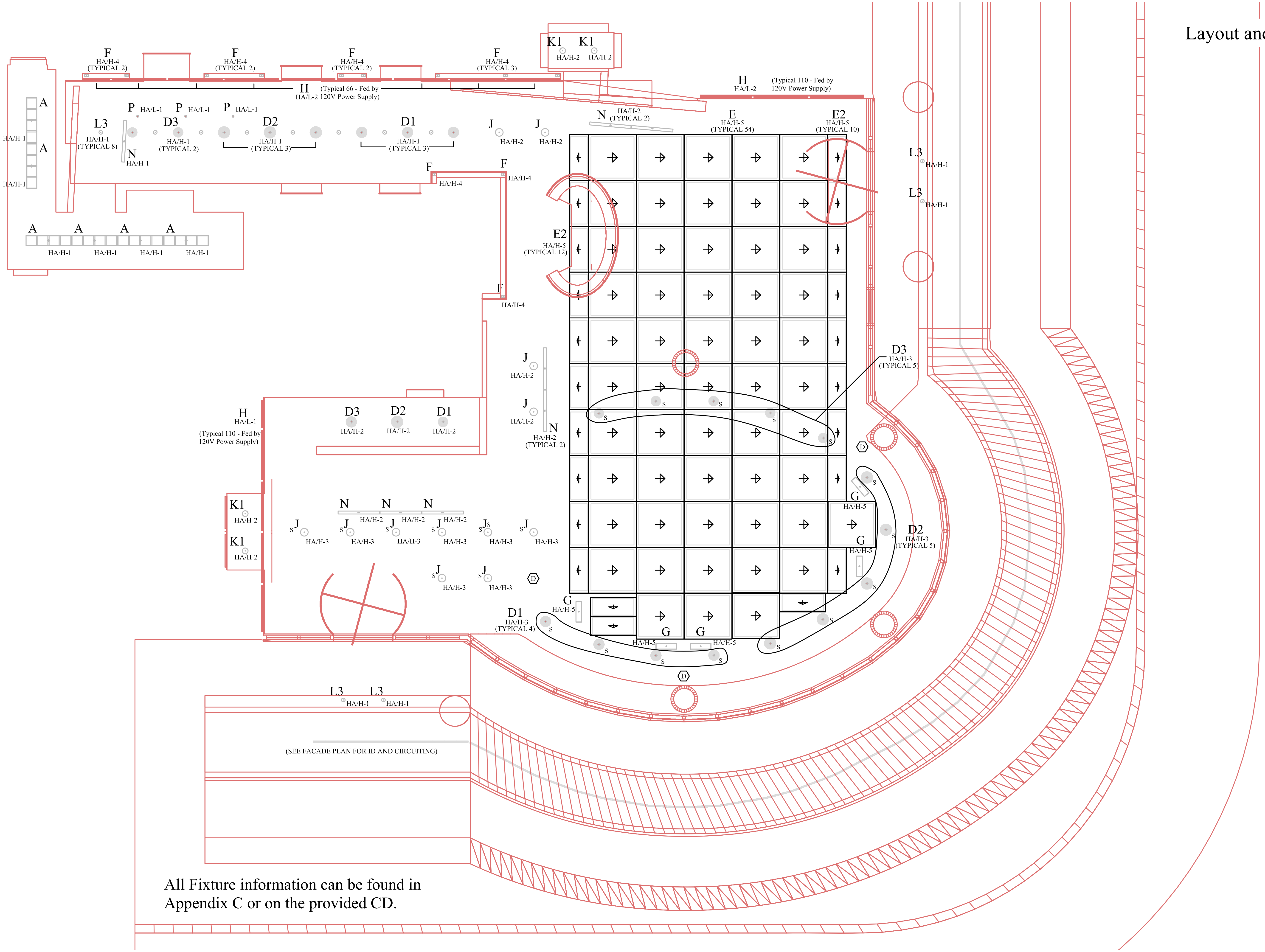
The horizontal illuminance suggested for the lobby space is 100 lux. Since the space has very little activity, no areas for reading or writing, and no distinct tasks are performed within the space, 100 lux is reasonable. However, as the cornerstone of the building, it would be desirable for the space to have a much higher illuminance level to 300 lux and possibly higher dependent on the illuminance levels of the adjacent spaces.

This increase in illuminance on the horizontal plane is desirable for the work and tasks of the security station as well. The illuminance should not cause the security monitoring to be compromised, so one would not go as high as 500 lux, but should be increased nonetheless.

Vertical Illuminance – Rating: 6

Vertical illuminance components of the fixtures are already accounted for through basic distributions and diffuse reflections from the floor and low walls. The daylighting also acts as a vertically oriented area source for better vertical illumination. For these reasons, vertical illuminance in the range of 30 to 50 lux should not have to be distinctly accounted for in the lighting design.

Layout and Circuiting



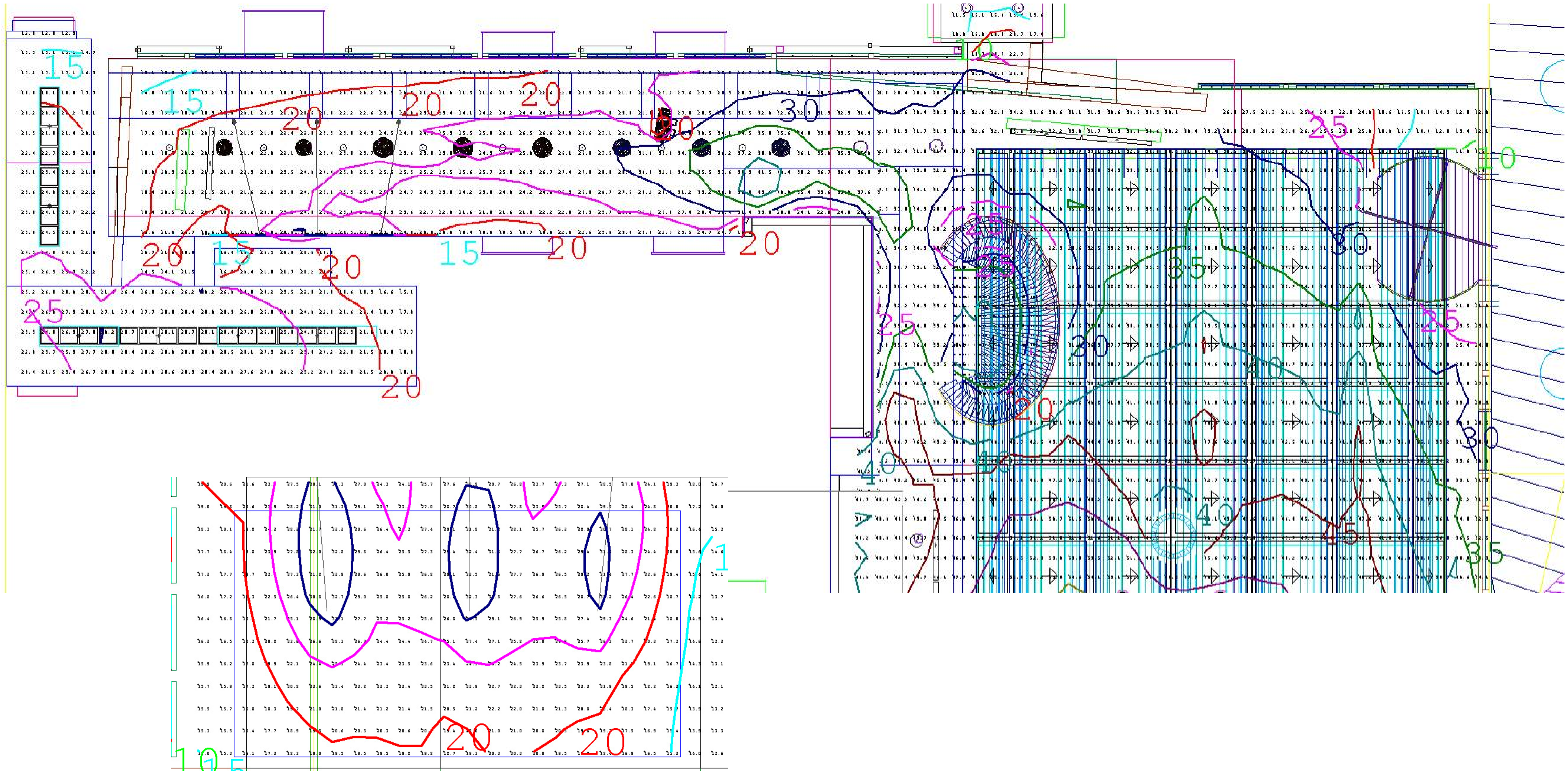
All Fixture information can be found in Appendix C or on the provided CD.

Entrance Lobby Floor Plan, Lighting Layout and Circuiting Diagram

All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D") or Occupancy ("O") Sensor

Not to Scale

Performance



Large Artwork in Elevator Lobby

Floor
Illuminance Values
(Fc)
Average=34.11
Maximum=56.3
Minimum=4.4
Avg/Min=7.75
Max/Min=12.80

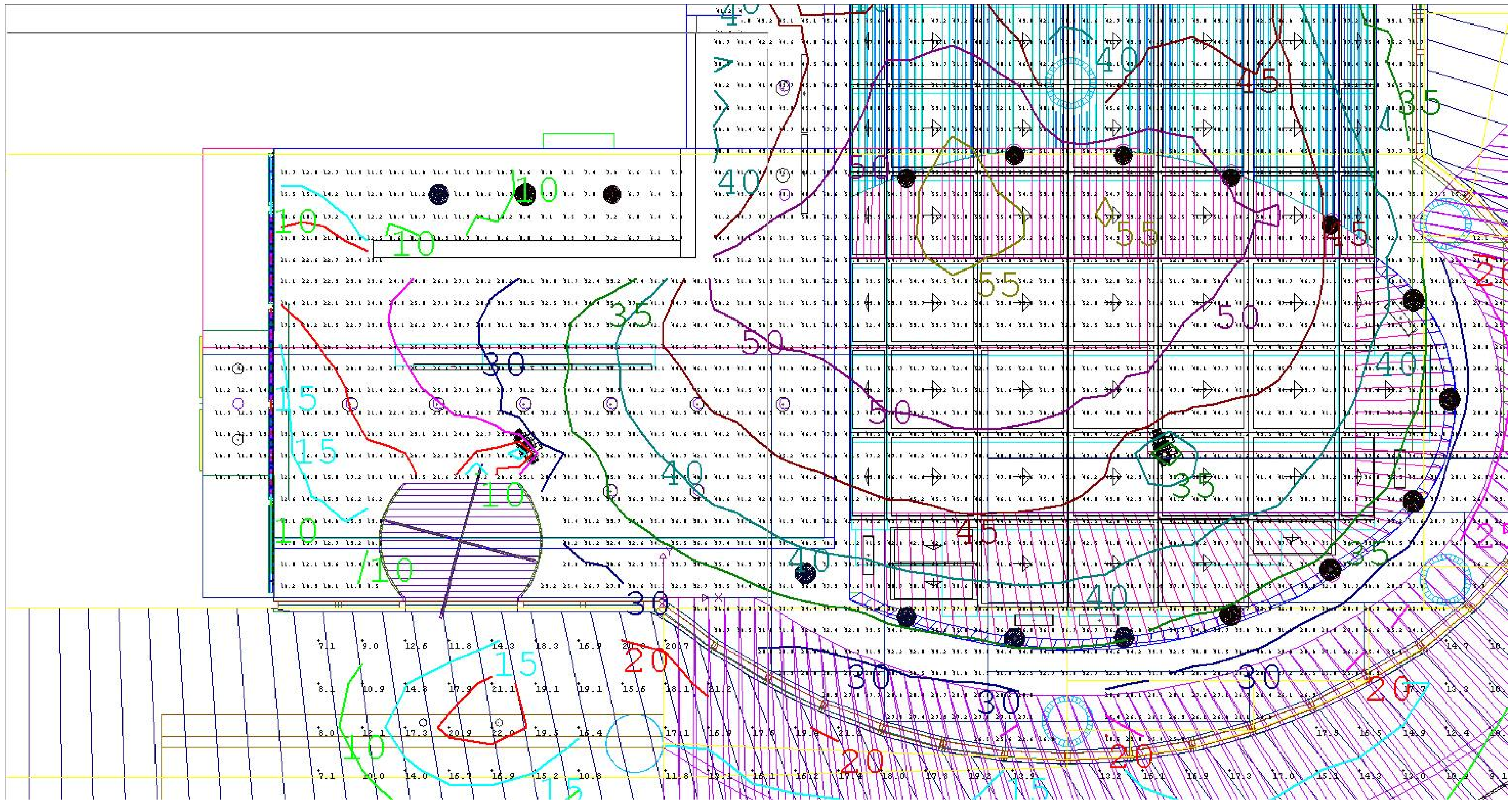
Art1
Illuminance Values
(Fc)
Average=22.82
Maximum=32.9
Minimum=13.1
Avg/Min=1.74
Max/Min=2.51

Trans Wall East
Illuminance Values
(Fc)
Average=15.31
Maximum=42.4
Minimum=5.9
Avg/Min=2.59
Max/Min=7.19

Desk
Illuminance Values
(Fc)
Average=35.68
Maximum=43.9
Minimum=13.2
Avg/Min=2.70
Max/Min=3.33

Facade Stuff
Calc Pts

Main Canopy
Illuminance Values
(Fc)
Average=8.06
Maximum=22.0
Minimum=1.3
Avg/Min=6.20
Max/Min=16.92



ASHRAE Power Density Calculation

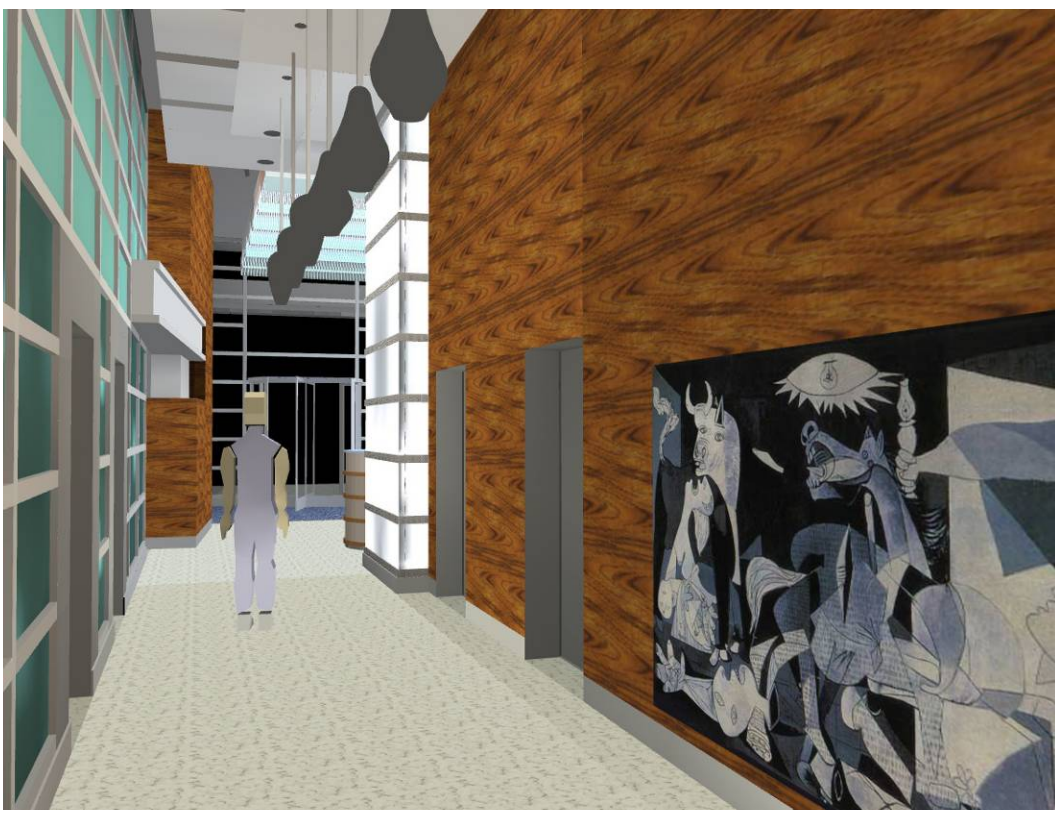
ASHRAE Power Density Allowance for Office:			1.3 W/sf
ASHRAE Power Density Adjustment for Decorative Lighting:			1.0 W/sf
Lobby square footage:	2900 sf	ASHRAE allowance:	6670 W
Existing Power Density:	1.61 W/sf	Meets ASHRAE 90.1 (including decorative allowance)	

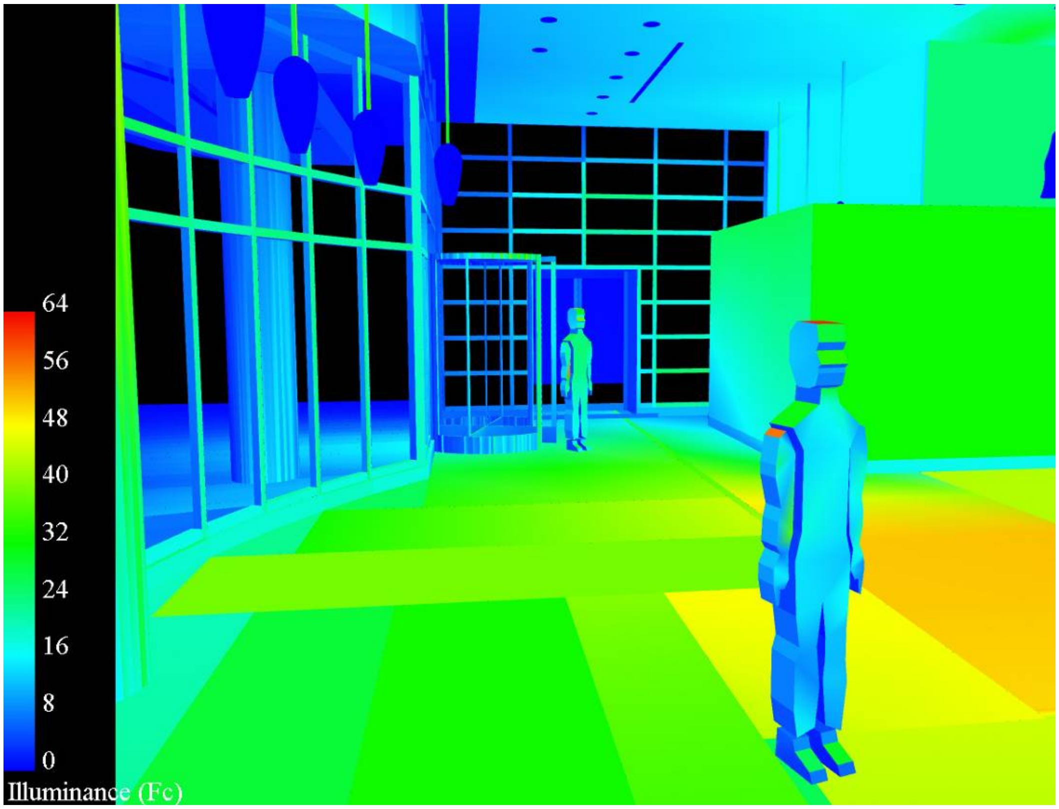
Entrance Lobby	A	D1	D2	D3	E1	E2	F
Luminaire	6	8	9	8	54	22	15
Wattage	32	35	35	35	32	32	35
Total Power	189	276	311	276	1701	693	525

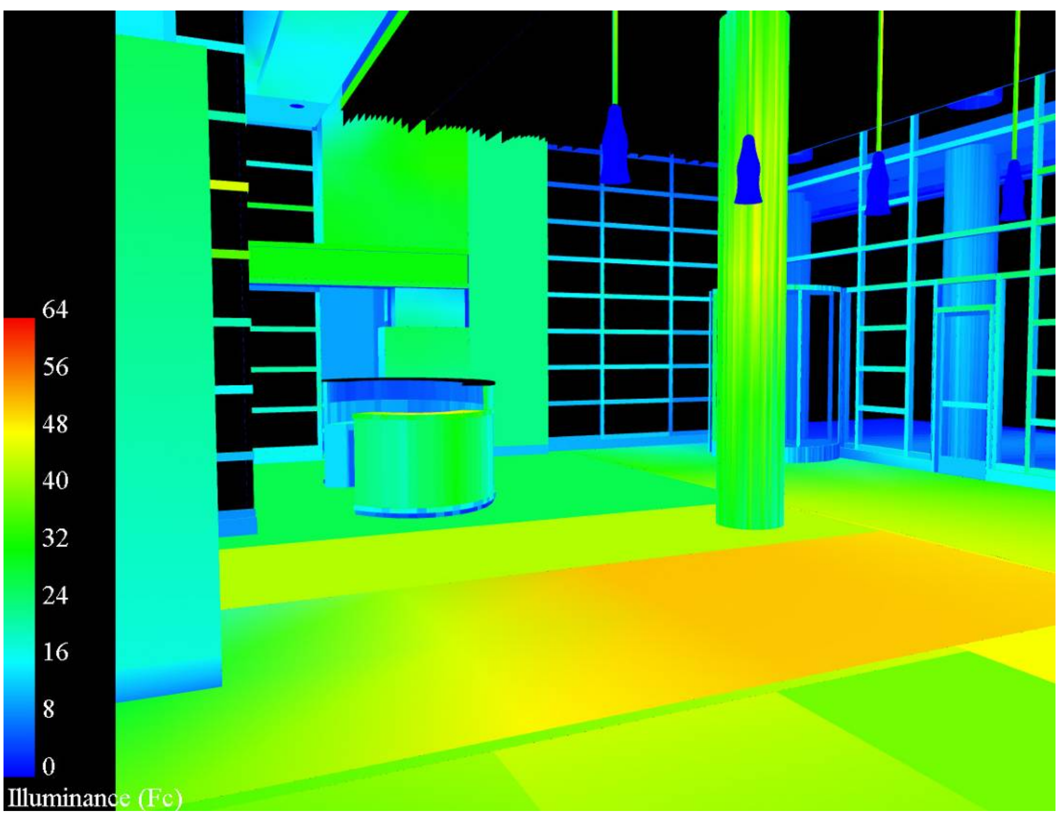
G	H	J	K1	L3	N	P			
5	210	12	4	12	8	3			Power Density
17	1	58	20	50	32	37	SUM (VA)	Area (sf)	
85	210	696	78	600	252	111	6002.5	2900	**2.070 W/sf**

New design meets ASHRAE 90.1 Standard

Renderings




64
56
48
40
32
24
16
8
0
Illuminance (Fc)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32
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16
8
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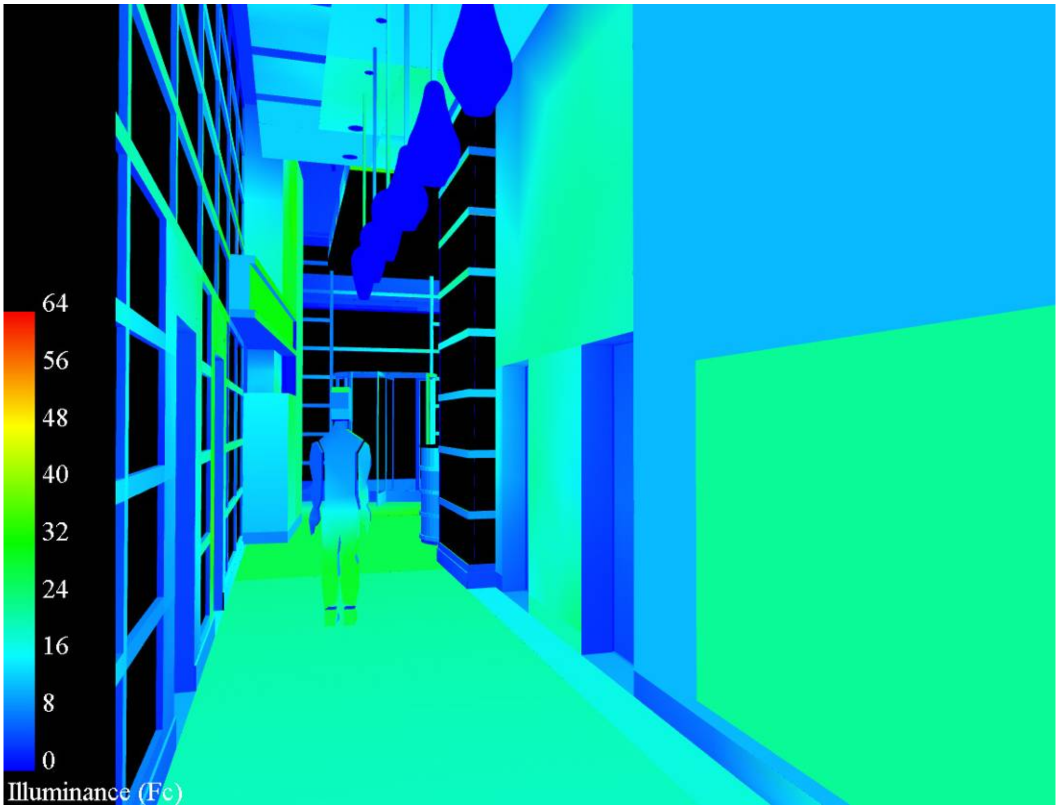
Illuminance (Fc)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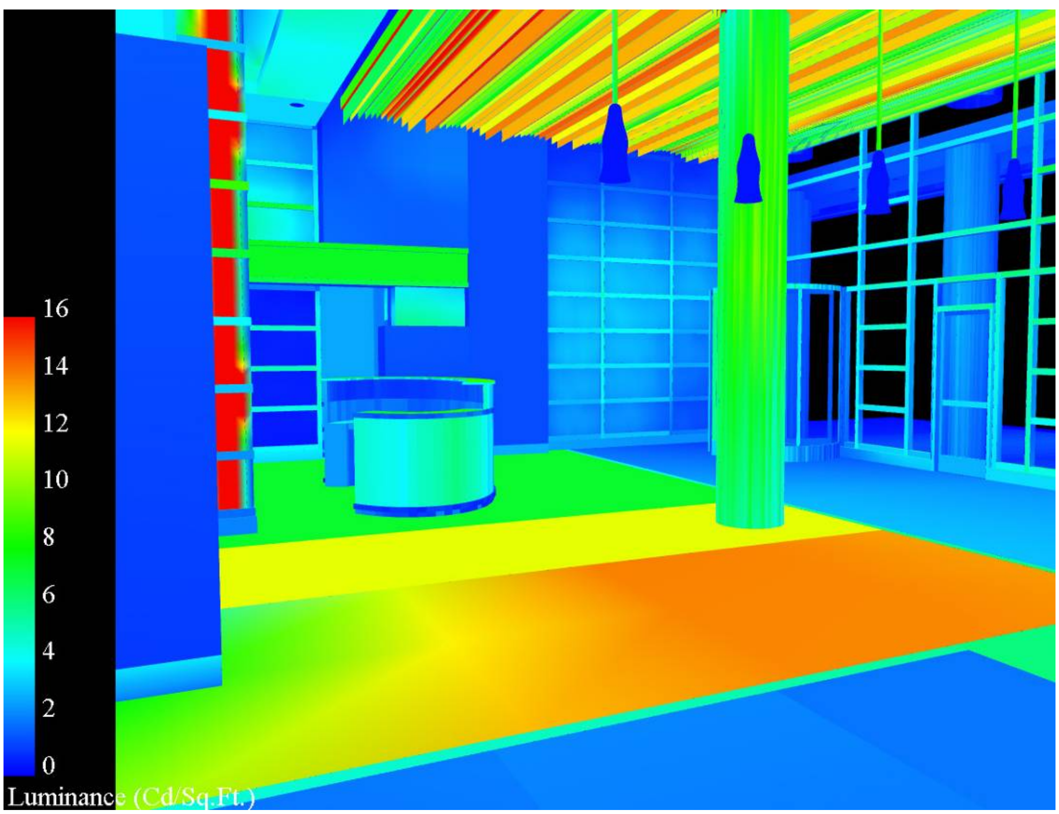
56
48
40
32
24
16
8
0
Illuminance (Fc)


16
14
12
10
8
6
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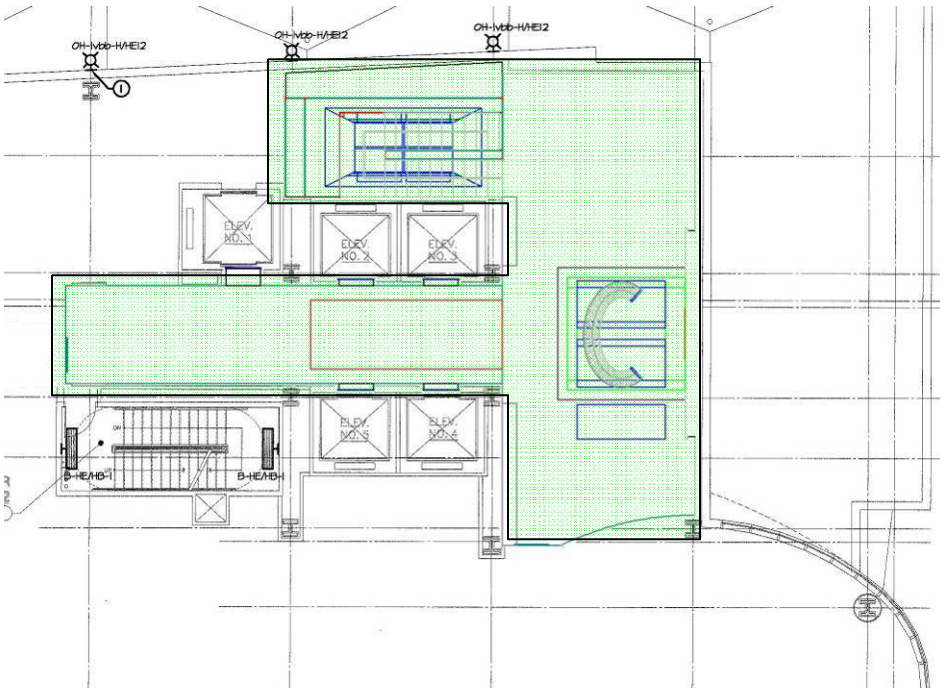
2
0
Luminance (Cd/Sq.Ft.)

Reception



Special Luminaires

The Reception has a single "specially created" luminaire system, as opposed to the special luminaires created for other spaces (listed in the research). The skylights in the Reception space serve as "skylights" all day, and all night long if the occupants so desire. Just below the skylight itself, two recessed 8" deep bays were cut into the ceiling plenum. Within these spaces were place linear fluorescents with wallwash characteristics. Each wallwash was aimed at the opposite wall "facing" downward to keep as much downlight as possible on the walls.

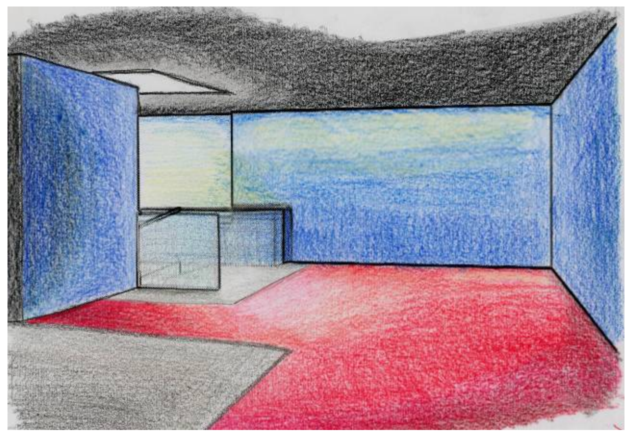
To account for the vast light loss through the skylights during hours of operation when the sun was already down, or the sky was considered too dark for any adequate light penetration, the system has an integrated shade-on-rails system with a small motor mounted in another recessed space. These systems are only located above the stairwell skylight and the two reception desk skylights. While the depths of the "bays" vary between the two skylight types, they operate in the same manner and are constructed in nearly identical detail.

The details for the two skylight systems are located in Appendix C.

Surface Materials

The Reception area did not exist architecturally prior to the lighting design. For this reason, all of the materials used were relative to the available textures and colors present in AGI32. For all textures and painted surfaces, please view the actual renderings (as they appear in greater bulk) for these spaces. For the most part, architectural materials closely coincide with the materials already listed for the façade, lobby, and parking structure. For detailed surface illustrations and reflectances, reference the previous sections.

Design Concept



The concept for the reception area is specific to a high-profile business entrance with the intention of impressing their business clients. The concept developed for the fall semester was completed based on a limited three-dimensional development of the space. The further design concept was developed as the three office spaces came into being. The space concept for the fall semester is illustrated below.

The concept focuses on the availability of daylight at the reception desk and the development of daylight penetration in the newly-created stairwell. The concept of the space, architecturally, was to lead the individual along a given path and the lighting design paralleled this concept by highlighting points of interest and creating an even illuminance across the waiting area.

Design Criteria

Appearance of Space and Luminaires – Rating: 9

The appearance of the reception area is of utmost importance to the office tenant. As this is the first impression a visitor will receive, it is very important that the space exude sophistication and prestige. The luminaires need to be high-profile and stylish, and the space needs to have rich color and significant emphasis on the most important areas of the space. All of the dead zones, while not so dark that they seem cavernous, should be significantly lower than the travel paths, points of ingress and egress, and areas of congregation.

Color Appearance and Contrast – Rating: 8

The colors of the space, since they should be rich and visually stimulating, need to come through accurately and cannot become skewed by lower CRI lamps. Since the combination of colors was designed to work together within the space, altering them, graying them out, or causing them to seem too bright and washed out all should be eliminated. The advantage of this space is that daylighting will be used for the majority of the emphasized spaces, which will bring out all of the true colors of the space.

Daylighting Integration and Control – Rating: 9

Daylighting integration and control in this space is of utmost importance. Not only because 3 main skylights illuminate the area around the reception area and the transition space toward the elliptical conference room, but also because of the integration of the stairwell skylight at the western corner of the space. Daylighting control should be implemented in an on/off manner to reduce the consumed load in the space when daylight levels are more than adequate to illuminate the space.

Direct Glare – Rating: 5

The direct glare within the space is not a major concern given the types of luminaires used throughout the space. Additionally, the skylight wells with diffuse walls will not contribute to a glare condition, and the depth of the skylights prevents the major components of direct glare resulting from the sun to become a factor.

Light Distribution on Surfaces – Rating: 6

Light distribution on surfaces is a mediocre criterion that should be met relative to "hot spots" or points of interest (as described below). The light distribution uniformity on surfaces is not a concern and gradients exist on almost every wall in the space. Light distribution should have a gradient at the hot-spot areas, and should maintain a fairly uniform illuminance level in the gathering areas.

Luminance of Surfaces – Rating: 6

Luminances of surfaces are particularly important for only two areas. First, the walls behind the artwork located at the south walls needs to have a distinct visual contrast so the artwork seems to pop out of the wall and the borders of the artwork are well defined. At the West wall, with the larger piece of artwork, luminance of the wall was intended to melt into the artwork given the piece. Since the building has a theme revolving around water, and the picture is of water, the intention was to "extend" the picture into the walls and illuminate the actual work fairly well to emphasize the painting. Luminances of other surfaces only lend emphasis to the delineation of space and architectural direction of visitors and occupants.

Modeling of Faces and Objects– Rating: 7

Modeling of faces within the space is limited to the receptionist and the entering visitor. For this reason, specific downlight were provided at the countertop so reflected light would highlight the shadows created on the faces by the skylights and other downlighting components. The ambient uplighting and small contribution of wall reflectances also aids in the modeling of faces. Objects throughout the space are few, and modeling is limited to the grain and texture of the paintings. For this small design criterion, the accenting lights were placed at higher grazing angles to induce very slight shadows from the texturing.

Points of Interest – Rating: 10

Points of interest in a space that was specifically designed to lead individuals through the space through materiality and lighting, is of utmost importance. The points of interest are the employee entrance to the east, the reception desk at the elevator lobby, the waiting area at the northwest, and the stairwell to the west.

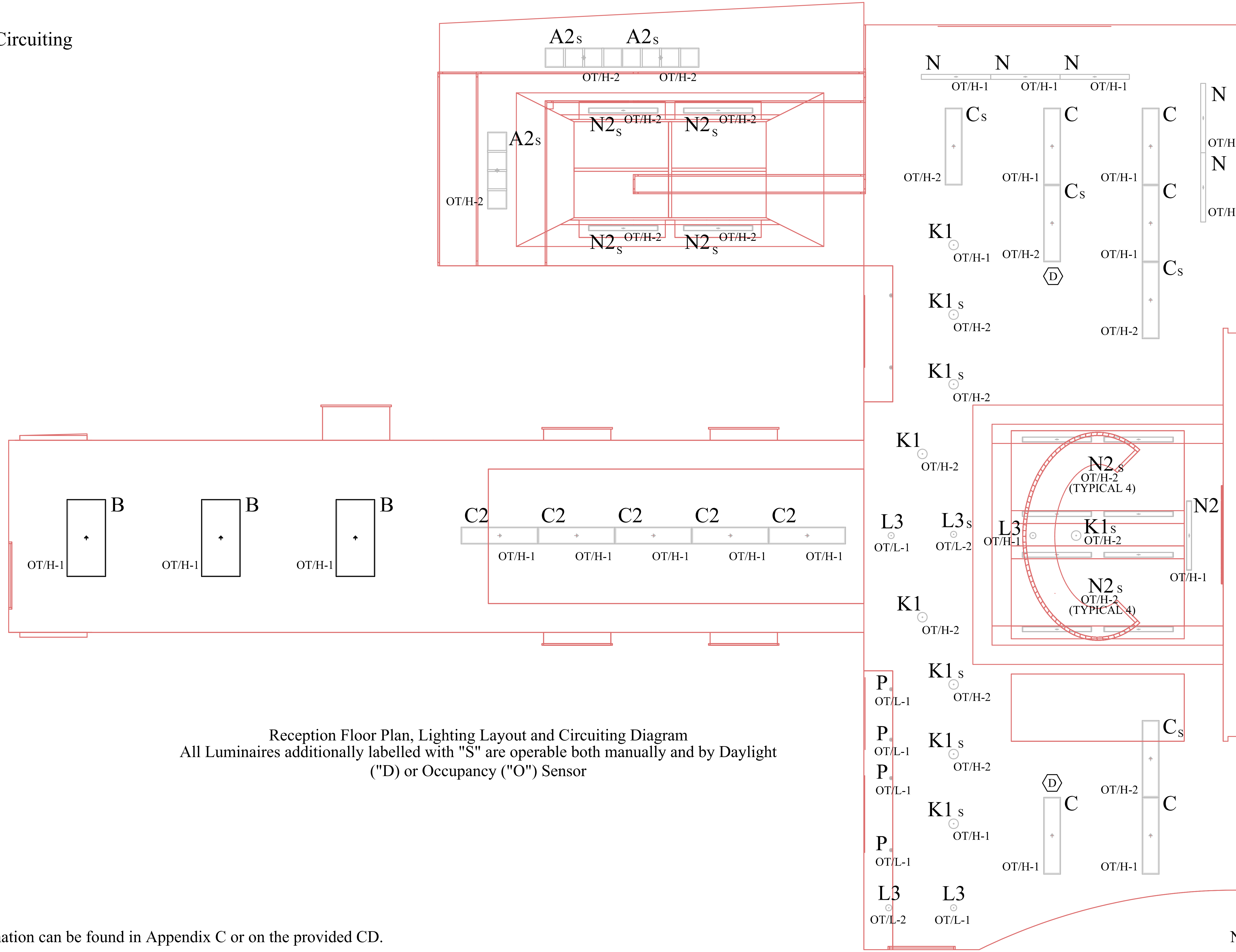
Horizontal Illuminance – Rating: 7

Horizontal Illuminance is relative to the floor for the most part, with specific attention paid to the desktop workplane of the reception desk. Horizontal illuminance should be maintained between 200 lux and 400 lux with exceptions occurring for clear-sky daylight penetration (where the illuminances will significantly exceed these values).

Vertical Illuminance – Rating: 5

The only vertical illuminance requirements in the space have been covered in the facial and object modeling of the space. This level should not exceed the horizontal illuminance, but still should be above 100lux.

Layout and Circuiting

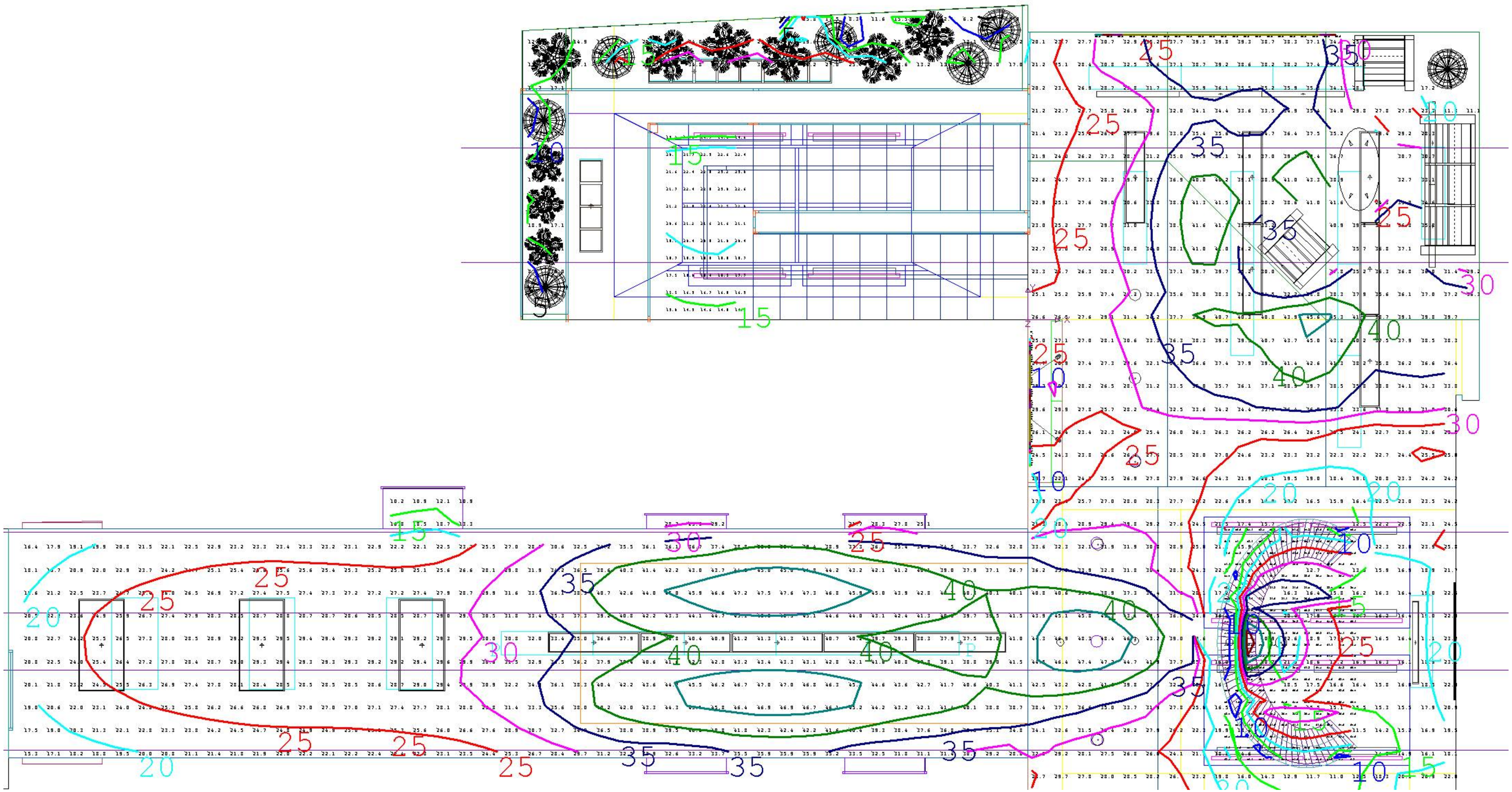


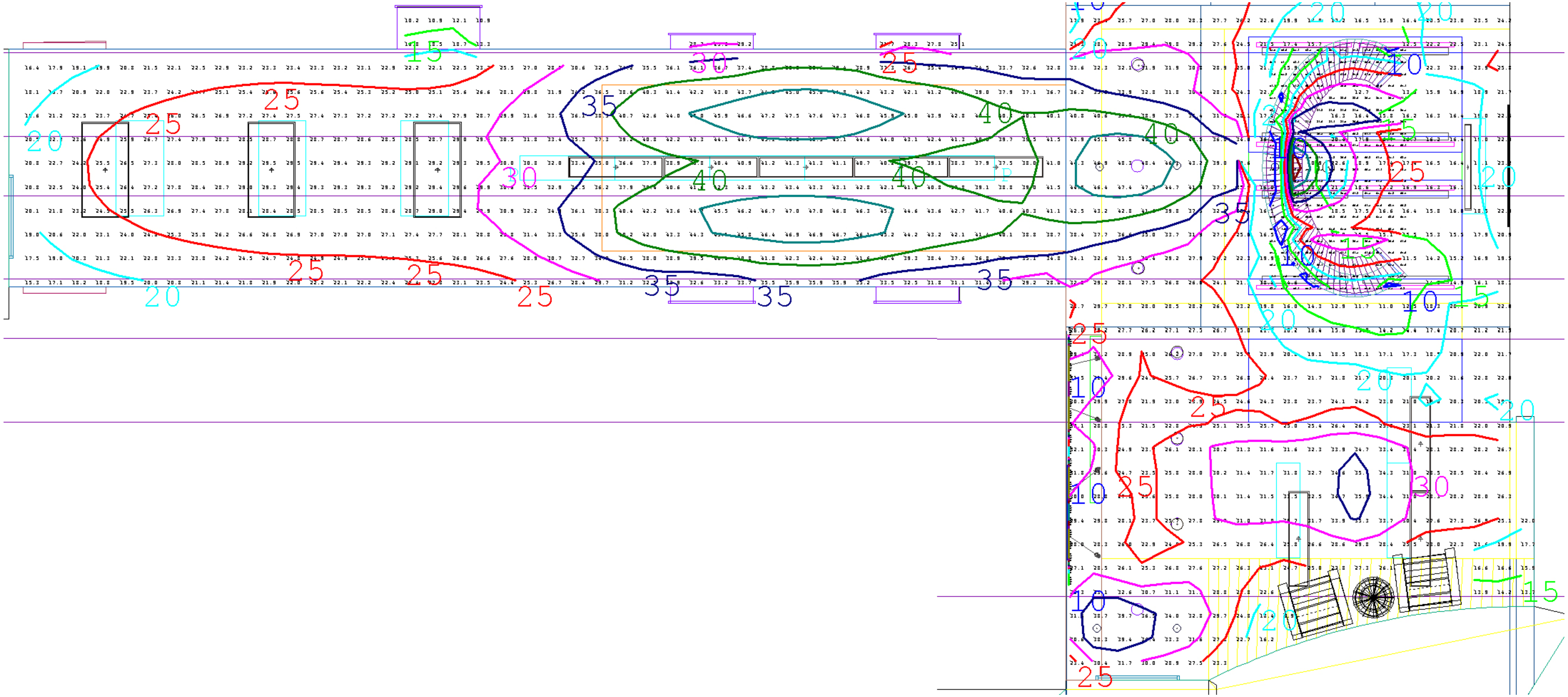
Reception Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D) or Occupancy ("O") Sensor

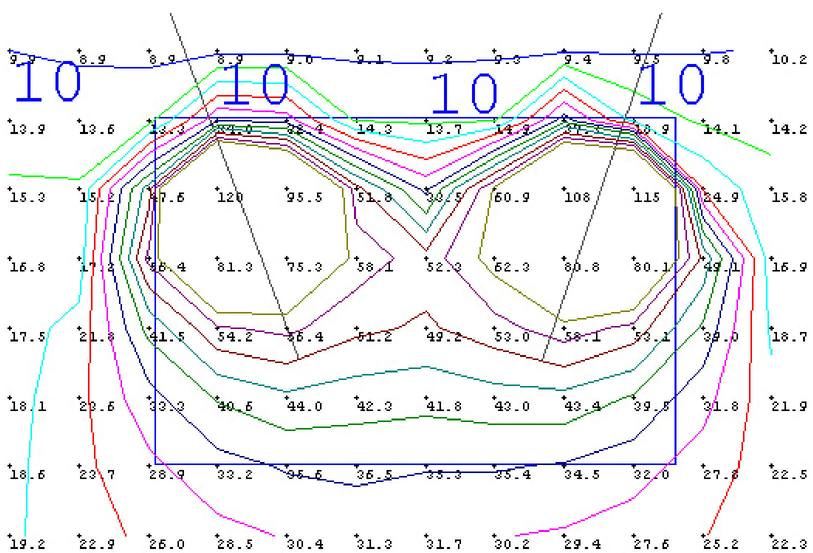
All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

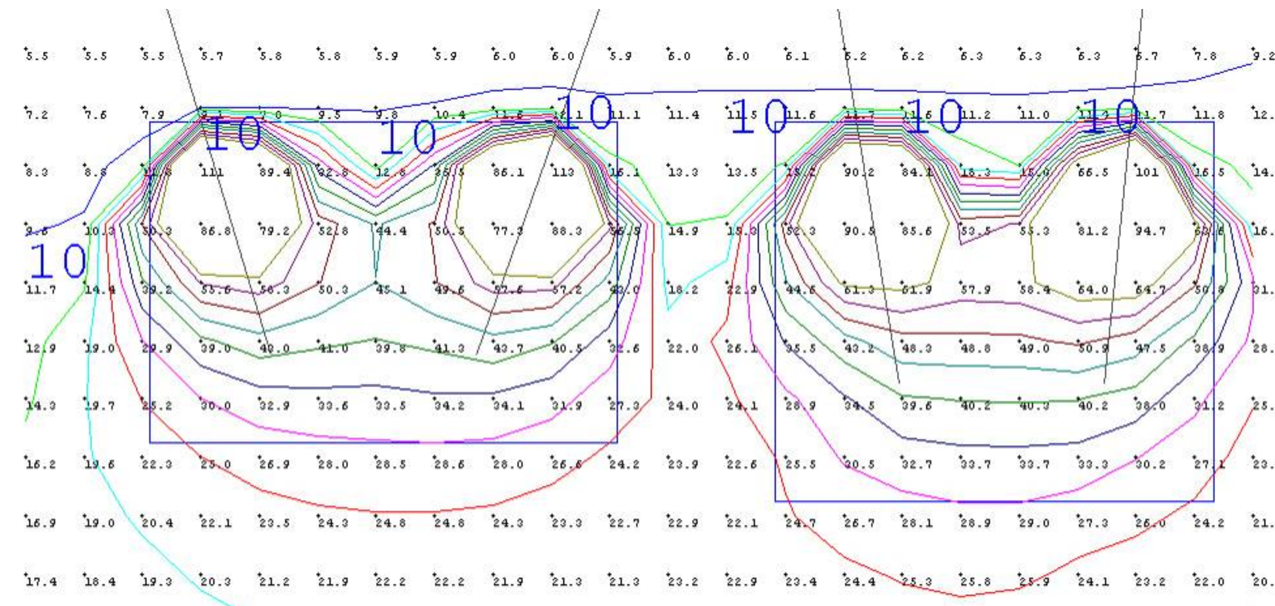
Performance



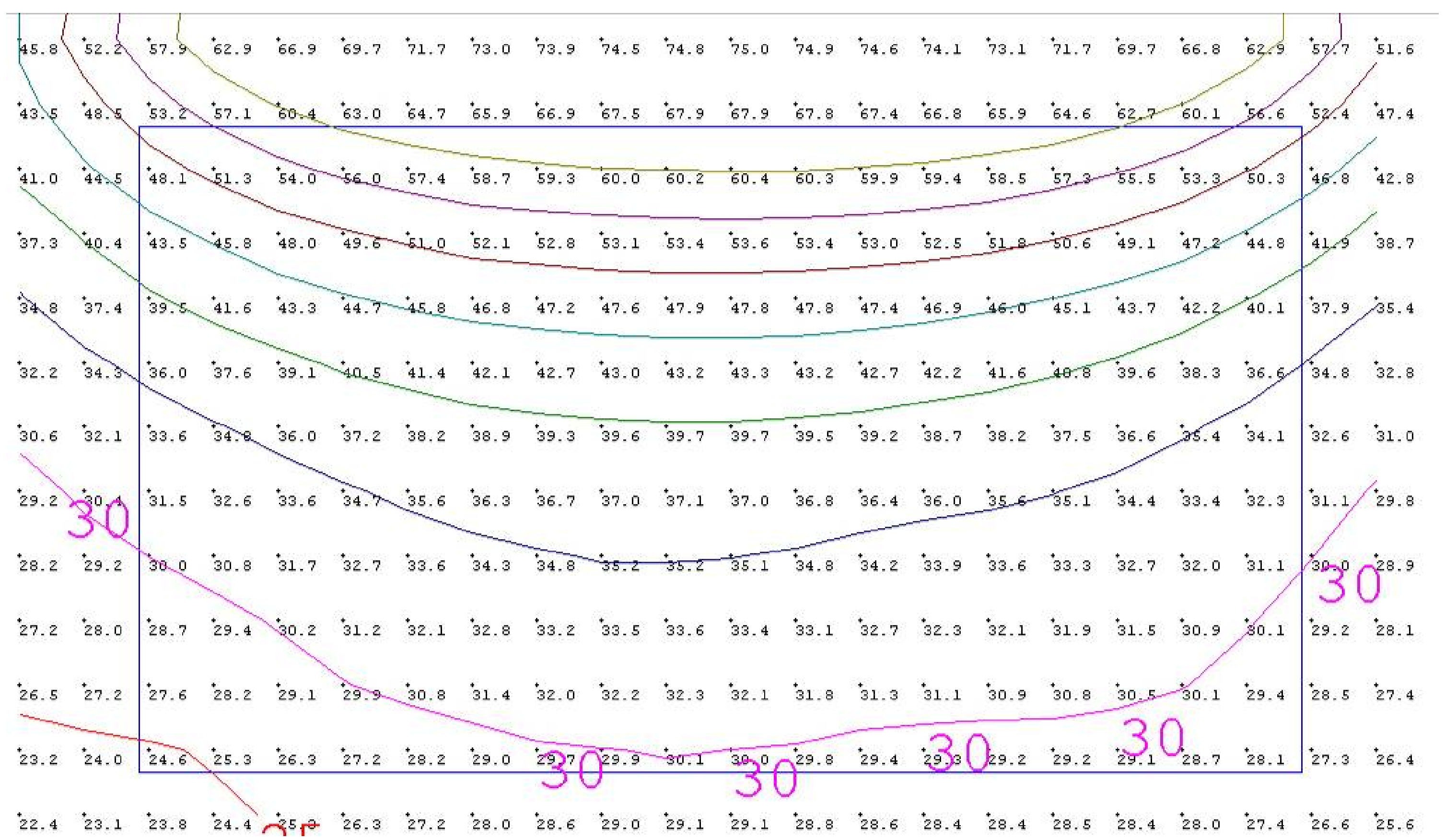




Artwork on Slower South Wall



Artwork on Upper South Wall



"Large" Artwork on North Wall

Art
Illuminance Values
(Fc)
Average=29.59
Maximum=113
Minimum=5.5
Avg/Min=5.38
Max/Min=20.67

Art_1
Illuminance Values
(Fc)
Average=34.62
Maximum=120
Minimum=8.9
Avg/Min=3.89
Max/Min=13.53

Art_2
Illuminance Values
(Fc)
Average=42.79
Maximum=75.0
Minimum=22.4
Avg/Min=1.91
Max/Min=3.35

Floor
Illuminance Values
(Fc)
Average=29.04
Maximum=48.4
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

Stair Landing
Illuminance Values
(Fc)
Average=19.36
Maximum=23.2
Minimum=13.0
Avg/Min=1.49
Max/Min=1.78

Front Desk
Illuminance Values
(Fc)
Average=24.75
Maximum=53.1
Minimum=5.4
Avg/Min=4.58
Max/Min=9.83

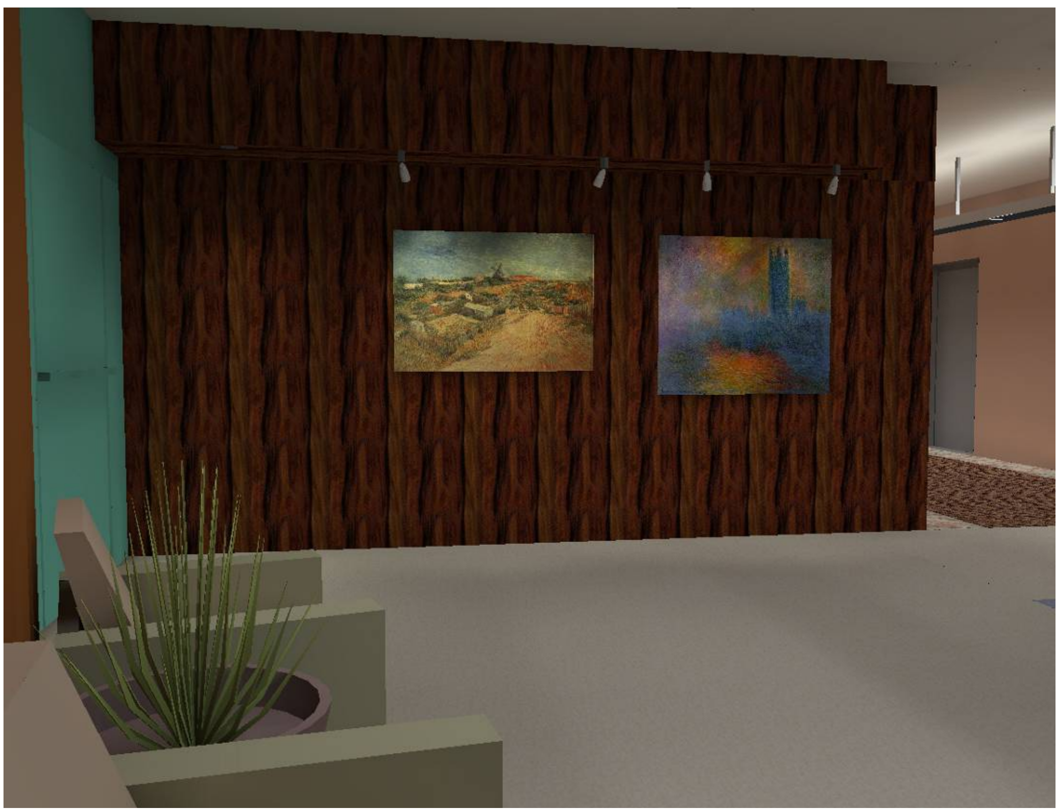
ASHRAE Power Density Calculation

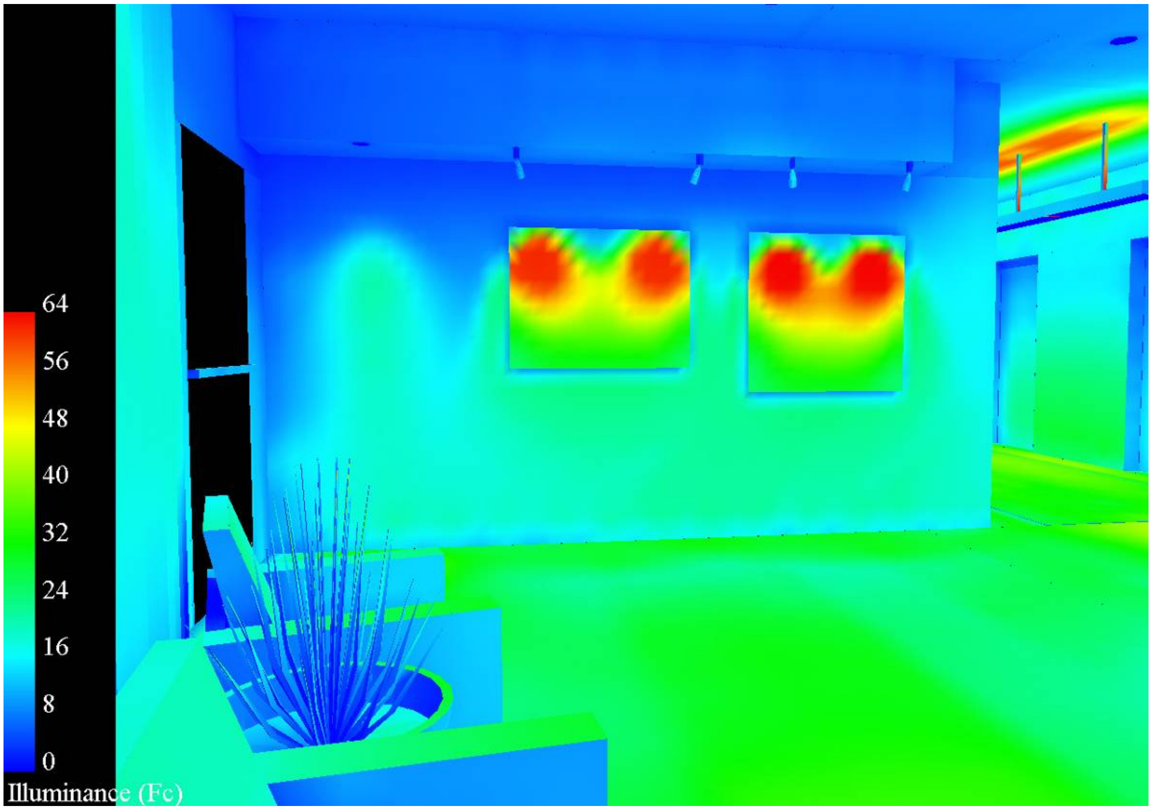
ASHRAE Power Density Allowance for Office/Lobby: 1.1 W/sf
ASHRAE Power Density Adjustment for Decorative Lighting: 0.5 W/sf

Reception square footage: 1540 sf ASHRAE allowance: 2772 W

Reception	A2	B	C	C2	K1	L3	N	N2			
Luminaire	3	3	9	5	8	5	5	13			Power Density
Wattage	59	63	32	59	20	50	32	59	SUM (VA)	Area (sf)	
Total Power	176	189	284	293	156	250	158	761	2264.5	1540	**1.470 W/sf**

Renderings




64
56
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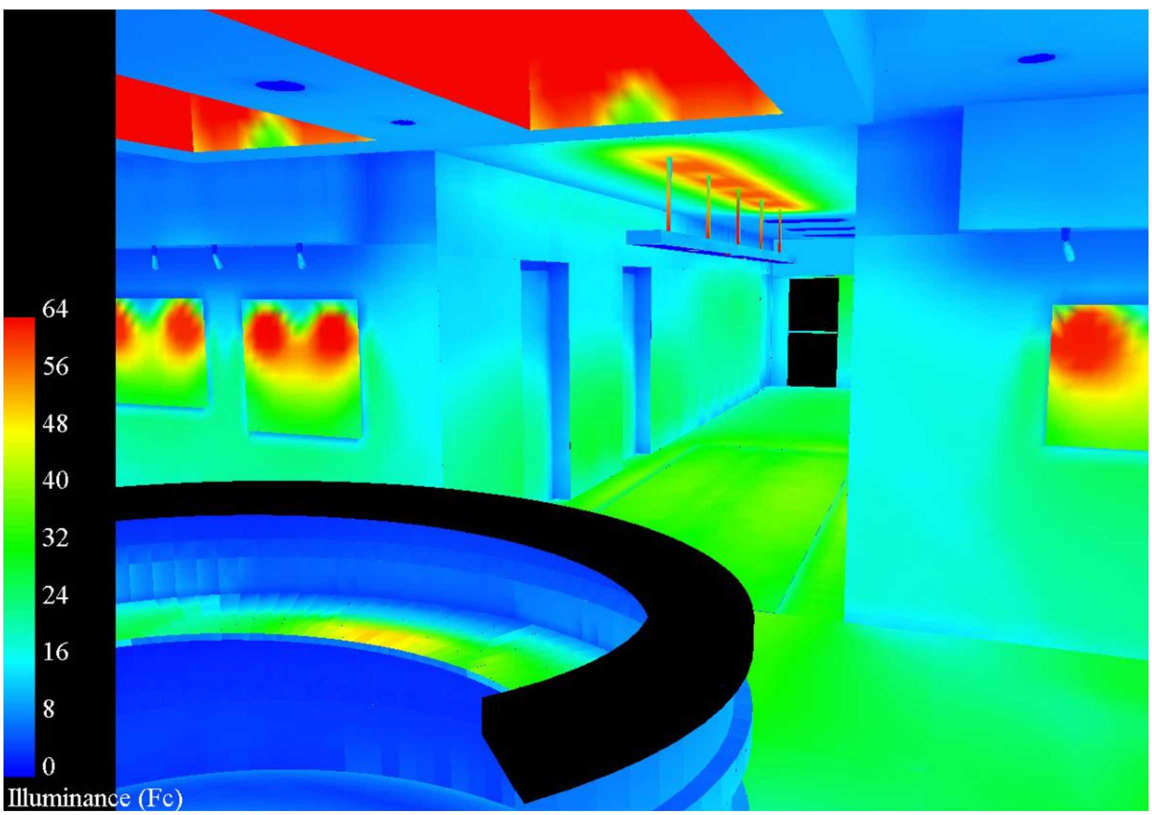
32
24
16
8
0
Illuminance (Fc)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56
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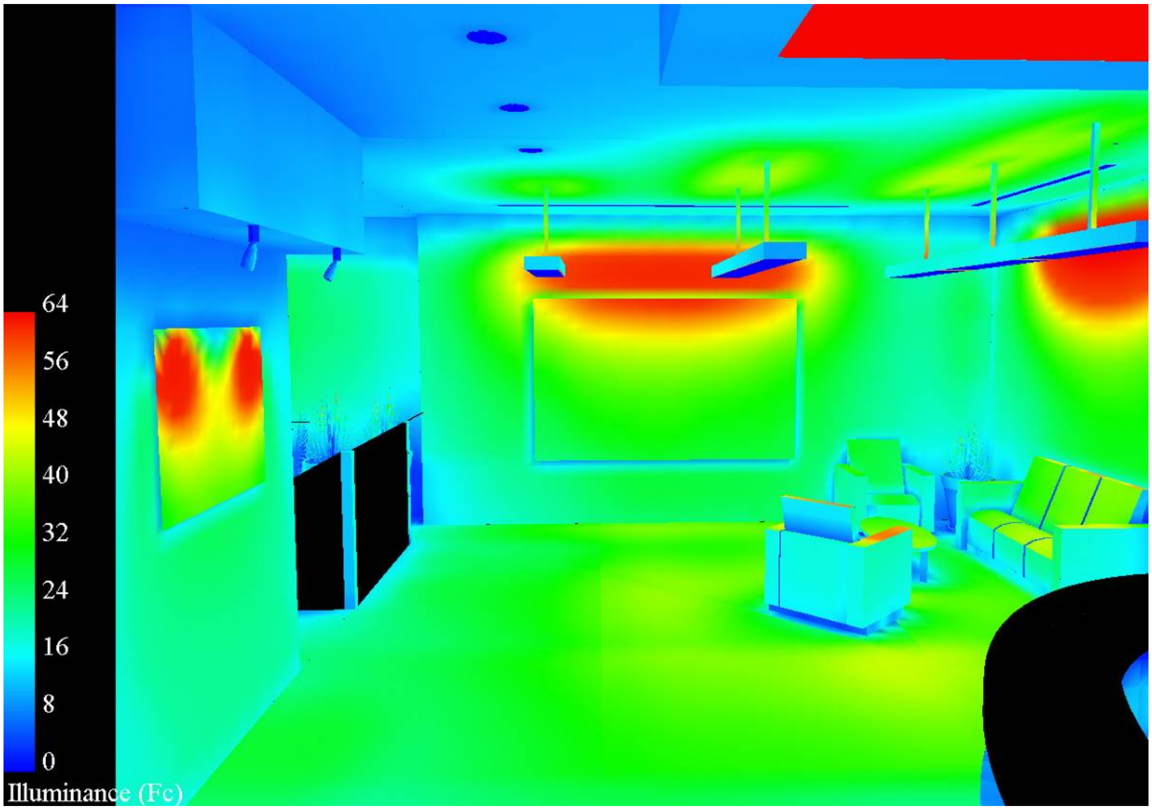
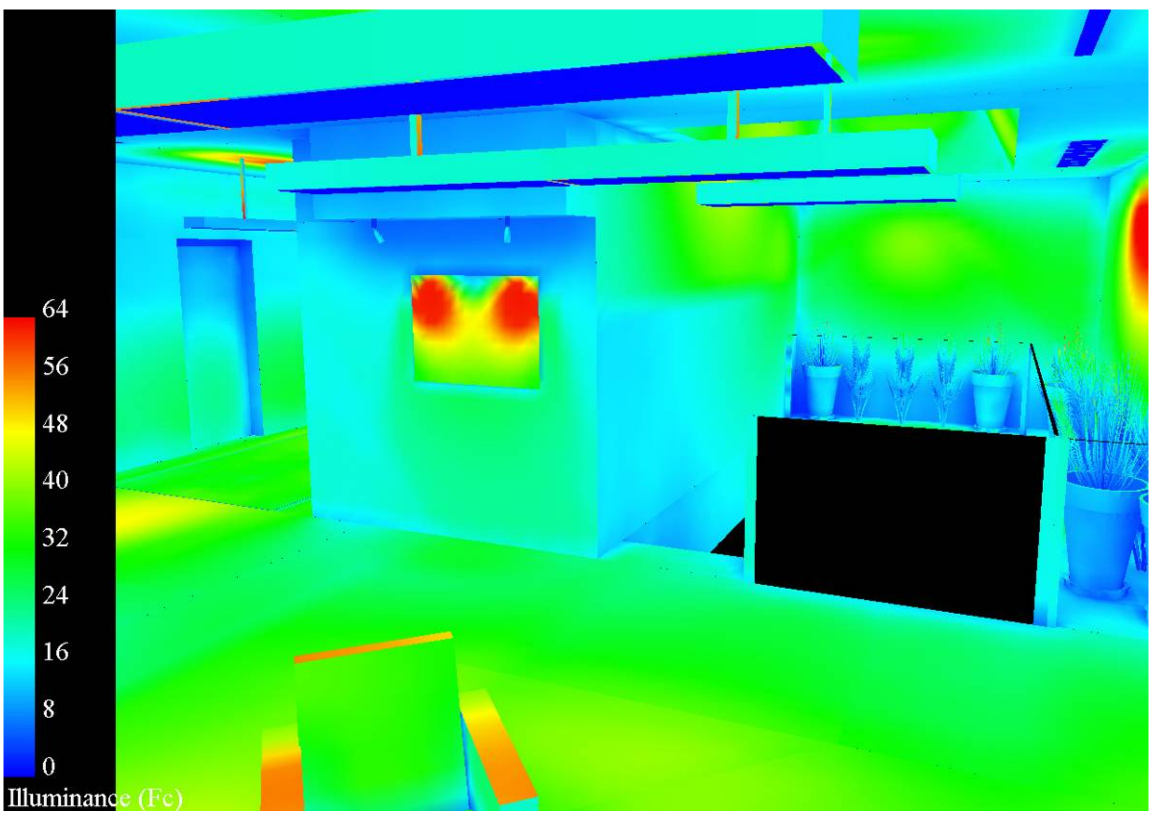
16
8
0
Illuminance (Fc)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)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8
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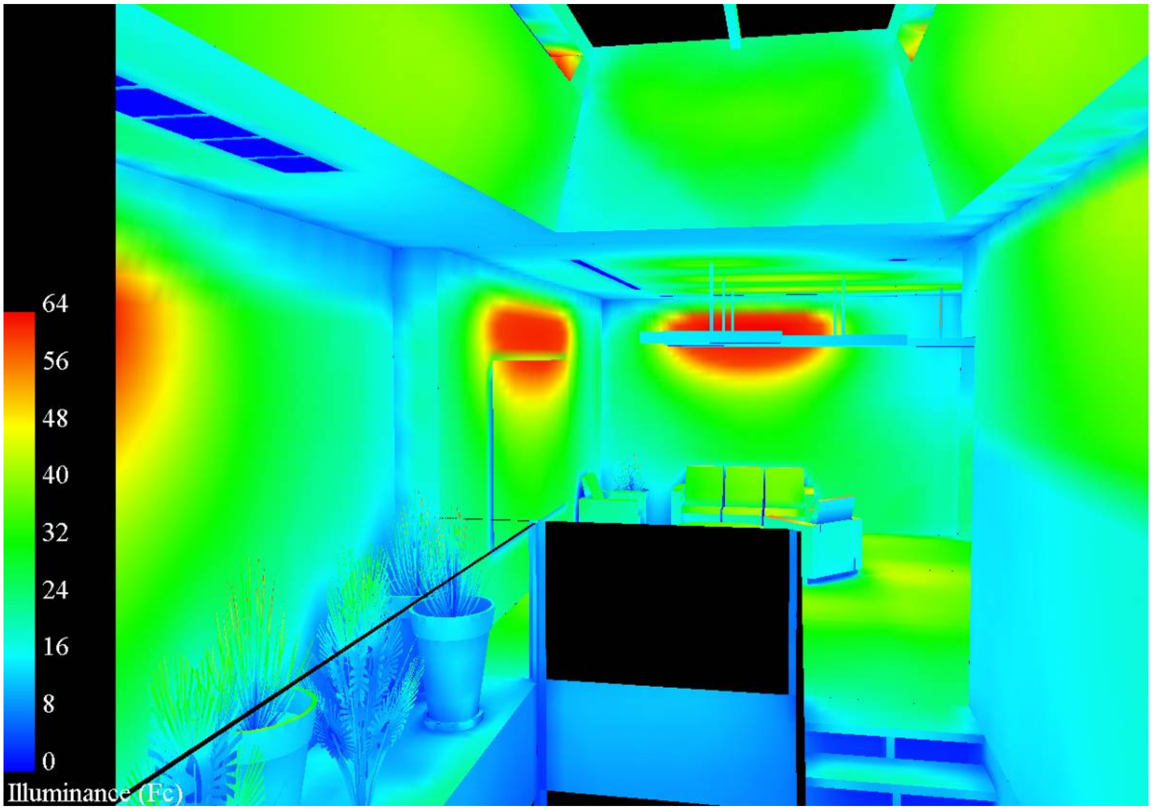
Illuminance (Fc)


64
56
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8
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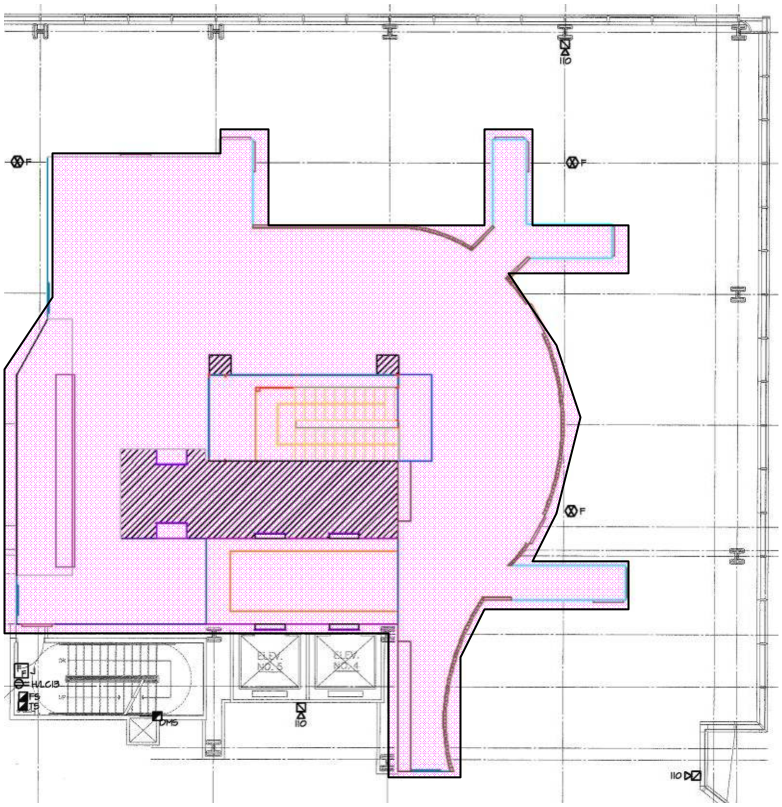
Illuminance (Fc)

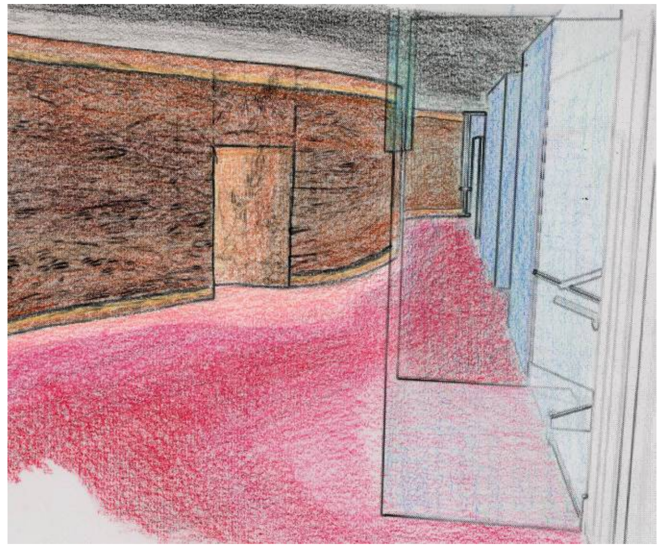
Conference Lobby



Surface Materials

The Reception area did not exist architecturally prior to the lighting design. For this reason, all of the materials used were relative to the available textures and colors present in AGI32. For all textures and painted surfaces, please view the actual renderings (as they appear in greater bulk) for these spaces. For the most part, architectural materials closely coincide with the materials already listed for the façade, lobby, and parking structure. For detailed surface illustrations and reflectances, reference the previous sections.

Design Concept



The design concept for the Conference Lobby focuses on maintaining waiting-room patience, focusing the congregation of visitors, and creating a warm comfortable atmosphere. The materials and color choices exemplify these design choices, and the illumination levels psychologically prevent individuals from wandering about the space – especially to service areas and employee entrances.

The secondary design concept was to maximize the penetration of the daylight from the stairwell skylight into the space. This penetration would further focus any visitor's attention on the stairwell, and keep them in the specific waiting area the architecture intended for them. This assumes, with some psychological significance, that visitors who are foreign to the space and unaware of its detailed layout will be drawn like moths – a valid assumption for the space in question.

Design Criteria

Appearance of Space and Luminaires – Rating: 6

Appearance of the luminaires in the Conference Lobby is not of dire concern as it was in other spaces. Because this space is located on the second-tier level of the office building, it is understood subconsciously that luminaires exist, and therefore are ignored by the typical visitor. Once the visitor is well into the space (think – typical client), they are there to do their business and leave in the shortest amount of time possible. Their impression of the area has been solidified and need not be improved.

Color Appearance and Contrast – Rating: 5

Color appearance in this space is of medium concern since the overall color theme is to be warm and inviting, which implies that the colors are all brown and wood tone with the occasional "flash of brilliance". Contrast in the space is also of less concern, save the transition area to the "rear" conference rooms. These corridors should be darker, but not so dark that they are quite uninviting.

Daylighting Integration and Control – Rating: 7

Daylight integration was completed through the stairwell skylight and the transparent windows located above the conference rooms for slight daylight penetration from all surrounding curtainwall openings. Daylighting control for the main and secondary waiting areas will be important, since excessive uplighting will not provide any additional illuminance under just about any sky condition.

Direct Glare – Rating: 5

Direct Glare is not a concern within the space except in one particular location. All of the luminaires throughout the space have diffusing lenses or deep louvers to avoid all of these direct glare problems. The sole area of concern is the stairwell. On the descent, direct glare into suspended luminaires of the main waiting area should be carefully considered. An appropriate distance should be maintained such that the visitor cannot see the lamp in the suspended fixture.

Light Distribution on Surfaces – Rating: 6

Light distribution on surfaces is relative only to the floor. Light distribution on the floor of the main waiting area should be fairly uniform with a decrease at the westernmost pillar. The light level should again increase at the secondary waiting area and remain uniform in that area. The light level at the entrance door to the employee offices should peak and the service elevator rear door should have the lowest illuminance so emphasis is not placed on the “dirtiest” area.

Luminance of Surfaces – Rating: 4

Luminance of surfaces is not a major concern in this space. The space is pretty much just a large, well-lit room with varying surfaces. The luminance of the wood walls will be considerably less in the main waiting area, but more so in the transition areas to the rear corridors. This reduced luminance will give a better depth to the wood veneer. The only other specific luminance with any significant contribution to the look and atmosphere of the space will be the translucent glass walls and doors leading to the employee offices.

Modeling of Faces and Objects– Rating: 6

The modeling of faces and objects within this space is also of medium concern. Faces are of medium importance because of the initial face-to-face meetings between clients and directors. Objects in the space are few, and their modeling has little impact on the space.

Points of Interest – Rating: 5

Points of interest in the space are less important than in prior spaces because of the lack of movement through the space. Points of interest for the employees are focused at the south end of the space on the support areas. Beyond this, points of interest are limited to the stairwell which will receive either a large amount of daylight or a focused amount of faux daylight via the skylight well.

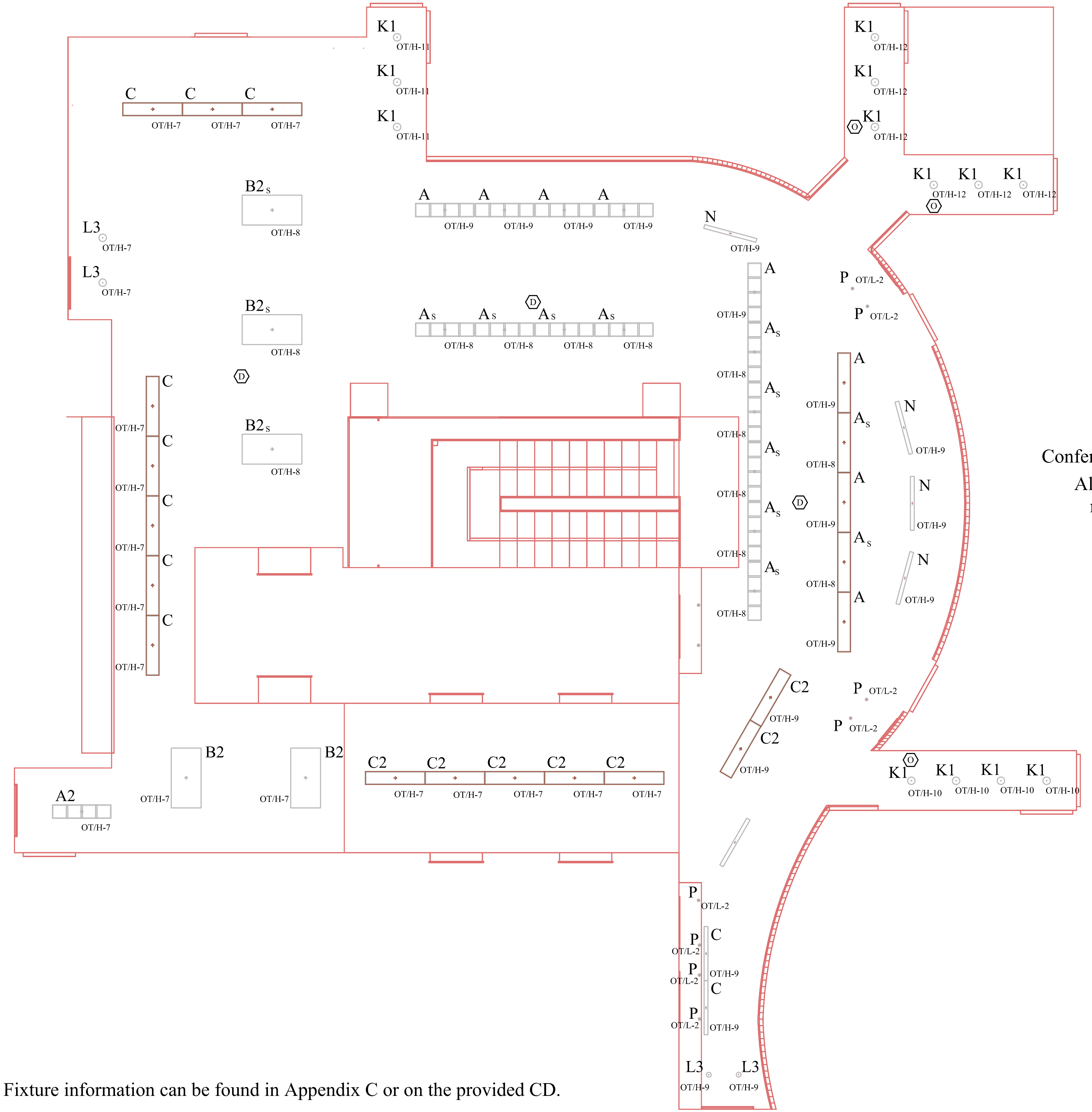
Horizontal Illuminance – Rating: 7

Horizontal illuminance in this space should be similar to the illuminance in the entrance lobby. The illuminance level need not be very high because no specific task is being completed in this area. The horizontal illuminance on the floor should be between 200 lux and 400 lux except in the areas immediately bordering the skylight well where the value will be much higher.

Vertical Illuminance – Rating: 5

Vertical illuminance is limited mostly to the walls and the artwork. Facial modeling vertical illuminances need not be much higher than the reflected values will dictate. The uplighting and diffused light from the luminaires will be enough to produce the requisite 50 lux up to 200 lux on any vertical surface (excluding the artwork which is much higher).

Layout and Circuiting

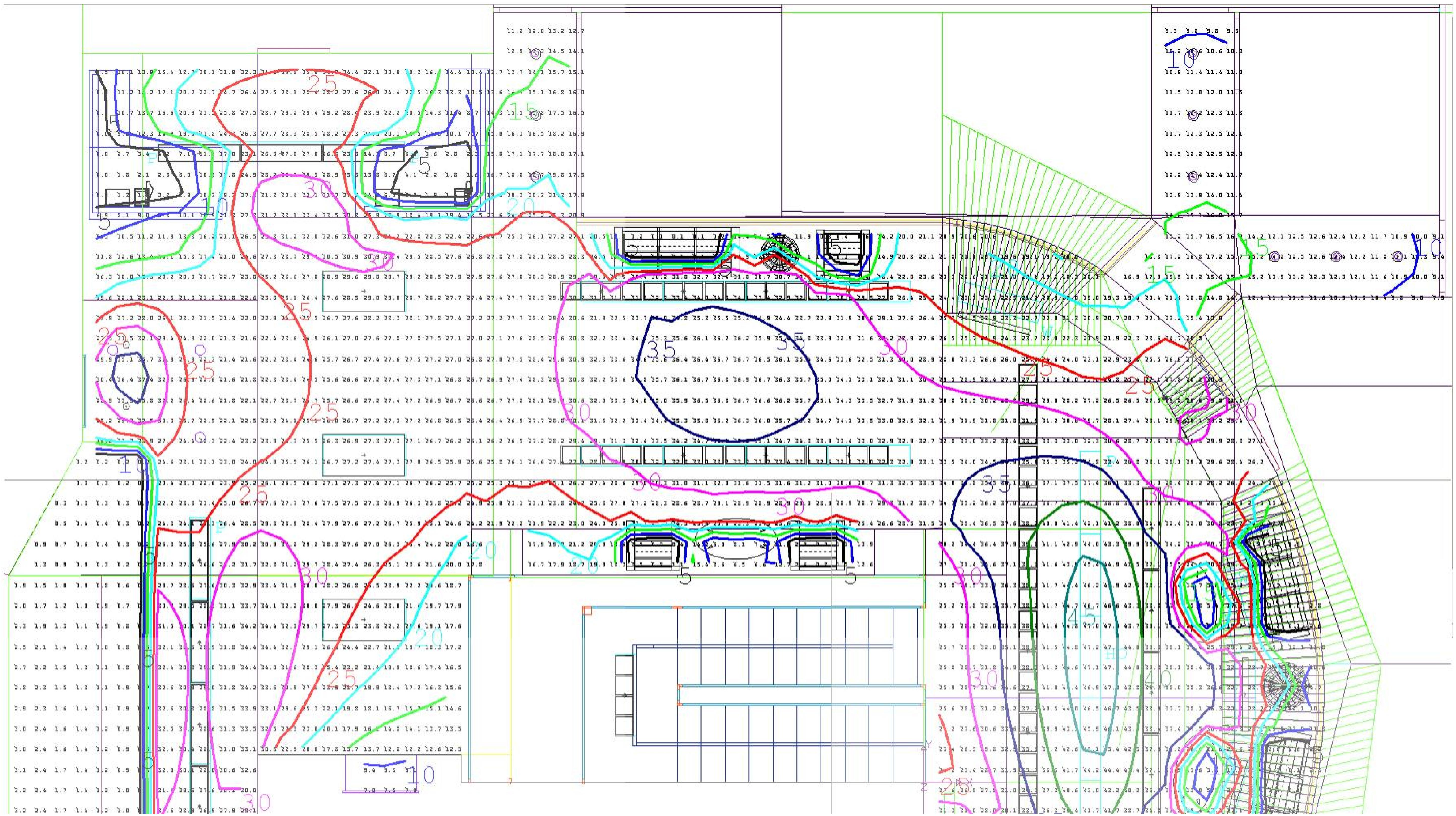


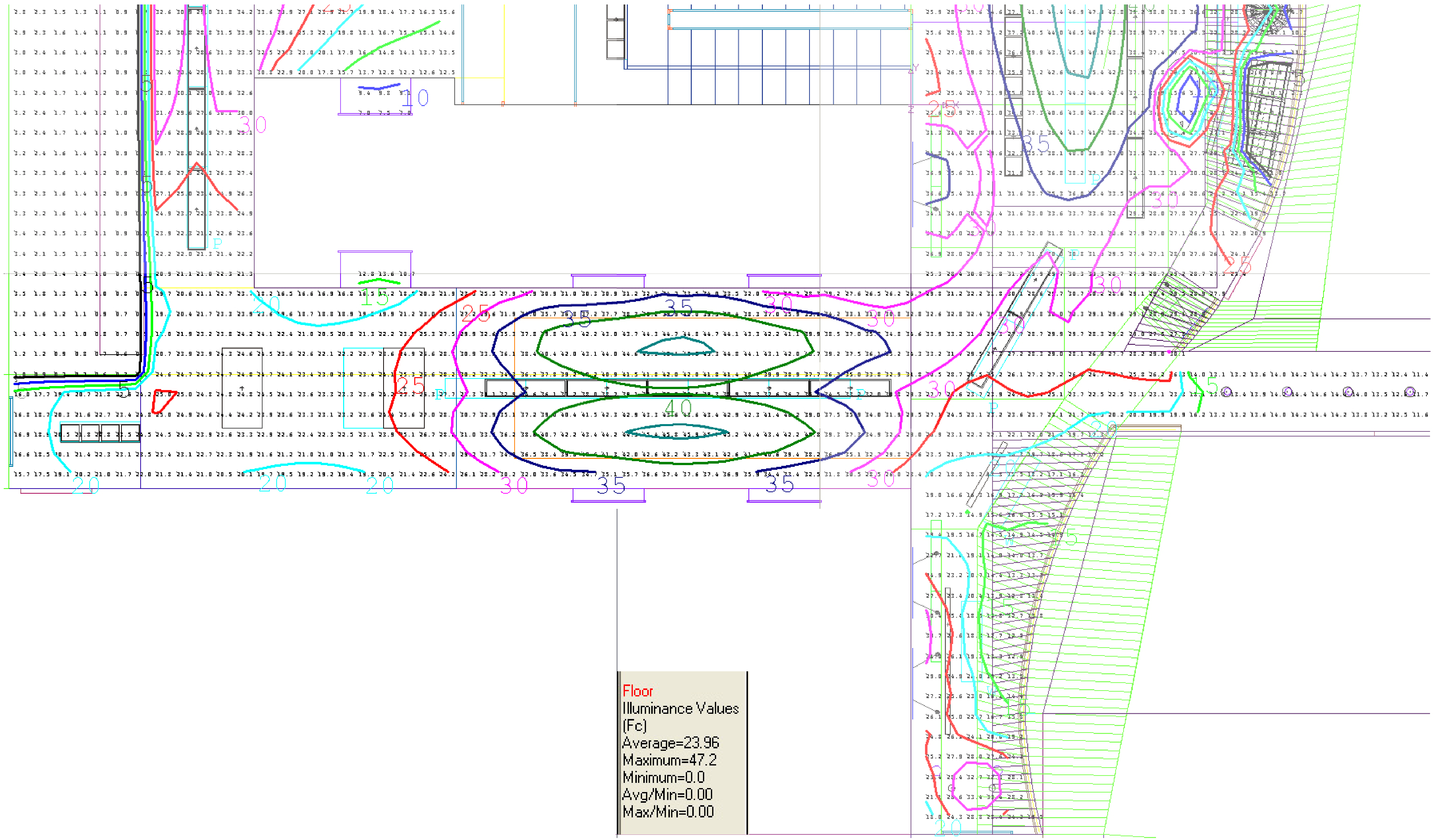
Conference Lobby Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D") or Occupancy ("O") Sensor

All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

Performance




Floor
Illuminance Values
(Fc)
Average=23.96
Maximum=47.2
Minimum=0.0
Avg/Min=0.00
Max/Min=0.00

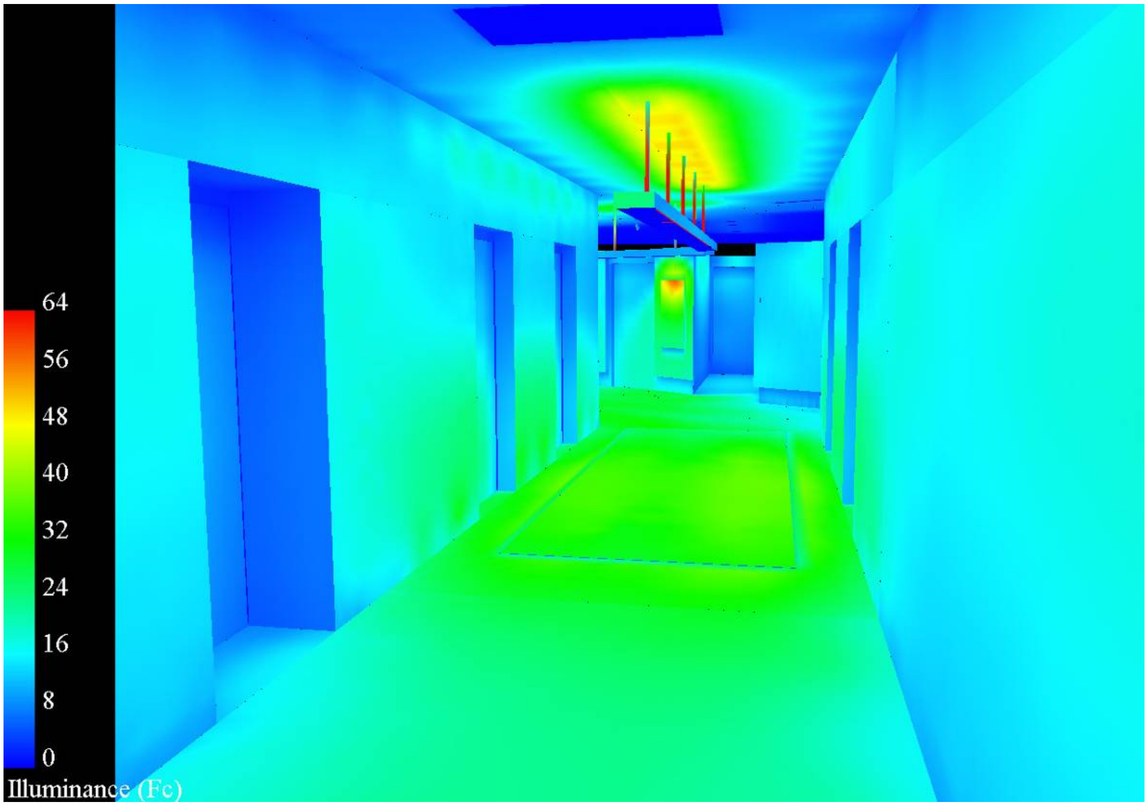
ASHRAE Power Density Calculation

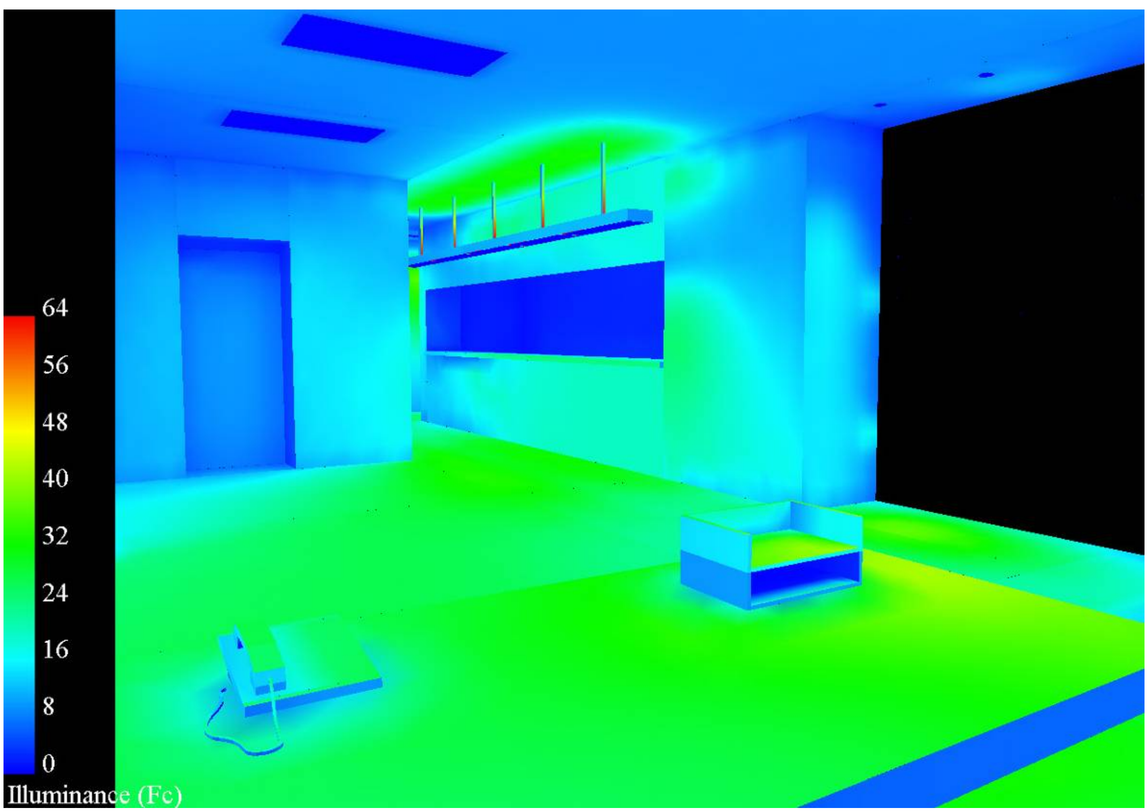
ASHRAE Power Density Allowance for Office: 1.1 W/sf

Conference Lobby square footage: 2770 sf ASHRAE allowance: 3601 W

Conference Lobby	A	A2	B2	C	C2	K1			
Luminaire	14	1	5	10	5	13			
Wattage	32	59	117	32	59	20			
Total Power	441	59	585	315	293	254			
	K1	L3	N	P2					
	13	4	7	10					Power D
	20	50	32	37		SUM (VA)	Area (sf)		
	254	200	221	370		2736	2770		**0.988**

Renderings


64
56
48
40
32
24
16
8
0
Illuminance (Fc)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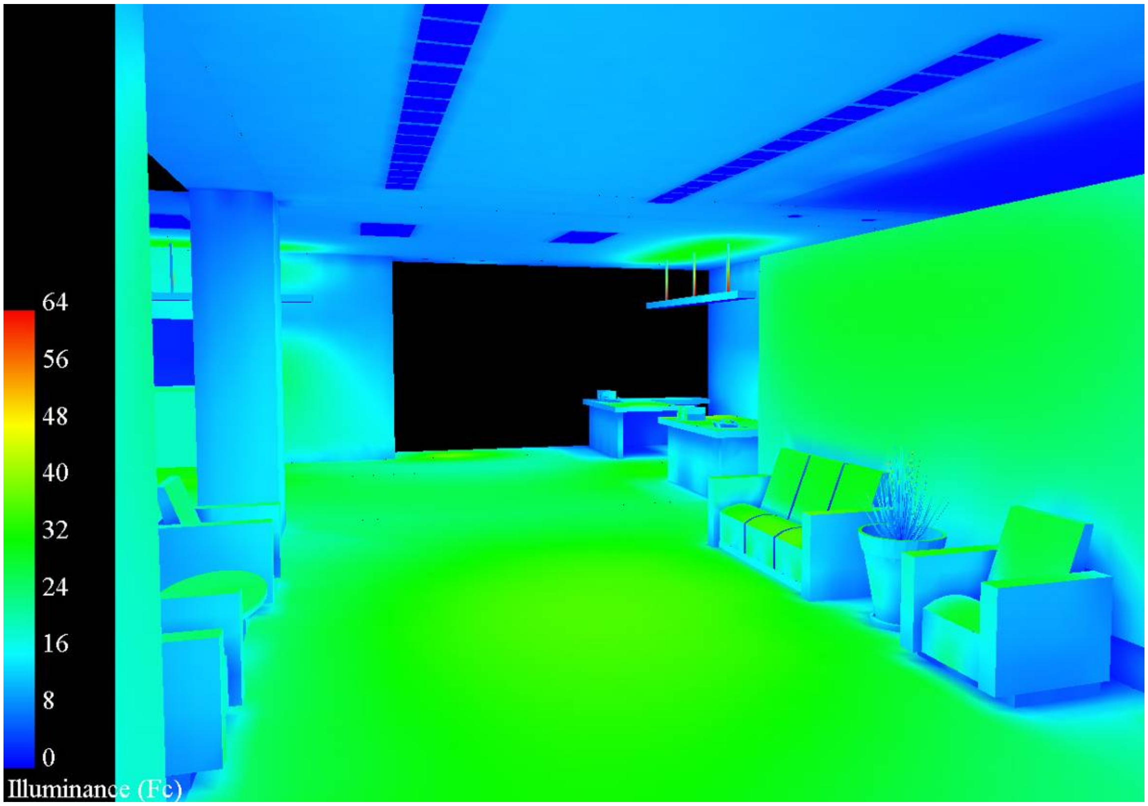
40
32
24
16
8
0
Illuminance (Fc)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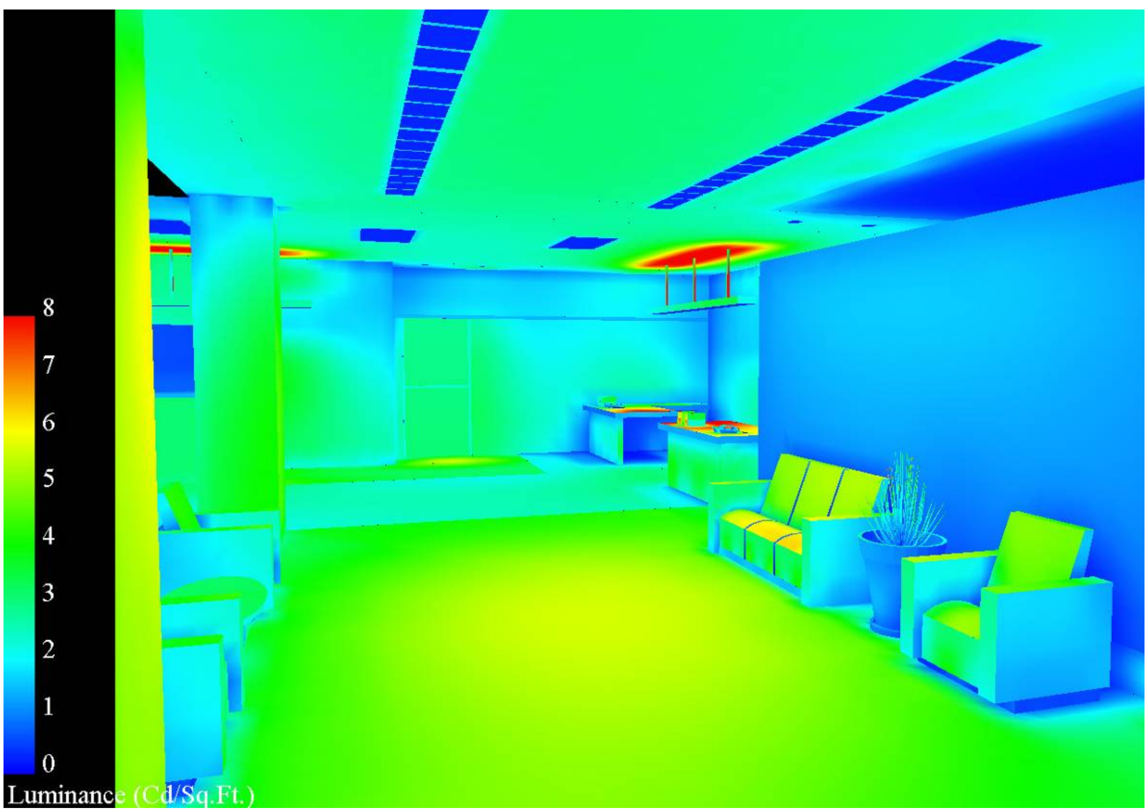
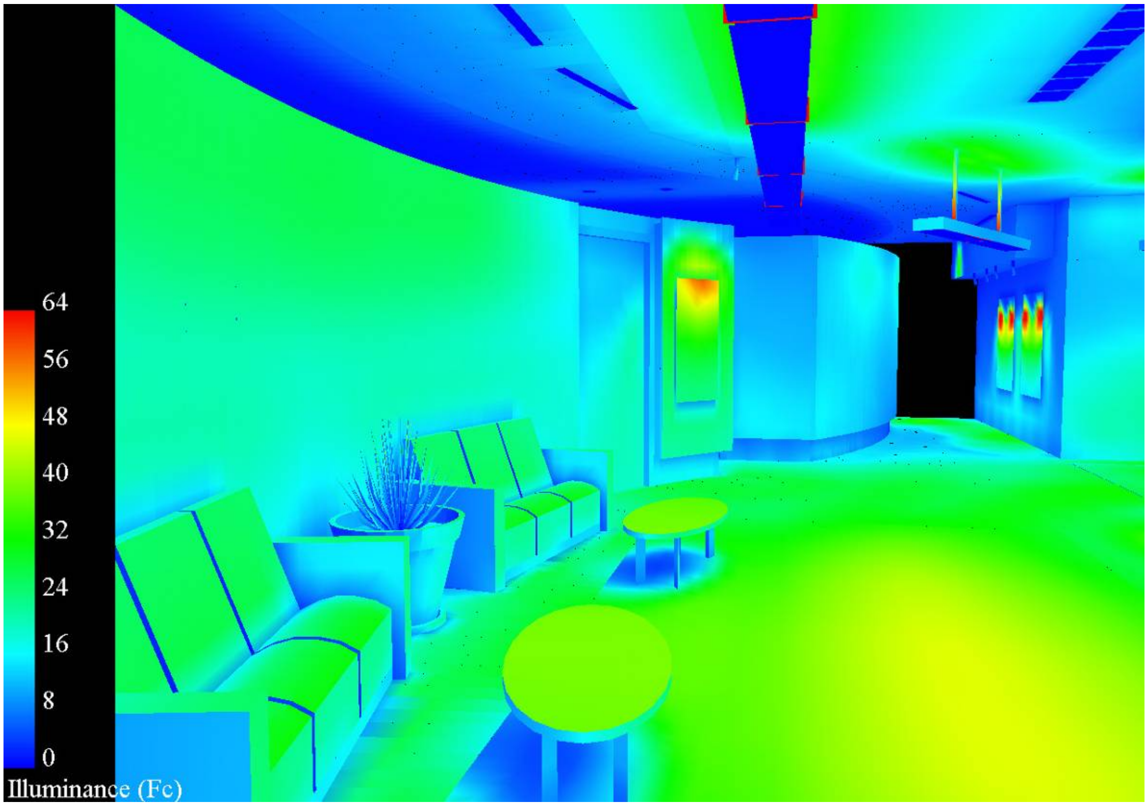
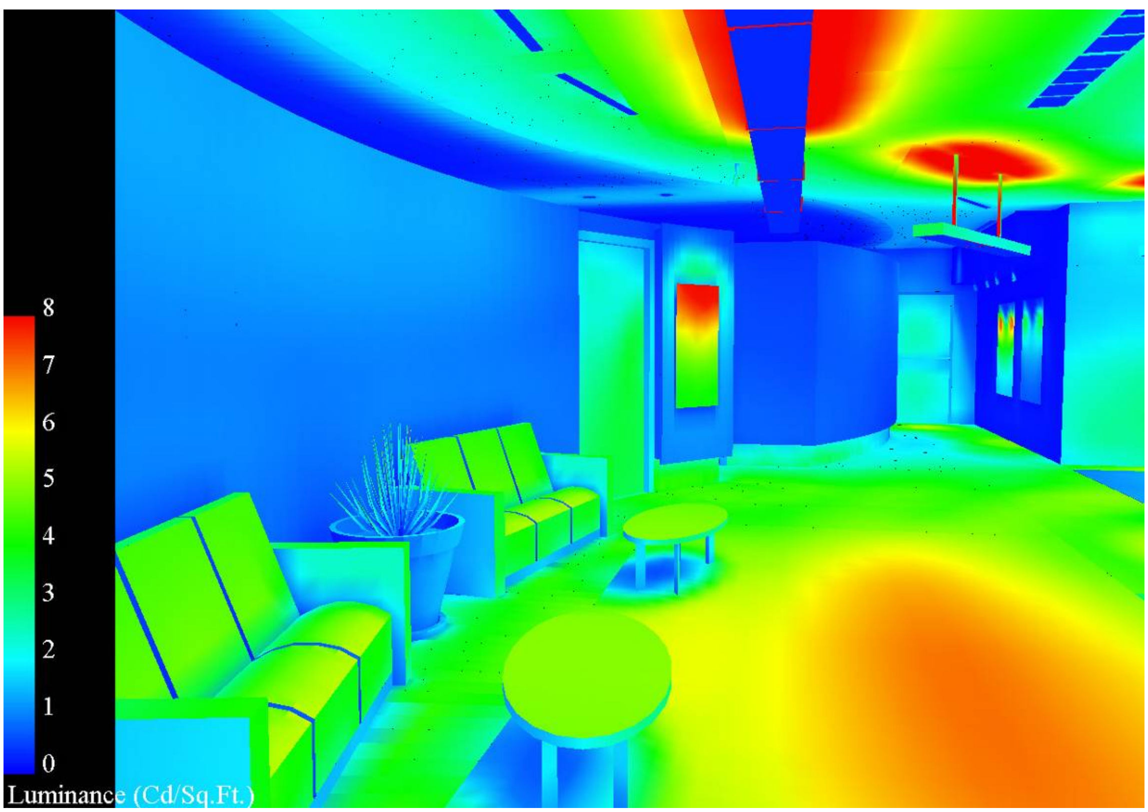
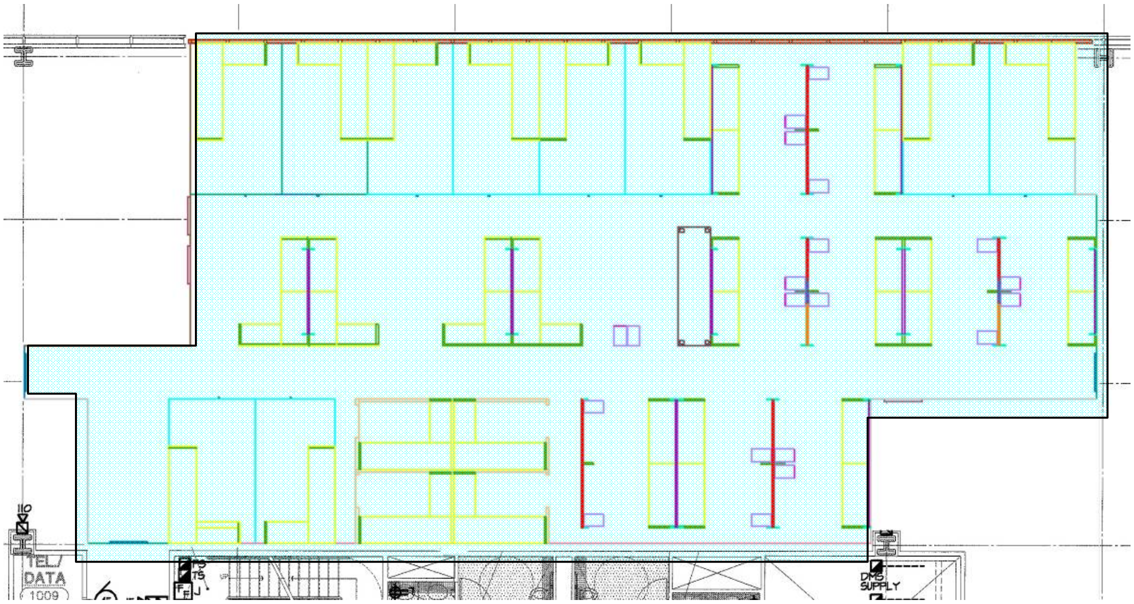
56
48
40
32
24
16
8
0
Illuminance (Fc)


8
7
6
5
4
3
2
1
0
Luminance (Cd/Sq.Ft.)


64
56
48
40
32
24
16
8
0
Illuminance (Fc)


8
7
6
5
4
3
2
1
0
Luminance (Cd/Sq.Ft.)

Open Office



Special Luminaires

The special luminaire systems in this space make up the vast majority of the lighting for the space. As was partially detailed in the research description, the desk-system luminaire is based at a height of 5'. The uplighting component spreads across the ceiling in much the same manner as any suspended indirect fixture would, but the downlight component is "funneled" into the translucent glass and reflector space immediately below the lamp. This allows the majority of the lamp lumens to be spread in an indirect manner, but also creates a glowing effect on the glass to illuminate the workplane from the front of the individual, in much the same manner a task light would. The difference being that the "new system" is an area source and has a less-steep falloff gradient across the desk.

The major design issue is one of glare. The lamp was placed low enough in the bay that glare from any angle perpendicular to the lamp orientation is impossible. The glare possibility from viewing angles in the direction of lamp orientation was eliminated by the use of 1' high reflective barriers. The most extreme angle was calculated and the lamp depth adjusted accordingly. No person with an eye level less than 6' would be able to view the lamp unless they crawled up on top of the desk and looked directly in.

The details and dimensions for the design can be found in Appendix C.

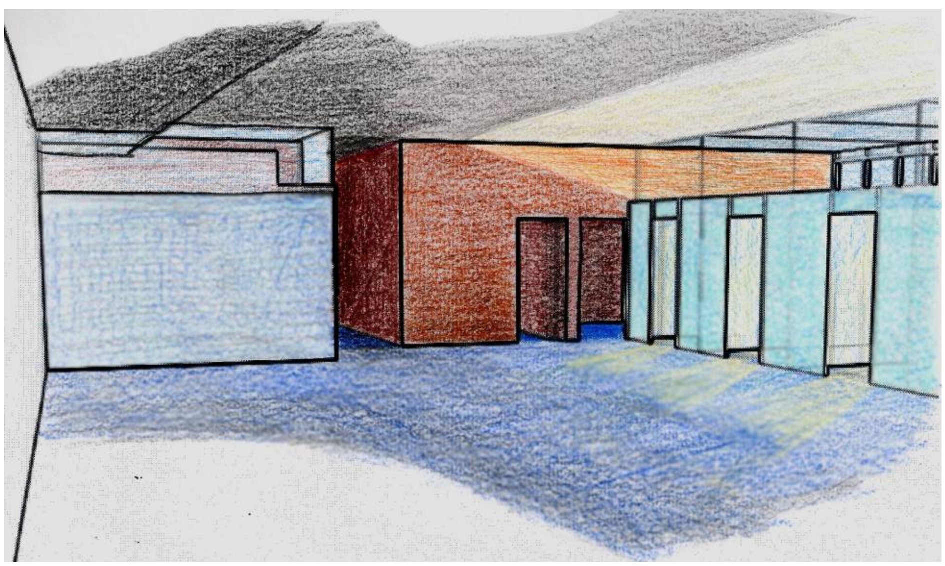
Surface Materials

The Reception area did not exist architecturally prior to the lighting design. For this reason, all of the materials used were relative to the available textures and colors present in AGI32. For all textures and painted surfaces, please view the actual renderings (as they appear in greater bulk) for these spaces. For the most part, architectural materials closely coincide with the materials already listed for the façade, lobby, and parking structure. For detailed surface illustrations and reflectances, reference the previous sections.

Design Concept

The design concept for the Open Office space focused on a single element, from which the remainder of the design was developed. Within the open office, the main task area is the desk in front of each individual. While this does not come as a surprise to any lighting designer, the attempt in this space was to create a "luminaire" that focused all of its output to the task plane. Combining this idea with the contrast limits of the computer screen with near and far geometry, it was decided that a luminous wall in front of the task plane would best illuminate the desk surfaces. This led to a few significant advantages. First, no veiling reflections from high luminance ceiling sections or luminaires would be present. Second, no shadowing would occur on the workplane if the individual was bent over their desk writing. And third, the contrast from looking at the computer screen compared with the "cubicle" wall would be significantly reduced, as would the contrast from workspace to open office corridors.

Further, the design concept was developed in relation to the architectural concept developed in the architectural breadth. With the division of space, and the intention of the design to keep the ceiling open, there needed to be a significant replacement of suspended luminaires in the space. Beyond this, suspended luminaires were eliminated from the private offices to better illuminate the walls for the "area" source impact intended in the architectural design.



Design Criteria

Appearance of Space and Luminaires – Rating: 8

Appearance of the Open Office is of major concern in relation to the architecture of the space. The luminaire appearance is of major concern since the architecture dictates that it be as invisible as possible. The remainder of the luminaires should be as hidden as possible unless it is specifically calls out a particular architectural element.

Color Appearance and Contrast – Rating: 7

Color appearance in the space is important, but not as much so as the contrast between surfaces and areas within the space. Given the major uplighting component proposed, the ceiling contrast should be minimized, and the difference between the workplane and surrounding areas should not be excessive. Color variation throughout the space is significant when considering the floor color, the translucent private office glass color, and the ceiling and wall paints. These colors should all appear vibrant and accurate to their hues. The daylighting component in the space should help brighten up these colors and minimize the shift toward blue-grays.

Daylighting Integration and Control – Rating: 9

Daylighting integration in the space is a given for the glass curtainwall bordering the eastern façade (for this particular space – east and south facades in other spaces). Daylighting integration is not a major concern, but the control is. Each of the private offices, acting as a large glowing light source because of the transmitted light helps decrease the daylighting component and actually diffuses the daylight better than any other method would achieve. The daylight penetration into the private offices would require absolute control of the luminaires in these areas.

Direct Glare – Rating: 10

Because of the location and orientation of the luminaires, the direct glare component could be one of two options – either very minimal, or unbelievably excessive. The construction and implementation of the desk luminaire design needs to account for this issue and its distinct importance

Light Distribution on Surfaces – Rating: 7

The light distribution on surfaces was discussed previously. Light distribution for these areas only needs to be located in two areas, the workplane or desktop at which every employee works, and the floor in the corridors that every occupant uses to traverse the space. The distribution should be as uniform as possible on the desktop and should be continuous in the corridors.

Luminance of Surfaces – Rating: 7

The only surfaces with major luminance concerns are the translucent glass walls and doors again, but also the translucent cubicle walls that will serve as luminaires for the desktops. These luminances should not be very high as they will blind the employee at their workstation, and the glow from the rows of private offices would seem to overbearing as a soft light source.

Modeling of Faces and Objects– Rating: 5

Again, modeling of faces and objects did not take on any vast importance in the space. Of course faces and objects should be well illuminated from all directions which would be accomplished by diffuse light spread throughout the space, but there needn't be any special consideration given to ensuring high illuminances on faces. As long as the appearance of the face is not overwhelmed by facial shadows, the modeling should be sufficient with any office design.

Points of Interest – Rating: 7

There are four distinct points of interest in the space, two located at the ends of each major axis corridor. For the corridor next to the row of private offices (nearest the curtainwall), a light at the end of the corridor should illuminate the wall forcing the wall to seem closer than it actually is. At the opposite end of this corridor is the dark wood-panel wall of the office conference room. The end of this corridor should have higher illuminance to bring attention to the location of the conference room and the physical end of the hallway.

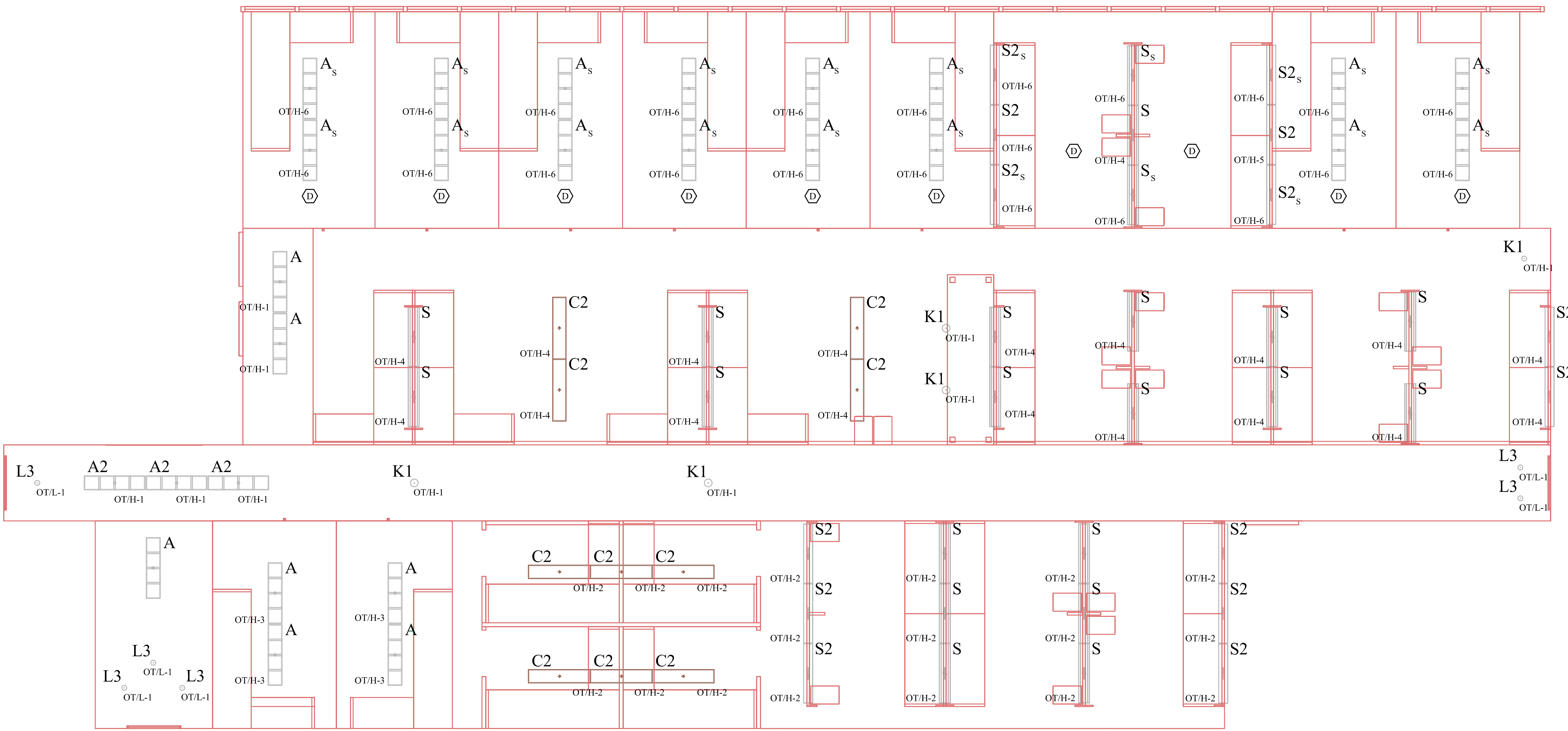
For the main corridor through the space (nearest the core), the entrance and exit glass door should be illuminated as a point of interest for entering the Conference Lobby or exiting the Open Office. At the other end, the intersection of the minor exit hallway and the end of the Open Office corridor should be accented as well.

Horizontal Illuminance – Rating: 9

The horizontal illuminance is of greater importance in this space than it has been in any other space. The desk tasks involve small print, number-crunching, etc. requiring the space to have a higher horizontal illuminance than any of the other space. For this reason, the desk illuminance should be upward of 400 lux, preferably around 500 lux or more. Horizontal illuminance in the corridors should be consistent with the other spaces averaging near 200 lux or more.

Vertical Illuminance – Rating: 5

As was stated for the modeling of faces and objects, vertical illuminance is not of great concern in this space. The only areas that would benefit from vertical illuminance are the private offices where diffuse reflected light from the glass would better illuminate the space. Additionally the more the walls of the private office are lit, the more light will transmit through a larger area source to the interior space.

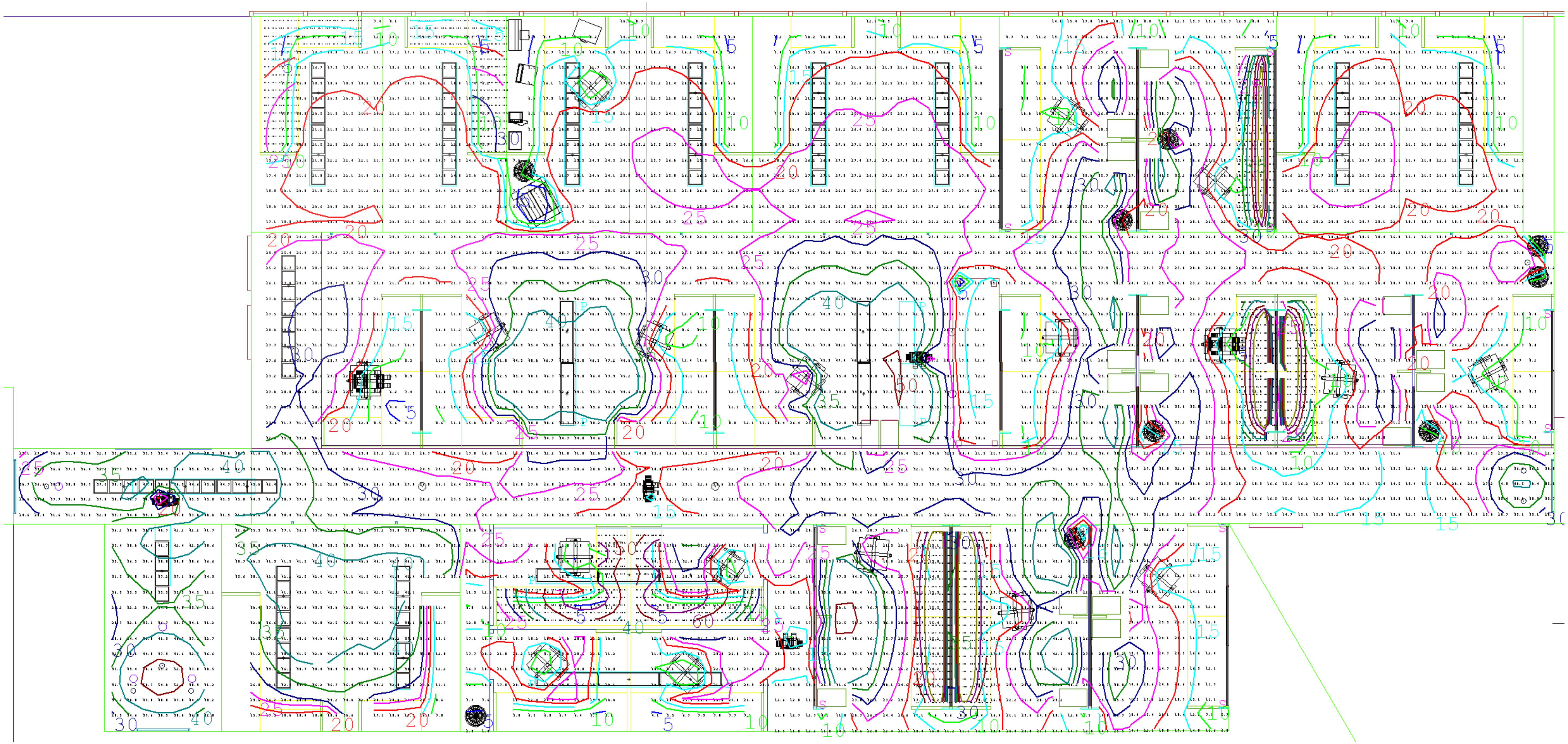


Open Office Floor Plan, Lighting Layout and Circuiting Diagram
All Luminaires additionally labelled with "S" are operable both manually and by Daylight ("D") or Occupancy ("O") Sensor

All Fixture information can be found in Appendix C or on the provided CD.

Not to Scale

Performance



Floor
Illuminance
Values(Fc)
Average=24.59
Maximum=54.0
Minimum=0.1
Avg/Min=
245.90
Max/Min=
540.00

Private Desk
Illuminance
Values(Fc)
Average=21.57
Maximum=33.0
Minimum=11.0
Avg/Min=1.96
Max/Min=3.00

Cubicle Desk
Illuminance
Values(Fc)
Average=50.89
Maximum=69.7
Minimum=19.8
Avg/Min=2.57
Max/Min=3.52

5ft Desk
Illuminance
Values(Fc)
Average=54.71
Maximum=107
Minimum=17.0
Avg/Min=3.22
Max/Min=6.34

6ft Desk
Illuminance
Values(Fc)
Average=67.61
Maximum=116
Minimum=27.8
Avg/Min=2.43
Max/Min=4.19

6ft Half Desk
Illuminance
Values(Fc)
Average=46.09
Maximum=83.5
Minimum=20.9
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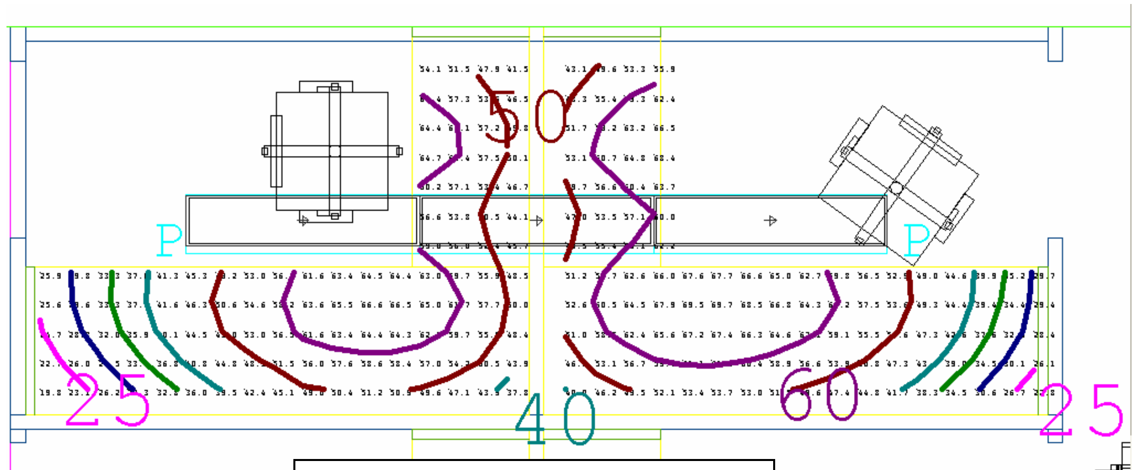
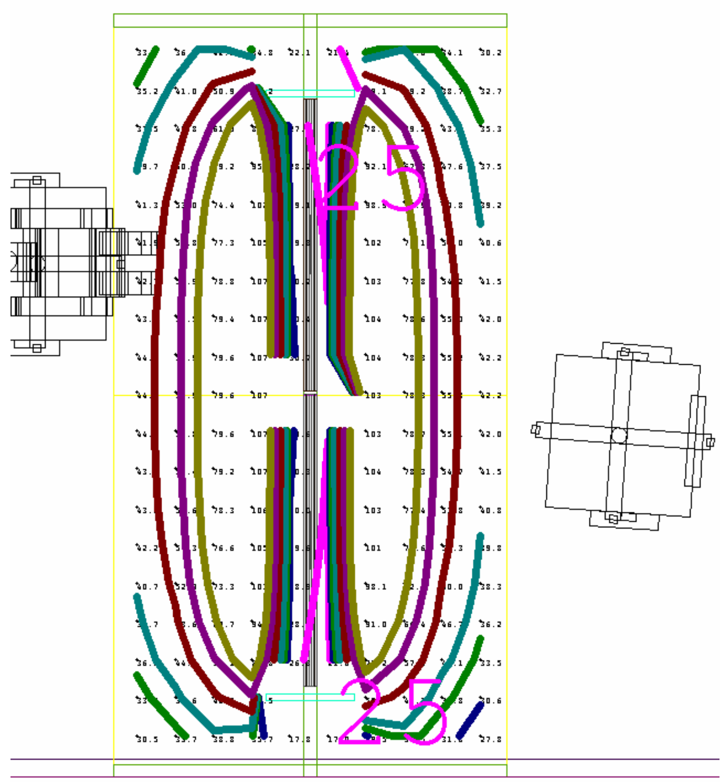
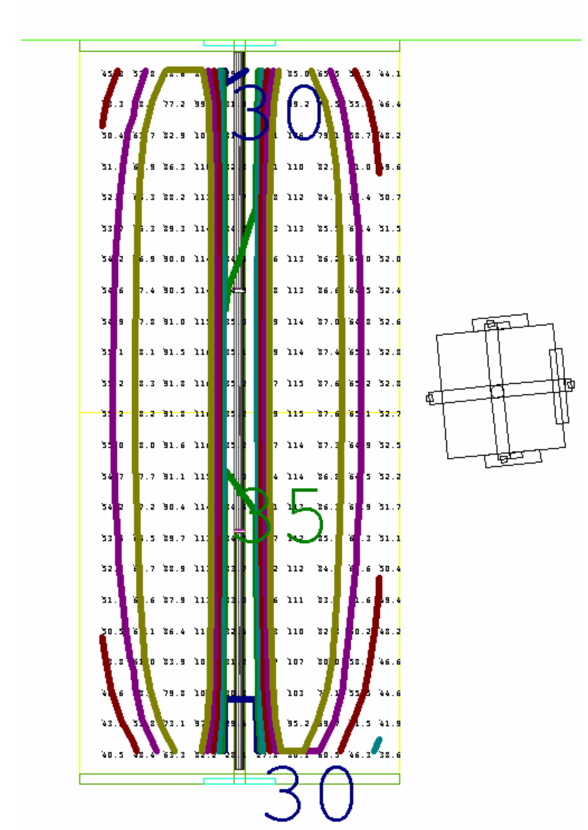
Max/Min=4.00



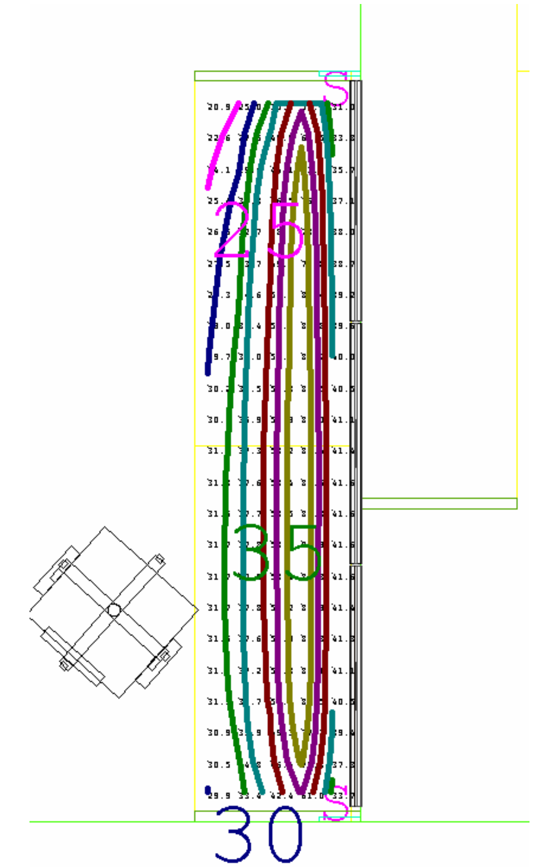
Manager Cubicle – East Wall



5ft “Full Desk”



6ft – “Full Desk”



6ft – “Half Desk”

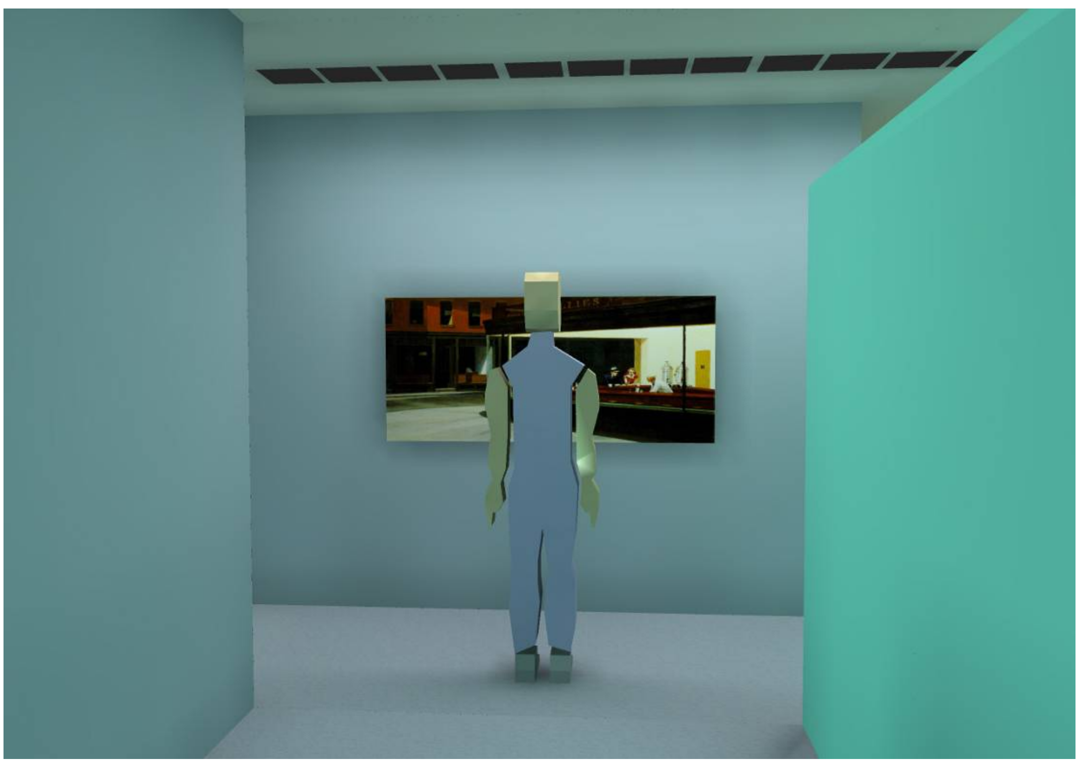
ASHRAE Power Density Calculation

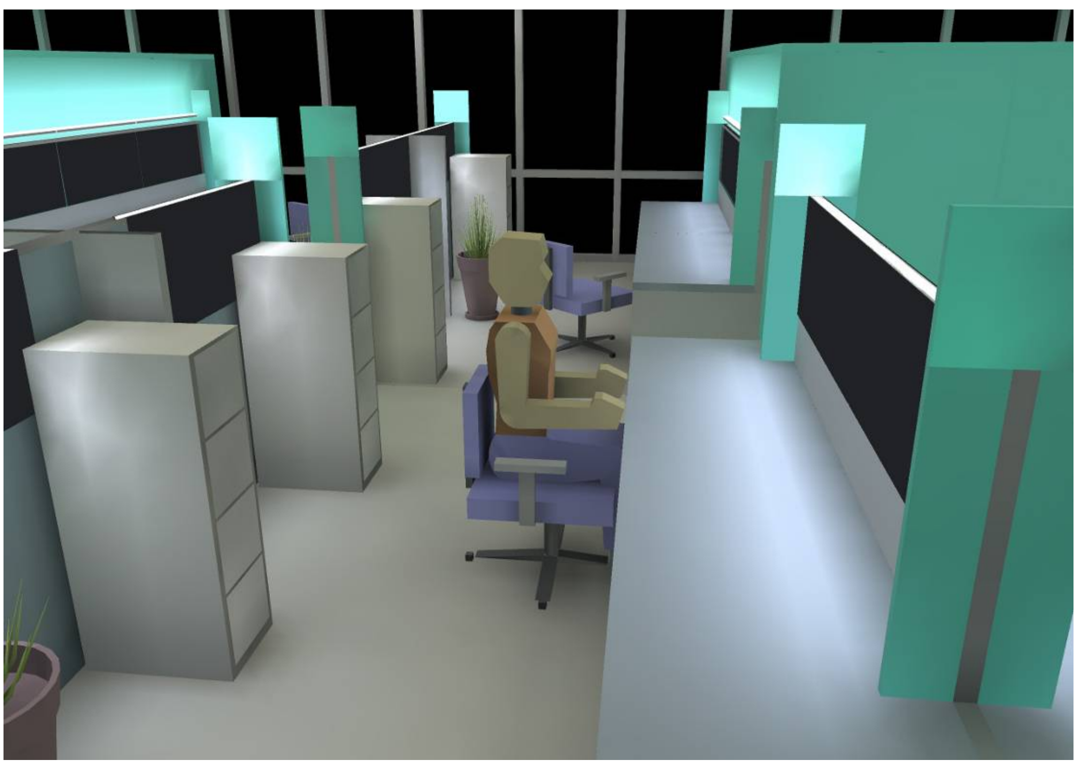
ASHRAE Power Density Allowance for Office: 1.1 W/sf

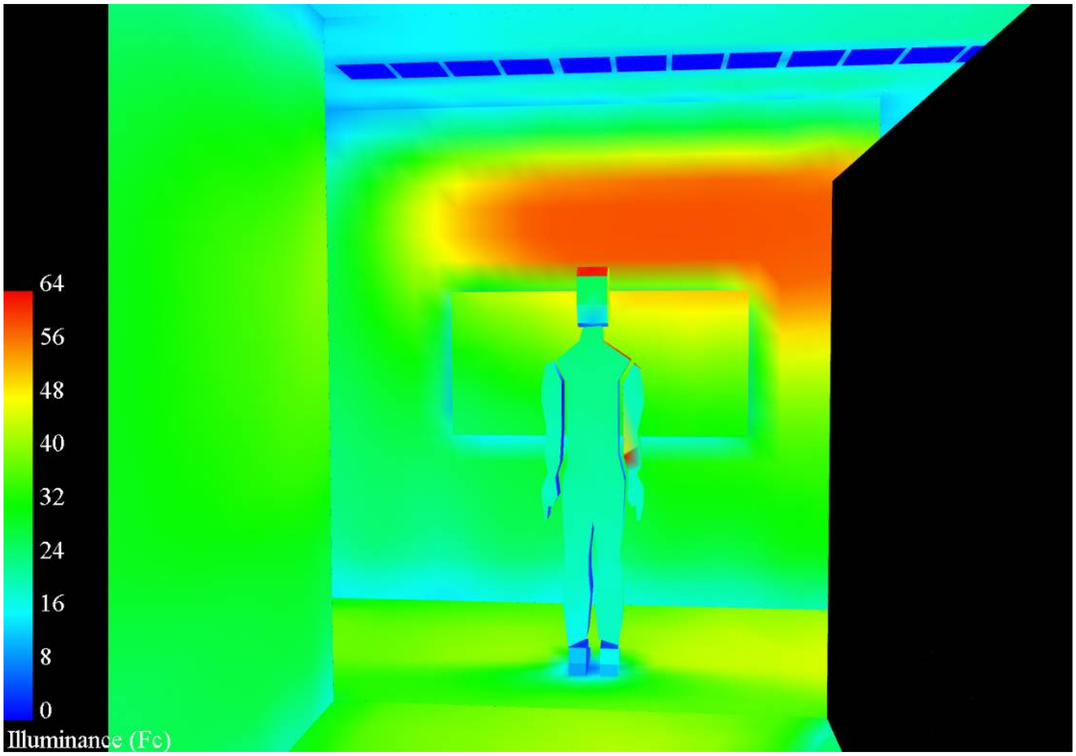
Conference Lobby square footage: 3800 sf ASHRAE allowance: 4180 W

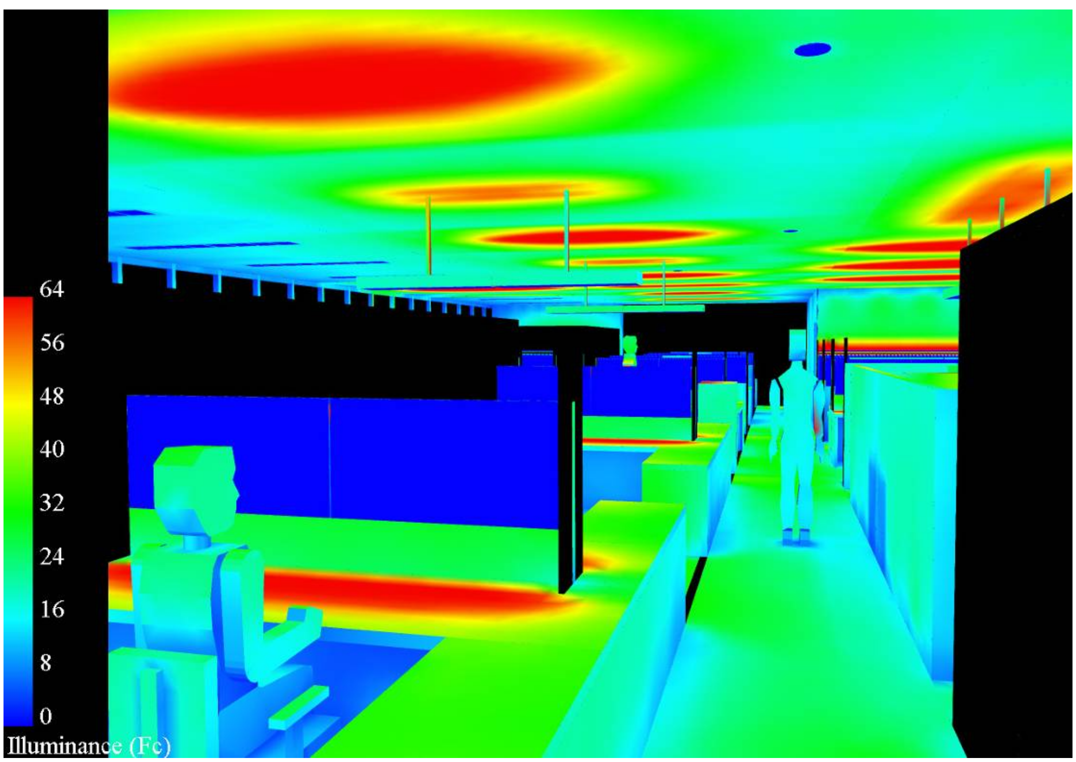
Open Office	A	A2	C2	K1	L3	S	S2			
Luminaire	23	3	10	5	6	21	14			Power Density
Wattage	32	59	59	20	50	59	32	SUM (VA)	Area (sf)	
Total Power	725	176	585	98	300	1229	441	3552	3800	**0.935 W/sf**

Renderings






64
56
48
40
32
24
16
8
0
Illuminance (Fc)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56
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40
32
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8
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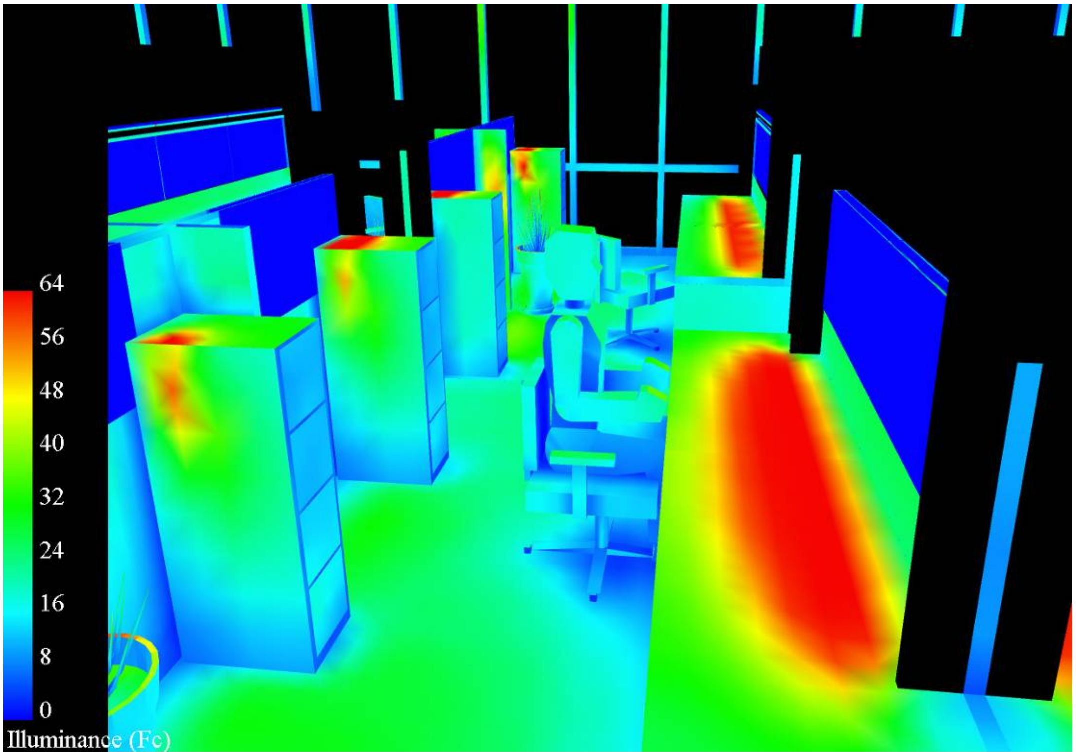
Illuminance (Fc)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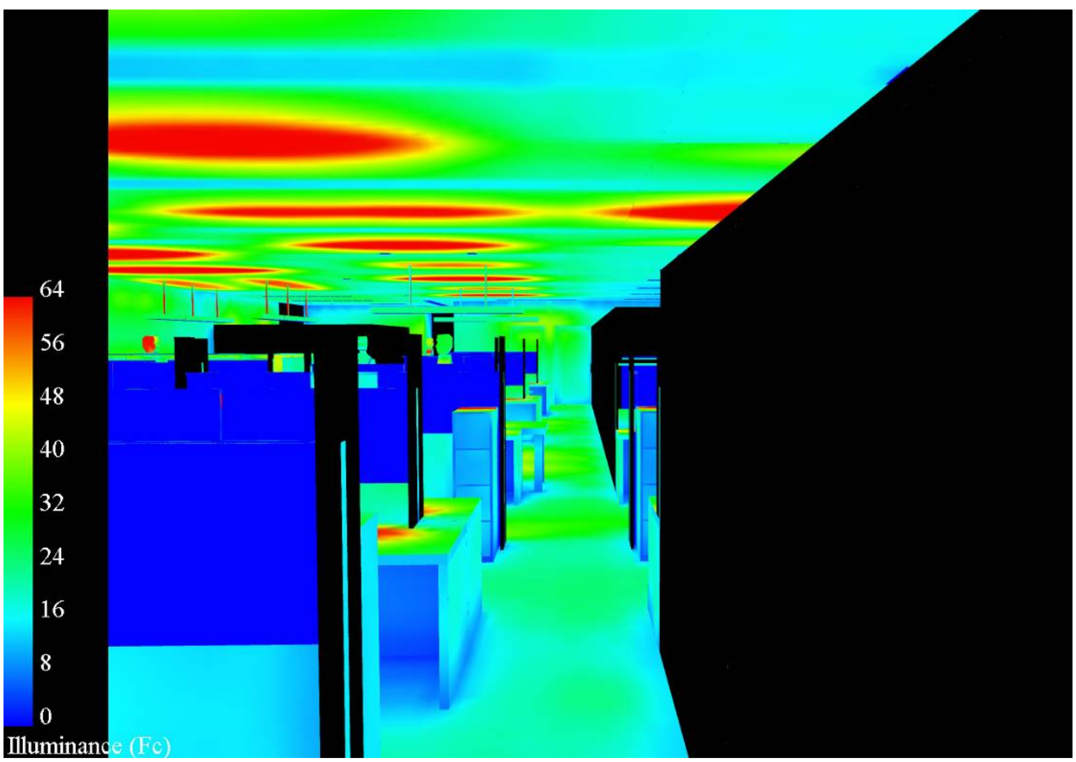
8
0
Illuminance (Fc)


64
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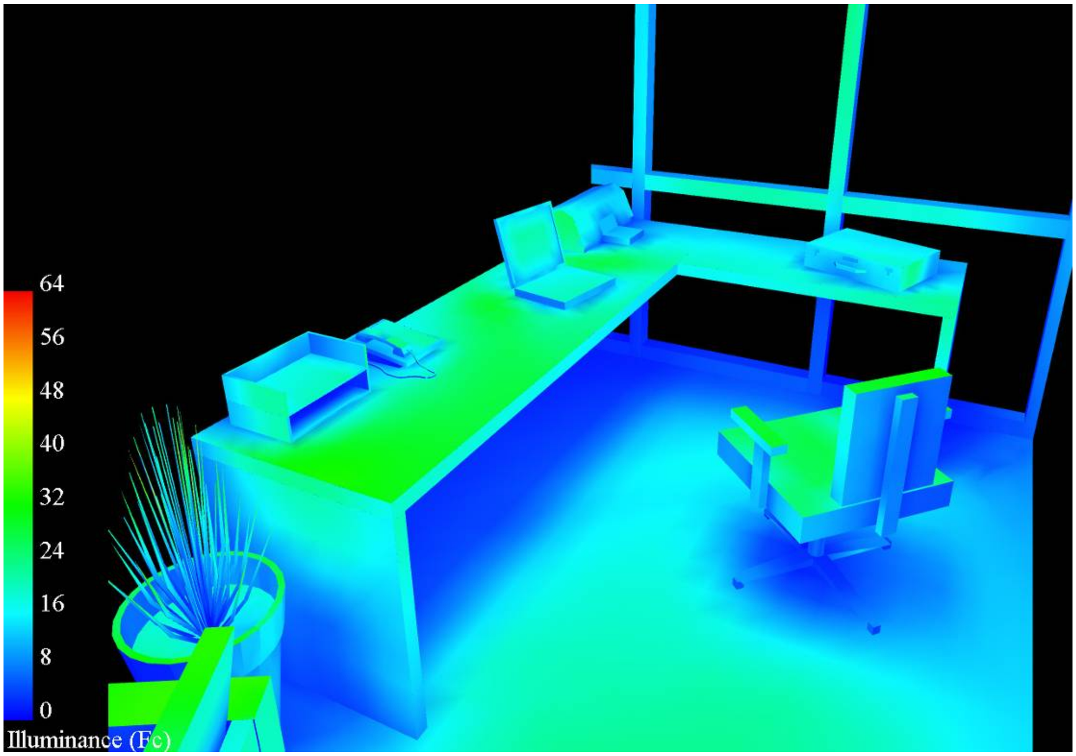
Illuminance (Fc)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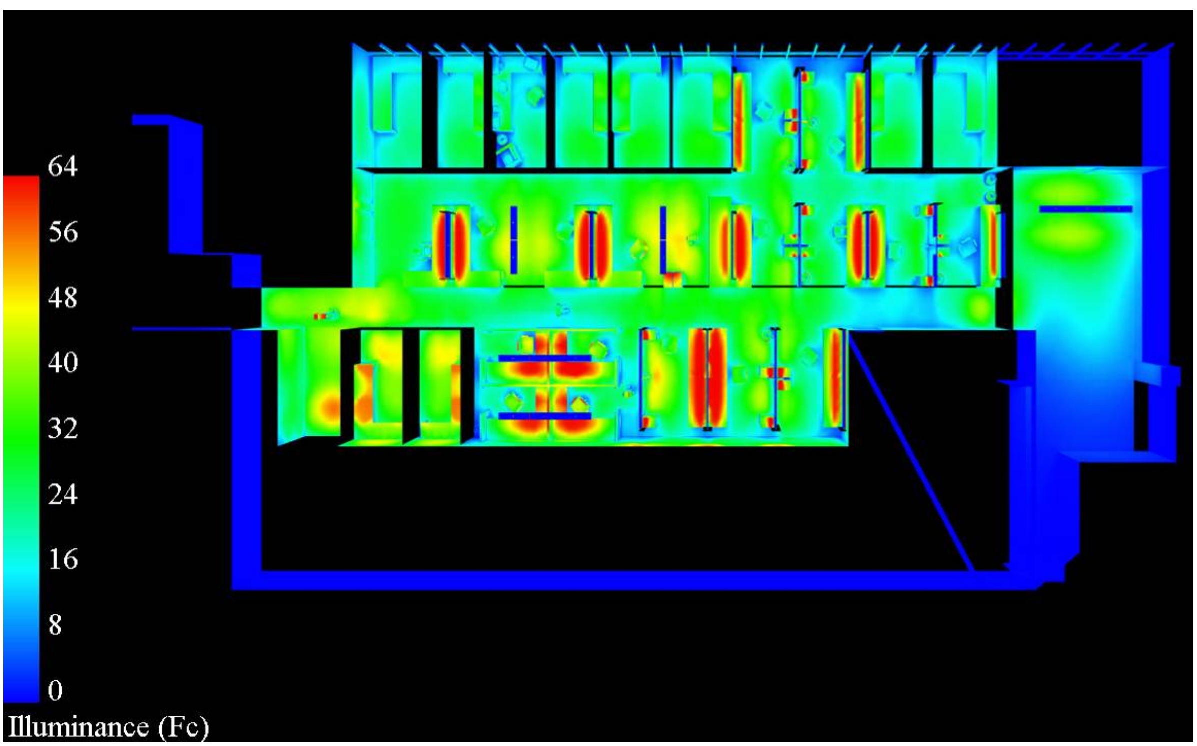
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Illuminance (Fc)

Electrical Depth

Electrical Depth

The entire electrical depth is based around a complete redesign of the existing electrical system which was modeled in its entirety for Technical Assignment #2. Given a tenant fit-out building, all electrical loads had to be estimated and the entire system designed around uncertainty. Technical Assignment #2 allowed for the modeling of a maximum capacity building and the comparison with the current system was a near match, if slightly oversized and undersized at some points.

This depth topic was to compare and contrast the current distribution system with a distribution system that would allow for less conductor and conduit runs, while increasing reliability. The new system would treat the building as a single-owner entity, in essence managed in it's entirety by Pentagon Management LLC. The comparison of costs will be the results and the lower cost will prevail.

Relationship with Thesis Project

Integration within the thesis is focused mainly on the Mechanical Breadth and utilizes the energy consumption information from some of the spaces in the Lighting Depth. The Electrical Depth and Mechanical Breadth are intertwined through their power distribution and generation capabilities. This is further explained in the Mechanical Breadth.

Proposal

The proposal for the Electrical Depth is to accept a single utility service pull and distribute power through the building using the Main Bus as a spinal cord from which almost all other loads are tapped. The "brain" of this system will be the Main distribution board, and the nerves will be reduced feeder lengths that don't have to span multiple floors to terminate at their associated panels. The proposal also includes the alteration of the current emergency distribution system and emergency power source. The new emergency power system will take some distinct power requirements into consideration and add an unprecedented reliability for blackouts, brownouts, building power failures, and any relative catastrophe that will eliminate power for any extended period of time.

Modeling Loads

The modeling of loads was crucial to the design of the current system and because such information was not available, had to be reconstructed based on architectural plan, and then compared with current system configurations for accuracy. Such loads that were given, including all mechanical motors loads and any electrical input requirements given in the base-building design, were injected directly into the model. The model is increased in accuracy considerably with these specifics – a secondary goal of the redesign. All loads taken from the schedules were converted from their specified horsepower or MCA requirements and converted to their kVA equivalents and/or amperage inputs.

Using NEC 2002 guidelines for approximating lighting and receptacle loads, space layouts otherwise not available for load analysis could be modeled. Such calculations are shown in the following sections.

Office

Office loads were easy to come by and were easily approximated based on the measured square footage of the office floors plans. From NEC Table 220.3(A), Unit Loads based on occupancy are given in VA per square foot, with a sub note (b) indicating that in banks and office buildings, an additional load can be added to account for general-purpose receptacles outlets. The lighting load for Office Buildings is listed at 3.5 VA per square foot with a 1 VA per square foot allowance for the receptacles. Combining the receptacle loads into a single table and calculating the Demand based on Table 220.13, adding together the lighting load and multiplying by an architectural factor accounting for the loss of usable space to partitions, etc., the final demand load for a given office floor is calculated and used in panelboard calculations. The tables used for calculation can be found in Appendix D .

As part of the office system design and to segregate the office metering panels from the house distribution, all remaining motor loads at or above the 10th floor were connected to the appropriate panels, but no house receptacles were considered "free of charge". Any and all power outlets for a given floor would be circuited to the office tenant panel and metered for consumption and billing by the building management authority, <u>not</u> the utility.

Retail

The retail loads were easier to calculate based on the approximate sizes as used by the current tenants. The lighting was approximated again from NEC at 2 VA per square foot and receptacles were calculated based on the overall demand factor for receptacles throughout the building. There was also an additional power allowance for display lighting (or "Show Windows") at 200 VA per linear foot of display window. As a demand criterion based on current tenant information, a demand factor of 3.0 was applied to all of the retail loads to account for excessive power consumption for restaurants and other electrically intensive commerce (a spa with any number of heating elements and cosmetic equipment, for further example). Tables for calculations can also be found in Appendix D .

Condominium

Condominium load modeling was much easier than either of the previous two modeling methodologies. Having experience in the dwelling unit load calculation and approximation, a very accurate model was able to be constructed and individual condominium loads based on size were calculated. Using a basic electrical appliance outline and applying the same NEC table values for dwelling units of 3 VA per square foot, a specific load calculation was made for each of the 27 units. The loadcenter calculation table along with the square footage lighting and receptacle approximation is given in Appendix D .

Distribution Configuration and Explanations

The new distribution configuration is relatively simple to understand as previously described. Supplemental to this is the riser diagram which illustrates the distribution system much better. Please refer to Appendix D for specifics regarding the distribution system. A textual analysis will describe the basic layout of the system here.

Service from a single high voltage entrance is brought in directly to the 15 kV switchgear. Voltage is reduced through the two medium voltage transformers on each end of the double ended Main switchboard. This switchboard had to be upsized to reflect the new power flow through the building to a 4000A switchboard with 4000A breakers respectively. From the main switchboard many individual loads are fed directly (namely the major heating and cooling pumps, the main retail distribution panel, the south-end high voltage parking panel (because of its remote location), the two basement high voltage panels feeding all other mechanical/electrical room loads and major motor equipment, and the basement emergency panel. The major component of the distribution system that the Main switchboard feeds is the 3200A bus duct servicing all of the above ground floors.

Alterations – Parking Garage

Major differences in the distribution systems of the parking garage include the complete rewiring of the light fixtures, and the electrical zoning of the three serving panels. Unlike the original design wherein a single panel serves half of the first 6 floors and a second serves the other half, the new design focuses on the remoteness of the southern area of the parking garage. Using the remote electrical closet, the southernmost panelboard feeds a third of the floors from basement up to the 9th (top) parking deck. This should minimize the draw of the panel feeder and branch circuits to the end loads. The remaining two panels required to provide power to the garage serve two-thirds of the lower 5 floors, and two thirds of the upper 4 floors respectively. This is not specifically modeled in the riser diagram, but can be seen in the general feeder layout in Appendix D . Additionally, the parking garage panelboards also serve the façade lighting requirements through the parking low-voltage panels. These panels serve two functions, but were initially installed to serve the 120V power supplies of the façade LED fixtures. Appropriate location of the high voltage panels and subsequent low-voltage panels was designed to specifically coincide with the zoning of the parking fixtures and the location of the LED power supplies so as to, again, minimize feeder and branch circuit draw. Because of the placement of the panels (described in detail in the condominium section) the high voltage emergency panel could also be centrally located to reduce voltage drop and help to minimize conductor runs.

Alterations – Condominium

The condominium alterations are considerable. By taking out the entire condo bus duct, distribution to each of the condominiums had to be efficient, adequate, and reduce the feeder length as much as possible. Considering the condo bus duct ran through the electrical rooms serving the condominiums, the new design used the same bus duct path and the same electrical rooms to provide distribution to the entire section of building from ground floor to 9-Mezzanine. With such a small space allocated for the electrical closet, a maximum of three electrical elements was allowed in a closet. This did mean that some feeders were routed between floors, but also meant that the available space was maximized in the same manner as the bus duct, disconnects, and meter racks were in the original design.

The bus duct rises through these electrical closets as mentioned. The second floor contains the first condominium low-voltage distribution panel which feeds the first two floors of condominiums. The fifth floor houses the second serving condos on floors 4-6 and the third is located at the eighth floor serving floors 7-9 (9 contains double height condominiums extending up to 9-Mezzanine.

These same condominium electrical closets house the high- and low voltage parking panelboards as mentioned in the previous section. They house the transformers as well. The beginning of the office alteration design starts at the 9th floor and there is nothing located at the 9-Mezzanine floor. This was not by choice, but was specifically indicated as not possible in the architectural drawings (although a waste of space, the design was intended to stay within the current guidelines and not make any exceptions). The 9th floor houses the electrical distribution panel for the condominium elevators as well as the long-draw for the parking elevators. The reasoning for not connecting the parking elevators to the remote-location parking panel was two fold – first, local law requires the elevators be placed on a standby panel with automatic transfer to emergency power when main power fails; and second, because of the power requirements and relative feeder length.

Alterations – Office

The office tower has much of the same distribution system in the new design as it had in the old design. The bus duct in the old design fed the office tenant (to be fitted out) electrical closets solely as it does in the new design. The bus duct also ran adjacent to the condo bus duct in the office design up until the 10th floor where it was diverted to the central/core electrical closet. In the new design the bus duct acts as the condo bus and diverts to the central/core electrical closet. The main difference on the upper floors of the office space is that instead of separate feeders to the house panels extending over 10 floors to their respective end uses, the feeder length are limited to the distance from closet to bus duct – or a mere 20' maximum. This becomes especially helpful in the upper house panels (floors 13-16) where the feeder must space 0ver 130' before reaching the nearest of the panels (or almost 200' in the case of the house panel located at the 16th floor). Instead, such panels as the House Standby "HB" are fed directly from the bus duct, again, a no more than 20' feeder length.

Panelboard Layouts and Assumptions

Panelboard layouts as listed in Appendix D are for both systems for their numerical comparison (and to prove that the work was actually completed). The layout of the panels is concerned with the circuiting and accurate modeling of the loads at the panelboard, and not necessarily within the panelboard. Panelboard circuiting was completed solely to illustrate which panels would be filled, which loads were three and single phase, and the routing of low-voltage panelboards through one another and, overall, into the main bus duct and main switchboard. All circuits not specifically filled by the general electrical requirements are not necessarily spaces, but instead are considered negligible in the overall distribution scheme. This assumption is valid given the base-building modeling method and oversized load parameters (proven further in the electrical load analysis in the Mechanical Breadth).

Metering and Tenant Billing

Differences in the metering of the building also exist and were a focus of the alteration in the distribution system as well. In the current system, office tenants pay a lease including all heating and electric power consumption. The property is billed for the overall building usage of power for house, standby, emergency, and office tenant panels from the office and retail service. Based on costs, the management bills the individual tenants either through a yearly cost projection average, or through monthly lease adjustments based on the average energy consumption of the office tower. The condominium tenants are individually metered and the management bills each condominium separately for their power consumption. This system requires that the management take into consideration the service voltages, the distribution costs (building-purchased transformers, etc.) and demand for each entity separately. Given the fact that there are three separate service voltages, this can be quite cumbersome.

In the new design, the proposal is to meter the office tenants individually (as seen on the riser) and meter the condominium by levels and average out the power consumption over the entire condo service section through the "Condo Association" fee. Since the house receptacles and cooling towers for the office are circuited directly to the office tenant and house panels, the building virtually sees "no power consumption" from the upper 7 floors (excluding the elevator banks, the building pressurization fans, etc). Because the offices are now billed for their separate energy consumption and altogether for their heating and hot water, management begins to see an immediate decrease in billing complexity. And considering the condominiums run from a separate heating and cooling loop, the association fee can be increased and justified to include all of the utility payments for the condominium.

The greatest advantage to this system is that the management is billed for the commercial price of electricity, steam and gas, but is allowed to charge the tenant for the residential, or secondary, price of electricity, gas and steam. With a condo association fee, the price can be maintained and fluctuations decreased simply by balancing the bills with an increased (but not immorally exorbitant) profit margin in favor of the management. More of this is detailed in the brief Construction Management Breadth.

Emergency Distribution Design and Analysis

The emergency system is the focal point of the electrical depth work. The current system allows for a maximum of 350kW of electricity to be consumed by the entire building in the case of a power failure, or other emergency where electricity is interrupted. This power consumption is limited to those panelboards connected through the automatic transfer switches to the emergency distribution panel. In the current design, this means the power is only supplied to the elevators throughout the building (but not the parking garage), and the emergency lighting throughout the building. While this can be deemed as only the necessity, it implies solely that an emergency requiring evacuation has occurred. But two things were not taken into consideration. First, all conditions where the power loss is not the result of an emergency. Second, the fact that the condominiums are residences and those people cannot simply “leave” if the power isn’t working. For this reason, the attempt was to power all vital circuits to sustain “livability” conditions in the condominiums while electrical service was not functioning.

The new system maintains power to all of the elevators just as the last system did, but also includes the elevators in the parking garage. The new system also supplies power to all of the emergency lighting – and based on the slight increase in the number of emergency panelboards, extra lighting for the condominium residences to prolong the allure of livability as long as necessary. In addition to these loads, the Evaporative Fluid Cooler and two condominium pumps are also powered to provide heating and cooling as necessary to the condominiums in the case that power is lost for greater than 12 hours in winter or summer conditions, respectively. The water source heat pumps in each of the condominium units have the ability to be connected to and emergency outlet (an outlet painted or colored red, denoting emergency power only) which received no power unless there is an emergency condition. Likewise, the same panels to which the WSHP circuits are routed to also have single receptacle circuits drawn to each of the kitchens for use in maintaining power to the refrigerator compressor. This means 54 circuits total are used for emergency conditions, fire alarm devices, single condo unit refrigerator circuits, and single condo unit WSHP circuits. (On the riser and in the panelboards these are located on panels HE / LC, HE / LC2 and HE / LC3) This added reliability prevents anyone from freezing in the winter, baking in the summer, and prevents food loss in the case of a multi-day outage. Because these condominium tenants pay their Condo Association fees, they should be entitled to a portion of the buildings emergency power backup so they can enjoy the comfort of their own home when waiting for power restoration. For all pertinent calculations and diagrams refer to the riser diagram or the panelboard schedules in Appendix D.

Cost Analysis

The cost analysis of this system's increased emergency capacity and reduced feeder and conduit draws is given in a comparison table. Each of the systems was modeled in a 3D environment to accurately measure the feeder lengths and provide a congruency to all of the similar systems and locations. This prevents fudging the numbers for or against either system and results in a very accurate comparison. The 3D models can be seen in illustrations in Appendix D or viewed in AutoCAD from the enclosed CD. The cost analysis is given below considering the current system in its entirety and the new system in its full splendor. Notice that by subtracting the new emergency requirements, a few of the new design's panels can be omitted and the generator cost would be the same, increasing the profitability of the already profitable new design. The cost comparison is given below.

Current Design	Cost	**New Design**	Cost	Difference
CONDUCTOR TOTAL	#REF!	CONDUCTOR TOTAL	$ 121,743.91	#REF!
TOTAL BUS	$ 446,295.00	TOTAL BUS	$ 447,153.00	$ (858.00)
TOTAL PANEL	$ 82,894.00	TOTAL PANEL	#REF!	#REF!
TOTAL SWITCHBOARD	$ 20,815.00	TOTAL SWITCHBOARD	$ -	$ 20,815.00
TOTAL ATS	$ 26,302.00	TOTAL ATS	$ 33,532.00	$ (7,230.00)
TOTAL MAIN	$ 6,150.00	TOTAL MAIN	$ 7,425.00	$ (1,275.00)
TOTAL XFMR	$ 206,585.00	TOTAL XFMR	$ 241,872.00	$ (35,287.00)
TOTAL GENERATOR	$ 76,550.00	TOTAL GENERATOR	$ 114,850.00	$ (38,300.00)
GRAND TOTAL	#REF!	GRAND TOTAL	#REF!	#REF!

Conclusions

The conclusion for the electrical depth redesign is simple – the redesign is better with very few reasons to the contrary. It saves money, provides a greater redundancy, can make the management company a greater profit (if just through normal billing, or the Condo Association combined fees), and could overall reduce the construction cost of the electrical systems of the building. There are a few higher initial costs for select system components, but overall is still cheaper. Because of the reduced number/lengths of conductors, and the heat gain associated with those conductors carrying current, the building might even see a marginal decrease in the buildings consumed power. And less power costs less money no matter what.

Mechanical Breadth

Mechanical Breadth

The Mechanical Breadth was intended to integrate the Electrical Depth with an alternative energy source for heating the building water systems in place of steam. Based on an idea to produce electricity from the heating and cooling water loops, the generation of electricity could easily be combined with hot water generation in a combined heat and power source such as microturbines. These microturbines are the basis for the mechanical breadth design and integration to the electrical system.

Relationship with Thesis Project

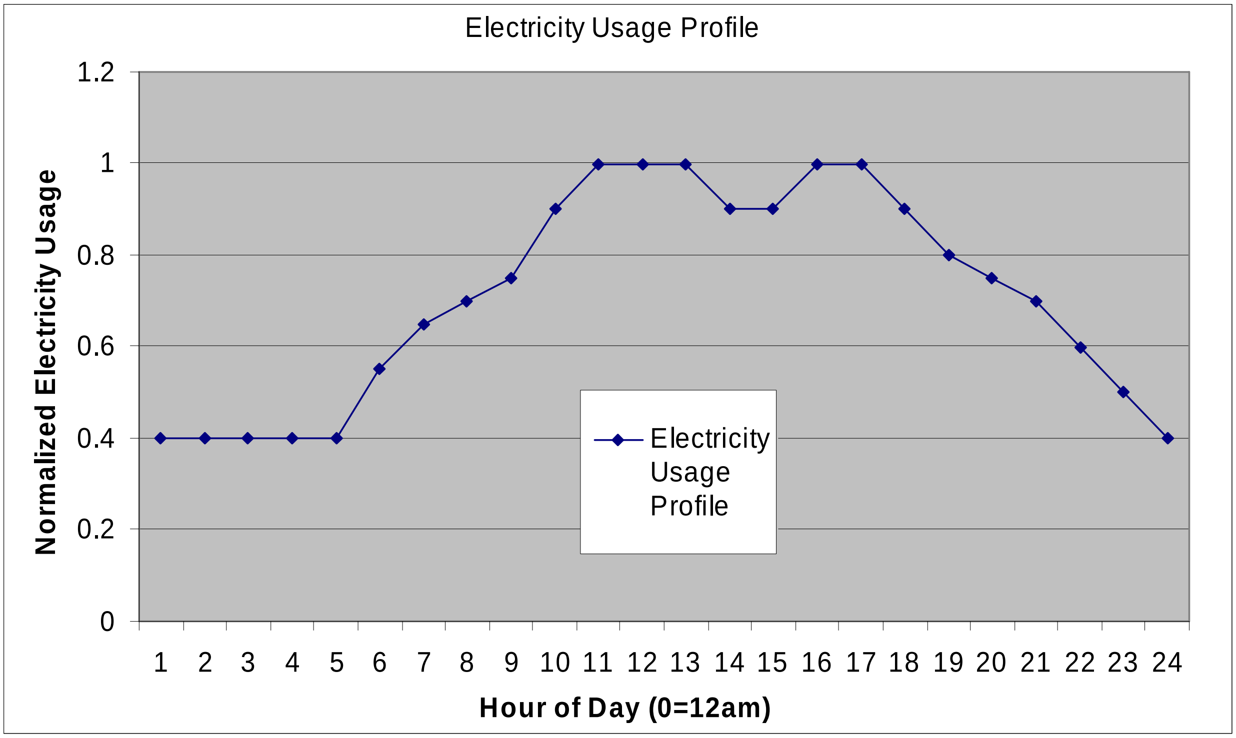
Using a combined heat and power production unit such as the microturbine with integrated heat recovery, at any given point when the building needs heating, the generation of power could offset the electrical demand put directly on the utility service. While the microturbine does not directly affect any other system in the building, it does impact the electrical design, especially considering the emphasis put on emergency power generation.

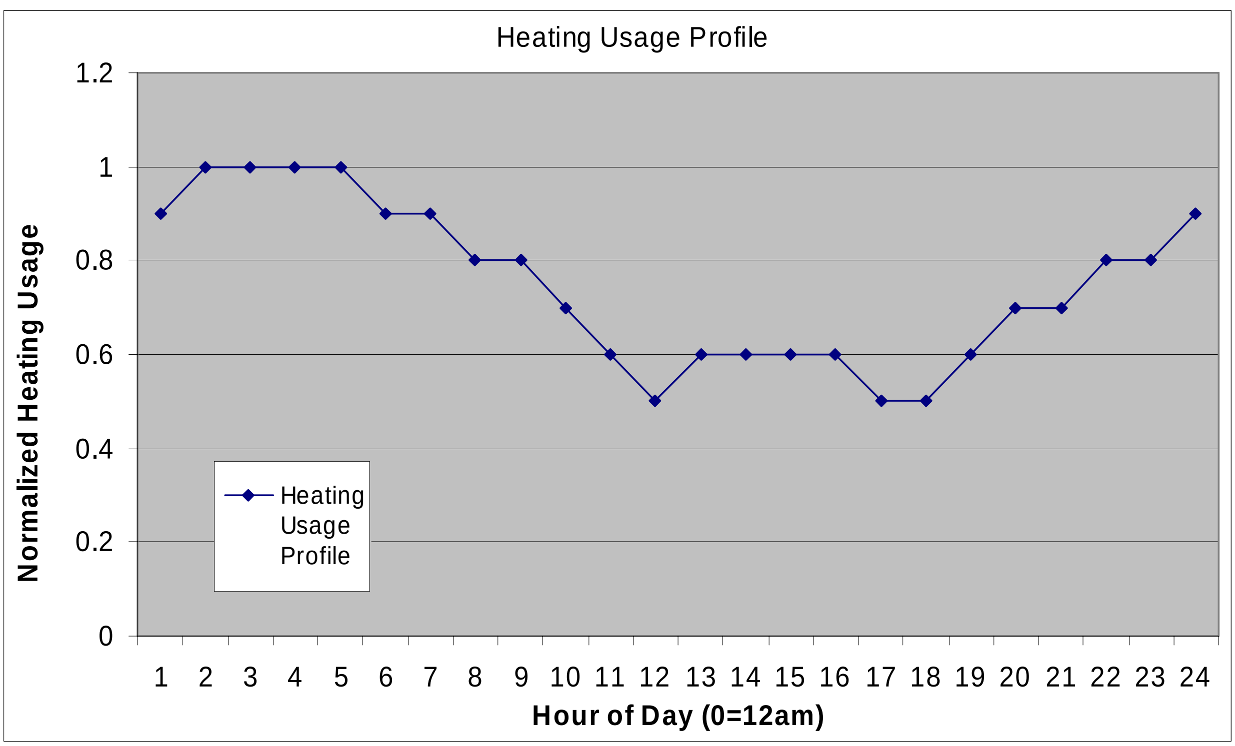
Proposal

The proposed system is to replace the condominium heat exchangers entirely and replace them with Capstone C65 Microturbines running on natural gas. In addition to this complete replacement, the new system will replace the current office heat exchangers with 7 Capstone C65 Microturbines. This will not completely replace the steam service to the building as will be described, but will attempt to produce as much heating power for the building's water systems as possible using the Microturbines up to the point of over-generation at full running capacity. This should effectively reduce the steam demand as close to zero as possible. The offset to be compared is the cost of natural gas for running each of these microturbines.

Load Modeling

The energy records for the past 16 months were obtained from WE Energies for natural gas, electricity, and steam service to Cathedral Place. The natural gas was all but non-existent for the office tower, very low for the condominium section, and not present for the parking garage. Steam consumption was provided in Mlbs for each of the preceding months separately for the Condominiums and Office Tower. Since the Microturbines would be replacing the steam as a heat source, it was necessary to model the steam usage for each day of a given month. The steam usage for the month was divided by the supplied number of days between meter readings to obtain a daily steam usage profile. A load profile for both electricity usage and heating usage was developed as a part of the design, normalized to a maximum value of 1 (equivalent to 100% heating usage). The profiles for Electrical usage and Heating usage can be seen below.


Electricity Usage Profile
Normalized Electricity Usage
1.2
1
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day (0=12am)
Electricity Usage Profile


Heating Usage Profile
Normalized Heating Usage
1.2
1
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day (0=12am)
Heating Usage Profile

Using these profiles and dividing by their respective areas, the fraction of the total steam usage in a day was calculated to obtain consumption per hour. This puts the most steam and electricity consumed when the profile is the greatest, and the least consumed when the profile is the lowest. This profiling technique well-approximates the steam usage throughout the day and allows the comparison to get much more detailed. While introducing some inaccuracies, the method improves the accuracy of the calculations by using realistic, and in the case of the steam consumption, actual statistics.

Once the steam usage per hour per month for an entire year was tabulated, (as seen in Appendix E) the number of Btus was calculated based on the enthalpy of the entering steam, magnified by a factor 1.25 as a "safety factor", and also tabulated. Thus the heat required per hour per month for an entire year was charted for comparison with the Btu input and output requirements of the microturbines.

Microturbine Usage and Parallelizing

For the condominium steam usage, the number of microturbines required to produce enough steam to over-generate for every hour of every month was determined and tabulated. The resulting over-generation of steam would be used in parallel with the office microturbines to preheat the inlet water. Using the office steam usage in Btu per hour per month tabulation, the number of over-generated Btus was subtracted from the office required Btus, and the remaining quantity divided by the thermal output of the microturbine. Unlike the condominium setup, the largest number of turbines not exceeding 7 was determined such that no over-generation occurred. The remainder of the Btu requirement would be fulfilled by the steam utility and thus, the total steam required for the month based on this "deficit" was calculated.

For every microturbine that was used, the number of therms of natural gas consumed was tabulated per hour and summed per month. Also based on the number of microturbines used, the electricity generation was tabulated. This quantity was subtracted from the tabulated electricity usage with the same method as described earlier. When the generation exceeded the demand, the value was placed at 0. When the demand exceeded the generation, the value was tabulated and summed across a month to get the overall resultant kWh usage for a given month.

These values were then put into an equation to calculate the monthly energy bill based on the current energy prices. The yearly cost of the system was then calculated and compared to the current energy bill's consumption multiplied by the same utility rates used to compute the cost of the new system (apples to apples).

There are a few assumptions that should be addressed immediately. First, the assumption is made that the hot water exchange of heat between the Condominium unit and the Office units is perfect. While this would not be the case, it is used for simplification of calculation, but without neglecting its contribution. Second, the load profile developed is an accurate representation of the energy usage with respect to each utility. While this was developed independently, the error in the profile should be relatively marginal. Third, the variance in steam usage for a given day of the month is offset both positively and negatively throughout the month to average within marginal error to the "average day" tabulated in these calculations. Fourth, the enthalpy of the steam entering the heat exchangers and resulting Btu consumption of the building is based on the inlet pressure of 2 psig as noted for the heat exchangers in the drawings. Even if the steam was superheated it will not have an enthalpy much greater than the value used. Fifth, the cost of natural gas varies considerably throughout the year and the cost calculated used a standard rate for natural gas consumption. The cost used was obtained from the utility company for the month of April, a cooler, but closer to average heating month for price comparison.

Integration with Electrical System and Emergency Distribution

The initial intention of the microturbine was its ability to generate electricity. The number of microturbines specified in this design breadth was relative to the amount of electricity it could produce and deliver to the emergency power distribution system. 9 microturbines have the ability to generate 585kW of electricity and when considering the loss in efficiency due to ambient temperatures, in excess of 525kW. This amount of electricity was taken from the emergency system demand in the new Electrical Depth distribution design.

In the case where the microturbines are connected at the emergency throw of the ATS (and not putting electricity directly into the Main switchboard), transfer of power would be instantaneous if the units were running, and power would be uninterrupted the necessary emergency equipment based on a logical emergency loading profile (condominium tenants needing to plug in their heat pumps and refrigerators minutes after the initial loss of power) and microturbine startup lag. In the case when all of the turbines are not connected and running simultaneously, the emergency condition would dictate, through any basic controller, that the microturbines must all start up and run until the emergency condition is cleared.

In addition to the electrical benefits of having instant energy, the microturbines are also producing heat for both the entire condominium section and the entire office section because of their electrical inefficiency. This added bonus would allow the office tenants to possibly wait out the emergency condition of electricity were to be restored within a few hours.

Combined Heat and Power Yearly Analysis

The combined heat and power analysis hinges on a variety of initial conditions and assumptions that cannot be immediately accounted for. A set of assumptions was used to calculate a few example conditions where the system design either benefits or hinders the project. The largest obstacle in this design is the initial cost of the microturbines, as can be seen in the payback periods and differences in cost. The detailed analyses are listed below.

Current System

Equipment		Cost
HX-0.1,0.2	2	$ 4,600.00
P-0.7,0.8	2	$ 10,400.00
HX-0.3,0.4	2	$ 15,600.00
P-0.1,0.2	2	$ 5,800.00
P-0.3,0.4	2	$ 17,400.00
350kw GenSet		$ 76,550.00
TOTAL		$ 130,350.00
To get same redundancy in new system		
TOTAL		$ 245,200.00

New System

Equipment		Cost
P-0.7,0.8	2	$ 10,400.00
HX-0.3,0.4	2	$ 15,600.00
P-0.1,0.2	2	$ 5,800.00
P-0.3,0.4	2	$ 17,400.00
C65	9	$ 1,260,000.00
TOTAL		$ 1,309,200.00

Current System Yearly Utility Cost

	CONDO			OFFICE			
	Energy			Energy			Total Cost
	Steam	Electric	Gas	Steam	Electric	Gas	
Month	Mlbs	kWh	therms	Mlbs	kWh	therms	
03/29/06	86	10,880	4	775	366,966	0	$ 43,840.18
02/27/06	112	10,240	4	1,024	389,779	0	$ 48,044.62
01/30/06	95	11,840	4	871	383,628	0	$ 46,348.93
12/29/05	128	10,080	6	1,112	359,923	0	$ 45,847.71
11/29/05	87	11,840	8	681	405,047	0	$ 47,014.60
10/27/05	42	11,520	6	341	396,403	0	$ 43,304.73
09/28/05	34	23,760	6	231	526,654	0	$ 56,499.00
08/29/05	35	25,280	6	344	479,409	0	$ 52,823.30
07/29/05	34	25,840	4	364	497,050	0	$ 54,756.40
06/29/05	34	17,360	6	244	448,960	0	$ 48,296.77
05/31/05	42	13,680	8	365	346,209	0	$ 38,743.33
04/29/05	44	12,240	7	464	355,141	0	$ 40,222.16
						TOTAL	$ 565,741.73

New System Yearly Utility Cost – 1.25 Safety Factor, $1.05 per therm – Payback NEVER

GENERATED				MAIN					
	Energy			Energy				Total Cost	Difference
	Steam	Electric	Gas	Steam	Electric	Gas			
Month	Mlbs	kWh	therms	Mlbs	kWh	therms			
03/29/06	0	971	0	236	239279	20469.5		$ 47,111.99	$ (3,271.81)
02/27/06	0	19526	0	318	191917	29817.9		$ 52,654.45	$ (4,609.83)
01/30/06	0	6159	0	226	197510	21985.4		$ 44,446.76	$ 1,902.17
12/29/05	0	29642	0	309	162457	30577.9		$ 50,338.40	$ (4,490.69)
11/29/05	0	0	0	200	248338	16178.2		$ 43,219.96	$ 3,794.64
10/27/05	0	0	0	148	359589	7585.8		$ 44,724.26	$ (1,419.53)
09/28/05	0	0	0	67	441655	5817.2		$ 50,355.45	$ 6,143.54
08/29/05	0	0	0	111	475717	7585.8		$ 55,908.61	$ (3,085.31)
07/29/05	0	0	0	150	444456	7583.8		$ 53,108.27	$ 1,648.14
06/29/05	0	0	0	91	392059	5817.2		$ 45,637.31	$ 2,659.47
05/31/05	0	0	0	130	308572	7587.8		$ 39,556.51	$ (813.18)
04/29/05	0	0	0	207	283953	10366.1		$ 40,634.21	$ (412.06)
		**Does not include 10% tax credit					TOTAL	$ 567,696.18	$ (1,954.45)

**Assumes 1.5 cents buyback for generated electricity

New System Yearly Utility Cost – 1.0 Safety Factor, $1.05 per therm – Payback in 89.9 years

GENERATED				MAIN				Difference
	Energy			Energy			Total Cost	
	Steam	Electric	Gas	Steam	Electric	Gas		
Month	Mlbs	kWh	therms	Mlbs	kWh	therms		
03/29/06	0	0	0	188	273408	16174.2	$ 45,598.86	$ (1,758.68)
02/27/06	0	7826	0	246	228967	23754.0	$ 49,543.69	$ (1,499.07)
01/30/06	0	0	0	195	232301	16932.2	$ 42,398.62	$ 3,950.31
12/29/05	0	12312	0	232	193876	24766.7	$ 46,981.31	$ (1,133.60)
11/29/05	0	0	0	156	275638	12641.0	$ 41,844.98	$ 5,169.63
10/27/05	0	0	0	125	375189	5817.2	$ 44,219.51	$ (914.78)
09/28/05	0	0	0	23	441655	5817.2	$ 50,028.82	$ 6,470.18
08/29/05	0	0	0	97	491317	5817.2	$ 55,476.92	$ (2,653.62)
07/29/05	0	0	0	126	460056	5815.2	$ 52,600.23	$ 2,156.17
06/29/05	0	0	0	36	392059	5817.2	$ 45,234.80	$ 3,061.97
05/31/05	0	0	0	111	324172	5819.2	$ 39,088.03	$ (344.70)
04/29/05	0	0	0	141	297603	8597.4	$ 39,622.76	$ 599.40
		**Does not include 10% tax credit				TOTAL	$ 552,638.52	$ 13,103.21
		**Assumes 1.5 cents buyback for generated electricity						

New System Yearly Utility Cost – 1.25 Safety Factor, $0.955 per therm – Payback in 74.9 Years

GENERATED				MAIN				Difference
	Energy			Energy			Total Cost	
	Steam	Electric	Gas	Steam	Electric	Gas		
Month	Mlbs	kWh	therms	Mlbs	kWh	therms		
03/29/06	0	971	0	236	239279	20469.5	$ 44,999.55	$ (1,159.36)
02/27/06	0	19526	0	318	191917	29817.9	$ 49,577.25	$ (1,532.63)
01/30/06	0	6159	0	226	197510	21985.4	$ 42,177.86	$ 4,171.07
12/29/05	0	29642	0	309	162457	30577.9	$ 47,182.77	$ (1,335.05)
11/29/05	0	0	0	200	248338	16178.2	$ 41,550.36	$ 5,464.24
10/27/05	0	0	0	148	359589	7585.8	$ 43,941.41	$ (636.68)
09/28/05	0	0	0	67	441655	5817.2	$ 49,755.12	$ 6,743.88
08/29/05	0	0	0	111	475717	7585.8	$ 55,125.75	$ (2,302.46)
07/29/05	0	0	0	150	444456	7583.8	$ 52,325.62	$ 2,430.78
06/29/05	0	0	0	91	392059	5817.2	$ 45,036.97	$ 3,259.80
05/31/05	0	0	0	130	308572	7587.8	$ 38,773.45	$ (30.12)
04/29/05	0	0	0	207	283953	10366.1	$ 39,564.44	$ 657.72
		**Does not include 10% tax credit				TOTAL	$ 550,010.54	$ 15,731.19
		**Assumes 1.5 cents buyback for generated electricity						

New System Yearly Utility Cost – 1.0 Safety Factor, $0.955 per therm – Payback in 43.1 Years

GENERATED				MAIN				
	Energy			Energy				Difference
	Steam	Electric	Gas	Steam	Electric	Gas	Total Cost	
Month	Mlbs	kWh	therms	Mlbs	kWh	therms		
03/29/06	0	0	0	188	273408	16174.2	$ 43,929.68	$ (89.50)
02/27/06	0	7826	0	246	228967	23754.0	$ 47,092.27	$ 952.35
01/30/06	0	0	0	195	232301	16932.2	$ 40,651.21	$ 5,697.72
12/29/05	0	12312	0	232	193876	24766.7	$ 44,425.39	$ 1,422.32
11/29/05	0	0	0	156	275638	12641.0	$ 40,540.42	$ 6,474.18
10/27/05	0	0	0	125	375189	5817.2	$ 43,619.18	$ (314.45)
09/28/05	0	0	0	23	441655	5817.2	$ 49,428.49	$ 7,070.51
08/29/05	0	0	0	97	491317	5817.2	$ 54,876.58	$ (2,053.29)
07/29/05	0	0	0	126	460056	5815.2	$ 52,000.10	$ 2,756.30
06/29/05	0	0	0	36	392059	5817.2	$ 44,634.47	$ 3,662.31
05/31/05	0	0	0	111	324172	5819.2	$ 38,487.49	$ 255.84
04/29/05	0	0	0	141	297603	8597.4	$ 38,735.50	$ 1,486.65
						TOTAL	$ 538,420.79	$ 27,320.94

**Does not include 10% tax credit
**Assumes 1.5 cents buyback for generated electricity

Conclusion

The general conclusion for this mechanical breadth is that it is a terrible idea. While the redundancy exists and is better than the Generator Set and the microturbines have an infinite utility downtime supply, the cost is extremely prohibitive. The utility cost does not seem to be very large when comparing the two systems and their relative heat contributions per dollar are very similar. Even with the variations in the calculations, the difference in the cost per year does not increase quickly enough to offset the initial cost. Sadly, this very redundant system is not useful as an installation in Cathedral Place. If the building was located in a much colder climate (somewhere described as “arctic tundra”) where heating was necessary all year long, the initial cost might be offset by the difference in utility. Regardless, it is not a viable solution for Cathedral Place.

Overall Conclusion

The preceding analyses and thesis project cannot be summed up in a single paragraph, or in the following page. Many of the proposed systems within this project were a success. And anything that is not a complete failure is a success.

The Lighting design, while conceptual in many areas, was balanced by the realistic design of alternate spaces. Designs worked off of one another and specifically off of the designs and concepts developed in other depth and breadth topics. Without going through a punchlist of successes and failures, it is difficult to come to any solid, black-and-white conclusion about the project. The only certainty is that the author is now further aware of the intricate web all of the systems of a building weave. No single system governed the remaining systems without a little give-and-take. Sometimes the give and take was purely cost-based. Sometimes the feasibility was stretching the concept. Regardless, no task within this investigation was flawed to the extent that it could not be reasonably completed.

Overall, the thesis was a success. Many obstacles were overcome, and some of them had to be bypassed. Others simply prevented the design from reaching fruition (as was the limiting case in the appropriate modeling and rendering of particular lighting spaces). There would not be a single alteration to the investigation that would not compromise the knowledge gained on the whole.

“We learned something very important today. We found another way that didn’t work.”

References

2001 ASHRAE Handbook – Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA. 2001.

2002 National Electric Code. National Fire Protection Association. 2002.
Ander, Gregg. *Daylighting Performance and Design*. John Wiley & Sons, Inc. Hoboken, NJ. 2003.

ANSI/ASHRAE 90.1-2004: Energy Standard for Buildings Except Low-Rise Residential Buildings. IP Edition. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA. 2004.

Hughes, David. *Electrical Systems in Buildings*. Delmar Publishers Inc. Albany, NY. 1988.

Rea, Mark S. *The IESNA Lighting Handbook: Reference & Application*. Illuminating Engineering Society of North America. New York, NY. 2000.

Reed Construction Data. *Means Electrical Cost Data 2005 Book*. 28th Edition. Reed Business Information. Kingston, MA. 2005.

Philips / Lumileds. *LUXEON® K2 Emitter. 2006.*
Luxeon Thermal Design Guide. 2006
Lumen Maintenance of White Luxeon Light Sources. 2005.
http://www.lumileds.com/

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To my love, Bethy, with whom I have tried every last bit of patience. To the girl who supports me, the girl who comforts me, and the girl who never asks for much in return, thank you.

To everyone inhabiting Room 330 for the better half of a month, cheers.

Thesis:

Joel Lee – Van Buren Management – the owner/developer and firm for allowing me to study in detail the intricacies of their building.

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Ted Dannerth – Electrical Consultant – thank you for making yourself available to answer questions and provide input.

"*The structural kids" of 330* – who helped me figure out what I could and could not do with my Cantilevered Canopy.

The AE Faculty – thank you to everyone who provided useful input and assisted in my better understanding of many of my theoretical systems.

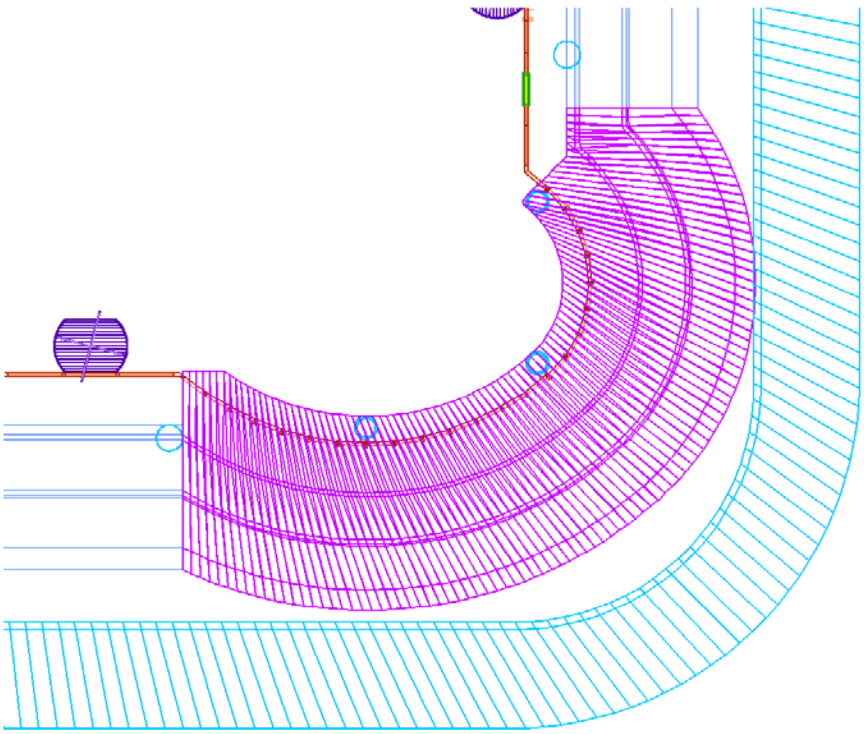
~~Never put off 'til tomorrow what you could do today.~~ Put thesis off 'til tomorrow.

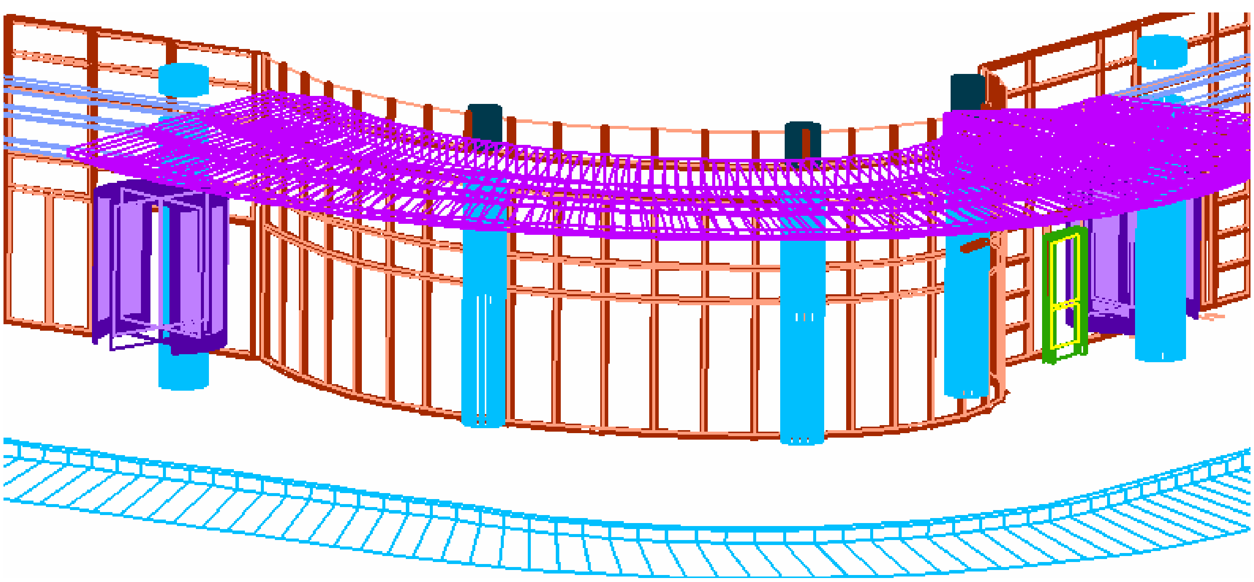
Appendices

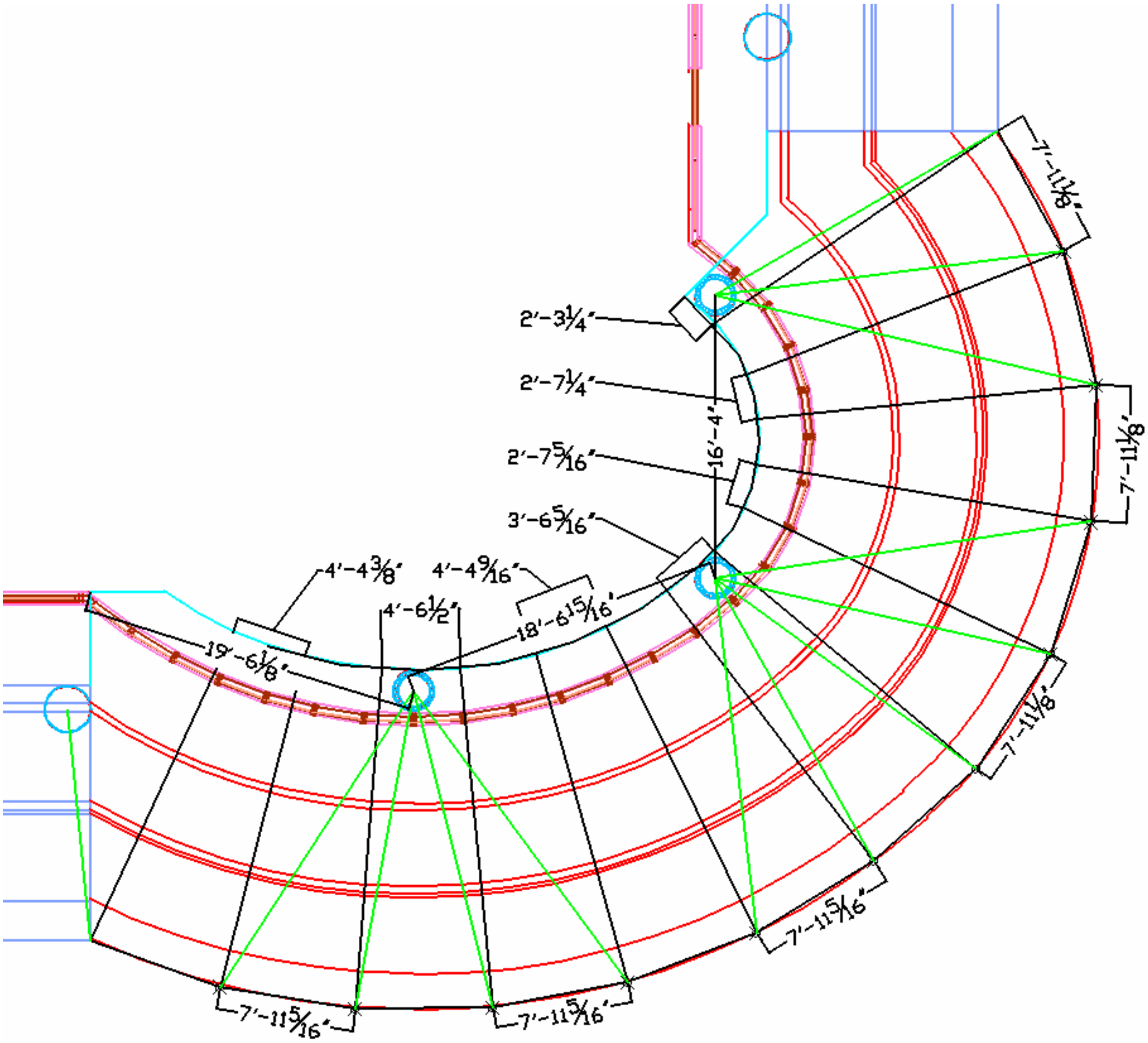
Appendix A - Architectural

For all items referring to the Architectural Breadth, one must find the information on the included CD. The information provided on the CD is the compilation of the Fall semester's work, and is mainly contained within the Architectural Final Submittal.

Appendix B – Structural






7'-11⅛"
2'-3¼"
2'-7¼"
16'-4"
7'-11⅛"
2'-7⁵⁄₁₆"
3'-6⁵⁄₁₆"
4'-4⅜"
4'-4⁹⁄₁₆"
4'-6½"
18'-6¹⁵⁄₁₆"
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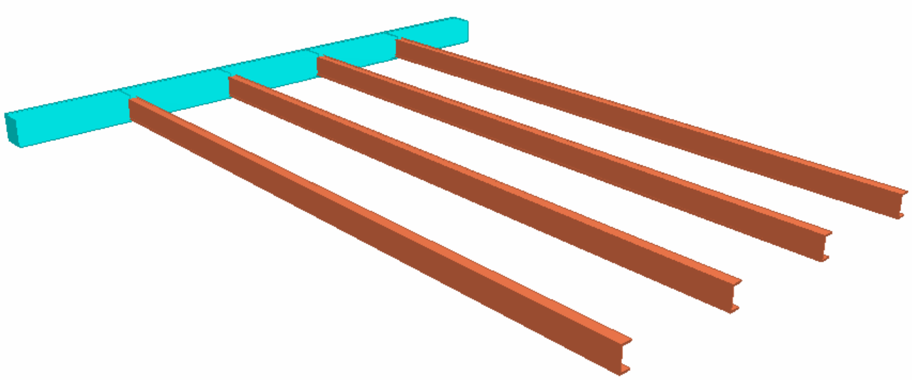
7'-11⁵⁄₁₆"



Appendix C – Lighting

Luminaire	Description	Detail Asmt	Lamp	# Lamps	Lamp Wattage	Ballast	Luminaire Wattage	Light Output	Total LLF
A	Lithonia 1'x4' Louvered Troffer F28T5/835		F28T5 / 835	1	28	ICN-2S28@277	31.5	2600	0.810
A2	Lithonia 1'x4' Louvered Troffer F54T5/835		F54T5 / 835	1	54	ICN4S5490C2LS@277	58.5	4450	0.770
B	Lithonia 2'x4' Louvered Troffer F28T5/835		F28T5 / 835	2	28	ICN-2S28@277	63	2600	0.810
B2	Lithonia 2'x4' Louvered Troffer F54T5/835		F54T5 / 835	2	54	ICN4S5490C2LS@277	117	4450	0.770
C	Ledalite Achieva Pendant Dir/Ind. Louvered F28T5/835		F28T5 / 835	1	28	ICN-2S28@277	31.5	2600	0.820
C2	Ledalite Achieva Pendant Dir/Ind. Louvered F54T5/835		F54T5 / 835	1	54	ICN4S5490C2LS@277	58.5	4450	0.780
D1	Decorative/Artwork Luminaire "Tuby" - Sandblasted glass	A	FT36DL / 830	1	36	ICN-2S39@277V	34.5	2900	0.640
D2	Decorative/Artwork Luminaire "Bulby" - Sandblasted glass	B	FT36DL / 830	1	36	ICN-2S39@277V	34.5	2900	0.640
D3	Decorative/Artwork Luminaire "Ghosty" - Sandblasted glass	C	FT36DL / 830	1	36	ICN-2S39@277V	34.5	2900	0.640
E1	Full Barrel Fluorescent Reflector - 50"x48" area, Alanod Miro 3	D	F28T5 / 841	1	28	ICN-2S28@277	31.5	2600	0.730
E2	"Half" Barrel Fluorescent Reflector - 50"x48" area, Alanod Miro 3	E	F28T5 / 841	1	28	ICN-2S28@277	31.5	2600	0.730
F	Lithonia Narrow 4' Narrow Strip		F32T8 / 835	1	32	VOP-2P32-SC	35	3000	0.800
G	Lithonia 2' Twin Task Light		F14T5 / 841	1	14	ICN-2S28@277	17	1200	0.710
H	Luxeon K2 LED 1' Luminaire White		LED	1	0	**NONE**	1	60	0.730
H1	Luxeon K2 LED 1' Luminaire Purple		LED	1	0	**NONE**	1	60	0.730
H2	Luxeon K2 LED 1' Luminaire Green		LED	1	0	**NONE**	1	60	0.730
H3	Luxeon K2 LED 1' Luminaire Teal		LED	1	0	**NONE**	1	60	0.730
H4	Luxeon K2 LED 1' Luminaire Blue		LED	1	0	**NONE**	1	60	0.730
J	ERCO Lightcast Downlight 10in 2x26W CFL		CF26DD / 835	2	26	VH-2Q26-TP-W	58	1710	0.680
K	ERCO Lightcast Downlight 8in 1x18W CFL 13W		CF13DT / 835	1	13	VH-2B13-TP-W	13.5	900	0.670
K1	ERCO Lightcast Downlight 8in 1x18W CFL 18W		CF18DT / 827	1	18	RCF-2S18-M1-LS-QS	19.5	1200	0.760
K2	ERCO Lightcast Downlight 8in 1x18W CFL 26W		CF26DT / 827	1	26	RMB-1P26-S2	26	1800	0.700
K3	ERCO Lightcast Downlight 8in 1x18W CFL 32W		CF32DT / 827	1	32	RCF-2S26-H1-LD-QS	36	2400	0.710
L	ERCO Lightcast Downlight QPAR30 75W 10d		75W PAR30	1	75	**NONE**	75	1130	0.740
L1	ERCO Lightcast Downlight QPAR30 50W 10d		50W PAR30	1	50	**NONE**	50	900	0.750
L2	ERCO Lightcast Downlight QPAR30 75W 30d		75W PAR30	1	75	**NONE**	75	1130	0.740
L3	ERCO Lightcast Downlight QPAR30 50W 30d		50W PAR30	1	50	**NONE**	50	900	0.750

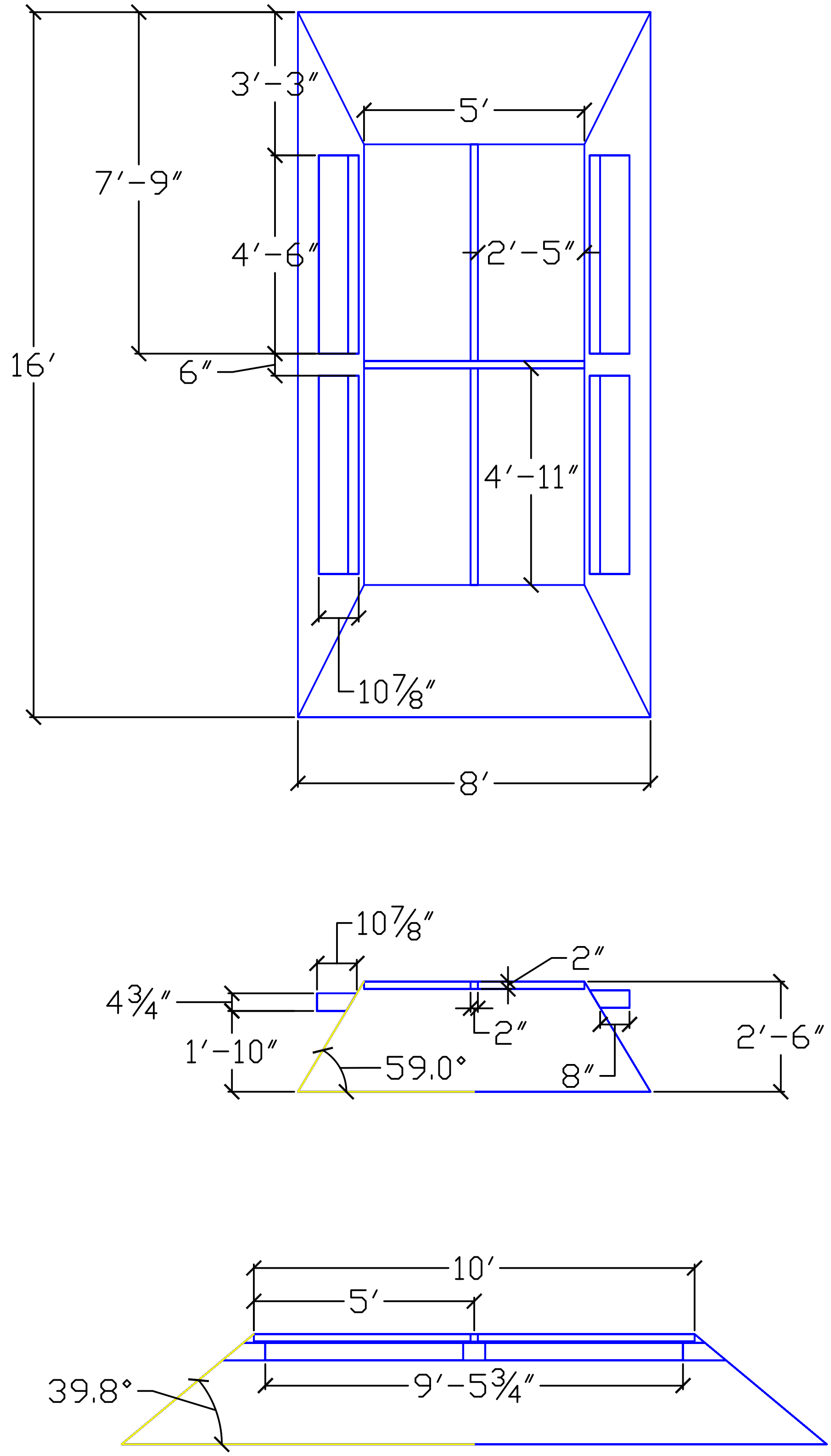
M	ERCO Beamer IV Spotlight 150W MH 10d Exterior Fixture	M150 / SS	1	150	71A5437BP	173	13000	0.410
M1	ERCO Beamer IV Spotlight 175W MH 10d Exterior Fixture	M175	1	175	IMH-175-C	191	14400	0.480
M2	ERCO Beamer IV Spotlight 250W MH 10d Exterior Fixture	M250	1	250	71A5731	294	22000	0.500
N	ERCO TFL Wallwasher F28T5	F28T5 / 835	1	28	ICN-2S28@277	31.5	2600	0.810
N2	ERCO TFL Wallwasher F54T5	F54T5 / 835	1	54	ICN4S5490C2LS@277	58.5	4450	0.770
P	ERCO Pollux Track Spotlight 35W MR16 10d	37MR16 / IR	1	37	**NONE**	37	700	0.750
P2	ERCO Pollux Track Spotlight 35W MR16 60d	37MR16 / IR	1	37	**NONE**	37	700	#N/A
Q	ERCO Cylinder Surface Mounted Downlight 35W MH	MC39T6	1	39	IMH-50-A	44	3300	0.610
R	Cooper/MCGraw Edison PSL 150W MH Parking Structure Fixture	M150 / SS	1	150	71A5437BP	173	13000	0.420
R2	Cooper/MCGraw Edison PSL 175W MH Parking Structure Fixture	M175	1	175	IMH-175-C	191	14400	0.500
S	Translucent Framed Luminaire / Desk System Full	F54T5 / 841	1	54	ICN4S5490C2LS@277	58.5	4450	0.830
S2	Translucent Framed Luminaire / Desk System Half	F28T5 / 841	1	28	ICN-2S28@277	31.5	2600	0.860

Luminaire	Description	Lamp	Lamp Lumen Depr.	Category	Clean	Dirt Condition	Luminaire Dirt Depr	Room Surface Dirt Depreciation	Ballast Factor		Total LLF
A	Lithonia 1'x4' Louvered Troffer F28T5/835	F28T5 / 835	0.930	IV	12	C	0.88	0.95	1.03		0.801
A2	Lithonia 1'x4' Louvered Troffer F54T5/835	F54T5 / 835	0.930	IV	12	C	0.88	0.95	0.99		0.770
B	Lithonia 2'x4' Louvered Troffer F28T5/835	F28T5 / 835	0.930	IV	12	C	0.88	0.95	1.03		0.801
B2	Lithonia 2'x4' Louvered Troffer F54T5/835	F54T5 / 835	0.930	IV	12	C	0.88	0.95	0.99		0.770
C	Ledalite Achieva Pendant Dir/Ind. Louvered F28T5/835	F28T5 / 835	0.930	II	12	C	0.94	0.9	1.03		0.810
C2	Ledalite Achieva Pendant Dir/Ind. Louvered F54T5/835	F54T5 / 835	0.930	II	12	C	0.94	0.9	0.99		0.779
D1	Decorative/Artwork Luminaire "Tuby" - Sandblasted glass	FT36DL / 830	0.860	IV	12	C	0.88	0.89	0.94		0.633
D2	Decorative/Artwork Luminaire "Bulby" - Sandblasted glass	FT36DL / 830	0.860	IV	12	C	0.88	0.89	0.94		0.633
D3	Decorative/Artwork Luminaire "Ghosty" - Sandblasted glass	FT36DL / 830	0.860	IV	12	C	0.88	0.89	0.94		0.633
E1	Full Barrel Fluorescent Reflector - 50"x48" area, Alanod Miro 3	F28T5 / 841	0.930	IV	24	C	0.8	0.95	1.03		0.728
E2	"Half" Barrel Fluorescent Reflector - 50"x48" area, Alanod Miro 3	F28T5 / 841	0.930	IV	24	C	0.8	0.95	1.03		0.728
F	Lithonia Narrow 4' Narrow Strip	F32T8 / 835	0.950	II	36	VC	0.92	0.9	1.01		0.794
G	Lithonia 2' Twin Task Light	F14T5 / 841	0.930	IV	24	C	0.8	0.9	1.06		0.710
H	Luxeon K2 LED 1' Luminaire White	LED	0.900	-	-	-	0.85	0.95	1		0.727
H1	Luxeon K2 LED 1' Luminaire Purple	LED	0.900	-	-	-	0.85	0.95	1		0.727
H2	Luxeon K2 LED 1' Luminaire Green	LED	0.900	-	-	-	0.85	0.95	1		0.727
H3	Luxeon K2 LED 1' Luminaire Teal	LED	0.900	-	-	-	0.85	0.95	1		0.727
H4	Luxeon K2 LED 1' Luminaire Blue	LED	0.900	-	-	-	0.85	0.95	1		0.727
J	ERCO Lightcast Downlight 10in 2x26W CFL	CF26DD / 835	0.860	IV	12	C	0.88	0.95	0.94		0.676
K	ERCO Lightcast Downlight 8in 1x18W CFL 13W	CF13DT / 835	0.860	IV	12	C	0.88	0.95	0.92		0.661
K1	ERCO Lightcast Downlight 8in 1x18W CFL 18W	CF18DT / 827	0.860	IV	12	C	0.88	0.95	1.05		0.755
K2	ERCO Lightcast Downlight 8in 1x18W CFL 26W	CF26DT / 827	0.860	IV	12	C	0.88	0.95	0.96		0.690
K3	ERCO Lightcast Downlight 8in 1x18W CFL 32W	CF32DT / 827	0.860	IV	12	C	0.88	0.95	0.98		0.705
L	ERCO Lightcast Downlight QPAR30 75W 10d	75W PAR30	0.885	IV	12	C	0.88	0.95	1		0.740
L1	ERCO Lightcast Downlight QPAR30 50W 10d	50W PAR30	0.889	IV	12	C	0.88	0.95	1		0.743
L2	ERCO Lightcast Downlight QPAR30 75W 30d	75W PAR30	0.885	IV	12	C	0.88	0.95	1		0.740
L3	ERCO Lightcast Downlight QPAR30 50W 30d	50W PAR30	0.889	IV	12	C	0.88	0.95	1		0.743

M	ERCO Beamer IV Spotlight 150W MH 10d Exterior Fixture	M150 / SS	0.577	IV	24	C	0.8	0.92	0.95		0.403
M1	ERCO Beamer IV Spotlight 175W MH 10d Exterior Fixture	M175	0.646	IV	24	C	0.8	0.92	1		0.475
M2	ERCO Beamer IV Spotlight 250W MH 10d Exterior Fixture	M250	0.773	IV	24	C	0.8	0.85	0.95		0.499
N	ERCO TFL Wallwasher F28T5	F28T5 / 835	0.930	IV	12	C	0.88	0.95	1.03		0.801
N2	ERCO TFL Wallwasher F54T5	F54T5 / 835	0.930	IV	12	C	0.88	0.95	0.99		0.770
P	ERCO Pollux Track Spotlight 35W MR16 10d	37MR16 / IR	0.886	IV	12	C	0.88	0.95	1		0.740
P2	ERCO Pollux Track Spotlight 35W MR16 10d	37MR16 / IR	0.886	IV	12	C	0.88	0.95	1		0.740
Q	ERCO Cylinder Surface Mounted Downlight 35W MH	MC39T6	0.788	V	24	C	0.83	0.92	1		0.602
R	Cooper/MCGraw Edison PSL 150W MH Parking Structure Fixture	M150 / SS	0.577	V	24	C	0.83	0.92	0.95		0.419
R2	Cooper/MCGraw Edison PSL 175W MH Parking Structure Fixture	M175	0.646	V	24	C	0.83	0.92	1		0.493
S	Translucent Framed Luminaire / Desk System Full	F54T5 / 841	0.930	II	12	C	0.94	0.95	0.99		0.822
S2	Translucent Framed Luminaire / Desk System Half	F28T5 / 841	0.930	II	12	C	0.94	0.95	1.03		0.855

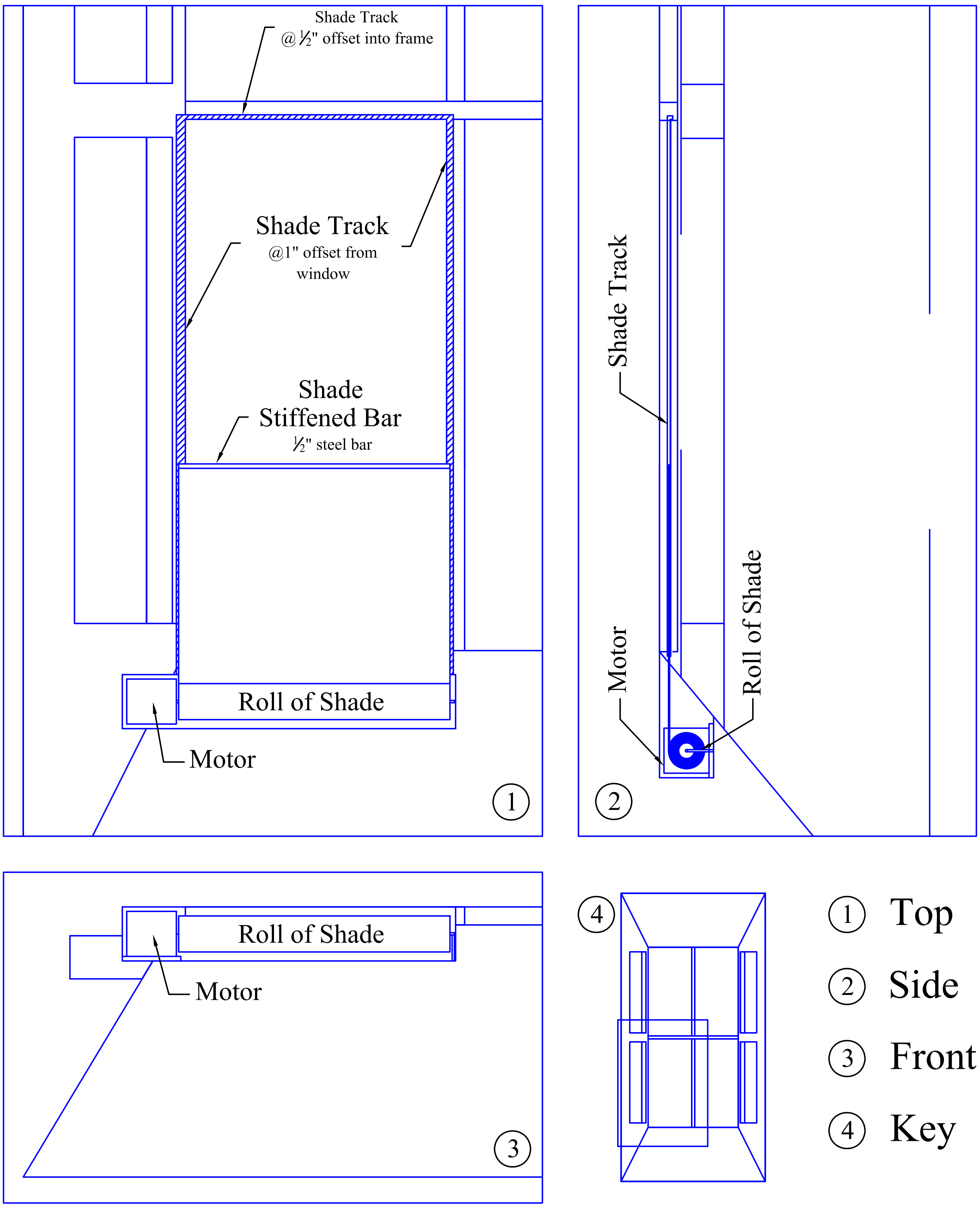
Lamp	Ballast?	Wattage	Voltage	Ballast Name	# Lamps	Input Power	Ballast Factor	Power per Lamp
F30T8 / 835	Y	30	277	VOP-2P32-SC	1	33	1.01	33
F30T8 / 841	Y	30	277	VOP-2P32-SC	1	33	1.01	33
F32T8 / 835	Y	32	277	VOP-2P32-SC	1	35	1.01	35
F32T8 / 841	Y	32	277	VOP-2P32-SC	1	35	1.01	35
F32T8 / 835	Y	32	277	VOP-2P32-SC	1	35	1.01	35
F32T8 / 841	Y	32	277	VOP-2P32-SC	1	35	1.01	35
F14T5 / 841	Y	14	277	ICN-2S28@277	2	34	1.06	17
F28T5 / 835	Y	28	277	ICN-2S28@277	2	63	1.03	31.5
F28T5 / 841	Y	28	277	ICN-2S28@277	2	63	1.03	31.5
F54T5 / 835	Y	54	277	ICN4S5490C2LS@277	2	117	0.99	58.5
F54T5 / 841	Y	54	277	ICN4S5490C2LS@277	2	117	0.99	58.5
M150 / SS	Y	150	277	71A5437BP	1	173	0.95	173
M175 / C	Y	175	277	IMH-175-C	1	191	1	191
M175 / C / MED	Y	175	277	IMH-175-C	1	191	1	191
M175	Y	175	277	IMH-175-C	1	191	1	191
M175 / MED	Y	175	277	IMH-175-C	1	191	1	191
M250 / C	Y	250	277	71A5731	1	294	0.95	294
M250	Y	250	277	71A5731	1	294	0.95	294
M250 / MED	Y	250	277	71A5731	1	294	0.95	294
CF13DT / 835	Y	13	277	VH-2B13-TP-W	2	27	0.92	13.5
CF13DT / 841	Y	13	277	VH-2B13-TP-W	2	27	0.92	13.5
CF18DT / 827	Y	18	120	RCF-2S18-M1-LS-QS	2	39	1.05	19.5
CF26DD / 835	Y	26	277	VH-2Q26-TP-W	2	58	0.94	29
CF26DD / 841	Y	26	277	VH-2Q26-TP-W	2	58	0.94	29
CF26DT / 827	Y	26	277	RMB-1P26-S2	1	26	0.96	26
CF32DT / 827	Y	32	120	RCF-2S26-H1-LD-QS	1	36	0.98	36
FT36DL / 835	Y	36	277	ICN-2S39@277V	2	69	0.94	34.5
FT36DL / 841	Y	36	277	ICN-2S39@277V	2	69	0.94	34.5
FT36DL / 830	Y	36	277	ICN-2S39@277V	2	69	0.94	34.5
37MR16 / IR	N	37	120	**NONE**	1	37	1	37
37MR16 / IR	N	37	120	**NONE**	1	37	1	37
MC39T6	Y	39	277	IMH-50-A	1	44	1	44
75W PAR30	N	75	120	**NONE**	1	75	1	75
50W PAR30	N	50	120	**NONE**	1	50	1	50
75W PAR30	N	75	120	**NONE**	1	75	1	75
50W PAR30	N	50	120	**NONE**	1	50	1	50
LED	PS	0	120	**NONE**	1	1	1	1

Lamp	Additional Lamp Data	Initial Lumens	Mean Lumens	CRI	CCT	Life	Angle	LLD	Full Name
F32T8 / 835	/ XP / ECO	3000	2850	85	3500	24000		0.950	F32T8 / 835/ XP / ECO
F32T8 / 835	/ XPS / ECO	3100	2945	85	3500	30000		0.950	F32T8 / 835/ XPS / ECO
F14T5 / 841	/ ECO	1200	1116	82	4100	20000		0.930	F14T5 / 841/ ECO
F28T5 / 835	/ ECO	2600	2418	82	3500	20000		0.930	F28T5 / 835/ ECO
F28T5 / 841	/ ECO	2600	2418	82	4100	20000		0.930	F28T5 / 841/ ECO
F54T5 / 835	/ HO / ECO	4450	4138	85	3500	25000		0.930	F54T5 / 835/ HO / ECO
F54T5 / 841	/ HO / ECO	4450	4138	85	4100	25000		0.930	F54T5 / 841/ HO / ECO
M150 / SS		13000	7500	65	4000	10000		0.577	M150 / SS
M175		14400	9300	65	4200	10000		0.646	M175
M250		22000	17000	65	4200	10000		0.773	M250
CF13DT / 835		900	774	82	3500	12000		0.860	CF13DT / 835
CF18DT / 827		1200	1032	82	2700	12000		0.860	CF18DT / 827
CF26DD / 835		1710	1470	82	3500	12000		0.860	CF26DD / 835
CF26DT / 827		1800	1548	82	2700	12000		0.860	CF26DT / 827
CF32DT / 827		2400	2064	82	2700	12000		0.860	CF32DT / 827
FT36DL / 830	/ RS	2900	2494	82	3000	12000		0.860	FT36DL / 830/ RS
37MR16 / IR	/ NSP10	700	620	100	2700	4000	10	0.886	37MR16 / IR/ NSP10
37MR16 / IR	/ WFL60	700	620	100	2700	4000	60	0.886	37MR16 / IR/ WFL60
MC39T6		3300	2600	81	3000	12000		0.788	MC39T6
75W PAR30	/ NSP10	1130	1000	100	2950	2500	10	0.885	75W PAR30/ NSP10
50W PAR30	/ NSP10	900	800	100	2810	3000	10	0.889	50W PAR30/ NSP10
75W PAR30	/ NFL25	1130	1000	100	2950	2500	25	0.885	75W PAR30/ NFL25
50W PAR30	/ NFL25	900	900	100	2810	3000	25	1.000	50W PAR30/ NFL25
LED		60	54	85	4100	50000		0.900	LED



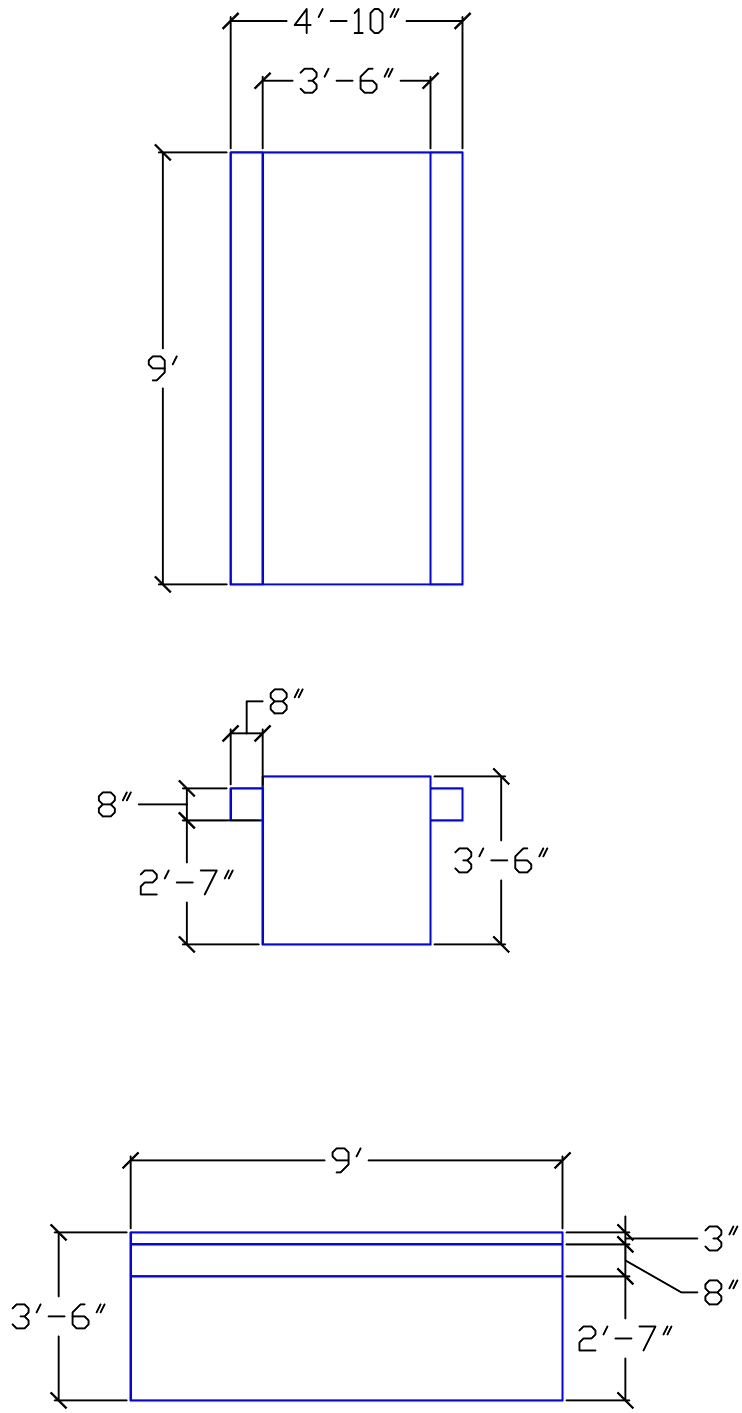
Stairwell Skylight Dimensions

Scale: ¼" = 1'



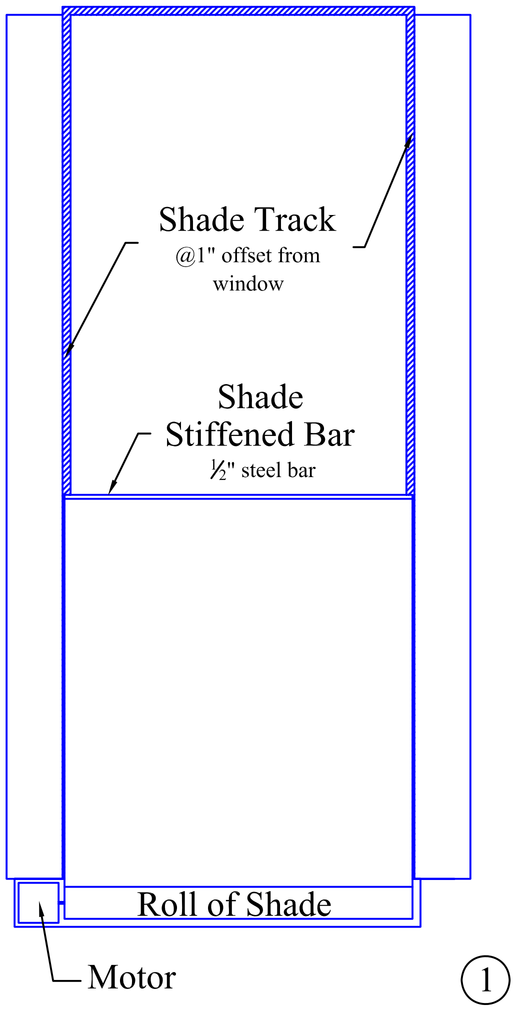
Stairwell Skylight Detail and Shades Detail

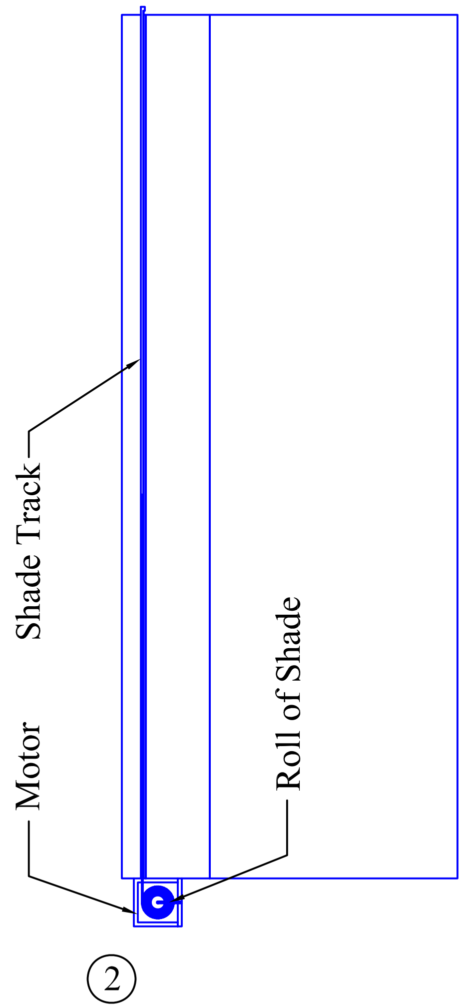
Scale: ¾" = 1'

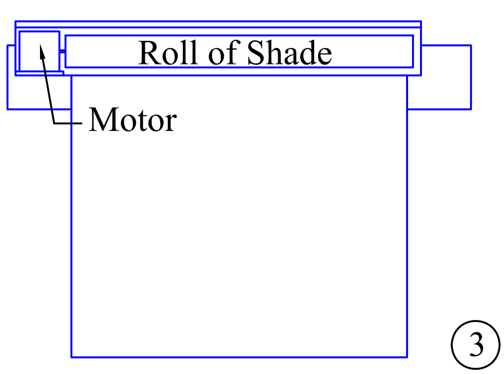


Reception Desk Skylight Dimensions

Scale: ¼" = 1'







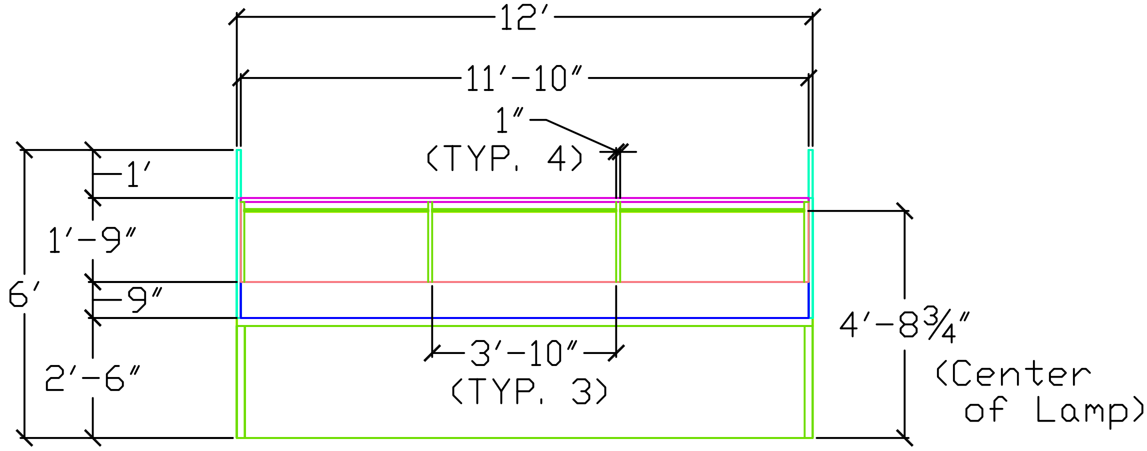
① Top

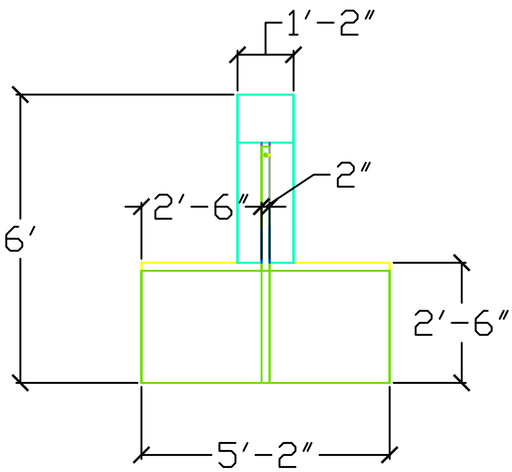
② Side

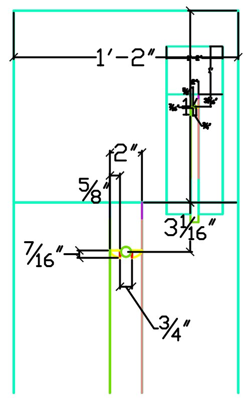
③ Front

Reception Desk Skylight Details and Shades Detail

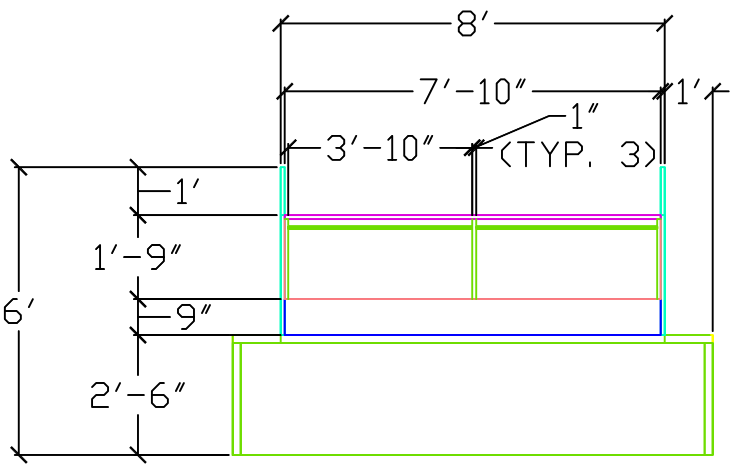
Scale: ½" = 1'





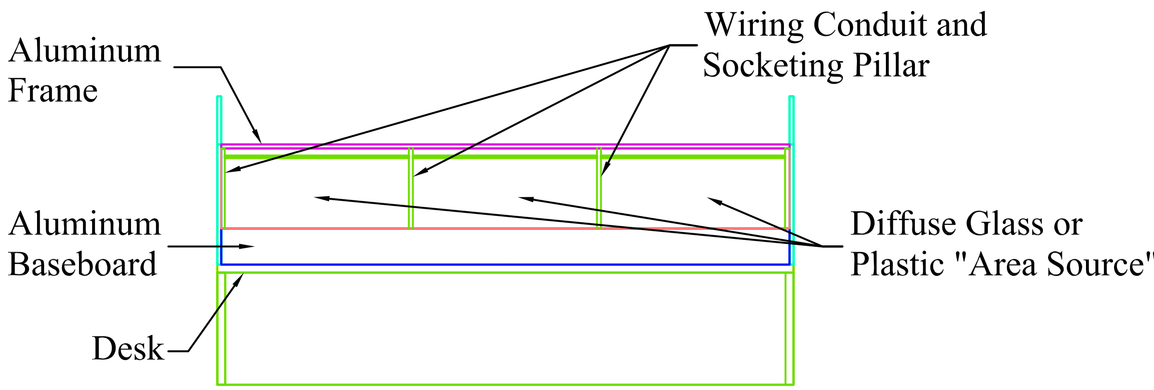


Scale: 1" = 1'

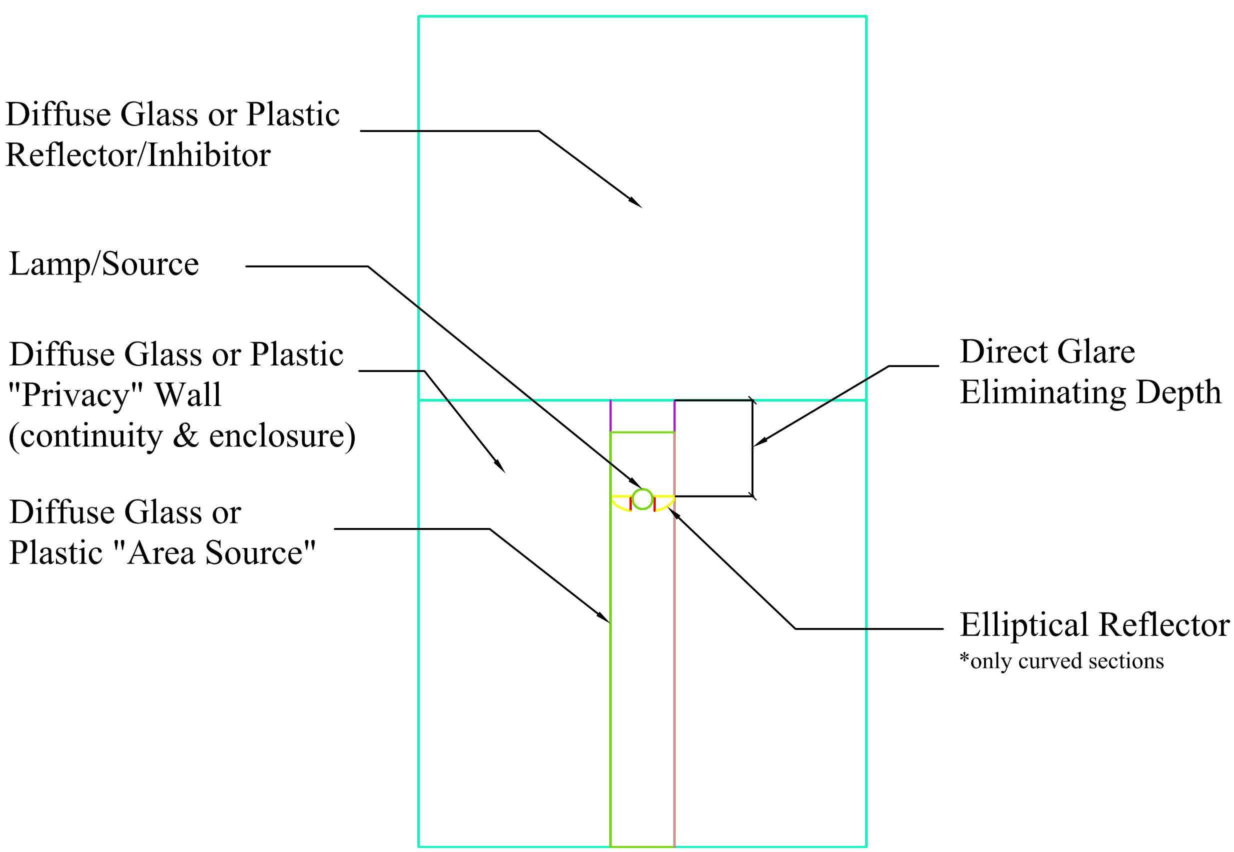


Open Office Desk Dimensions

Scale: ¼" = 1'

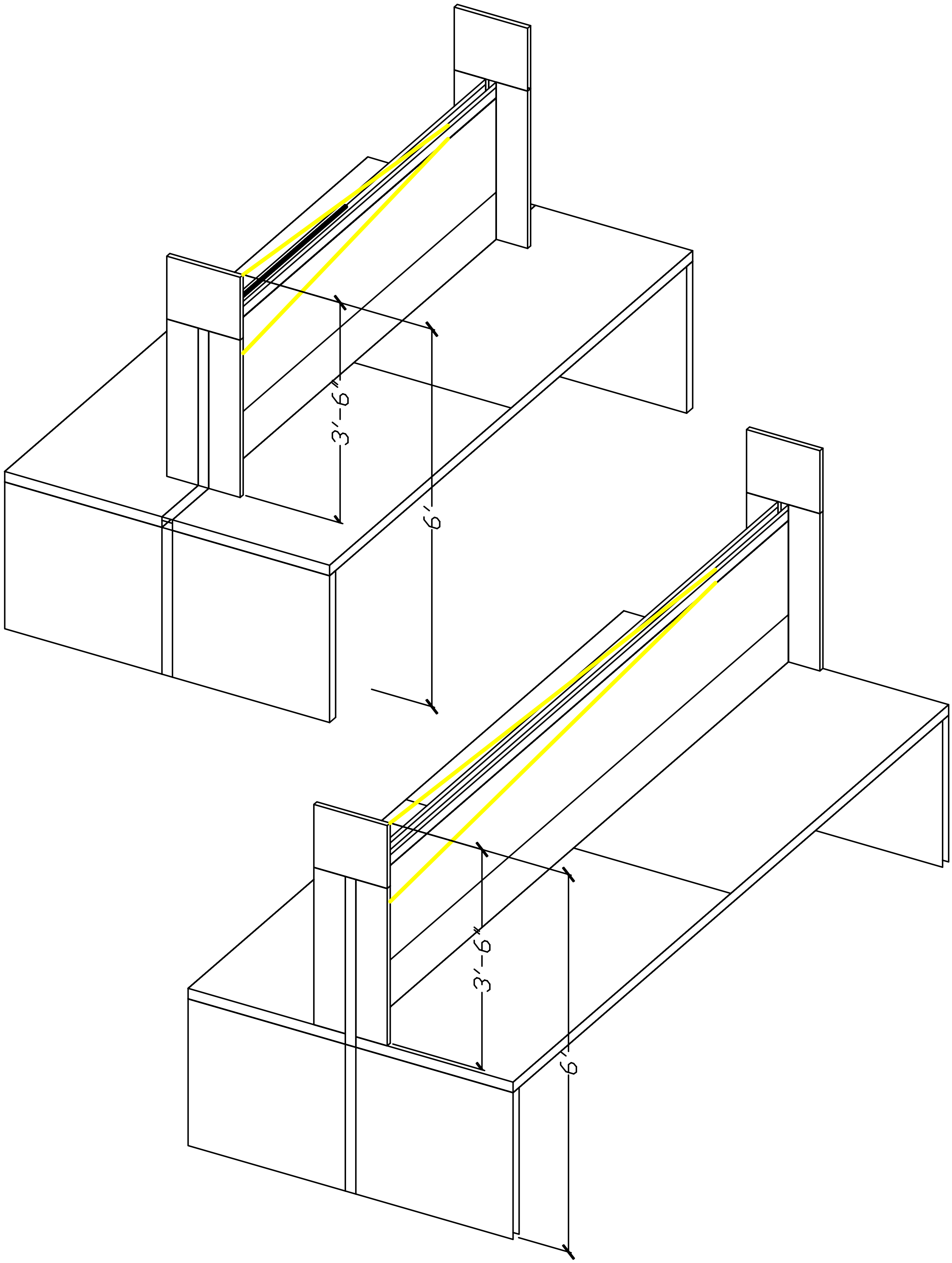


Scale: ¼" = 1'



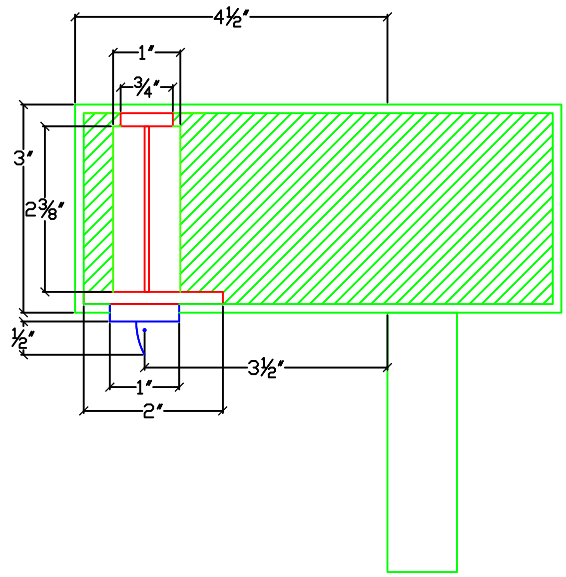
Open Office Desk Detail and Profile

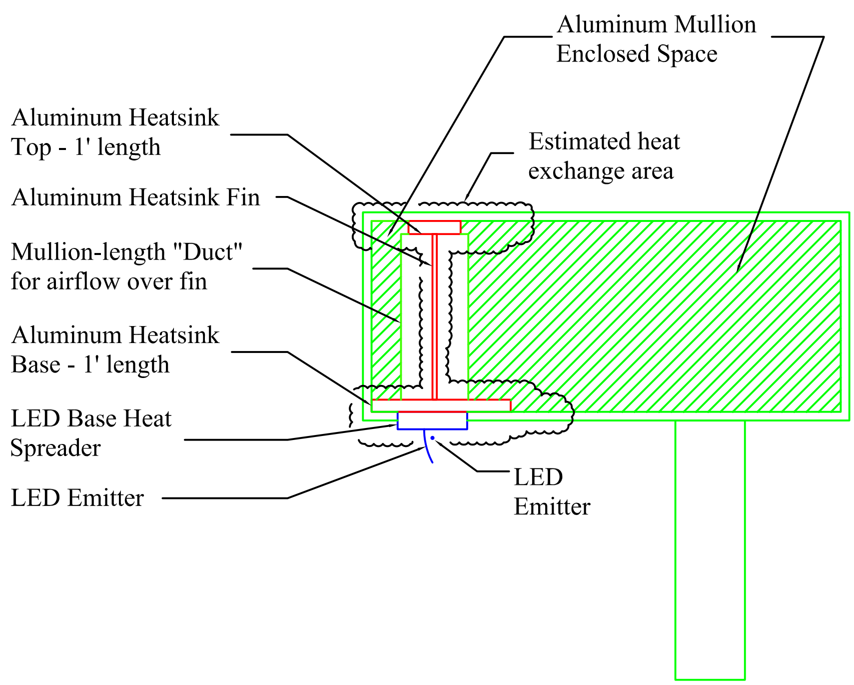
Scale: 1" = 1'



Open Office Desk Glare Angle Detail

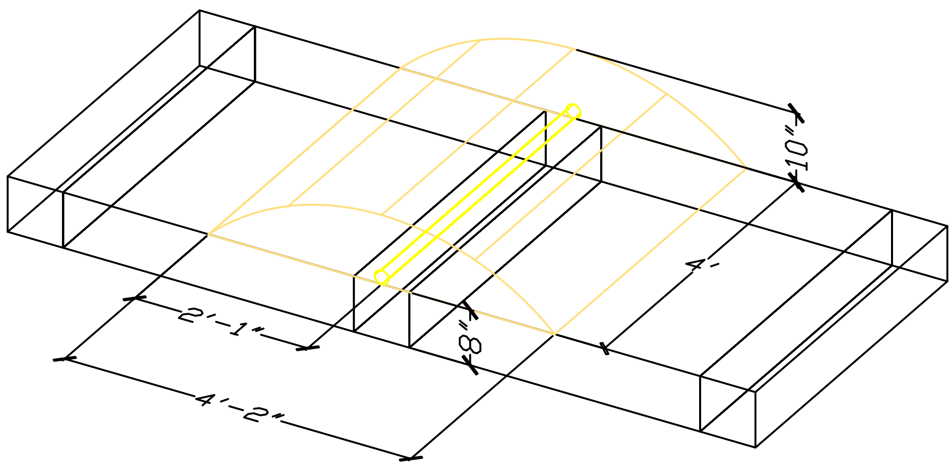
Scale: ½" = 1'



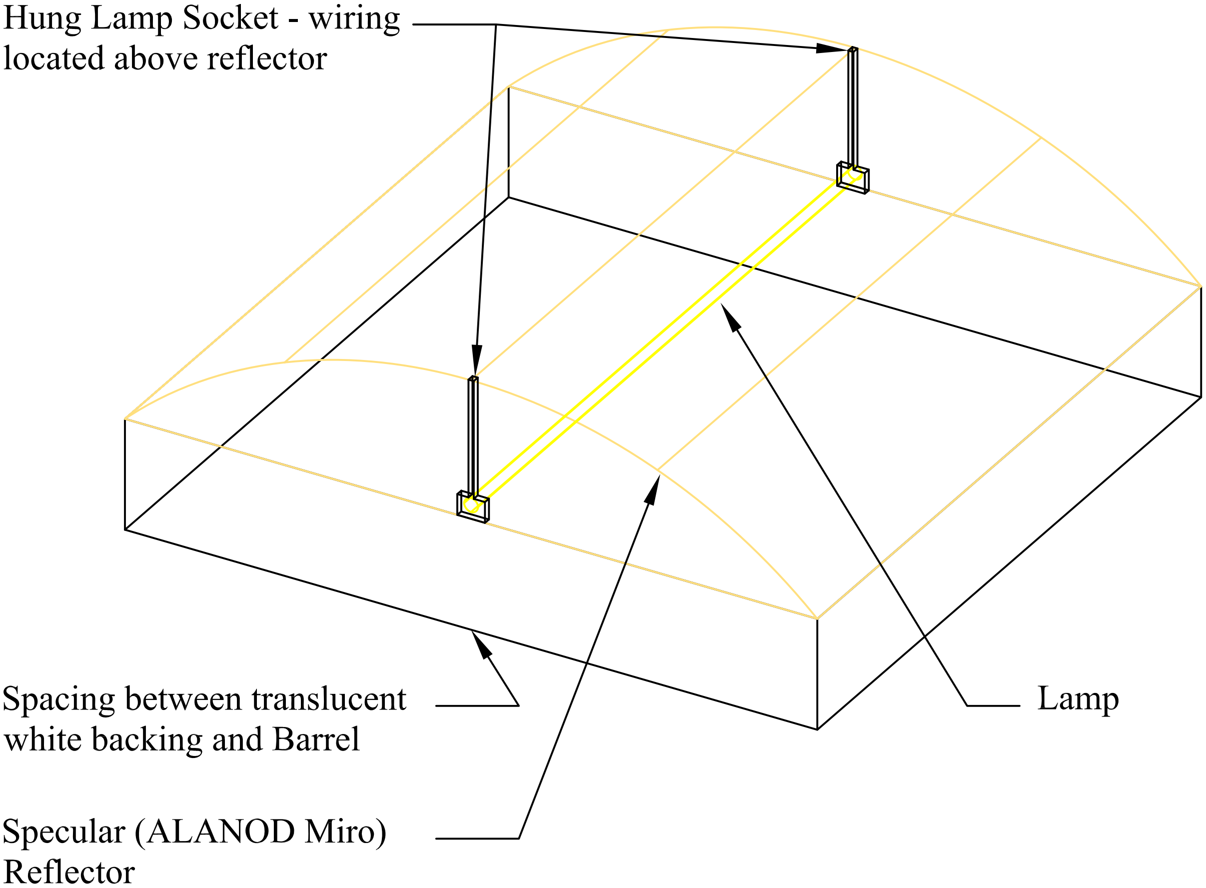


LED Installation on Mullion Dimension and Detail

Scale: 4" = 1'



Scale: ½" = 1'



Lobby "Barrel" Luminaire Dimension and Detail

Scale: 1" = 1'

Catalog Number	Type

FEATURES

OPTICAL SYSTEM

- Matte white polyester powder paint finished reflectors provide uniform light distribution. Optional diffuse aluminum stepped reflectors available
- Diffuser controls direct light distribution and glare by shielding lamps from direct view.
- Shielding snaps into place.
- Light traps prevent light leaks between shielding and endplates.

SHIELDING

- Straight Blade Louver (SBL) sides of perforated metal with staggered round holes and solid blade louvered center. Sides and louver backed with white acrylic diffuser.

ELECTRICAL SYSTEM

- Class P, thermally-protected, resetting, HPF, Non-PCB, UL Listed, CSA-certified electromagnetic ballast is standard. Energy saving and electronic ballast are sound rated A. Standard combinations are CBM approved and conform to UL 935.

HOUSING

- Housing is powder painted cold rolled steel. All edges hemmed or rounded.
- Trims available for standard 1" tee bar, mini-tee bar, screw slot grids.
- Drywall ceiling adapters available.
- Fixtures can be row mounted end to end.

LISTING

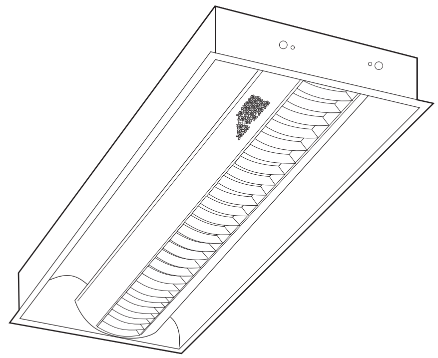
- UL listed and labeled. Listed and labeled to comply with Canadian and Mexican Standards (see options).

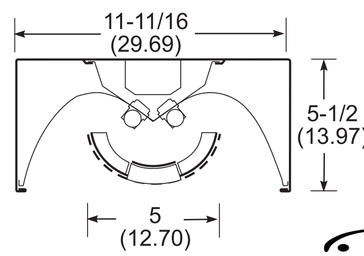
Specifications subject to change without notice.

Direct/Indirect General Lighting System

AV 1'x4' SBL

T8, T5 or T5HO
1 or 2 lamp
Compact Fluorescent
1 lamp in cross section





Avante®
Recessed Direct/Indirect Lighting

ORDERING INFORMATION

Example: **AV G 2 32 SBL 120 GEB**

AV __ __ __ SBL __ __ __

Series
AV 1[1] wide. For lamps in tandem add prefix **T**. Example: **TAV**.

Trim Type
G Grid trim
ST Screw slot

Lamps in Cross Section
1, 2

Lamp Type
32 32W T8 (48")
28T5 28W T5 (46")
54HOT5 54W T5 HO (46")
CF40 40W TT5 (24")[2]
CF50 50W TT5 (24")[2]
CF55 55W TT5 (24")[2]

Diffuser
SBL Straight blade louver, round holes.

Light Distribution
(blank) Symmetric Distribution

Voltage
120, 277, 347
Others available

Options
GEB Electronic ballast, <20% THD.
GEB10IS Electronic ballast, ≤10% THD, Instant Start.
GEB10RS Electronic ballast, ≤10% THD, Rapid Start.
ADEZ Advance Mark X two-wire dimming ballast. (T8 only)
EL Emergency battery pack (nominal 300 lumens, see Life Safety section).
GLR Internal fast-blow fuse.
GMF Internal slow-blow fuse.
LP Lamped. Specify lamp type and color.
PWS1836 6' prewire, 3/8" dia., 18-gauge, 3 wires.
RIF Radio interference filter.
HTC T-bar safety clips (snap-on).
LATC T-bar safety clips (screw-on).
CSA Listed and labeled to comply with Canadian Standards.
NOM Listed and labeled to comply with Mexican Standards.

Reflector Option
ASR Aluminum stepped reflector.

Accessories

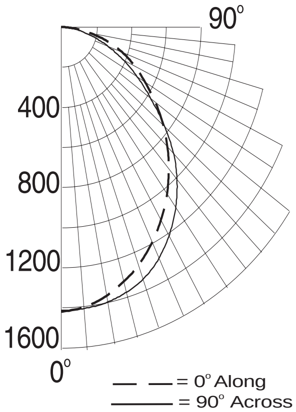
Order as separate catalog number.

DGA14[1] Flanged grid to drywall adapter, unit installation.

Notes:
1 Use G trim plus DGA accessory for fixture trim flange and fixture support in plaster or plasterboard ceilings.
2 1 lamp in cross section, 2 lamps end to end in fixture.

AV 1x4 SBL Direct/Indirect General Lighting

AV G 2 32 SBL 120, (2) F32 T8 lamps, 2900 lumens per lamp, s/m (along) = 1.2, s/m (across) = 1.3, test no. LTL7107



CANDLEPOWER SUMMARY

Angle	0	45	90
0	1422	1422	1422
5	1408	1419	1419
15	1332	1363	1388
25	1213	1263	1305
35	1058	1108	1147
45	874	896	929
55	672	649	637
65	475	368	400
75	277	178	189
85	64	47	40
90	0	0	0

COEFFICIENT OF UTILIZATION %

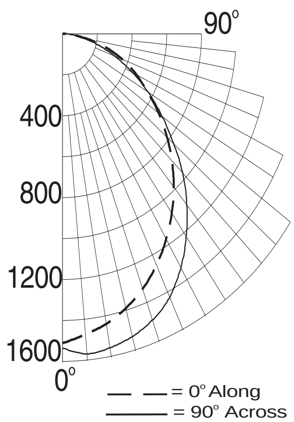
Floor	20									
Ceiling	80			70			50			0
Wall	70	50	30	70	50	30	50	30	10	0
RCR 0	76	76	76	75	75	75	71	71	71	64
1	70	67	65	68	66	63	63	61	59	54
2	64	59	55	62	58	54	55	52	49	46
3	59	52	47	57	51	46	49	45	42	39
4	54	46	41	52	45	40	44	39	36	33
5	49	41	36	48	41	35	39	35	31	29
6	46	37	32	45	37	31	36	31	27	26
7	42	34	28	41	33	28	32	28	24	23
8	40	31	26	39	31	25	30	25	22	20
9	37	28	23	36	28	23	27	23	20	18
10	35	26	21	34	26	21	25	21	18	17

ZONAL LUMEN SUMMARY

Zone	Lumens	% Lamp	% Fixture
0-30º	1097	18.9	29.4
0-40º	1785	30.8	47.9
0-60º	3058	52.7	82.1
60-90º	666	11.5	17.9
0-90º	3724	64.2	100.0
90º-180º	0	0.0	0.0
0-180º	3724	64.2	100.0

Efficiency = 64.2%

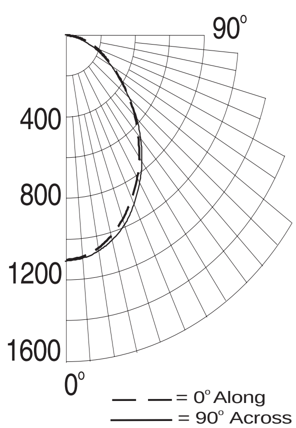
TAV G 1 CF40 SBL 120, (2) 40W TT5RS lamp, 3150 lumens per lamp, s/m (along) = 1.2, s/m (across) = 1.3, test no. LTL7119



RCR

Efficiency = 61.0%

AV G 2 32 SBL 120 ASR*, (2) F32 T8 lamps, 2850 lumens per lamp, s/m (along) = 1.1, s/m (across) = 1.2, test no. LTL7077



CANDLEPOWER SUMMARY

Angle	0	45	90
0	1101	1101	1101
5	1090	1096	1093
15	1015	1029	1037
25	891	909	926
35	736	743	772
45	563	559	588
55	389	375	391
65	244	208	238
75	134	94	105
85	30	23	14
90	0	0	0

COEFFICIENT OF UTILIZATION %

Floor	20									
Ceiling	80			70			50			0
Wall	70	50	30	70	50	30	50	30	10	0
RCR 0	50	50	50	49	49	49	47	47	47	42
1	46	45	43	45	44	42	42	41	40	36
2	43	39	37	42	39	36	37	35	33	31
3	39	35	32	38	34	31	33	31	29	27
4	36	31	28	35	31	28	30	27	25	23
5	33	28	25	32	28	24	27	24	22	20
6	31	26	22	30	25	22	24	21	19	18
7	29	23	20	28	23	20	22	19	17	16
8	27	21	18	26	21	18	21	18	16	15
9	25	20	16	25	19	16	19	16	14	13
10	24	18	15	23	18	15	18	15	13	12

ZONAL LUMEN SUMMARY

Zone	Lumens	% Lamp	% Fixture
0-30º	808	14.2	33.6
0-40º	1274	22.4	53.0
0-60º	2049	35.9	35.2
60-90º	357	6.3	14.5
0-90º	2406	42.2	100.0
90º-180º	0	0.0	0.0
0-180º	2406	42.2	100.0

Efficiency = 42.2%

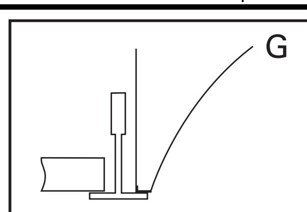
*ASR - Aluminum stepped reflector

For additional photometric information, visit our website at 'lithonia.com'.

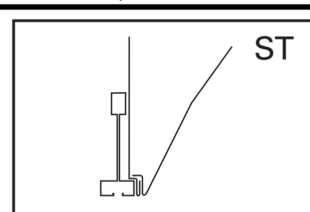
MOUNTING DATA

Mounting Data Ceiling Type	Appropriate Trim Type
Exposed grid tee	G
Concealed grid tee	G
Screw slot	ST
Plaster or plasterboard	G*

*DGA accessory available to provide ceiling trim flange and fixture support for plaster or plasterboard ceiling. Recommended rough-in dimensions for DGA installation is 12-3/4" x 24-3/4" (Tolerance is +1/8", -0”).



Lay-in Trim
(exposed grid tee)



Screw Slot
(screw slot tee)

AV 1x4 SBL

AV1x4SBL.p65

LITHONIA LIGHTING
ARCHITECTURAL INDOOR LIGHTING
ONE LITHONIA WAY, CONYERS, GEORGIA 30012, TELEPHONE 770-922-9000, FAX 770-860-3129
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Avante®

1' X 2' and 2' X 2'

2 X 2 symmetric, SBL

1 X 2 asymmetric, MDR

Recessed Direct/Indirect Lighting

Intended Use

An exceptional general lighting product that performs well in large spaces with high ceilings. Asymmetric products deliver uniform vertical illumination. They produce excellent corridor lighting or accent lighting for retail applications in continuous rows.

Features

Optimum mix of directional and diffuse reflected light for balanced illumination between task and proximate walls, enhanced visual comfort and minimized shadows.

Available in 1'x2' and 2'x2' symmetric distributions for general area lighting applications. Unique 1'x2' design suitable for corridor applications.

1'x2' asymmetric distribution available for dedicated wall washing or in combination with symmetric luminaires to maintain perimeter illumination.

Choice of shielding options.

Matte-white polyester powder paint finished reflectors provide uniform light distribution. Optional diffuse aluminum stepped reflectors available.

Shieldings pivot and swing down for easy lamp access.

Injection-molded plastic light traps prevent light leaks between shielding and end plates.

Compatible with screw slot and most 2-foot ceiling grids.

Covered by one or more of the following patents: 5,988,829; 399,586; 411,641; 413,402; 2,212,513; 87,513.

Listings – UL Listed (standard). CSA Certified or NOM Certified (see Options).

Ordering Information

Example: **AV G 1 CF40 MDR 120 GEB**

Series

- **AV** 1' wide, symmetric and asymmetric distribution
- **2AV** 2'wide, symmetric distribution

Trim type

- **G** Grid trim
- **ST** Screw slot

Air function

- (blank) Standard
- **A** Air supply/return[1]

Number of lamps

1, 2[2], 3[3]
Not included.

Lamp type

14T5	14W	T5 (22")
17	17W	T8(24")
24T5HO	24W	T5 HO (22")
CF40	40W	TT5 (24")
CF50	50W	TT5 (24")
CF55	55W	TT5 (24")

Diffuser

- **MDR** Metal diffuser, round holes
- **SBL** Straight blade louver, round holes[1]
- **MDM** Metal diffuser, mini slots.
- **ADP** Acrylic diffuser, linear prismatic lens[1,3]

Others available; consult factory.

Light distribution

- (blank) Symmetric distribution
- **ASY** Asymmetric distribution (AV only)

Voltage

120, 277, 347, MVOLT*
Others available.
* 120-277V. Must specify GEB10IS or GEB10PS.

Options

GEB	T8 electronic ballast, <20% THD
GEB10IS	T8 electronic ballast, <10% THD, instant start
GEB10PS	T5 electronic ballast, ≤10% THD, program start
GEB10RS	T8 electronic ballast, <10% THD, rapid start
ALG	Acrylic litter guard
GLR	Internal fast-blow fuse
EL	Emergency battery pack for T8 (nominal 300 lumens)
EL55	Emergency battery pack for T5/T5HO (nominal 390-700 lumens)[4]
PWS1836	6' prewired, 3/8" dia., 18-ga., 3 wires
LP_	Lamped. Specify lamp type and color
APB	Air pattern control blades (Not available with ASY distribution)
NYC	New York City approved
CP	Chicago Plenum approved[5]
CSA	CSA Certified
NOM	NOM Certified

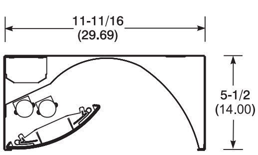
Reflector Options

ASR Aluminum stepped reflector

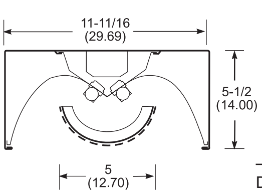
See page 29 for others.

Ballast/Lamp Compatibility

	17	14T5	24T5HO	CF40	CF50	CF55
GEB	■			■	■ 6	■ 6
GEB10IS	■					
GEB10PS		■	■			
GEB10RS	■					

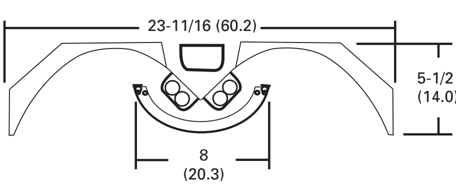


1x2 asymmetric



1x2 symmetric

Dimensions are shown in **inches (centimeters)** unless otherwise noted.



2x2 symmetric

Availability and Dimensions

Size	Series	Number of Lamps	Lamp Type	Height in.(cm)
1x2 (blank)	AV	1, 2 1	14T5, 17, 24T5HO CF40, CF50, CF55	5½ (14.0)
1x2 ASY	AV AV	1, 2 1	14T5, 17, 24T5HO CF40, CF50, CF55	5½ (14.0) 5½ (14.0)
2x2	2AV	1, 2, 3	14T5, 17, 24T5HO, CF40, CF50, CF55	5½ (14.0)

NOTES:
1 Not available in AV 1x2 asymmetric.
2 2-lamp available only in AV 1x2 with 14T5, 17, or 24T5HO.
3 Available with 2x2 only.
4 Not available in Canada.
5 Not available with air supply return.
6 Specify ballast manufacturer.

Accessories (Order separately)

DGA_ Drywall ceiling adapter, unit installation. Use G trim plus DGA for support in plaster ceilings. (Add **12** for 1x2, **22** for 2x2)

Avante®

1' X 4' and 2' X 4'

Intended Use

An exceptional general lighting product that performs well in large spaces with high ceilings. Asymmetric products deliver uniform vertical illumination. They produce excellent corridor lighting or accent lighting for retail applications in continuous rows.

Features

The optimum mix of directional and diffuse reflected light combine for balanced illumination between task and proximate walls, enhanced visual comfort and minimized shadows.

Available in 1'x4' and 2'x4' symmetric distributions for general area lighting applications. End-to-end row mounting capability.

1'x4' asymmetric distribution available for dedicated wall washing or in combination with symmetric luminaires to maintain perimeter illumination.

Available with a variety of shielding options.

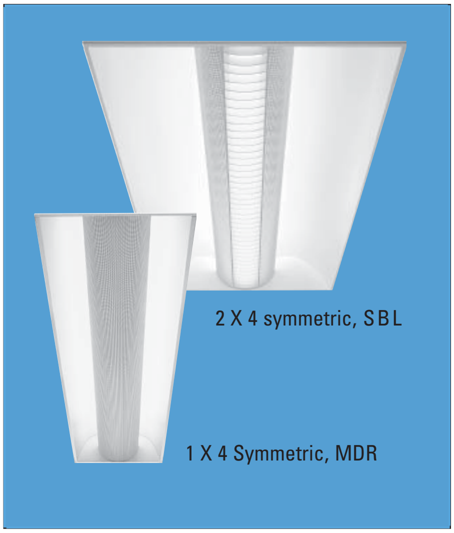
Matte-white polyester powder paint finished reflectors provide uniform light distribution. Optional diffuse aluminum stepped reflectors available.

Shieldings pivot on light trap and swing down for easy lamp access.

Injection-molded plastic light traps prevent light leaks between shielding and end plates.

Covered by one or more of the following patents: 5,988,829; 399,586; 411,641; 413,402; 2,212,513; 87,513.

Listings – UL Listed (standard). CSA Certified or NOM Certified (see Options).



Ordering Information

Example: **2AV G 3 32 MDR 120 GEB**

Series
- **AV** 1' wide, symmetric and asymmetric distribution
- **2AV** 2'wide, symmetric distribution

Trim type
- **G** Grid trim
- **ST** Screw slot

Air function
- (blank) Standard
- **A** Air supply/ return[1]

Number of lamps
- **1, 2, 3**[2]

Not included.

Lamp type
- **28T5** 28W T5 (46")
- **32** 32W T8 (48")
- **54T5HO** 54W T5 HO (46")

Diffuser
- **MDR** Metal diffuser, round holes
- **SBL** Straight blade louver, round holes[1]
- **MDM** Metal diffuser, mini slots.
- **ADP** Acrylic diffuser, linear prismatic lens[2]

Light distribution
- (blank) Symmetric distribution
- **ASY** Asymmetric distribution (AV only)

Voltage
- **120, 277, 347, MVOLT***

Others available.

*120-277V. Must specify GEB10IS or GEB10PS.

Options
- **GEB** T8 electronic ballast, <20% THD
- **GEB10IS** T8 electronic ballast, <10% THD, instant start
- **GEB10PS** T5 electronic ballast, ≤10% THD, program start
- **GEB10RS** T8 electronic ballast, <10% THD, rapid start
- **ALG** Acrylic litter guard
- **GLR** Internal fast-blow fuse
- **EL** Emergency battery pack for T8 (nominal 300 lumens)
- **EL55** Emergency battery pack for T5/T5HO (nominal 390-700 lumens)[3]
- **PWS1836** 6' prewired, 3/8" dia., 18-ga., 3 wires
- **APB** Air pattern control blades (Not available with ASY distribution)
- **LP_** Lamped. Specify lamp type and color
- **NYC** New York City approved
- **CP** Chicago Plenum approved[4]
- **CSA** CSA Certified
- **NOM** NOM Certified

Reflector Options
- **ASR** Aluminum stepped reflector

See page 29 for others.

Accessories (Order separately)

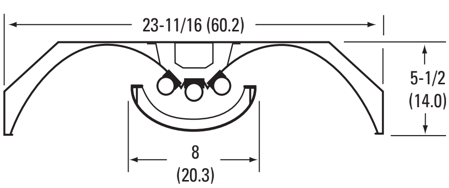
DGA_ Drywall ceiling adapter, unit installation. Use G trim plus DGA for support in plaster ceilings. (Add **14** for 1x4, **24** for 2x4)

Ballast/Lamp Compatibility

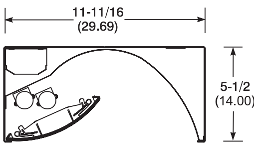
	32	28T5	54T5HO
GEB	■		
GEB10IS	■		
GEB10RS	■		
GEB10PS		■	■

NOTES:
1. Not available in AV 1x4 asymmetric.
2. Available only with 2AV.
3. Not available in Canada.
4. Not available with air supply return.

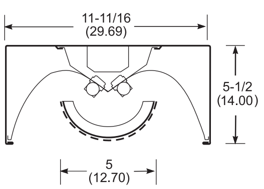
Dimensions are shown in **inches (centimeters)** unless otherwise noted.



2x4 symmetric



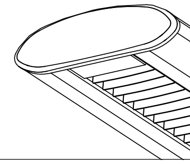
1x4 asymmetric



1x4 symmetric

Availability and Dimensions

Size	Series	Number of Lamps	Lamp Type	Height in.(cm)
1x4	AV	1, 2	28T5, 32, 54T5HO	5½ (14.0)
2x4	2AV	1, 2, 3	28T5, 32, 54T5HO	5½ (14.0)



Suspended

1T5HO

Direct/Indirect High Performance

8817H01

- Designed to accommodate up to 3T8 or 3T5HO lamps
- Optional Variable Optics™ provide additional up or downlight where needed
- Variable position mounting allows for flexibility in mount locations
- Optional high-performance version offers enhanced ceiling uniformity
- Standard orders can ship in 9 working days
- Factory pre-wired with quick-wire connectors

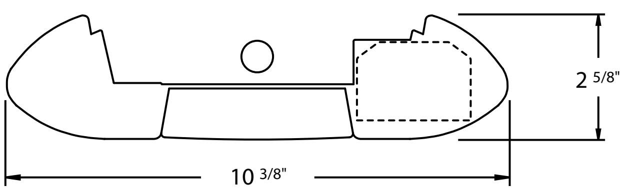
Order Number Guide

Example: 8817 H01PN 12 12EW

881	7	H01	_	_	_	_	_	E	_
Series	***Type***	***Lamping***	***Lower Optics (Louver Type)***	***Upper Optics***	***Length***	***Wiring***	***Voltage***	***Ballast***	***Finish***
Achieva	**7** - Direct/ Indirect High Performance	1T5HO	**W** - White **P** - Semi-Specular **S** - Specular **M** - Semi-Specular VDT **R** - Specular VDT	**N** - None (30% Dn) **D** - 60% Down Kit **G** - 80% Down Kit **J** - 100% Down Kit **U** - 80% Up Kit	**04** - 4ft **08** - 8ft **12** - 12ft	**1** - 1cct **3** - 1cct w/ Emergency cct **5** - 1cct w/ Battery Pack **7** - 1cct w/ Dimming **8** - 1cct w/ Thru Wire	**1** - 120V **2** - 277V **3** - 347V* *Consult factory for availability	Electronic	**W** - Standard White **C** - Factory Color **X** - Custom Color

Not all product and/or wiring options shown. Some combinations of product options may not be available or recommended (see below for optics details). Consult factory for more information.

Cross Section



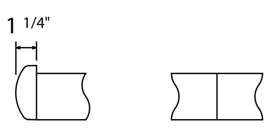
Modules

Module*	Mount Spacing*
4ft	4′ 0″
8ft	8′ 0″
12ft	12′ 0″

* Module length excludes endcaps. Nominal mount spacing for individually mounted modules with fixed position mounts.

Individual modules can be joined together to form longer runs (see below).

Ends / Joints



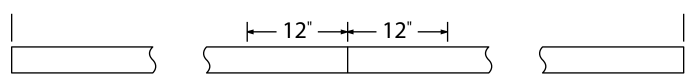
Louvers

Number of louver cells per 4ft:

- **W** - White .... 34 cells
- **P** - Semi-Specular .... 15 cells
- **S** - Specular .... 15 cells
- **M** - Semi-Specular VDT .... 30 cells
- **R** - Specular VDT .... 30 cells

Mounting in Runs

Fixed position mounts supplied standard at ends. Variable position mounts supplied standard at joints. Variable position mounts cannot be located on 4ft modules. Optional variable position mounts at ends available upon request (8ft and 12ft modules only).



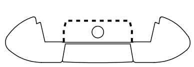
Fixed position mount at end

Variable position mount can be located up to 12" from joint (on 8ft and 12ft modules only)

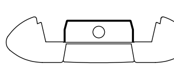
Fixed position mount at end

Optics

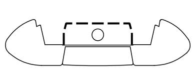
Variable Optics



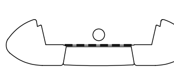
D - 60% Down Kit*



J - 100% Down Kit*



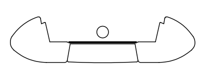
G - 80% Down Kit*



U - 80% Up Kit

* Downlight kits are not recommended with white louvers (lower optics option W), due to potential for excessive louver brightness.

Accessories



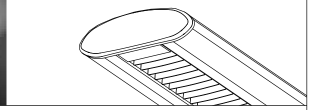
Lamp Guard*

* Lamp guard is not available with an uplight kit (upper optics option U).

L0096 Rev. 3

 Phone: 604-888-6811 Toll Free Fax: 1-800-665-LEDA (5332) Fax: 604-888-2003 www.ledalite.com

Ledalite



Specifications

Housing: 6063 T5 extruded aluminum.

Optical System: Constructed of 96% reflective white steel to produce a direct/indirect distribution. High performance version utilizes additional highly specular aluminum reflectors. Louvers are available in white blades and aluminum specular or semi-specular blades. White louver blades are spaced 1.3" apart and are 1.1" deep (34 cells per 4ft section). Standard specular and semi-specular louver blades are spaced 3" apart and are 1" deep (15 cells per 4ft section). Specular VDT and semi-specular VDT louver blades are spaced 1.5" apart and are 1" deep (30 cells per 4ft section). Optional Variable Optics™ kits provide additional up or downlight where needed.

Ends: Aluminum die-cast endcaps, baked powder coat finish for color.

Joints: Self-aligning joining system.

Mounting: Fixed position mounts supplied standard at ends. Variable position mounts supplied standard at joints. Variable position mounts can be located on 8ft or 12ft modules within 12" of joint or end. Aircraft cable gripper is tamper-resistant and provides infinite vertical adjustment capability. Aircraft cable, crimp and cable gripper independently tested to meet stringent safety requirements.

Electrical: Factory pre-wired to section ends with quick-wire connectors.

Ballast: Electronic.

Weight: 2.7 lb per ft.

Approvals: Certified to UL and CSA standards.

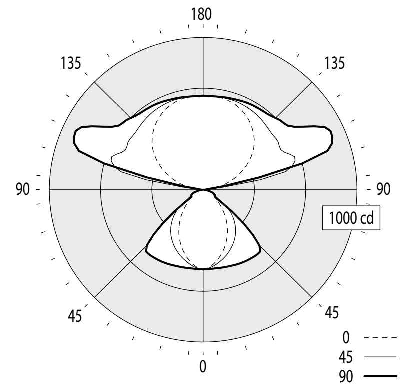
Finish: High quality powder coat. Available in Ledalite standard white (textured matte finish), and a selection of other factory and custom colors. Consult factory for details.

Due to continuing product improvements, Ledalite reserves the right to change specifications without notice.

Photometry

IES files for these and other photometric options, including downlight kits, can be downloaded online at www.ledalite.com

White Louvers - WN (Lower/Upper Optics Code)



Report Summary

Report #	2101359
Efficiency	88.0%
Peak Candela Value	914 @ 115°
Peak to Zenith Ratio	1.5 : 1
RP-1-04 Compliance	VDT Intensive

Avg. Luminance (cd/m²)

Vertical Angle	Horizontal Angle 0	45	90
55	913	1424	1265
65	784	921	989
75	687	761	1002
85	661	716	772

Candela Distribution

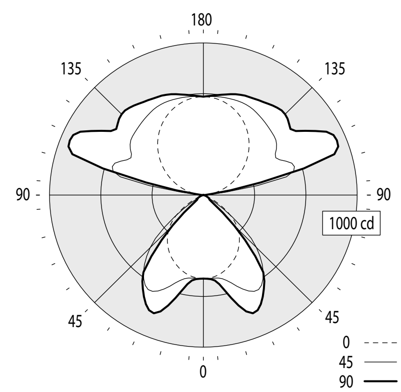
Vertical Angle	Horizontal Angle 0	22.5	45	67.5	90	Zonal Lumens
0	522	522	522	522	522	
5	508	508	513	519	522	49
15	444	451	475	509	527	136
25	362	375	426	493	538	202
35	269	288	365	469	548	238
45	173	193	285	417	517	232
55	109	110	170	157	151	132
65	69	69	81	81	87	76
75	37	36	41	42	54	44
85	12	11	13	11	14	14
90	3	4	5	5	5	
95	36	60	22	15	17	67
105	154	295	599	598	667	469
115	272	359	583	848	914	586
125	382	439	581	689	721	511
135	469	504	586	660	667	448
145	534	553	604	642	645	375
155	582	589	615	634	636	283
165	609	610	618	625	625	176
175	618	617	618	618	617	60
180	617	617	617	617	617	

Coefficients of Utilization (%)

Ceiling	80				70			50			0
Wall	70	50	30	10	70	50	30	50	30	10	0
RCR											
0	89	89	89	89	80	80	80	62	62	62	24
1	82	78	75	72	73	70	67	55	53	51	21
2	75	68	63	59	66	61	57	48	45	43	18
3	68	60	54	50	61	54	49	43	39	36	15
4	62	53	47	42	56	48	43	38	34	31	13
5	57	48	41	36	51	43	37	34	30	27	12
6	53	43	36	31	47	38	33	31	26	23	10
7	49	38	32	27	43	35	29	28	23	20	9
8	45	35	28	24	40	31	26	25	21	18	8
9	42	32	25	21	37	29	23	23	19	16	7
10	39	29	23	19	35	26	21	21	17	14	7

Floor reflectance: 20

Semi-Specular Louvers - PN (Lower/Upper Optics Code)



Report Summary

Report #	9900358
Efficiency	95.4%
Peak Candela Value	940 @ 112.5°
Peak to Zenith Ratio	1.5 : 1
RP-1-04 Compliance	VDT Intensive

Avg. Luminance (cd/m²)

Vertical Angle	Horizontal Angle 0	45	90
55	2700	2274	668
65	1003	463	521
75	157	94	31
85	94	0	0

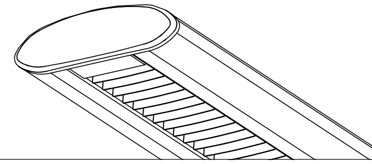
Candela Distribution

Vertical Angle	Horizontal Angle 0	22.5	45	67.5	90	Zonal Lumens
0	549	549	549	549	549	
5	546	546	550	553	555	55
15	518	529	581	660	701	171
25	470	515	696	818	836	307
35	404	509	675	692	692	376
45	317	453	488	360	283	305
55	190	272	160	45	47	138
65	52	76	24	30	27	44
75	5	4	3	2	1	5
85	1	1	0	0	0	0
90	0	0	0	0	0	
95	24	92	30	17	19	78
105	115	269	608	711	676	485
115	219	343	548	850	934	571
125	321	413	581	673	734	499
135	418	488	611	725	751	464
145	502	552	636	709	733	395
155	570	599	657	700	710	300
165	618	631	656	681	687	185
175	643	646	651	655	656	64
180	647	647	647	647	647	

Coefficients of Utilization (%)

Ceiling	80				70			50			0
Wall	70	50	30	10	70	50	30	50	30	10	0
RCR											
0	98	98	98	98	88	88	88	69	69	69	30
1	90	86	83	80	81	78	75	62	60	58	27
2	82	76	71	67	74	69	64	55	52	50	24
3	76	67	61	56	68	61	56	49	45	42	21
4	69	60	53	48	62	54	49	44	40	37	18
5	64	54	46	41	57	49	43	39	35	32	16
6	59	48	41	36	53	44	38	36	31	28	14
7	54	43	36	31	49	39	33	32	28	24	13
8	50	39	32	28	45	36	30	29	25	22	11
9	47	36	29	24	42	33	27	27	22	19	10
10	43	33	26	22	39	30	24	25	20	17	9

Floor reflectance: 20



Suspended

2T5HO

Direct/Indirect High Performance

8817H02

- Designed to accommodate up to 3T8 or 3T5HO lamps
- Optional Variable Optics™ provide additional up or downlight where needed
- Variable position mounting allows for flexibility in mount locations
- Optional high-performance version offers enhanced ceiling uniformity
- Standard orders can ship in 9 working days
- Factory pre-wired with quick-wire connectors

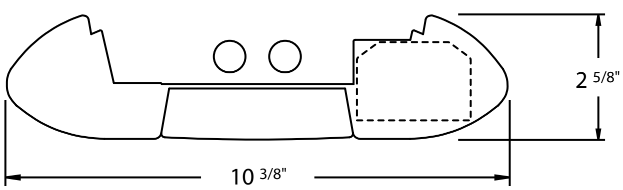
Order Number Guide

Example: 8817 H02PN 12 12EW

881	7	H02	_	_	_	_	_	E	_
Series	***Type***	***Lamping***	***Lower Optics (Louver Type)***	***Upper Optics***	***Length***	***Wiring***	***Voltage***	***Ballast***	***Finish***
Achieva	**7** - Direct/ Indirect High Performance	2T5HO	**W** - White **P** - Semi-Specular **S** - Specular **M** - Semi-Specular VDT **R** - Specular VDT	**N** - None (30% Dn) **D** - 60% Down Kit **G** - 80% Down Kit **J** - 100% Down Kit **U** - 80% Up Kit	**04** - 4ft **08** - 8ft **12** - 12ft	**1** - 1cct **2** - 2cct **3** - 1cct w/ Emergency cct **4** - 2cct w/ Emergency cct **5** - 1cct w/ Battery Pack **6** - 2cct w/ Battery Pack **7** - 1cct w/ Dimming **8** - 1cct w/ Thru Wire **9** - 2cct w/ Thru Wire	**1** - 120V **2** - 277V **3** - 347V* *Consult factory for availability	Electronic	**W** - Standard White **C** - Factory Color **X** - Custom Color

Not all product and/or wiring options shown. Some combinations of product options may not be available or recommended (see below for optics details). Consult factory for more information.

Cross Section



Modules

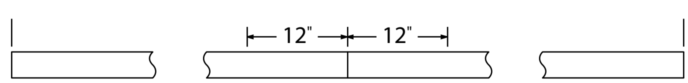
Module*	Mount Spacing*
4ft	4′ 0″
8ft	8′ 0″
12ft	12′ 0″

* Module length excludes endcaps. Nominal mount spacing for individually mounted modules with fixed position mounts.

Individual modules can be joined together to form longer runs (see below).

Mounting in Runs

Fixed position mounts supplied standard at ends. Variable position mounts supplied standard at joints. Variable position mounts cannot be located on 4ft modules. Optional variable position mounts at ends available upon request (8ft and 12ft modules only).

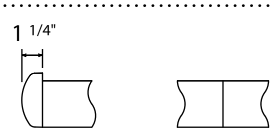


Fixed position mount at end

Variable position mount can be located up to 12″ from joint (on 8ft and 12ft modules only)

Fixed position mount at end

Ends / Joints



Endcap

Joint

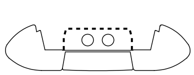
Louvers

Number of louver cells per 4ft:

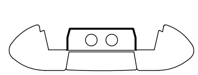
- **W** - White .... 34 cells
- **P** - Semi-Specular .... 15 cells
- **S** - Specular .... 15 cells
- **M** - Semi-Specular VDT .... 30 cells
- **R** - Specular VDT .... 30 cells

Optics

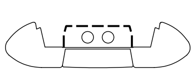
Variable Optics



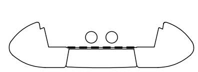
D - 60% Down Kit*



J - 100% Down Kit*



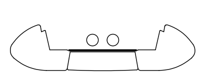
G - 80% Down Kit*



U - 80% Up Kit

* Downlight kits are not recommended with white louvers (lower optics option W), due to potential for excessive louver brightness.

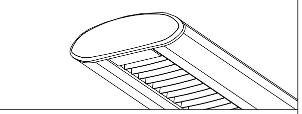
Accessories



Lamp Guard*

* Lamp guard is not available with an uplight kit (upper optics option U).

L0096 Rev. 3



Specifications

Housing: 6063 T5 extruded aluminum.

Optical System: Constructed of 96% reflective white steel to produce a direct/indirect distribution. High performance version utilizes additional highly specular aluminum reflectors. Louvers are available in white blades and aluminum specular or semi-specular blades. White louver blades are spaced 1.3" apart and are 1.1" deep (34 cells per 4ft section). Standard specular and semi-specular louver blades are spaced 3" apart and are 1" deep (15 cells per 4ft section). Specular VDT and semi-specular VDT louver blades are spaced 1.5" apart and are 1" deep (30 cells per 4ft section). Optional Variable Optics™ kits provide additional up or downlight where needed.

Ends: Aluminum die-cast endcaps, baked powder coat finish for color.

Joints: Self-aligning joining system.

Mounting: Fixed position mounts supplied standard at ends. Variable position mounts supplied standard at joints. Variable position mounts can be located on 8ft or 12ft modules within 12" of joint or end. Aircraft cable gripper is tamper-resistant and provides infinite vertical adjustment capability. Aircraft cable, crimp and cable gripper independently tested to meet stringent safety requirements.

Electrical: Factory pre-wired to section ends with quick-wire connectors.

Ballast: Electronic.

Weight: 2.7 lb per ft.

Approvals: Certified to UL and CSA standards.

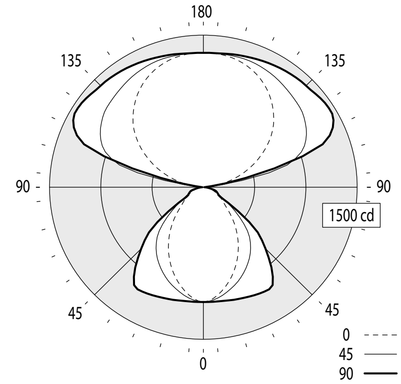
Finish: High quality powder coat. Available in Ledalite standard white (textured matte finish), and a selection of other factory and custom colors. Consult factory for details.

Due to continuing product improvements, Ledalite reserves the right to change specifications without notice.

Photometry

IES files for these and other photometric options, including downlight kits, can be downloaded online at www.ledalite.com

White Louvers - WN (Lower/Upper Optics Code)



Candela Distribution

Vertical Angle	Horizontal Angle 0	22.5	45	67.5	90	Zonal Lumens
0	1132	1132	1132	1132	1132	
5	1102	1104	1117	1128	1134	107
15	963	977	1037	1109	1150	294
25	782	812	931	1076	1176	438
35	578	621	798	1017	1178	512
45	368	411	608	725	857	453
55	226	234	327	387	416	285
65	143	144	168	160	160	156
75	77	78	89	88	114	92
85	24	22	30	25	33	30
90	5	8	10	10	9	
95	64	122	42	20	21	105
105	295	567	848	709	717	675
115	545	754	1103	1322	1393	1021
125	779	911	1199	1395	1449	1033
135	971	1055	1244	1395	1416	945
145	1119	1170	1284	1382	1399	799
155	1229	1253	1315	1365	1373	606
165	1296	1304	1327	1346	1348	376
175	1324	1325	1326	1327	1327	129
180	1325	1325	1325	1325	1325	

Report Summary

Report #	2101360
Efficiency	86.6%
Peak Candela Value	1452 @ 122.5 °
Peak to Zenith Ratio	1.1 : 1
RP-1-04 Compliance	VDT Normal

Coefficients of Utilization (%)

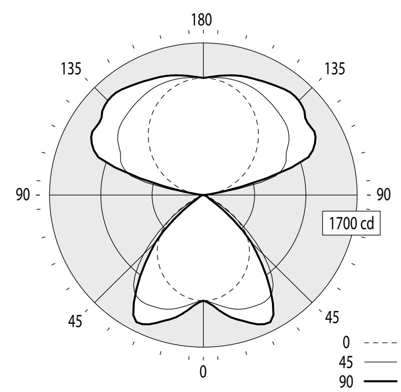
Ceiling	80				70			50			0
Wall	70	50	30	10	70	50	30	50	30	10	0
RCR											
0	88	88	88	88	79	79	79	62	62	62	25
1	81	77	74	71	72	69	67	55	53	51	22
2	74	68	63	59	66	61	57	48	45	43	19
3	67	60	54	49	60	54	49	43	39	36	16
4	62	53	47	42	55	48	42	38	34	31	14
5	57	47	41	36	51	43	37	34	30	27	12
6	52	42	36	31	47	38	33	31	27	23	11
7	48	38	32	27	43	35	29	28	24	21	10
8	45	34	28	24	40	31	26	25	21	18	9
9	41	31	25	21	37	29	23	23	19	16	8
10	39	29	23	19	35	26	21	21	17	15	7

Floor reflectance: 20

Avg. Luminance (cd/m²)

Vertical Angle	Horizontal Angle 0	45	90
55	1893	2739	3484
65	1625	1910	1819
75	1429	1652	2116
85	1323	1653	1819

Semi-Specular Louvers - PN (Lower/Upper Optics Code)



Candela Distribution

Vertical Angle	Horizontal Angle 0	22.5	45	67.5	90	Zonal Lumens
0	1180	1180	1180	1180	1180	
5	1174	1183	1212	1237	1242	119
15	1119	1191	1319	1412	1439	368
25	1018	1163	1366	1538	1593	619
35	878	1086	1325	1335	1291	748
45	693	918	933	779	749	637
55	420	579	403	223	161	338
65	111	150	56	49	47	91
75	10	9	7	4	4	11
85	2	1	0	0	1	1
90	0	0	0	0	0	
95	50	109	34	22	22	99
105	241	507	830	760	723	655
115	456	691	1009	1281	1360	960
125	663	837	1155	1328	1407	979
135	856	985	1228	1434	1493	931
145	1025	1116	1274	1421	1470	794
155	1158	1216	1316	1395	1420	603
165	1252	1280	1330	1371	1384	376
175	1302	1308	1319	1327	1330	128
180	1309	1309	1309	1309	1309	

Report Summary

Report #	9900360
Efficiency	90.9%
Peak Candela Value	1498 @ 137.5 °
Peak to Zenith Ratio	1.1 : 1
RP-1-04 Compliance	VDT Normal

Coefficients of Utilization (%)

Ceiling	80				70			50			0
Wall	70	50	30	10	70	50	30	50	30	10	0
RCR											
0	94	94	94	94	84	84	84	68	68	68	31
1	86	83	80	77	78	75	72	60	59	57	28
2	79	73	68	64	71	66	62	54	51	48	25
3	72	65	59	54	65	59	54	48	44	41	22
4	67	58	51	46	60	53	47	43	39	36	19
5	61	51	45	40	55	47	41	39	34	31	17
6	56	46	39	34	51	42	36	35	30	27	15
7	52	42	35	30	47	38	32	32	27	24	13
8	48	38	31	27	44	35	29	29	24	21	12
9	45	34	28	24	41	32	26	26	22	19	11
10	42	31	25	21	38	29	23	24	20	17	10

Floor reflectance: 20

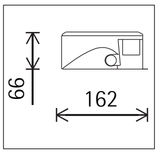
Avg. Luminance (cd/m²)

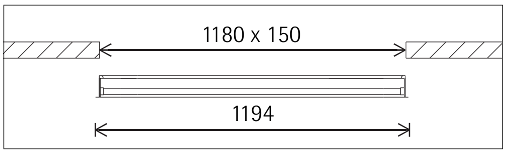
Vertical Angle	Horizontal Angle 0	45	90
55	5969	5727	2288
65	2141	1080	907
75	315	220	126
85	187	0	94

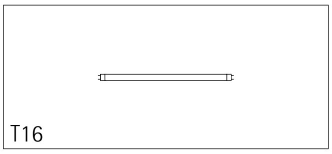
ERCO

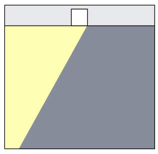
TFL Wallwasher

for fluorescent lamps









17 A033186

65040.000 Reflector silver
T16 28W G5 2600lm
ECG

Product description
Housing: sheet metal, white (RAL9002) powder-coated.
2 cable entries. Through-wiring possible. 5-pole terminal block.
Electronic control gear.
Wallwasher reflector: aluminium, anodised, satin matt. Hinged baffle to simplify lamp replacement.
Weight 4.00kg

ERCO Leuchten GmbH
Postfach 24 60
58505 Lüdenscheid
Germany
Tel.:+49 2351 551-0
Fax.:+49 2351 551-300
info@erco.com

Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/65040.000

ERCO

TFL Wallwasher

Planning data

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.94	0.89	0.81	0.72	0.88	0.80	0.69	0.59	0.84	0.74	0.61	0.52
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

Hours of operation (h)	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000
LLMF	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.88
LSF	1	1	1	1	1	1	1	1	1	1

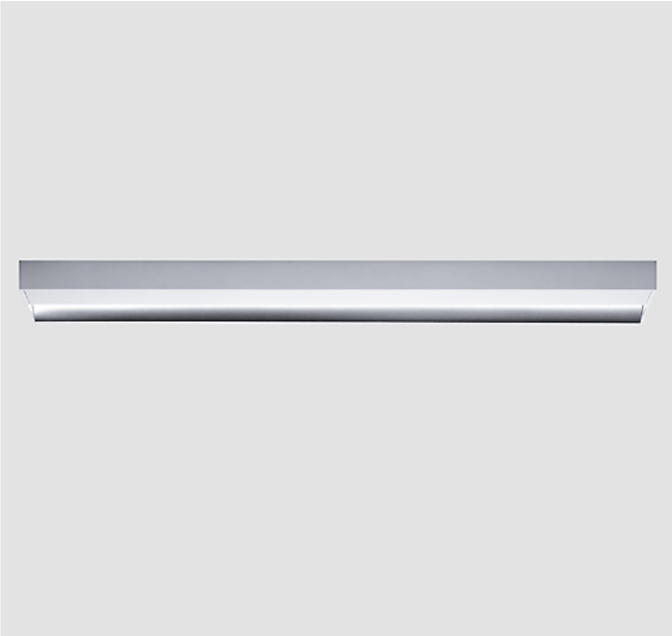
MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

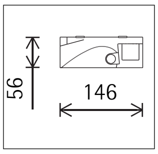
Illuminance E_n (lx)
Specifications:
Number of luminaires n > 5
Wall height (m) 3
T16 28W G5 2600lm

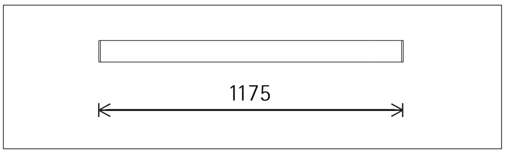
Offset from wall (m)	1.00		1.00		1.25		1.25	
Luminaire spacing (m)	1.25		1.50		1.25		1.75	
	below the luminaire	between the luminaires	below the luminaire	between the luminaires	below the luminaire	between the luminaires	below the luminaire	between the luminaires
0.250	285	228	258	176	123	117	93	79
0.500	624	559	559	430	396	382	313	252
0.750	619	579	540	463	506	488	390	331
1.000	510	490	439	401	460	450	348	315
1.250	412	403	352	335	394	389	297	278
1.500	333	327	284	275	333	329	250	240
1.750	269	265	230	225	280	277	211	205
2.000	217	213	185	182	235	233	178	174
2.250	176	172	151	149	197	194	150	147
2.500	144	140	125	122	164	162	126	124
2.750	118	116	104	101	137	135	107	105

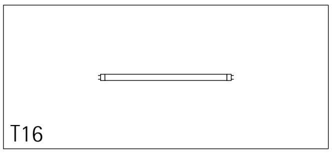
TFL Wallwasher

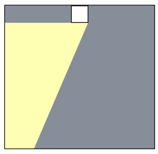
for fluorescent lamps











65043.000 White (RAL9002)
T16 28W G5 2600lm
ECG

Product description
Housing: aluminium profile, powder-coated.
1 cable entries. Through-wiring possible. 3-pole terminal block.
Electronic control gear.
Wallwasher reflector: aluminium, silver, satin matt anodised. Hinged cover for lamp replacement.
Weight 4.00kg

ERCO Leuchten GmbH
Postfach 24 60
58505 Lüdenscheid
Germany
Tel.:+49 2351 551-0
Fax.:+49 2351 551-300
info@erco.com

Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/65043.000

ERCO

TFL Wallwasher

Planning data

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.94	0.89	0.81	0.72	0.88	0.80	0.69	0.59	0.84	0.74	0.61	0.52
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

Hours of operation (h)	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000
LLMF	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.88
LSF	1	1	1	1	1	1	1	1	1	1

MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

Illuminance E_n (lx)
Specifications:
Number of luminaires n > 5
Wall height (m) 3
T16 28W G5 2600lm

Offset from wall (m)	1.00		1.00		1.25		1.25	
Luminaire spacing (m)	1.25		1.50		1.25		1.75	
	below the luminaire	between the luminaires	below the luminaire	between the luminaires	below the luminaire	between the luminaires	below the luminaire	between the luminaires
0.250	285	228	258	176	123	117	93	79
0.500	624	559	559	430	396	382	313	252
0.750	619	579	540	463	506	488	390	331
1.000	510	490	439	401	460	450	348	315
1.250	412	403	352	335	394	389	297	278
1.500	333	327	284	275	333	329	250	240
1.750	269	265	230	225	280	277	211	205
2.000	217	213	185	182	235	233	178	174
2.250	176	172	151	149	197	194	150	147
2.500	144	140	125	122	164	162	126	124
2.750	118	116	104	101	137	135	107	105

Catalog Number	Type

FEATURES

- Available in tandem-wired lengths.
- Heavy-duty channel, die-formed from code-gauge steel.
- Sturdy channel cover secured by captive quarter-turn latch for easy access to wireway.
- High-gloss, baked white enamel finish.
- Endplate and channel connector furnished with each fixture.
- For unit or row installations, surface or suspended mounting.
- Guaranteed for one year against mechanical defects in manufacture.

SPECIFICATIONS

BALLAST — Thermally protected, resetting, Class P, HPF, non-PCB, UL listed, CSA-certified ballast is standard. Rapid start ballasts are sound rated A. Standard combinations are CBM approved and conform to UL 935.

WIRING & ELECTRICAL — Fixture conforms to UL 1570 and is suitable for damp locations. AWM, TFN or THHN wire used throughout, rated for required temperatures.

MATERIALS — Housing formed from cold-rolled steel. No asbestos is used in this product.

FINISH — Five-stage iron-phosphate pretreatment ensures superior paint adhesion and rust resistance. Painted parts finished with high-gloss, baked white enamel.

LISTING — UL listed and labeled. CSA certified (see options). NOM labeled (see options).

Specifications subject to change without notice.

ENERGY

- Luminaire Efficiency Rating (LER)

  One lamp minimum LER.FS = 52.
  Based on 34W T12, 2650 lumen lamp and energy-saving magnetic ballast factor = .87 and input watts = 42.

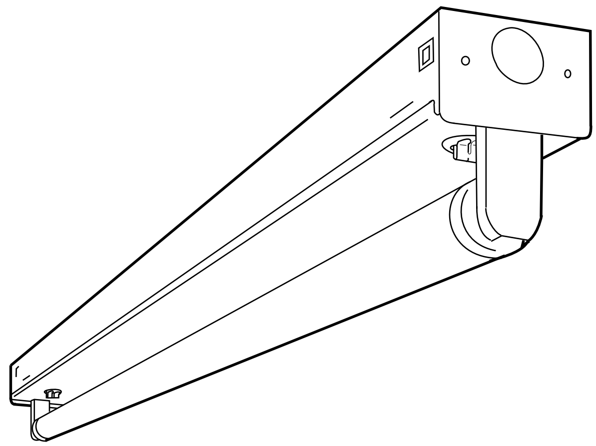
Calculated in accordance with NEMA standard LE-5. See LER sheet for details.

Standard Strip

S

Rapid Start

1-1/2', 2', 3' or 4' length
1 lamp



PHOTOMETRICS

Calculated using the zonal cavity method in accordance with IESNA LM41 procedure. Floor reflectances are 20%. Lamp configurations shown are typical. Full photometric data on these and other configurations available upon request.

S 1 40
Report ITL 18240
S/MH (along) 1.2 (across) 1.6
Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
1	94	89	84	89	84	80	76	72	69
2	84	75	68	80	72	65	64	59	54
3	76	65	57	72	62	54	56	49	44
4	70	57	48	65	54	46	49	42	37
5	63	50	41	59	48	39	43	36	30
10	42	29	21	39	28	20	25	19	14

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	388	12.1	12.8
0-40	663	20.7	21.9
0-60	1332	41.6	44.0
0-90	2245	70.2	74.2
90-180	782	24.4	25.8
0-180	3027	94.6	100.0

S 1 32
Report LTL 5725
S/MH (along) 1.2 (across) 1.6
Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
1	97	91	86	92	87	82	79	75	72
2	87	77	70	82	74	67	67	61	56
3	78	67	58	74	64	56	58	52	46
4	71	59	50	67	56	48	51	44	38
5	65	51	42	61	49	41	45	37	32
10	43	30	22	41	28	21	26	20	15

Zonal Lumens Summary

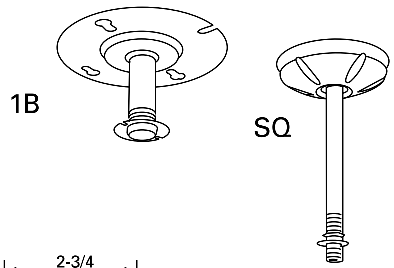
Zone	Lumens	%Lamp	%Fixture
0-30	388	13.4	13.9
0-40	660	22.8	23.7
0-60	1307	45.1	46.9
0-90	2176	75.0	78.1
90-180	609	21.0	21.9
0-180	2786	96.1	100.0

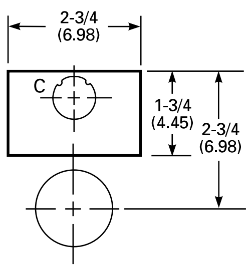
MOUNTING DATA

For unit or row installation, surface or stem mounting.

Unit installation — Minimum of two hangers required.

Row installation — One hanger per channel plus one per row required.

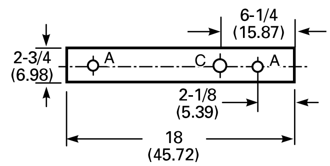


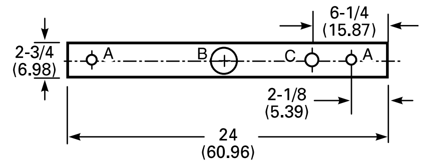


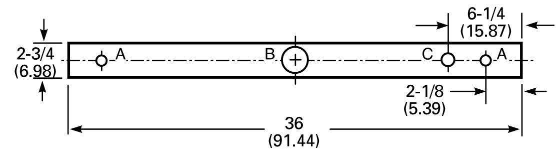
A = 11/16 (1.74) Dia. K.O.
B = 2 (5.08) Dia. K.O.
C = 7/8 (2.22) Dia. K.O.

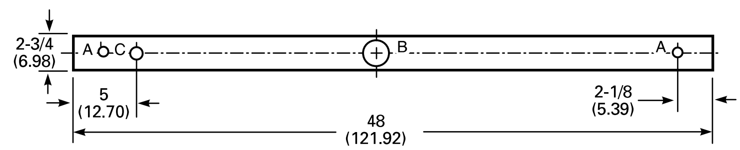
DIMENSIONS

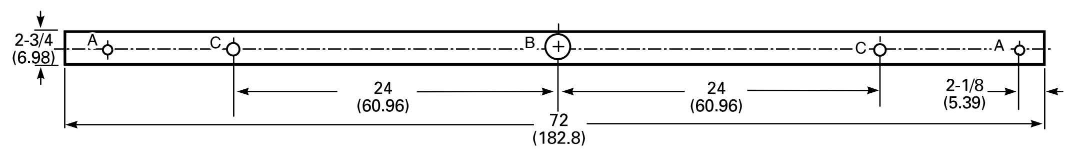
Inches (centimeters). Subject to change without notice.

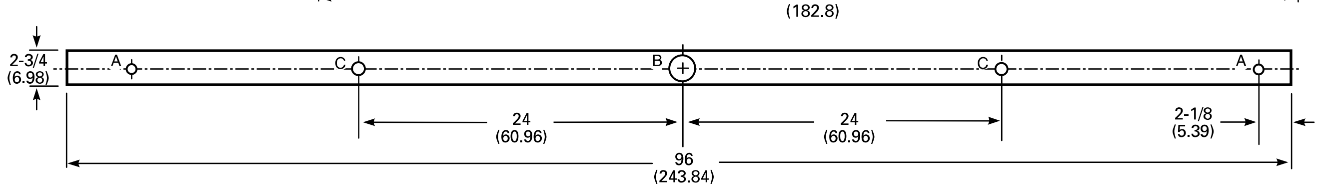












ORDERING INFORMATION

Example: **S 1 30 120 HPF GLR**

S — **Series**

- **S** Standard strip[1]

1 — **Number of lamps**

- **1** Not included

Lamp type

- **15** 15W TS T12 (18")[3]
- **15PH** 15W PH T12 (18")[2]
- **17** 17W T8 (24")
- **20PH** 20W PH T12 (24")[2]
- **20** 20W TS T12 (24")[3]
- **25** 25W T8 (36")
- **30PH** 30W PH T12 (36")[2]
- **30** 30W RS T12 (36")
- **32** 32W T8 (48")
- **40** 40W T12 (48")[5]

Voltage

- **120, 277, 347**
- Others available

Options

- **ES** Energy-saving ballasts (30W or 40W lamps only).
- **GEB** Electronic ballasts, $\leq$20% THD.
- **GEB10** Electronic ballasts, $\leq$10% THD.
- **HPF** High power factor ballast (15W, 20W and 30W only).
- **LPF** Low power factor ballast (15W, 20W and 30W only).
- **EL** Emergency battery pack (nominal 300 lumens; See Life Safety Section). Not CSA.
- **GLR** Internal fast-blow fuse (add **X** for external).
- **GMF** Internal slow-blow fuse (add **X** for external).
- **CS1** 6' cordset, NEMA 5-15P SJT, U-ground plug, 120V.
- **CS3** 6' cordset, NEMA L5-15P SJT, twist-lock plug, 120V.
- **PLF__** Plug in wiring, specify number of branch circuits and hot wires (**A**-black, **B**-Red, **C**-Blue, **AB** or **AC**).
- **CSA** CSA-labeled for US shipment to Canada.
- **NOM** NOM-labeled for shipment to Mexico.
- **SW** Palletized and stretch-wrapped.

Accessories

Order as separate catalog numbers.

- **SQ_** Swivel-stem hanger (specify length in 2" increments).
- **1B** Ceiling spacer (adjusts from 1-1/2" to 2-1/2" from ceiling).
- **WGS** Wireguard, 4' white, for unshielded S strip.[4]
- **WGSSMR** Wireguard, 4' white, for S strip with SSMR reflector.[4]
- **WGSASR** Wireguard, 4' white, for S strip with SASR reflector.[4]
- **SSMR 48WH** Symmetric reflector, 4' white.[4]
- **SASR 48WH** Asymmetric reflector, 4' white.[4]
- **S48WG** Wireguard, 4' white, Canada only.[4]

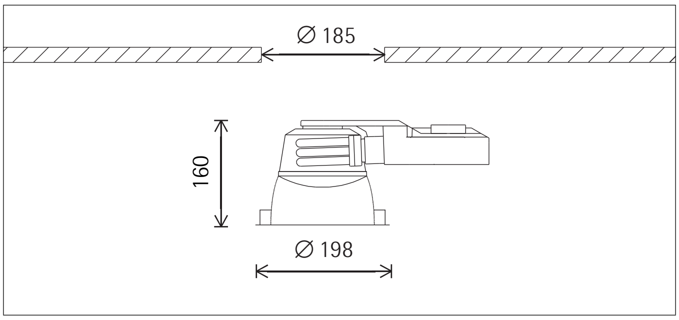
Notes:
1 For tandem double-length unit, add prefix T. Example: **TS**
2 PH ballasts available in low power factor 120V only.
3 Specify **HPF** or **LPF** in options section for 120V, **HPF** standard on 277V.
4 Order two for 8' fixtures.
5 LPF is available for residential buildings only.

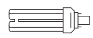
LITHONIA LIGHTING
COMMERCIAL & INDUSTRIAL FLUORESCENT LIGHTING
P.O. BOX A, CONYERS, GEORGIA 30207-0067, TELEPHONE 770 922-9000, FAX 770 860-3106

ERCO

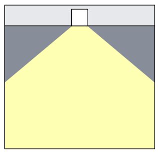
Lightcast Downlight

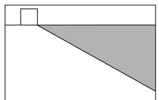
for TC-T lamps





TC-TEL

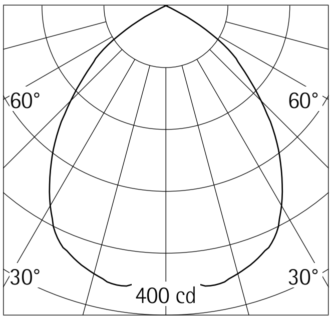




Size 6
30°

22221.000 Reflector silver
TC-TEL 18W GX24q-2 1150lm
ECG

Product description
Housing: cast aluminium, designed as heat sink.
Mounting ring: cast aluminium, white (RAL9002) powder-coated. Tools not required for mounting with 4-point support and screw fixing.
Junction box for through-wiring, 5-pole terminal block, integrated cable clamp. Electronic control gear.
Darklight reflector: aluminium, bright anodised. Cut-off angle 30°.
Diffuser as lamp cover: plastic, translucent, can be removed for lamp replacement without tools.
Weight 1.70kg



TC-TEL 18W GX24q-2 1150lm

LOR 0.59
UGR 19.1
65° < 200 cd/m²

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info@erco.com

Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/22221.000

ERCO

Lightcast Downlight

Planning data

22221.000	TC-TEL 18W GX24q-2 1150lm	
Connected load	P:	20 W
Connected load per 100lx	P*:	2.9 W/m²
Number of luminaires per 100lx	n*:	14.7 1/100m²

22221.000	TC-TEL 18W GX24q-2 1150lm			
Number of luminaires per 100m² for	100lx	200lx	300lx	500lx
	15	30	44	74

22221.000	TC-TEL 18W GX24q-2 1150lm			
Module (m)	1.2x1.8	1.8x1.8	1.8x2.4	2.4x2.4
Illuminance E_n (lx)	315	210	158	118

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.94	0.89	0.81	0.72	0.88	0.80	0.69	0.59	0.84	0.74	0.61	0.52
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

Hours of operation (h)	1000	2000	4000	6000	8000	10000
LLMF	0.97	0.92	0.88	0.85	0.83	0.83
LSF	1	1	1	1	1	1

MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

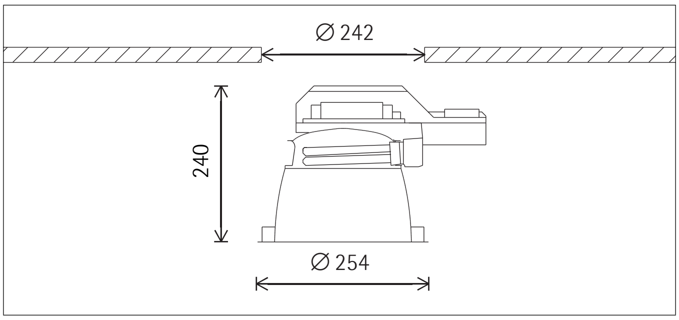
Correction table

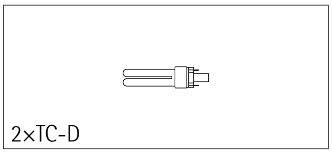
Ceiling		0.70	0.70	0.70	0.50	0
Wall		0.70	0.50	0.20	0.20	0
Floor		0.50	0.20	0.20	0.10	0
k	0.6	76	57	48	47	43
k	1.0	99	76	67	65	61
k	1.5	116	90	82	79	75
k	2.5	130	100	94	89	85
k	3.0	134	103	99	93	89

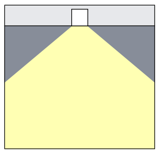
ERCO

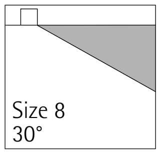
Lightcast Downlight

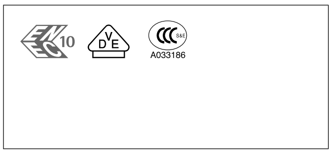
for TC-D lamps

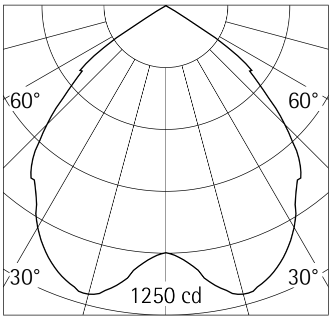












2×TC-D 26W G24d-3 1800lm

LOR	0.64
UGR	21.4
65° <	200 cd/m²

22214.000 Reflector silver
2×TC-D 26W G24d-3 1800lm

Product description
Housing: cast aluminium, designed as heat sink.
Mounting ring: cast aluminium, white (RAL9002) powder-coated.
Tools not required for mounting with 4-point support and screw fixing.
Junction box for through-wiring, 5-pole terminal block, integrated cable clamp.
2 sets of low-loss control gear.
Darklight reflector: aluminium, bright anodised. Cut-off angle 30°.
Weight 3.70kg

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Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/22214.000

ERCO

Lightcast Downlight

Planning data

22214.000	TC-D 26W G24d-3 1800lm	
Connected load	P:	62 W
Connected load per 100lx	P*:	2.7 W/m²
Number of luminaires per 100lx	n*:	4.3 1/100m²

22214.000	TC-D 26W G24d-3 1800lm			
Number of luminaires per 100m² for	100lx	200lx	300lx	500lx
	5	9	13	22

22214.000	TC-D 26W G24d-3 1800lm			
Module (m)	1.2x1.8	1.8x1.8	1.8x2.4	2.4x2.4
Illuminance E_n (lx)	1077	718	538	404

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.94	0.89	0.81	0.72	0.88	0.80	0.69	0.59	0.84	0.74	0.61	0.52
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

Hours of operation (h)	1000	2000	4000	6000	8000	10000
LLMF	0.97	0.92	0.88	0.85	0.83	0.83
LSF	1	1	1	1	1	1

MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

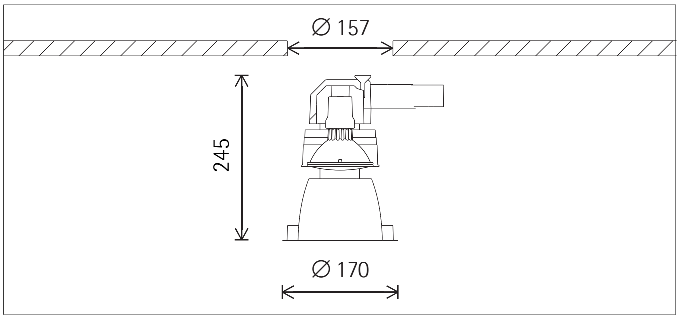
Correction table

Ceiling	0.70	0.70	0.70	0.50	0
Wall	0.70	0.50	0.20	0.20	0
Floor	0.50	0.20	0.20	0.10	0
k 0.6	76	57	47	47	43
k 1.0	100	76	68	66	62
k 1.5	116	90	83	80	76
k 2.5	130	100	95	90	85
k 3.0	134	103	99	93	89

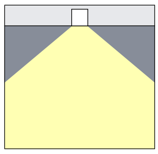
ERCO

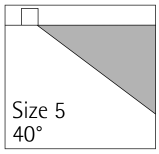
Lightcast Downlight

for PAR lamps



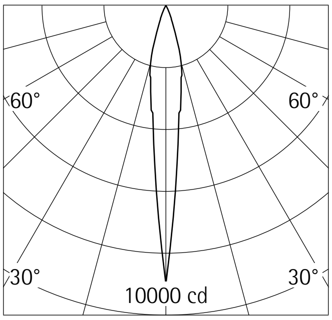

QPAR30





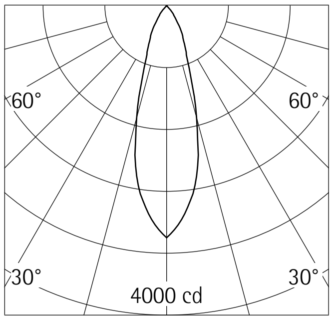
22617.000 Reflector silver
QPAR30 100W 230V E27 10°
QPAR30 100W 230V E27 30°

Product description
Housing: cast aluminium, designed as heat sink.
Mounting ring: cast aluminium, white (RAL9002) powder-coated.
Tools not required for mounting with 4-point support and screw fixing.
Junction box for through-wiring, 5-pole terminal block, integrated cable clamp.
Darklight reflector: aluminium, bright anodised. Cut-off angle 40°.
Weight 1.00kg



QPAR30 100W 230V E27 10°

h(m)	E(lx)	D(m) 10°
1	9000	0.17
2	2250	0.35
3	1000	0.52
4	562	0.70
5	360	0.87



QPAR30 100W 230V E27 30°

h(m)	E(lx)	D(m) 30°
1	3000	0.54
2	750	1.07
3	333	1.61
4	188	2.14
5	120	2.68

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Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/22617.000

ERCO

Lightcast Downlight

Planning data

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.98	0.94	0.90	0.86	0.95	0.91	0.86	0.81	0.94	0.90	0.84	0.79
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

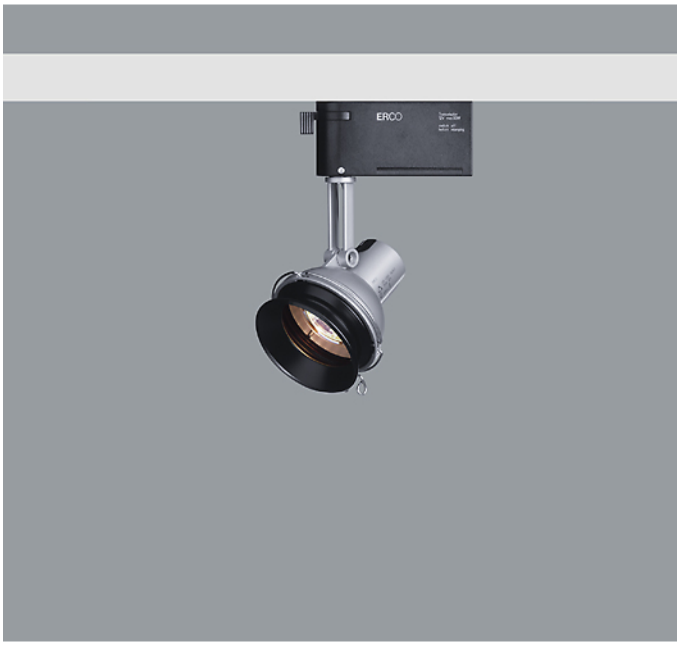
Hours of operation (h)	1000	2000
LLMF	0.98	0.95
LSF	1	1

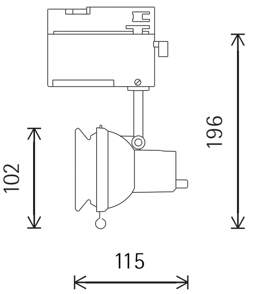
MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

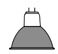
ERCO

Pollux Spotlight

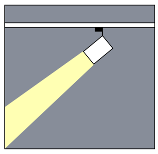
with transadapter for low-voltage halogen lamps

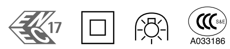






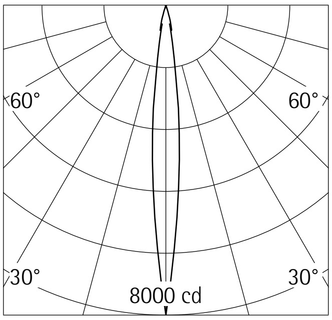
QR-CBC51





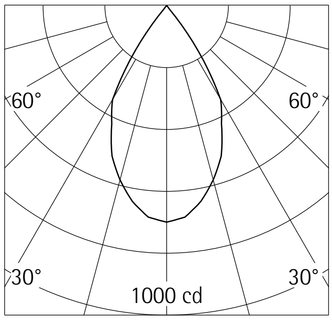
73750.000 Silver
QR-CBC51 35W 12V GU5.3 10°
QR-CBC51 35W 12V GU5.3 60°

Product description
Housing and bracket: cast aluminium, powder-coated. 0°-90° tilt. Bracket on transadapter rotatable through 360°.
ERCO Transadapter for 3-circuit track: plastic. Electronic transformer 230/12V, 20-50W. Potentiometer for brightness control 10%-100%. LED function indicator. Circuit pre-selection.
Anti-dazzle ring: metal, black powder-coated, attached to the spotlight by means of a circular spring; to be removed for lamp replacement.
Use dimmers for electronic transformers (trailing edge).
Weight 0.32kg



QR-CBC51 35W 12V GU5.3 10°

h(m)	E(lx)	D(m) 10°
1	8000	0.17
2	2000	0.35
3	889	0.52
4	500	0.70
5	320	0.87



QR-CBC51 35W 12V GU5.3 60°

h(m)	E(lx)	D(m) 60°
1	700	1.15
2	175	2.31
3	78	3.46
4	44	4.62
5	28	5.77

Mounting
ERCO 3-circuit track
Hi-trac track
Monopoll track

ERCO Leuchten GmbH
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Fax.:+49 2351 551-300
info@erco.com

Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/73750.000

Pollux Spotlight

Planning data

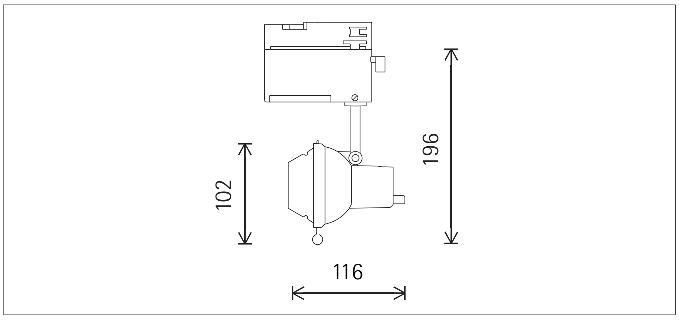
Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.98	0.94	0.90	0.86	0.95	0.91	0.86	0.81	0.94	0.90	0.84	0.79
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

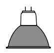
Hours of operation (h)	1000	2000
LLMF	0.98	0.95
LSF	1	1

MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

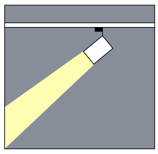
ERCO Pollux Spotlight

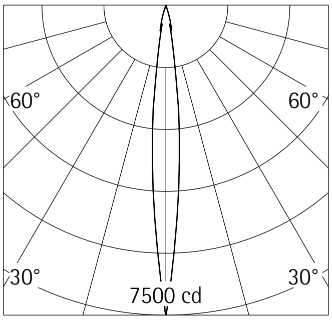
with transadapter for low-voltage halogen lamps



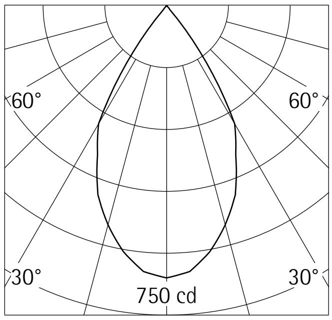


QR-CBC51





QR-CBC51 35W 12V GU5.3 10°



QR-CBC51 35W 12V GU5.3 60°

73756.000 Silver
QR-CBC51 35W 12V GU5.3 10°
QR-CBC51 35W 12V GU5.3 60°

Product description
Housing and bracket: cast aluminium, powder-coated. 0°-90° tilt.
Bracket on transadapter rotatable through 360°.
ERCO Transadapter for 3-circuit track: plastic. Electronic transformer 230/12V, 20-50W. Potentiometer for brightness control 10%-100%. LED function indicator.
Circuit pre-selection.
Anti-dazzle cone: metal, black powder-coated, attached to the spotlight by means of a circular spring; to be removed for lamp replacement.
Use dimmers for electronic transformers (trailing edge).
Weight 0.32kg

QR-CBC51 35W 12V GU5.3 10°

h(m)	E(lx)	D(m) 10°
1	7547	0.17
2	1887	0.35
3	839	0.52
4	472	0.70
5	302	0.87

QR-CBC51 35W 12V GU5.3 60°

h(m)	E(lx)	D(m) 60°
1	660	1.15
2	165	2.31
3	73	3.46
4	41	4.62
5	26	5.77

Mounting
ERCO 3-circuit track
Hi-trac track
Monopoll track

ERCO Leuchten GmbH
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Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/73756.000

ERCO

Pollux Spotlight

Planning data

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.98	0.94	0.90	0.86	0.95	0.91	0.86	0.81	0.94	0.90	0.84	0.79
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

Hours of operation (h)	1000	2000
LLMF	0.98	0.95
LSF	1	1

MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

TYPE:

CATALOG #:

McGRAW-EDISON®

DESCRIPTION

The McGraw-Edison PSL Parking Structure Luminaire is a multi-purpose parking luminaire. The refractor provides proper 3D illumination for parking garages while the glare guard and light trespass shield add extra measure of visual comfort and control. The PSL improves drivers vision and pedestrian safety in parking garage facilities.

SPECIFICATION FEATURES

A ···Housing
Die-cast, low copper, marine-grade alloy (A360) aluminum is precision formed. Extra heavy wall thickness (min. 0.123") housing provides exceptional heat sinking to keep components cool. Screw bosses are cast into back of housing for structural integrity.

B ···Wiring
Plug Ease™ wiring system; lead wires are encased in a liquid injection-molded silicone gasket, which provides water-and dust-tight seal between housing and junction box.

C ····Hardware
Stainless steel Philips head fasteners. Recessed screw heads on casting. Fasteners are captive in the die-cast during relamping and sealed via silicone gasket. Gaskets compress for proper sealing.

D ··Socket
HID—4KV pulse rated medium-base with nickel-plated screw shell.

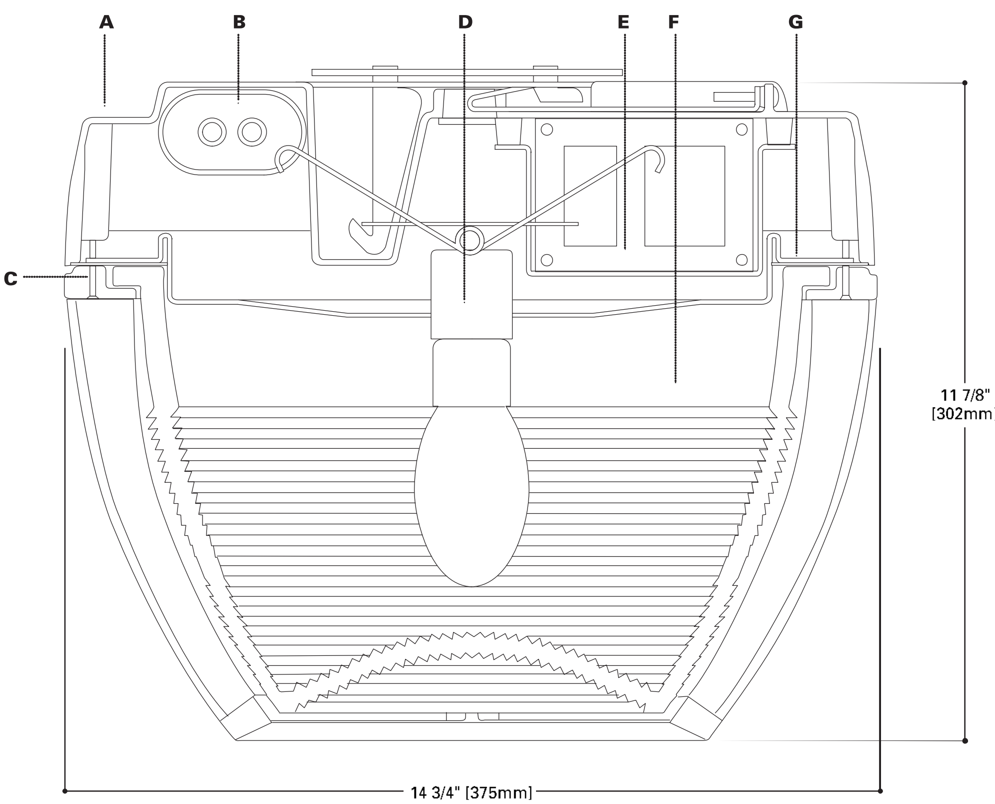
E ···Ballast
HID—HPF, -20° starting Dual-Tap standard. For use with up to 175W Metal Halide lamp, 150W High Pressure Sodium or 85W QL Induction.

F ···Optics
Molded tempered borosilicate glass refractor. Glass shock-absorbing system consists of 16 gauge steel ring to support the full round lens; the lens floats on the injection-molded silicone gasket for additional protection. Main specular aluminum reflectors are one-piece spun. Uplight windows provide a wide distribution high above the 90° plane for elimination of the cave effect. Optional polycarbonate lens available.

G ···Lens Gaskets
Liquid injection-molded silicone gasket provides continuous seal between housing and refractor assembly.

H ···Labels
U.L. listed and CSA certified for wet locations in all mounting positions; IP65 rated.

I ···Finish
Fixture is painted white to minimize contrast borders between the fixture and the ceiling plane, allowing the units visual luminance to blend in. Premium TGIC textured thermoset polyester powder coat finish protects and provides a durable, rugged finish.



PSLPARKING STRUCTURE LUMINAIRE

70-200W

Metal Halide

Pulse Start Metal Halide

High Pressure Sodium

Electrodeless Fluorescent

BOROSILICATE GLASS

PARKING STRUCTURE

LUMINAIRE

ENERGY DATA

High Reactance Ballast Input Watts
70W HPS HPF (95 Watts)
70W MH HPF (94 Watts)
100W HPS HPF (130 Watts)
100W MH HPF (129 Watts)
150W HPS HPF (190 Watts)

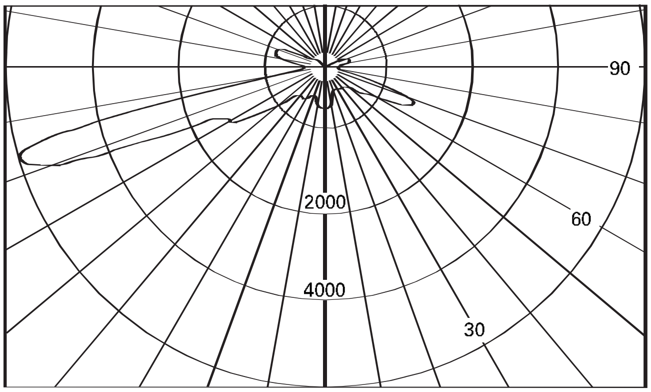
CWA Ballast Input Watts
175W MH HPF (210 Watts)
200W MH HPF (232 Watts)

SHIPPING DATA

Approximate Net Weight:
34 lbs. (15 kgs.)

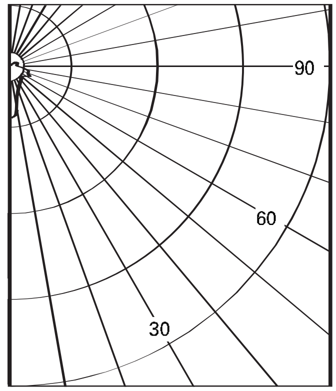
PHOTOMETRICS

IES File# H39164



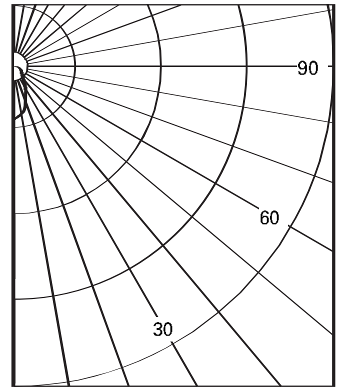
Maximum CD Throw — Driving Aisle

IES File# H39165



Driver Aisle with GG60

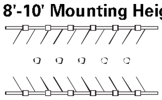
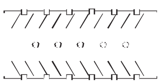
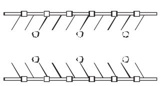
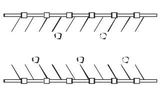
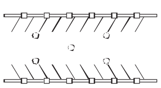
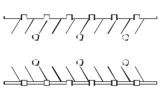
IES File# H39166



Side Throw with LTS

PSL-175-MH-MT
175-Watt MH
14,400-Lumen Clear Lamp

APPLICATION DATA

60' Wide Bays, 8'-10' Mounting Height	Layout	Spacing	Lamp Wattage	Horizontal Ave. fc	Horizontal Min. fc	Horizontal Max./Min.	Vertical Min. fc @ 5'
	Single Row	20' Spacing	175W Metal Halide 14,400 Lumens	5.1	2.0	9.8	2.8
	Single Row with GG60	20' Spacing	175W Metal Halide 14,400 Lumens	5.2	2.1	9.8	3.0
	Double Row	40' Spacing/ 30' Separation	100W Metal Halide 8,500 Lumens	2.8	1.1	7.2	1.0
	Alternating Double Row	20' Spacing/ 30' Separation	100W Metal Halide 8,500 Lumens	2.8	1.1	6.9	0.9
	Combination 2/1 Row	30' Spacing/ 30' Separation	100W Metal Halide 8,500 Lumens	2.8	1.2	7.2	0.6
	Double Row With GG60	40' Spacing/ 30' Separation	85W QL 6,000 Lumens	2.2	1.0	4.1	1.1

Reflectance: 20% Floor, 0% Walls, 20% Ceiling

ORDERING INFORMATION

SAMPLE NUMBER: PSL-175-MH-MT-WH

Product Family
PSL=Parking Structure Luminaire

Lamp Wattage
70=70W
85=85W [1]
100=100W
150=150W
175=175W
200=200W [2]

Lamp Type
MH=Metal Halide
MP=Pulse Start Metal Halide [2]
HPS=High Pressure Sodium
QL=Electrodeless Fluorescent [1]

Voltage
120
208
240
277
480
MT=Multi-Tap wired 277V [3]
TT=Triple-Tap wired 347V [4]
DT=Dual-Tap wired 277V [5]

Color [6]
WH=White
AP=Grey
BZ=Bronze
BK=Black

Options (add as suffix)
F=Single Fuse (120, 277, 347V) [7]
FF=Double Fuse (208, 240, 480V) [7]
Q=Quartz Restrike (Hot Restrike Only)
EM=Quartz Restrike with Time Delay (Strikes at cold start)
EM/SC=Emergency Separate Circuit
CT=Conduit Taps
LAG=Less Antenna Guard [8]
PL=Polycarbonate Lens (AccUView Inhibitor Applied) [9]
TR=Tamper Proof

Accessories (order separately)
PSL/BGL-XX=Bird Guard [10]
PSL/GG60=Glare Guard
PSL/TM=Trunnion Mount Kit
PSL/LTS-XX=Light Trespass Shield [10]
L=Lamp Included [11]

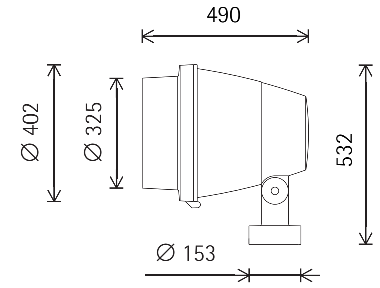
NOTES: 1 85W QL Electrodeless Fluorescent only. 120 or 240V only. **2** 200W MP only. **3** Multi-Tap 120/208/240/277V wired 277V. **4** Triple-Tap 120/277/347V wired 347V. **5** Dual-Tap 120/277V wired 277V. **6** Other finish colors available. Consult McGraw-Edison Architectural Colors brochure. **7** Must specify single voltage. **8** Removes standard cast aluminum protective cage assembly. **9** Maximum use of (2) GG60's or (2) LTS accessories when used with wattages in excess of 100W. **10** Must specify color on BGL and LTS accessories (Example: PSL/LTSWH). **11** Lamp is shipped separate from luminaire. Lamp is Cooper designated product based on luminaire requirements. Specified lamps must be ordered as a separate line item. **12** For complete product data, reference the McGraw-Edison Specification binder. **13** Specifications and dimensions subject to change without notice. **14** Products also available in non-US voltages and frequencies for international markets. **15** Consult your Cooper Lighting Representative for availability and ordering information.

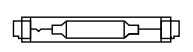
NOTE: Specifications and Dimensions subject to change without notice.

ERCO

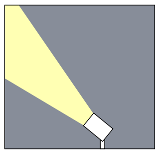
Beamer IV Projector

with mounting plate for metal halide lamps

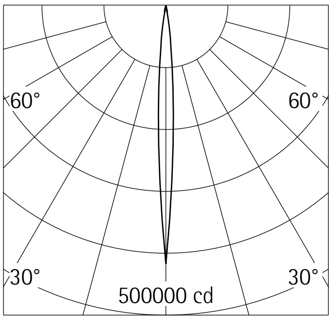




HIT-DE



IP65



HIT-DE 250W Fc2 20000lm

h(m)	E(lx)	D(m) 7°
2	104390	0.24
4	26098	0.49
6	11599	0.73
8	6524	0.98
10	4176	1.22

34009.000 Graphit m
HIT-DE 250W Fc2 20000lm

Product description
Housing, hinge and mounting plate: corrosion-resistant cast aluminium, No-Rinse surface treatment. Double powder-coated. Optimised surface for reduced accumulation of dirt. Hinge with internal wiring, 130° tilt. Graduated disc: corrosion-resistant aluminium. Mounting plate rotatable through 240°.
2 cable entries. Through-wiring possible. 3-pole terminal block.
Control gear with temperature controller, timer-ignitor.
Capacitor.
Spot reflector: aluminium, silver anodised, mirror-finish.
Screw-fastened snoot with safety glass: corrosion-resistant cast aluminium, double powder-coated.
Cross-baffle: metal, black lacquered. Cut-off angle 50°. Without spill light.
Protection mode IP65: dust-proof and water jet-proof.
Weight 19.50kg
Maximum wind load area 0.18m²

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info@erco.com

Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/34009.000

ERCO

Beamer IV Projector

Planning data

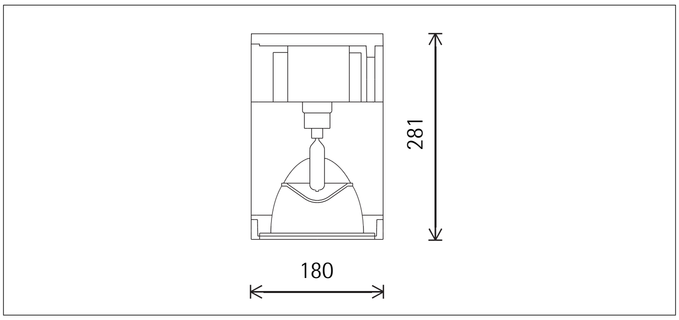
Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.98	0.94	0.90	0.86	0.95	0.91	0.86	0.81	0.94	0.90	0.84	0.79
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

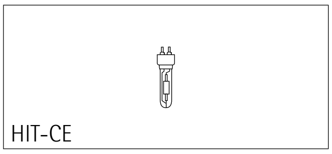
Hours of operation (h)	1000	2000	4000	6000	8000	10000	12000
LLMF	0.87	0.79	0.71	0.67	0.63	0.61	0.60
LSF	1	1	1	1	1	1	1

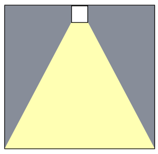
MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

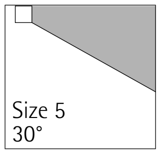
Cylinder Surface-mounted downlight

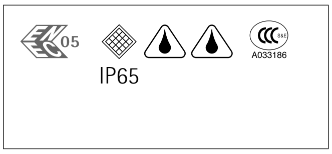
for metal halide lamps





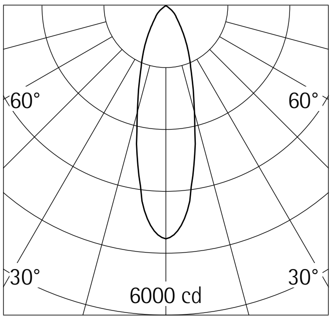






85045.000 Graphit m
HIT-CE 35W G12 3300lm

Product description
Cylinder and mounting plate: corrosion-resistant cast aluminium, No-rinse surface treatment. Double powder-coated.
Control gear with temperature controller, timer-ignitor, capacitor. 1 cable entry. Through-wiring possible. 3-pole terminal block.
Darklight reflector: aluminium, silver, bright anodised. Cut-off angle 30°. Diffuser as lamp cover: glass, frosted.
Fixing ring with safety glass: corrosion-resistant cast aluminium, double powder-coated. To be removed together with Darklight reflector for lamp replacement.
Tamper-proof screw.
Protection mode IP65: dust-proof and water jet-proof.
Weight 4.65kg



HIT-CE 35W G12 3300lm

h(m)	E(lx)	D(m) 29°
1	4521	0.52
2	1130	1.03
3	502	1.55
4	283	2.07
5	181	2.59

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Technical Region: 230V/50Hz
Edition: December 16, 2005
Please download the current version from
www.erco.com/85045.000

ERCO

Cylinder Surface-mounted downlight

Planning data

Cleaning (a)	1				2				3			
Ambient conditions	P	C	N	D	P	C	N	D	P	C	N	D
LMF	0.98	0.94	0.90	0.86	0.95	0.91	0.86	0.81	0.94	0.90	0.84	0.79
RSMF	0.99	0.98	0.96	0.95	0.97	0.96	0.95	0.94	0.97	0.96	0.95	0.94

Hours of operation (h)	1000	2000	4000	6000	8000	10000	12000
LLMF	0.89	0.84	0.81	0.79	0.77	0.76	0.75
LSF	1	1	1	1	1	1	1

MF	LMFxRSMFxLLMFxLSF
MF	Maintainance Factor
LMF	Lumiaire Maintenance Factor
RSMF	Room Surface Maintenance Factor
LLMF	Lamp Lumens Maintenance Factor
LSF	Lamp Survival Factor
P	Room pure
C	Room clean
N	Room normal
D	Room dirty

Return to: TRU-AIM IR® MR16 Print Page

Product Number: 58641

Order Abbreviation: 37MR16/IR/SP10/C 12V

General Description: Tungsten Halogen Tru-Aim MR16 IR UV-Stop Capsule With Axial Filament, Hard Dichroic Reflector GU5.3 Bi-Pin Base 37Watt 12Volt Narrow Spot Beam

Product Information	
Abbrev. With Packaging Info.	37MR16IRSP10C 12V 20/CS 1/SKU
Average Rated Life (hr)	4000
Base	GU5.3 Bipin
Beam Angle (deg)	10
Beam Type	NSP
Bulb	MR16
Centerbeam Candlepower (cp)	12500
Class	C (gas)
Color Rendering Index (CRI)	100
Color Temperature/CCT (K)	3000
Diameter (in)	2
Diameter (mm)	50.8
Ecologic	YES
Family Brand Name	TRU-AIM® IR
Filament	AXIAL
Horizontal Beam Angle (deg)	10
Maximum Overall Length - MOL (in)	1.75
Maximum Overall Length - MOL (mm)	44.45
Nominal Voltage (V)	12.00
Nominal Wattage (W)	37.00
Vertical Beam Angle (deg)	10

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC

Footnotes

- UV Filter capsule with axial filament in constant color, hard coated Dichroic reflector and infrared reflective coating on the lamp capsule.
- Infrared lamp technology

Return to: TRU-AIM IR® MR16 | Print Page

photo not available

Product Number:	58837
Order Abbreviation:	37MR16/IR/WFL60/C 12V
General Description:	ENERGY SAVING, LOW VOLTAGE, WIDE FLOOD MR16. 12 VOLTS. DICHROIC REFLECTOR PASSES HEAT OUT OF THE BACK OF THE BULB.

Product Information	
Abbrev. With Packaging Info.	37MR16IRWFL60C 12V 20/CS 1/SKU
Average Rated Life (hr)	4000
Base	GU5.3 Bipin
Beam Angle (deg)	60
Beam Type	WFL
Bulb	MR16
Centerbeam Candlepower (cp)	1100
Class	C (gas)
Diameter (in)	2
Diameter (mm)	50.8
Ecologic	YES
Filament	AXIAL
Horizontal Beam Angle (deg)	60
Lamp Finish	Reflector
Maximum Overall Length - MOL (in)	1.75
Maximum Overall Length - MOL (mm)	44.45
Nominal Voltage (V)	12.00
Nominal Wattage (W)	37.00
Vertical Beam Angle (deg)	60

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC ™

Footnotes

- Infrared lamp technology
- Max. seal temperature 350 C (662F)
- UV Filter capsule with axial filament in covered constant color, hard coated dichroic reflector and

Return to: CAPSYLITE IR® PAR30

Print Page

photo not available

Product Number: 14132

Order Abbreviation: 50PAR30/CAP/IR/NFL25 130V

General Description: 50 WATT PAR 30 FLOOD LAMP. 130 VOLTS. ENERGY EFFICIENT INFRARED CONSERVING TECHNOLOGY.

Product Information	
Abbrev. With Packaging Info.	50PAR30CAPIRNFL25 130V 15/CS 1/SKU
Approx. Lumens	900
Average Rated Life (hr)	3000
Base	E26 Medium
Beam Angle (deg)	25
Beam Type	NFL
Bulb	PAR30
Centerbeam Candlepower (cp)	2900
Class	C (gas)
Color Temperature/CCT (K)	2810
Diameter (in)	3.75
Diameter (mm)	95.25
Ecologic	YES
Family Brand Name	CAPSYLITE® IR® PAR30
Filament	CC-8
Horizontal Beam Angle (deg)	25
Lamp Finish	Reflector
Maximum Overall Length - MOL (in)	3.625
Maximum Overall Length - MOL (mm)	92.075
Nominal Voltage (V)	130.00
Nominal Wattage (W)	50.00
Vertical Beam Angle (deg)	25

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

E ECOLOGIC™ ★ I/O

| Return to: Enclosed Fixtures | | Print Page |

Product Number: 64325

Order Abbreviation: MC39T6/U/G12/940 PB 90V

General Description: 39W, 4000K, high CRI, reduced color shift, high performance, T6/G12 metal halide lamp, clear, universal burn

Product Information	
Abbrev. With Packaging Info.	MC39T6UG12940PB 90V 12/CS 1/SKU
ANSI Code	M130/E
Approx. Lumens (initial - horizontal)	3200
Approx. Lumens (initial - vertical)	3200
Approx. Lumens (mean - horizontal)	2560
Approx. Lumens (mean - vertical)	2560
Arc Length (in)	0.19
Arc Length (mm)	4.8
Average Rated Life - Horizontal (hr)	12000
Average Rated Life - Vertical (hr)	12000
Base	G12
Bulb	T6
Color Rendering Index (CRI)	87
Color Temperature/CCT (K)	4200
Diameter (in)	0.75
Diameter (mm)	19
Family Brand Name	Metalarc® Powerball
Fixture Requirement	E
Hot Restrike Time (min)	2-15
Lamp Finish	Clear
Light Center Length - LCL (in)	2.2
Light Center Length - LCL (mm)	56
Maximum Base Temperature - Fahrenheit	536
Maximum Base Temperature - Celsius	282
Maximum Bulb Temperature - Fahrenheit	842
Maximum Bulb Temperature - Celsius	450
Maximum Overall Length - MOL (in)	3.94

Return to: DULUX T/E (triple, 4-Pin) | Print Page

photo not available

Product Number:	20760
Order Abbreviation:	CF18DT/E/827
General Description:	DULUX 18W triple compact fluorescent lamp with 4-pin base, 2700K color temperature, 82 CRI, for use with electronic and dimming ballasts

Product Information	
Abbrev. With Packaging Info.	CF18DTE827 50/CS 1/SKU
Average Rated Life (hr)	12000
Base	GX24Q-2
Bulb	T4
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	2700
Family Brand Name	Dulux® T/E
Initial Lumens at 25C	1200
Mean Lumens at 25C	1032
Maximum Overall Length - MOL (in)	4.6
Maximum Overall Length - MOL (mm)	116
NEMA Generic Designation (current)	CFTR18W/GX24Q/827
Nominal Wattage (W)	18.00

Additional Product Information

Product Documents, Graphs, and Images

Compatible Ballast

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Rule of Thumb for Compact Fluorescent Lamps: Divide wattage of incandescent lamp by 4 to determine approximate wattage of compact fluorescent lamp that will provide similar light output.
- Minimum starting temperature is a function of the ballast; consult the ballast manufacturer.
- There is a NEMA supported, industry issue where T2, T4, and T5 fluorescent and compact fluorescent lamps operated on high frequency ballasts may experience an abnormal end-of-life phenomenon. This end-of-life phenomenon can resultin one or both of the following: 1. Bulb wall cracking near the lamp base. 2. The lamp can overheat in the base area and possibly melt the

Return to: DULUX D/E (double, 4-Pin) | Print Page

Product Number: 20673

Order Abbreviation: CF26DD/E/835

General Description: DULUX 26W double compact fluorescent lamp with 4-pin base, integral EOL, 3500K color temperature, 82 CRI, for use with electronic and dimming ballasts, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	CF26DDE835 50/CS 1/SKU
Average Rated Life (hr)	12000
Base	G24Q-3
Bulb	T4
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	3500
Family Brand Name	Dulux® D/E
Industry Standards	IEC 60901- 2526
Initial Lumens at 25C	1710
Mean Lumens at 25C	1470
Maximum Overall Length - MOL (in)	6.5
Maximum Overall Length - MOL (mm)	166
NEMA Generic Designation (current)	CFQ26W/G24Q/835
Nominal Wattage (W)	26.00

Additional Product Information

Product Documents, Graphs, and Images

Compatible Ballast

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Rule of Thumb for Compact Fluorescent Lamps: Divide wattage of incandescent lamp by 4 to determine approximate wattage of compact fluorescent lamp that will provide similar light output.
- Minimum starting temperature is a function of the ballast; consult the ballast manufacturer.
- There is a NEMA supported, industry issue where T2, T4, and T5 fluorescent and compact fluorescent lamps operated on high frequency ballasts may experience an abnormal end-of-life phenomenon. This end-of-life phenomenon can resultin one or both of the following: 1. Bulb wall

Return to: DULUX T/E (triple, 4-Pin)   Print Page

Product Number:	20767
Order Abbreviation:	CF26DT/E/827
General Description:	DULUX 26W triple compact fluorescent lamp with 4-pin base, integral EOL, 2700K color temperature, 82 CRI, for use with electronic and dimming ballasts

Product Information	
Abbrev. With Packaging Info.	CF26DTE827 50/CS 1/SKU
Average Rated Life (hr)	12000
Base	GX24Q-3
Bulb	T4
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	2700
Family Brand Name	Dulux® T/E
Industry Standards	IEC 60901- 3426
Initial Lumens at 25C	1800
Mean Lumens at 25C	1548
Maximum Overall Length - MOL (in)	5.2
Maximum Overall Length - MOL (mm)	124
NEMA Generic Designation (current)	CFTR26W/GX24Q/827
NEMA Generic Designation (old)	CFM26W/GX24Q/827
Nominal Wattage (W)	26.00

Additional Product Information

Product Documents, Graphs, and Images

Compatible Ballast

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Rule of Thumb for Compact Fluorescent Lamps: Divide wattage of incandescent lamp by 4 to determine approximate wattage of compact fluorescent lamp that will provide similar light

Return to: Dulux L High Lumen (single, long, 4-Pin) | Print Page

Product Number: 20581

Order Abbreviation: FT36DL/830

General Description: DULUX 36W long compact fluorescent lamp with 4-pin base, 3000K color temperature, 82 CRI, for use on magnetic, electronic and dimming ballasts

Product Information	
Abbrev. With Packaging Info.	FT36DL830 10/CS 1/SKU
Average Rated Life (hr)	12000
Base	2G11
Bulb	T5
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	3000
Family Brand Name	Dulux® L
Industry Standards	ANSI C78.901 - 2001
Initial Lumens at 25C	2900
Mean Lumens at 25C	2494
Maximum Overall Length - MOL (in)	16.6
Maximum Overall Length - MOL (mm)	422
NEMA Generic Designation (current)	FT36W/2G11/830
Nominal Wattage (W)	36.00

Additional Product Information

Product Documents, Graphs, and Images

Compatible Ballast

Packaging Information

ECOLOGIC

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- These lamps may also be operated on rapid start circuits. On rapid start circuits the 24 watt lamp operates at 27 watts and the 36 watt lamp operated at 39 watts. Rated life is unchanged.
- Rule of Thumb for Compact Fluorescent Lamps: Divide wattage of incandescent lamp by 4 to

Return to: Octron 800 XP | Print Page

Product Number: 21763

Order Abbreviation: FO32/835/XP/ECO

General Description: 32W, 48" MOL, T8 OCTRON XP Extended Performance fluorescent lamp, 3500K color temperature, rare earth phosphor, 85 CRI, suitable for IS or RS operation, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FO32835XPECO 30/CS 1/SKU
Actual Length (in)	47.78
Actual Length (mm)	1213.6
Average Rated Life (hr)	24000
Base	Medium Bipin
Bulb	T8
Color Rendering Index (CRI)	85
Color Temperature/CCT (K)	3500
Diameter (in)	1.10
Diameter (mm)	27.9
Family Brand Name	OCTRON® 800 XP®, ECOLOGIC®
Industry Standards	ANSI C78.81 - 2001
Initial Lumens at 25C	3000
Mean Lumens at 25C	2850
Nominal Length (in)	48
Nominal Wattage (W)	32.00

Additional Product Information

Product Documents, Graphs, and Images

Compatible Ballast

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Life rating of OCTRON XP lamps operated on instant start electronic ballasts is 18,000 hours

Return to: Octron 800 XPS

Print Page

Product Number: 21697

Order Abbreviation: FO32/835/XPS/ECO

General Description: 32W, 48" MOL, T8 OCTRON XPS Extended Performance Super fluorescent lamp, 3500K color temperature, rare earth phosphor, 85 CRI, suitable for IS or RS operation, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FO32835XPSECO 30/CS 1/SKU
Actual Length (in)	47.78
Actual Length (mm)	1213.6
Average Rated Life (hr)	30000
Base	Medium Bipin
Bulb	T8
Color Rendering Index (CRI)	85
Color Temperature/CCT (K)	3500
Diameter (in)	1.10
Diameter (mm)	27.9
Family Brand Name	Octron® 800 XPS, Ecologic
Industry Standards	ANSI C78.81 - 2001
Initial Lumens at 25C	3100
Mean Lumens at 25C	2945
Nominal Length (in)	48
Nominal Wattage (W)	32.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC™

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Lumen output rated on high frequency operation. 60 HZ operation would result in lower lumen output.
- Minimum starting temperature is a function of the ballast; consult the ballast manufacturer.
- OCTRON lamps should be operated only with magnetic rapid start ballasts designed to operate 265 mA, T-8 lamps or high frequency (electronic) ballasts that are either instant start, or rapid start, or programmed rapid start specifically designed to operate T8 lamps. OCTRON lamps may be operated on instant start ballasts with ballast factors ranging from a minimum of 0.71 to a

Return to: Octron 800 XP

Print Page

Product Number: 21767

Order Abbreviation: FO32/841/XP/ECO

General Description: 32W, 48" MOL, T8 OCTRON XP Extended Performance fluorescent lamp, 4100K color temperature, rare earth phosphor, 85 CRI, suitable for IS or RS operation, ECOLOGIC

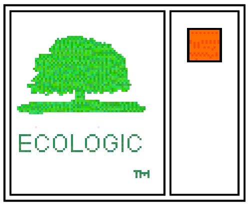
Product Information	
Abbrev. With Packaging Info.	FO32841XPECO 30/CS 1/SKU
Actual Length (in)	47.78
Actual Length (mm)	1213.6
Average Rated Life (hr)	24000
Base	Medium Bipin
Bulb	T8
Color Rendering Index (CRI)	85
Color Temperature/CCT (K)	4100
Diameter (in)	1.10
Diameter (mm)	27.9
Family Brand Name	OCTRON® 800 XP®, ECOLOGIC®
Industry Standards	ANSI C78.81 - 2001
Initial Lumens at 25C	3000
Mean Lumens at 25C	2850
Nominal Length (in)	48
Nominal Wattage (W)	32.00

Additional Product Information

Product Documents, Graphs, and Images

Compatible Ballast

Packaging Information



Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Life rating of OCTRON XP lamps operated on instant start electronic ballasts is 18,000 hours

Return to: Octron 800 XPS Print Page

Product Number: 21681

Order Abbreviation: FO32/841/XPS/ECO

General Description: 48" MOL, T8 OCTRON XPS Extended Performance Super fluorescent lamp, 4100K color temperature, rare earth phosphor, 85 CRI, ECOLOGIC suitable for IS and RS operation, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FO32841XPSECO 30/CS 1/SKU
Actual Length (in)	47.78
Actual Length (mm)	1213.6
Average Rated Life (hr)	30000
Base	Medium Bipin
Bulb	T8
Color Rendering Index (CRI)	85
Color Temperature/CCT (K)	4100
Diameter (in)	1.10
Diameter (mm)	27.9
Family Brand Name	Octron® 800 XPS, Ecologic
Industry Standards	ANSI C78.81 - 2001
Initial Lumens at 25C	3150
Mean Lumens at 25C	2990
Nominal Length (in)	48
Nominal Wattage (W)	32.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.
- The life ratings of fluorescent lamps are based on 3 hr. burning cycles under specified conditions and with ballast meeting ANSI specifications. If burning cycle is increased, there will be a corresponding increase in the average hours life.
- Lumen output rated on high frequency operation. 60 HZ operation would result in lower lumen output.
- Minimum starting temperature is a function of the ballast; consult the ballast manufacturer.
- OCTRON lamps should be operated only with magnetic rapid start ballasts designed to operate 265 mA, T-8 lamps or high frequency (electronic) ballasts that are either instant start, or rapid start, or programmed rapid start specifically designed to operate T8 lamps. OCTRON lamps may be operated on instant start ballasts with ballast factors ranging from a minimum of 0.71 to a

Return to: Pentron Standard | Print Page

Product Number: 20914

Order Abbreviation: FP14/841/ECO

General Description: 14W, T5 PENTRON fluorescent lamp, 4100K color temperature, rare earth phosphor, 82 CRI, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FP14841ECO 40/CS 1/SKU
Actual Length (in)	22.2
Actual Length (mm)	563.2
Average Rated Life (hr)	20000
Base	Miniature Bipin
Bulb	T5
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	4100
Diameter (in)	0.67
Diameter (mm)	17.0
Family Brand Name	PENTRON® ECO®
Initial Lumens at 25C	1200
Initial Lumens at 35C	1350
Mean Lumens at 25C	1116
Mean Lumens at 35C	1256
Nominal Length (in)	24
Nominal Wattage (W)	14.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC™

Footnotes

- Approximate initial lumens after 100 hours operation.

Return to: Pentron Standard | Print Page

Product Number:	20901
Order Abbreviation:	FP28/835/ECO
General Description:	28W, T5 PENTRON fluorescent lamp, 3500K color temperature, rare earth phosphor, 82 CRI, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FP28835ECO 40/CS 1/SKU
Actual Length (in)	45.8
Actual Length (mm)	1163.2
Average Rated Life (hr)	20000
Base	Miniature Bipin
Bulb	T5
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	3500
Diameter (in)	0.67
Diameter (mm)	17.0
Family Brand Name	PENTRON® ECO®
Initial Lumens at 25C	2600
Initial Lumens at 35C	2900
Mean Lumens at 25C	2418
Mean Lumens at 35C	2697
Nominal Length (in)	48
Nominal Wattage (W)	28.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.

Return to: Pentron Standard | Print Page

Product Number:	20902
Order Abbreviation:	FP28/841/ECO
General Description:	28W, T5 PENTRON fluorescent lamp, 4100K color temperature, rare earth phosphor, 82 CRI, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FP28841ECO 40/CS 1/SKU
Actual Length (in)	45.8
Actual Length (mm)	1163.2
Average Rated Life (hr)	20000
Base	Miniature Bipin
Bulb	T5
Color Rendering Index (CRI)	82
Color Temperature/CCT (K)	4100
Diameter (in)	0.67
Diameter (mm)	17.0
Family Brand Name	PENTRON® ECO®
Initial Lumens at 25C	2600
Initial Lumens at 35C	2900
Mean Lumens at 25C	2418
Mean Lumens at 35C	2697
Nominal Length (in)	48
Nominal Wattage (W)	28.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

Footnotes

- Approximate initial lumens after 100 hours operation.

Return to: Pentron HO

Print Page

Product Number:	20904
Order Abbreviation:	FP54/835/HO/ECO
General Description:	54W, T5 PENTRON high output (HO) fluorescent lamp, 3500K color temperature, rare earth phosphor, 85 CRI, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FP54835HOECO 40/CS 1/SKU
Actual Length (in)	45.8
Actual Length (mm)	1163.2
Average Rated Life (hr)	25000
Base	Miniature Bipin
Bulb	T5
Color Rendering Index (CRI)	85
Color Temperature/CCT (K)	3500
Diameter (in)	0.67
Diameter (mm)	17.0
Family Brand Name	PENTRON® ECO®
Initial Lumens at 25C	4450
Initial Lumens at 35C	5000
Mean Lumens at 25C	4138
Mean Lumens at 35C	4650
Nominal Length (in)	48
Nominal Wattage (W)	54.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC TM

Footnotes

- Approximate initial lumens after 100 hours operation.

Return to: Pentron HO

Print Page

Product Number:	20906
Order Abbreviation:	FP54/841/HO/ECO
General Description:	54W, T5 PENTRON high output (HO) fluorescent lamp, 4100K color temperature, rare earth phosphor, 85 CRI, ECOLOGIC

Product Information	
Abbrev. With Packaging Info.	FP54841HOECO 40/CS 1/SKU
Actual Length (in)	45.8
Actual Length (mm)	1163.2
Average Rated Life (hr)	25000
Base	Miniature Bipin
Bulb	T5
Color Rendering Index (CRI)	85
Color Temperature/CCT (K)	4100
Diameter (in)	0.67
Diameter (mm)	17.0
Family Brand Name	PENTRON® ECO®
Initial Lumens at 25C	4450
Initial Lumens at 35C	5000
Mean Lumens at 25C	4138
Mean Lumens at 35C	4650
Nominal Length (in)	48
Nominal Wattage (W)	54.00

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC ™

Footnotes

- Approximate initial lumens after 100 hours operation.

Return to: Standard & Pro-Tech (>150W) | Print Page

Product Number: 64471

Order Abbreviation: M175/U

General Description: 175W general lighting metal halide lamp, universal burn, clear

Product Information	
Abbrev. With Packaging Info.	M175U 6/CS 1/SKU
ANSI Code	M57/E
Approx. Lumens (initial - horizontal)	12800
Approx. Lumens (initial - vertical)	14400
Approx. Lumens (mean - horizontal)	9300
Approx. Lumens (mean - vertical)	9300
Arc Length (in)	1.02
Arc Length (mm)	26
Average Rated Life - Horizontal (hr)	7500
Average Rated Life - Vertical (hr)	10000
Base	E39 Mogul
Bulb	BT28
Color Rendering Index (CRI)	65
Color Temperature/CCT (K)	4200
Diameter (in)	3.5
Diameter (mm)	89
Family Brand Name	Metalarc®
Fixture Requirement	E
Hot Restrike Time (min)	7-12
Lamp Finish	Clear
Light Center Length - LCL (in)	5
Light Center Length - LCL (mm)	127
Maximum Base Temperature - Fahrenheit	482
Maximum Base Temperature - Celsius	250
Maximum Bulb Temperature - Fahrenheit	752
Maximum Bulb Temperature - Celsius	400
Maximum Overall Length - MOL (in)	8.31
Maximum Overall Length - MOL (mm)	211
Nominal Voltage (V)	132.00
Nominal Wattage (W)	175.00
Operating Position	Universal
Warm-up Time (min)	2-4

Return to: Standard & Pro-Tech (>150W) | Print Page

Product Number: 64479

Order Abbreviation: M175/U/MED

General Description: Compact 175W reduced outer jacket, universal burn metal halide lamp, clear

Product Information	
Abbrev. With Packaging Info.	M175UMED 20/CS 1/SKU
ANSI Code	M57/E
Approx. Lumens (initial - horizontal)	12800
Approx. Lumens (initial - vertical)	14400
Approx. Lumens (mean - horizontal)	9300
Approx. Lumens (mean - vertical)	9300
Arc Length (in)	1.02
Arc Length (mm)	26
Average Rated Life - Horizontal (hr)	7500
Average Rated Life - Vertical (hr)	10000
Base	E26 Medium
Bulb	E17
Color Rendering Index (CRI)	65
Color Temperature/CCT (K)	4000
Diameter (in)	2.13
Diameter (mm)	54
Family Brand Name	Compact Metalarc®
Fixture Requirement	E
Hot Restrike Time (min)	7-12
Lamp Finish	Clear
Light Center Length - LCL (in)	3.39
Light Center Length - LCL (mm)	86
Maximum Base Temperature - Fahrenheit	410
Maximum Base Temperature - Celsius	210
Maximum Bulb Temperature - Fahrenheit	752
Maximum Bulb Temperature - Celsius	400
Maximum Overall Length - MOL (in)	5.43
Maximum Overall Length - MOL (mm)	138
Nominal Voltage (V)	132.00
Nominal Wattage (W)	175.00
Operating Position	Universal
Warm-up Time (min)	2-4

ADVANCE

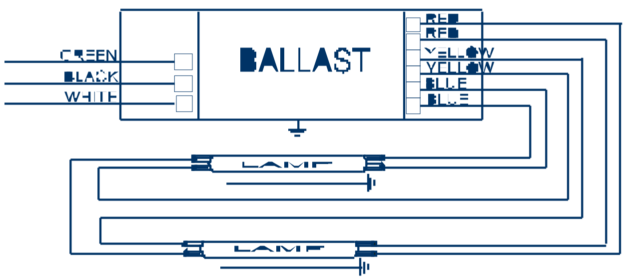
ICN-2S28@277

Brand Name	CENTIUM T5
Ballast Type	Electronic
Starting Method	Programmed Start
Lamp Connection	Series
Input Voltage	277
Input Frequency	50/60 HZ
Status	Active

Electrical Specifications

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Input Power (ANSI Watts)	Ballast Factor	MAX THD %	Power Factor	MAX Lamp Current Crest Factor	B.E.F.
F14T5	1	14	0/-18	0.07	19	1.07	20	0.90	1.7	5.63
* F14T5	2	14	0/-18	0.13	34	1.06	10	0.98	1.7	3.12
F21T5	1	21	0/-18	0.10	26	1.03	15	0.95	1.7	3.96
F21T5	2	21	0/-18	0.17	48	1.02	10	0.98	1.7	2.13
F28T5	1	28	0/-18	0.12	33	1.04	10	0.98	1.7	3.15
F28T5	2	28	0/-18	0.23	63	1.03	10	0.99	1.7	1.63
F35T5	1	35	0/-18	0.15	41	1.01	10	0.98	1.7	2.46
F35T5	2	35	0/-18	0.28	77	1.00	10	0.99	1.7	1.30

Wiring Diagram



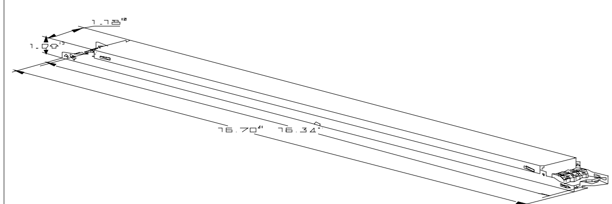
The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

	in.	cm.
Black	0	0
White	0	0
Blue	0	0
Red	0	0
Yellow	0	0
Gray	0	0
Violet	0	0

	in.	cm.
Yellow/Blue	0	0
Blue/White	0	0
Brown	0	0
Orange	0	0
Orange/Black	0	0
Black/White	0	0
Red/White	0	0

Enclosure



Enclosure Dimensions

OverAll (L)	Width (W)	Height (H)	Mounting (M)
16.70 "	1.18 "	1.00 "	16.34 "
16 7/10	1 9/50	1	16 17/50
42.4 cm	3 cm	2.5 cm	41.5 cm

Revised 09/01/2004

Data is based upon tests performed by Advance Transformer in a controlled environment and representative of relative performance. Actual performance can vary depending on operating conditions. Specifications are subject to change without notice. All specifications are nominal unless otherwise noted.

ADVANCE TRANSFORMER CO.

O'HARE INTERNATIONAL CENTER · 10275 WEST HIGGINS ROAD · ROSEMONT, IL 60018

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Corporate Offices: Phone: 800-322-2086

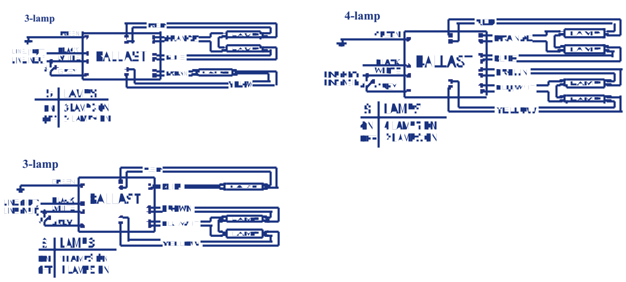
ICN4S5490C2LS@277

Brand Name	CENTIUM T5
Ballast Type	Electronic
Starting Method	Programmed Start
Lamp Connection	Series/Parallel
Input Voltage	277
Input Frequency	50/60 HZ
Status	Active

Electrical Specifications

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Input Power (ANSI Watts)	Ballast Factor	MAX THD %	Power Factor	MAX Lamp Current Crest Factor	B.E.F.
F54T5/HO	1	54	0/-18	0.24	62	0.99	30	0.90	1.7	1.60
* F54T5/HO	2	54	0/-18	0.43	117	0.99	10	0.98	1.7	0.85
F54T5/HO	3	54	0/-18	0.66	179	1.00	10	0.98	1.7	0.56
F54T5/HO	4	54	0/-18	0.86	234	1.00	10	0.98	1.7	0.43

Wiring Diagram



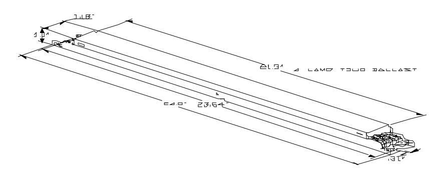
The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

	in.	cm.
Black	0	0
White	0	0
Blue	0	0
Red	0	0
Yellow	0	0
Gray	0	0
Violet	0	0

	in.	cm.
Yellow/Blue	0	0
Blue/White	0	0
Brown	0	0
Orange	0	0
Orange/Black	0	0
Black/White	0	0
Red/White	0	0

Enclosure



Enclosure Dimensions

OverAll (L)	Width (W)	Height (H)	Mounting (M)
24 "	1.18 "	1 "	23.64 "
24	1 9/50	1	23 16/25
61 cm	3 cm	2.5 cm	60 cm

Revised 10/04/2005

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Corporate Offices: Phone: 800-322-2086

ADVANCE

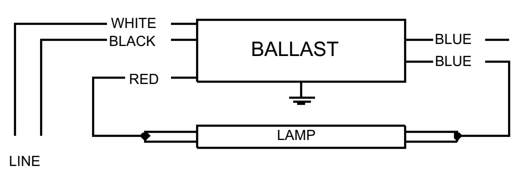
VOP-2P32-SC

Brand Name	OPTANIUM
Ballast Type	Electronic
Starting Method	Instant Start
Lamp Connection	Parallel
Input Voltage	277
Input Frequency	50/60 HZ
Status	Active

Electrical Specifications

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Input Power (ANSI Watts)	Ballast Factor	MAX THD %	Power Factor	MAX Lamp Current Crest Factor	B.E.F.
F17T8	1	17	0/-18	0.08	19	1.02	15	0.95	1.7	5.37
F17T8	2	17	0/-18	0.11	31	0.90	15	0.97	1.7	2.90
F25T8	1	25	0/-18	0.10	27	1.02	15	0.97	1.7	3.78
F25T8	2	25	0/-18	0.16	43	0.88	10	0.99	1.7	2.05
F32T8	1	32	0/-18	0.13	35	1.01	15	0.98	1.7	2.89
F32T8	2	32	0/-18	0.20	55	0.88	10	0.99	1.7	1.60
* F32T8/ES (30W)	1	30	60/16	0.12	33	1.01	15	0.97	1.7	3.06
F32T8/ES (30W)	2	30	60/16	0.19	52	0.88	10	0.99	1.7	1.69
F40T8	1	40	32/00	0.15	41	1.01	15	0.99	1.7	2.46
F40T8	2	40	32/00	0.24	67	0.88	10	0.99	1.7	1.31

Wiring Diagram



Diag. 68

Insulate unused blue lead for 1000V

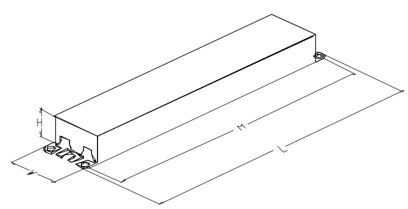
The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

	in.	cm.
Black	25L	63.5
White	25L	63.5
Blue	31R	78.7
Red	37L	94
Yellow	0	0
Gray	0	0
Violet	0	0

	in.	cm.
Yellow/Blue	0	0
Blue/White	0	0
Brown	0	0
Orange	0	0
Orange/Black	0	0
Black/White	0	0
Red/White	0	0

Enclosure



Enclosure Dimensions

OverAll (L)	Width (W)	Height (H)	Mounting (M)
9.50 "	1.7 "	1.18 "	8.90 "
9 1/2	1 7/10	1 9/50	8 9/10
24.1 cm	4.3 cm	3 cm	22.6 cm

Revised 06/09/2003

Data is based upon tests performed by Advance Transformer in a controlled environment and representative of relative performance. Actual performance can vary depending on operating conditions. Specifications are subject to change without notice. All specifications are nominal unless otherwise noted.

ADVANCE TRANSFORMER CO.
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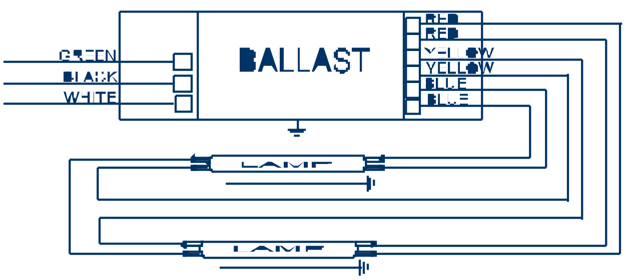
Corporate Offices: Phone: 800-322-2086

Electrical Specifications

ICN-2S39@277V	
Brand Name	CENTIUM T5
Ballast Type	Electronic
Starting Method	Programmed Start
Lamp Connection	Series
Input Voltage	277
Input Frequency	50/60 HZ
Status	Active

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Input Power (ANSI Watts)	Ballast Factor	MAX THD %	Power Factor	MAX Lamp Current Crest Factor	B.E.F.
FT36W/2G11	1	36	0/-18	0.13	36	0.96	15	0.95	1.7	2.67
* FT36W/2G11	2	36	0/-18	0.25	69	0.94	10	0.98	1.7	1.36

Wiring Diagram



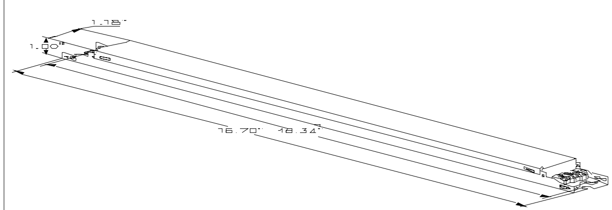
The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

	in.	cm.
Black	0	0
White	0	0
Blue	0	0
Red	0	0
Yellow	0	0
Gray	0	0
Violet	0	0

	in.	cm.
Yellow/Blue	0	0
Blue/White	0	0
Brown	0	0
Orange	0	0
Orange/Black	0	0
Black/White	0	0
Red/White	0	0

Enclosure



Enclosure Dimensions

OverAll (L)	Width (W)	Height (H)	Mounting (M)
16.70 "	1.18 "	1.00 "	16.34 "
16 7/10	1 9/50	1	16 17/50
42.4 cm	3 cm	2.5 cm	41.5 cm

Revised 09/01/2004

Data is based upon tests performed by Advance Transformer in a controlled environment and representative of relative performance. Actual performance can vary depending on operating conditions. Specifications are subject to change without notice. All specifications are nominal unless otherwise noted.

ADVANCE TRANSFORMER CO.
O'HARE INTERNATIONAL CENTER · 10275 WEST HIGGINS ROAD · ROSEMONT, IL 60018
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Corporate Offices: Phone: 800-322-2086

ADVANCE

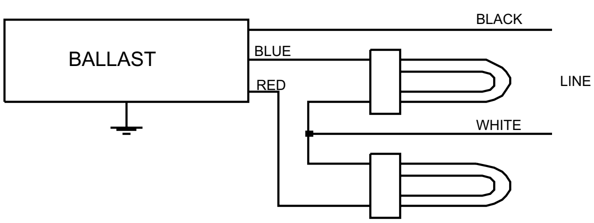
VH-2Q18-TP-W

Brand Name	COMPACT-HPF
Ballast Type	Magnetic
Starting Method	Pre-Heat
Lamp Connection	Series
Input Voltage	277
Input Frequency	60 HZ
Status	Active

Electrical Specifications

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Starting Current (Amps)	Open Circuit (Amps)	Input Power (Watts)	Ballast Factor	MAX THD %	Power Factor
* CFM18W/GX24D	2	18	50/10	0.15	0.28	0.00	40	0.96	25	0.97
CFQ18W/G24D	2	18	50/10	0.15	0.28	0.00	42	0.93	15	1.00

Wiring Diagram



Diag. 51

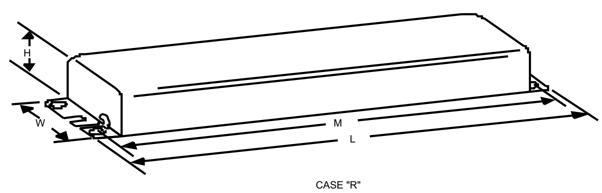
The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

	in.	cm.
Black	15	38.1
White		0
Blue	15	38.1
Red	15	38.1
Yellow		0
Gray		0
Violet		0

	in.	cm.
Yellow/Blue		0
Blue/White		0
Brown		0
Orange		0
Orange/Black		0
Black/White		0
Red/White		0

Enclosure



Enclosure Dimensions

OverAll (L)	Width (std)/(TP)	Height (H)	Mounting (M)
9.50 "	2.375 "	1.6875 "	8.90625 "
9 1/2	2 3/8	1 11/16	8 29/32
24.1 cm	6 cm / 0 cm	4.3 cm	22.6 cm

Revised 07/01/1999

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Corporate Offices: Phone: 800-322-2086

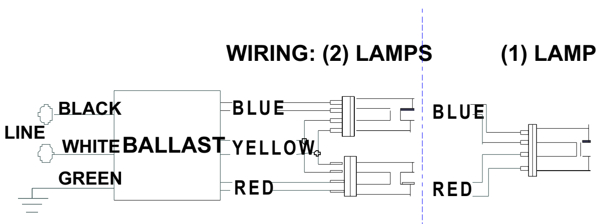
RCF-2S18-M1-LS-QS

Brand Name	SMARTMATE
Ballast Type	Electronic
Starting Method	Rapid Start
Lamp Connection	Series
Input Voltage	120
Input Frequency	60 HZ
Status	Active

Electrical Specifications

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Input Power (ANSI Watts)	Ballast Factor	MAX THD %	Power Factor	MAX Lamp Current Crest Factor	B.E.F.
CFQ18W/G24Q	1	18	0/-18	0.16	19	1.00	10	0.97	1.5	5.26
CFQ18W/G24Q	2	18	0/-18	0.30	35	0.95	10	0.99	1.5	2.71
CFS16W/GR10Q	2	16	0/-18	0.31	37	1.00	10	0.99	1.5	2.70
CFS21W/GR10Q	1	21	0/-18	0.16	20	0.90	10	0.97	1.5	4.50
CFS21W/GR10Q	2	21	0/-18	0.16	40	0.91	10	0.97	1.5	2.28
CFTR18W/GX24Q	1	18	0/-18	0.17	20	1.05	10	0.97	1.5	5.25
* CFTR18W/GX24Q	2	18	0/-18	0.33	39	1.05	10	0.99	1.5	2.69

Wiring Diagram

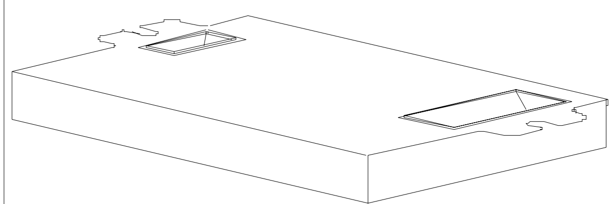


Green Terminal must be Grounded

The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

Enclosure



Enclosure Dimensions

OverAll (L)	Width (W)	Height (H)	Mounting (M)
4.98 "	2.4 "	1.0 "	4.6 "
4 49/50	2 2/5	1	4 3/5
12.6 cm	6.1 cm	2.5 cm	11.7 cm

Revised 09/02/2004

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Corporate Offices: Phone: 800-322-2086

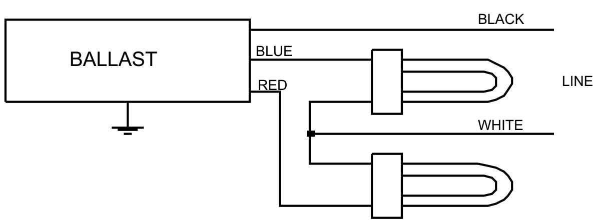
VH-2Q26-TP-W

Brand Name	COMPACT-HPF
Ballast Type	Magnetic
Starting Method	Pre-Heat
Lamp Connection	Series
Input Voltage	277
Input Frequency	60 HZ
Status	Active

Electrical Specifications

Lamp Type	Num. of Lamps	Rated Lamp Watts	Min. Start Temp (°F/C)	Input Current (Amps)	Starting Current (Amps)	Open Circuit (Amps)	Input Power (Watts)	Ballast Factor	MAX THD %	Power Factor
* CFM26W/GX24D	2	26	50/10	0.21	0.32	0.00	58	0.94	25	1.00
CFQ26W/G24D	2	26	50/10	0.20	0.32	0.00	55	0.87	20	0.99

Wiring Diagram



Diag. 51

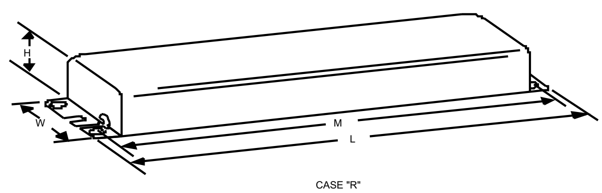
The wiring diagram that appears above is for the lamp type denoted by the asterisk (*)

Standard Lead Length (inches)

	in.	cm.
Black	15	38.1
White		0
Blue	15	38.1
Red	15	38.1
Yellow		0
Gray		0
Violet		0

	in.	cm.
Yellow/Blue		0
Blue/White		0
Brown		0
Orange		0
Orange/Black		0
Black/White		0
Red/White		0

Enclosure



Enclosure Dimensions

OverAll (L)	Width (std)/(TP)	Height (H)	Mounting (M)
9.50 "	2.375 "	1.6875 "	8.90625 "
9 1/2	2 3/8	1 11/16	8 29/32
24.1 cm	6 cm / 0 cm	4.3 cm	22.6 cm

Revised 09/28/1999

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Corporate Offices: Phone: 800-322-2086

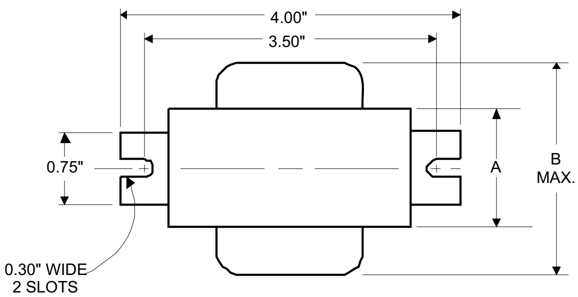
ADVANCE

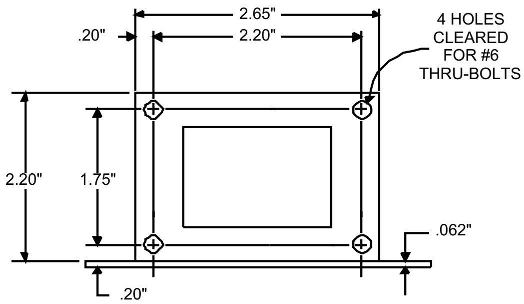
Metal Halide Lamp Ballast

Catalog Number 71A5437BP
For 150W M102
60 Hz R-HPF
Status: Active

DIMENSIONS AND DATA

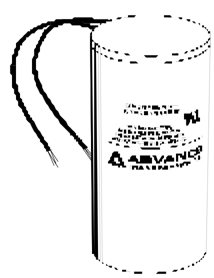
2 5/8 X 2 3/16 CORE





INPUT VOLTS		277
CIRCUIT TYPE	R-HPF	
POWER FACTOR (min)	90%	
REGULATION		
Line Volts	±5%	
Lamp Watts	±10%	
LINE CURRENT (Amps)		
Operating		0.63
Open Circuit		1.50
Starting		0.70
UL TEMPERATURE RATINGS		
Insulation Class	H(180°C)	
Coil Temperature Code	1029	B
MIN. AMBIENT STARTING TEMP.	-20°F or -30°C	
NOM. OPEN CIRCUIT VOLTAGE	277	
INPUT VOLTAGE AT LAMP DROPOUT		170
INPUT WATTS	173	
RECOMMENDED FUSE (Amps)		5
CORE and COIL		
Dimension (A)	2.50	
Dimension (B)	4.00	
Weight (lbs.)	4.2	
Lead Lengths	12"	
CAPACITOR REQUIREMENT		
Microfarads	14.0	
Volts (min.)	280	
Fault Current Withstand (amps)		
60 Hz TEST PROCEDURES (Refer to Advance Test Procedure for HID Ballasts - Form 1270)		
High Potential Test (Volts)		
1 minute	2000	
2 seconds	2500	
Open Circuit Voltage Test (Volts)	250-305	
Short-Circuit Current Test (Amps)		
Secondary Current	2.00-2.50	
Input Current		0.50 - - - -
		0.75

Capacitor: 7C140M33-R



Capacitance: 14
Dia/Oval Dim: 1.5
Height: 2.9
Temp Rating: 105°C

Ignitor: INTEGRAL

An ignitor integral to the core and coil assembly is used to start the lamp.

Ballast to Lamp Distance (BTL) = 2 feet
Temp Rating: 125°C

Wiring Diagram:

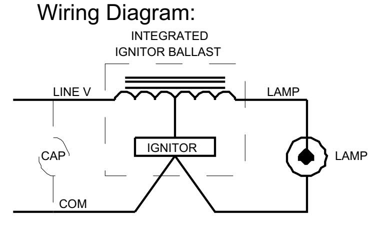


Fig. H

Ordering Information

Order Suffix	Description
500DB	Ballast With Integral Igniter and Dry Film Capacitor
510DB	Ballast w/Welded Bracket, Integral Igniter & Dry Film Cap.
600B	Ballast and Integral Ignitor, No Capacitor
610B	Ballast w/Welded Bracket and Integral Igniter, No Capacitor

Data is based upon tests performed by Advance Transformer in a controlled environment and representative of relative performance. Actual performance can vary depending on operating conditions. Specifications are subject to change without notice.

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05/15/03

e-Vision® Electronic Ballast for Metal Halide Lamps

ADVANCE

Catalog Number IMH-50-A
For (1) 39W ANSI M130 or
(1) 50W ANSI M110 Metal Halide Lamp
120-277V 50/60Hz Electronic
Status: Active

DIMENSIONS AND DATA

Lamp Data Number	Lamp Data Watts	Input Volts	Catalog Number*	Line Current (Amps)	Input Power (W)	Ballast Factor	Max THD (%)	Min Power Factor	Wiring Dia	Figure	Weight (lb)	Max Distance to Lamp (ft)
39 Watt Lamp, ANSI Code M130 Minimum Starting Temp -30°C/-20°F												
1	39	120	IMH-50-A-xxx	0.38	45	1.0	15	0.9	1	A	1.4	5
		277		0.16	44							
50 Watt Lamp, ANSI Code M110 Minimum Starting Temp -30°C/-20°F												
1	50	120	IMH-50-A-xxx	0.47	56	1.0	15	0.9	2	A	1.4	5
		277		0.20	55							

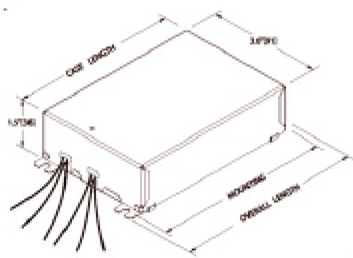
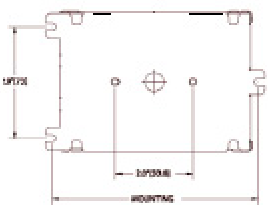
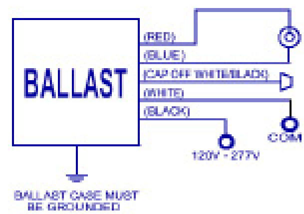


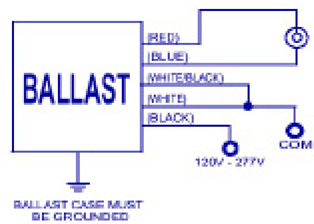
Figure A



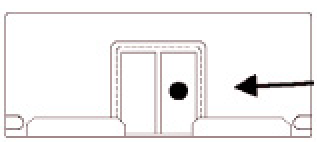
CASE LENGTH = 4.72" [120mm]
MOUNTING LENGTH = 5.20" [132mm]
MOUNTING WIDTH = 2.87" [73mm]
OVERALL LENGTH = 5.51" [140mm]
CASE WIDTH = 3.62" [92mm]
HEIGHT = 1.50" [38mm]



Wiring Diagram 1



Wiring Diagram 2



MEASURE CASE TEMPERATURE ON RIGHT HEAT SINK CLIP AT BALAST END

Case Temperature Measurement Location

INSTALLATION & APPLICATION NOTES:

1. Maximum allowable case temperature is 85°C. See figure above for measurement location
2. Ignition pulse is 4 kV max
3. All leads are 12 inches long
4. Ballast output will shutdown after 20 minutes if lamp fails to ignite
5. Power must be cycled off – then on, after replacing lamp

*Ordering Information

Order Suffix	Description
-LF	Ballast with side exit leads and mounting feet
-BLS	Ballast with bottom exit leads and mounting studs

Data is based on tests performed by Advance transformer in a controlled environment and representative of relative performance. Actual performance can vary depending on operating conditions. Specifications are subject to change without notice. All specifications are nominal unless otherwise noted.

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A DIVISION OF PHILIPS ELECTRONICS NORTH AMERICA CORPORATION

10/11/05

e-Vision® Electronic Ballast for Metal Halide Lamps

Catalog Number IMH-175-C
For (1) 150W ANSI M102, M142 or (1) 175W ANSI M137, M152 Metal Halide Lamp
120-277V 50/60Hz Electronic
Status: Released

DIMENSIONS AND DATA

Lamp Data		Input Volts	Catalog Number*	Line Current (Amps)	Input Power (W)	Ballast Factor	Max THD (%)	Min Power Factor	Wiring Dia	Figure	Weight (lb)	Max Distance to Lamp (ft)
Number	Watts											
150 Watt Lamp, ANSI Code M102 or M142 (or 150W HPS Lamp ANSI S56) Minimum Starting Temp -30°C/-20°F												
1	150	120	IMH-175-C-xxx	1.4	169	1.0	15	0.9	1	C	2.5	5
		277		0.6	166							
175 Watt Lamp, ANSI Code M137 or M152 Minimum Starting Temp -30°C/-20°F												
1	175	120	IMH-175-C-xxx	1.7	194	1.0	15	0.9	2	C	2.5	5
		277		0.7	191							

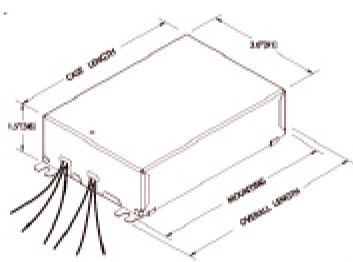
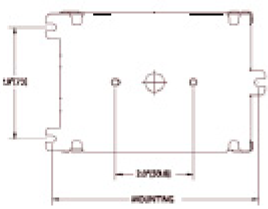
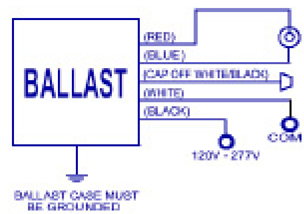


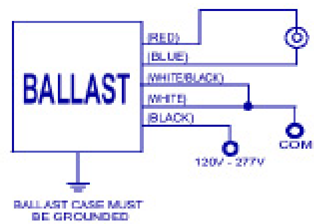
Figure C



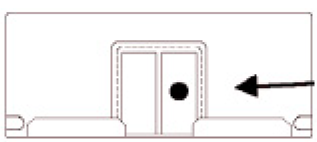
CASE LENGTH = 7.3" [184]
MOUNTING LENGTH = 7.7" [195]
MOUNTING WIDTH = 2.9" [73]
OVERALL LENGTH = 8.02" [204]
CASE WIDTH = 3.6" [91]
HEIGHT = 1.5" [38]



Wiring Diagram 1



Wiring Diagram 2



MEASURE CASE TEMPERATURE ON RIGHT HEAT SINK CLIP AT BALAST END

Case Temperature Measurement Location

INSTALLATION & APPLICATION NOTES:

1. Maximum allowable case temperature is 85°C. See figure above for measurement location
2. Ignition pulse is 4 kV max
3. All leads are 12 inches long
4. Ballast output will shutdown after 20 minutes if lamp fails to ignite
5. Power must be cycled off – then on, after replacing lamp

*Ordering Information

Order Suffix	Description
-LF	Ballast with side exit leads and mounting feet
-BLS	Ballast with bottom exit leads and mounting studs

Appendix D – Electrical

TYPICAL LOADCENTER

Load	VA	Demand	Demand Load
Unit Panel	Condo (Typ)		
Voltage	208/120V 3P,4W		
Breaker	100A		
Load	VA	Demand	Demand Load
Dishwasher	1092	0.75	819
Refrigerator	1800	1	1800
Disposal	720	0.75	540
Range	8320	0.8	6656
Range Hood	250	0.75	187.5
Kitchen Recept	1500	1	1500
Kitchen Recept	1500	1	1500
Washer/Dryer	5000	1	5000
Exhaust Fan per Bath	300	0.75	225
Water Heater	3800	0.75	2850
		Total Demand Load	21077.5
		Total Demand Current	58.51

Residential Lighting Load Calculation

Unit	Area (sf)	NEC Design Load (VA/sf)	Load per Unit (VA)	Demand	Demand Load
300	1848	3.0	5544	A*	3890.4
301	691	3.0	2073	A*	2073
302	1026	3.0	3078	A*	3027.3
303	1652	3.0	4956	A*	3684.6
400	1848	3.0	5544	A*	3890.4
401	691	3.0	2073	A*	2073
402	1026	3.0	3078	A*	3027.3
403	1652	3.0	4956	A*	3684.6
500	1848	3.0	5544	A*	3890.4
501	1719	3.0	5157	A*	3754.95
502	1652	3.0	4956	A*	3684.6
600	1848	3.0	5544	A*	3890.4
601	1719	3.0	5157	A*	3754.95
602	1652	3.0	4956	A*	3684.6
700	1848	3.0	5544	A*	3890.4
701	691	3.0	2073	A*	2073
702	1026	3.0	3078	A*	3027.3
703	1652	3.0	4956	A*	3684.6
800	1848	3.0	5544	A*	3890.4
801	1719	3.0	5157	A*	3754.95
803	1652	3.0	4956	A*	3684.6
900a	2541	3.0	7623	A*	4618.05
902	1026	3.0	3078	A*	3027.3
903	1652	3.0	4956	A*	3684.6
1000	3335	3.0	10005	A*	5451.75
1001	2945	3.0	8835	A*	5042.25
1002	2985	3.0	8955	A*	5084.25
All	45792	3.0		Total	98923.95

Residential Total Load Calculation						
Unit	Lighting Load (VA)	Power Load (VA)	Total Load for Unit (VA)	Load Per Floor	Demand	Demand Load (kVA) Per Floor
300	3890.4	21077.5	24967.9			
301	2073	21077.5	23150.5			
302	3027.3	21077.5	24104.8			
303	3684.6	21077.5	24762.1	96985.3	0.34	32.98
400	3890.4	21077.5	24967.9			
401	2073	21077.5	23150.5			
402	3027.3	21077.5	24104.8			
403	3684.6	21077.5	24762.1	96985.3	0.34	32.98
500	3890.4	21077.5	24967.9			
501	3754.95	21077.5	24832.45			
502	3684.6	21077.5	24762.1	74562.45	0.34	25.35
600	3890.4	21077.5	24967.9			
601	3754.95	21077.5	24832.45			
602	3684.6	21077.5	24762.1	74562.45	0.34	25.35
700	3890.4	21077.5	24967.9			
701	2073	21077.5	23150.5			
702	3027.3	21077.5	24104.8			
703	3684.6	21077.5	24762.1	96985.3	0.34	32.98
800	3890.4	21077.5	24967.9			
801	3754.95	21077.5	24832.45			
803	3684.6	21077.5	24762.1	74562.45	0.34	25.35
900a	4618.05	21077.5	25695.55			
902	3027.3	21077.5	24104.8			
903	3684.6	21077.5	24762.1	74562.45	0.34	25.35
1000	5451.75	21077.5	26529.25			
1001	5042.25	21077.5	26119.75			
1002	5084.25	21077.5	26161.75	78810.75	0.34	26.80
All	98923.95			668016.45		227.13
				Total Load from Residences (kVA)		454.25

NEC Total Load - 10-17 House and Office Space ONLY						
Floor	# Receptacles - House	House Receptacle Load (VA)	Approximate House Power Load (VA)	Office Receptacle Load (VA)	Approximate Office Power Load (VA)	Total Load (kVA)
10	12	2160	995	22450	33675	47.44
11	12	2160	995	22450	33675	47.44
12	12	2160	995	22450	33675	47.44
13	12	2160	995	22450	33675	47.44
14	12	2160	995	22450	33675	47.44
15	12	2160	995	22450	33675	47.44
16	12	2160	995	22450	33675	47.44
17	12	2160	150	11500	33675	40.91
Subtotal Recept Load (kVA)		17.28		168.65		185.93
NEC Demand (kVA)		13.64		89.33		97.97
Total Office Load (kVA)						373.01

NEC Receptacle Count - House and Office Space ONLY					
Floor	# Receptacles - House	Load (VA)	Approximate Office Load (VA)	NEC Factor	Total Load (kVA)
Bsmt	43	7740	0	0.519	4.01706
1	49	8820	0	0.519	4.57758
2	14	2520	0	0.519	1.30788
3	14	2520	0	0.519	1.30788
4	14	2520	0	0.519	1.30788
5	14	2520	0	0.519	1.30788
6	14	2520	0	0.519	1.30788
7	14	2520	0	0.519	1.30788
8	14	2520	0	0.519	1.30788
9	14	2520	0	0.519	1.30788
10	12	2160	22450	0.519	12.77259
11	12	2160	22450	0.519	12.77259
12	12	2160	22450	0.519	12.77259
13	12	2160	22450	0.519	12.77259
14	12	2160	22450	0.519	12.77259
15	12	2160	22450	0.519	12.77259
16	12	2160	22450	0.519	12.77259
17	12	2160	11500	0.519	7.08954
Subtotal Recept Load (kVA)		54.00			115.55535
NEC Demand (kVA)		32.00			62.78
Total Receptacle Load (kVA)					169.56
Total NEC Demand Recept Load (kVA)					89.78

NEC Receptacle Count - Parking and Retail ONLY				
Floor	# Receptacles - House	Approximation for Retail	Approximation for Parking (VA)	Total Load (VA)
Bsmt	3	0	540	540
1	4	11329.77	720	12049.77
2	4	0	720	720
3	4	0	720	720
4	4	0	720	720
5	4	0	720	720
6	4	0	720	720
7	4	0	720	720
8	4	0	720	720
9	5	0	900	900
10	1	0	180	180
Total Receptacle Load (kVA)				18.71
Total NEC Demand Recept Load (kVA)				14.35

NEC Retail Receptacle Calculations					
Floor	Space	Area of Space	Display Window Length (ft)	NEC Factor	Load Approximation
1	Retail 1	1750	15	0.519	2465.25
	Retail 2	2325	15	0.519	2763.675
	Retail 3	2325	0	0.519	1206.675
	Retail 4	4080	0	0.519	2117.52
	Retail 5	5350	0	0.519	2776.65
Total Recept and Display Load (kVA)					11.33

NEC Retail Lighting Calculations					
Floor	Space	Area of Space	NEC Design Load	NEC Factor	Approximation
1	Retail 1	1750	2.5	1.25	5468.75
	Retail 2	2325	2.5	1.25	7265.625
	Retail 3	2325	2.5	1.25	7265.625
	Retail 4	4080	2.5	1.25	12750
	Retail 5	5350	2.5	1.25	16718.75
Total Recept and Display Load (kVA)					49.47

Load Criteria	Factor
Lighting (assume all continuous)	1.25
Motors	
First Motor	2.5
Remaining motors	1
Receptacles	0.519
Retail Load	3
Office Load	0.85
Condo Load	0.34

Lighting
NEC

Motors
NEC

Receptacles

House Total	17299
Office Total	168650
Residential Total	45792
Parking and Retail Total	18710
TOTAL	250451
NEC Demand	
10kVA + 0.5(X-10kVA)	130225

Factor = 0.5200

Condo
NEC

Retail

**Assume upsizing factor for two large restaurants, one spa, and two electronic boutiques.

Office

**Assume tenant fitout area will have 15% floor area reduction for partitions, "dead space", etc.

Start Point	End Point	Length	Conductors	#	Neutrals	Conduit	Conductor Cost	Neutral Cost	Conduit Cost	TOTAL
Bus	Bus	401	2500	1						
P / HA	Lights B	247	#12	1		3/4"	$ 89.91		$ 881.79	$ 971.70
	Lights 1	259	#12	1		3/4"	$ 94.28		$ 924.63	$ 1,018.91
	Lights 2	280	#12	1		3/4"	$ 101.92		$ 999.60	$ 1,101.52
	Lights 3	292	#12	1		3/4"	$ 106.29		$ 1,042.44	$ 1,148.73
	Lights 4	302	#12	1		3/4"	$ 109.93		$ 1,078.14	$ 1,188.07
	Lights 5	312	#12	1		3/4"	$ 113.57		$ 1,113.84	$ 1,227.41
	Lights 6	323	#12	1		3/4"	$ 117.57		$ 1,153.11	$ 1,270.68
	Lights 7	333	#12	1		3/4"	$ 121.21		$ 1,188.81	$ 1,310.02
	Lights 8	343	#12	1		3/4"	$ 124.85		$ 1,224.51	$ 1,349.36
	Lights 9	354	#12	1		3/4"	$ 128.86		$ 1,263.78	$ 1,392.64
P / HB	Lights B	583	#12	1		3/4"	$ 212.21		$ 2,081.31	$ 2,293.52
	Lights 1	579	#12	1		3/4"	$ 210.76		$ 2,067.03	$ 2,277.79
	Lights 2	575	#12	1		3/4"	$ 209.30		$ 2,052.75	$ 2,262.05
	Lights 3	575	#12	1		3/4"	$ 209.30		$ 2,052.75	$ 2,262.05
P / HC	Lights 4	575	#12	1		3/4"	$ 209.30		$ 2,052.75	$ 2,262.05
	Lights 5	574	#12	1		3/4"	$ 208.94		$ 2,049.18	$ 2,258.12
	Lights 6	575	#12	1		3/4"	$ 209.30		$ 2,052.75	$ 2,262.05
P / HD	Lights 7	575	#12	1		3/4"	$ 209.30		$ 2,052.75	$ 2,262.05
	Lights 8	575	#12	1		3/4"	$ 209.30		$ 2,052.75	$ 2,262.05
	Lights 9	574	#12	1		3/4"	$ 208.94		$ 2,049.18	$ 2,258.12
HS/ HA	Elev 10	346	#4	3		1-1/4"	$ 1,058.76		$ 2,127.90	$ 3,186.66
	Elev 11	362	#4	3		1-1/4"	$ 1,107.72		$ 2,226.30	$ 3,334.02
	Elev 6	55	#4	3		1-1/4"	$ 168.30		$ 338.25	$ 506.55
	Elev 7	48	#4	3		1-1/4"	$ 146.88		$ 295.20	$ 442.08
HS / HB	CT-0.1	91	#4	3		1-1/4"	$ 278.46		$ 559.65	$ 838.11
	CT0.2	103	#4	3		1-1/4"	$ 315.18		$ 633.45	$ 948.63
	EFC-R.1	88	#1	3		1-1/2"	$ 426.36		$ 640.64	$ 1,067.00
	F-R.1	151	#12	3		3/4"	$ 164.89		$ 539.07	$ 703.96
	F-R.3	148	#8	3		3/4"	$ 253.52		$ 528.36	$ 781.88
	F-R.4	145	#12	3		3/4"	$ 158.34		$ 517.65	$ 675.99
	F-R.5	137	#12	3		3/4"	$ 149.60		$ 489.09	$ 638.69
	Elev 1	131	#4	3		1-1/4"	$ 400.86		$ 805.65	$ 1,206.51
	Elev 2	137	#4	3		1-1/4"	$ 419.22		$ 842.55	$ 1,261.77
	Elev 3	142	#4	3		1-1/4"	$ 434.52		$ 873.30	$ 1,307.82
	Elev 4	146	#4	3		1-1/4"	$ 446.76		$ 897.90	$ 1,344.66
	Elev 5	150	#4	3		1-1/4"	$ 459.00		$ 922.50	$ 1,381.50
EMDP	HS / HB	313	500	4	#3	3-1/2"	$ 7,812.48	$ 359.95	$ 6,995.55	$ 15,167.98
	HE / HD	262	#8	4	#10	1"	$ 598.41	$ 112.40	$ 1,231.40	$ 1,942.21
	HS / HA	209	4/0	4	#4	2-1/2"	$ 2,750.44	$ 213.18	$ 2,946.90	$ 5,910.52
	HE / HC	178	500	4	#3	3-1/2"	$ 4,442.88	$ 204.70	$ 3,978.30	$ 8,625.88
	HE / HB	146	#8	4	#10	1"	$ 333.46	$ 62.63	$ 686.20	$ 1,082.30
	HE / HA	85	#8	4	#10	1"	$ 194.14	$ 36.47	$ 399.50	$ 630.11
RTDP	Tenants	407	3/0	4	#6	2-1/2"	$ 4,493.28	$ 311.36	$ 5,738.70	$ 10,543.34
Main	P / HA	394	#1	4	#6	2"	$ 2,545.24	$ 301.41	$ 3,431.74	$ 6,278.39
C / LC	Condos 9	180	#3	4	#8	1-1/4"	$ 828.00	$ 102.78	$ 1,107.00	$ 2,037.78
	Condos 8	172	#3	4	#8	1-1/4"	$ 791.20	$ 98.21	$ 1,057.80	$ 1,947.21
	Condos 7	208	#3	4	#8	1-1/4"	$ 956.80	$ 118.77	$ 1,279.20	$ 2,354.77
C / LB	Condos 6	208	#3	4	#8	1-1/4"	$ 956.80	$ 118.77	$ 1,279.20	$ 2,354.77
	Condos 5	172	#3	4	#8	1-1/4"	$ 791.20	$ 98.21	$ 1,057.80	$ 1,947.21
	Condos 4	180	#3	4	#8	1-1/4"	$ 828.00	$ 102.78	$ 1,107.00	$ 2,037.78
C / LA	Condos 3	208	#3	4	#8	1-1/4"	$ 956.80	$ 118.77	$ 1,279.20	$ 2,354.77
	Condos 2	200	#3	4	#8	1-1/4"	$ 920.00	$ 114.20	$ 1,230.00	$ 2,264.20
									CONDUCTOR TOTAL	$ 121,743.91

	Size/Rating	Length		Bus Cost			
Bus Duct	3000	398	Pow-R-Way III	$ 447,153.00			
						TOTAL BUS	$ 447,153.00
Panels	Size/Rating	Breaker		Panel Cost	Breaker Cost		
P / HA	100	100	PRL2a-100	$ 1,242.00	$ 637.00		
P / LA	100	60	PRL1a-100	$ 679.00	$ 546.00		
P / HB	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
P / LB	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
P / HC	100	100	PRL2a-100	$ 1,242.00	$ 637.00		
P / LC	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
P / HD	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
P / LD	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
C / LA	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
C / LB	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
C / LC	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
H / HA	400	400	PRL2a-400	$ 1,632.00	$ 2,360.00		
H / LA	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
H / HB	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
H / LB	60	60	PRL1a-100	$ 679.00	$ 546.00		
H / HC	60	60	PRL2a-100	$ 1,242.00	$ 546.00		
H / LC	60	60	PRL1a-100	$ 679.00	$ 546.00		
H / HD	60	60	PRL2a-100	$ 1,242.00	$ 546.00		
H / LD	60	60	PRL1a-100	$ 679.00	$ 546.00		
H / HE	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
H / LE	60	60	PRL1a-100	$ 679.00	$ 546.00		
HE / HA	60	60	PRL2a-100	$ 1,242.00	$ 546.00		
HE / LA	60	60	PRL1a-100	$ 679.00	$ 546.00		
HE / HB	60	60	PRL2a-100	$ 1,242.00	$ 546.00		
HE / HC	60	60	PRL2a-100	$ 1,242.00	$ 546.00		
HE / LC3	400	400	PRL1a-400	$ 1,310.00	$ 2,360.00		
HE / LC2	400	400	PRL1a-400	$ 1,310.00	$ 2,360.00		
HE / LC	600	600	PRL3a-600	$ 2,298.00	$ 3,370.00		
HE / HD	60	60	PRL2a-100	$ 1,242.00	$ 546.00		
HE / LD	60	60	PRL1a-100	$ 679.00	$ 546.00		
HS / HA	400	225	PRL2a-400	$ 1,632.00	$ 1,367.00		
HS / HB	400	400	PRL2a-400	$ 1,632.00	$ 2,360.00		
HS / LB	60	60	PRL1a-100	$ 679.00	$ 546.00		
MAIN	4000	4000		$ -	$ -		
BUS	3200	3200		$ -	$ -		
EM / DP	800	800	PRL3a-800	$ 3,676.00	$ 4,370.00		
RT / DP	600	600	PRL3a-600	$ 2,298.00	$ 3,370.00		
						TOTAL PANEL	$ 88,306.00
Switchboards	Board	Breaker		Board Cost	Breaker Cost		
NONE				$ -	$ -		
						TOTAL SWBD	$ -
ATSs	Size			ATS Cost			
ATS1	60			$ 3,072.00			
ATS2	60			$ 3,072.00			
ATS3	60			$ 3,072.00			
ATS4	60			$ 3,072.00			
ATS5	60			$ 3,072.00			
ATS6	225			$ 4,900.00			
ATS7	60			$ 3,072.00			
ATS8	600			$ 10,200.00			
						TOTAL ATS	$ 33,532.00
Main Dist	Board	Breaker		Board Cost	Breaker Cost		
Main	4000	4000		$ 7,425.00			
						TOTAL MAIN	$ 7,425.00

Xfmrs	Size		Xfmr Cost		
THS / LB	15	H48M28T15A	$ 2,665.00		
TH / LE	15	H48M28T15A	$ 2,665.00		
THE / LD	15	H48M28T15A	$ 2,665.00		
TH / LD	15	H48M28T15A	$ 2,665.00		
TH / LC	15	H48M28T15A	$ 2,665.00		
TP / LD	75	H48M28T75A	$ 6,280.00		
THE / LC	225	H48M28T22A	$ 17,130.00		
TP / LC	45	H48M28T45A	$ 4,445.00		
TP / LB	75	H48M28T75A	$ 6,280.00		
TP / LA	15	H48M28T15A	$ 2,665.00		
TH / LA	45	H48M28T45A	$ 4,445.00		
TH / LB	15	H48M28T15A	$ 2,665.00		
THE / LA	15	H48M28T15A	$ 2,665.00		
Medium Voltage	2000/2660		$ 90,986.00		
Medium Voltage	2000/2660		$ 90,986.00		
				TOTAL XFMR	$ 241,872.00

Emerg Generator	Size kW		Gen Cost		
C18 600kW	600	Caterpillar	$ 114,850.00	GENERATOR TOTAL	$ 114,850.00

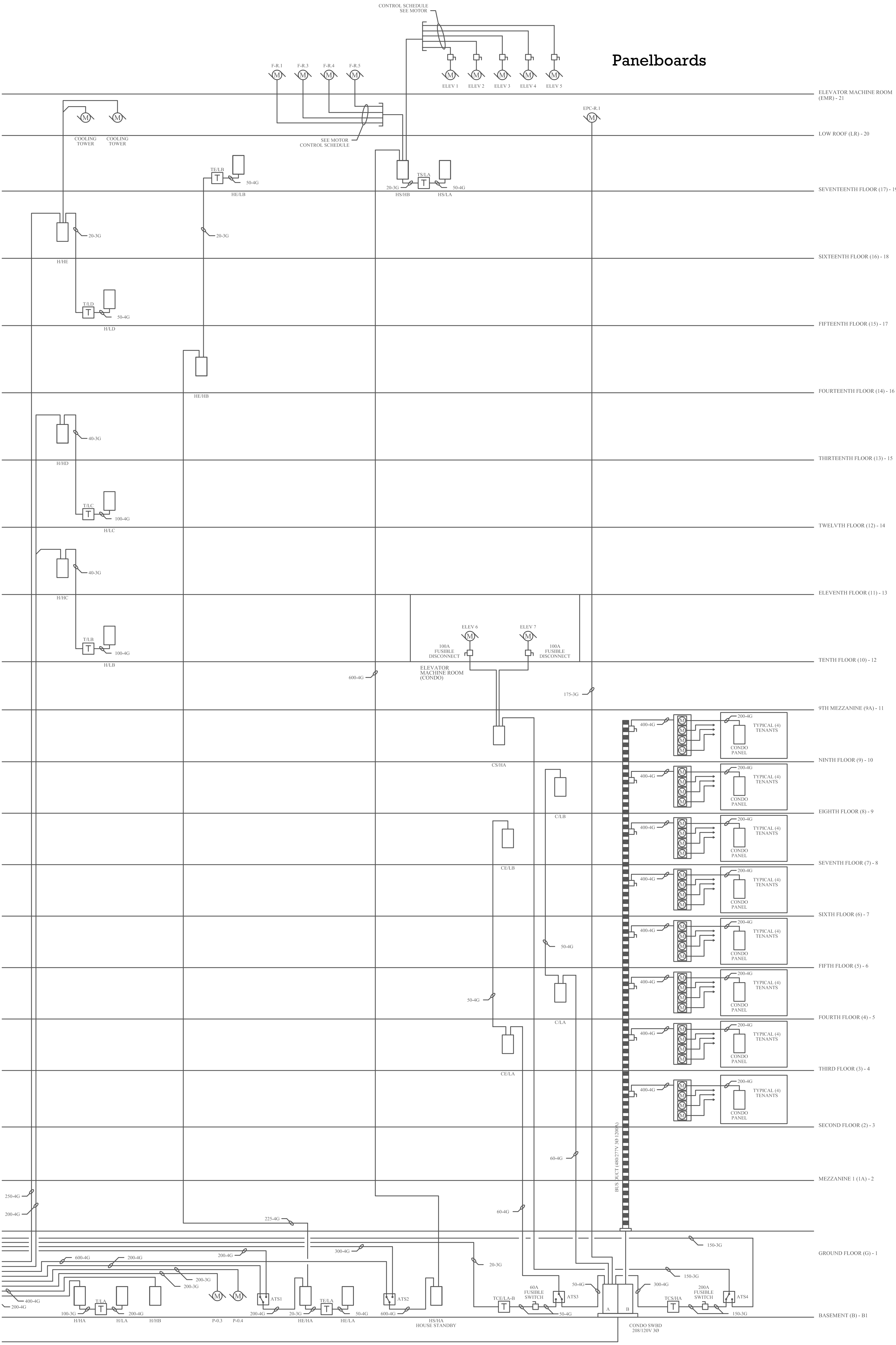
	Bus	Length		Bus Cost			
Bus Duct	2500	398	Pow-R-Way III	$ 359,991.00			
	1200	186	Pow-R-Way III	$ 86,304.00			
						TOTAL BUS	$ 446,295.00
	Panel	Breaker		Panel Cost	Breaker Cost		
C/MSB	2000	2000		$ -	$ -		
C/LA	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
C/LB	100	100	PRL1a-100	$ 679.00	$ 637.00		
CE/LB	50	60	PRL1a-100	$ 679.00	$ 546.00		
P/HA	600	600	PRL3a-600	$ 2,298.00	$ 3,370.00		
P/HB	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
P/LC	100	100	PRL1a-100	$ 679.00	$ 637.00		
MAIN SWBD	3000	3000		$ -	$ -		
H/HA	200	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
HE/LA	50	60	PRL1a-100	$ 679.00	$ 546.00		
HS/HA	600	600	PRL3a-600	$ 2,298.00	$ 3,370.00		
H/LB	100	100	PRL1a-100	$ 679.00	$ 637.00		
HE/HB	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
H/LD	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
H/HE	250	400	PRL2a-400	$ 1,632.00	$ 2,360.00		
RT/DP	1000	1000	PRL4-1200	$ 3,016.00	$ 5,425.00		
CS/HA	150	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
EM/DP	600	600	PRL3a-600	$ 2,298.00	$ 3,370.00		
CE/LA	50	60	PRL1a-100	$ 679.00	$ 546.00		
P/LB	225	225	PRL1a-225	$ 834.00	$ 1,367.00		
PE/HA	70	60	PRL2a-100	$ 1,242.00	$ 546.00		
P/HC	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
H/LA	200	225	PRL1a-225	$ 834.00	$ 1,367.00		
H/HB	400	400	PRL2a-400	$ 1,632.00	$ 2,360.00		
HE/HA	200	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
H/HC	200	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
H/LC	100	100	PRL1a-100	$ 679.00	$ 637.00		
H/HD	225	225	PRL2a-225	$ 1,360.00	$ 1,367.00		
HE/LB	20	60	PRL1a-100	$ 679.00	$ 546.00		
HS/HB	600	600	PRL3a-600	$ 2,298.00	$ 3,370.00		
HS/LA	20	60	PRL1a-100	$ 679.00	$ 546.00		
OFFICE BUS DUCT	2500	2500		$ -	$ -		
CONDO BUS DUCT	1200	1200		$ -	$ -		
						TOTAL PANEL	$ 82,894.00
Switchboards	Board	Breaker		Board Cost	Breaker Cost		
Condo	2000	1200		$ 4,650.00	$ 8,960.00		
		800			$ 7,205.00		
						TOTAL SWBD	$ 20,815.00
ATSs	Size			ATS Cost			
ATS1	225			$ 4,900.00			
ATS2	600			$ 10,200.00			
ATS3	100			$ 3,151.00			
ATS4	225			$ 4,900.00			
ATS5	100			$ 3,151.00			
						TOTAL ATS	$ 26,302.00
Main Dist	Board	Breaker		Board Cost	Breaker Cost		
Main	3000	3000		$ 6,150.00			
						TOTAL MAIN	$ 6,150.00

Xfmrs	Size		Xfmr Cost		
T / LA	75	V48M28T75CU	$ 6,320.00		
T / LB	30	V48M28T30CU	$ 3,425.00		
T / LC	30	V48M28T30CU	$ 3,425.00		
T / LD	30	V48M28T30CU	$ 3,425.00		
TE / LA	15	V48M28T15CU	$ 2,875.00		
TE / LB	15	V48M28T15CU	$ 2,875.00		
TS / LA	15	V48M28T15CU	$ 2,875.00		
TP / LB	75	V48M28T75CU	$ 6,320.00		
TP / LC	15	V48M28T15CU	$ 2,875.00		
TPE / LA	15	V48M28T15CU	$ 2,875.00		
TCE / LA-B	15	V48M28T15CU	$ 2,875.00		
TCS / HA	112.5	V29M47T12N	$ 9,280.00		
Medium Voltage	3000		$ 78,570.00		
Medium Voltage	112.5		$ 78,570.00		
				TOTAL XFMR	$ 206,585.00

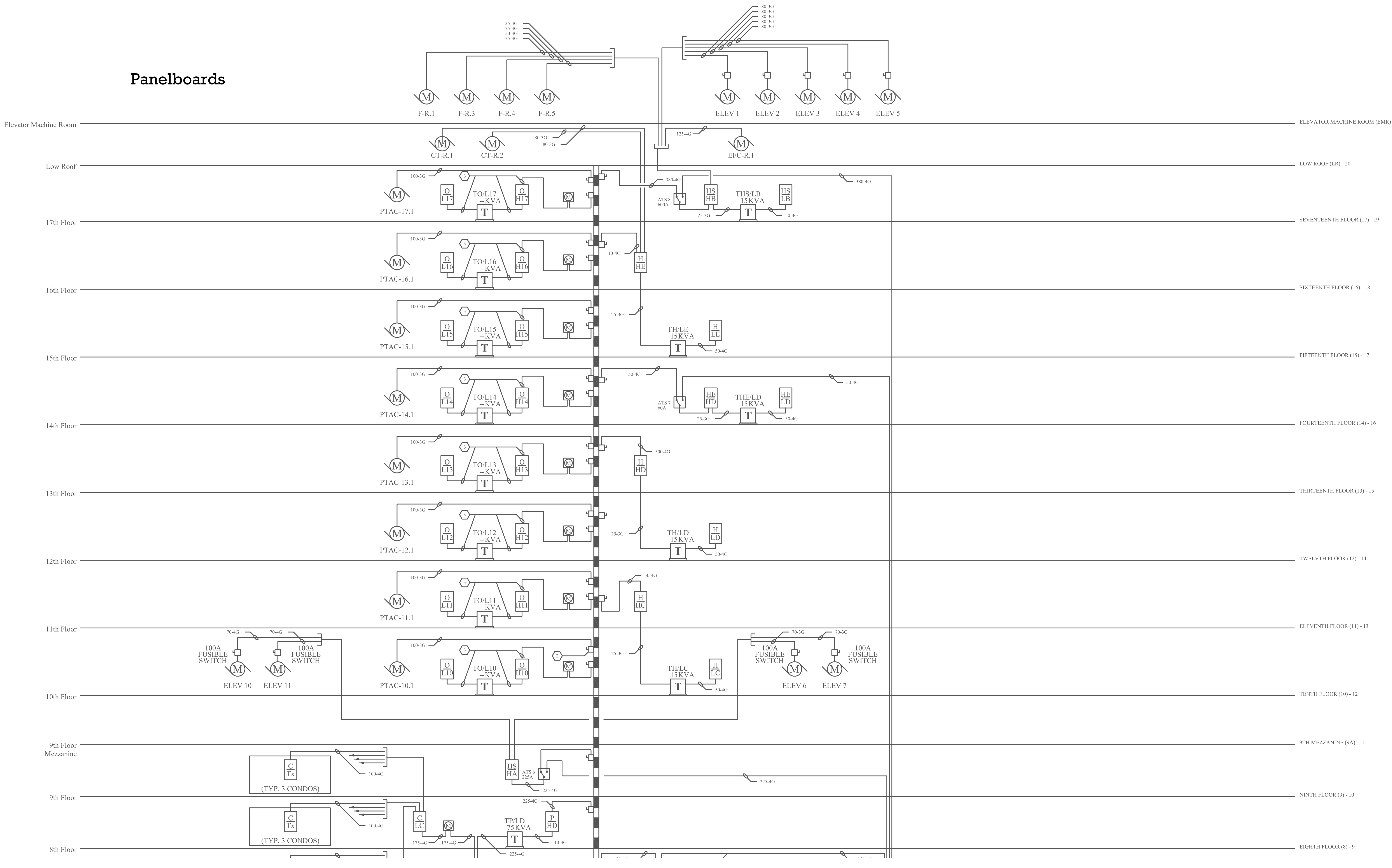
Emerg Generator	Size kW		Cost		
C15 350kW	350	Caterpillar	$ 76,550.00	GENERATOR TOTAL	$ 76,550.00

Panelboards

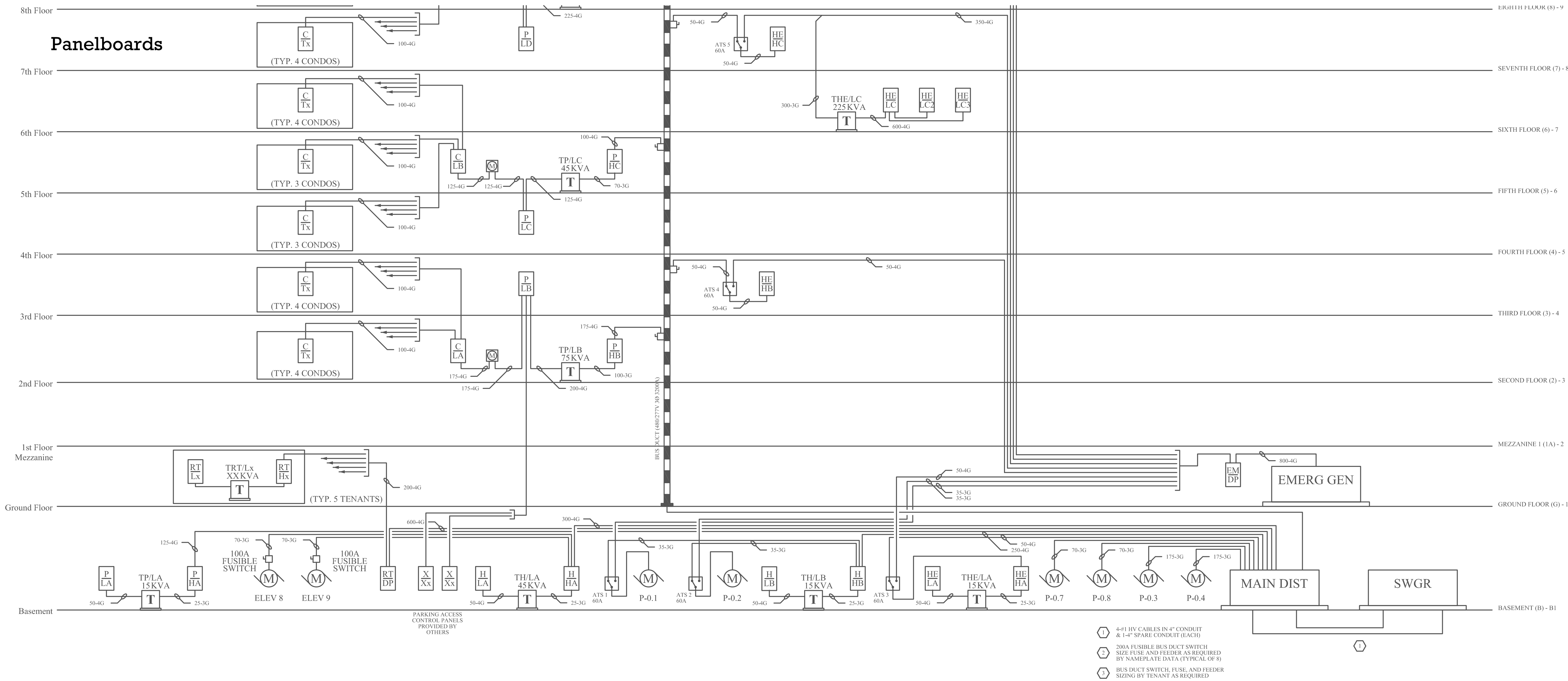
Panelboards



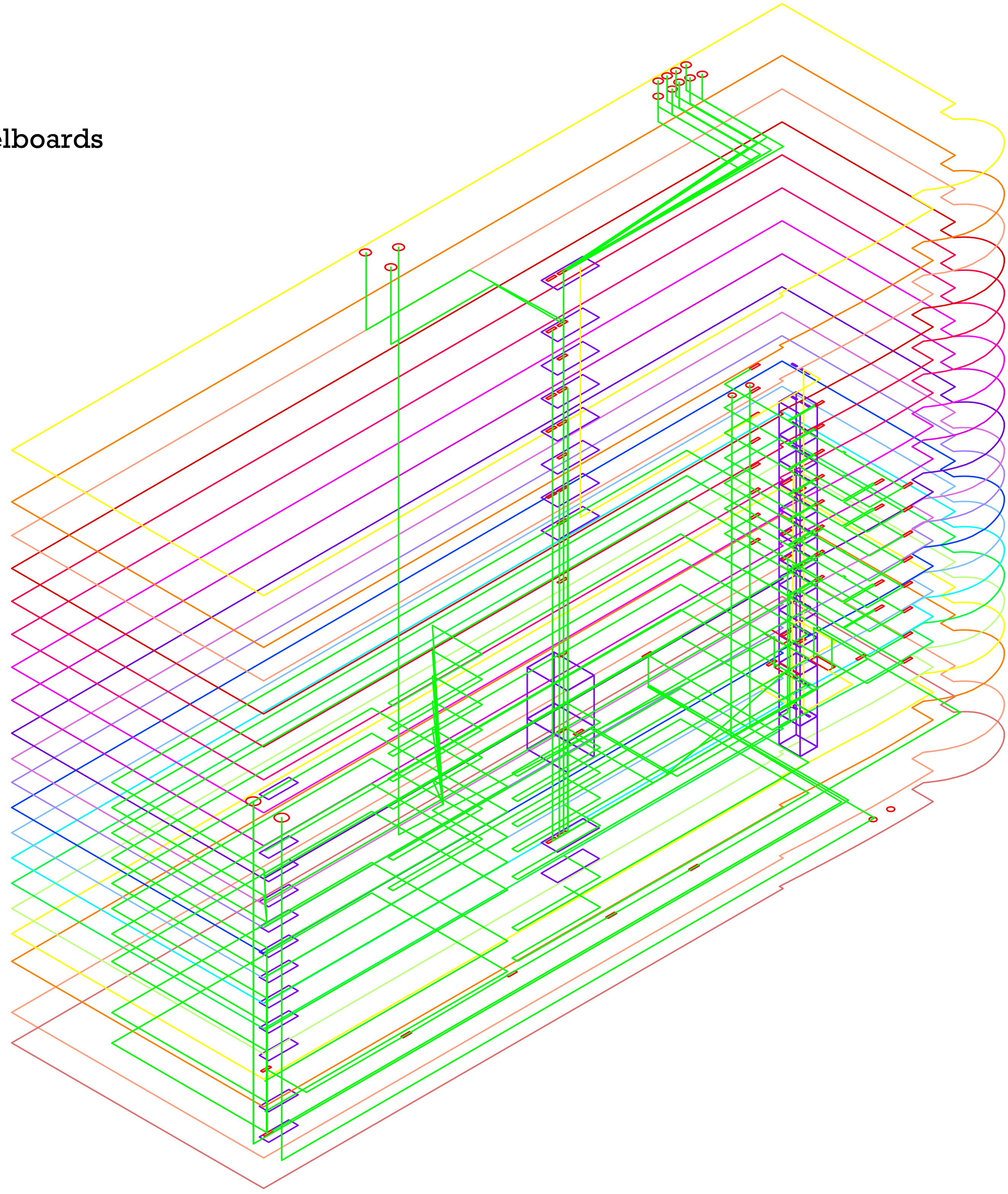
Panelboards

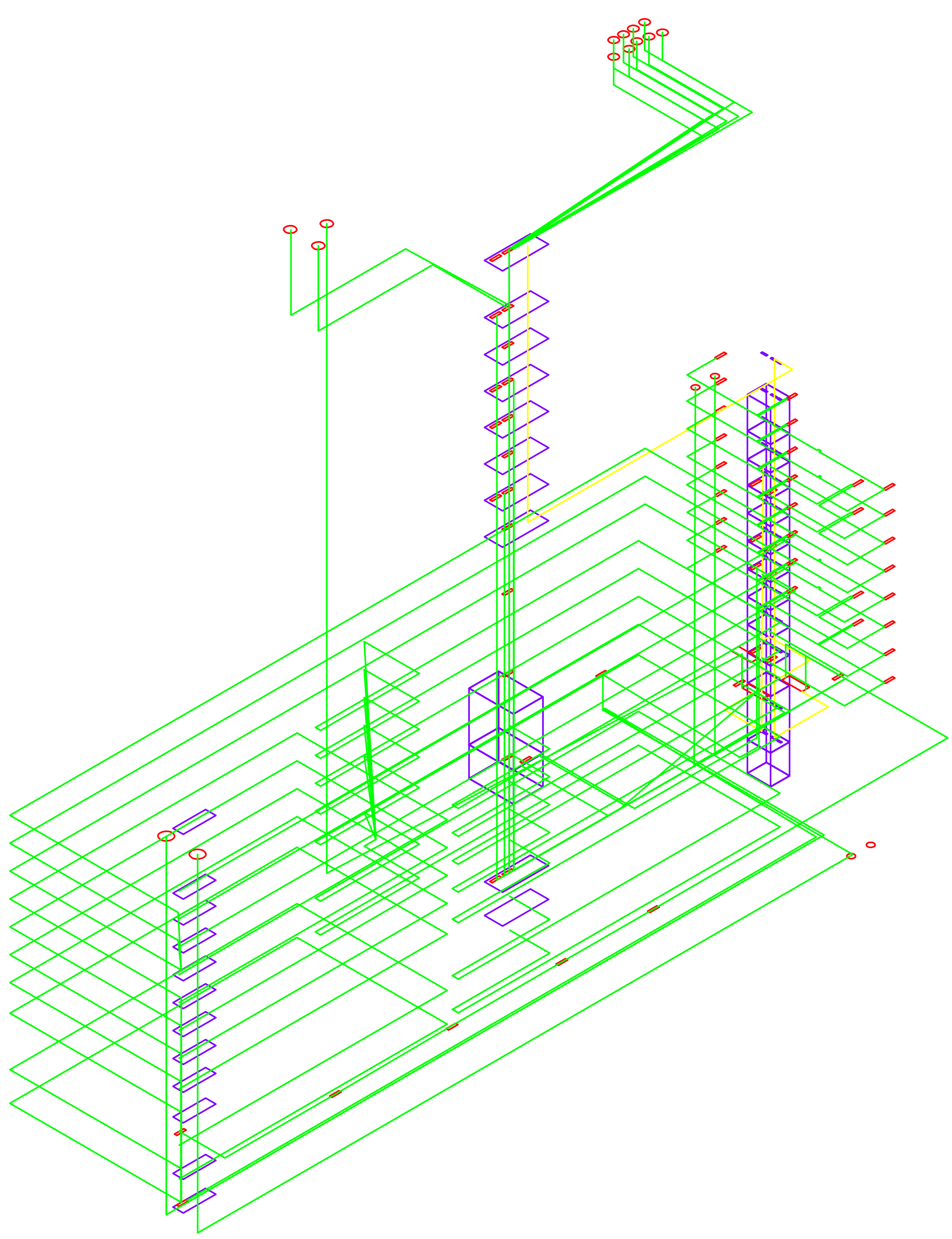


Panelboards

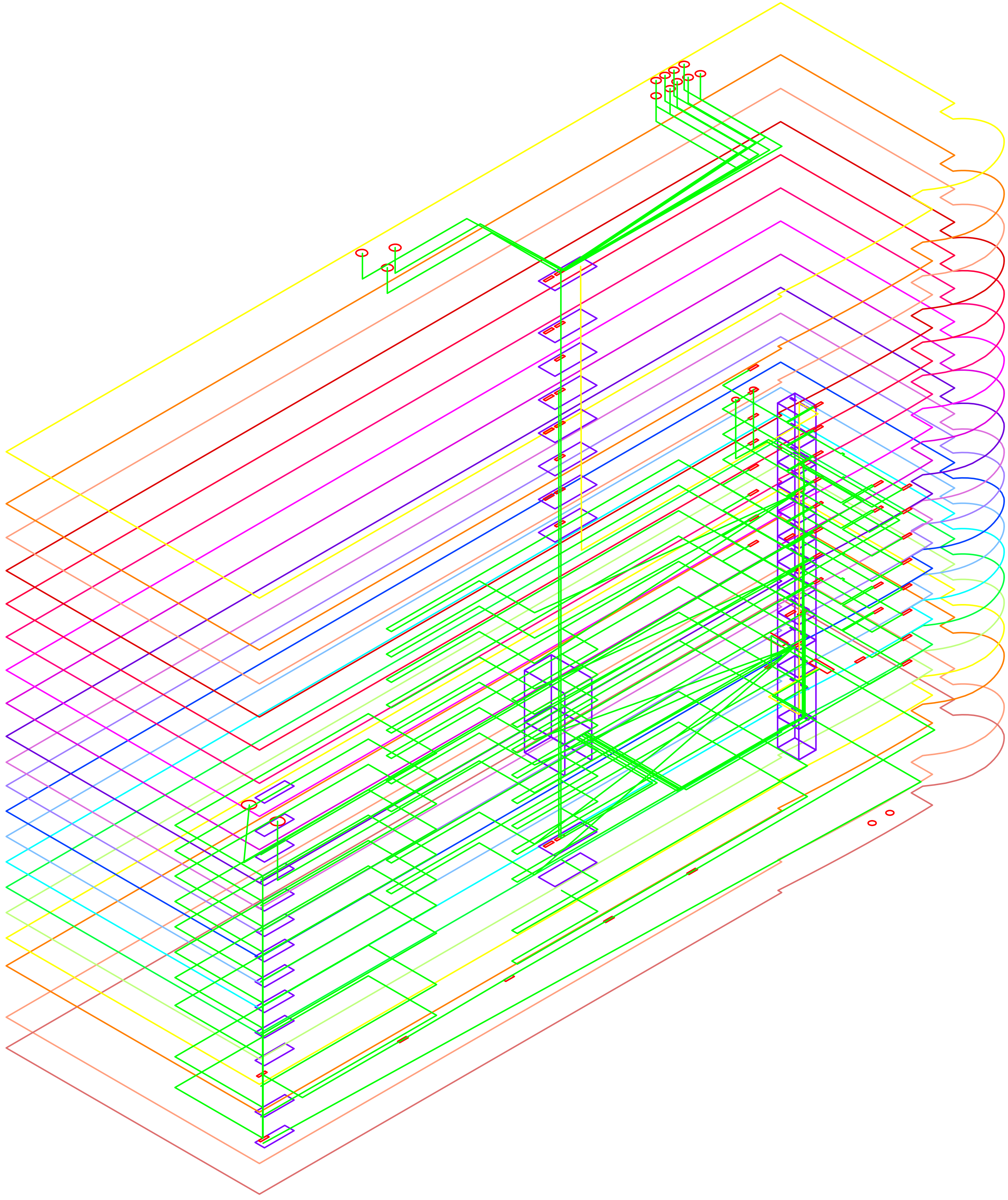


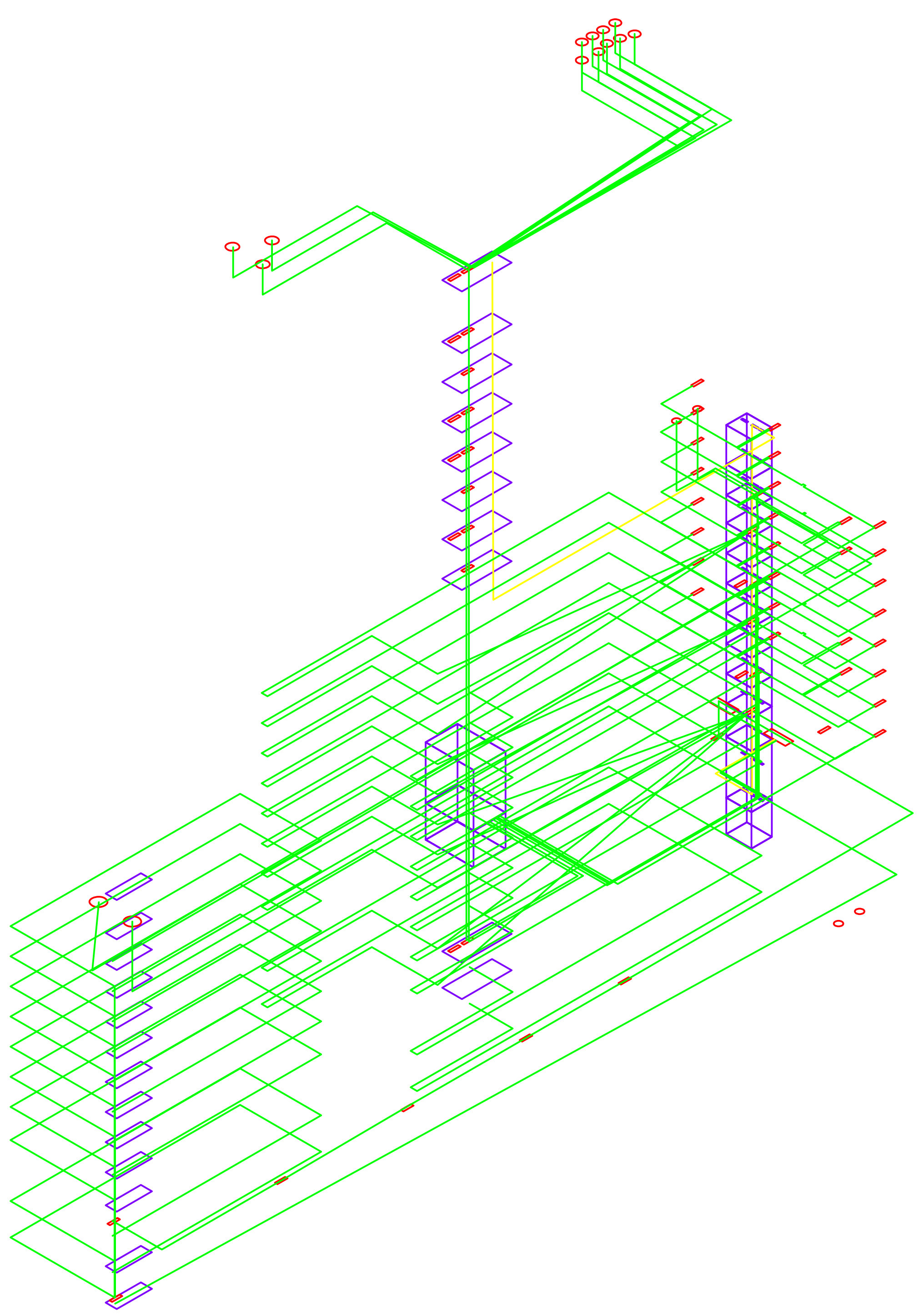
Panelboards





Panelboards





Panelboards

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / HA	1	ECUH-1.1	4.00	1.00	4.00	4.81	20	3	1.33						Voltage	480	/277V, 3P
	1	ECUH-1.1	4.00	1.00	4.00	4.81	20	3		1.33					Breaker	125	
	1	ECUH-1.1	4.00	1.00	4.00	4.81	20	3			1.33				Bus	100	
	2	ECUH-2.1	4.00	1.00	4.00	4.81	20	3	1.33						A.I.C	65k	
	2	ECUH-2.1	4.00	1.00	4.00	4.81	20	3		1.33							
	2	ECUH-2.1	4.00	1.00	4.00	4.81	20	3			1.33						
	3	ECUH-3.1	4.00	1.00	4.00	4.81	20	3	1.33								
	3	ECUH-3.1	4.00	1.00	4.00	4.81	20	3		1.33							
	3	ECUH-3.1	4.00	1.00	4.00	4.81	20	3			1.33						
	4	ECUH-4.1	4.00	1.00	4.00	4.81	20	3	1.33								
	4	ECUH-4.1	4.00	1.00	4.00	4.81	20	3		1.33							
	4	ECUH-4.1	4.00	1.00	4.00	4.81	20	3			1.33						
	5	ECUH-5.1	4.00	1.00	4.00	4.81	20	3	1.33								
	5	ECUH-5.1	4.00	1.00	4.00	4.81	20	3		1.33							
	5	ECUH-5.1	4.00	1.00	4.00	4.81	20	3			1.33						
	6	ECUH-6.1	4.00	1.00	4.00	4.81	20	3	1.33								
	6	ECUH-6.1	4.00	1.00	4.00	4.81	20	3		1.33							
	6	ECUH-6.1	4.00	1.00	4.00	4.81	20	3			1.33						
	7	ECUH-7.1	4.00	1.00	4.00	4.81	20	3	1.33								
	7	ECUH-7.1	4.00	1.00	4.00	4.81	20	3		1.33							
	7	ECUH-7.1	4.00	1.00	4.00	4.81	20	3			1.33						
	8	ECUH-8.1	4.00	1.00	4.00	4.81	20	3	1.33								
	8	ECUH-8.1	4.00	1.00	4.00	4.81	20	3		1.33							
	8	ECUH-8.1	4.00	1.00	4.00	4.81	20	3			1.33						
	9	ECUH-9.1	4.00	1.00	4.00	4.81	15	3	1.33								
	9	ECUH-9.1	4.00	1.00	4.00	4.81	15	3		1.33							
	9	ECUH-9.1	4.00	1.00	4.00	4.81	15	3			1.33						
	10	F-9.2	1.49	2.50	3.73	4.49	15	3	1.24								
	11	F-9.2	1.49	2.50	3.73	4.49	15	3		1.24							
	12	F-9.2	1.49	2.50	3.73	4.49	15	3			1.24						
	13	T-P / LA	6.73	1.00	6.73	8.10	0	3	2.24								
	14	T-P / LA	6.73	1.00	6.73	8.10	0	3		2.24							
	15	T-P / LA	6.73	1.00	6.73	8.10	0	3			2.24						
	16	Garage Lighting South	3.82	1.25	4.78	17.23	30	1	4.78								
	17	Garage Lighting South	3.82	1.25	4.78	17.23	30	1		4.78							
	18	Garage Lighting South	3.82	1.25	4.78	17.23	30	1			4.78						
	19	Garage Lighting South	3.82	1.25	4.78	17.23	30	1	4.78								
	20	Garage Lighting South	3.82	1.25	4.78	17.23	30	1		4.78							
	21	Garage Lighting South	3.82	1.25	4.78	17.23	30	1			4.78						
	22	Façade Beamers	0.50	1.25	0.63	2.26	20	1	0.63								
	23	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	24	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	25	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	26-33	COLLATERAL	0.50	1.00	0.50	1.80	20	1		0.50							
	34-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									25.66	25.54	25.04			Board			
													kVA	Size		Breaker	
T-P / HA													76.236	91.69754		125	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / LA	1	Clearwater Pump 1	0.49	2.50	1.23	10.25	30	1	1.23						Voltage	208	/120V, 3P
	2	EUH-0.1	5.00	1.00	5.00	13.88	20	3		1.67					Breaker	50	
	3	EUH-0.1	5.00	1.00	5.00	13.88	20	3			1.67				Bus	100	
	4	EUH-0.1	5.00	1.00	5.00	13.88	20	3	1.67						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									2.90	2.17	1.67			Board			
													kVA	Size		Breaker	
T-P / LA													6.7309	18.68311		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / HB	1	ACU-1.1	12.90	2.50	32.25	38.79	50	3	10.75						Voltage	480	/277V, 3P
	2	ACU-1.1	12.90	2.50	32.25	38.79	50	3		10.75					Breaker	175	
	3	ACU-1.1	12.90	2.50	32.25	38.79	50	3			10.75				Bus	225	
	4	Coiling Door 1	0.37	1.00	0.37	0.45	15	3	0.12						A.I.C	65k	
	4	Coiling Door 1	0.37	1.00	0.37	0.45	15	3		0.12							
	5	Coiling Door 1	0.37	1.00	0.37	0.45	15	3			0.12						
	5	Coiling Door 2	0.37	1.00	0.37	0.45	15	3	0.12								
	6	Coiling Door 2	0.37	1.00	0.37	0.45	15	3		0.12							
	6	Coiling Door 2	0.37	1.00	0.37	0.45	15	3			0.12						
	7	F-1.1	1.49	1.00	1.49	1.79	15	3	0.50								
	7	F-1.1	1.49	1.00	1.49	1.79	15	3		0.50							
	8	F-1.1	1.49	1.00	1.49	1.79	15	3			0.50						
	8	F-1.2	1.49	1.00	1.49	1.79	15	3	0.50								
	9	F-1.2	1.49	1.00	1.49	1.79	15	3		0.50							
	9	F-1.2	1.49	1.00	1.49	1.79	15	3			0.50						
	10	ECUH-2.2	4.00	1.00	4.00	4.81	20	3	1.33								
	10	ECUH-2.2	4.00	1.00	4.00	4.81	20	3		1.33							
	11	ECUH-2.2	4.00	1.00	4.00	4.81	20	3			1.33						
	11	ECUH-3.2	4.00	1.00	4.00	4.81	20	3	1.33								
	12	ECUH-3.2	4.00	1.00	4.00	4.81	20	3		1.33							
	12	ECUH-3.2	4.00	1.00	4.00	4.81	20	3			1.33						
	13	T-P / LB	55.68	1.00	55.68	66.97	0	3	18.56								
	14	T-P / LB	55.68	1.00	55.68	66.97	0	3		18.56							
	15	T-P / LB	55.68	1.00	55.68	66.97	0	3			18.56						
	16	Garage Lighting N-2	3.82	1.25	4.78	17.23	30	1	4.78								
	17	Garage Lighting N-3	3.82	1.25	4.78	17.23	30	1		4.78							
	18	Garage Lighting N-4	3.82	1.25	4.78	17.23	30	1			4.78						
	19	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	20	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	21	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	22	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	23-42	SPACE	0.00		0.00	0.00	-	1		0.00							
									38.49	37.99	37.99			Board			
													kVA	Size		Breaker	
T-P / HB													114.48	137.7035		175	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / LB	1	Overhead Door	0.56	2.50	1.40	3.88	15	3	0.47						Voltage	208	/120V, 3P
	2	Overhead Door	0.56	1.00	0.56	1.55	15	3		0.19					Breaker	200	
	3	Overhead Door	0.56	1.00	0.56	1.55	15	3			0.19				Bus	225	
	4	CUH-1.1	0.06	1.00	0.06	0.50	20	1	0.06						A.I.C	65k	
	5	Façade Canopy Lighting	0.60	1.25	0.75	6.25	20	1		0.75							
	6	Façade Curve Lighting 3	0.60	1.25	0.75	6.25	20	1			0.75						
	7	Façade Curve Lighting 4	0.60	1.25	0.75	6.25	20	1	0.75								
	8	T-C / LA	52.03	1.00	52.03	62.58	0	3		17.34							
	9	T-C / LA	52.03	1.00	52.03	62.58	0	3			17.34						
	10	T-C / LA	52.03	1.00	52.03	62.58	0	3	17.34								
	11	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	12	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	13	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	14	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	15-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									18.62	18.78	18.28			Board			
													kVA	Size		Breaker	
T-P / LB													55.68	154.5509		200	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / HC	1	ECUH-4.2	4.00	1.00	4.00	4.81	20	3	1.33						Voltage	480	/277V, 3P
	1	ECUH-4.2	4.00	1.00	4.00	4.81	20	3		1.33					Breaker	100	
	1	ECUH-4.2	4.00	1.00	4.00	4.81	20	3			1.33				Bus	100	
	2	ECUH-5.2	4.00	1.00	4.00	4.81	20	3	1.33						A.I.C	65k	
	2	ECUH-5.2	4.00	1.00	4.00	4.81	20	3		1.33							
	2	ECUH-5.2	4.00	1.00	4.00	4.81	20	3			1.33						
	3	ECUH-6.2	4.00	1.00	4.00	4.81	20	3	1.33								
	3	ECUH-6.2	4.00	1.00	4.00	4.81	20	3		1.33							
	3	ECUH-6.2	4.00	1.00	4.00	4.81	20	3			1.33						
	4	T-P / LC	34.43	1.00	34.43	41.41	0	3	11.48								
	5	T-P / LC	34.43	1.00	34.43	41.41	0	3		11.48							
	6	T-P / LC	34.43	1.00	34.43	41.41	0	3			11.48						
	7	Garage Lighting N-5	3.82	1.25	4.78	17.23	30	1	4.78								
	8	Garage Lighting N-6	3.82	1.25	4.78	17.23	30	1		4.78							
	9	Garage Lighting N-7	3.82	1.25	4.78	17.23	30	1			4.78						
	10	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	11	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	12	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	13	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	14-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									20.75	20.25	20.25			Board			
													kVA	Size		Breaker	
T-P / HC													61.254	73.67682		100	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / LC	1	Façade Lattice Lighting	0.60	1.25	0.75	6.25	20	1	0.75						Voltage	208	/120V, 3P
	2	Façade Curve Lighting 5	0.50	1.25	0.63	5.20	20	1		0.63					Breaker	125	
	3	Façade Curve Lighting 6	0.50	1.25	0.63	5.20	20	1			0.63				Bus	225	
	4	Façade Curve Lighting 7	0.50	1.25	0.63	5.20	20	1	0.63						A.I.C	65k	
	5	T-C / LB	31.30	1.00	31.30	37.65	0	3		10.43							
	6	T-C / LB	31.30	1.00	31.30	37.65	0	3			10.43						
	7	T-C / LB	31.30	1.00	31.30	37.65	0	3	10.43								
	8	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	9	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	10	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	11	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	12-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									11.81	11.56	11.06			Board			
													kVA	Size		Breaker	
T-P / LC													34.429	95.56468		125	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / HD	1	ACU-9.1	12.90	2.50	32.25	38.79	50	2	16.13						Voltage	480	/277V, 3P
	2	ACU-9.1	12.90	2.50	32.25	38.79	50	2		16.13					Breaker	200	
	3	ACU-9.1	12.90	2.50	32.25	38.79	50	2			16.13				Bus	225	
	4	ECUH-9.2	4.00	1.00	4.00	4.81	15	3	1.33						A.I.C	65k	
	4	ECUH-9.2	4.00	1.00	4.00	4.81	15	3		1.33							
	4	ECUH-9.2	4.00	1.00	4.00	4.81	15	3			1.33						
	5	ECUH-9.3	4.00	1.00	4.00	4.81	15	3	1.33								
	5	ECUH-9.3	4.00	1.00	4.00	4.81	15	3		1.33							
	5	ECUH-9.3	4.00	1.00	4.00	4.81	15	3			1.33						
	6	ECUH-7.2	4.00	1.00	4.00	4.81	20	3	1.33								
	6	ECUH-7.2	4.00	1.00	4.00	4.81	20	3		1.33							
	6	ECUH-7.2	4.00	1.00	4.00	4.81	20	3			1.33						
	7	ECUH-8.2	4.00	1.00	4.00	4.81	20	3	1.33								
	7	ECUH-8.2	4.00	1.00	4.00	4.81	20	3		1.33							
	8	ECUH-8.2	4.00	1.00	4.00	4.81	20	3			1.33						
	8	ECUH-9.4	4.00	1.00	4.00	4.81	20	3	1.33								
	9	ECUH-9.4	4.00	1.00	4.00	4.81	20	3		1.33							
	9	ECUH-9.4	4.00	1.00	4.00	4.81	20	3			1.33						
	10	T-P / LD	62.14	1.00	62.14	74.74	0	3	20.71								
	11	T-P / LD	62.14	1.00	62.14	74.74	0	3		20.71							
	12	T-P / LD	62.14	1.00	62.14	74.74	0	3			20.71						
	13	Garage Lighting N-8	3.82	1.25	4.78	17.23	30	1	4.78								
	14	Garage Lighting N-9	3.82	1.25	4.78	17.23	30	1		4.78							
	15	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	16	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	17	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	18	COLLATERAL	0.50	1.00	0.50	1.80	20	1			0.50						
	19-42	SPACE	0.00	1.00	0.00	0.00	-	1	0.00								
									48.28	48.28	44.00			Board			
													kVA	Size		Breaker	
T-P / HD													140.56	169.0709		200	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
P / LD	1	RTU-10.1	9.90	2.50	24.75	68.70	35	3	8.25						Voltage	208	/120V, 3P
	2	RTU-10.1	9.90	2.50	24.75	68.70	35	3		8.25					Breaker	225	
	3	RTU-10.1	9.90	2.50	24.75	68.70	35	3			8.25				Bus	225	
	4	UH-9.1	0.04	1.00	0.04	0.31	20	1	0.04						A.I.C	65k	
	4	UH-9.2	0.04	1.00	0.04	0.31	20	1		0.04							
	4	UH-9.3	0.04	1.00	0.04	0.31	20	1			0.04						
	4	UH-9.4	0.04	1.00	0.04	0.31	20	1	0.04								
	4	UH-9.5	0.04	1.00	0.04	0.31	20	1		0.04							
	4	UH-9.6	0.04	1.00	0.04	0.31	20	1			0.04						
	4	UH-9.8	0.04	1.00	0.04	0.31	20	1	0.04								
	4	UH-9.9	0.04	1.00	0.04	0.31	20	1		0.04							
	4	UH-9.10	0.04	1.00	0.04	0.31	20	1			0.04						
	5	T-C / LC	32.55	1.00	32.55	39.15	0	3		10.85							
	6	T-C / LC	32.55	1.00	32.55	39.15	0	3			10.85						
	7	T-C / LC	32.55	1.00	32.55	39.15	0	3	10.85								
	8	Façade Lattice Lighting	0.60	1.25	0.75	6.25	20	1		0.75							
	9	Façade Crown Lighting	0.60	1.25	0.75	6.25	20	1			0.75						
	10	Façade Curve Lighting 8	0.50	1.25	0.63	5.20	20	1	0.63								
	11	Façade Curve Lighting 9	0.50	1.25	0.63	5.20	20	1		0.63							
	12	Façade Curve Lighting 9M	0.50	1.25	0.63	5.20	20	1			0.63						
	13	Façade Curve Lighting 10	0.50	1.25	0.63	5.20	20	1	0.63								
	14	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	15	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	16	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	17	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	18-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									20.46	21.09	20.59			Board			
													kVA	Size		Breaker	
T-P / LD													62.138	172.4776		225	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
C / LA	1	WSHP-1.6	8.50	2.50	21.25	58.98	30	3	7.08						Voltage	208	/120V, 3P
	2	WSHP-1.6	8.50	2.50	21.25	58.98	30	3		7.08					Breaker	175	
	3	WSHP-1.6	8.50	2.50	21.25	58.98	30	3			7.08				Bus	225	
	4	WSHP-1.8	6.50	1.00	6.50	18.04	30	3	2.17						A.I.C	65k	
	5	WSHP-1.8	6.50	1.00	6.50	18.04	30	3		2.17							
	6	WSHP-1.8	6.50	1.00	6.50	18.04	30	3			2.17						
	7	Condos Level 2	32.98	0.34	11.21	31.12	40	3	3.74								
	8	Condos Level 2	32.98	0.34	11.21	31.12	40	3		3.74							
	9	Condos Level 2	32.98	0.34	11.21	31.12	40	3			3.74						
	10	Condos Level 3	32.98	0.34	11.21	31.12	40	3	3.74								
	11	Condos Level 3	32.98	0.34	11.21	31.12	40	3		3.74							
	12	Condos Level 3	32.98	0.34	11.21	31.12	40	3			3.74						
	13	Condo Recept Level 2	0.65	0.52	0.34	2.83	20	1	0.34								
	14	Condo Recept Level 2	0.65	0.52	0.34	2.83	20	1		0.34							
	15	Condo Recept Level 3	0.65	0.52	0.34	2.83	20	1			0.34						
	16	Condo Recept Level 3	0.65	0.52	0.34	2.83	20	1	0.34								
	17	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	18	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	19	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	20	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	21-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									17.40	17.56	17.06			Board			
													kVA	Size		Breaker	
T-C / LA													52.031	144.4225		175	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
C / LB	1	F-6.1	0.13	2.50	0.32	2.64	20	1	0.32						Voltage	208	/120V, 3P
	2	Condos Level 4	25.35	0.34	8.62	23.93	30	3		2.87					Breaker	125	
	3	Condos Level 4	25.35	0.34	8.62	23.93	30	3			2.87				Bus	225	
	4	Condos Level 4	25.35	0.34	8.62	23.93	30	3	2.87						A.I.C	65k	
	5	Condos Level 5	25.35	0.34	8.62	23.93	30	3		2.87							
	6	Condos Level 5	25.35	0.34	8.62	23.93	30	3			2.87						
	7	Condos Level 5	25.35	0.34	8.62	23.93	30	3	2.87								
	8	Condos Level 6	32.98	0.34	11.21	31.12	40	3		3.74							
	9	Condos Level 6	32.98	0.34	11.21	31.12	40	3			3.74						
	10	Condos Level 6	32.98	0.34	11.21	31.12	40	3	3.74								
	11	Condo Recept Level 4	0.65	0.52	0.34	2.83	20	1		0.34							
	12	Condo Recept Level 4	0.65	0.52	0.34	2.83	20	1			0.34						
	13	Condo Recept Level 5	0.65	0.52	0.34	2.83	20	1	0.34								
	14	Condo Recept Level 5	0.65	0.52	0.34	2.83	20	1		0.34							
	15	Condo Recept Level 6	0.65	0.52	0.34	2.83	20	1			0.34						
	16	Condo Recept Level 6	0.65	0.52	0.34	2.83	20	1	0.34								
	17	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	18	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	19	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	20	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	21-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									10.48	10.66	10.16			Board			
													kVA	Size		Breaker	
T-C / LB													31.304	86.89054		125	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
C / LC	1	AC-10.1	0.56	2.50	1.40	3.88	15	3	0.47						Voltage	208	/120V, 3P
	2	AC-10.1	0.56	2.50	1.40	3.88	15	3		0.47					Breaker	125	
	3	AC-10.1	0.56	2.50	1.40	3.88	15	3			0.47				Bus	225	
	4	F-7.1	0.13	1.00	0.13	1.06	20	1	0.13						A.I.C	65k	
	4	F-8.1	0.13	1.00	0.13	1.06	20	1		0.13							
	4	F-9.1	0.13	1.00	0.13	1.06	20	1			0.13						
	5	Condos Level 7	25.35	0.34	8.62	23.93	30	3		2.87							
	6	Condos Level 7	25.35	0.34	8.62	23.93	30	3			2.87						
	7	Condos Level 7	25.35	0.34	8.62	23.93	30	3	2.87								
	8	Condos Level 8	25.35	0.34	8.62	23.93	30	3		2.87							
	9	Condos Level 8	25.35	0.34	8.62	23.93	30	3			2.87						
	10	Condos Level 8	25.35	0.34	8.62	23.93	30	3	2.87								
	11	Condos Level 9	26.80	0.34	9.11	25.29	40	3		3.04							
	12	Condos Level 9	26.80	0.34	9.11	25.29	40	3			3.04						
	13	Condos Level 9	26.80	0.34	9.11	25.29	40	3	3.04								
	14	Condo Recept Level 7	0.65	1.00	0.65	5.45	20	1		0.65							
	15	Condo Recept Level 7	0.65	1.00	0.65	5.45	20	1			0.65						
	16	Condo Recept Level 8	0.65	1.00	0.65	5.45	20	1	0.65								
	17	Condo Recept Level 8	0.65	1.00	0.65	5.45	20	1		0.65							
	18	Condo Recept Level 9	0.65	1.00	0.65	5.45	20	1			0.65						
	19	Condo Recept Level 9	0.65	1.00	0.65	5.45	20	1	0.65								
	20	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	21	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	22	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	23	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	24-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									10.68	11.18	10.68			Board			
													kVA	Size		Breaker	
T-C / LC													32.552	90.3559		125	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / HA	1	F-0.2	1.49	1.00	1.49	1.79	15	3	0.50						Voltage	480	/277V, 3P
	2	F-0.2	1.49	1.00	1.49	1.79	15	3		0.50					Breaker	300	
	3	F-0.2	1.49	1.00	1.49	1.79	15	3			0.50				Bus	400	
	4	AHU-1.1	2.24	1.00	2.24	2.69	15	3	0.75						A.I.C	65k	
	5	AHU-1.1	2.24	1.00	2.24	2.69	15	3		0.75							
	6	AHU-1.1	2.24	1.00	2.24	2.69	15	3			0.75						
	7	ACCU-1.1	18.40	1.00	18.40	22.13	30	3	6.13								
	8	ACCU-1.1	18.40	1.00	18.40	22.13	30	3		6.13							
	9	ACCU-1.1	18.40	1.00	18.40	22.13	30	3			6.13						
	10	ACCU-1.2	18.40	1.00	18.40	22.13	30	3	6.13								
	11	ACCU-1.2	18.40	1.00	18.40	22.13	30	3		6.13							
	12	ACCU-1.2	18.40	1.00	18.40	22.13	30	3			6.13						
	13	WSHP-1.1	11.50	1.00	11.50	13.83	20	3	3.83								
	14	WSHP-1.1	11.50	1.00	11.50	13.83	20	3		3.83							
	15	WSHP-1.1	11.50	1.00	11.50	13.83	20	3			3.83						
	16	WSHP-1.9	11.50	1.00	11.50	13.83	20	3	3.83								
	17	WSHP-1.9	11.50	1.00	11.50	13.83	20	3		3.83							
	18	WSHP-1.9	11.50	1.00	11.50	13.83	20	3			3.83						
	19	Trash Compactor	2.24	1.00	2.24	2.69	20	3	0.75								
	20	Trash Compactor	2.24	1.00	2.24	2.69	20	3		0.75							
	21	Trash Compactor	2.24	1.00	2.24	2.69	20	3			0.75						
	22	Elevator 8	26.11	2.50	65.28	78.51	90	3	21.76								
	23	Elevator 8	26.11	2.50	65.28	78.51	90	3		21.76							
	24	Elevator 8	26.11	2.50	65.28	78.51	90	3			21.76						
	25	Elevator 9	26.11	1.00	26.11	31.41	90	3	8.70								
	26	Elevator 9	26.11	1.00	26.11	31.41	90	3		8.70							
	27	Elevator 9	26.11	1.00	26.11	31.41	90	3			8.70						
	28	T-H / LA	33.10	1.00	33.10	39.82	0	3	11.03								
	29	T-H / LA	33.10	1.00	33.10	39.82	0	3		11.03							
	30	T-H / LA	33.10	1.00	33.10	39.82	0	3			11.03						
	31	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	32	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	33	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	34	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	35-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									63.92	63.42	63.42			Board			
													kVA	Size		Breaker	
T-H / HA													190.76	229.4442		300	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / LA	1	CUH-0.1	0.08	1.00	0.08	0.67	20	1	0.08						Voltage	208	/120V, 3P
	1	CUH-0.2	0.08	1.00	0.08	0.67	20	1		0.08					Breaker	125	
	1	CUH-0.3	0.08	1.00	0.08	0.67	20	1			0.08				Bus	225	
	1	CUH-0.4	0.08	1.00	0.08	0.67	20	1	0.08						A.I.C	65k	
	1	CUH-1.2	0.08	1.00	0.08	0.67	20	1		0.08							
	1	CUH-1.4	0.08	1.00	0.08	0.67	20	1			0.08						
	1	CUH-1.5	0.08	1.00	0.08	0.67	20	1	0.08								
	1	UH-0.1	0.05	1.00	0.05	0.42	20	1		0.05							
	1	UH-0.2	0.05	1.00	0.05	0.42	20	1			0.05						
	1	F-1.3	0.25	1.00	0.25	2.05	20	1	0.25								
	1	F-1.4	0.37	1.00	0.37	3.11	20	1		0.37							
	2	AC-0.1	0.56	1.00	0.56	1.55	15	2			0.28						
	3	AC-0.1	0.56	1.00	0.56	1.55	15	2	0.28								
	4	WSHP-0.1	5.70	2.50	14.25	39.55	25	2		7.13							
	5	WSHP-0.1	5.70	2.50	14.25	39.55	25	2			7.13						
	6	Clearwater Pump 2	1.12	1.00	1.12	9.32	40	1	1.12								
	6	Sanitary Pump	1.12	1.00	1.12	9.32	40	1		1.12							
	6	Circulation Pump 1	0.13	1.00	0.13	1.06	20	1			0.13						
	6	Circulation Pump 2	0.13	1.00	0.13	1.06	20	1	0.13								
	7	Compressor A6.1	12.90	1.00	12.90	35.81	50	2		6.45							
	8	Compressor A6.1	12.90	1.00	12.90	35.81	50	2			6.45						
	9	P-1.2	0.19	1.00	0.19	1.55	15	1	0.19								
	9	P-1.1	0.19	1.00	0.19	1.55	15	1		0.19							
	10	Façade Canopy Lighting	0.60	1.25	0.75	6.25	20	1	0.75								
	11	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	12	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	13	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	14	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	15-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									2.95	15.96	14.19			Board			
													kVA	Size		Breaker	
T-H / LA													33.103	91.88563		125	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / HB	1	P-0.7	29.84	2.50	74.60	89.73	90	3	24.87						Voltage	480	/277V, 3P
	2	P-0.7	29.84	2.50	74.60	89.73	90	3		24.87					Breaker	250	
	3	P-0.7	29.84	2.50	74.60	89.73	90	3			24.87				Bus	225	
	4	P-0.8	29.84	1.00	29.84	35.89	90	3	9.95						A.I.C	65k	
	5	P-0.8	29.84	1.00	29.84	35.89	90	3		9.95							
	6	P-0.8	29.84	1.00	29.84	35.89	90	3			9.95						
	7	F-0.1	0.75	1.00	0.75	0.90	15	3	0.25								
	8	F-0.1	0.75	1.00	0.75	0.90	15	3		0.25							
	9	F-0.1	0.75	1.00	0.75	0.90	15	3			0.25						
	10	CP-0.1	2.24	1.00	2.24	2.69	15	3	0.75								
	11	CP-0.1	2.24	1.00	2.24	2.69	15	3		0.75							
	12	CP-0.1	2.24	1.00	2.24	2.69	15	3			0.75						
	13	AHU-1.2	2.24	1.00	2.24	2.69	15	3	0.75								
	14	AHU-1.2	2.24	1.00	2.24	2.69	15	3		0.75							
	15	AHU-1.2	2.24	1.00	2.24	2.69	15	3			0.75						
	16	WSHP-1.7	11.50	1.00	11.50	13.83	20	3	3.83								
	17	WSHP-1.7	11.50	1.00	11.50	13.83	20	3		3.83							
	18	WSHP-1.7	11.50	1.00	11.50	13.83	20	3			3.83						
	19	WSHP-1.10	15.50	1.00	15.50	18.64	20	3	5.17								
	20	WSHP-1.10	15.50	1.00	15.50	18.64	20	3		5.17							
	21	WSHP-1.10	15.50	1.00	15.50	18.64	20	3			5.17						
	22	Dom. Booster Pump	17.34	1.00	17.34	20.86	50	3	5.78								
	23	Dom. Booster Pump	17.34	1.00	17.34	20.86	50	3		5.78							
	24	Dom. Booster Pump	17.34	1.00	17.34	20.86	50	3			5.78						
	25	F-1.5	1.49	1.00	1.49	1.79	15	3	0.50								
	26	F-1.5	1.49	1.00	1.49	1.79	15	3		0.50							
	27	F-1.5	1.49	1.00	1.49	1.79	15	3			0.50						
	28	P-0.1	5.60	1.00	5.60	6.73	50	3	1.87								
	29	P-0.1	5.60	1.00	5.60	6.73	50	3		1.87							
	30	P-0.1	5.60	1.00	5.60	6.73	50	3			1.87						
	31	P-0.2	5.60	1.00	5.60	6.73	50	3	1.87								
	32	P-0.2	5.60	1.00	5.60	6.73	50	3		1.87							
	33	P-0.2	5.60	1.00	5.60	6.73	50	3			1.87						
	34	T-H / LB	0.50	1.00	0.50	0.60	0	3	0.17								
	35	T-H / LB	0.50	1.00	0.50	0.60	0	3		0.17							
	36	T-H / LB	0.50	1.00	0.50	0.60	0	3			0.17						
	37	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	38	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	39	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	40	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	41	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
	42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									56.23	55.73	55.73			Board			
													kVA	Size		Breaker	
T-H / HB													167.69	201.6979		250	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / LB	1	SPARE	0.00	1.00	0.00	0.00	20	1	0.00						Voltage	208	/120V, 3P
	2	SPARE	0.00	1.00	0.00	0.00	20	1		0.00					Breaker	50	
	3	SPARE	0.00	1.00	0.00	0.00	20	1			0.00				Bus	60	
	4	COLLATERAL	0.50	1.00	0.50	4.16	20	1	0.50						A.I.C	65k	
	5-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									0.50	0.00	0.00			Board			
													kVA	Size		Breaker	
T-H / LB													0.5	1.387861		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / HC	1	T-H / LC	0.94	1.00	0.94	1.14	0	3	0.31						Voltage	480	/277V, 3P
	2	T-H / LC	0.94	1.00	0.94	1.14	0	3		0.31					Breaker	50	
	3	T-H / LC	0.94	1.00	0.94	1.14	0	3			0.31				Bus	60	
	4	SPARE	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	8-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									0.81	0.31	0.31			Board			
													kVA	Size		Breaker	
T-H / HC													1.4439	1.736706		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / LC	1	F-10.1	0.13	2.50	0.32	2.64	20	1	0.32						Voltage	208	/120V, 3P
	2	F-11.1	0.13	1.00	0.13	1.06	20	1		0.13					Breaker	50	
	3	SPARE	0.00	1.00	0.00	0.00	20	1			0.00				Bus	60	
	4	SPARE	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	COLLATERAL	0.50	1.00	0.50	4.16	20	1			0.50						
	7-42	SPACE	0.00	1.00	0.00	0.00	-	1	0.00								
									0.32	0.13	0.50			Board			
													kVA	Size		Breaker	
T-H / LC													0.9439	2.619921		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / HD	1	T-H / LD	3.20	1.00	3.20	3.84	0	3	1.07						Voltage	480	/277V, 3P
	2	T-H / LD	3.20	1.00	3.20	3.84	0	3		1.07					Breaker	50	
	3	T-H / LD	3.20	1.00	3.20	3.84	0	3			1.07				Bus	60	
	4	SPARE	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	8-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									1.57	1.07	1.07			Board			
													kVA	Size		Breaker	
T-H / HD													3.6957	4.445224		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / LD	1	F-12.1	0.13	2.50	0.32	2.64	20	1	0.32						Voltage	208	/120V, 3P
	1	F-13.1	0.13	1.00	0.13	1.06	20	1		0.13					Breaker	50	
	1	F-14.1	0.13	1.00	0.13	1.06	20	1			0.13				Bus	60	
															A.I.C	65k	
	2	Façade Curve Lighting 11	0.50	1.25	0.63	5.20	20	1		0.63							
	3	Façade Curve Lighting 12	0.60	1.25	0.75	6.25	20	1			0.75						
	4	Façade Curve Lighting 13	0.60	1.25	0.75	6.25	20	1	0.75								
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									1.07	1.25	0.88			Board			
													kVA	Size		Breaker	
T-H / LD													3.1957	8.870348		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / HE	1	RTU--R.1	23.90	1.00	23.90	28.75	35	3	7.97						Voltage	480	/277V, 3P
	2	RTU--R.1	23.90	1.00	23.90	28.75	35	3		7.97					Breaker	200	
	3	RTU--R.1	23.90	1.00	23.90	28.75	35	3			7.97				Bus	225	
	4	T-H / LE	3.70	1.00	3.70	4.45	0	3	1.23						A.I.C	65k	
	5	T-H / LE	3.70	1.00	3.70	4.45	0	3		1.23							
	6	T-H / LE	3.70	1.00	3.70	4.45	0	3			1.23						
	7	CT-R.1	29.84	2.50	74.60	207.07	90	3	24.87								
	8	CT-R.1	29.84	2.50	74.60	207.07	90	3		24.87							
	9	CT-R.1	29.84	2.50	74.60	207.07	90	3			24.87						
	7	CT-R.2	29.84	1.00	29.84	82.83	90	3	9.95								
	8	CT-R.2	29.84	1.00	29.84	82.83	90	3		9.95							
	9	CT-R.2	29.84	1.00	29.84	82.83	90	3			9.95						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	9	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	10	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	11-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									44.51	44.01	44.01			Board			
													kVA	Size		Breaker	
T-H / HE													132.54	159.4157		200	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
H / LE	1	F-15.1	0.13	2.50	0.32	2.64	20	1	0.32						Voltage	208	/120V, 3P
	1	F-16.1	0.13	1.00	0.13	1.06	20	1		0.13					Breaker	50	
	1	F-17.1	0.13	1.00	0.13	1.06	20	1			0.13				Bus	60	
															A.I.C	65k	
	2	Façade Curve Lighting 14	0.80	1.25	1.00	8.33	20	1		1.00							
	3	Façade Curve Lighting 15	0.40	1.25	0.50	4.16	20	1			0.50						
	4	Façade Curve Lighting 16	0.40	1.25	0.50	4.16	20	1	0.50								
	5	Façade Curve Lighting 17	0.50	1.25	0.63	5.20	20	1		0.63							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	9	COLLATERAL	0.50	1.00	0.50	4.16	20	1			0.50						
	10-42	SPACE	0.00	1.00	0.00	0.00	-	1	0.00								
									0.82	1.75	1.13			Board			
													kVA	Size		Breaker	
T-H / LE													3.6957	10.25821		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / HA	1	T-HE / LA	0.50	1.00	0.50	0.60	0	3	0.17						Voltage	480	/277V, 3P
	2	T-HE / LA	0.50	1.00	0.50	0.60	0	3		0.17					Breaker	50	
	3	T-HE / LA	0.50	1.00	0.50	0.60	0	3			0.17				Bus	60	
	4	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1		0.00							
	6	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1			0.00						
	7	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1	0.00								
	8	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	9	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	10	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	11	COLLATERAL	0.50	1.00	0.50	1.80	20	1		0.50							
	12-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									0.17	0.67	0.17			Board			
													kVA	Size		Breaker	
T-HE / HA													1	1.202813		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / LA	1	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1	0.00						Voltage	208	/120V, 3P
	2	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1		0.00					Breaker	50	
	3	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1			0.00				Bus	60	
	4	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									0.00	0.50	0.00			Board			
													kVA	Size		Breaker	
T-HE / LA													0.5	1.387861		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / HB	1	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1	0.00						Voltage	480	/277V, 3P
	2	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1		0.00					Breaker	50	
	3	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1			0.00				Bus	60	
	4	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	1.80	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									0.00	0.50	0.00			Board			
													kVA	Size		Breaker	
T-HE / HB													0.5	0.601407		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / HC	1	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1	0.00						Voltage	480	/277V, 3P
	2	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	3		0.00					Breaker	50	
	3	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	3			0.00				Bus	60	
	4	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	1.80	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									0.00	0.50	0.00			Board			
													kVA	Size		Breaker	
T-HE / HC													0.5	0.601407		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / LC3	1	Cond WSHP 1	5.70	1.00	5.70	20.57	20	1	5.70						Voltage	208	/120V, 3P
	2	Cond WSHP 2	5.70	1.00	5.70	20.57	20	1		5.70					Breaker	250	
	7	Cond WSHP 3	5.70	1.00	5.70	20.57	20	1			5.70				Bus	400	
	8	Cond WSHP 4	5.70	1.00	5.70	20.57	20	1	5.70						A.I.C	65k	
	13	Cond WSHP 5	5.70	1.00	5.70	20.57	20	1		5.70							
	14	Cond WSHP 6	5.70	1.00	5.70	20.57	20	1			5.70						
	19	Cond WSHP 7	5.70	1.00	5.70	20.57	20	1	5.70								
	20	Cond WSHP 8	5.70	1.00	5.70	20.57	20	1		5.70							
	25	Cond WSHP 9	5.70	1.00	5.70	20.57	20	1			5.70						
	26	Cond WSHP 10	5.70	1.00	5.70	20.57	20	1	5.70								
	31	Cond WSHP 11	5.70	1.00	5.70	20.57	20	1		5.70							
	32	Cond WSHP 12	5.70	1.00	5.70	20.57	20	1			5.70						
	37	Cond WSHP 13	5.70	1.00	5.70	20.57	20	1	5.70								
	38	Cond WSHP 14	5.70	1.00	5.70	20.57	20	1		5.70							
									28.50	28.50	22.80			Board			
													kVA	Size		Breaker	
T-HE / LC3													79.8	221.5027		250	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / LC2	1	Cond WSHP 15	5.70	1.00	5.70	20.57	20	1	5.70						Voltage	208	/120V, 3P
	2	Cond WSHP 16	5.70	1.00	5.70	20.57	20	1		5.70					Breaker	250	
	7	Cond WSHP 17	5.70	1.00	5.70	20.57	20	1			5.70				Bus	400	
	8	Cond WSHP 18	5.70	1.00	5.70	20.57	20	1	5.70						A.I.C	65k	
	13	Cond WSHP 19	5.70	1.00	5.70	20.57	20	1		5.70							
	14	Cond WSHP 20	5.70	1.00	5.70	20.57	20	1			5.70						
	19	Cond WSHP 21	5.70	1.00	5.70	20.57	20	1	5.70								
	20	Cond WSHP 22	5.70	1.00	5.70	20.57	20	1		5.70							
	25	Cond WSHP 23	5.70	1.00	5.70	20.57	20	1			5.70						
	26	Cond WSHP 24	5.70	1.00	5.70	20.57	20	1	5.70								
	31	Cond WSHP 25	5.70	1.00	5.70	20.57	20	1		5.70							
	32	Cond WSHP 26	5.70	1.00	5.70	20.57	20	1			5.70						
	37	Cond WSHP 27	5.70	1.00	5.70	20.57	20	1	5.70								
	38	Cond WSHP 28	5.70	1.00	5.70	20.57	20	1		5.70							
									28.50	28.50	22.80			Board			
													kVA	Size		Breaker	
T-HE / LC2													79.8	221.5027		250	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / LC	1	Condo Fridge 1	1.80	1.00	1.80	6.50	20	1	1.80						Voltage	208	/120V, 3P
	2	Condo Fridge 2	1.80	1.00	1.80	6.50	20	1		1.80					Breaker	600	
	3	Condo Fridge 3	1.80	1.00	1.80	6.50	20	1			1.80				Bus	600	
	4	Condo Fridge 4	1.80	1.00	1.80	6.50	20	1	1.80						A.I.C	65k	
	5	Condo Fridge 5	1.80	1.00	1.80	6.50		1		1.80							
	6	Condo Fridge 6	1.80	1.00	1.80	6.50		1			1.80						
	7	Condo Fridge 7	1.80	1.00	1.80	6.50		1	1.80								
	8	Condo Fridge 8	1.80	1.00	1.80	6.50		1		1.80							
	9	Condo Fridge 9	1.80	1.00	1.80	6.50		1			1.80						
	10	Condo Fridge 10	1.80	1.00	1.80	6.50		1	1.80								
	11	Condo Fridge 11	1.80	1.00	1.80	6.50		1		1.80							
	12	Condo Fridge 12	1.80	1.00	1.80	6.50		1			1.80						
	13	Condo Fridge 13	1.80	1.00	1.80	6.50		1	1.80								
	14	Condo Fridge 14	1.80	1.00	1.80	6.50		1		1.80							
	15	Condo Fridge 15	1.80	1.00	1.80	6.50		1			1.80						
	16	Condo Fridge 16	1.80	1.00	1.80	6.50		1	1.80								
	17	Condo Fridge 17	1.80	1.00	1.80	6.50		1		1.80							
	18	Condo Fridge 18	1.80	1.00	1.80	6.50		1			1.80						
	19	Condo Fridge 19	1.80	1.00	1.80	6.50		1	1.80								
	20	Condo Fridge 20	1.80	1.00	1.80	6.50		1		1.80							
	21	Condo Fridge 21	1.80	1.00	1.80	6.50		1			1.80						
	22	Condo Fridge 22	1.80	1.00	1.80	6.50		1	1.80								
	23	Condo Fridge 23	1.80	1.00	1.80	6.50		1		1.80							
	24	Condo Fridge 24	1.80	1.00	1.80	6.50		1			1.80						
	25	Condo Fridge 25	1.80	1.00	1.80	6.50		1	1.80								
	26	Condo Fridge 26	1.80	1.00	1.80	6.50		1		1.80							
	27	Condo Fridge 27	1.80	1.00	1.80	6.50		1			1.80						
	28	Condo Fridge 28	1.80	1.00	1.80	6.50		1	1.80								
	23	T-HE / LC2	79.80	1.00	79.80	95.98	0	3		26.60							
	24	T-HE / LC2	79.80	1.00	79.80	95.98	0	3			26.60						
	25	T-HE / LC2	79.80	1.00	79.80	95.98	0	3	26.60								
	26	T-HE / LC3	79.80	1.00	79.80	95.98	0	3		26.60							
	27	T-HE / LC3	79.80	1.00	79.80	95.98	0	3			26.60						
	28	T-HE / LC3	79.80	1.00	79.80	95.98	0	3	26.60								
	29	SPACE	0.50	1.00	0.50	1.80	-	1		0.50							
	30-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									71.20	69.90	69.40			Board			
													kVA	Size		Breaker	
T-HE / LC													210.5	584.2896		600	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / HD	1	T-HE / LD	0.50	1.00	0.50	0.60	0	3	0.17						Voltage	480	/277V, 3P
	2	T-HE / LD	0.50	1.00	0.50	0.60	0	3		0.17					Breaker	50	
	3	T-HE / LD	0.50	1.00	0.50	0.60	0	3			0.17				Bus	60	
	4	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	2	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	3		0.00							
	3	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	3			0.00						
	4	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1	0.00								
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	1.80	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									0.17	0.67	0.17			Board			
													kVA	Size		Breaker	
T-HE / HD													1	1.202813		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HE / LD	1	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1	0.00						Voltage	208	/120V, 3P
	2	FIRE EQUIPMENT	0.00	1.00	0.00	0.00	20	1		0.00					Breaker	50	
	3	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1			0.00				Bus	60	
	4	EMERG LIGHTS	0.00	1.00	0.00	0.00	20	1	0.00						A.I.C	65k	
	5	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	6	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	7	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	8	COLLATERAL	0.50	1.00	0.50	4.16	20	1		0.50							
	9-42	SPACE	0.00	1.00	0.00	0.00	-	1			0.00						
									0.00	0.50	0.00			Board			
													kVA	Size		Breaker	
T-HE / LD													0.5	1.387861		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HS / HA	1	Elevator 6	26.11	2.50	65.28	78.51	90	3	21.76						Voltage	480	/277V, 3P
	2	Elevator 6	26.11	2.50	65.28	78.51	90	3		21.76					Breaker	225	
	3	Elevator 6	26.11	2.50	65.28	78.51	90	3			21.76				Bus	400	
	4	Elevator 7	26.11	1.00	26.11	31.41	90	3	8.70						A.I.C	65k	
	5	Elevator 7	26.11	1.00	26.11	31.41	90	3		8.70							
	6	Elevator 7	26.11	1.00	26.11	31.41	90	3			8.70						
	7	AHU-9.1	10.44	1.00	10.44	12.56	30	3	3.48								
	8	AHU-9.1	10.44	1.00	10.44	12.56	30	3		3.48							
	9	AHU-9.1	10.44	1.00	10.44	12.56	30	3			3.48						
	10	F-9.3	5.97	1.00	5.97	7.18	20	3	1.99								
	11	F-9.3	5.97	1.00	5.97	7.18	20	3		1.99							
	12	F-9.3	5.97	1.00	5.97	7.18	20	3			1.99						
	13	Elevator 10	26.11	1.00	26.11	31.41	90	3	8.70								
	14	Elevator 10	26.11	1.00	26.11	31.41	90	3		8.70							
	15	Elevator 10	26.11	1.00	26.11	31.41	90	3			8.70						
	16	Elevator 11	26.11	1.00	26.11	31.41	90	3	8.70								
	17	Elevator 11	26.11	1.00	26.11	31.41	90	3		8.70							
	18	Elevator 11	26.11	1.00	26.11	31.41	90	3			8.70						
	19	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	20	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	21	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	22	COLLATERAL	0.50	1.00	0.50	1.80	20	1	0.50								
	23-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									53.84	53.34	53.34			Board			
													kVA	Size		Breaker	
T-HS / HA													160.52	193.0719		225	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HS / HB	1	Elevator 1	37.30	2.50	93.25	112.16	125	3	31.08						Voltage	480	/277V, 3P
	2	Elevator 1	37.30	2.50	93.25	112.16	125	3		31.08					Breaker	400	
	3	Elevator 1	37.30	2.50	93.25	112.16	125	3			31.08				Bus	400	
	4	Elevator 2	37.30	1.00	37.30	44.86	125	3	12.43						A.I.C	65k	
	5	Elevator 2	37.30	1.00	37.30	44.86	125	3		12.43							
	6	Elevator 2	37.30	1.00	37.30	44.86	125	3			12.43						
	7	Elevator 3	37.30	1.00	37.30	44.86	125	3	12.43								
	8	Elevator 3	37.30	1.00	37.30	44.86	125	3		12.43							
	9	Elevator 3	37.30	1.00	37.30	44.86	125	3			12.43						
	10	Elevator 4	37.30	1.00	37.30	44.86	125	3	12.43								
	11	Elevator 4	37.30	1.00	37.30	44.86	125	3		12.43							
	12	Elevator 4	37.30	1.00	37.30	44.86	125	3			12.43						
	13	Elevator 5	37.30	1.00	37.30	44.86	125	3	12.43								
	14	Elevator 5	37.30	1.00	37.30	44.86	125	3		12.43							
	15	Elevator 5	37.30	1.00	37.30	44.86	125	3			12.43						
	16	F-R.1	1.12	1.00	1.12	1.35	15	3	0.37								
	17	F-R.1	1.12	1.00	1.12	1.35	15	3		0.37							
	18	F-R.1	1.12	1.00	1.12	1.35	15	3			0.37						
	19	F-R.2	2.24	1.00	2.24	2.69	15	3	0.75								
	20	F-R.2	2.24	1.00	2.24	2.69	15	3		0.75							
	21	F-R.2	2.24	1.00	2.24	2.69	15	3			0.75						
	22	F-R.3	5.60	1.00	5.60	6.73	20	3	1.87								
	23	F-R.3	5.60	1.00	5.60	6.73	20	3		1.87							
	24	F-R.3	5.60	1.00	5.60	6.73	20	3			1.87						
	25	F-R.4	14.92	1.00	14.92	17.95	60	3	4.97								
	26	F-R.4	14.92	1.00	14.92	17.95	60	3		4.97							
	27	F-R.4	14.92	1.00	14.92	17.95	60	3			4.97						
	28	F-R.5	1.12	1.00	1.12	1.35	15	3	0.37								
	29	F-R.5	1.12	1.00	1.12	1.35	15	3		0.37							
	30	F-R.5	1.12	1.00	1.12	1.35	15	3			0.37						
	31	EFC-R.1	22.38	1.00	22.38	26.92	125	3	7.46								
	32	EFC-R.1	22.38	1.00	22.38	26.92	125	3		7.46							
	33	EFC-R.1	22.38	1.00	22.38	26.92	125	3			7.46						
	34	T-HS / LB	0.50	1.00	0.50	0.60	0	3	0.17								
	35	T-HS / LB	0.50	1.00	0.50	0.60	0	3		0.17							
	36	T-HS / LB	0.50	1.00	0.50	0.60	0	3			0.17						
	37	SPARE	0.00	1.00	0.00	0.00	20	3	0.00								
	38	SPARE	0.00	1.00	0.00	0.00	20	3		0.00							
	39	SPARE	0.00	1.00	0.00	0.00	20	3			0.00						
	40-42	SPACE	0.00	1.00	0.00	0.00	-	3	0.00								
									96.77	96.77	96.77			Board			
													kVA	Size		Breaker	
T-HS / HB													290.32	349.2019		400	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
HS / LB	1	SPARE	0.00	1.00	0.00	0.00	20	1	0.00						Voltage	208	/120V, 3P
	2	SPARE	0.00	1.00	0.00	0.00	20	1		0.00					Breaker	50	
	3	SPARE	0.00	1.00	0.00	0.00	20	1			0.00				Bus	60	
	4	COLLATERAL	0.50	1.00	0.50	4.16	20	1	0.50						A.I.C	65k	
	5-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									0.50	0.00	0.00			Board			
													kVA	Size		Breaker	
T-HS / LB													0.5	1.387861		50	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
MAIN	1	P-0.3	74.60	2.50	186.50	224.32	200	3	62.17						Voltage	480	/277V, 3P
	2	P-0.3	74.60	2.50	186.50	224.32	200	3		62.17					Breaker	4000	
	3	P-0.3	74.60	2.50	186.50	224.32	200	3			62.17				Bus	4000	
	4	P-0.4	74.60	1.00	74.60	89.73	200	3	24.87						A.I.C	65k	
	5	P-0.4	74.60	1.00	74.60	89.73	200	3		24.87							
	6	P-0.4	74.60	1.00	74.60	89.73	200	3			24.87						
	22	P-0.1	5.60	1.00	5.60	6.73	50	3	1.87								
	23	P-0.1	5.60	1.00	5.60	6.73	50	3		1.87							
	24	P-0.1	5.60	1.00	5.60	6.73	50	3			1.87						
	25	P-0.2	5.60	1.00	5.60	6.73	50	3	1.87								
	26	P-0.2	5.60	1.00	5.60	6.73	50	3		1.87							
	27	P-0.2	5.60	1.00	5.60	6.73	50	3			1.87						
	7	T-P / HA	76.24	1.00	76.24	91.70	0	3	25.41								
	8	T-P / HA	76.24	1.00	76.24	91.70	0	3		25.41							
	9	T-P / HA	76.24	1.00	76.24	91.70	0	3			25.41						
	10	T-RT / DP	182.90	1.00	182.90	219.99	0	3	60.97								
	11	T-RT / DP	182.90	1.00	182.90	219.99	0	3		60.97							
	12	T-RT / DP	182.90	1.00	182.90	219.99	0	3			60.97						
	13	T-H / HA	190.76	1.00	190.76	229.44	0	3	63.59								
	14	T-H / HA	190.76	1.00	190.76	229.44	0	3		63.59							
	15	T-H / HA	190.76	1.00	190.76	229.44	0	3			63.59						
	16	T-H / HB	167.69	1.00	167.69	201.70	0	3	55.90								
	17	T-H / HB	167.69	1.00	167.69	201.70	0	3		55.90							
	18	T-H / HB	167.69	1.00	167.69	201.70	0	3			55.90						
	19	T-HE / HA	1.00	1.00	1.00	1.20	0	3	0.33								
	20	T-HE / HA	1.00	1.00	1.00	1.20	0	3		0.33							
	21	T-HE / HA	1.00	1.00	1.00	1.20	0	3			0.33						
	22	T-BUS	1932.58	1.00	1932.58	2324.53	0	3	644.19								
	23	T-BUS	1932.58	1.00	1932.58	2324.53	0	3		644.19							
	24	T-BUS	1932.58	1.00	1932.58	2324.53	0	3			644.19						
									941.15	941.15	941.15			Board			
													kVA	Size		Breaker	
T-MAIN													2823.4	3396.072		4000	

Panel	Switch	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
BUS	1	PTAC-10.1	74.60	2.50	186.50	224.32	0	3	62.17						Voltage	480	/277V, 3P
	2	PTAC-10.1	74.60	2.50	186.50	224.32	0	3		62.17					Breaker	3200	
	3	PTAC-10.1	74.60	2.50	186.50	224.32	0	3			62.17				Bus	3200	
	4	PTAC-11.1	74.60	1.00	74.60	89.73	0	3	24.87						A.I.C	65k	
	5	PTAC-11.1	74.60	1.00	74.60	89.73	0	3		24.87							
	6	PTAC-11.1	74.60	1.00	74.60	89.73	0	3			24.87						
	7	PTAC-12.1	74.60	1.00	74.60	89.73	0	3	24.87								
	8	PTAC-12.1	74.60	1.00	74.60	89.73	0	3		24.87							
	9	PTAC-12.1	74.60	1.00	74.60	89.73	0	3			24.87						
	10	PTAC-13.1	74.60	1.00	74.60	89.73	0	3	24.87								
	11	PTAC-13.1	74.60	1.00	74.60	89.73	0	3		24.87							
	12	PTAC-13.1	74.60	1.00	74.60	89.73	0	3			24.87						
	13	PTAC-14.1	74.60	1.00	74.60	89.73	0	3	24.87								
	14	PTAC-14.1	74.60	1.00	74.60	89.73	0	3		24.87							
	15	PTAC-14.1	74.60	1.00	74.60	89.73	0	3			24.87						
	16	PTAC-15.1	74.60	1.00	74.60	89.73	0	3	24.87								
	17	PTAC-15.1	74.60	1.00	74.60	89.73	0	3		24.87							
	18	PTAC-15.1	74.60	1.00	74.60	89.73	0	3			24.87						
	19	PTAC-16.1	74.60	1.00	74.60	89.73	0	3	24.87								
	20	PTAC-16.1	74.60	1.00	74.60	89.73	0	3		24.87							
	21	PTAC-16.1	74.60	1.00	74.60	89.73	0	3			24.87						
	22	PTAC-17.1	74.60	1.00	74.60	89.73	0	3	24.87								
	23	PTAC-17.1	74.60	1.00	74.60	89.73	0	3		24.87							
	24	PTAC-17.1	74.60	1.00	74.60	89.73	0	3			24.87						
	25	Office Tenant Floor10	47.44	0.85	40.33	48.50	60	3	13.44								
	26	Office Tenant Floor10	47.44	0.85	40.33	48.50	60	3		13.44							
	27	Office Tenant Floor10	47.44	0.85	40.33	48.50	60	3			13.44						
	28	Office Tenant Floor 11	47.44	0.85	40.33	48.50	60	3	13.44								
	29	Office Tenant Floor 11	47.44	0.85	40.33	48.50	60	3		13.44							
	30	Office Tenant Floor 11	47.44	0.85	40.33	48.50	60	3			13.44						
	31	Office Tenant Floor12	47.44	0.85	40.33	48.50	60	3	13.44								
	32	Office Tenant Floor12	47.44	0.85	40.33	48.50	60	3		13.44							
	33	Office Tenant Floor12	47.44	0.85	40.33	48.50	60	3			13.44						
	34	Office Tenant Floor13	47.44	0.85	40.33	48.50	60	3	13.44								
	35	Office Tenant Floor13	47.44	0.85	40.33	48.50	60	3		13.44							
	36	Office Tenant Floor13	47.44	0.85	40.33	48.50	60	3			13.44						
	37	Office Tenant Floor14	47.44	0.85	40.33	48.50	60	3	13.44								
	38	Office Tenant Floor14	47.44	0.85	40.33	48.50	60	3		13.44							
	39	Office Tenant Floor14	47.44	0.85	40.33	48.50	60	3			13.44						
	40	Office Tenant Floor15	47.44	0.85	40.33	48.50	60	3	13.44								
	41	Office Tenant Floor15	47.44	0.85	40.33	48.50	60	3		13.44							
	42	Office Tenant Floor15	47.44	0.85	40.33	48.50	60	3			13.44						
	43	Office Tenant Floor16	47.44	0.85	40.33	48.50	60	3	13.44								
	44	Office Tenant Floor16	47.44	0.85	40.33	48.50	60	3		13.44							
	45	Office Tenant Floor16	47.44	0.85	40.33	48.50	60	3			13.44						
	46	Office Tenant Floor17	40.91	0.85	34.78	41.83	60	3	11.59								
	47	Office Tenant Floor17	40.91	0.85	34.78	41.83	60	3		11.59							
	48	Office Tenant Floor17	40.91	0.85	34.78	41.83	60	3			11.59						
	49	T-HS / HB	290.32	1.00	290.32	349.20	0	3	96.77								
	50	T-HS / HB	290.32	1.00	290.32	349.20	0	3		96.77							
	51	T-HS / HB	290.32	1.00	290.32	349.20	0	3			96.77						
	52	T-H / HE	132.54	1.00	132.54	159.42	0	3	44.18								
	53	T-H / HE	132.54	1.00	132.54	159.42	0	3		44.18							
	54	T-H / HE	132.54	1.00	132.54	159.42	0	3			44.18						
	55	T-HE / HD	1.00	1.00	1.00	1.20	0	3	0.33								
	56	T-HE / HD	1.00	1.00	1.00	1.20	0	3		0.33							
	57	T-HE / HD	1.00	1.00	1.00	1.20	0	3			0.33						
	58	T-H / HD	3.70	1.00	3.70	4.45	0	3	1.23								
	59	T-H / HD	3.70	1.00	3.70	4.45	0	3		1.23							
	60	T-H / HD	3.70	1.00	3.70	4.45	0	3			1.23						
	61	T-H / HC	1.44	1.00	1.44	1.74	0	3	0.48								
	62	T-H / HC	1.44	1.00	1.44	1.74	0	3		0.48							
	63	T-H / HC	1.44	1.00	1.44	1.74	0	3			0.48						
	64	T-HS / HA	160.52	1.00	160.52	193.07	0	3	53.51								
	65	T-HS / HA	160.52	1.00	160.52	193.07	0	3		53.51							
	66	T-HS / HA	160.52	1.00	160.52	193.07	0	3			53.51						
	67	T-P / HD	140.56	1.00	140.56	169.07	0	3	46.85								
	68	T-P / HD	140.56	1.00	140.56	169.07	0	3		46.85							
	69	T-P / HD	140.56	1.00	140.56	169.07	0	3			46.85						
	70	T-P / HC	61.25	1.00	61.25	73.68	0	3	20.42								
	71	T-P / HC	61.25	1.00	61.25	73.68	0	3		20.42							
	72	T-P / HC	61.25	1.00	61.25	73.68	0	3			20.42						
	73	T-P / HB	114.48	1.00	114.48	137.70	0	3	38.16								
	74	T-P / HB	114.48	1.00	114.48	137.70	0	3		38.16							
	75	T-P / HB	114.48	1.00	114.48	137.70	0	3			38.16						
	76	T-HE / HC	0.50	1.00	0.50	0.60	0	3	0.17								
	77	T-HE / HC	0.50	1.00	0.50	0.60	0	3		0.17							
	78	T-HE / HC	0.50	1.00	0.50	0.60	0	3			0.17						
	79	T-HE / HB	0.50	1.00	0.50	0.60	0	3	0.17								
	80	T-HE / HB	0.50	1.00	0.50	0.60	0	3		0.17							
	81	T-HE / HB	0.50	1.00	0.50	0.60	0	3			0.17						
									644.19	644.19	644.19			Board		3200	
													kVA	Size		Breaker	
T-BUS													1932.6	2324.527		3200	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
EM / DP	1	T-HS / HB	290.32	1.00	290.32	349.20	0	3	96.77						Voltage	480	/277V, 3P
	2	T-HS / HB	290.32	1.00	290.32	349.20	0	3		96.77					Breaker	700	
	3	T-HS / HB	290.32	1.00	290.32	349.20	0	3			96.77				Bus	800	
	4	T-HE / HD	1.00	1.00	1.00	1.20	0	3	0.33						A.I.C	65k	
	5	T-HE / HD	1.00	1.00	1.00	1.20	0	3		0.33							
	6	T-HE / HD	1.00	1.00	1.00	1.20	0	3			0.33						
	7	T-HE / HC	0.50	1.00	0.50	0.60	0	3	0.17								
	8	T-HE / HC	0.50	1.00	0.50	0.60	0	3		0.17							
	9	T-HE / HC	0.50	1.00	0.50	0.60	0	3			0.17						
	10	T-HE / HB	0.50	1.00	0.50	0.60	0	3	0.17								
	11	T-HE / HB	0.50	1.00	0.50	0.60	0	3		0.17							
	12	T-HE / HB	0.50	1.00	0.50	0.60	0	3			0.17						
	13	T-HE / HA	1.00	1.00	1.00	1.20	0	3	0.33								
	14	T-HE / HA	1.00	1.00	1.00	1.20	0	3		0.33							
	15	T-HE / HA	1.00	1.00	1.00	1.20	0	3			0.33						
	13	P-0.1	5.60	1.00	5.60	6.73	50	3	1.87								
	14	P-0.1	5.60	1.00	5.60	6.73	50	3		1.87							
	15	P-0.1	5.60	1.00	5.60	6.73	50	3			1.87						
	13	P-0.2	5.60	1.00	5.60	6.73	50	3	1.87								
	14	P-0.2	5.60	1.00	5.60	6.73	50	3		1.87							
	15	P-0.2	5.60	1.00	5.60	6.73	50	3			1.87						
	16	T-HE / LC	210.50	1.00	210.50	253.19	0	3	70.17								
	17	T-HE / LC	210.50	1.00	210.50	253.19	0	3		70.17							
	18	T-HE / LC	210.50	1.00	210.50	253.19	0	3			70.17						
	16	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	17	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	18	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	19	COLLATERAL	0.50	1.00	0.50	4.16	20	1	0.50								
	20-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									172.17	171.67	171.67			Board			
													kVA	Size		Breaker	
T-EM / DP													515.51	620.0634		700	

Panel	Ckt	Load	kVA	Factor	Demand kVA	Amps	Brkr	Pole	A	B	C				Details		
RT / DP	1	Retail 1	7.93	3.00	23.80	66.07	80	3	7.93						Voltage	208	/120V, 3P
	2	Retail 1	7.93	3.00	23.80	66.07	80	3		7.93					Breaker	600	
	3	Retail 1	7.93	3.00	23.80	66.07	80	3			7.93				Bus	600	
	4	Retail 2	10.03	3.00	30.09	83.52	100	3	10.03						A.I.C	65k	
	5	Retail 2	10.03	3.00	30.09	83.52	100	3		10.03							
	6	Retail 2	10.03	3.00	30.09	83.52	100	3			10.03						
	7	Retail 3	8.47	3.00	25.42	70.55	90	3	8.47								
	8	Retail 3	8.47	3.00	25.42	70.55	90	3		8.47							
	9	Retail 3	8.47	3.00	25.42	70.55	90	3			8.47						
	10	Retail 4	14.87	3.00	44.60	123.80	150	3	14.87								
	11	Retail 4	14.87	3.00	44.60	123.80	150	3		14.87							
	12	Retail 4	14.87	3.00	44.60	123.80	150	3			14.87						
	13	Retail 5	19.50	3.00	58.49	162.34	200	3	19.50								
	14	Retail 5	19.50	3.00	58.49	162.34	200	3		19.50							
	15	Retail 5	19.50	3.00	58.49	162.34	200	3			19.50						
	16	SPARE	0.00	1.00	0.00	0.00	20	1	0.00								
	17	SPARE	0.00	1.00	0.00	0.00	20	1		0.00							
	18	SPARE	0.00	1.00	0.00	0.00	20	1			0.00						
	19	COLLATERAL	0.50	1.00	0.50	4.16	20	1	0.50								
	20-42	SPACE	0.00	1.00	0.00	0.00	-	1		0.00							
									61.30	60.80	60.80			Board			
													kVA	Size		Breaker	
T-RT / DP													182.9	507.6673		600	

Appendix E – Mechanical

Product Specification

Technical Specifications and Descriptions for a Single Capstone® MicroTurbine™ (Enclosed and Recuperated)

Summary

This Product Specification describes the Capstone MicroTurbine power generating system (hereafter referred to by Capstone as a MicroTurbine). The MicroTurbine provides on-site electrical power for primary or standby applications, and for peak shaving, base loading, and/or capacity additions. MicroTurbine(s) may generate power in parallel with an electrical utility (Grid Connect mode), or isolated from the utility (Stand Alone mode). The system consists of a turbine engine, solid-state power electronics, a fuel system, and an indoor/outdoor-rated enclosure.

MicroTurbine systems are available in 30, 60, or 65 kW versions, known as C30, C60 or C65 models. The C60 and C65 have an option to include a top-mounted heat exchanger, marketed by Capstone as the Integrated Combined Heat and Power package (ICHP). The ICHP option includes an exhaust heat recovery unit and exhaust diverter to allow full or partial recovery of exhaust energy. This allows the user to realize high total system efficiency with respect to incoming fuel energy, while providing economical operation and operational flexibility.

Major MicroTurbine components include a compressor, a recuperator (exhaust gas heat exchanger), a combustor, a turbine, and a generator. The turbine engine is air-cooled and supported on air-lubricated compliant foil bearings. The compressor impeller, turbine rotor, and generator rotor are mounted on a single shaft, which comprises the only moving part in the engine. Power electronics are solid-state, double conversion type, producing three-phase alternating current output power from the high-frequency alternating current engine output.

Definitions

- ISO conditions are defined as: 15 °C (59 °F), 60% relative humidity, and sea level pressure of 101.3 kPa (14.696 psia).
- SCFM: Standard Cubic Feet per Minute (standard references ISO temperature and pressure)
- HHV: Higher Heating Value
- LHV: Lower Heating Value
- HPNG: High Pressure Natural Gas
- LPNG: Low Pressure Natural Gas
- kW_{th} – Kilowatt (thermal)
- kW_e – Kilowatt (electric)
- Scf: Standard cubic feet (standard references ISO temperature and pressure)
- SG: Sour Gas
- SLPM: Standard Liters per Minute (standard references ISO temperature and pressure).
- L/DG: Landfill/Digester Gas.

Performance Ratings at Full Load Power

Table 1 summarizes performance ratings at full load power and ISO conditions.

Table 1. Performance Ratings

Product	Net Power Output	Net Efficiency (LHV)	Nominal Net Heat Rate (LHV)	Nominal Generator Heat Rate
Model C30 (HPNG, SG, or L/DG) (without gas compression option)	30 (+0/-1) kW net 3 Phase 400/480 Volts AC 46 A per phase max continuous, 50/60 Hz	26 (± 2)% (Efficiency values might be lower if fuel gas compression is required for L/DG)	13,800 kJ (13,100 Btu /kWh)	12,800 kJ (12,200 Btu/kWh)
Model C30 (LPNG)	28 (+0/-1) kW net 3 Phase 400/480 Volts AC 46 A per phase max continuous, 50/60 Hz	25 (± 2)% (at 5 psig fuel inlet pressure)	14,400 kJ (13,700 Btu /kWh)	12,300 kJ (11,600 Btu/kWh)
Model C30 (Liquid Fuel)	29 (+1/-1) kW net 3 Phase 400/480 Volts AC 46 A per phase max continuous, 50/60 Hz	25 (± 2)%	14,400 kJ (13,700 Btu /kWh)	13,400 kJ (12,700 Btu/kWh)
Model C60 (HPNG) (without gas compression option)	60 (+0/-2) kW net 3 Phase 400/480 Volts AC 100 A per phase max continuous, 50/60 Hz	28 (± 2)%	12,900 kJ (12,200 Btu /kWh)	12,000 kJ (11,400 Btu/kWh)
Model C65 (HPNG) (without gas compression option)	65 (+0/-2) kW net 3 Phase 400/480 Volts AC 100 A per phase max continuous, 50/60 Hz	29 (± 2)%	12,400 kJ (11,800 Btu /kWh)	11,600 kJ (11,000 Btu /kWh)

Performance Derating

Performance is affected by ambient temperature and elevation. The performance ratings listed are at full load power at ISO conditions. Performance derating occurs at ambient temperatures and elevations above ISO conditions and is also affected by air inlet pressure, back pressure and system parasitic loads (i.e. gas compressor, battery charging).

Typical derating curves for power output and efficiency based on ambient temperature are shown in the curves on the following pages. These curves assume no parasitic losses and zero inlet and exhaust back pressure.

Electrical Performance Ratings at Full Load Power

Table 2 presents the electrical performance ratings for C30, C60 and C65 MicroTurbines operating in the Grid Connect mode at ISO conditions with zero back pressure.

Table 2. Electrical Performance Ratings in Grid Connect Mode

Parameter	Model C30 (HPNG)	Model C60 & ICHP (HPNG)	Model C65 & C65 ICHP (HPNG)
Net Power Output (without gas compression)	30 (+0/-1) kW net 30 kVA max at 480 VAC	60 (+0/-2) kW net 60 kVA max at 480 VAC	65 (+0/-2) kW net 65 kVA max at 480 VAC
Net Electrical Efficiency (LHV)	26 (±2) %	28 (±2) %	29 (±2) %
Nominal Net Heat Rate (LHV)	13,800 kJ (13,100 Btu /kWh)	12,900 kJ (12,200 Btu /kWh)	12,400 kJ (11,800 Btu /kWh)
Nominal Voltage Operating Range	400 to 480 VAC	400 to 480 VAC	400 to 480 VAC
Nominal Frequency Operating Range	50/60 Hz	50/60 Hz	50/60 Hz
Output Voltage Connection	3-phase, 3 or 4 wire wye (The Grid must be neutral grounded)	3-phase, 3 or 4 wire wye (The Grid must be neutral grounded)	3-phase, 3 or 4 wire wye (The Grid must be neutral grounded)
Output Current (maximum)	46 Amps RMS steady state	100 Amps RMS steady state	100 Amps RMS steady state
Current THD	IEEE 519 compliant, 5%	IEEE 519 compliant, 5%	IEEE 519 compliant, 5%

Table 3 presents the electrical performance ratings for a MicroTurbine operating in the Stand Alone mode at ISO conditions.

Table 3. Electrical Performance Ratings in Stand Alone Mode

Parameter	Model C30	Model C60	Model C65
Net Power Output	30 (+0/-1) kW net 38.2 kVA max at 480 VAC	60 (+0/-2) kW net 83 kVA max at 480 VAC	65 (+0/-2) kW net 83 kVA max at 480 VAC
Nominal Voltage Operating Range	400 to 480 VAC	400 to 480 VAC	400 to 480 VAC
Frequency Operating Range	10 to 60 Hz	10 to 60 Hz	10 to 60 Hz
Output Voltage Connection	3-phase, 4 wire wye (Neutral must be solidly grounded)	3-phase, 4 wire wye (Neutral must be solidly grounded)	3-phase, 4 wire wye (Neutral must be solidly grounded)
Output Current [1]	46 Amps RMS maximum steady state	125 Amps RMS maximum steady state	125 Amps RMS maximum steady state
Voltage THD	IEEE 519 Compliant, 5%	IEEE 519 Compliant, 5%	IEEE 519 Compliant, 5%

(1) Values assume linear load

Fuel Input Requirements at Full Load Power

Table 4 presents fuel input requirements at full load power and ISO conditions.

Table 4. Fuel Input Requirements

Product	Fuel Type	Fuel Heat Content Range (HHV)	Nominal Full Power Steady State Fuel Flow (HHV) (Notes 1 and 2)
Model C30 (HPNG, SG)	NG	30,700 – 47,500 kJ/m^3 (825 to 1275 Btu/scf)	457,000 kJ/hr (433,000 Btu/hr)
	High Btu	46,600 – 79,400 kJ/m^3 (1252 to 2131 Btu/scf)	
Model C30 (LPNG)	NG	30,700 – 47,500 kJ/m^3 (825 to 1275 Btu/scf)	444,000 kJ/hr (420,000 Btu/hr)
Model C30 (L/DG)	Low Btu	12,100 – 32,100 kJ/m^3 (325 to 861 Btu/scf)	457,000 kJ/hr (433,000 Btu/hr)
	Sour Low Btu	12,100 – 32,100 kJ/m^3 (325 to 861 Btu/scf)	
Model C30 (Liquid Fuel)	-	ASTM D975 Diesel Fuel No. 2-D ASTM D3699 Kerosene No. 1-K ASTM D1655 (Jet-A) MIL-DTL-83133E (JP-8) MIL-DTL-5624U (JP-5)	459,000 kJ/hr (435,000 Btu/hr)
Model C60 & C60 ICHP	NG	30,700 – 47,500 kJ/m^3 (825 to 1275 Btu/scf)	849,000 kJ/hr (804,000 Btu/hr)
	High Btu	46,600 – 79,400 kJ/m^3 (1252 to 2131 Btu/scf)	
	LPG	93,700 – 110,000 kJ/m^3 (2516 to 2962 Btu/scf)	
Model C65 & C65 ICHP	NG	30,700 – 47,500 kJ/m^3 (825 to 1275 Btu/scf)	888,000 kJ/hr (842,000 Btu/hr)
	High Btu	46,600 - 67,000 kJ/m^3 (1250 to 1800 Btu/scf)	
	Landfill	12,100 - 22,300 kJ/m^3 (325 to 600 Btu/scf)	
	Digester	20,500 - 32,600 kJ/m^3 (550 to 875 Btu/scf)	
	Propane	91,300 - 95,000 kJ/m^3 (2450 to 2550 Btu/scf)	

Note 1. The ratio of Higher Heating Value (HHV) to Lower Heating Value (LHV) is assumed to be 1.1.
Note 2. Onload fuel flows can be up to two times higher than the steady state values.

Exhaust Output Ratings at Full Load Power

Table 5 presents exhaust output ratings at full load power and ISO conditions, using natural gas.

Table 5. Exhaust Output Ratings

Parameter	Model C30	Model C60	Model C65
Nominal Exhaust Gas Temp	HPNG: 275°C (530°F) Liquid: 275°C (530 °F)	305 °C (580 °F)	309 °C (588 °F)
Nominal Total Exhaust Energy	HPNG: 327,000 kJ/hr (310,000 Btu/hr) Liquid: 327,000 kJ/hr (310,000 Btu/hr)	571,000 kJ/hr (541,000 Btu/hr)	591,000 kJ/hr (561,000 Btu/hr)
NOx Emissions	HPNG: <9 ppm V @ 15% O_2 Liquid: <35 ppm V @ 15% O_2	<9 ppm V @ 15% O_2	<9 ppm V @ 15% O_2
Exhaust Mass Flow	HPNG: 0.31 kg/s (0.69 lbm/s) Liquid: 0.31 kg/s (0.69 lbm/s)	0.48 kg/s (1.06 lbm/s)	0.49 kg/s (1.08 lbm/s)

NOTE: These are the final exhaust temperature and exhaust energy if the heat exchanger is bypassing exhaust heat. Temperature and exhaust energy will be lower while recovering heat.

Acoustic Emissions Ratings at Full Load Power

Table 7 presents nominal acoustic emissions ratings, captured at full rated output power at a distance of 10 meters (33 feet).

Table 7. Acoustic Emissions Ratings

	Model C60 and C65 (Industrial Package)	Model C30 (Industrial Package)
Acoustic Emissions	70 dBA*	65 dBA

* Note 65 dVA with inlet silencer option.

MicroTurbine Dimensions and Weights

Table 8 summarizes dimensions and weights of the MicroTurbine systems.

Table 8. MicroTurbine Dimensions and Weights

Parameter	Model C30 (Industrial Package)	Model C60 & C65	Model C60 & C65 ICHP
Height	1943 mm (76.5 inches)	2110 mm (83 inches)	2,390 mm (94 inches)
Width	762 mm (30 inches)	762 mm (30 inches)	762 mm (30 inches)
Depth	1516 mm (59.7 inches)	1956 mm (77 inches)	1956 mm (77 inches)
Weight	405 kg (891lb) (Grid Connect) 578 kg (1271lb) (Dual Mode)	758 kg (1671lb) (Grid Connect) 1121 kg (2471 lb) (Dual Mode)	1000 kg (2,200 lb) (Grid Connect) 1,364 kg (3,000 lb) (Dual Mode)

MicroTurbine Temperature Ratings

Table 9 summarizes the temperature ratings of MicroTurbine systems. The C60 and C65, and C60 and C65 ICHP systems maybe stored dry within a temperature range of -40 to 65 °C (-40 to 149 °F). System is not to be stored wet.

Table 9. MicroTurbine Temperature Ratings

Parameter	Model C30	Model C60/ C65 (and C60/C65 ICHP)
Operating Temperature	-20 to 50°C (-4 to 122°F)	-20 to 50°C (-4 to 122°F)
Storage Temperature	-40 to 65 °C (-40 to 149 °F)	-40 to 65 °C (-40 to 149 °F)

Engine Cycling Life

Consult Capstone for specific guidance if application requires more than 10,000 onload operations from idle to full power, or repeated cycling of more than 50% of engine power range within five minute intervals.

Integral Heat Exchanger

The ICHP heat exchanger, in heat recovery mode, recovers the exhaust energy of the C60 MicroTurbine. Tables 10 thru 12 show the ICHP system heat recovery in full heat recovery mode for water at various inlet water temperatures. The minimum heat recovery is 3 kW_{th}(10 MBtu/hr) in full bypass mode.

Table 10. C60 ICHP with Copper Core Heat Recovery Module

Water Temperature		Heat Recovery
Inlet	Outlet	
30°C (85°F)	41°C (106°F)	123 kW_{th} (420 MBtu/hr)
60°C (140°F)	70°C (159°F)	110 kW_{th} (375 MBtu/hr)
85°C (185°F)	94°C (201°F)	98 kW_{th} (335 MBtu/hr)

Table 11. C65 ICHP with Copper Core Heat Recovery Module

Water Temperature		Heat Recovery
Inlet	Outlet	
30°C (85°F)	41°C (106°F)	126 kW_{th} (430 MBtu/hr)
60°C (140°F)	70°C (159°F)	112 kW_{th} (380 MBtu/hr)
85°C (185°F)	94°C (202°F)	100 kW_{th} (345 MBtu/hr)

Table 12. C65 ICHP with Stainless Steel Heat Recovery Module

Water Temperature		Heat Recovery
Inlet	Outlet	
30°C (85°F)	37°C (98°F)	78 kW_{th} (265 MBtu/hr)
60°C (140°F)	67°C (152°F)	70 kW_{th} (240 MBtu/hr)
85°C (185°F)	91°C (196°F)	63 kW_{th} (215 MBtu/hr)

Conditions:
- ±10% performance range
- 2.5 l/s (40 gal/min) water flow
- Full power output @ 60 kW_e or 65 kW_e
- ISO Conditions

Condo Heating

Month	Days	Usage (Mlbs)	lbs/day	lbs / hr 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Max (lbs/hr)
03/29/06	30	86	2866.7	143	159	159	159	159	143	143	127	127	111	96	80	96	96	96	96	80	80	96	111	111	127	127	143	159.3
02/27/06	28	112	4000.0	200	222	222	222	222	200	200	178	178	156	133	111	133	133	133	133	111	111	133	156	156	178	178	200	222.2
01/30/06	32	95	2968.8	148	165	165	165	165	148	148	132	132	115	99	82	99	99	99	99	82	82	99	115	115	132	132	148	164.9
12/29/05	30	128	4266.7	213	237	237	237	237	213	213	190	190	166	142	119	142	142	142	142	119	119	142	166	166	190	190	213	237.0
11/29/05	33	87	2636.4	132	146	146	146	146	132	132	117	117	103	88	73	88	88	88	88	73	73	88	103	103	117	117	132	146.5
10/27/05	29	42	1448.3	72	80	80	80	80	72	72	64	64	56	48	40	48	48	48	48	40	40	48	56	56	64	64	72	80.5
09/28/05	30	34	1133.3	57	63	63	63	63	57	57	50	50	44	38	31	38	38	38	38	31	31	38	44	44	50	50	57	63.0
08/29/05	31	35	1129.0	56	63	63	63	63	56	56	50	50	44	38	31	38	38	38	38	31	31	38	44	44	50	50	56	62.7
07/29/05	30	34	1133.3	57	63	63	63	63	57	57	50	50	44	38	31	38	38	38	38	31	31	38	44	44	50	50	57	63.0
06/29/05	29	34	1172.4	59	65	65	65	65	59	59	52	52	46	39	33	39	39	39	39	33	33	39	46	46	52	52	59	65.1
05/31/05	32	42	1312.5	66	73	73	73	73	66	66	58	58	51	44	36	44	44	44	44	36	36	44	51	51	58	58	66	72.9
04/29/05	29	44	1517.2	76	84	84	84	84	76	76	67	67	59	51	42	51	51	51	51	42	42	51	59	59	67	67	76	84.3
03/31/05	30	84	2800.0	140	156	156	156	156	140	140	124	124	109	93	78	93	93	93	93	78	78	93	109	109	124	124	140	155.6
03/01/05	29	87	3000.0	150	167	167	167	167	150	150	133	133	117	100	83	100	100	100	100	83	83	100	117	117	133	133	150	166.7
01/31/05	32	127	3968.8	198	220	220	220	220	198	198	176	176	154	132	110	132	132	132	132	110	110	132	154	154	176	176	198	220.5
12/30/04	29	98	3379.3	169	188	188	188	188	169	169	150	150	131	113	94	113	113	113	113	94	94	113	131	131	150	150	169	187.7
12/01/04	34	60	1764.7	88	98	98	98	98	88	88	78	78	69	59	49	59	59	59	59	49	49	59	69	69	78	78	88	98.0
10/28/04	29	33	1137.9	57	63	63	63	63	57	57	51	51	44	38	32	38	38	38	38	32	32	38	44	44	51	51	57	63.2
09/29/04	30	28	933.3	47	52	52	52	52	47	47	41	41	36	31	26	31	31	31	31	26	26	31	36	36	41	41	47	51.9
08/30/04	31	28	903.2	45	50	50	50	50	45	45	40	40	35	30	25	30	30	30	30	25	25	30	35	35	40	40	45	50.2
07/30/04	30	22	733.3	37	41	41	41	41	37	37	33	33	29	24	20	24	24	24	24	20	20	24	29	29	33	33	37	40.7
06/30/04	29	30	1034.5	52	57	57	57	57	52	52	46	46	40	34	29	34	34	34	34	29	29	34	40	40	46	46	52	57.5

Office Heating

Month	Days	Usage (Mlbs)	lbs/hr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Max (lbs/hr)
03/29/06	30	775	25833.3	1292	1435	1435	1435	1435	1292	1292	1148	1148	1005	861	718	861	861	861	861	718	718	861	1005	1005	1148	1148	1292	1435.2
02/27/06	28	1,024	36571.4	1829	2032	2032	2032	2032	1829	1829	1625	1625	1422	1219	1016	1219	1219	1219	1219	1016	1016	1219	1422	1422	1625	1625	1829	2031.7
01/30/06	32	871	27218.8	1361	1512	1512	1512	1512	1361	1361	1210	1210	1059	907	756	907	907	907	907	756	756	907	1059	1059	1210	1210	1361	1512.2
12/29/05	30	1,112	37066.7	1853	2059	2059	2059	2059	1853	1853	1647	1647	1441	1236	1030	1236	1236	1236	1236	1030	1030	1236	1441	1441	1647	1647	1853	2059.3
11/29/05	33	681	20636.4	1032	1146	1146	1146	1146	1032	1032	917	917	803	688	573	688	688	688	688	573	573	688	803	803	917	917	1032	1146.5
10/27/05	29	341	11758.6	588	653	653	653	653	588	588	523	523	457	392	327	392	392	392	392	327	327	392	457	457	523	523	588	653.3
09/28/05	30	231	7700.0	385	428	428	428	428	385	385	342	342	299	257	214	257	257	257	257	214	214	257	299	299	342	342	385	427.8
08/29/05	31	344	11096.8	555	616	616	616	616	555	555	493	493	432	370	308	370	370	370	370	308	308	370	432	432	493	493	555	616.5
07/29/05	30	364	12133.3	607	674	674	674	674	607	607	539	539	472	404	337	404	404	404	404	337	337	404	472	472	539	539	607	674.1
06/29/05	29	244	8413.8	421	467	467	467	467	421	421	374	374	327	280	234	280	280	280	280	234	234	280	327	327	374	374	421	467.4
05/31/05	32	365	11406.3	570	634	634	634	634	570	570	507	507	444	380	317	380	380	380	380	317	317	380	444	444	507	507	570	633.7
04/29/05	29	464	16000.0	800	889	889	889	889	800	800	711	711	622	533	444	533	533	533	533	444	444	533	622	622	711	711	800	888.9
03/31/05	30	923	30766.7	1538	1709	1709	1709	1709	1538	1538	1367	1367	1196	1026	855	1026	1026	1026	1026	855	855	1026	1196	1196	1367	1367	1538	1709.3
03/01/05	29	1,058	36482.8	1824	2027	2027	2027	2027	1824	1824	1621	1621	1419	1216	1013	1216	1216	1216	1216	1013	1013	1216	1419	1419	1621	1621	1824	2026.8
01/31/05	32	1,376	43000.0	2150	2389	2389	2389	2389	2150	2150	1911	1911	1672	1433	1194	1433	1433	1433	1433	1194	1194	1433	1672	1672	1911	1911	2150	2388.9
12/30/04	29	1,091	37620.7	1881	2090	2090	2090	2090	1881	1881	1672	1672	1463	1254	1045	1254	1254	1254	1254	1045	1045	1254	1463	1463	1672	1672	1881	2090.0
12/01/04	34	832	24470.6	1224	1359	1359	1359	1359	1224	1224	1088	1088	952	816	680	816	816	816	816	680	680	816	952	952	1088	1088	1224	1359.5
10/28/04	29	480	16551.7	828	920	920	920	920	828	828	736	736	644	552	460	552	552	552	552	460	460	552	644	644	736	736	828	919.5
09/29/04	30	256	8533.3	427	474	474	474	474	427	427	379	379	332	284	237	284	284	284	284	237	237	284	332	332	379	379	427	474.1
08/30/04	31	275	8871.0	444	493	493	493	493	444	444	394	394	345	296	246	296	296	296	296	246	246	296	345	345	394	394	444	492.8
07/30/04	30	166	5533.3	277	307	307	307	307	277	277	246	246	215	184	154	184	184	184	184	154	154	184	215	215	246	246	277	307.4
06/30/04	29	90	3103.4	155	172	172	172	172	155	155	138	138	121	103	86	103	103	103	103	86	86	103	121	121	138	138	155	172.4

Condo Electric

Month	Days	Usage (kWh)	kWh per da	kWh/ hr 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Max (kWh)
3/29/2006	30	10,880	362.7	8.5	8.5	8.5	8.5	8.5	11.7	13.9	14.9	16.0	19.2	21.3	21.3	21.3	19.2	19.2	21.3	21.3	19.2	17.1	16.0	14.9	12.8	10.7	8.5	21.33
2/27/2006	28	10,240	365.7	8.6	8.6	8.6	8.6	8.6	11.8	14.0	15.1	16.1	19.4	21.5	21.5	21.5	19.4	19.4	21.5	21.5	19.4	17.2	16.1	15.1	12.9	10.8	8.6	21.51
1/30/2006	32	11,840	370.0	8.7	8.7	8.7	8.7	8.7	12.0	14.1	15.2	16.3	19.6	21.8	21.8	21.8	19.6	19.6	21.8	21.8	19.6	17.4	16.3	15.2	13.1	10.9	8.7	21.76
12/29/2005	30	10,080	336.0	7.9	7.9	7.9	7.9	7.9	10.9	12.8	13.8	14.8	17.8	19.8	19.8	19.8	17.8	17.8	19.8	19.8	17.8	15.8	14.8	13.8	11.9	9.9	7.9	19.76
11/29/2005	33	11,840	358.8	8.4	8.4	8.4	8.4	8.4	11.6	13.7	14.8	15.8	19.0	21.1	21.1	21.1	19.0	19.0	21.1	21.1	19.0	16.9	15.8	14.8	12.7	10.6	8.4	21.11
10/27/2005	29	11,520	397.2	9.3	9.3	9.3	9.3	9.3	12.9	15.2	16.4	17.5	21.0	23.4	23.4	23.4	21.0	21.0	23.4	23.4	21.0	18.7	17.5	16.4	14.0	11.7	9.3	23.37
9/28/2005	30	23,760	792.0	18.6	18.6	18.6	18.6	18.6	25.6	30.3	32.6	34.9	41.9	46.6	46.6	46.6	41.9	41.9	46.6	46.6	41.9	37.3	34.9	32.6	28.0	23.3	18.6	46.59
8/29/2005	31	25,280	815.5	19.2	19.2	19.2	19.2	19.2	26.4	31.2	33.6	36.0	43.2	48.0	48.0	48.0	43.2	43.2	48.0	48.0	43.2	38.4	36.0	33.6	28.8	24.0	19.2	47.97
7/29/2005	30	25,840	861.3	20.3	20.3	20.3	20.3	20.3	27.9	32.9	35.5	38.0	45.6	50.7	50.7	50.7	45.6	45.6	50.7	50.7	45.6	40.5	38.0	35.5	30.4	25.3	20.3	50.67
6/29/2005	29	17,360	598.6	14.1	14.1	14.1	14.1	14.1	19.4	22.9	24.6	26.4	31.7	35.2	35.2	35.2	31.7	31.7	35.2	35.2	31.7	28.2	26.4	24.6	21.1	17.6	14.1	35.21
5/31/2005	32	13,680	427.5	10.1	10.1	10.1	10.1	10.1	13.8	16.3	17.6	18.9	22.6	25.1	25.1	25.1	22.6	22.6	25.1	25.1	22.6	20.1	18.9	17.6	15.1	12.6	10.1	25.15
4/29/2005	29	12,240	422.1	9.9	9.9	9.9	9.9	9.9	13.7	16.1	17.4	18.6	22.3	24.8	24.8	24.8	22.3	22.3	24.8	24.8	22.3	19.9	18.6	17.4	14.9	12.4	9.9	24.83
3/31/2005	30	12,240	408.0	9.6	9.6	9.6	9.6	9.6	13.2	15.6	16.8	18.0	21.6	24.0	24.0	24.0	21.6	21.6	24.0	24.0	21.6	19.2	18.0	16.8	14.4	12.0	9.6	24.00
3/1/2005	29	11,040	380.7	9.0	9.0	9.0	9.0	9.0	12.3	14.6	15.7	16.8	20.2	22.4	22.4	22.4	20.2	20.2	22.4	22.4	20.2	17.9	16.8	15.7	13.4	11.2	9.0	22.39
1/31/2005	32	11,920	372.5	8.8	8.8	8.8	8.8	8.8	12.1	14.2	15.3	16.4	19.7	21.9	21.9	21.9	19.7	19.7	21.9	21.9	19.7	17.5	16.4	15.3	13.1	11.0	8.8	21.91
12/30/2004	29	10,960	377.9	8.9	8.9	8.9	8.9	8.9	12.2	14.5	15.6	16.7	20.0	22.2	22.2	22.2	20.0	20.0	22.2	22.2	20.0	17.8	16.7	15.6	13.3	11.1	8.9	22.23
12/1/2004	34	12,800	376.5	8.9	8.9	8.9	8.9	8.9	12.2	14.4	15.5	16.6	19.9	22.1	22.1	22.1	19.9	19.9	22.1	22.1	19.9	17.7	16.6	15.5	13.3	11.1	8.9	22.15
10/28/2004	29	18,080	623.4	14.7	14.7	14.7	14.7	14.7	20.2	23.8	25.7	27.5	33.0	36.7	36.7	36.7	33.0	33.0	36.7	36.7	33.0	29.3	27.5	25.7	22.0	18.3	14.7	36.67
9/29/2004	30	24,720	824.0	19.4	19.4	19.4	19.4	19.4	26.7	31.5	33.9	36.4	43.6	48.5	48.5	48.5	43.6	43.6	48.5	48.5	43.6	38.8	36.4	33.9	29.1	24.2	19.4	48.47
8/30/2004	31	25,280	815.5	19.2	19.2	19.2	19.2	19.2	26.4	31.2	33.6	36.0	43.2	48.0	48.0	48.0	43.2	43.2	48.0	48.0	43.2	38.4	36.0	33.6	28.8	24.0	19.2	47.97
7/30/2004	30	11,040	368.0	8.7	8.7	8.7	8.7	8.7	11.9	14.1	15.2	16.2	19.5	21.6	21.6	21.6	19.5	19.5	21.6	21.6	19.5	17.3	16.2	15.2	13.0	10.8	8.7	21.65
6/30/2004	29	6,000	206.9	4.9	4.9	4.9	4.9	4.9	6.7	7.9	8.5	9.1	11.0	12.2	12.2	12.2	11.0	11.0	12.2	12.2	11.0	9.7	9.1	8.5	7.3	6.1	4.9	12.17
6/1/2004	33	7,600	230.3	5.4	5.4	5.4	5.4	5.4	7.5	8.8	9.5	10.2	12.2	13.5	13.5	13.5	12.2	12.2	13.5	13.5	12.2	10.8	10.2	9.5	8.1	6.8	5.4	13.55
4/29/2004	29	8,400	289.7	6.8	6.8	6.8	6.8	6.8	9.4	11.1	11.9	12.8	15.3	17.0	17.0	17.0	15.3	15.3	17.0	17.0	15.3	13.6	12.8	11.9	10.2	8.5	6.8	17.04

Office Electric

Month	Days	Usage (kWh)	kWh per da	kWh/ hr 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Max (kWh)
3/29/2006	28	366,966	13105.9	308	308	308	308	308	424	501	540	578	694	771	771	771	694	694	771	771	694	617	578	540	463	385	308	770.94
3/1/2006	29	389,779	13440.7	316	316	316	316	316	435	514	553	593	712	791	791	791	712	712	791	791	712	633	593	553	474	395	316	790.63
1/31/2006	32	383,628	11988.4	282	282	282	282	282	388	458	494	529	635	705	705	705	635	635	705	705	635	564	529	494	423	353	282	705.20
12/30/2005	29	359,923	12411.1	292	292	292	292	292	402	475	511	548	657	730	730	730	657	657	730	730	657	584	548	511	438	365	292	730.07
12/1/2005	33	405,047	12274.2	289	289	289	289	289	397	469	505	542	650	722	722	722	650	650	722	722	650	578	542	505	433	361	289	722.01
10/29/2005	29	396,403	13669.1	322	322	322	322	322	442	523	563	603	724	804	804	804	724	724	804	804	724	643	603	563	482	402	322	804.06
9/30/2005	34	526,654	15489.8	364	364	364	364	364	501	592	638	683	820	911	911	911	820	820	911	911	820	729	683	638	547	456	364	911.17
8/27/2005	28	479,409	17121.8	403	403	403	403	403	554	655	705	755	906	1007	1007	1007	906	906	1007	1007	906	806	755	705	604	504	403	1007.16
7/30/2005	31	497,050	16033.9	377	377	377	377	377	519	613	660	707	849	943	943	943	849	849	943	943	849	755	707	660	566	472	377	943.17
6/29/2005	32	448,960	14030.0	330	330	330	330	330	454	536	578	619	743	825	825	825	743	743	825	825	743	660	619	578	495	413	330	825.29
5/28/2005	29	346,209	11938.2	281	281	281	281	281	386	456	492	527	632	702	702	702	632	632	702	702	632	562	527	492	421	351	281	702.25
4/29/2005	30	355,141	11838.0	279	279	279	279	279	383	453	487	522	627	696	696	696	627	627	696	696	627	557	522	487	418	348	279	696.35
3/30/2005	29	327,971	11309.3	266	266	266	266	266	366	432	466	499	599	665	665	665	599	599	665	665	599	532	499	466	399	333	266	665.26
3/1/2005	31	347,842	11220.7	264	264	264	264	264	363	429	462	495	594	660	660	660	594	594	660	660	594	528	495	462	396	330	264	660.04
1/29/2005	30	344,878	11495.9	270	270	270	270	270	372	440	473	507	609	676	676	676	609	609	676	676	609	541	507	473	406	338	270	676.23
12/30/2004	29	325,874	11237.0	264	264	264	264	264	364	430	463	496	595	661	661	661	595	595	661	661	595	529	496	463	397	331	264	661.00
12/1/2004	33	379,358	11495.7	270	270	270	270	270	372	440	473	507	609	676	676	676	609	609	676	676	609	541	507	473	406	338	270	676.22
10/29/2004	29	367,308	12665.8	298	298	298	298	298	410	484	522	559	671	745	745	745	671	671	745	745	671	596	559	522	447	373	298	745.05
9/30/2004	33	450,378	13647.8	321	321	321	321	321	442	522	562	602	723	803	803	803	723	723	803	803	723	642	602	562	482	401	321	802.81
8/28/2004	29	396,021	13655.9	321	321	321	321	321	442	522	562	602	723	803	803	803	723	723	803	803	723	643	602	562	482	402	321	803.29
7/30/2004	31	412,261	13298.7	313	313	313	313	313	430	508	548	587	704	782	782	782	704	704	782	782	704	626	587	548	469	391	313	782.28
6/29/2004	31	326,301	10525.8	248	248	248	248	248	341	402	433	464	557	619	619	619	557	557	619	619	557	495	464	433	372	310	248	619.17
5/29/2004	29	287,271	9905.9	233	233	233	233	233	320	379	408	437	524	583	583	583	524	524	583	583	524	466	437	408	350	291	233	582.70
4/30/2004	34	295,870	8702.1	205	205	205	205	205	282	333	358	384	461	512	512	512	461	461	512	512	461	410	384	358	307	256	205	511.89

New Design - # Microturbines Used - Condo

Hr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

New Design - Fraction Microturbine Usage

Month	Days	Usage (therm)	lbs/day	lbs/hr 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3/29/2006			2866.7	0.49	0.55	0.55	0.55	0.55	0.49	0.49	0.44	0.44	0.38	0.33	0.27	0.33	0.33	0.33	0.33	0.27	0.27	0.33	0.38	0.38	0.44	0.44	0.49
2/27/2006			4000.0	0.69	0.76	0.76	0.76	0.76	0.69	0.69	0.61	0.61	0.53	0.46	0.38	0.46	0.46	0.46	0.46	0.38	0.38	0.46	0.53	0.53	0.61	0.61	0.69
1/30/2006			2968.8	0.51	0.57	0.57	0.57	0.57	0.51	0.51	0.45	0.45	0.40	0.34	0.28	0.34	0.34	0.34	0.34	0.28	0.28	0.34	0.40	0.40	0.45	0.45	0.51
12/29/2005			4266.7	0.73	0.81	0.81	0.81	0.81	0.73	0.73	0.65	0.65	0.57	0.49	0.41	0.49	0.49	0.49	0.49	0.41	0.41	0.49	0.57	0.57	0.65	0.65	0.73
11/29/2005			2636.4	0.45	0.50	0.50	0.50	0.50	0.45	0.45	0.40	0.40	0.35	0.30	0.25	0.30	0.30	0.30	0.30	0.25	0.25	0.30	0.35	0.35	0.40	0.40	0.45
10/27/2005			1448.3	0.25	0.28	0.28	0.28	0.28	0.25	0.25	0.22	0.22	0.19	0.17	0.14	0.17	0.17	0.17	0.17	0.14	0.14	0.17	0.19	0.19	0.22	0.22	0.25
9/28/2005			1133.3	0.19	0.22	0.22	0.22	0.22	0.19	0.19	0.17	0.17	0.15	0.13	0.11	0.13	0.13	0.13	0.13	0.11	0.11	0.13	0.15	0.15	0.17	0.17	0.19
8/29/2005			1129.0	0.19	0.22	0.22	0.22	0.22	0.19	0.19	0.17	0.17	0.15	0.13	0.11	0.13	0.13	0.13	0.13	0.11	0.11	0.13	0.15	0.15	0.17	0.17	0.19
7/29/2005			1133.3	0.19	0.22	0.22	0.22	0.22	0.19	0.19	0.17	0.17	0.15	0.13	0.11	0.13	0.13	0.13	0.13	0.11	0.11	0.13	0.15	0.15	0.17	0.17	0.19
6/29/2005			1172.4	0.20	0.22	0.22	0.22	0.22	0.20	0.20	0.18	0.18	0.16	0.13	0.11	0.13	0.13	0.13	0.13	0.11	0.11	0.13	0.16	0.16	0.18	0.18	0.20
5/31/2005			1312.5	0.23	0.25	0.25	0.25	0.25	0.23	0.23	0.20	0.20	0.18	0.15	0.13	0.15	0.15	0.15	0.15	0.13	0.13	0.15	0.18	0.18	0.20	0.20	0.23
4/29/2005			1517.2	0.26	0.29	0.29	0.29	0.29	0.26	0.26	0.23	0.23	0.20	0.17	0.14	0.17	0.17	0.17	0.17	0.14	0.14	0.17	0.20	0.20	0.23	0.23	0.26
			2800.0	0.48	0.53	0.53	0.53	0.53	0.48	0.48	0.43	0.43	0.37	0.32	0.27	0.32	0.32	0.32	0.32	0.27	0.27	0.32	0.37	0.37	0.43	0.43	0.48
			3000.0	0.51	0.57	0.57	0.57	0.57	0.51	0.51	0.46	0.46	0.40	0.34	0.29	0.34	0.34	0.34	0.34	0.29	0.29	0.34	0.40	0.40	0.46	0.46	0.51
			3968.8	0.68	0.76	0.76	0.76	0.76	0.68	0.68	0.61	0.61	0.53	0.45	0.38	0.45	0.45	0.45	0.45	0.38	0.38	0.45	0.53	0.53	0.61	0.61	0.68
			3379.3	0.58	0.64	0.64	0.64	0.64	0.58	0.58	0.52	0.52	0.45	0.39	0.32	0.39	0.39	0.39	0.39	0.32	0.32	0.39	0.45	0.45	0.52	0.52	0.58
			1764.7	0.30	0.34	0.34	0.34	0.34	0.30	0.30	0.27	0.27	0.24	0.20	0.17	0.20	0.20	0.20	0.20	0.17	0.17	0.20	0.24	0.24	0.27	0.27	0.30
			1137.9	0.20	0.22	0.22	0.22	0.22	0.20	0.20	0.17	0.17	0.15	0.13	0.11	0.13	0.13	0.13	0.13	0.11	0.11	0.13	0.15	0.15	0.17	0.17	0.20
			933.3	0.16	0.18	0.18	0.18	0.18	0.16	0.16	0.14	0.14	0.12	0.11	0.09	0.11	0.11	0.11	0.11	0.09	0.09	0.11	0.12	0.12	0.14	0.14	0.16
			903.2	0.16	0.17	0.17	0.17	0.17	0.16	0.16	0.14	0.14	0.12	0.10	0.09	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.12	0.12	0.14	0.14	0.16
			733.3	0.13	0.14	0.14	0.14	0.14	0.13	0.13	0.11	0.11	0.10	0.08	0.07	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.10	0.10	0.11	0.11	0.13
			1034.5	0.18	0.20	0.20	0.20	0.20	0.18	0.18	0.16	0.16	0.14	0.12	0.10	0.12	0.12	0.12	0.12	0.10	0.10	0.12	0.14	0.14	0.16	0.16	0.18

New Design - "Leftover" MBH

	MBH																							
lbs/day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2866.7	224	199	199	199	199	224	224	248	248	272	296	320	296	296	296	296	320	320	296	272	272	248	248	224
4000.0	138	104	104	104	104	138	138	171	171	205	239	272	239	239	239	239	272	272	239	205	205	171	171	138
2968.8	216	191	191	191	191	216	216	241	241	266	291	315	291	291	291	291	315	315	291	266	266	241	241	216
4266.7	118	82	82	82	82	118	118	154	154	189	225	261	225	225	225	225	261	261	225	189	189	154	154	118
2636.4	241	219	219	219	219	241	241	263	263	285	307	329	307	307	307	307	329	329	307	285	285	263	263	241
1448.3	331	318	318	318	318	331	331	343	343	355	367	379	367	367	367	367	379	379	367	355	355	343	343	331
1133.3	354	345	345	345	345	354	354	364	364	373	383	392	383	383	383	383	392	392	383	373	373	364	364	354
1129.0	355	345	345	345	345	355	355	364	364	374	383	393	383	383	383	383	393	393	383	374	374	364	364	355
1133.3	354	345	345	345	345	354	354	364	364	373	383	392	383	383	383	383	392	392	383	373	373	364	364	354
1172.4	351	342	342	342	342	351	351	361	361	371	381	391	381	381	381	381	391	391	381	371	371	361	361	351
1312.5	341	330	330	330	330	341	341	352	352	363	374	385	374	374	374	374	385	385	374	363	363	352	352	341
1517.2	325	313	313	313	313	325	325	338	338	351	364	376	364	364	364	364	376	376	364	351	351	338	338	325
2800.0	229	205	205	205	205	229	229	252	252	276	299	323	299	299	299	299	323	323	299	276	276	252	252	229
3000.0	213	188	188	188	188	213	213	239	239	264	289	314	289	289	289	289	314	314	289	264	264	239	239	213
3968.8	140	107	107	107	107	140	140	174	174	207	240	273	240	240	240	240	273	273	240	207	207	174	174	140
3379.3	185	156	156	156	156	185	185	213	213	242	270	298	270	270	270	270	298	298	270	242	242	213	213	185
1764.7	307	292	292	292	292	307	307	322	322	336	351	366	351	351	351	351	366	366	351	336	336	322	322	307
1137.9	354	345	345	345	345	354	354	364	364	373	383	392	383	383	383	383	392	392	383	373	373	364	364	354
933.3	370	362	362	362	362	370	370	377	377	385	393	401	393	393	393	393	401	401	393	385	385	377	377	370
903.2	372	364	364	364	364	372	372	379	379	387	395	402	395	395	395	395	402	402	395	387	387	379	379	372
733.3	385	378	378	378	378	385	385	391	391	397	403	409	403	403	403	403	409	409	403	397	397	391	391	385
1034.5	362	353	353	353	353	362	362	371	371	379	388	397	388	388	388	388	397	397	388	379	379	371	371	362

New Design - Office Required Energy Usage

MBH

0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
25833.3	1639	1870	1870	1870	1870	1639	1639	1408	1408	1177	946	715	946	946	946	946	715	715	946	1177	1177	1408	1408	1639
36571.4	2498	2825	2825	2825	2825	2498	2498	2172	2172	1845	1519	1192	1519	1519	1519	1519	1192	1192	1519	1845	1845	2172	2172	2498
27218.8	1746	1989	1989	1989	1989	1746	1746	1503	1503	1260	1018	775	1018	1018	1018	1018	775	775	1018	1260	1260	1503	1503	1746
37066.7	2554	2887	2887	2887	2887	2554	2554	2222	2222	1889	1556	1223	1556	1556	1556	1556	1223	1223	1556	1889	1889	2222	2222	2554
20636.4	1247	1434	1434	1434	1434	1247	1247	1059	1059	872	684	497	684	684	684	684	497	497	684	872	872	1059	1059	1247
11758.6	517	623	623	623	623	517	517	411	411	304	198	92	198	198	198	198	92	92	198	304	304	411	411	517
7700.0	201	272	272	272	272	201	201	129	129	58	-13	-84	-13	-13	-13	-13	-84	-84	-13	58	58	129	129	201
11096.8	445	544	544	544	544	445	445	347	347	248	150	52	150	150	150	150	52	52	150	248	248	347	347	445
12133.3	520	627	627	627	627	520	520	414	414	307	200	93	200	200	200	200	93	93	200	307	307	414	414	520
8413.8	255	332	332	332	332	255	255	178	178	101	23	-54	23	23	23	23	-54	-54	23	101	101	178	178	255
11406.3	481	584	584	584	584	481	481	379	379	277	174	72	174	174	174	174	72	72	174	277	277	379	379	481
16000.0	828	969	969	969	969	828	828	687	687	546	405	264	405	405	405	405	264	264	405	546	546	687	687	828
30766.7	1989	2259	2259	2259	2259	1989	1989	1719	1719	1449	1180	910	1180	1180	1180	1180	910	910	1180	1449	1449	1719	1719	1989
36482.8	2417	2734	2734	2734	2734	2417	2417	2099	2099	1782	1464	1147	1464	1464	1464	1464	1147	1147	1464	1782	1782	2099	2099	2417
43000.0	2959	3337	3337	3337	3337	2959	2959	2582	2582	2204	1826	1449	1826	1826	1826	1826	1449	1449	1826	2204	2204	2582	2582	2959
37620.7	2527	2857	2857	2857	2857	2527	2527	2198	2198	1868	1538	1208	1538	1538	1538	1538	1208	1208	1538	1868	1868	2198	2198	2527
24470.6	1457	1668	1668	1668	1668	1457	1457	1246	1246	1036	825	614	825	825	825	825	614	614	825	1036	1036	1246	1246	1457
16551.7	839	981	981	981	981	839	839	697	697	555	413	271	413	413	413	413	271	271	413	555	555	697	697	839
8533.3	246	322	322	322	322	246	246	169	169	93	17	-59	17	17	17	17	-59	-59	17	93	93	169	169	246
8871.0	268	346	346	346	346	268	268	189	189	110	32	-47	32	32	32	32	-47	-47	32	110	110	189	189	268
5533.3	14	65	65	65	65	14	14	-36	-36	-87	-137	-188	-137	-137	-137	-137	-188	-188	-137	-87	-87	-36	-36	14
3103.4	-138	-105	-105	-105	-105	-138	-138	-172	-172	-205	-239	-272	-239	-239	-239	-239	-272	-272	-239	-205	-205	-172	-172	-138

New Design - # Microturbines Used - Office

Hr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	3	4	4	4	4	3	3	3	3	2	2	1	2	2	2	2	1	1	2	2	2	3	3	3
	5	6	6	6	6	5	5	5	5	4	3	2	3	3	3	3	2	2	3	4	4	5	5	5
	4	4	4	4	4	4	4	3	3	3	2	1	2	2	2	2	1	1	2	3	3	3	3	4
	6	6	6	6	6	6	6	5	5	4	3	2	3	3	3	3	2	2	3	4	4	5	5	6
	2	3	3	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2
	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	1	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1
	4	5	5	5	5	4	4	4	4	3	2	2	2	2	2	2	2	2	2	3	3	4	4	4
	5	6	6	6	6	5	5	4	4	4	3	2	3	3	3	3	2	2	3	4	4	4	4	5
	7	7	7	7	7	7	7	6	6	5	4	3	4	4	4	4	3	3	4	5	5	6	6	7
	6	6	6	6	6	6	6	5	5	4	3	2	3	3	3	3	2	2	3	4	4	5	5	6
	3	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	3
	1	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

New Design - Steam Energy Required

MBH																									Steam Required
0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
25833.3	559	430	430	430	430	559	559	328	328	457	226	355	226	226	226	226	355	355	226	457	457	328	328	559	7.8507329
36571.4	698	665	665	665	665	698	698	372	372	405	439	472	439	439	439	439	472	472	439	405	405	372	372	698	10.584772
27218.8	306	549	549	549	549	306	306	423	423	180	298	415	298	298	298	298	415	415	298	180	180	423	423	306	7.5313395
37066.7	394	727	727	727	727	394	394	422	422	449	476	503	476	476	476	476	503	503	476	449	449	422	422	394	10.304543
20636.4	527	354	354	354	354	527	527	339	339	152	324	137	324	324	324	324	137	137	324	152	152	339	339	527	6.6711058
11758.6	157	263	263	263	263	157	157	411	411	304	198	92	198	198	198	198	92	92	198	304	304	411	411	157	4.942322
7700.0	201	272	272	272	272	201	201	129	129	58	0	0	0	0	0	0	0	0	0	58	58	129	129	201	2.2393284
11096.8	85	184	184	184	184	85	85	347	347	248	150	52	150	150	150	150	52	52	150	248	248	347	347	85	3.6969567
12133.3	160	267	267	267	267	160	160	414	414	307	200	93	200	200	200	200	93	93	200	307	307	414	414	160	4.998288
8413.8	255	332	332	332	332	255	255	178	178	101	23	0	23	23	23	23	0	0	23	101	101	178	178	255	3.0370688
11406.3	121	224	224	224	224	121	121	379	379	277	174	72	174	174	174	174	72	72	174	277	277	379	379	121	4.3240569
16000.0	468	249	249	249	249	468	468	327	327	186	405	264	405	405	405	405	264	264	405	186	186	327	327	468	6.9010305
30766.7	549	459	459	459	459	549	549	279	279	369	460	190	460	460	460	460	190	190	460	369	369	279	279	549	8.3119256
36482.8	617	574	574	574	574	617	617	659	659	342	384	427	384	384	384	384	427	427	384	342	342	659	659	617	10.412894
43000.0	439	817	817	817	817	439	439	422	422	404	386	369	386	386	386	386	369	369	386	404	404	422	422	439	9.8401846
37620.7	367	697	697	697	697	367	367	398	398	428	458	488	458	458	458	458	488	488	458	428	428	398	398	367	9.8350579
24470.6	377	588	588	588	588	377	377	526	526	316	465	254	465	465	465	465	254	254	465	316	316	526	526	377	9.0739472
16551.7	479	261	261	261	261	479	479	337	337	195	413	271	413	413	413	413	271	271	413	195	195	337	337	479	7.0939698
8533.3	246	322	322	322	322	246	246	169	169	93	17	0	17	17	17	17	0	0	17	93	93	169	169	246	2.8870505
8871.0	268	346	346	346	346	268	268	189	189	110	32	0	32	32	32	32	0	0	32	110	110	189	189	268	3.2377823
5533.3	14	65	65	65	65	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0.273991
3103.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Net Elec "Used"in Building - Positive = Consumption, Negative = Generation

(kW/hr)

Hr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	56.9	-8.1	-8.1	-8.1	-8.1	176	255	295	334	518	597	662	597	518	518	597	662	583	439	399	360	215	136	56.9
	-65	-130	-130	-130	-130	56.7	138	178	219	406	552	617	552	471	471	552	617	536	390	284	243	97.3	16.1	-65
	-34	-34	-34	-34	-34	74.8	148	249	285	394	532	597	532	459	459	532	597	524	387	285	249	176	103	-34
	-155	-155	-155	-155	-155	-43	32.4	135	172	350	490	555	490	415	415	490	555	480	340	237	200	59.9	-15	-155
	102	37.2	37.2	37.2	37.2	214	288	325	362	474	613	613	613	539	539	613	613	539	464	362	325	251	177	102
	201	201	201	201	201	325	408	514	556	680	762	762	762	680	680	762	762	680	597	556	514	431	349	201
	318	318	318	318	318	462	558	605	653	797	893	893	893	797	797	893	893	797	701	653	605	510	414	318
	292	292	292	292	292	450	556	674	726	885	990	990	990	885	885	990	990	885	779	726	674	568	463	292
	268	268	268	268	268	417	516	631	680	829	929	929	929	829	829	929	929	829	730	680	631	531	432	268
	279	279	279	279	279	408	494	537	580	709	796	796	796	709	709	796	796	709	623	580	537	451	365	279
	161	161	161	161	161	270	343	444	481	590	662	662	662	590	590	662	662	590	517	481	444	371	299	161
	158	93.5	93.5	93.5	93.5	267	339	375	411	519	656	656	656	584	584	656	656	584	512	411	375	303	231	158