Final Report

Susquehanna Center Renovations & Expansion

Brad Gaugh

April 7, 2011

SUSQUEHANNA CENTER RENOVATIONS & EXPANSIONS

BEL AIR, MARYLAND

BRAD GAUGH

LIGHTING/ ELECTRICAL OPTION

http://www.engr.psu.edu/ae/thesis/portfolios/2011/bmg5052/index.html

PROJECT TEAM

Owner —Harford Community College

Architect — Hord Coplan Macht

Construction Manager —Turner Construction

Landscape Architect —Site Resources

Civil Engineer —Site Resources

Structural Engineer —CMJ Structural Engineering

MEP Engineering —Burdette Koehler Murphy & Associates

Lighting Consultant —Dunlop Lighting Design

Telecommunications —Spexsys

Natatorium —Counsilman Hunsaker

STATISTICS

Size—110, 000 SF

Height—2 : 1 Above Ground @ 45ft

Construction Dates—April 2011—August 2012

Project Delivery Method—Design—Bid—Build

Project Cost—$28 Million

STRUCTURE

The foundation is comprised of a two way slab and the slabs' thicknesses range from 3 1/2" to 10". The super structure is composed of concrete and steel columns at varying locations. The steel columns are located in all areas except the main arena, which is supported by concrete columns. The roof system is comprised of composite decking and trusses at 8' on center in the main and auxiliary gym.

ARCHITECTURE

The athletic facility uses primarily three main types of materials on the façade to distinguish between the two main floors; the arena level and main level. The architect uses matte painted concrete block for supporting walls that start at the arena level and end at the main level. At the main level, glazing is used as the distinguishing factor and allows for interesting perspectives and views looking out of building from the concourse at the main level. Lastly, the architect uses an aesthetically appealing design for the down spouts by forming a V-shape on the sides of the main arena.

LIGHTING and ELECTRICAL

The service entrance is supplied by BGE 's pad mounted transformer, which is stepped down to 480Y/277 V, 3 PH., 4W. The main switchboard is sized at 3200 A and the emergency power is supplied by a 60 W generator at 75 KVA. The lighting is primarily linear fluorescent luminaires and the main and auxiliary gym is illuminated by metal halide pulse start fixtures.

MECHANICAL

The mechanical system takes advantage of a variable air volume fan coil system consisting of energy recovery AHU's that reduce cooling and heating demands for units. The cooling is generated by an air cooled high efficiency chiller and the extracted heat from this unit is collected in a DX refrigeration system and used to reheat the pool. There is also a rain harvest collection system, which supplies water to urinals and toilets.

Table of Contents

Executive Summary

The Susquehanna Center, located in Bel Air, Maryland is an expansion and renovation to the practice facility for the men's basketball team for Harford Community College. The Center will serve as the main hub for the sports community on campus. The expansion includes the addition of a 5,000 seat arena and a college sports program weight training room. Also, the Center upgraded its practice facilities and domestic swimming complex located in the basement. The building is LEED certified which, will create and interesting blend of energy efficiency in the exciting and festive sports world.

This report looks into the past two semester's research in its aid to redesign four spaces with the Susquehanna Center. The four spaces to be redesigned are the building façade, the main lobby, the Auxiliary Gymnasium, and the Fitness and Weight room. The main focus of the report is the redesign of the lighting and electrical systems within the four spaces. The lighting design concept was to accentuate the message that this Center is the hub of the sports community and to invoke the exciting nature that surrounds the thrill of watching college athletics.

The electrical depth of this reports looks into the branch circuitry and control systems used for the new lighting design. It also contains a comprehensive study on the protection of all electrical devices and the coordination between those devices. The protection entails a short circuit calculation by hand, a SKM power tools model to confirm short circuit calculations and an arc flash study to determine the hazards of working on certain pieces of equipment.

The mechanical and structural breadths take another step forward in the lighting redesign of the Auxiliary Gymnasium. The redesign of the Auxiliary Gymnasium introduces day-lighting into the space by the use skylights. The structural breadth analyzes how the truss system will be impacted and the mechanical breadth analyzes how the chiller's cooling load will be impacted.

Building Statistics

Building Name: Susquehanna Center Renovations and Expansion

Location and Site: Bel, Air, Maryland

Building Occupant Name: Harford Community College

Building Function Types: The building is comprised of a number of spaces that serve the community college's needs to be the center for the sports complex. Within the facility is a weight room, Auxiliary Gymnasium, indoor pool and 5,000 seat main basketball arena.

Size: 100,000 SF

Stories: 3 Stories with one story below grade

Construction Dates: April 2011 – August 2012

Project Delivery Method: $28 million

Project Team Directory:

Architect	Hord Coplan Macht	http://www.hcm2.com/
Construction Manager	Turner Construction	http://www.turnerconstruction.com/
General Contractor	Not Selected	
Landscape Architect	Site Resources	http://www.siteresourcesinc.com/
Civil Engineer	Site Resources	http://www.siteresourcesinc.com/
Structural Engineer	CMJ Structural Engineers	http://www.cmjeng.com/
MEP Engineer	Burdette Koehler Murphy & Associates	http://www.bkma.com/
Lighting Consultant	Dunlop Lighting Design	http://www.dunloplighting.com/
Telecommunications	Spexsys	http://www.spexsys.com/
Natatorium	Counsilman Hunsaker	http://chah2o.com/

Table 1. Project Team Directory

Codes:

- International Building Code IBC 2006
- International Mechanical Code IMC 2006
- International Electric Code IEC 2006
- International Plumbing Code IPC 2006
- National Life Safety/ Fire Code NFPA 101 2006

Zoning: Agricultural (AG)

Building Enclosure: The exterior of the Susquehanna Center is comprised of matte painted concrete block, sizes ranging from 4x8 to 16x24, as well as aluminum paneling to support glazing at entrances of the athletic facility. Painted aluminum down spouts are used in an appealing V-shape on the main arena side of the building. The roofing system is compiled of different membranes, with varying sizes of insulation and sheathing, which combine to make up 5 different types of roofing systems. Type one is consisted of a single ply membrane with two layers of insulation and ½" roof sheathing supported by metal deck. This type is used over main gym. The second type is 4 ply B.U. roof with an aggregate surface. Underlying this surface is tapered insulation supported by a concrete slab. The third type consists of a single ply membrane with tapered insulation supported by metal deck, and the fourth type also supported by metal is made up of a single ply membrane and ½" sheathing. The fifth type is where the roofing system joins the existing building. The components of the system are similar to the system of type two, except that the tapered insulation is used to match the thickness of the existing roof.

Sustainability Features: The Susquehanna Center is currently seeking out LEED accreditation, and thus there are numerous sustainable design features throughout most systems within the building. The bulk of the sustainable features were designed to be incorporated in the mechanical and electrical systems. The mechanical system utilizes air cooled high efficiency chillers, solar heating systems for the pool, multiple energy recovery air handling systems above the arena, and a rain harvesting system for toilets and urinals. The electrical systems take advantage of occupancy and vacancy sensors in classrooms, bathrooms and some offices. Also, electronic shading devices mounted on the west facing wall of the main entry enable proper day lighting techniques.

Construction: Construction on the Susquehanna Center has not yet begun, but the predicted construction periods are from April 2011 till August 2012. As of now the building is in the bidding phase and the general contractor has not been selected. However, Turner Construction has been hired by the owner to act as a construction manager on the project. The building method chosen for this building is design-bid-build, and the initial budget is approximated at $28 million. The building is a renovation and expansion to the existing basketball facility that is already located on Harford Community College's campus, in which its front façade faces Thomas Run Road of Bel Air, MD

Electrical: The power distribution system for this building is a simple radial system, with the service entrance point on the North West portion of the building on the main level. The building is fed by a 2000kVA pad mounted transformer supplied by Baltimore Gas and Electric (BGE). The secondary side of the transfer is listed at 480Y/277V, 3PH, 4W. The main switchgear is rated at 3200A and 42000AIC. This switchboard then feeds distribution Panels located throughout the corners of the building, which in turn feeds lighting and receptacle Panels. These Panels and loads are listed at 480Y/277V, 3PH, 4W and 208Y/120V, 3PH, 4W respectively. There are additional transformers used to step loads down to the 208Y/120V voltage system.

Lighting: As the building is designed to meet USGBC's standards for LEED accreditation, the lighting is designed to use energy conscious fluorescent and metal halide pulse start luminaires. This allows the design to use minimum energy consumption and meet ASHRAE 90.1 standards on lighting power density. The lobby, bathrooms, classrooms, and other spaces use linear fluorescent and compact fluorescent down lights with electronic ballasts to limit power factor and light loss. The low bay metal halide luminaires in the Auxiliary Gymnasium and main arena use restrike technology on certain luminaires to allow for instant switching.

Mechanical: The mechanical system for this building utilizes variable air volume air handling units (AHU), which all have total energy recovery wheels that greatly reduce the cooling and heating demand for the units. The cooling is generated by an air cooled high efficiency chiller and the pool uses a solar heating system as the primary source of heating. The AHU for the pool has a DX refrigeration system that uses hot refrigerant gas to reheat the air, so that it can be properly de-humidified. Lastly there is a rain water harvest system, which takes water from the Arena roof and stores a 10,000 gallon underground storage tank. This water is then filtered and pumped to be used in toilets and urinals throughout the arena.

Structural: The foundation of the building is comprised of concrete column footers ranging in size from 5'x7'x1'-7" to 11'x11'x2'. The main floor is a two way slab, in which the slab's thickness is 3-1/2" and the grade beams with a thickness of 10". The superstructure of the building is composed of both concrete and steel beams. The concrete beams are 16"x16" and 18"x38", while the steel beams are primarily W10x33 and HSS 6x6x1/2. The main arena utilizes 60" deep 96SLHSP trusses to span 157' laterally.

Fire Protection: The fire alarm control Panel is located at the main level of the lobby. There are numerous signal and detection devices throughout the building. There are horn strobes located throughout the corridors and large public spaces. Smoke detectors, manual pull stations and signaling devices are also located per standard NFPA 72 requirements.

Telecommunications: There are voice/ data outlets located in offices and classrooms to allow for telephone and internet connections. There is also an intercom system that serves the main arena of the gym to allow for commentary during games.

Large Work Space – Auxiliary Gymnasium

Space Description

This space is rather unique as it serves multiple purposes for multiple users. It serves as a secondary court to practice for the Harford Community College's basketball team, a court for recreational basketball organizations, an indoor batting cage, and any other uses that seem feasible. There are six retractable basketball goals with backboards that allow for 3 different configurations of basketball courts. Only one of those courts is actually full size, while the other two are condensed versions. There is padding with graphics and varying colors that are located on the walls and also help create a dynamic space.

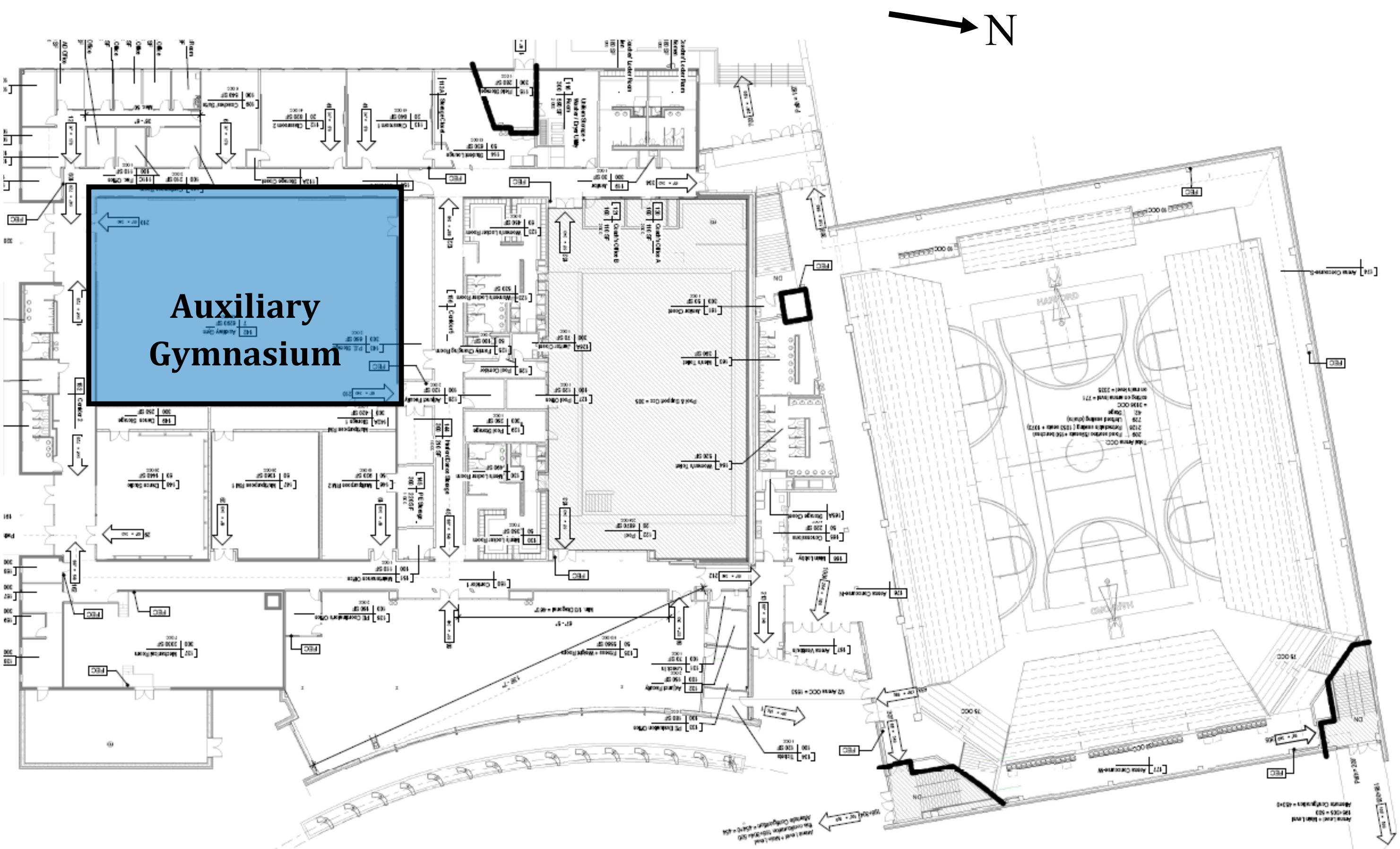
Materials

Material	Description	Properties
Floor	athletic wood flooring	$\rho = 0.20$
Walls	gypsum board painted matte white	$\rho = 0.9$
	gypsum board painted matte blue	$\rho = 0.14$
	cmu painted matte white	$\rho = 0.9$
	cmu painted matte blue	$\rho = 0.14$
	padding painted matte a light blue	$\rho = 0.14$
Ceiling	exposed ceiling structure painted matte white	$\rho = 0.9$

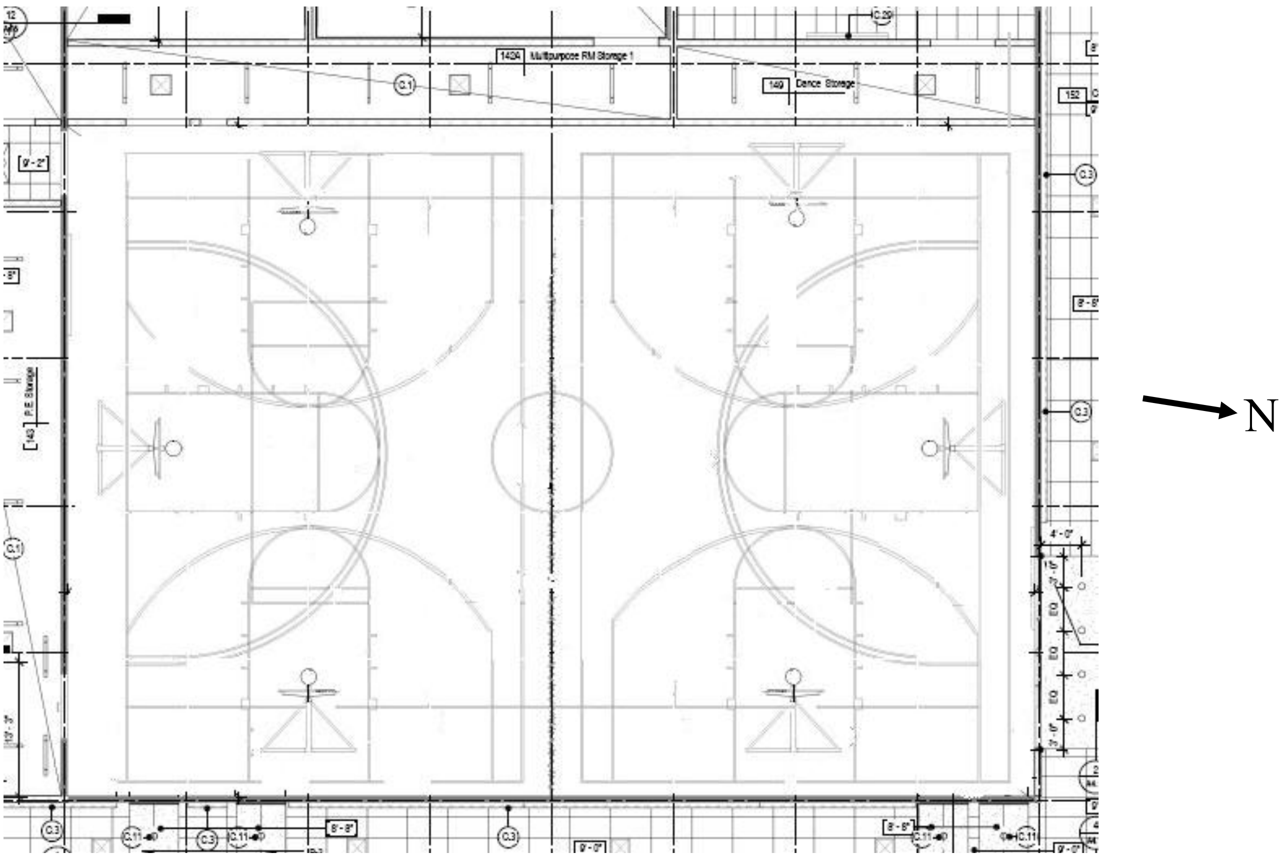
Table 2. Auxiliary Gymnasium Materials

Brad Gaugh
Lighting/ Electrical Option
Dr. Kevin Houser/ Prof. Dannerth

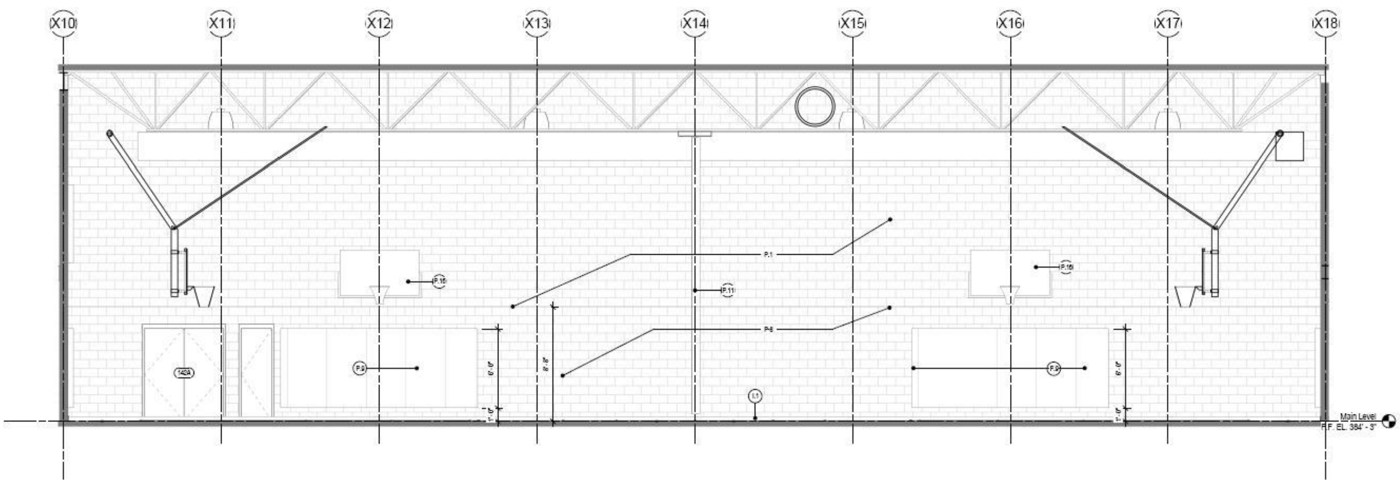
Drawings



Drawing 1. Building Floor Plan labeling Auxiliary Gymnasium



Drawing 2. Auxiliary Gymnasium Floor Plan



Drawing 3. Auxiliary Gymnasium Section

Design Concept

Since the gymnasium will not include spectators, the lighting must focus primarily on the individuals using the court and the court area itself. The light levels on the court must be uniform in order to eliminate the effect of shadowing and inappropriate modeling of 3-dimensional surfaces. When lighting the floor to a uniform level, one must be conscious of the consequences of direct glare from the luminaires. Since the primary use of the court is to be used for basketball which is an aerial sport, the individuals head will be looking up at the basket, thus the luminaires must be able to avoid discomfort from direct and reflected glare.

The gymnasium was a prime candidate to introduce day-lighting into the space to help consume the watts of energy of the high power fluorescent luminaires. A thorough and comprehensive day-lighting design will allow savings on the electrical consumption. Another aspect of the redesign was to eliminate the high intensity discharge lighting that was originally chosen for the space because these luminaires consume twice the amount of energy that a high bay fluorescent luminaire will put forth for the same light output.

Design Considerations and Criteria

IESNA 2000 Design Considerations (Sports and Recreation Class II)

Very Important Design Considerations

- Direct Glare
  - Avoiding glare is a necessity when designing a lighting scheme for a basketball court, since you do not want to blind the players on the court, so that they cannot perform the tasks at hand.
- Light Distribution on Task Plane (Uniformity)
  - Uniformity allows players to be able to see without being distracted or confused by brighter spots on the floor.
- Reflected Glare
  - Players should be able to see and perform the visible tasks necessary for playing this aerial sport. The lighting design should avoid distraction and glare issues.
- Shadows
  - Shadowing must be avoided as it may cause darkness on certain spots on the floor, which will not allow players to complete tasks as it may cause confusion.

Important Design Considerations

- Color Appearance (and Color Contrast)
  - Players must be able to distinguish between teams and team colors as well as the definition and color of the ball.
- Day-lighting Integration and Control
  - This aspect provides a psychological one. An aspect not directed at players specifically, but to all individuals within the space.
- Flicker and Strobe
  - Any type of distraction created by the lighting design must be avoided in order to allow players to complete the tasks associated with playing basketball.
- Luminaire Noise
  - Players and coaches must be able to communicate with each other on the court and thus the background noise must be kept to a minimum.
- Modeling of Faces and Objects
  - Being able to identify the basketball and players faces allows for aerial tasks to be completed and for communication to be simpler.

IESNA 2000 Design Criteria (Sports and Recreation Class II)

- Horizontal Illuminance
  - E = 800 lx or 80 fc
- Uniformity
  - CV Ratio = < 0.21
  - Max : Min = < 2.5: 1

ASHRAE Standards 90.1

- Lighting Power Density
  - Gymnasium/ Exercise Center (Exercise Area)
  - LPD = 2.3 W/ft^2

Luminaires

Type		Manufacturer	Product Name	Catalog Number	Description	Lamp	Voltage	Ballast	Watts	Location
G1		Lithonia Lighting	I-Beam	IB 454L WDS MVOLT	2x4 Fluorescent high bay luminaire utilizing cool running technology. The housing is made of heavy gauge steel with high gloss baked white enamel.	FP54 841 HO ECO	MVOLT	Mark 10 Powerline	54	Auxiliary Gymnasium

Table 3. Auxiliary Gymnasium Luminaire Schedule

NOTE: See Appendix A for complete luminaire schedule and Appendix B for specification sheets

Light Loss Factors

Luminaire Type	Lamp Lumen Depreciation	Lamp Dirt Depreciation	Room Surface Dirt Depreciation	Ballast Factor	Total Light Loss Factor
G1	0.93	0.95	0.98	1.00	0.87

Table 4. Auxiliary Gymnasium Light Loss Factors

Controls

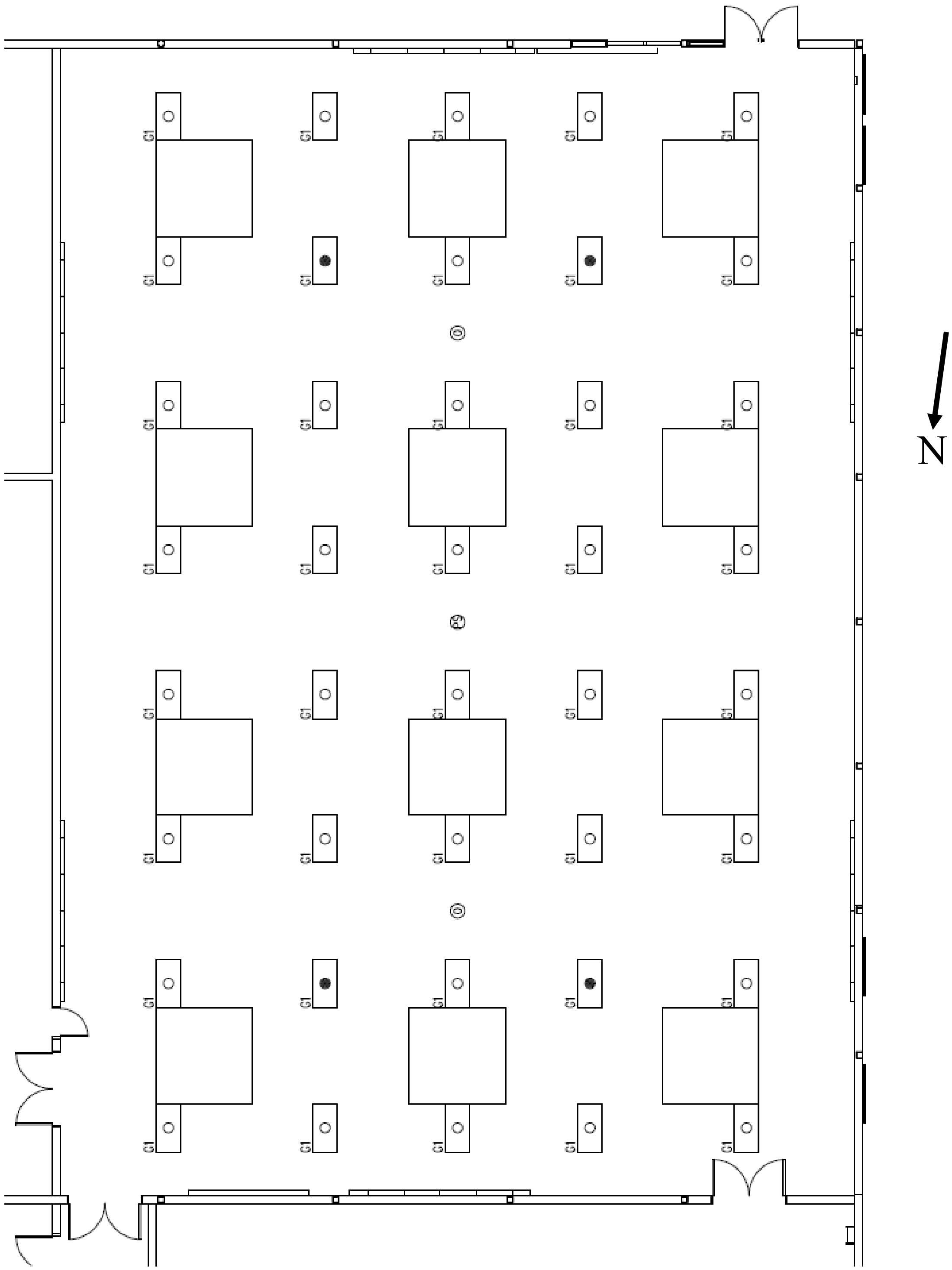
The controls within the Auxiliary Gymnasium have one main goal, which is to monitor the amount of energy that is being consumed proportionally to how much light is on the court. There is a photocell, which will be connected to a Lutron Grafik Eye to monitor the daylight levels and will dim the fluorescent high bay luminaires via a relay.

The emergency luminaires will be controlled by an emergency lighting interface that will turn on the luminaires when normal power has been lost. A control schedule and wiring diagram has been provided to illustrate the nature of the system. See Appendix A for complete control schedule.

Type		Manufacturer	Product Name	Catalog Number	Description	Location
DP		Lutron	Dimming Panel	GP8-2774T8-ML-20-CGP344	480Y/277V 3PH., 4W Dimming Panel with 8 circuits	
GE		Lutron	Grafik Eye QS	QSGRJ-xP	Interface unit that will serve as the main control unit for the entire system	Gymnasium
DC		Lutron	Automatic Day-Lighting Control	OMX-DACPI	Interface that will interpret and control photocell and dimming proportions	Gymnasium
O		Lutron	Passive Infrared Ceiling Sensor	LOS-CIR 1500-WH	Passive infrared occupancy sensor with 1500 SF coverage.	Gymnasium
PC		Lutron	Ceiling Mounted Photocell	MW-PS-WH	Ceiling mounted photocell that will measure day-light levels.	Gymnasium
EM		Lutron	Emergency Lighting Interface	LUT-ELI-3PH	Relay device that will automatically switch the emergency lights on when normal power has been lost.	Gymnasium

Table 5. Auxiliary Gymnasium Control Schedule

Lighting Plan



Drawing 4. Auxiliary Gymnasium Lighting Floor Plan

Performance Data

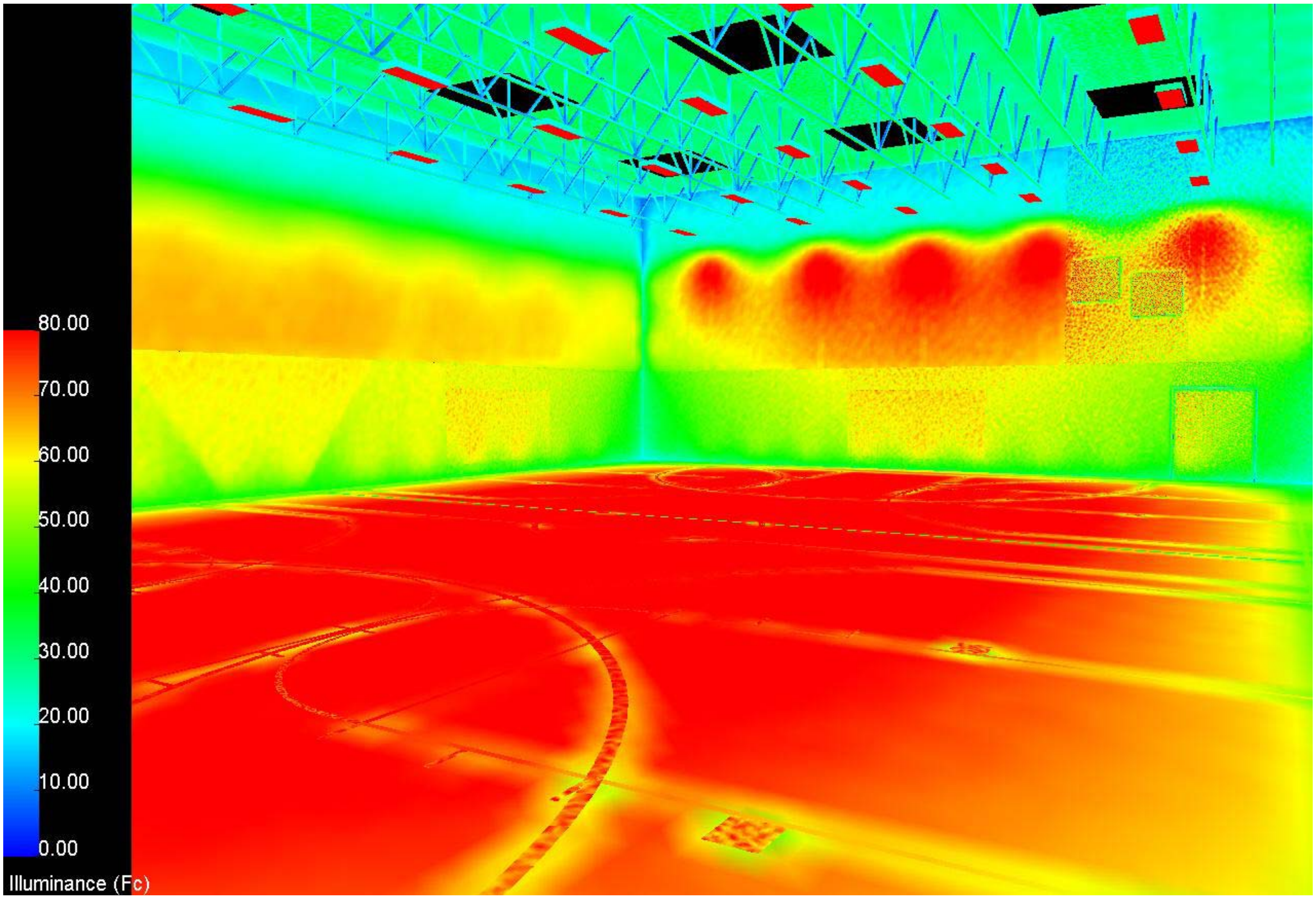


Image 1. Auxiliary Gymnasium Electric Light Only Pseudo Diagram

Daylight Contribution

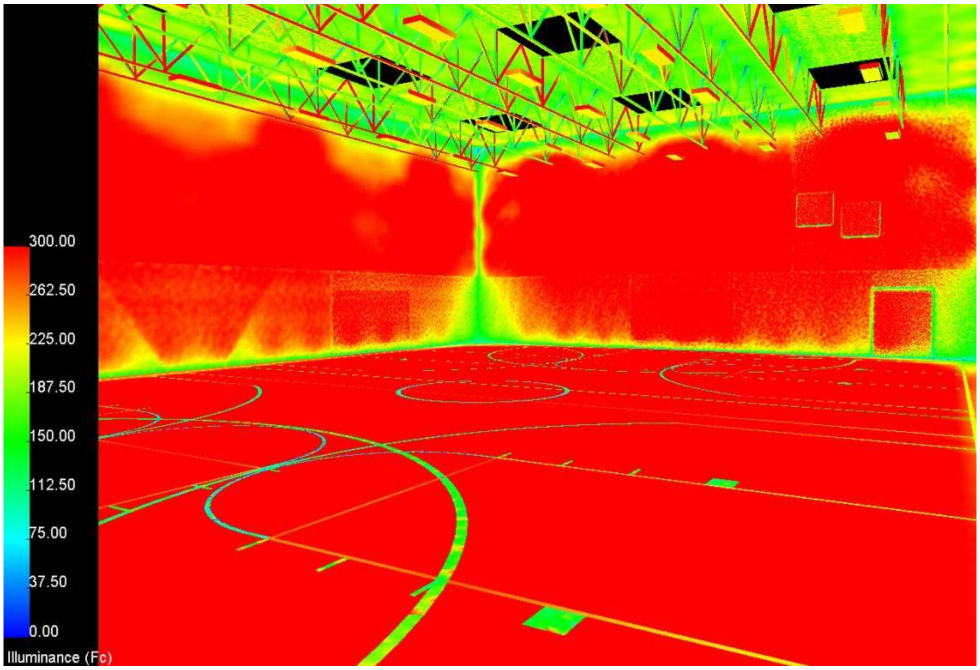


Image 2. Auxiliary Gymnasium Daylight - Summer Solstice Clear Sky Pseudo Diagram

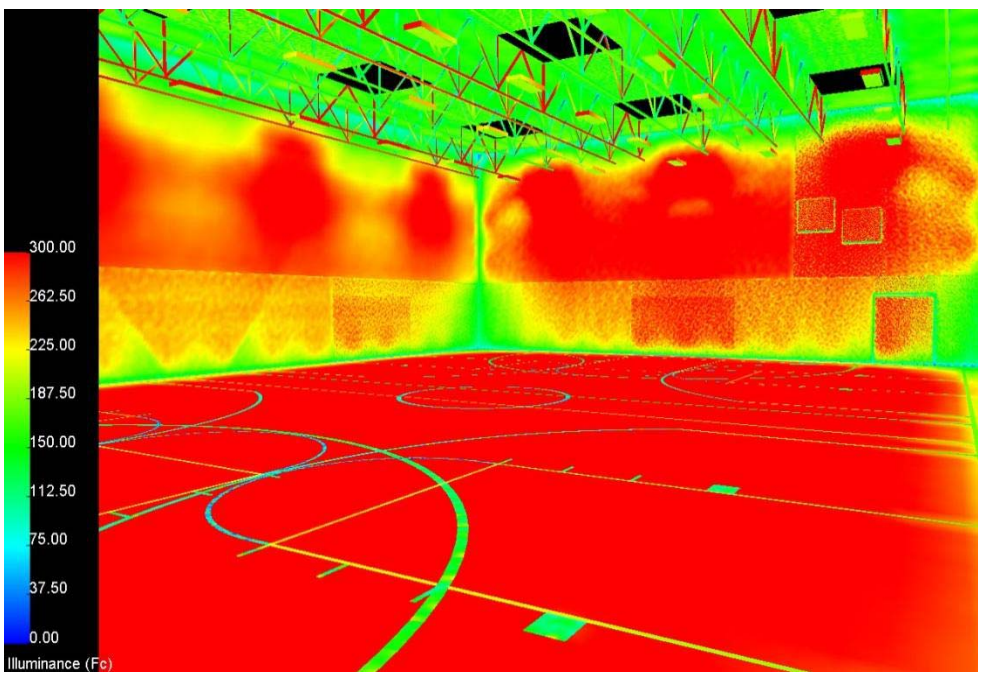


Image 3. Auxiliary Gymnasium Daylight - Summer Solstice Partly Cloudy Sky Pseudo Diagram

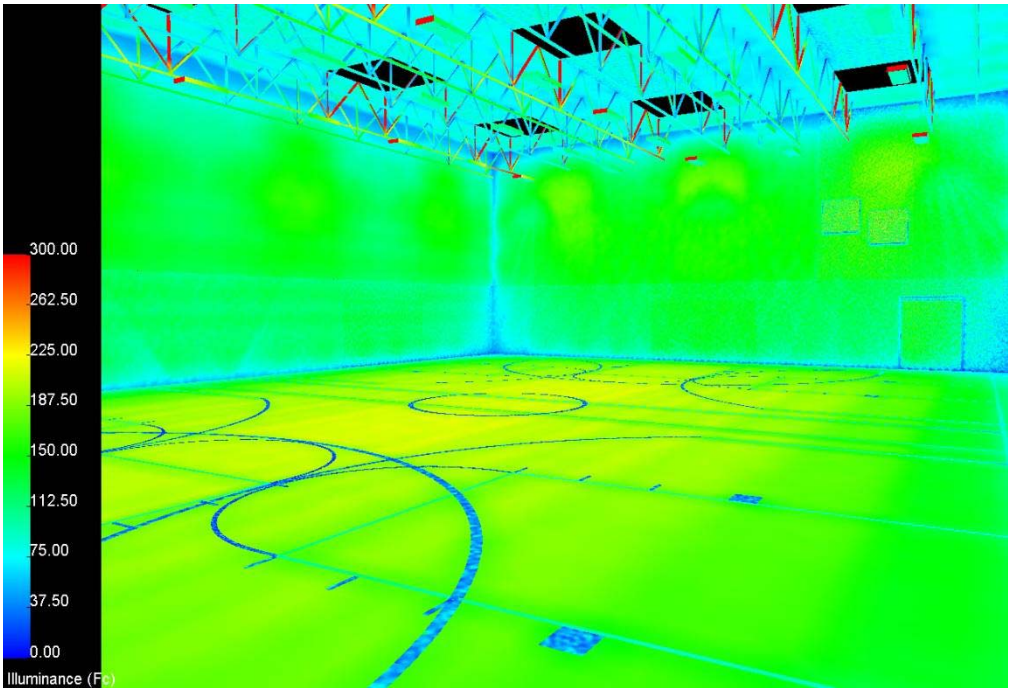


Image 4. Auxiliary Gymnasium Daylight - Winter Solstice Clear Sky Pseudo Diagram

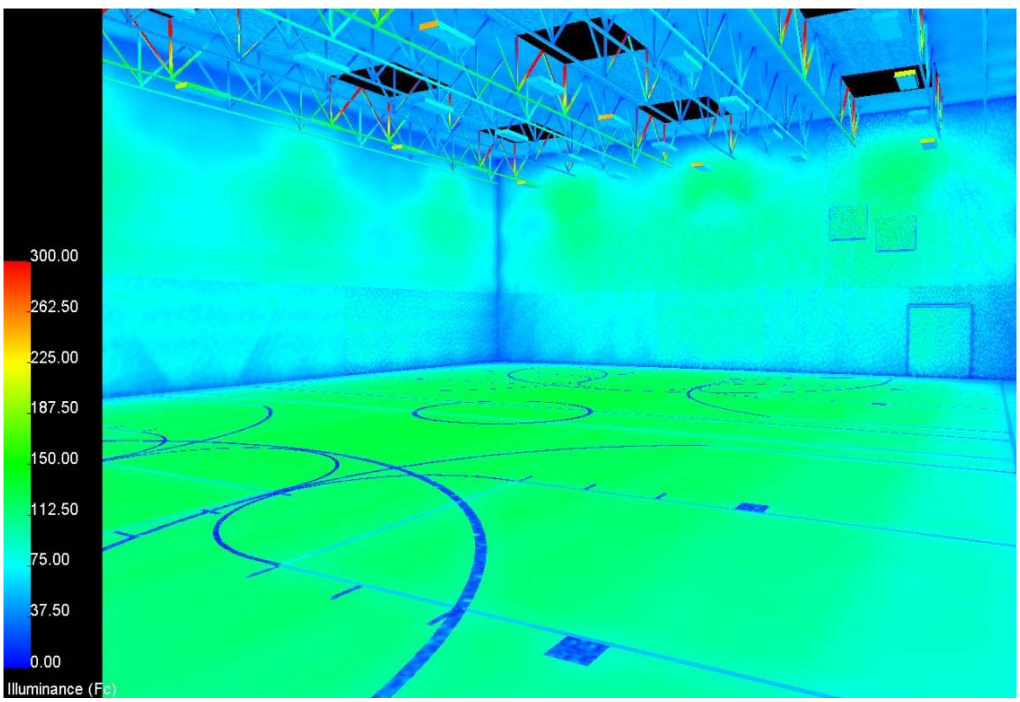


Image 5. Auxiliary Gymnasium Daylight - Winter Solstice Partly Cloudy Sky Pseudo Diagram

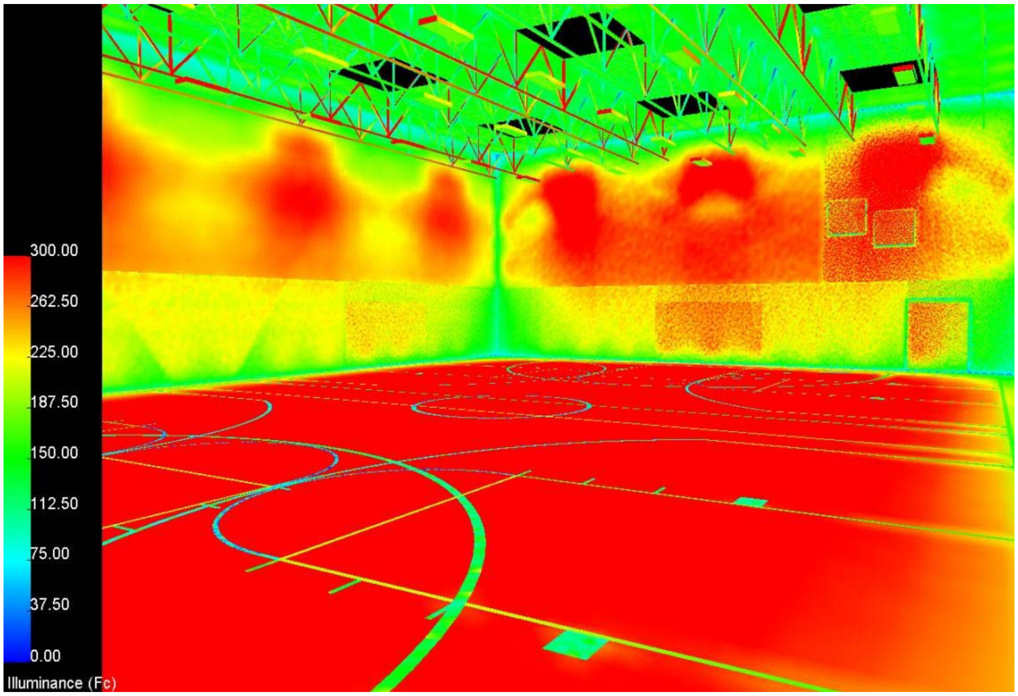


Image 6. Auxiliary Gymnasium Daylight - Equinox Clear Sky Pseudo Diagram

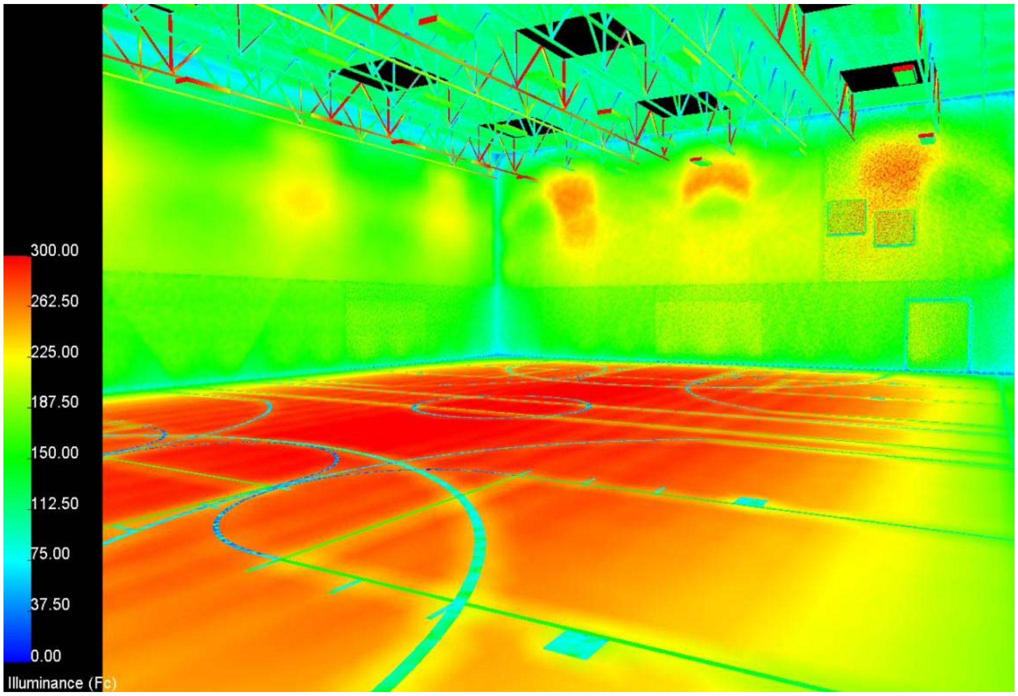


Image 7. Auxiliary Gymnasium Daylight - Equinox Partly Cloudy Sky Pseudo Diagram

Performance Summary

The space redesign was driven by the addition of skylights in order to lower and eliminate the consumption of unnecessary power. The high bay fluorescent luminaires were able to deliver the recommended IESNA illumination level at the work plane at 81fc. The integration between the skylights and dimming capabilities of the fluorescent allow for the space to accommodate the ever-changing day-light levels throughout the day and year. Even with the skylights the lighting design is still able to maintain a uniform lighting mode, which will help with the individuals using the court to see and also identify shapes and 3-dimensionsal surfaces. With the control interfaces provided by Lutron the space will be able to save unnecessary wattage during prime day-light hours of the day.

The daylight scenarios are based off the summer solstice, winter solstice, and fall and spring equinox for the year 2011. The time of day stayed constant at 1:15 PM for all scenarios. The daylight scenarios concluded that the summer time will be the highest contributing factor of direct and reflected glare throughout the entire year. The Illuminance levels for this time of year are a bit alarming in that typically foot candle levels higher than 300 can cause severe issues for direct and reflected glare. This means that a shade device should be used to help eliminate some of the unnecessary daylight. Since the lighting design contains a photocell to control the light output, the luminaires will be able to dim down to five percent total light output, which would be the ideal case for all the scenarios depicted above.

Criterion	IESNA Recommended	Designed
Average Illuminance	80 fc	81fc
Max : Min Illuminance Ratio	2.5 : 1	2.2 : 1
Coefficient of Variance	0.21	0.16
LPD (6270 SF)	2.3 W/SF (14421 W)	1.6 W/SF (9640 W)

Table 6. Auxiliary Gymnasium Electric Light Only Results

Daylight Scenario	Avg Illuminance	Max : Min Ratio	Coefficient of Variance
	(80 fc)	(2.5 : 1)	(0.21)
Summer Clear Sky	443 fc	2.2	0.14
Summer Partly Cloudy Sky	377 fc	2.2	0.14
Winter Clear Sky	184	2.2	0.14
Winter Partly Cloudy	141	2.2	0.14
Equinox Clear Sky	341	2.2	0.14
Equinox Partly Cloudy Sky	263	2.2	0.14

Table 7. Auxiliary Gymnasium Day-lighting Results

Renderings

Image 8. Auxiliary Gymnasium Electric Light Only Rendering

Special Purpose Space – Fitness and Weight Room

Space Description

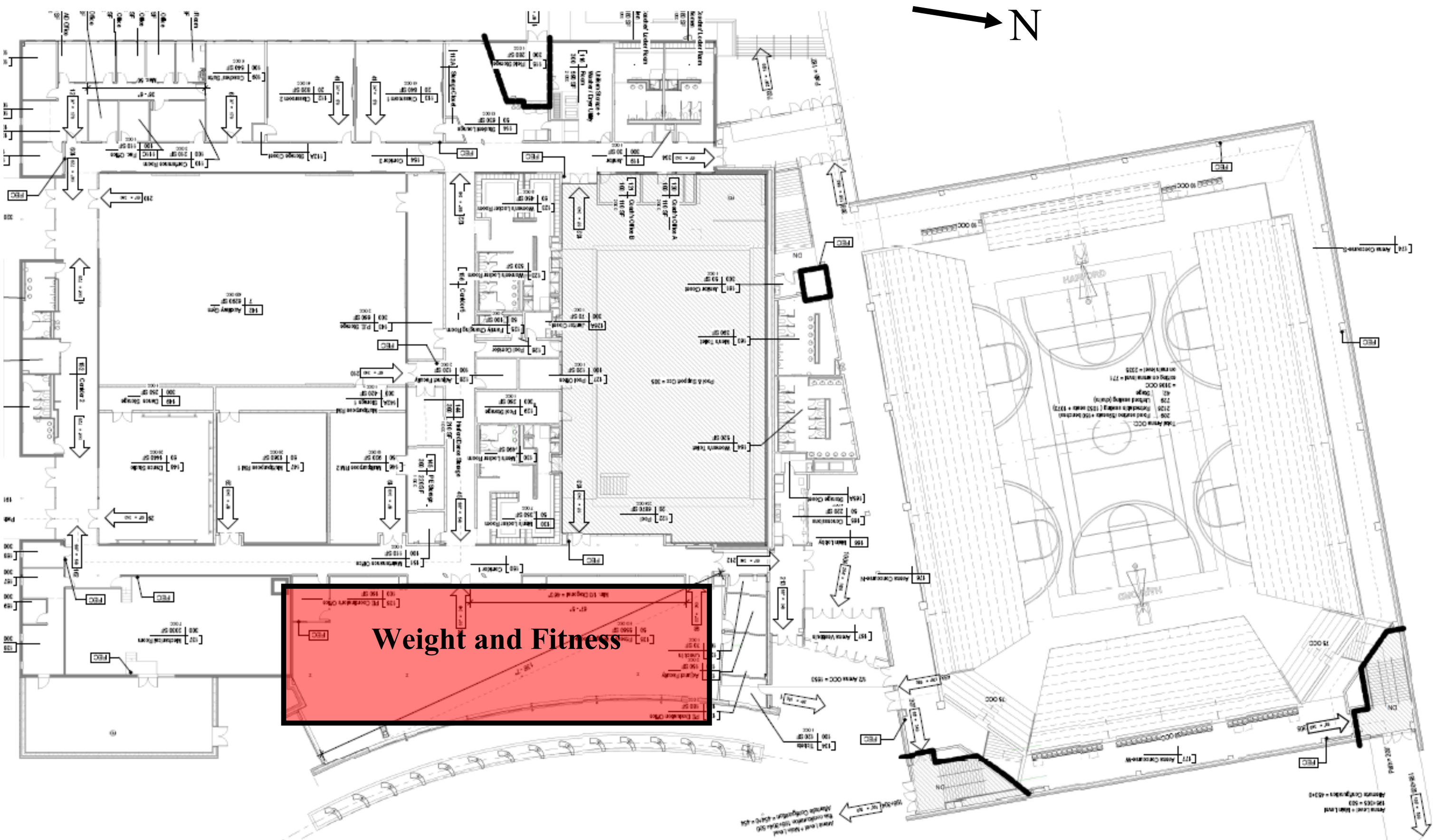
The Fitness and Weight room is a unique space due its geometry, varying ceiling heights, and materials. The ceiling varies in height throughout the space and as the height changes so does the material of the ceiling. Another interesting feature to this room is its unique geometry. The west facing wall is an exterior wall facing the parking lot and is made entirely of glass. This wall that provides outside views is also in an elegant curve. This space will primarily serves as the workout area for the athletes of Harford Community College and is filled with varying types workout equipment. This equipment ranges from treadmills, stationary bikes, weight machines, and benches for free weights.

Materials

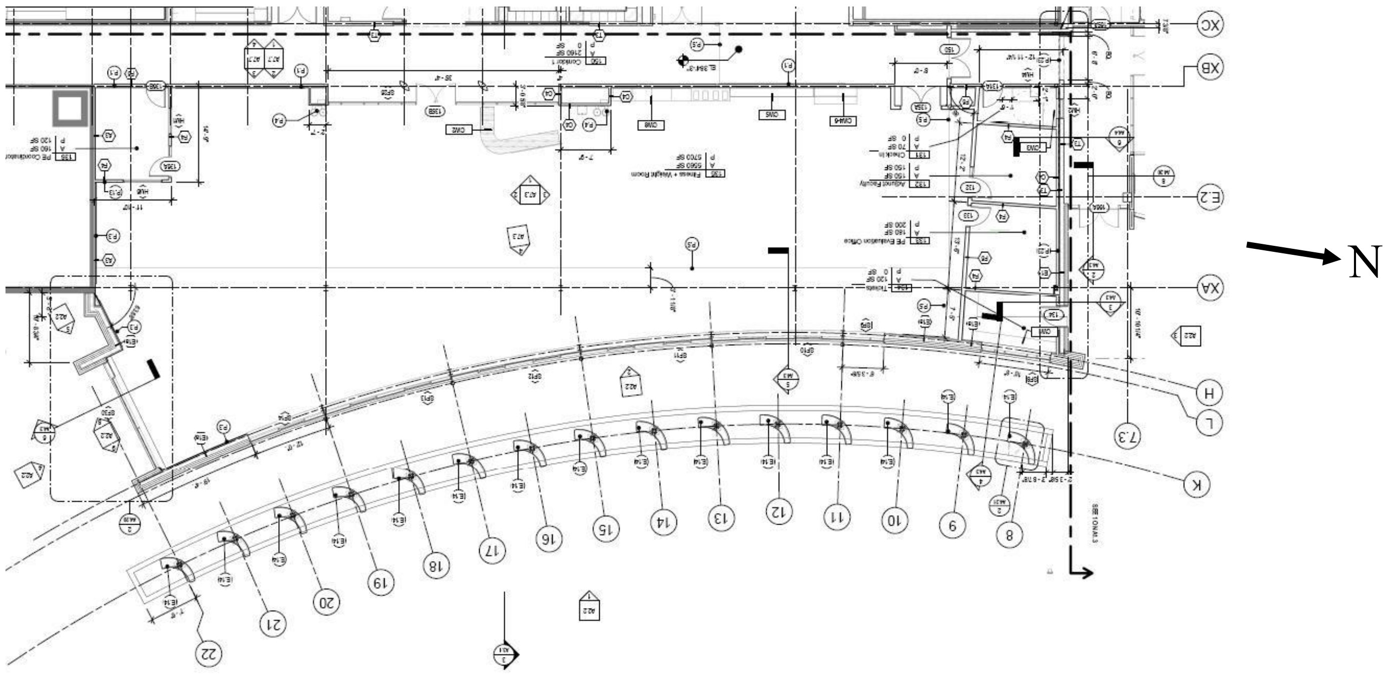
Material	Description	Properties
Floor	grey, teal, light green tiled carpet	$\rho = 0.12$
	grey athletic rubber flooring	$\rho = 0.07$
Walls	gypsum board with white finish paint	$\rho = 0.9$
	gypsum board with blue finish paint	$\rho = 0.14$
	gypsum board with dark blue finish paint	$\rho = 0.10$
	mirror	$\rho = 0.93$
	clear glazing store front system	$\rho = 0.05$
Ceiling	gypsum board with white finish	$\rho = 0.9$
	exposed structure, painted white	$\rho = 0.9$
	acoustical ceiling tile with white finish	$\rho = 0.75$

Table 8. Fitness and Weight Room Materials

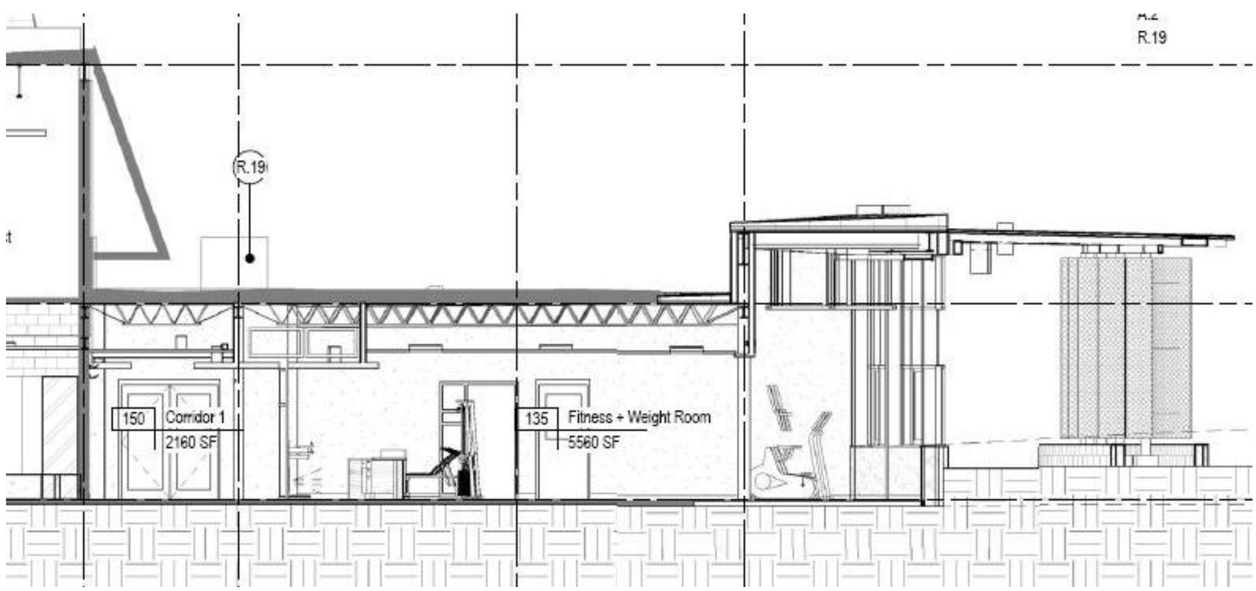
Drawings



Drawing 5. Building Floor Plan labeling Fitness and Weight Room



Drawing 6. Fitness and Weight Room Floor Plan



Drawing 7. Fitness and Weight Room Section

Design Concept

The Fitness and Weight room had a complicated yet interesting ceiling arrangement. Within this space the ceiling took on three different types of heights and three corresponding materials. With each new height a new material was presented within the space. The original lighting design neglected this fascinating arrangement and used bland down-lighting techniques to illuminate the space. The redesign will take a different approach and highlight the predominant ceiling material and height, which was gypsum board at 9'-0" above finished floor. The redesign will place emphasis on this ceiling by using a perimeter cove luminaire around the ceiling, which will use up-light to illuminate the ceiling to provide an ambient atmosphere within the weight room.

Design Considerations and Criteria

IESNA 2000 Design Considerations (Health Care Facilities – Physical Therapy Gymnasiums)

Reason:

The rehabilitation exercises that take place within a physical therapy session can be similar to those exercises condoned in a Fitness and Weight room. Both types of spaces require the ability to read, walk, lift, and stretch. These are all visual tasks that a lighting design will be required to abide by in a Fitness and Weight room or physical therapy gym.

Very Important Design Considerations

- Appearance of Space and Luminaires
    - The equipment in a Fitness and Weight room is generally organized in an orderly manner which makes it manageable for an individual to conduct proper exercise etiquette. It is also the responsibility of the lighting design to continue that relationship between furnishings and space.
- Color Appearance (and Contrast)
    - It is important that the lighting design accurately portrays the color aspects of the weights to avoid accidents and special issues.
- Daylight Integration and Control
    - Incorporating views of the exterior and outdoors is believed to be important for psychological reasons by providing cues about the time of day and weather.
- Flickering and Strobe

  - Flickering and strobe affects can be annoying and distracting. When handling weights it is important that an individual not get annoyed and distracted, in case of injury and accidents.

- Luminances of Room Surfaces
  - It is crucial all pieces of equipment maintain certain brightness, so that an individual working on that piece of equipment can operate it properly.

Important Design Considerations

- Direct Glare
  - Glare causes discomfort and can affect visibility. In an environment that constantly demands an individual to be aware of its surroundings, it is important that glare be avoided.
- Light Distribution on Surfaces
  - Abnormal patterns of light can cause shadows and affect visibility. It is essential for the lighting design to avoid abnormal patterns of light.
- Modeling of Face and Objects
  - The lighting design must reveal depth, shape and texture of objects in a weight room because it must assist an individual in interpreting what he/she is seeing and lifting.

IESNA 2000 Design Criteria (Health Care Facilities – Physical Therapy Gymnasiums)

- Horizontal Illuminance
  - E = 300 lx or 30 fc

ASHRAE Standards 90.1

- Lighting Power Density
  - Gymnasium/ Exercise Center (Exercise Area)
  - LPD = 0.9 W/ft^2

Luminaires

Type		Manufacturer	Product Name	Catalog Number	Description	Lamp	Voltage	Ballast	Watts	Location
W1		Gotham Lighting	AFLP	AFLP 1/32TRT 8AR LD MVOLT	8" low profile ceiling recessed down light with a galvanized steel housing and semi specular reflector.	CF32DT E IN 841 ECO	277	ICF 2S26 M1 BSQS	27	Weight
W2		Litecontrol	Acros M5	P-ID-59M 1 4 T5 PBCWM	4' direct/indirect pendant mounted luminaire with parabolic baffle with matte white finish.	FP54 841 HO ECO	277	ICN 4S5490 C2LS @277	53	Weight
W3		Focal Point	Cove light	FCVM 24 1T5 1C 277 E	Low profile luminaire with steel gauge housing and reflector fabricated of low iridescent aluminum.	FP28 841 PM ECO	277	ICN 2S54 N	29	Weight

Table 9. Fitness and Weight Room Luminaire Schedule

NOTE: See Appendix A for complete luminaire schedule and Appendix B for specification sheets

Light Loss Factors

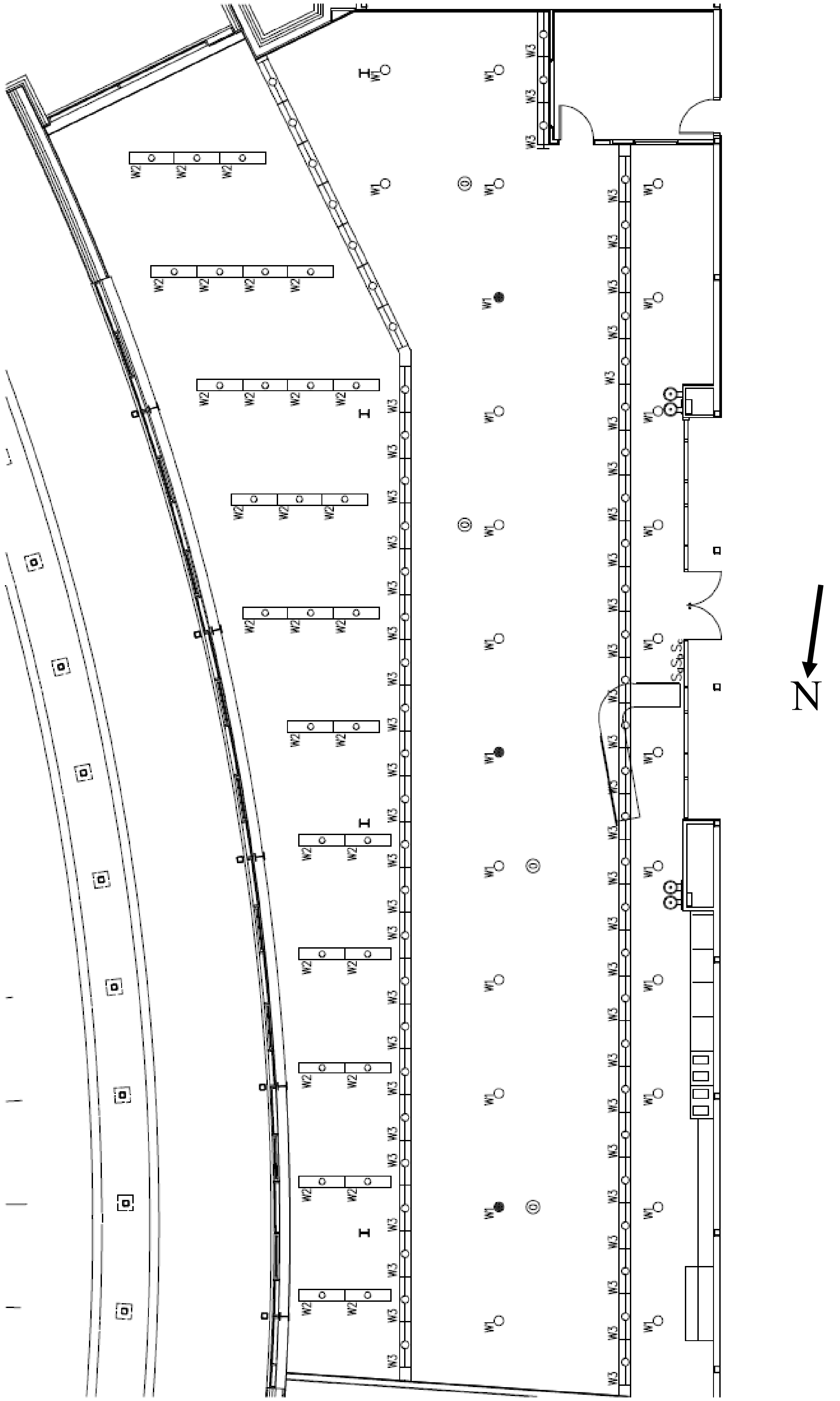
Light Loss Factors					
Luminaire Type	Lamp Lumen Depreciation	Lamp Dirt Depreciation	Room Surface Dirt Depreciation	Ballast Factor	Total Light Loss Factor
W1	0.83	0.92	0.98	0.98	0.73
W2	0.93	0.95	0.98	1.00	0.87
W3	0.95	0.95	0.98	1.05	0.93

Table 10. Fitness and Weight Room Light Loss Factors

Controls

The controls used in this space had two primary functions. First, the controls needed to be simple enough for any type of user to operate since the space will attract a wide variety of clientele. Secondly, the controls must adhere to ASHRAE 90.1 standards of automatic shut-off requirements for luminaires. Thus, vacancy sensors were used to override wall switches located at the entrance to the space. These sensors will use dual technology, infrared and ultrasonic technology to automatically shut-off the luminaires in a given amount of time without movement or heat detection. See Appendix A for complete control schedule.

Lighting Plan



Drawing 8. Fitness and Weight Room Lighting Floor Plan

Performance Data

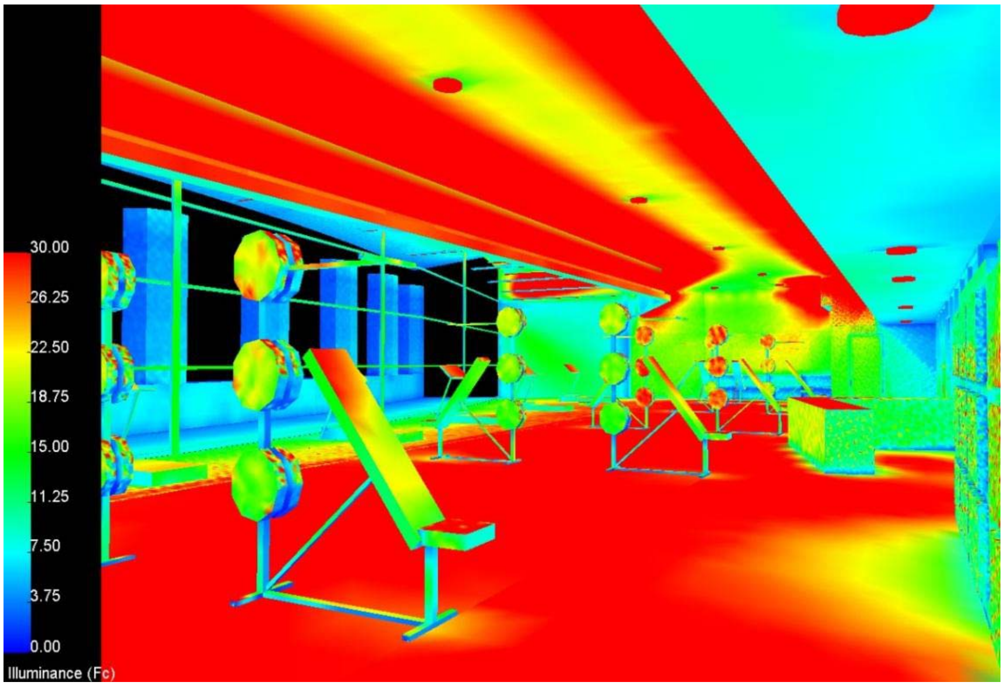


Image 7. Fitness and Weight Room Pseudo Diagram from locker area

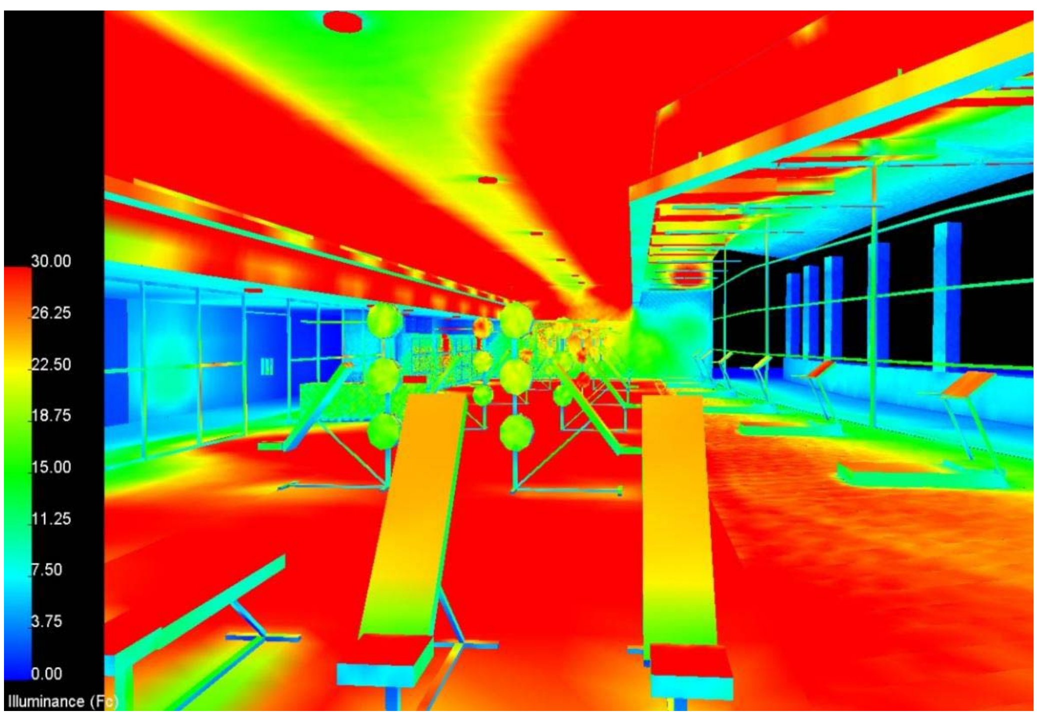


Image 8. Fitness and Weight Room Pseudo Diagram from weight area

Performance Summary

The design for the space was driven by the interesting arrangement of three different ceiling heights. Recessed down-lights were used in the gypsum board ceilings of the lower of the three ceilings. A cove light provided accent illumination on the ceiling of the second highest elevation, which covered most of the space. Down-lights were also used in this ceiling to provide additional illumination on the floor to achieve uniformity. An indirect/direct luminaire was used in the highest ceiling located near the glazed curvilinear wall. These luminaires were predominately using up-lighting with a small baffled slit in the underside of the housing to provide a small percentage of down light. These systems combined illuminated the floor to an average of 30 fc at the work plane height.

Criterion	IESNA Recommended	Designed
Average Illuminance	30 fc	29 fc
Max : Min Illuminance Ratio	-	2.2 : 1
Coefficient of Variance	-	0.16
LPD (5015 SF)	0.9 W/SF (4514 W)	0.83 W/SF (4142 W)

Table 11. Fitness and Weight Room Lighting Design Results

Renderings

Image 9. Fitness and Weight Room Rendering from locker area

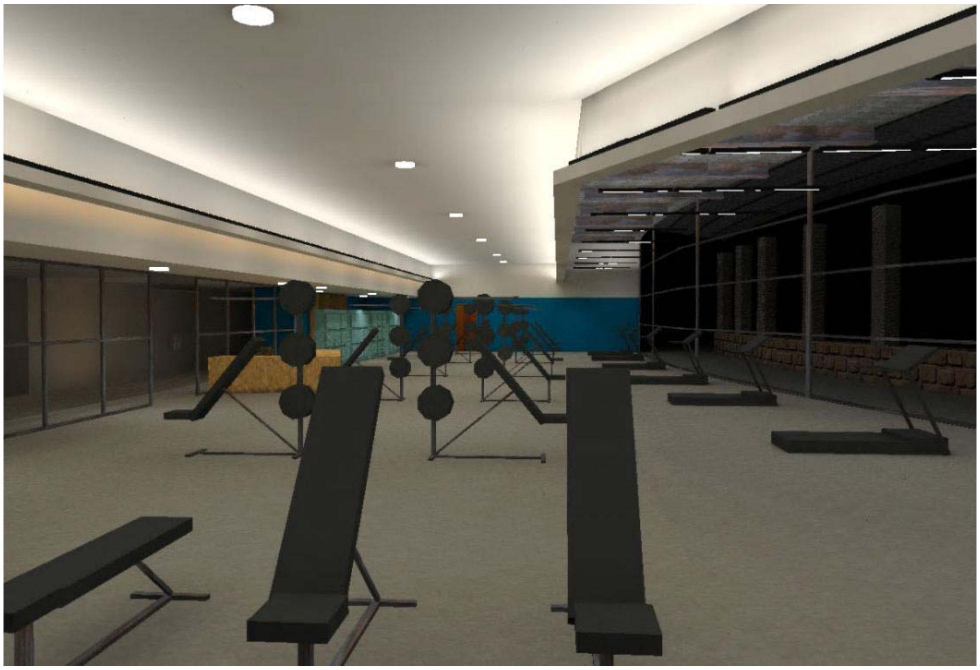


Image 10. Fitness and Weight Room Rendering from weight area

Circulation Space – Main Lobby

Space Description

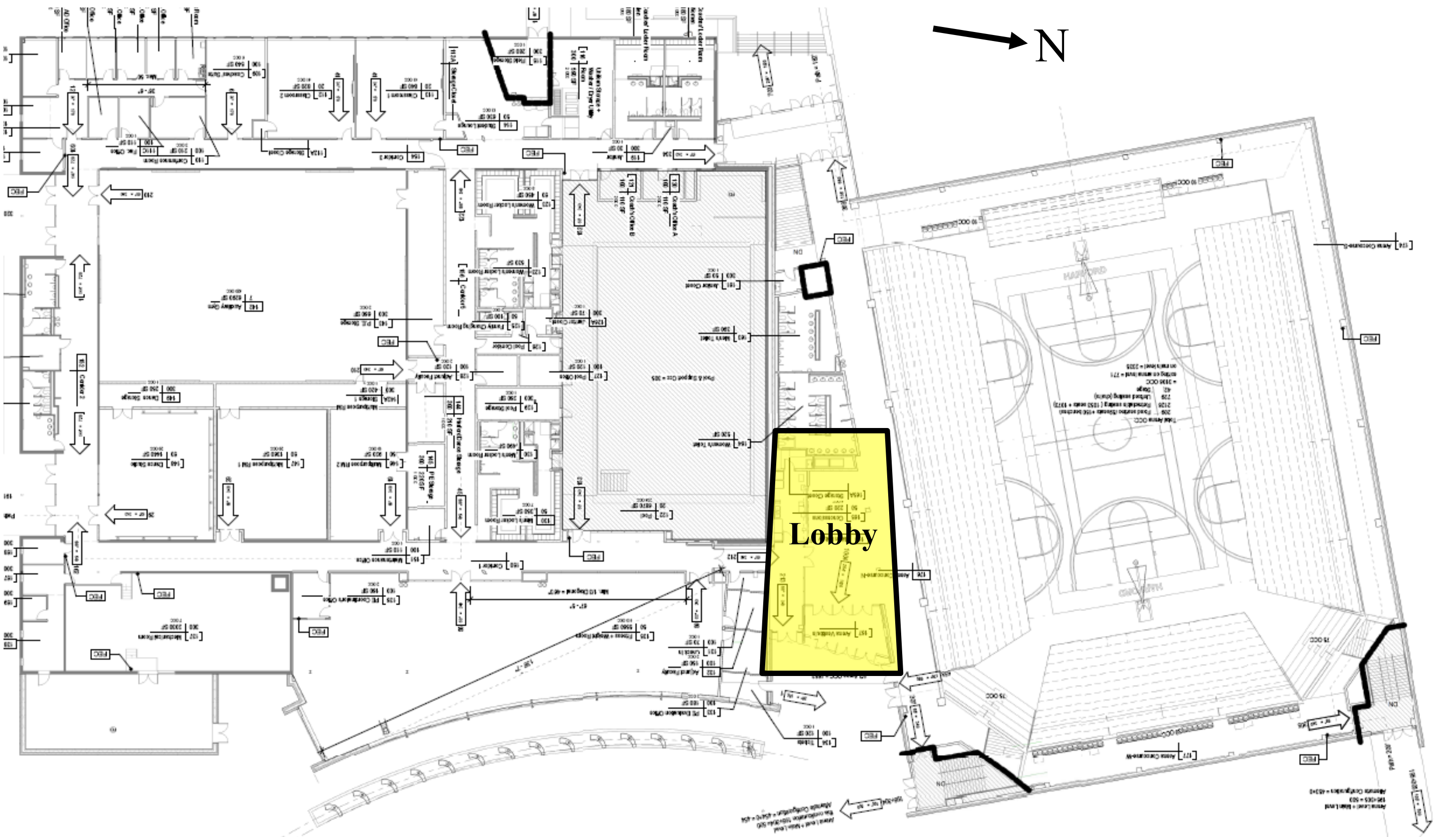
There is a small vestibule before you are greeted by the main lobby area. The main lobby is the primary circulation space for the facility as it grants access to multiple spaces within the building. It will be primarily used as the entrance and exit for the concourse of the main basketball arena. The lobby has an interesting architectural feature located in the ceiling. Although the ceiling finish is sealed concrete deck beams, there is a visual appealing wavy perforated aluminum element suspended from the ceiling. On one side of the lobby there is a display case which holds trophies plaques, and other awards.

Materials

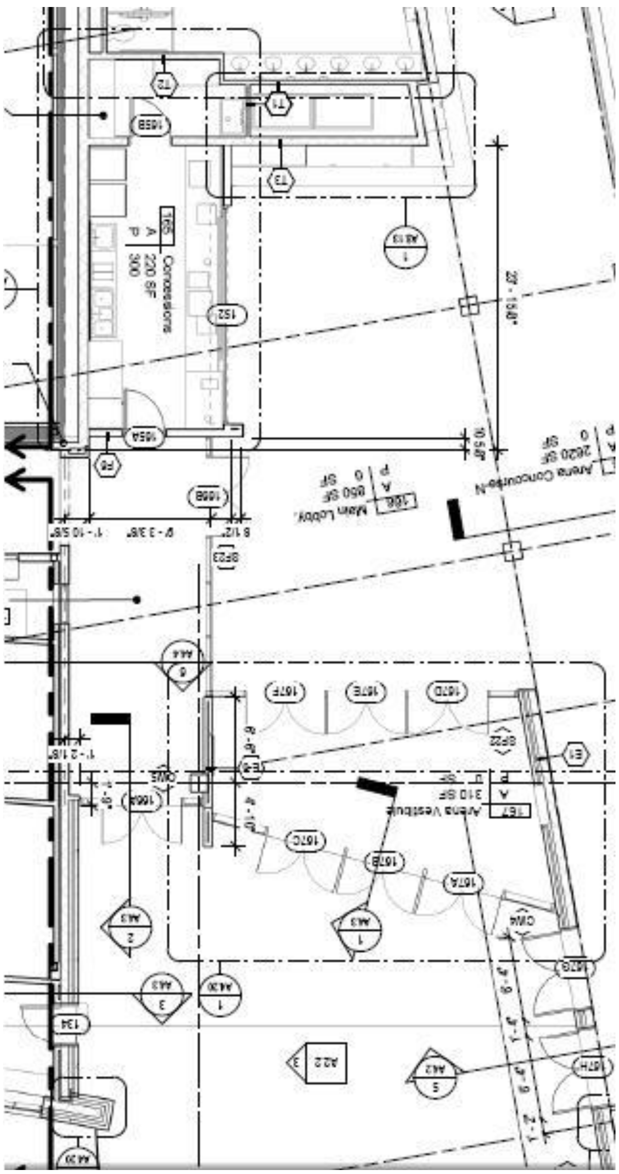
Material	Description	Properties
Vestibule Floor	carpeted Walk off mat, grey	ρ = 0.26
	carpeted Walk off mat, blue	ρ = 0.12
Vestibule Walls	gypsum Board with white finish paint	ρ = 0.9
Vestibule Ceiling	gypsum Board with white finish paint	ρ = 0.9
Storefront Doors	glazing of the storefront, clear glass	ρ = 0.05
	aluminum Paneling of storefront	ρ = 0.33
Main Lobby Floor	terrazzo tile flooring, off white	ρ = 0.7
Main Lobby Walls	gypsum Board with white finish paint	ρ = 0.9
Main Lobby Ceiling	exposed structure, painted white	ρ = 0.9
	wavy perforated aluminum Panels, painted blue	ρ = 0.14

Table 12. Main Lobby Materials

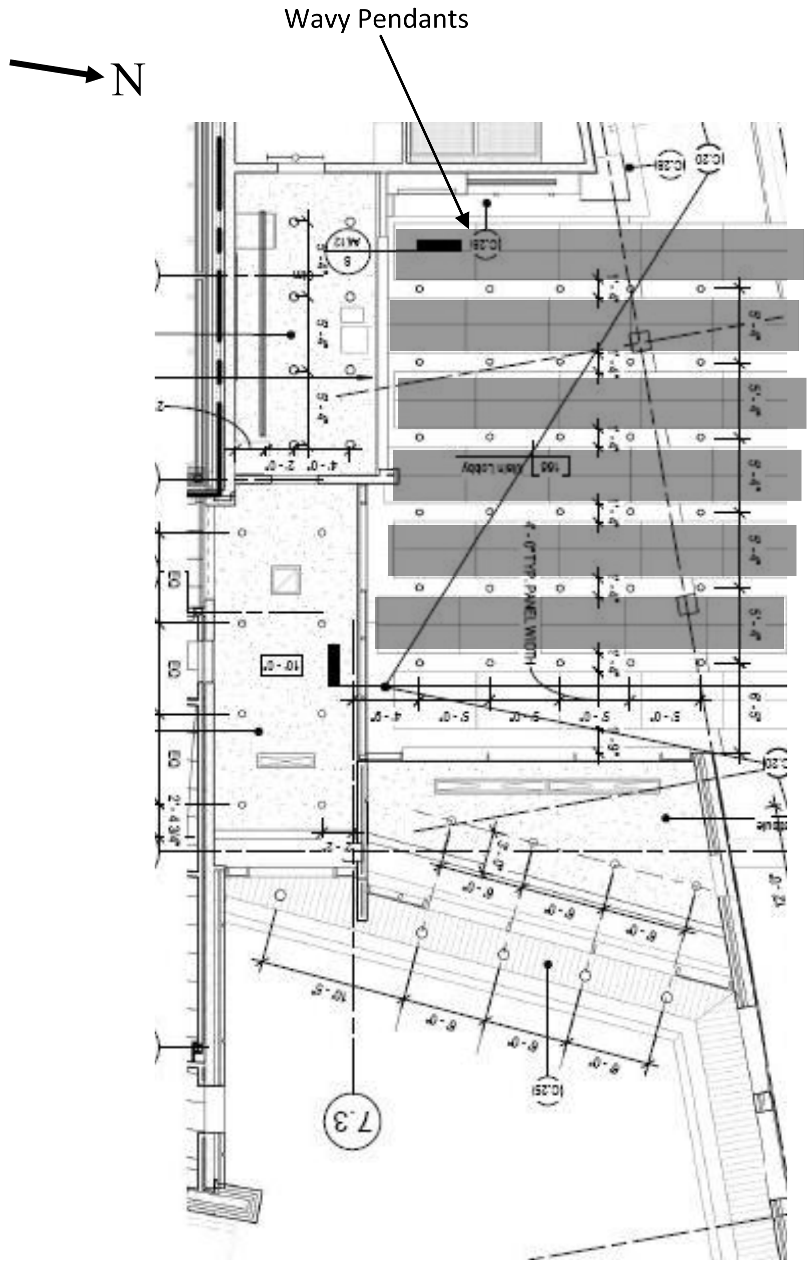
Drawings



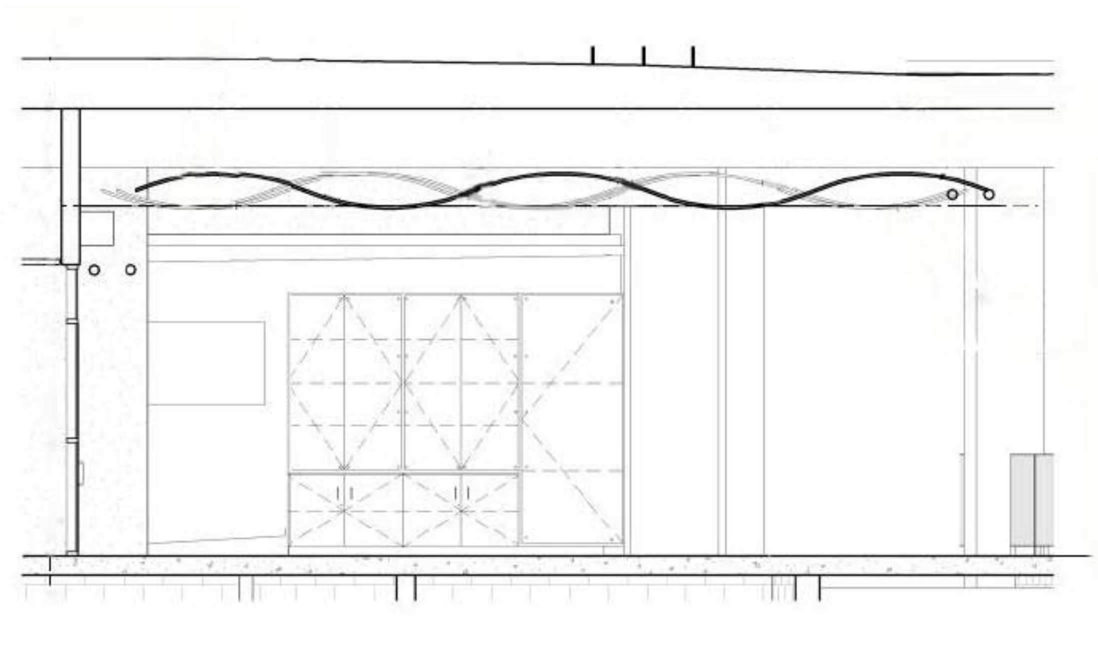
Drawing 9. Building Floor Plan labeling Main Lobby



Drawing 10. Main Lobby Floor Plan



Drawing 11. Main Lobby Floor Pendants



Drawing 11. Main Lobby Floor Section

Design Concept

The main lobby is the space that I have chosen to analyze for the psychological reinforcements created by the lighting design. The impression that the lighting design should invoke in this space is the somber/ festive system. In this case, I will mainly focus on the festive aspect of this impression system.

There are specific times when the lobby will need to come alive and create a festive atmosphere and those times include game days in the main arena. During a home game, it would be ideal to get all 5,000 home team fans in a joyous, peppy and upbeat state. A basketball event is meant to be fun and entertaining to watch with all the excitement on the court. A festive atmosphere in the lobby can prep the fans to be ready for an exhilarating experience.

Within the lobby are also certain architectural features such as a wavy pendant of two varying blue colors and honorary plaques of office members and board holders. The lighting design will need to incorporate them in the festive lighting scheme.

In order to create a gleeful, happy and upbeat environment, the lighting system will use bright light levels, non-uniform lighting mode, and movement of light. The honorary plaques will have a higher luminance than most surfaces in order to attract attention. The wavy pendants are made of perforated aluminum and using luminaires that illuminate the ceiling can create emphasis. Interesting light movement such as pulsating and slight movements can also reiterate the festive appeal.

Design Considerations and Criteria

IESNA 2000 *Design Considerations* (Lobby – General Lighting)

Very Important Design Considerations

- Appearance of Space and Luminaires
  - Since the lobby is typically the first place an individual is going to enter, then the appearance of the space needs to be impressionable and the luminaires should compliment that appearance.
- Color Appearance (and Contrast)
  - The lobby will have plaques of significant office members and board holders, thus the lighting for the plaque should demonstrate its significance. The lighting design should render the plaque in a way that embellishes the emphasis of those mentioned.

- Daylight Integration and Control
    - In a transitional space between the outdoors and indoors, the lighting design should incorporate daylight integration techniques, since it is believed that views of the outdoors provide important psychological comfort zones.
- Direct Glare
    - Glare is also a necessary design feature since it can cause discomfort and interfere with visibility as an individual enters the facility.
- Lighting Distribution on Surfaces
    - It is important to keep in mind the distribution of light hitting surfaces since awkward patterns of light can create shadows, affect task visibility, comfort and perceptions.
- Luminance of Room Surfaces
    - The lighting design in the lobby can utilize different luminances of surfaces to help attract attention to certain areas of room. For example, a higher luminance should be used to draw attention to the honorary plaques located on the wall.
- Modeling of Faces and Objects
    - The wavy pendants in the ceiling and honorary plaques are two architectural elements that will require appropriate modeling of their characteristics such as shape, texture and depth.
- Points of Interest
    - The lobby space includes wavy pendants and honorary plaques that will require the lighting design to emphasize the point of interest in this space.
- Reflected Glare
    - Glare causes issues of visibility and discomfort and should be avoided as individuals enter the building.

Important Design Considerations

- Light Distribution on Task Plane
  - Since the primary task in this space is walking, it is important to uniformly light the floor.
- Shadows
  - The lighting design should avoid creating shadows because shadows can alter visibility of tasks and place dark areas where brightness is essential.
- Sparkle/ Desirable Reflected Highlights
  - It is important that the lighting design use points of high luminance on a given spot to accentuate its elegance such as the honorary plaques.
- Surface Characteristics
  - The wavy pendant will need the lighting design's help to enhance its artistic creativity and splendor.

IESNA 2000 *Design Criteria* (Lobby – General Lighting)

- Horizontal Illuminance
  - E = 100 lx or 10 fc

ASHRAE Standards 90.1

- Lighting Power Density
  - Lobby
  - LPD = 1.1 W/ft^2

Luminaires

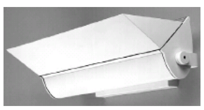
Type		Manufacturer	Product Name	Catalog Number	Description	Lamp	Voltage	Ballast	Watts	Location
W1		Gotham Lighting	AFLP	AFLP 1/32TRT 8AR LD MVOLT	8" low profile ceiling recessed down light with a galvanized steel housing and semi specular reflector.	CF32DT E IN 841 ECO	277	ICF 2S26 M1 BSQS	27	Lobby
L1		Gotham Lighting	8" PDPF	PDPF 32TRT 8AR LD CGL MVOLT	8" satin silver pendant supported by black cord. The housing is durable heavy gauge aluminum housing with specular reflector.	CF32DT E IN 841 ECO	277	ICF 2S26 M1 BSQS	27	Lobby
L2		Elliptipar	F114	F114-L140-F-02-2	Wall mounted wall washer with semi white gloss finish on the outside housing made of aluminum.	FT40DL 841 RS ECO	277	Integral Electronic Ballast	40	Lobby
L3		Philips Alkco	Slique T2	SK213-120-WHG	Sleek ¾" under cabinet fluorescent luminaire with miniature integral ballast. The housing is an extruded aluminum with a specular asymmetric reflector.	FM13 T2	120	Integral Miniature Ballast	13	Lobby

Table 13. Main Lobby Luminaire Schedule

NOTE: See Appendix A for complete luminaire schedule and Appendix B for specification sheets

Light Loss Factors

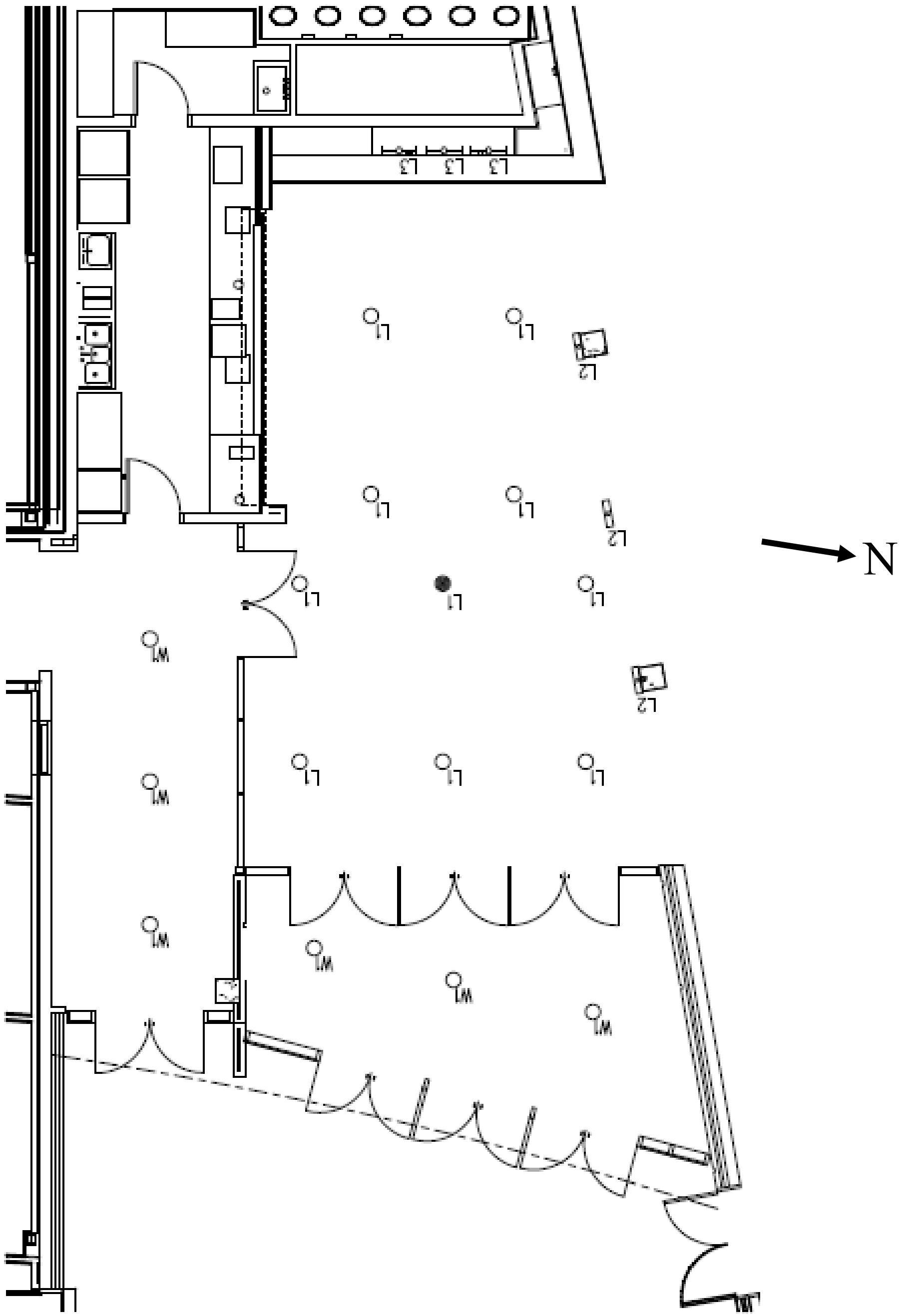
Light Loss Factors					
Luminaire Type	**Lamp Lumen Depreciation**	**Lamp Dirt Depreciation**	**Room Surface Dirt Depreciation**	**Ballast Factor**	**Total Light Loss Factor**
W1	0.83	0.92	0.97	0.98	0.73
L1	0.83	0.92	0.97	0.98	0.73
L2	0.9	0.92	0.97	1	0.80
L3	0.86	0.92	0.97	1	0.77

Table 14. Fitness and Weight Room Rendering from locker area

Controls:

The controls in this space will be controlled by a relay that is connected to an astronomical time clock located in the main electric room. Emergency lighting will use both the astronomical time clock and an emergency ballast relay, which will turn on the luminaire in the event of a power failure. See Appendix A for complete control schedule.

Lighting Plan



Drawing 9. Main Lobby Lighting Floor Plan

Performance Data

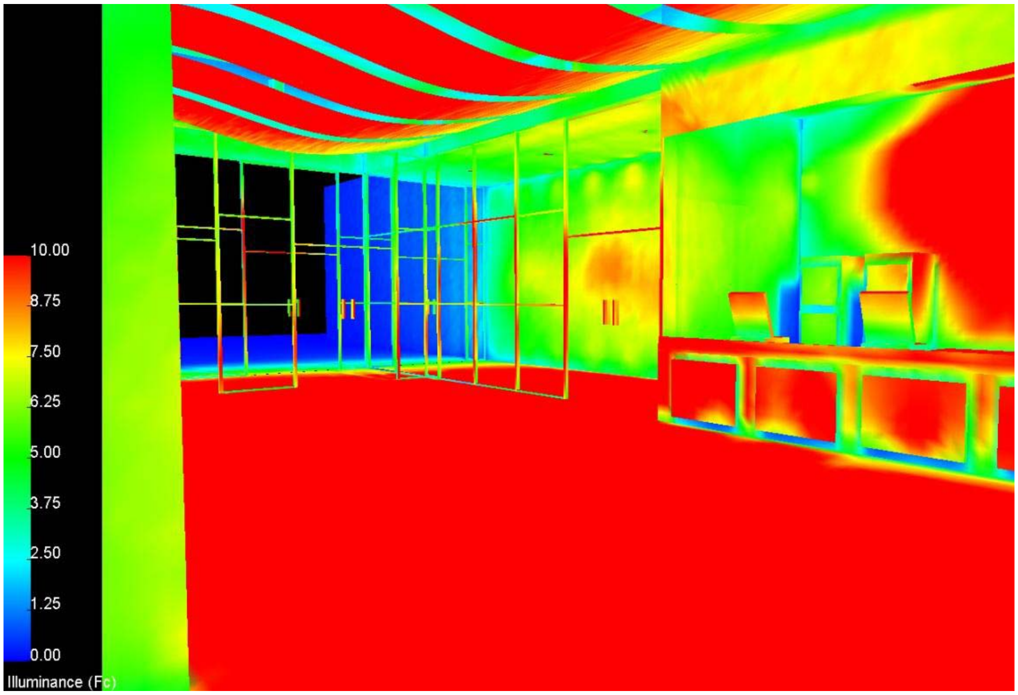


Image 11. Main Lobby Pseudo Diagram from concourse

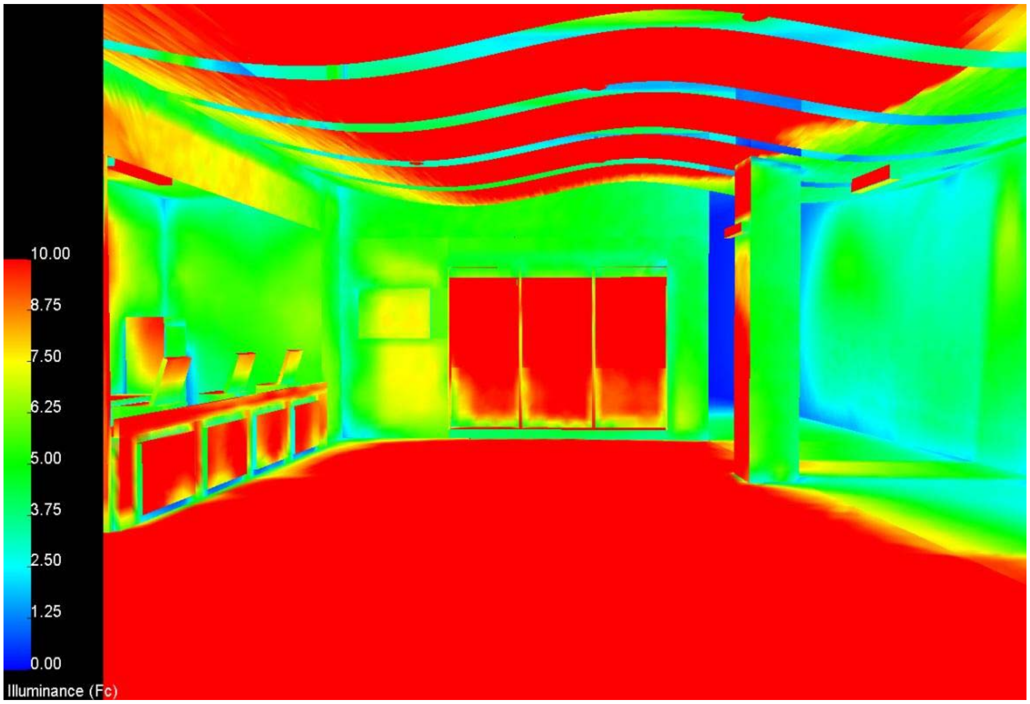


Image 12. Main Lobby Pseudo Diagram from entry

Performance Summary

The direct down-light pendant located at 12’-0” above finished floor are integrated between the spaces of the wavy architectural objects in the ceiling. These luminaires provide general illumination in the center of the space. For the same reasons, a recessed luminaire was used in the gypsum board ceiling in the adjacent vestibule. In order to create the impression of festiveness and excitement, further emphasis was placed on the architectural feature in the ceiling. Wall washers were mounted onto the columns to provide direct illumination on the wavy pendants to draw the occupant’s eyes to an interesting and pleasing apparatus. Highlighting this feature also provides higher illuminances at the ceiling and thus creating a non-uniform lighting mode. A slim sleek look fluorescent luminaire was used to accentuate the display case which will house trophies and honorary plaques.

Criterion	IESNA Recommended	Designed
Average Illuminance	10 fc	12 fc
Max : Min Illuminance Ratio	-	-
Coefficient of Variance	-	-
LPD (1490 SF)	1.1 W/SF (1640 W)	0.6 W/SF (790 W)

Table 15. Main Lobby Lighting Design Results

Renderings

Image 13. Main Lobby Rendering from concourse

Image 14. Main Lobby Rendering from entry

Exterior Space – Main Entry Façade

Space Description:

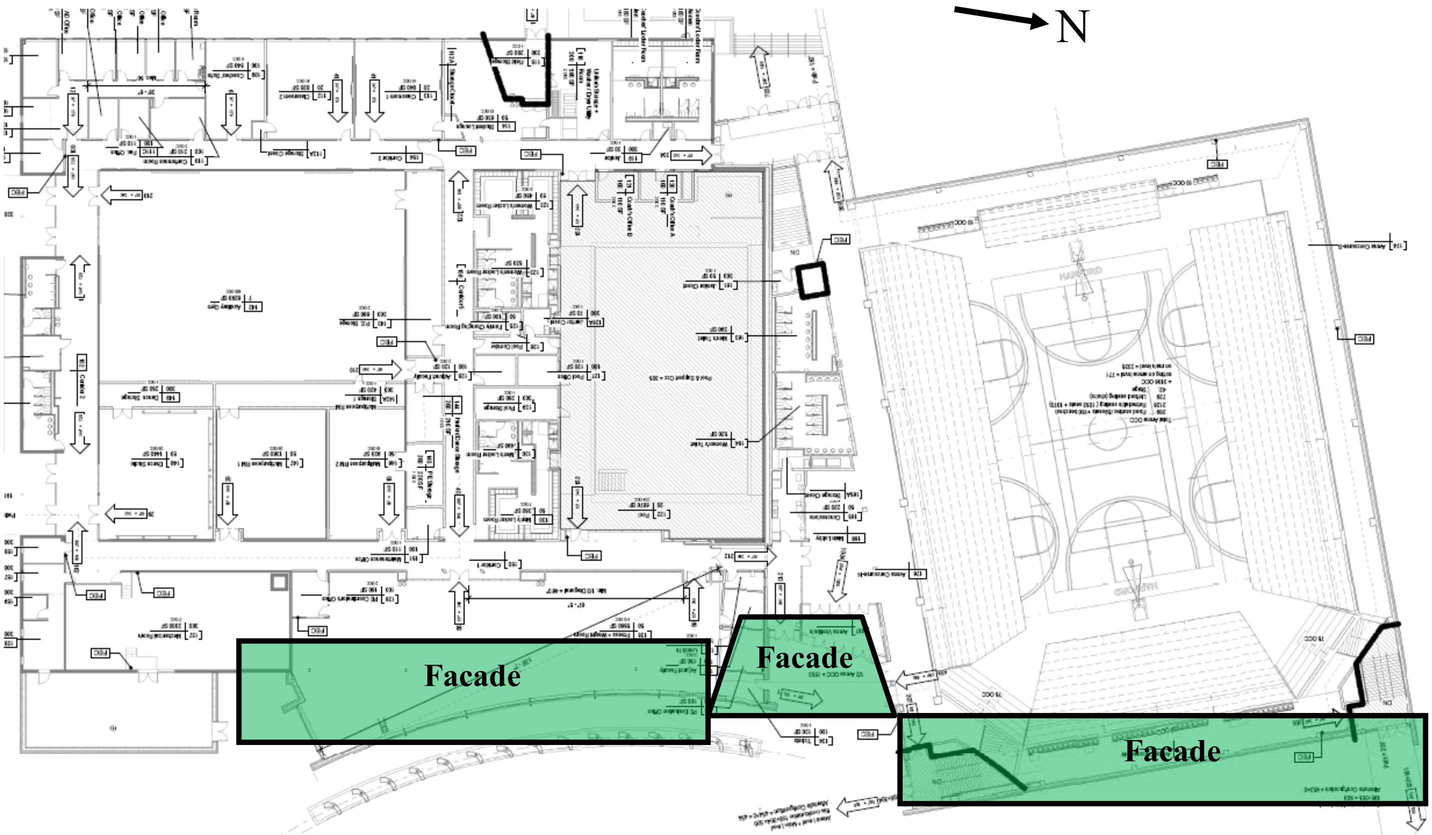
The façade of this facility is important due to the building's nature to house an athletic sporting team at the collegiate level. The facade is the first attraction of the building for fans, visitors, and players. It is important to set an admirable impression since this facility is new and could potentially be the highlight of sporting facilities in the area. The façade is composed of 4x8 and 16x24 nominal concrete block, aluminum glazing curtain wall, metal sheathing with black plastic lettering for the building sign, and concrete sidewalks.

Materials:

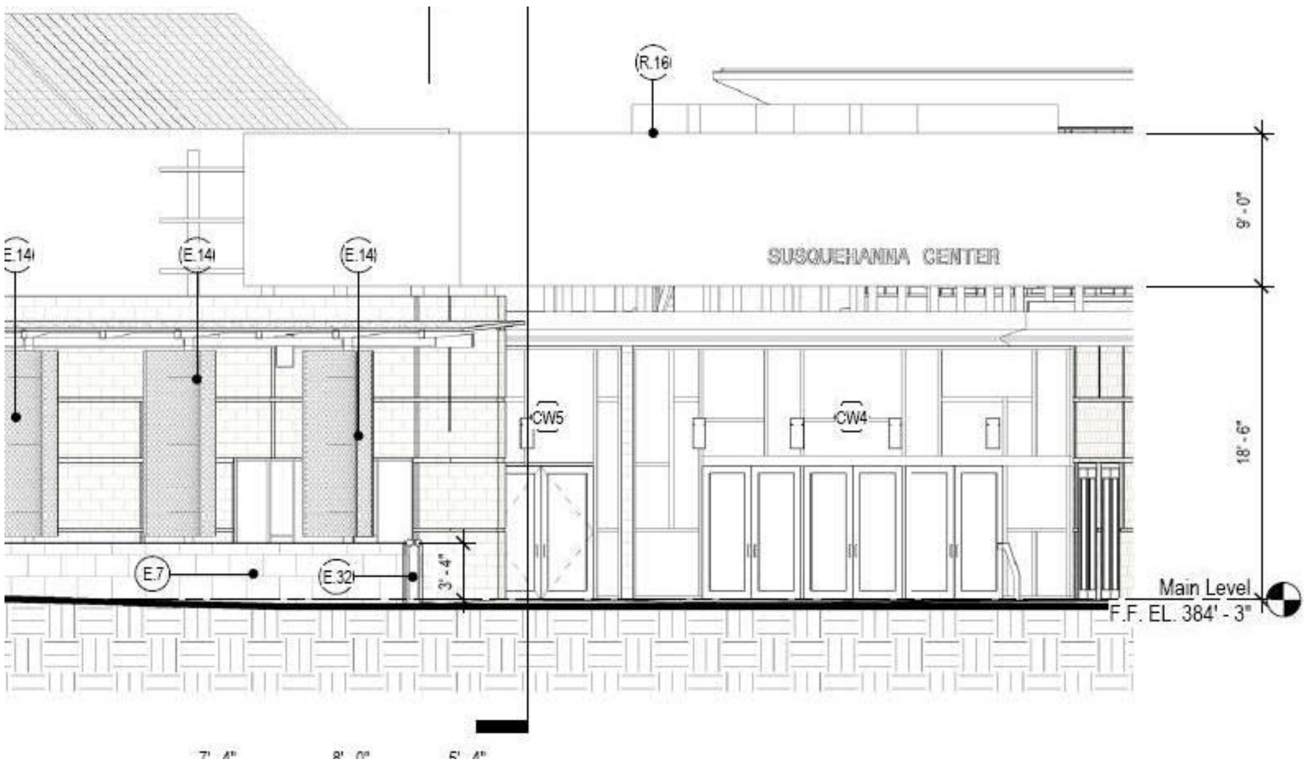
Material	Description	Properties
Sidewalk	cast in place concrete	ρ = 0.28
Facade	Brick and stone composite	ρ = 0.3
	Perforated aluminum Panels	ρ = 0.3
Curtain Wall System	glazing 1 of the curtain wall system	ρ = 0.74
	glazing 2 of the curtain wall system	ρ = 0.38
	Mullions of the curtain wall system	ρ = 0.33
Roofing	Composite aluminum Paneling	ρ = 0.33
Signage	Black plastic lettering	ρ = 0.02

Table 16. Façade Materials

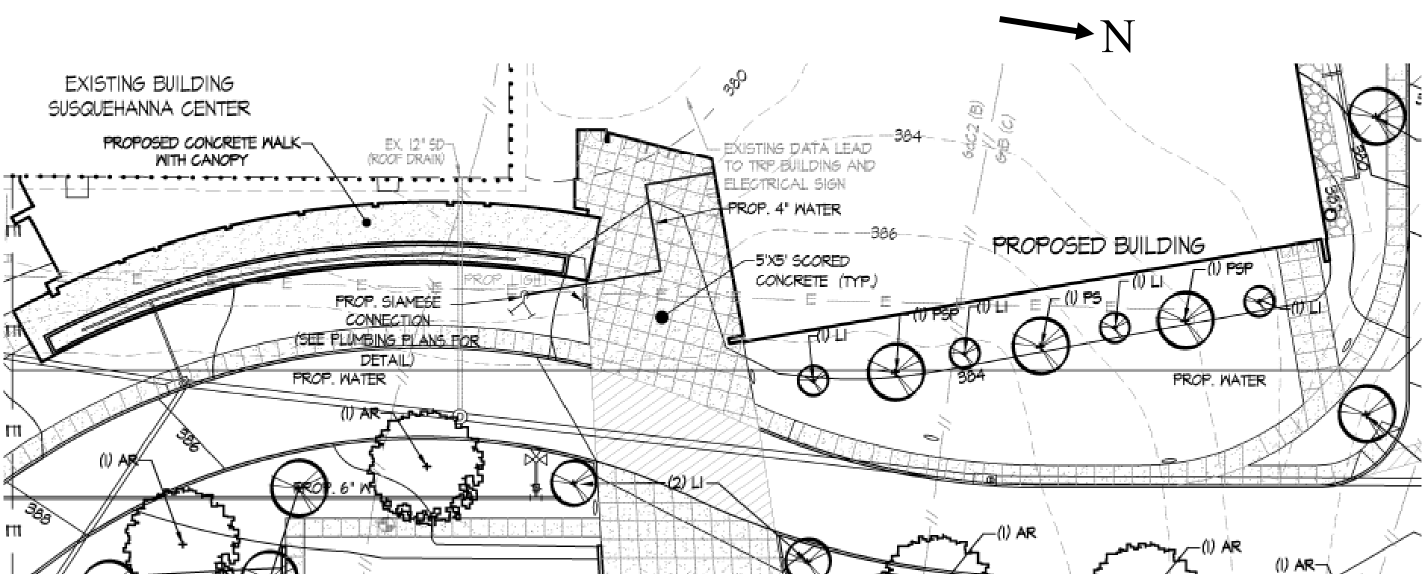
Drawings



Drawing 10. Building Floor Plan labeling Façade



Drawing 11. Façade Elevation



Drawing 12. Façade Planting Plan

Design Concept

Originally the design was to highlight the ornate nature of the roof overtop the main arena, but due to the upward light ratio, this concept proved to be inadequate. This change prompted the concept of highlighting the landscape in front of the main arena, with a LED luminaire aiming up vertically amongst the trees to cast shadows onto the façade. In the main entry sidewalk, a full cut version of the campus pole mounted luminaire will be used to illuminate the ground plane. Further emphasis of illumination was used at the entry with surface recessed circular luminaires. A wall washing luminaire will be used to illuminate the sign of the Center, which will create a higher light level at this particular location essentially guiding people to the light.

Design Considerations and Criteria

IESNA 2000 Design Considerations (Building Exteriors Entrances-Active)

Very Important Design Considerations

- Appearance and Shape of Luminaires
    - The lighting design of the façade should be appeasing and help accentuate the architectural features that define the building. The luminaires need to conform to architecture instead of protrude and take away from it.
- Color Appearance (and Color Contrast)
    - The color rendering of building materials is an essential piece of the architecture and impression that the building is trying to attain.
- Direct Glare
    - When lighting exterior facades it is key to incorporate glare because shining light into the eyes and faces of guests is not a pleasant feeling and is uncomfortable.
- Light Pollution and Trespass
    - Light pollution into the sky is an unwanted and unnecessary design practice and should be avoided to help reduce urban sky glow. Light trespass onto adjacent sites is also an unpleasant design feature and should be avoided as well.
- Modeling of Faces and Objects
    - Creating the depth, shape, and texture of objects is imperative when highlighting and emphasizing the architectural elements and features.

- Peripheral Detection
  - When an individual is gazing at the façade it is important that the lighting design help individuals interpret and inspect the textures and shapes of the architectural elements.
- Points of Interest
  - Ideally when highlighting the architecture and entrances, it is important for your design to focus on the points of interest such as certain architectural features.
- Reflected Glare
  - Reflected glare is just as important as direct glare, in which the unpleasantness of being blinded by light is not comfortable for an individual.
- Shadows
  - Shadows can help create the depth of 3D textures and materials of building.
- Source/ Task/ Eye Geometry
  - The geometry between the viewer's eyes and luminaire can be essential for creating contrast of architectural elements.
- Surface Characteristics
  - Surfaces can have different textures, specularity, and reflectance values, which can alter perceived brightness of illuminated surfaces, especially building facades.

Important Design Considerations

- Light Distributions on Surfaces
  - The spacing of luminaires can create shadows when not spaced correctly and hide certain elements of the architecture. Strange and confusing spacing of luminaires can also create brighter areas on walls.
- Sparkle/ Desired Reflected Highlights
  - Small points of high luminance can create visual interests.

IESNA 2000 Design Criteria (Building Exteriors Entrances-Active)

- Horizontal Illuminance on Sidewalk/ Entrance
    - E = 50 lx or 5 fc

ILE 2005 Guidance Notes For the Reduction of Obtrusive Light

- Category E2 – Low district brightness areas, rural, relatively dark urban locations
    - URL = 2.5%

ASHRAE Standards 90.1

- Lighting Power Density
    - Canopies – 1.25 W/SF
    - Wall/ Surfaces – 5W/lF or 0.2W/SF

Luminaires

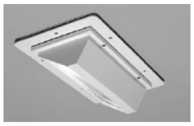
Type		Manufacturer	Product Name	Catalog Number	Description	Lamp	Voltage	Ballast	Watts	Location
S1		Elliptipar	251	M 251 70G T 07 1 00	Recessed metal halide wall wash for concrete/ outdoor applications with silicon seals and a silver corrosion resistant housing/ finish.	MC70T6/ U/ G12 /830	277	71A5237BP	85	Exterior
S2		Erco	Visor III Floor Wash Light	330304	Circular recessed floor wash light with silicon seals and corrosion resistant aluminum housing with silver finish.	MC39T6/ U/ G12 /830	277	71A50.37BP	48	Exterior
S3		Philips Gardco	Canopy	220 P 42TRF 277 NP	Circular down light with silicon seals and die cast aluminum housing and natural aluminum finish.	F42TBX/ 830/ A/ ECO	277	ICF 2S26 H1 LD@ 277	46	Exterior
S4		Erco	Beamer	34070	Hinged surface mounted direct luminaire with corrosion resistant cast aluminum and silicon seals.	MC20TC/ U/ G8.5 /830	277	71A50.37BP	25	Exterior
S5		Se'lux	Saturn 2 Cutoff	SAC2 R5 1 H070T6 830 SV 277 DS	Pole mounted die cast aluminum housing with full cutoff option and weatherproof gaskets. Match existing campus pole luminaire except with full cutoff option.	MC70T6/ U/ G12 /830	277	71A5237BP	85	Exterior
S6		Erco	Bollard	33348	Circular bollard with corrosion resistant cast aluminum and silicon seals. Reflector located at top of bollard.	MC39T6/ U/ G12 /830	277	71A50.37BP	48	Exterior
S7		Erco	Grass hopper	34035	Square LED ground mounted focal point luminaire with die cast aluminum corrosion resistant housing and silicon seals.	LED	277	N/A	14	Exterior

Table 17. Façade Luminaire Schedule

NOTE: See Appendix A for complete luminaire schedule and Appendix B for specification sheets

Light Loss Factors

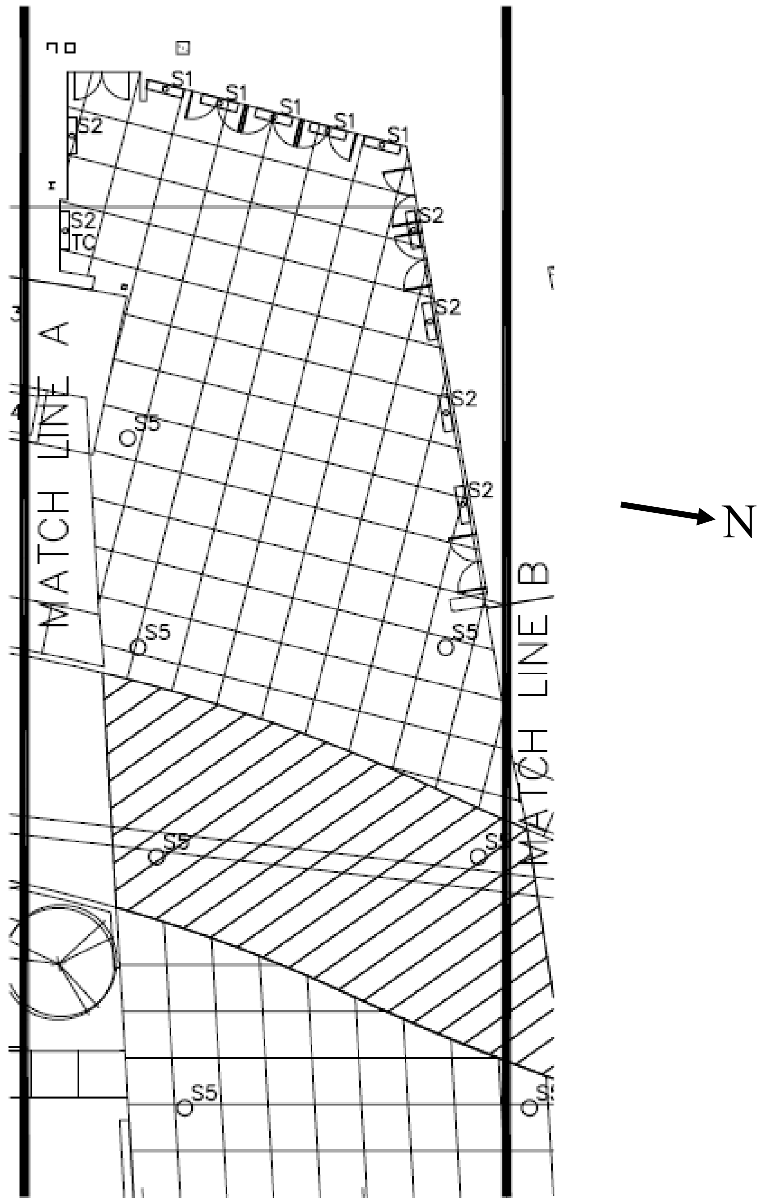
Light Loss Factors				
Luminaire Type	**Lamp Lumen Depreciation**	**Lamp Dirt Depreciation**	**Ballast Factor**	**Total Light Loss Factor**
S1	0.8	0.75	1.0	0.6
S2	0.86	0.75	1.02	0.66
S3	0.85	0.75	0.98	0.62
S4	0.85	0.75	0.98	0.62
S5	0.8	0.75	1.0	0.6
S6	0.86	0.75	1.02	0.6
S7	0.75	0.75	-	0.56

Table 18. Façade Light Loss Factors

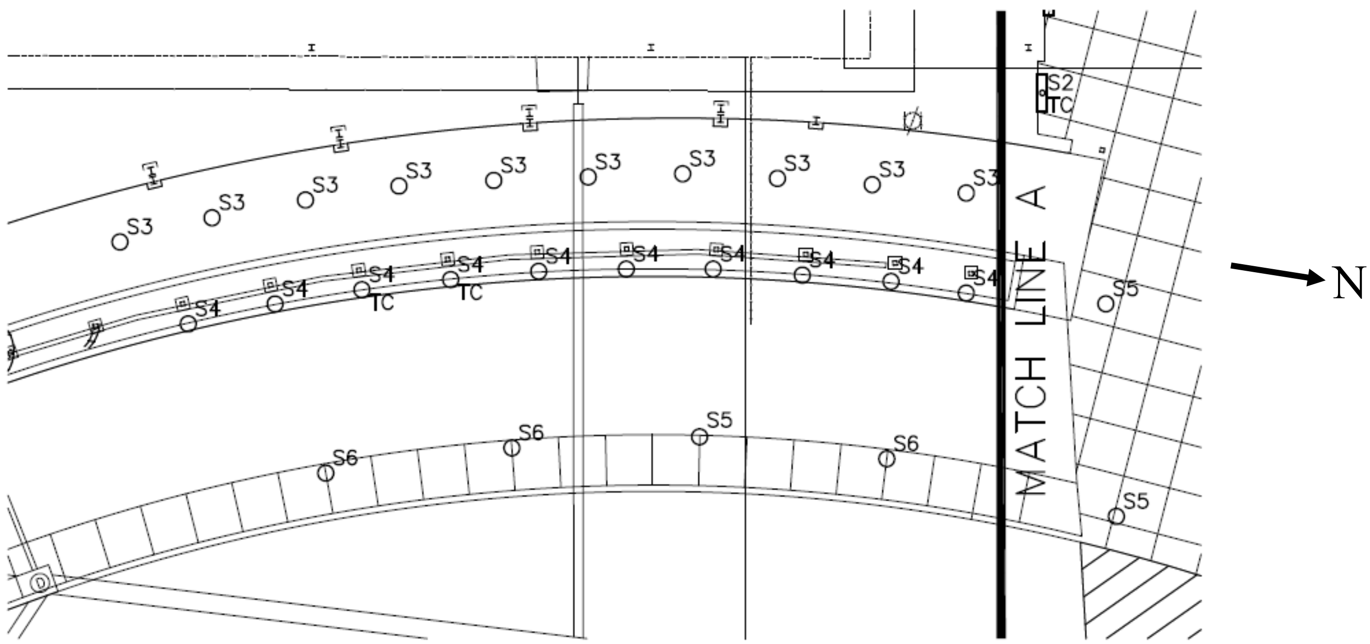
Controls

The controls in this space are typical of exterior lighting controls. Relays will connect to an astronomical time clock that will control the luminaires and allow them to turn on at the night time. See Appendix A for complete control schedule.

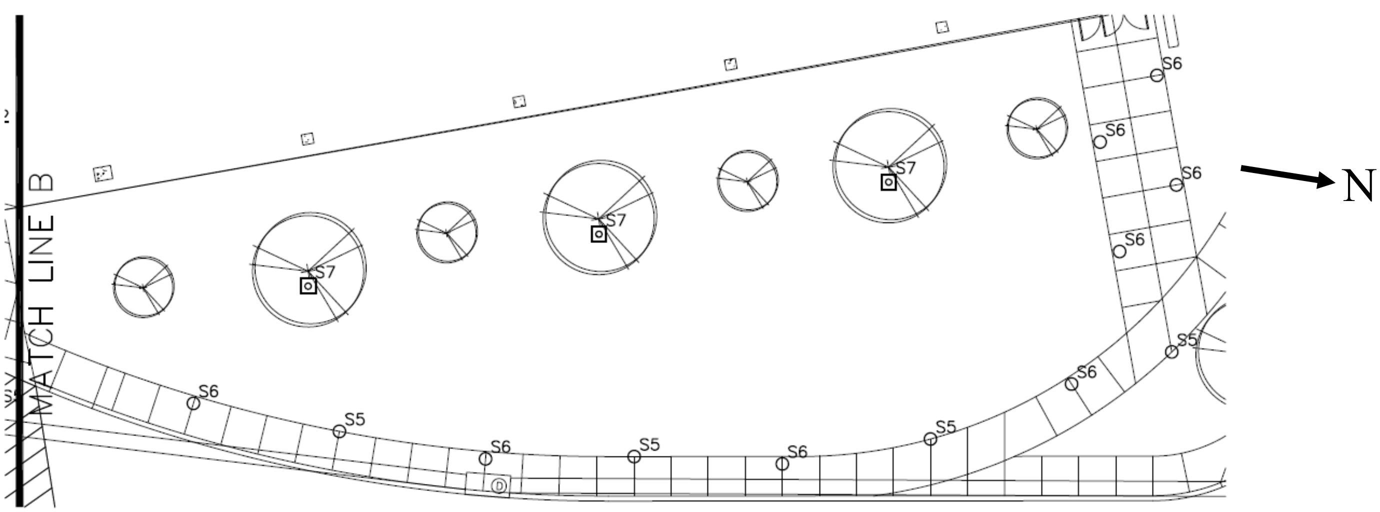
Lighting Plan



Drawing 12. Façade Lighting Plan



Drawing 13. Façade Lighting Plan



Drawing 14. Façade Lighting Plan

Performance Data

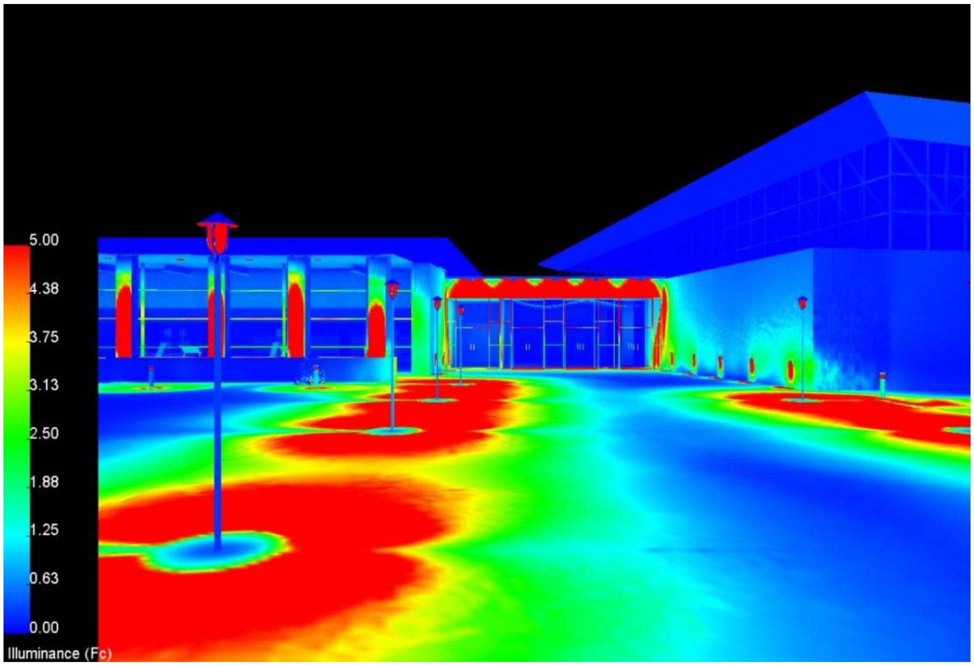


Image 15. Façade Pseudo Diagram from entry sidewalk

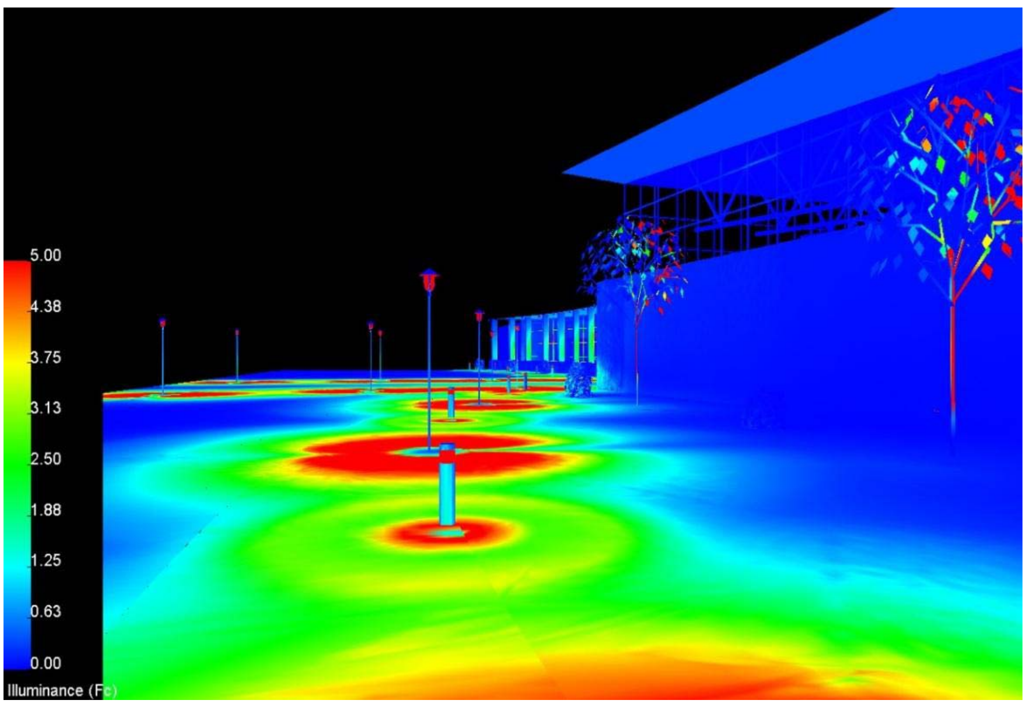


Image 16. Façade Pseudo Diagram from sidewalk on right

Performance Summary

The exterior lighting design's ultimate goal was to illuminate the pathways and put emphasis on the main entry to guide visitors and guests to the proper entrance. Harford Community College already has a standard for pole top sidewalk illumination luminaires and this luminaire was incorporated into the design with the exception that the luminaire is full-cutoff, so that it could meet dark sky requirements. Bollards that had complimented the architectural style of the pole mounted luminaire were used for smaller sidewalks to provide uniform illumination. The main entrance was emphasized with a wall washer above the door, which highlighted the Susquehanna Center sign. Further emphasis was placed on the entrance with the use of small wall recessed floor wash-lights, act as a guide for traffic. Lastly to create an aesthetic appeal to the façade direct focal point luminaires were used to illuminate the perforated shades on top of a stone wall.

Criterion	IESNA Recommended	Designed
Average Illuminance	5 fc	4.8 fc
Max : Min Illuminance Ratio	-	-
Coefficient of Variance	-	-
LPD Wall/ Surfaces (8400 SF)	0.2 W/SF (1680W)	0.23 W/SF (1950 W)
LPD Canopies (1400 SF)	1.25 W/SF (1750 W)	0.6 W/SF (775)
Total LPD (W Allowable)	3430 W	2725 W
ILE Upward Light Ratio	Category E – 0.02	0.018

Table 19. Façade Lighting Plan Results

Renderings

Image 17. Façade Rendering from entry sidewalk

Image 18. Façade Rendering from sidewalk on right

Electrical Depth – Branch Circuit Redesign

Space Descriptions:

The electrical redesigns of four spaces are the same four spaces, in which a lighting redesign was done. Those four spaces are the Auxiliary Gymnasium, Fitness and Weight Room, Main Lobby, and Main Entry Façade. The lobby is the primary circulation space that has hallways that branch off of it that will lead you to the adjacent Fitness and Weight room. The weight room is a typical fitness facility with all types of workout equipment available to students and athletes on the Harford Community College's campus. One of those branching hallways also leads to the Auxiliary Gymnasium, which is your standard full size basketball court with two smaller perpendicular courts.

The lighting redesign consisted mostly of replacing fluorescent troffers with fluorescent down-lights, wall washers, and other accent lighting hardware. All lighting in the Susquehanna Center is operated using 277 volts.

Panel Boards Affected

Panel Tag	Voltage	System	Exterior Façade	Main Lobby	Fitness and Weight Room	Auxiliary Gym
LPA	480Y/277V, 3P, 4W	N			**X**	**X**
LPB	480Y/277V, 3P, 4W	N		**X**		
SITE	480Y/277V, 3P, 4W	N	**X**			

Table 20. Panelboards Affected by Lighting Redesign

NOTE: The individual circuits that have been affected are highlighted in the following Panels with their respected colors.

Control Information and Space Layout

Auxiliary Gymnasium

The controls in the space will be primarily used to accommodate the daylight harvesting system that utilizes multiple Lutron products. The primary piece of equipment will be the photocell located in the center of the space that will relay information to the automated day-lighting control via a Lutron Grafik Eye. This Grafik Eye specializes in the utilization of daylight harvesting and will control the light output of the high bay fluorescent luminaires that provide general illumination. All luminaires in this space will be supplied with 277V and controlled by another Grafik Eye, which will be located in the main electric room. Emergency luminaires will have an emergency ballast controlled by both the Grafik Eye and Emergency Relay to switch the luminaire from normal power to emergency power. A new dimming Panel DP was introduced for this space, so that the luminaires could be dimmed. The panel is feed by Panel LPA and located in the Electric. See drawings for exact location.

Fitness and Weight Room

In this space the control system is simplistic in nature. The control system is comprised of a combination of vacancy sensors with wall switches. Wall switches will be the primary controller of the lights, but the vacancy sensor will provide the automatic shut-off requirements for ASHRAE 90.1. Emergency luminaires will have an emergency ballast controlled by both the wall switch and an emergency relay that will switch the luminaire from normal power to emergency power.

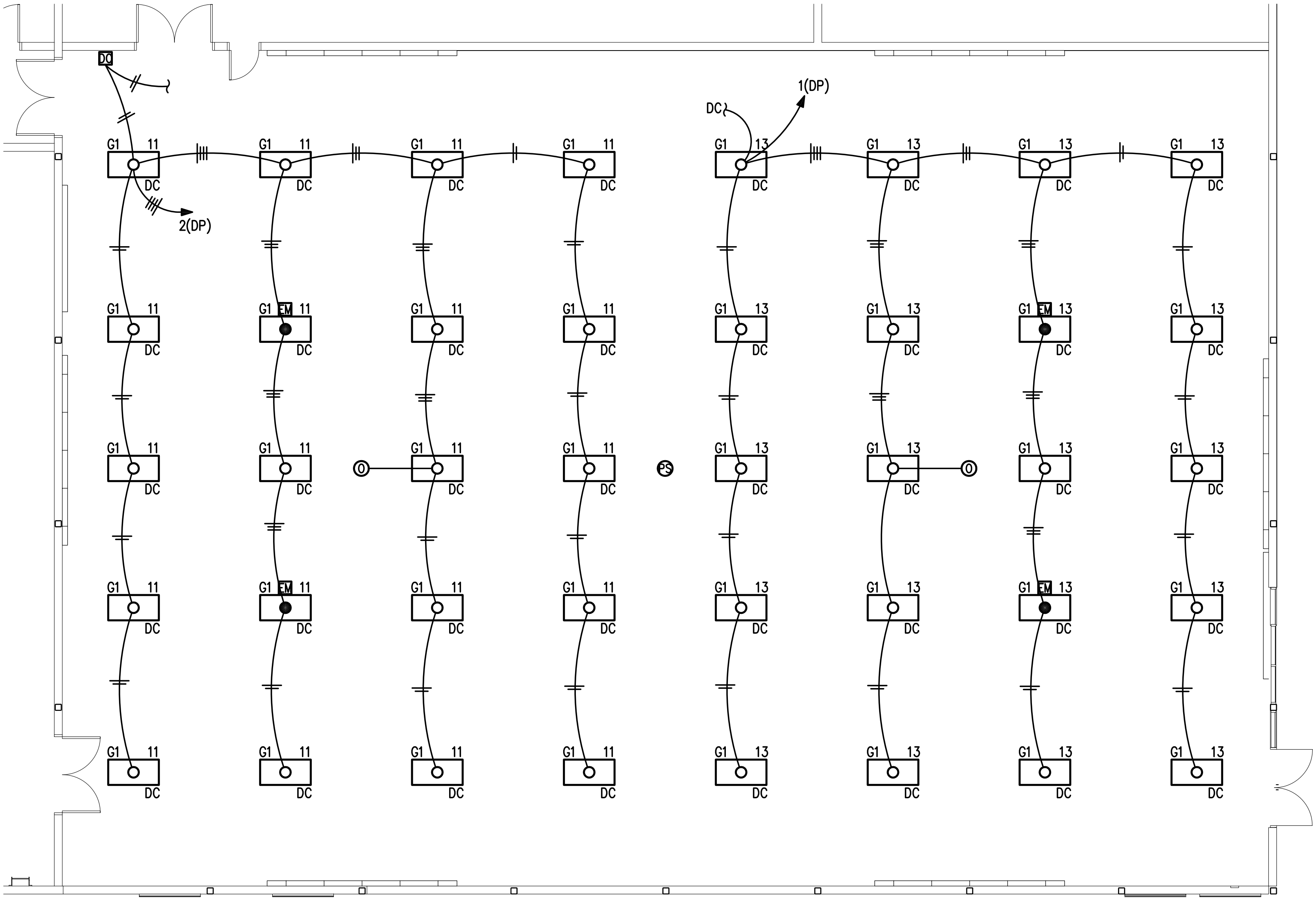
Main Lobby

Since this space is a circulation space the lighting will be controlled by an astronomical time clock. Emergency luminaires will have an emergency ballast controlled by both the astronomical time clock and an emergency relay that will switch the luminaire from normal power to emergency power.

Main Entry Façade

This space will be controlled via an astronomical time clock because it is located outside.

NOTE: See the following drawings in order above for Electrical Plans.



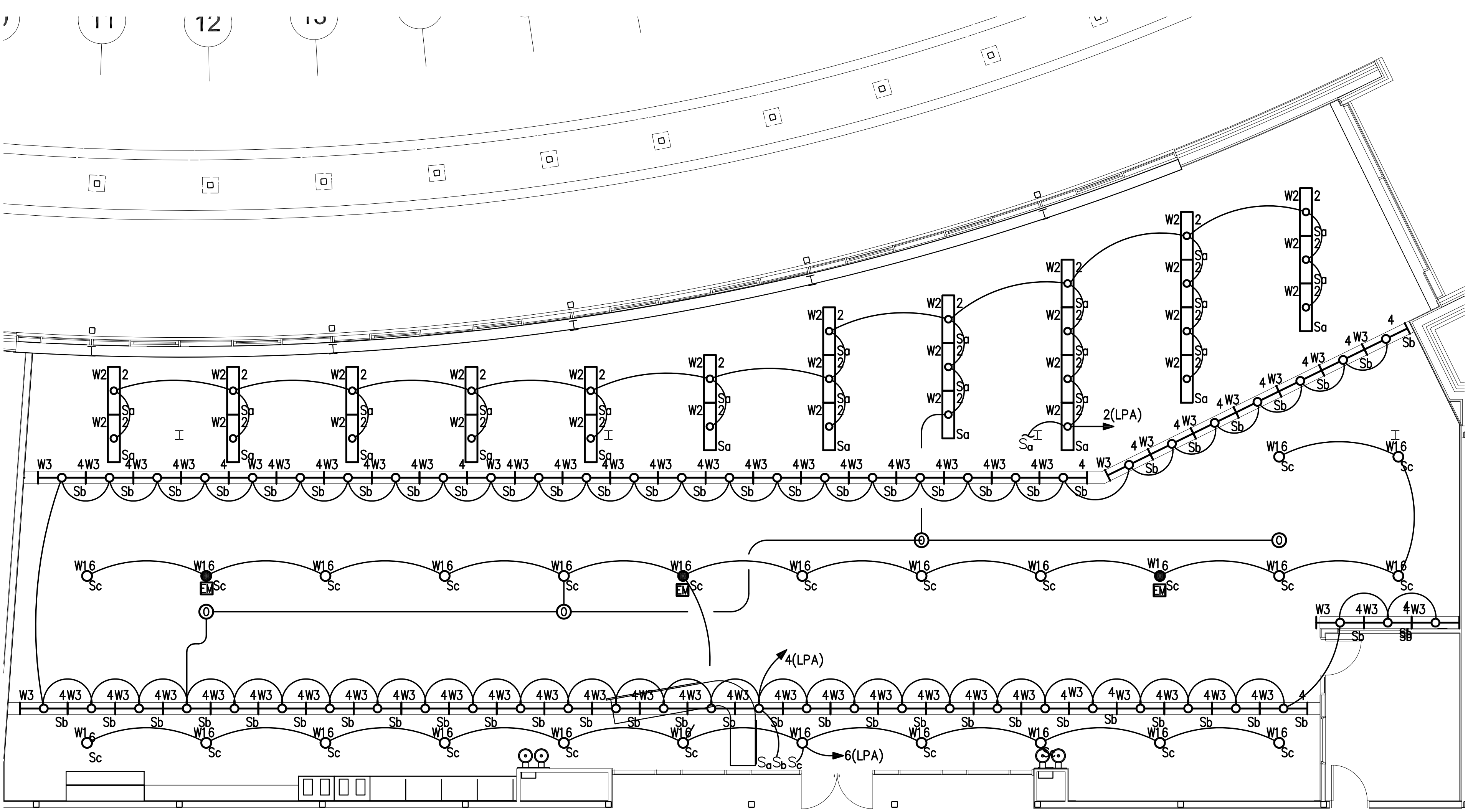
PROJECT NAME:
SUSQUEHANNA CENTER RENOVATIONS AND EXPANSION

NAME:
BRAD GAUGH

DWG NAME:
AUXILIARY GYMNASIUM LIGHTING PLAN

SCALE: 1/8" = 1'0"

E–



PROJECT NAME:
SUSQUEHANNA CENTER RENOVATIONS AND EXPANSION

NAME:
BRAD GAUGH

DWG NAME:
WEIGHT AND FITNESS LIGHTING PLAN

SCALE: 1/8" = 1'0"

E-

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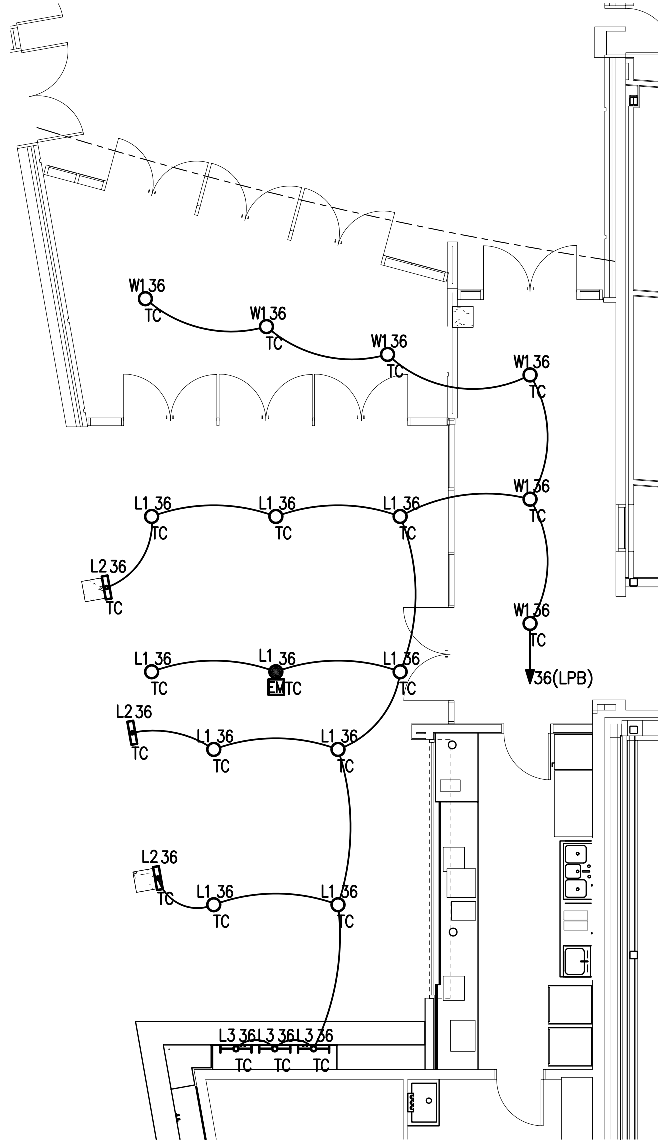


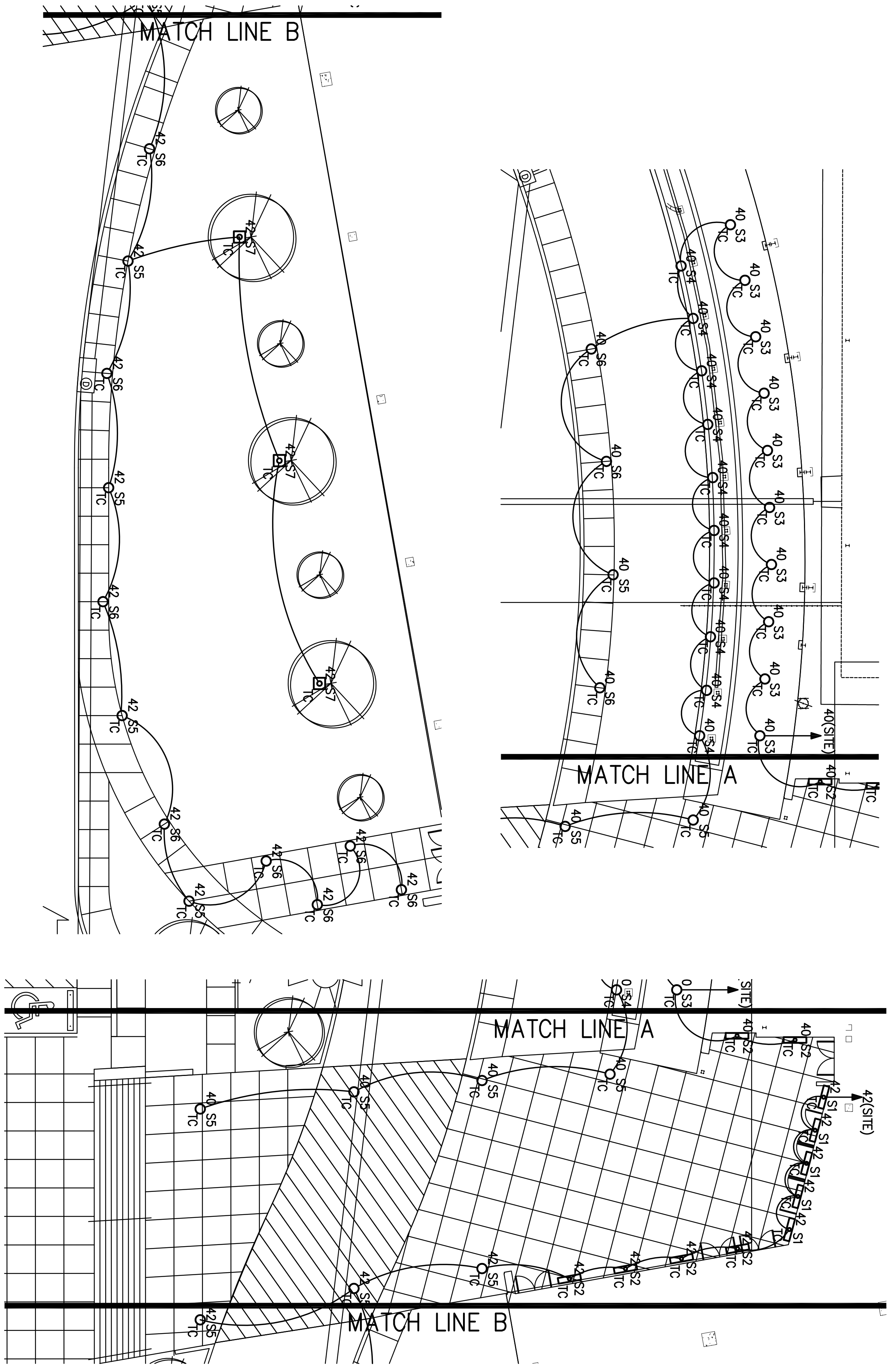
PROJECT NAME:
SUSQUEHANNA CENTER RENOVATIONS AND EXPANSION

NAME:
BRAD GAUGH

DWG NAME:
MAIN LOBBY LIGHTING PLAN

SCALE: 1/8" = 1'0"

E–



E-1

SCALE: 1/16" = 1'0"

DWG NAME: EXTERIOR LIGHTING PLAN

PROJECT NAME: SUSQUEHANNA CENTER RENOVATIONS AND EXPANSION

NAME: BRAD GAUGH

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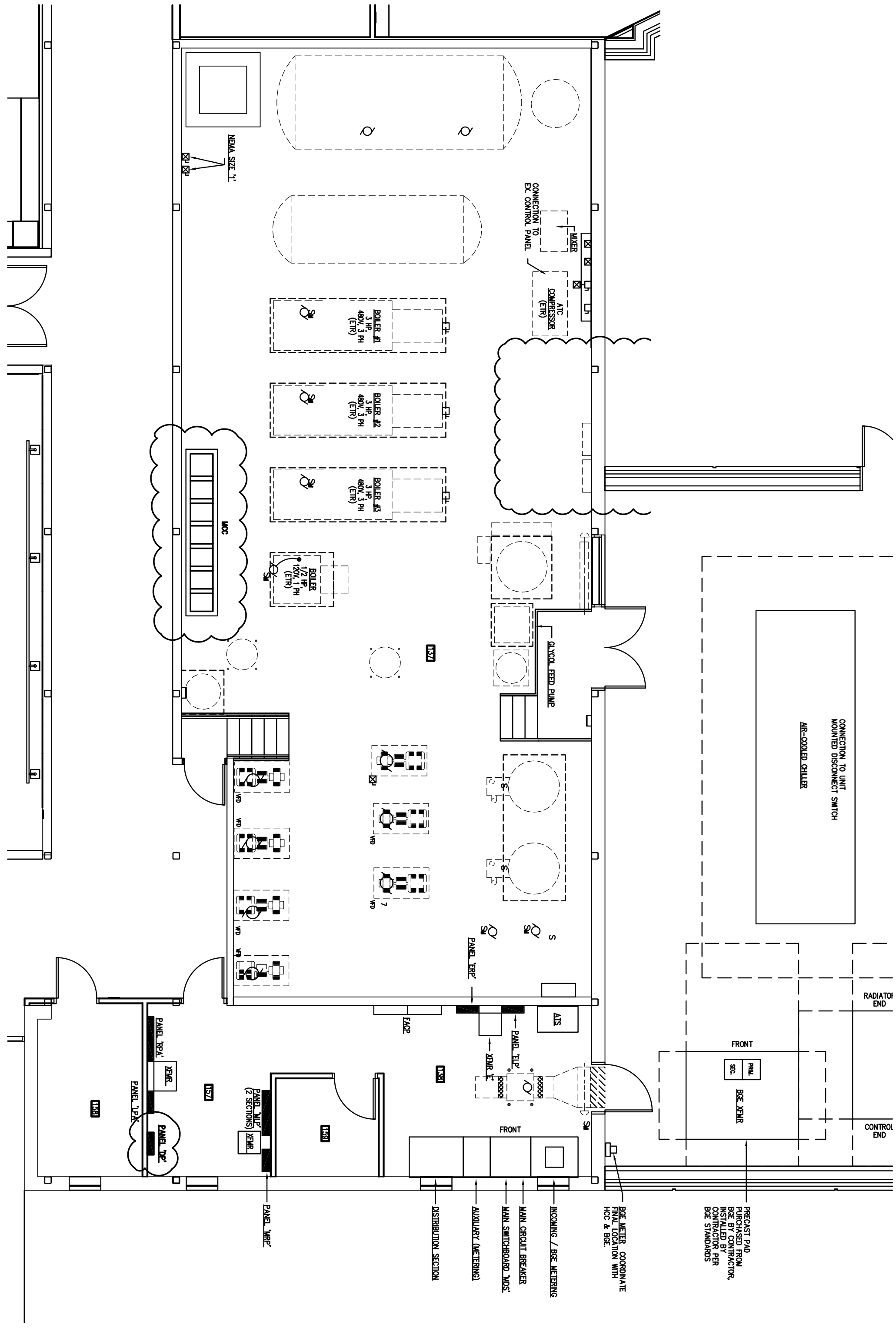

E-1	SCALE: 1/8" = 1'0"	DWG NAME: ELECTRIC ROOM NEW EQUIPMENT LOCATIONS	PROJECT NAME: SUSQUEHANNA CENTER RENOVATIONS AND EXPANSION	NAME: BRAD GAUGH

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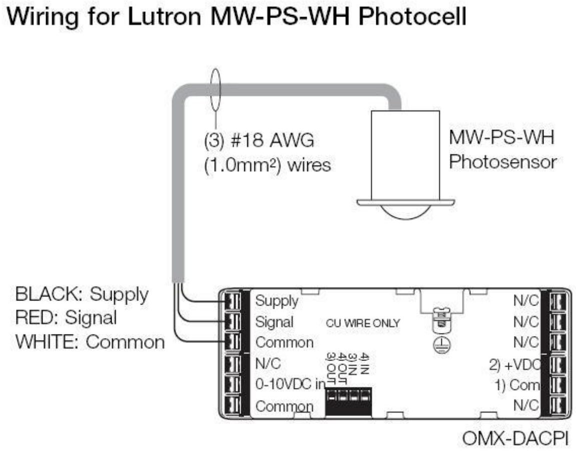
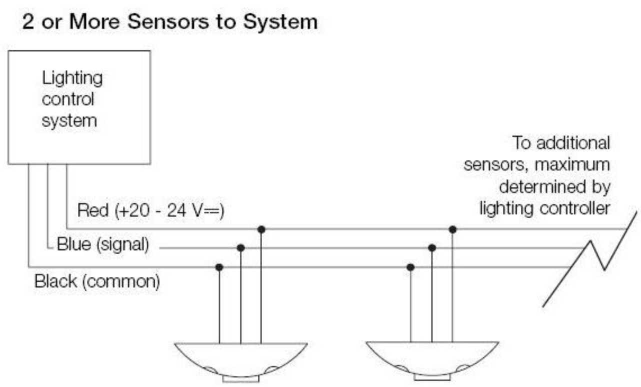
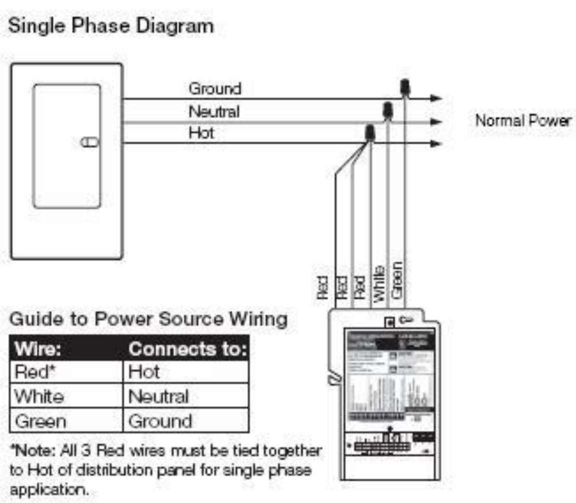
Control Wiring Diagrams



Drawing 19. Wiring Diagram of Photocell



Drawing 20. Wiring Diagram of Vacancy Sensors



Wire:	Connects to:
Red*	Hot
White	Neutral
Green	Ground

Drawing 21. Wiring Diagram of Lighting Relay

Existing Panelboards and Modified Circuits

PANEL LPA
AIC: 35,000
LOCATION: MAIN ELECT. RM. 157
MAIN: 225A MCB
MOUNTING: SURFACE
VOLTAGE: 480Y/ 277 3 PH 4 W
NOTE: 100% RATED NEUTRAL BUS

CKT	EQUIPMENT SERVED	LOAD (KVA) A	LOAD (KVA) B	LOAD (KVA) C	BREAKER P	BREAKER AMPS	BREAKER P	BREAKER AMPS	LOAD (KVA) A	LOAD (KVA) B	LOAD (KVA) C	EQUIPMENT SERVED	CKT
1	L 137, 38, 57-59 N TOILETS	2.3			1	20	1	20	1.7			L: FITNESS	2
3	L CORRI 150		2.1		1	20	1	20		2.8		L: FITNESS & OFFICES	4
5	L CORRI 152			1.7	1	20	1	20			1.3	L: FITNESS DL	6
7	L CORRI 152 & 56	2.7			1	20	1	20				L: FITNESS COVE	8
9	L 148		1.5		1	20	1	20		2.8		L: MULTI #1 & 2	10
11	L AUX GYM			3.6	1	20	1	20				L: 142A, 43-45, 49 & 51	12
13	L AUX GYM	3.6			1	20	1	20	0.4			L: EXT. BY SAIL	14
15	L 114		0.8		1	20	1	20		3.2		L: NE OFFICES	16
17	SPARE				1	20	1	20			2.8	L: 109, 112 & 113	18
19	SPARE				1	20	1	20				SPARE	20
21	SPACE				-	-	-	-				SPACE	22
23	SPACE				-	-	-	-				SPACE	24
25	SPACE				-	-	-	-				SPACE	26
27	SPACE				-	-	-	-				SPACE	28
29	SPACE				-	-	-	-				SPACE	30
31	SPACE				-	-	-	-				SPACE	32
33	SPACE				-	-	-	-				SPACE	34
35	SPACE				-	-	-	-				SPACE	36
37	PANEL 'RPA' TRANSFORMER	25.9			3	125	3	100	15.9			PANEL 'LPC'	38
39	-----		25.6		-	-	-	-		16.2		-----	40
41	-----			24.2	-	-	-	-			13.7	-----	42
		34.55	30.03	29.5	SUB-TOTALS				18	24.96	17.76		

CONNECTED LOAD:

A:	52.5 KVA	=	190 A
B:	55.0 KVA	=	199 A
C:	47.3 KVA	=	171 A

Drawing 22. Panel LPA Existing Loads

PANEL	LPB				MAIN:	225A MCB				VOLTAGE:	480Y/ 277 3 PH 4 W		
AIC:	25,000				MOUNTING:	SURFACE				NOTE:			
LOCATION:	ELECTRICAL RM. 010										100% RATED NEUTRAL BUS		
		LOAD (KVA)			BREAKER		BREAKER		LOAD (KVA)				
CKT	EQUIPMENT SERVED	A	B	C	P	AMPS	P	AMPS	A	B	C	EQUIPMENT SERVED	CKT
1	L: ARENA COURT	2.7			1	20	1	20	2.4			L: ARENA / THEATER	2
3	L: ARENA COURT		2.7		1	20	1	20		1.2		L: ARENA SEAT	4
5	L: ARENA COURT			2.7	1	20	1	20			1.5	L: ARENA SEAT	6
7	L: ARENA COURT	2.7			1	20	1	20	1			L: ARENA SEAT	8
9	L: ARENA COURT		2.7		1	20	1	20		0.8		L: ARENA SEAT	10
11	L: ARENA COURT			2.7	1	20	1	20			1	L: ARENA SEAT	12
13	L: ARENA COURT	2.7			1	20	1	20	0.8			L: ARENA SEAT	14
15	L: ARENA COURT		2.7		1	20	1	20		1		L: ARENA SEAT	16
17	L: ARENA COURT			2.7	1	20	1	20			0.8	L: ARENA SEAT	18
19	L: ARENA COURT	2.7			1	20	1	20	1			L: ARENA SEAT	20
21	L: ARENA DOWNLIGHT		0.4		1	20	1	20		0.8		L: ARENA SEAT	22
23	L: LOWER ENTRANCES			1.2	1	20	1	20			0.7	L: ARENA SEAT	24
25	L: TOILETS UPPER LEVEL	1.8			1	20	1	20	0.7			L: ARENA SEAT	26
27	L: TOILET LOWER LEVEL		1.8		1	20	1	20		1.7		L: ARENA SEAT	28
29	L: 010 & 011			1.2	1	20	1	20			1.7	L: ARENA SEAT	30
31	L: TOILET LOWER LEVEL	2			1	20	1	20	1.1			L: ARENA SEAT	32
33	L: CORRIDOR 116		2		1	20	1	20		1		L: ARENA SEAT	34
35	SPARE				1	20	1	20			1.3	L: CONCESSION	36
37	SPARE				1	20	1	20	0.6			L: UPPER ENTRANCES	38
39	SPARE				1	20	1	20		2.6		L: WALL LIGHTING	40
41	SPARE				1	20	1	20			0.6	L: STAIRS NW & SW	42
43	SPACE				-	-	-	-				SPACE	44
45	SPACE				-	-	-	-				SPACE	46
47	SPACE				-	-	-	-				SPACE	48
49	SPACE				-	-	-	-				SPACE	50
51	SPACE				-	-	-	-				SPACE	52
53	SPACE				-	-	-	-				SPACE	54
55	PANEL 'RPB' TRANSFORMER	18.4			3	150	-	-				SPACE	56
57	-----		17.3		-	-	-	-				SPACE	58
59	-----			17.1	-	-	-	-				SPACE	60
		33	29.6	27.6	SUB-TOTALS				7.6	9.1	7.6		

CONNECTED LOAD:

A:	40.6 KVA	=	147 A
B:	38.7 KVA	=	140 A
C:	35.2 KVA	=	127 A

Drawing 23. Panel LPB Existing Loads

PANEL SITE
A/C: 25,000
LOCATION: ROOM 011
MAIN: 225A MCB
MOUNTING: SURFACE
VOLTAGE: 480Y/ 277 3 PH 4 W
NOTE: 100% RATED NEUTRAL BUS

CKT	EQUIPMENT SERVED	LOAD (KVA) A	LOAD (KVA) B	LOAD (KVA) C	BREAKER P	BREAKER AMPS	BREAKER P	BREAKER AMPS	LOAD (KVA) A	LOAD (KVA) B	LOAD (KVA) C	EQUIPMENT SERVED	CKT
1	TENNIS COURT	1.8			2	20	1	20	1.8			SITE LIGHTING	2
3	-----		1.8		-	-	1	20		1.8		SITE LIGHTING	4
5	TENNIS COURT			1.8	2	20	1	20			1.8	SITE LIGHTING	6
7	-----	1.8			-	-	1	20	2			SITE LIGHTING	8
9	TENNIS COURT		1.8		2	20	1	20		2		SITE LIGHTING	10
11	-----			1.8	-	-	1	20			2.7	SITE LIGHTING	12
13	TENNIS COURT	1.8			2	20	1	20	2.4			SITE LIGHTING	14
15	-----		1.8		-	-	1	20		0.5		SITE LIGHTING	16
17	TENNIS COURT			1.8	2	20	1	20				SPARE	18
19	-----	1.8			-	-	3	20	1.3			DOCK LEVELER	20
21	TENNIS COURT		1.8		2	20	-	-		1.3		-----	22
23	-----			1.8	-	-	-	-			1.3	-----	24
25	TENNIS COURT	1.8			2	20	3	20	1.2			RAIN WATER	26
27	-----		1.8		-	-	-	-		1.2		-----	28
29	TENNIS COURT			1.8	2	20	-	-			1.2	-----	30
31	-----	1.8			-	-	3	25	4.2			PUMP RWHB #1 & 2	32
33	TENNIS COURT		1.8		2	20	-	-		4.2		-----	34
35	-----			1.8	-	-	-	-			4.2	-----	36
37	TENNIS COURT	1.8			2	20	1	20	1.2			"SAIL" LIGHTING	38
39	-----		1.8		-	-	1	20		1.2		"SAIL" LIGHTING	40
41	TENNIS COURT			1.8	2	20	1	20			0.4	CANOPY LIGHTING	42
43	-----	1.8			-	-	1	20	1.8			SOFFIT LIGHTING	44
45	TENNIS COURT		1.8		2	20	1	20		1.5		SOFFIT LIGHTING	46
47	-----			1.8	-	-	1	20			0.4	ENTRANCE (2)	48
49	TENNIS COURT	1.8			2	20	-	-				SPACE	50
51	-----		1.8		-	-	-	-				SPACE	52
53	TENNIS COURT			1.8	2	20	-	-				SPACE	54
55	-----	1.8			-	-	-	-				SPACE	56
57	TENNIS COURT		1.8		2	20	-	-				SPACE	58
59	-----			1.8	-	-	-	-				SPACE	60
61	TENNIS COURT	1.8			2	20	-	-				SPACE	62
63	-----		1.8		-	-	-	-				SPACE	64
65	SPARE				1	20	-	-				SPACE	66
67	SPARE				1	20	-	-				SPACE	68
69	SPACE				-	-	-	-				SPACE	70
71	SPACE				-	-	-	-				SPACE	72
73	SPACE				-	-	-	-				SPACE	74
75	SPACE				-	-	-	-				SPACE	76
77	SPACE				-		-	-				SPACE	78
79	SPACE				-	-	-	-				SPACE	80
81	SPACE				-	-	-	-				SPACE	82
83	SPACE				-	-	-	-				SPACE	84
		19.8	19.8	18	SUB-TOTALS				15.9	13.7	12		

CONNECTED LOAD:

A:	35.7 KVA	=	129 A
B:	33.5 KVA	=	121 A
C:	30 KVA	=	108 A

Drawing 24. Panel Site Existing Loads

Revised Panelboards and Modified Circuits

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->				LPA	Panel Location:			Electric Room		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	Toilets	2300	w	0.90	2300	2556	
2	A	Lighting	3	Fitness	1566	w	0.90	1566	1740	
3	B	Lighting	3	Corridor	2100	w	0.90	2100	2333	
4	B	Lighting	3	Fitness	1711	w	0.90	1711	1901	
5	C	Lighting	3	Corridor	1700	w	0.90	1700	1889	
6	C	Lighting	3	Fitness	675	w	0.90	675	750	
7	A	Lighting	3	Corridor	2700	w	0.90	2700	3000	
8	A	Space			0	w		0	0	
9	B	Lighting	3	Dance	1500	w	0.90	1500	1667	
10	B	Lighting	3	Multi	2800	w	0.90	2800	3111	
11	C	Space	3		0	w		0	0	
12	C	Lighting	3	Storage	1800	w	0.90	1800	2000	
13	A	Space	3		0	w		0	0	
14	A	Lighting	3	Sail	400	w	0.90	400	444	
15	B	Lighting	3	Lounge	800	w	0.90	800	889	
16	B	Lighting	3	Offices	3200	w	0.90	3200	3556	
17	C	Spare	9		0	w		0	0	
18	C	Lighting	3	Classroom	2800	w	0.90	2800	3111	
19	A	Spare	9		0	w		0	0	
20	A	Space			0	w		0	0	
21	B	Space			0	w		0	0	
22	B	Space			0	w		0	0	
23	C	Space			0	w		0	0	
24	C	Space			0	w		0	0	
25	A	Space			0	w		0	0	
26	A	Space			0	w		0	0	
27	B	Space			0	w		0	0	
28	B	Space			0	w		0	0	
29	C	Space			0	w		0	0	
30	C	Space			0	w		0	0	
31	A	Space			0	w		0	0	
32	A	Space			0	w		0	0	
33	B	Panel DP	9		1080	w		1080	1350	
34	B	Space			0	w		0	0	
35	C	* * *	9	* * *	1080	w		1080	1350	
36	C	Space			0	w		0	0	
37	A	Transformer RPA	9	Electric	25900	w		25900	32375	
38	A	Panel LPC	9	Electric	15900	w		15900	19875	
39	B	* * *	9	* * *	25600	w		25600	32000	
40	B	* * *	9	* * *	16200	w		16200	20250	
41	C	* * *	9	* * *	24200	w		24200	30250	
42	C	* * *	9	* * *	13700	w		13700	17125	
PANEL TOTAL								149.7	183.5	Amps= 220.8

PHASE LOADING							kW	kVA	%	Amps
	PHASE TOTAL	A					48.8	60.0	34%	216.6
	PHASE TOTAL	B					55.0	67.1	39%	242.1
	PHASE TOTAL	C					46.0	47.0	27%	169.7
LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		26.1	28.9		26.1	28.9	0.90		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		123.7	154.6		123.7	154.6	0.80		
	Total Demand Loads					149.7	183.5			
	Spare Capacity		20%			29.9	36.7			
	Total Design Loads					179.7	220.2	0.82	Amps=	265.0

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 20. Panel LPA New Loads

Panelboard	
Tag	LPA
Voltage System	480Y/ 277V
Calculated Design Load (kW)	180
Calculated Power Factor	0.82
Calculated Design Load (kVA)	220.226
Calculated Design Load (A)	265.0132371
Feeder	
Feeder Protection Size	400
Number of Sets	2
Wire Size	
Phase	2/0
Neutral	2/0
Ground	3
Wire Area (table 5)	
Each Phase	0.2223
Total – All phases	0.6669
Neutral	0.2223
Ground	0.0973
Total – All Wires	0.9865
Minimum Conduit Area (above * 2.5)	2.46625
Conduit Size (Table 4)	2”
Conduit Size (Table C.1)	2-1/2”
Feeder Length	25 ft
Final Voltage Drop (V)	12.3 V
Final Voltage Drop (%)	2.60%
Was feeder re-sized?	NO

Table 21. Panel LPA Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	LPA	MIN. C/B AIC:	35k
SIZE/TYPE BUS:	400A	PANEL LOCATION:	Electric Room	OPTIONS:	
SIZE/TYPE MAIN:	400A/3P MCB	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Toilets	2300	20A/1P	1	*			2	20A/1P	1566	Fitness	Lighting
Lighting	Corridor	2100	20A/1P	3		*		4	20A/1P	1711	Fitness	Lighting
Lighting	Corridor	1700	20A/1P	5			*	6	20A/1P	675	Fitness	Lighting
Lighting	Corridor	2700	20A/1P	7	*			8	20A/1P	0		Space
Lighting	Dance	1500	20A/1P	9		*		10	20A/1P	2800	Multi	Lighting
Space		0	20A/1P	11			*	12	20A/1P	1800	Storage	Lighting
Space		0	20A/1P	13	*			14	20A/1P	400	Sail	Lighting
Lighting	Lounge	800	20A/1P	15		*		16	20A/1P	3200	Offices	Lighting
Spare		0	20A/1P	17			*	18	20A/1P	2800	Classroom	Lighting
Spare		0	20A/1P	19	*			20	20A/1P	0		Space
Space		0	20A/1P	21		*		22	20A/1P	0		Space
Space		0	20A/1P	23			*	24	20A/1P	0		Space
Space		0	20A/1P	25	*			26	20A/1P	0		Space
Space		0	20A/1P	27		*		28	20A/1P	0		Space
Space		0	20A/1P	29			*	30	20A/1P	0		Space
Space		0	20A/1P	31	*			32	20A/1P	0		Space
Panel DP		1080	50A/2P	33		*		34	20A/1P	0		Space
* * *	* * *	1080		35			*	36	20A/1P	0		Space
Transformer RPA	Electric	25900	125A/3P	37	*			38	100A/3P	15900	Electric	Panel LPC
* * *	* * *	25600		39		*		40		16200	* * *	* * *
* * *	* * *	24200		41			*	42		13700	* * *	* * *

CONNECTED LOAD (KW) - A Ph.	48.77	TOTAL DESIGN LOAD (KW)	179.65
CONNECTED LOAD (KW) - B Ph.	54.99	POWER FACTOR	0.82
CONNECTED LOAD (KW) - C Ph.	45.96	TOTAL DESIGN LOAD (AMPS)	265

Table 22. Panel LPA Schedule

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->				LPB	Panel Location:			Electric Room		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	Arena	2700	w		2700	3375	
2	A	Lighting	3	Arena	2400	w		2400	3000	
3	B	Lighting	3	Arena	2700	w		2700	3375	
4	B	Lighting	3	Arena	1200	w		1200	1500	
5	C	Lighting	3	Arena	2700	w		2700	3375	
6	C	Lighting	3	Arena	1500	w		1500	1875	
7	A	Lighting	3	Arena	2700	w		2700	3375	
8	A	Lighting	3	Arena	1000	w		1000	1250	
9	B	Lighting	3	Arena	2700	w		2700	3375	
10	B	Lighting	3	Arena	800	w		800	1000	
11	C	Lighting	3	Arena	2700	w		2700	3375	
12	C	Lighting	3	Arena	1000	w		1000	1250	
13	A	Lighting	3	Arena	2700	w		2700	3375	
14	A	Lighting	3	Arena	800	w		800	1000	
15	B	Lighting	3	Arena	2700	w		2700	3375	
16	B	Lighting	3	Arena	100	w		100	125	
17	C	Lighting	3	Arena	2700	w		2700	3375	
18	C	Lighting	3	Arena	800	w		800	1000	
19	A	Lighting	3	Arena	2700	w		2700	3375	
20	A	Lighting	3	Arena	1000	w		1000	1250	
21	B	Lighting	3	Arena	400	w		400	500	
22	B	Lighting	3	Arena	800	w		800	1000	
23	C	Lighting	3	Toilets	1200	w		1200	1500	
24	C	Lighting	3	Arena	700	w		700	875	
25	A	Lighting	3	Toilets	1800	w		1800	2250	
26	A	Lighting	3	Arena	700	w		700	875	
27	B	Lighting	3	Toilets	1800	w		1800	2250	
28	B	Lighting	3	Arena	1700	w		1700	2125	
29	C	Lighting	3	Electric	1200	w		1200	1500	
30	C	Lighting	3	Arena	1700	w		1700	2125	
31	A	Lighting	3	Toilets	2000	w		2000	2500	
32	A	Lighting	3	Arena	1100	w		1100	1375	
33	B	Lighting	3	Corridor	2000	w		2000	2500	
34	B	Lighting	3	Arena	1000	w		1000	1250	
35	C	Space	9		0	w		0	0	
36	C	Lighting	3	Lobby	564	w		564	705	
37	A	RPB XMFR	9	Electric	18400	w		18400	23000	
38	A	Space	9		0	w		0	0	
39	B	* * *	9	* * *	17300	w		17300	21625	
40	B	Lighting	3	Wall	2600	w		2600	3250	
41	C	* * *	9	* * *	17100	w		17100	21375	
42	C	Lighting	3	Stairs	600	w		600	750	
PANEL TOTAL								112.3	140.3	Amps= 168.9

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL		A					40.0	50.0	37%	180.5
PHASE TOTAL		B					37.8	47.3	35%	170.6
PHASE TOTAL		C					34.5	38.7	28%	139.5
LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		59.5	74.3		59.5	74.3	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		52.8	66.0		52.8	66.0	0.80		
Total Demand Loads						112.3	140.3			
Spare Capacity			20%			22.5	28.1			
Total Design Loads						134.7	168.4	0.80	Amps=	202.6

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 23. Panel LPB New Loads

Panelboard	
Tag	LPB
Voltage System	480Y/ 277V
Calculated Design Load (kW)	134.7
Calculated Power Factor	0.8
Calculated Design Load (kVA)	168.4
Calculated Design Load (A)	202.6
Feeder	
Feeder Protection Size	225
Number of Sets	1
Wire Size	
Phase	4/0
Neutral	4/0
Ground	4
Wire Area (table 5)	
Each Phase	0.3237
Total – All phases	0.9711
Neutral	0.3237
Ground	0.0824
Total – All Wires	1.3772
Minimum Conduit Area (above * 2.5)	3.443
Conduit Size (Table 4)	2- 1/2"
Conduit Size (Table C.1)	2-1/2"
Feeder Length	100ft
Final Voltage Drop (V)	10.5 V
Final Voltage Drop (%)	2.20%
Was feeder re-sized?	NO

Table 24. Panel LPB Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	LPB	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electric Room	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Arena	2700	20A/1P	1	*			2	20A/1P	2400	Arena	Lighting
Lighting	Arena	2700	20A/1P	3		*		4	20A/1P	1200	Arena	Lighting
Lighting	Arena	2700	20A/1P	5			*	6	20A/1P	1500	Arena	Lighting
Lighting	Arena	2700	20A/1P	7	*			8	20A/1P	1000	Arena	Lighting
Lighting	Arena	2700	20A/1P	9		*		10	20A/1P	800	Arena	Lighting
Lighting	Arena	2700	20A/1P	11			*	12	20A/1P	1000	Arena	Lighting
Lighting	Arena	2700	20A/1P	13	*			14	20A/1P	800	Arena	Lighting
Lighting	Arena	2700	20A/1P	15		*		16	20A/1P	100	Arena	Lighting
Lighting	Arena	2700	20A/1P	17			*	18	20A/1P	800	Arena	Lighting
Lighting	Arena	2700	20A/1P	19	*			20	20A/1P	1000	Arena	Lighting
Lighting	Arena	400	20A/1P	21		*		22	20A/1P	800	Arena	Lighting
Lighting	Toilets	1200	20A/1P	23			*	24	20A/1P	700	Arena	Lighting
Lighting	Toilets	1800	20A/1P	25	*			26	20A/1P	700	Arena	Lighting
Lighting	Toilets	1800	20A/1P	27		*		28	20A/1P	1700	Arena	Lighting
Lighting	Electric	1200	20A/1P	29			*	30	20A/1P	1700	Arena	Lighting
Lighting	Toilets	2000	20A/1P	31	*			32	20A/1P	1100	Arena	Lighting
Lighting	Corridor	2000	20A/1P	33		*		34	20A/1P	1000	Arena	Lighting
Space	0	0	20A/1P	35			*	36	20A/1P	564	Lobby	Lighting
RPB XMFR	Electric	18400	150A/3P	37	*			38	20A/1P	0		Space
* * *	* * *	17300		39		*		40	20A/1P	2600	Wall	Lighting
* * *	* * *	17100		41			*	42	20A/1P	600	Stairs	Lighting

CONNECTED LOAD (KW) - A Ph.	40.00	TOTAL DESIGN LOAD (KW)	134.72
CONNECTED LOAD (KW) - B Ph.	37.80	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	34.46	TOTAL DESIGN LOAD (AMPS)	203

Table 25. Panel LPB Schedule

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->					Site	Panel Location:			Electric Room	
Nominal Phase to Neutral Voltage------->					277	Phase:			3	
Nominal Phase to Phase Voltage-------->					480	Wires:			4	
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	Tennis	1800	w		1800	2250	
2	A	Lighting	3	Site	1800	w		1800	2250	
3	B	* * *	3	* * *	1800	w		1800	2250	
4	B	Lighting	3	Site	1800	w		1800	2250	
5	C	Lighting	3	Tennis	1800	w		1800	2250	
6	C	Lighting	3	Site	1800	w		1800	2250	
7	A	* * *	3	* * *	1800	w		1800	2250	
8	A	Lighting	3	Site	2000	w		2000	2500	
9	B	Lighting	3	Tennis	1800	w		1800	2250	
10	B	Lighting	3	Site	200	w		200	250	
11	C	* * *	3	* * *	1800	w		1800	2250	
12	C	Lighting	3	Site	2700	w		2700	3375	
13	A	Lighting	3	Tennis	1800	w		1800	2250	
14	A	Lighting	3	Site	2400	w		2400	3000	
15	B	* * *	3	* * *	1800	w		1800	2250	
16	B	Lighting	3	Site	500	w		500	625	
17	C	Lighting	3	Tennis	1800	w		1800	2250	
18	C	Spare	9			w		0	0	
19	A	* * *	3	* * *	1800	w		1800	2250	
20	A	Dock Leveler	9	Site	1300	w		1300	1625	
21	B	Lighting	3	Tennis	1800	w		1800	2250	
22	B	* * *	9	* * *	1300	w		1300	1625	
23	C	* * *	3	* * *	1800	w		1800	2250	
24	C	* * *	9	* * *	1300	w		1300	1625	
25	A	Lighting	3	Tennis	1800	w		1800	2250	
26	A	Rain Water	9	Site	1200	w		1200	1500	
27	B	* * *	3	* * *	1800	w		1800	2250	
28	B	* * *	9	* * *	1200	w		1200	1500	
29	C	Lighting	3	Tennis	1800	w		1800	2250	
30	C	* * *	9	* * *	1200	w		1200	1500	
31	A	* * *	3	* * *	1800	w		1800	2250	
32	A	Pumps	9	Site	4200	w		4200	5250	
33	B	Lighting	3	Tennis	1800	w		1800	2250	
34	B	* * *	9	* * *	4200	w		4200	5250	
35	C	* * *	9	* * *	1800	w		1800	2250	
36	C	* * *	9	* * *	4200	w		4200	5250	
37	A	Lighting	3	Tennis	1800	w		1800	2250	
38	A	Lighting	3	Site	1200	w		1200	1500	
39	B	* * *	3	* * *	1800	w		1800	2250	
40	B	Lighting	3	Site	1375	w		1375	1719	
41	C	Lighting	3	Tennis	1800	w		1800	2250	
42	C	Lighting	3	Site	1638	w		1638	2048	
PANEL TOTAL								75.3	94.1	Amps= 113.3

PHASE LOADING							kW	kVA	%	Amps
	PHASE TOTAL	A					26.7	33.4	36%	120.5
	PHASE TOTAL	B					23.2	29.0	31%	104.6
	PHASE TOTAL	C					25.4	30.9	33%	111.7
LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		53.4	66.8		53.4	66.8	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		21.9	27.4		21.9	27.4	0.80		
	Total Demand Loads					75.3	94.1	0.80		
	Spare Capacity		20%			15.1	18.8			
	Total Design Loads					90.4	113.0	0.80	Amps=	135.9

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 26. Panel Site New Loads on first 42 Circuits

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->					Site	Panel Location:			Electric Room	
Nominal Phase to Neutral Voltage------->					277	Phase:			3	
Nominal Phase to Phase Voltage-------->					480	Wires:			4	
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
43	A	* * *	3	* * *	1800	w		1800	2250	
44	A	Lighting	3	Site	1800	w		1800	2250	
45	B	Lighting	3	Tennis	1800	w		1800	2250	
46	B	Lighting	3	Site	1500	w		1500	1875	
47	C	* * *	3	* * *	1800	w		1800	2250	
48	C	Spare	9			w		0	0	
49	A	Lighting	3	Tennis	1800	w		1800	2250	
50	A	Space				w		0	0	
51	B	* * *	3	* * *	1800	w		1800	2250	
52	B	Space				w		0	0	
53	C	Lighting	3	Tennis	1800	w		1800	2250	
54	C	Space				w		0	0	
55	A	* * *	3	* * *	1800	w		1800	2250	
56	A	Space				w		0	0	
57	B	* * *	3	* * *	1800	w		1800	2250	
58	B	Space				w		0	0	
59	C	* * *	3	* * *	1800	w		1800	2250	
60	C	Space				w		0	0	
61	A	Lighting	3	Tennis	1800	w		1800	2250	
62	A	Space				w		0	0	
63	B	* * *	3	* * *	1800	w		1800	2250	
64	B	Space				w		0	0	
65	C	Spare	9			w		0	0	
66	C	Space				w		0	0	
67	A	Spare	9			w		0	0	
68	A	Space				w		0	0	
69	B	Space				w		0	0	
70	B	Space				w		0	0	
71	C	Space				w		0	0	
72	C	Space				w		0	0	
73	A	Space				w		0	0	
74	A	Space				w		0	0	
75	B	Space				w		0	0	
76	B	Space				w		0	0	
77	C	Space				w		0	0	
78	C	Space				w		0	0	
79	A	Space				w		0	0	
80	A	Space				w		0	0	
81	B	Space				w		0	0	
82	B	Space				w		0	0	
83	C	Space				w		0	0	
84	C	Space				w		0	0	
PANEL TOTAL								23.1	28.9	Amps= 34.7

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL		A					9.0	11.3	39%	40.6
PHASE TOTAL		B					8.7	10.9	38%	39.3
PHASE TOTAL		C					5.4	6.8	23%	24.4
LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		23.1	28.9		23.1	28.9	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						23.1	28.9			
Spare Capacity			20%			4.6	5.8			
Total Design Loads						27.7	34.7	0.80	Amps=	41.7

Default Power Factor =	0.80
Default Demand Factor =	100 %

Table 27. Panel Site New Loads on second 42 Circuits

Panelboard		
Tag		Site
Voltage System		480Y/ 277V
Calculated Design Load (kW)		118.1
Calculated Power Factor		0.8
Calculated Design Load (kVA)		147.7
Calculated Design Load (A)		177.7
Feeder		
Feeder Protection Size		225
Number of Sets		1
Wire Size		
	Phase	4/0
	Neutral	4/0
	Ground	4
Wire Area (table 5)		
	Each Phase	0.3237
	Total – All phases	0.9711
	Neutral	0.3237
	Ground	0.0824
	Total – All Wires	1.3772
Minimum Conduit Area (above * 2.5)		3.443
Conduit Size (Table 4)		2- 1/2"
Conduit Size (Table C.1)		2-1/2"
Feeder Length		100ft
Final Voltage Drop (V)		10.5V
Final Voltage Drop (%)		2.20%
Was feeder re-sized?		NO

Table 28. Panel Site Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	Site	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electric Room	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Tennis	1800	20A/2P	1	*			2	20A/1P	1800	Site	Lighting
* * *	* * *	1800		3		*		4	20A/1P	1800	Site	Lighting
Lighting	Tennis	1800	20A/2P	5			*	6	20A/1P	1800	Site	Lighting
* * *	* * *	1800		7	*			8	20A/1P	2000	Site	Lighting
Lighting	Tennis	1800	20A/2P	9		*		10	20A/1P	200	Site	Lighting
* * *	* * *	1800		11			*	12	20A/1P	2700	Site	Lighting
Lighting	Tennis	1800	20A/2P	13	*			14	20A/1P	2400	Site	Lighting
* * *	* * *	1800		15		*		16	20A/1P	500	Site	Lighting
Lighting	Tennis	1800	20A/2P	17			*	18	20A/1P	0	0	Spare
* * *	* * *	1800		19	*			20	20A/3P	1300	Site	Dock Leveler
Lighting	Tennis	1800	20A/2P	21		*		22		1300	* * *	* * *
* * *	* * *	1800		23			*	24		1300	* * *	* * *
Lighting	Tennis	1800	20A/2P	25	*			26	20A/3P	1200	Site	Rain Water
* * *	* * *	1800		27		*		28		1200	* * *	* * *
Lighting	Tennis	1800	20A/2P	29			*	30		1200	* * *	* * *
* * *	* * *	1800		31	*			32	20A/3P	4200	Site	Pumps
Lighting	Tennis	1800	20A/2P	33		*		34		4200	* * *	* * *
* * *	* * *	1800		35			*	36		4200	* * *	* * *
Lighting	Tennis	1800	20A/2P	37	*			38	20A/1P	1200	Site	Lighting
* * *	* * *	1800		39		*		40	20A/1P	1375	Site	Lighting
Lighting	Tennis	1800	20A/2P	41			*	42	20A/1P	1638	Site	Lighting

CONNECTED LOAD (KW) - A Ph.	26.70	TOTAL DESIGN LOAD (KW)	90.38
CONNECTED LOAD (KW) - B Ph.	23.18	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	25.44	TOTAL DESIGN LOAD (AMPS)	136

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	Site	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electric Room	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
* * *	* * *	1800		43	*			44	20A/1P	1800	Site	Lighting
Lighting	Tennis	1800	20A/2P	45		*		46	20A/1P	1500	Site	Lighting
* * *	* * *	1800		47			*	48		0	0	Spare
Lighting	Tennis	1800	20A/2P	49	*			50		0	0	Space
* * *	* * *	1800		51		*		52		0	0	Space
Lighting	Tennis	1800	20A/2P	53			*	54		0	0	Space
* * *	* * *	1800		55	*			56		0	0	Space
* * *	* * *	1800	20A/2P	57		*		58		0	0	Space
* * *	* * *	1800		59			*	60		0	0	Space
Lighting	Tennis	1800	20A/2P	61	*			62		0	0	Space
* * *	* * *	1800		63		*		64		0	0	Space
Spare	0	0		65			*	66		0	0	Space
Spare	0	0		67	*			68		0	0	Space
Space	0	0		69		*		70		0	0	Space
Space	0	0		71			*	72		0	0	Space
Space	0	0		73	*			74		0	0	Space
Space	0	0		75		*		76		0	0	Space
Space	0	0		77			*	78		0	0	Space
Space	0	0		79	*			80		0	0	Space
Space	0	0		81		*		82		0	0	Space
Space	0	0		83			*	84		0	0	Space

CONNECTED LOAD (KW) - A Ph.	9.00	TOTAL DESIGN LOAD (KW)	27.72
CONNECTED LOAD (KW) - B Ph.	8.70	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	5.40	TOTAL DESIGN LOAD (AMPS)	42

Table 29. Panel Site Schedule

PANELBOARD SIZING WORKSHEET

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
Panel Tag-------------------------->					DP	Panel Location:			Electric		
Nominal Phase to Neutral Voltage------->					277	Phase:			1		
Nominal Phase to Phase Voltage-------->					554	Wires:			3		
1	L1	Lighting	3	Gym	1080	w		1080	1350		
2	L1	Lighting	3	Gym	1080	w		1080	1350		
3	L2	Space			0	w		0	0		
4	L2	Space			0	w		0	0		
5	L1	Space			0	w		0	0		
6	L1	Space			0	w		0	0		
7	L2	Space			0	w		0	0		
8	L2	Space			0	w		0	0		
PANEL TOTAL								2.2	2.7	Amps=	4.9
PHASE LOADING								kW	kVA	%	Amps
LEG TOTAL			L1					2.2	2.7	100%	9.7
LEG TOTAL			L2					0.0	0.0		0.0

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		2.2	2.7		2.2	2.7	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						2.2	2.7			
Spare Capacity			20%			0.4	0.5			
Total Design Loads						2.6	3.2	0.80	Amps=	5.8

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 30. Panel DP New Loads

Panelboard		
Tag		DP
Voltage System		277V
Calculated Design Load (kW)		2.6kW
Calculated Power Factor		0.8
Calculated Design Load (kVA)		3.2kVA
Calculated Design Load (A)		6A
Feeder		
Feeder Protection Size		50
Number of Sets		1
Wire Size		
	Phase	6
	Neutral	6
	Ground	10
Wire Area (table 5)		
	Each Phase	0.0507
	Total – All phases	0.1521
	Neutral	0.0507
	Ground	0.0211
	Total – All Wires	0.1732
Minimum Conduit Area (above * 2.5)		0.433
Conduit Size (Table 4)		3/4"
Conduit Size (Table C.1)		1"
Feeder Length		100ft
Final Voltage Drop (V)		3.2V
Final Voltage Drop (%)		1.10%
Was feeder re-sized?		NO

Table 31. Panel DP Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W	PANEL TAG: DP	MIN. C/B AIC: 10K	
SIZE/TYPE BUS: 225A	PANEL LOCATION: Electric	OPTIONS: PROVIDE FEED THROUGH LUGS	
SIZE/TYPE MAIN: 225A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 1L1B	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	L1		L2	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Gym	1080	20A/1P	1	*			2	20A/1P	1080	Gym	Lighting
Space		0	20A/1P	3			*	4	20A/1P	0		Space
Space		0	20A/1P	5	*			6	20A/1P	0		Space
Space		0	20A/1P	7			*	8	20A/1P	0		Space

CONNECTED LOAD (KW) - A Ph.	2.16	TOTAL DESIGN LOAD (KW)	2.59
CONNECTED LOAD (KW) - B Ph.		POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	0.00	TOTAL DESIGN LOAD (AMPS)	6

Table 32. Panel DP Schedule

Short Circuit and Protective Device Study

Description

A short circuit and protective device study were conducted in order to determine the electrical systems reliability to protect itself from faulty wiring, over-current circumstances, and any other problems that could occur. The short circuit study looked into three components of the electrical system. Those components are the service entrance, the next downstream Panel, and a circuit within that Panel. The protective device study will break down the characteristics of the protection that each of these components have. This report assumes all equipment is to be EATON Corporation and Cutler-Hammer products because the project has not been built or bided.

Short Circuit Calculations

Below are charts that break down the three components from the main switch board 'MDS' to the branch Panel 'MLP' and the circuit for roof top unit 4. The main switch board is 480Y/277V, 3PH. 4W, with a 3200 amp frame, the branch Panel 'MLP' is 480Y/277V, 3PH., 4W with a 600 amp frame, and the roof top unit 4 circuit is a 3P 70A breaker.

Available Fault Current Calculation

by John Sokolik — Ver. 6.3 — jmp1jds@earthlink.net

Utility Fault Current	0 amperes	kVA	=	2000	
		E	=	480	
$I = \frac{kVA \times 1000}{E \times 1.732}$ = trans. FLA		trans. FLA	=	2406	
$I_{sca} = \frac{\text{trans. FLA} \times 100}{\text{transformer Z}}$ =				2406	
				5.75	%
I_{sca} = ampere short-circuit current RMS symmetrical.		I_{sca}	=	41,838	amperes
Point to Point Method					Three Phase 480/277
	Length (distance) FEET	L	=	25	Aluminum in Nonmetallic Raceway
'f' factor = $\frac{1.732 \times L \times I}{N \times C \times E_{L-N}}$	(ASC)	I_{sca}	=	41,838	
	# conductors per phase	N	=	6	
	Phase conductor constant	C	=	23,492	Phase Conductor 750 kcmil
	Volt Line to Line	E_{L-L}	=	**480**	Volt
		f	=	0.027	
	Neutral conductor constant	C	=	23,492	Neutral Conductor 750 kcmil
Multiplier	Volt Line to Neutral	E_{L-N}	=	**277**	Volt
		f	=	0.046	
$M = \frac{1}{1+f}$	Line to Line	M	=	0.974	
	Line to Neutral	M	=	0.956	

Fault Current at Service Equipment

I_{sca} x M = fault current at terminals of main disconnect L- L = → **40,747** amperes

I_{sca} x M = fault current at terminals of main disconnect L- N = → **39,983** amperes

Table 33. Short Circuit Calculation Switchboard MDS

Fault Current from	Switchboard To Panel MLP					Copper in Metal Raceway	
						Three Phase	
Three Phase Feeder		Length (distance)	L	=	45		
'f ' factor = $\frac{1.732 \times L \times I}{N \times C \times E_{L-N}}$		(ASC)	Isca	=	40,747	Phase	39,983 Neutral
		# conductors per phase	N	=	2		
		Phase conductor constant	C	=	19,704	Phase Conductor	350 kcmil
		Volt Line to Line	E L-L	=	480	Volt	
			f	=	0.168		
		Neutral conductor constant	C	=	19,704	Neutral Conductor	350 kcmil
		Volt Line to Neutral	E L-N	=	277	Volt	
Multiplier			f	=	0.285		
$M = \frac{1}{1+f}$		Line to Line	M	=	0.856		
		Line to Neutral	M	=	0.778		
Isca x M = fault current at terminal of the panel L- L =						34,889	amperes
Isca x M = fault current at terminal of the panel L- N =						31,103	amperes
Calculation does not include motor contribution							

Table 34. Short Circuit Calculations Panel MLP

Branch Circuit Fault from	Panel MLP To RTU-4 Branch Circuit					Copper in Metal Raceway	
						Three Phase	
Three Phase Branch		Length (distance)	L	=	300		
'f ' factor = $\frac{1.732 \times L \times I}{N \times C \times E_{L-N}}$		(ASC)	Isca	=	34,889	Phase	31,103 Neutral
		# conductors per phase	N	=	1		
		Phase conductor constant	C	=	3,806	Phase Conductor	4
		Volt Line to Line	E L-L	=	480	Volt	
			f	=	9.923		
		Neutral conductor constant	C	=	3,806	Neutral Conductor	4
		Volt Line to Neutral	E L-N	=	277	Volt	
Multiplier			f	=	15.329		
$M = \frac{1}{1+f}$		Line to Line	M	=	0.092		
		Line to Neutral	M	=	0.061		
Isca x M = fault current at terminal of the panel L- L =						3,194	amperes
Isca x M = fault current at terminal of the panel L- N =						1,905	amperes
Calculation does not include motor contribution							

Table 35. Short Circuit Calculation RTU-4

Protective Devices

This portion of the report analyzes the coordination between protective devices used in the short circuit calculation by hand above. The devices that will be analyzed are the main circuit breaker for Switchboard MDS, Distribution Panel MLP, branch circuit RTU-4, and the motor for RTU-4. For proper coordination of protective devices the trip curve should ascend in an upstream fashion for the current rating. Thus, meaning the breaker for the RTU-4 should trip first, then the breaker for Panel MLP, and lastly the breaker for Switchboard MDS. The Time Current Curve (TCC) shown will indicate that indeed the breakers will trip in this fashion, with one altercation. As seen on the curve, if a spike of 3000A were to enter the system from one second or longer there is no differentiation between the MDS breaker and MLP breaker. This may cause little problems in the coordination process between breakers. The breaker type and color is specified for synchronization of TCC.

Switch Board 'MDS' – Magnum DS, RMS MDS-632 3200A 65kAIC

Panel 'MLP' – Thermal Magnetic M-Frame Circuit Breaker Type HLD, 600V, 3P600A, 65kAIC

Circuit 'RTU-4' –Thermal Magnetic F-Frame Circuit Breaker Type FDC, 480V, 3P70A, 35kAIC

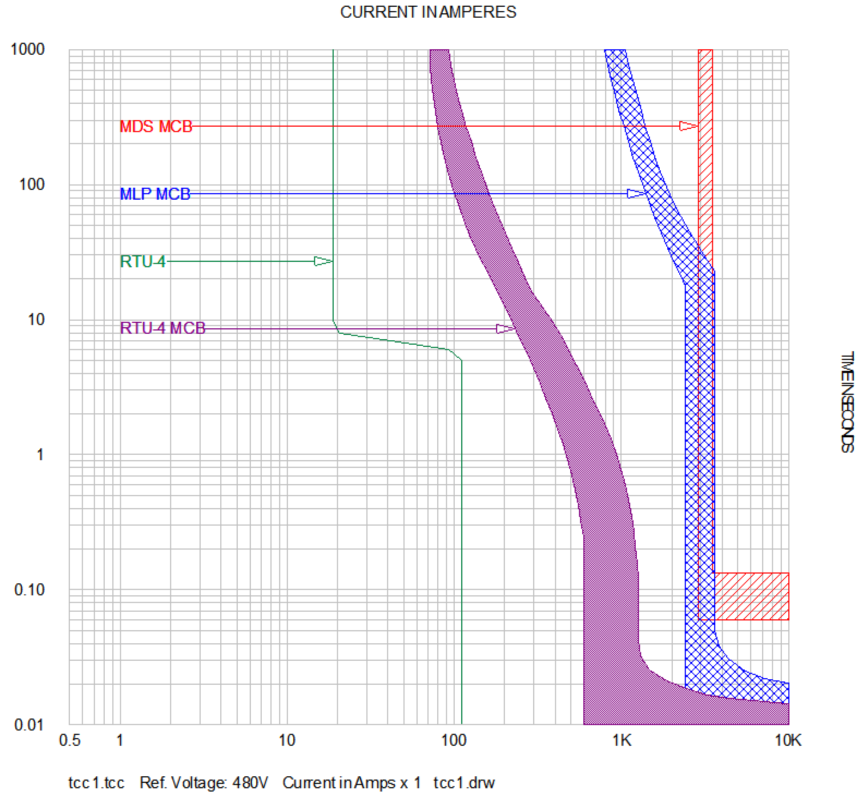


Image 24. TCC Curve for MDS, MLP, RTU-4 Coordination

Electrical Depth 1 – Motor Control Center

Description

This depth looked in to localizing a Motor Control Center within the main mechanical room. The Panel MLP was the primary load center for the space with disconnects located at individual pieces of HVAC equipment. The Motor Control Center took motors with the highest horsepower rating in the 480V Panel MLP and re-localized them with their motor starters and disconnects in the Motor Control Center. The Eaton 2006 Consulting Application Guide for Cutler-Hammer products was used in order to size to produce the layout of the Motor Control Center. Within the calculation the tables used within the guide are specified. See the following charts and drawings to see details of Motor Control Center and Appendix C for specification sheets.

							Table: 430.250 NEC			Table 30.1-88 Eaton			Table 30.1-27 & 30.1-2 Eaton	Table 30.1-27 & 30.1-2 Eaton
Tag	Equipment	HP	Volt	Phase	PF	kVA	NEC	MCA	FLA	Overcurrent Protection (MCCB)	HVAC Controller	Starter Type	Starter (NEMA Type)	# Spaces
CWP-1	CHD WTR PUMP #1 - CHESA	40	480	3	0.95	32.84	52	54.74	68.42	100	ATC	FVR	3	4
CWP-2	CHD WTR PUMP #2 - CHESA	40	480	3	0.95	32.84	52	54.74	68.42	100	ATC	FVR	3	4
HWP-3	HEATING PUMP - SUSQ	30	480	3	0.95	25.26	40	42.11	52.63	70	ATC	FVR	3	4
HWP-4	HEATING PUMP - SUSQ	30	480	3	0.95	25.26	40	42.11	52.63	70	ATC	FVR	3	4
RTU-3	RTU #3 SUPPLY	25	480	3	0.95	21.47	34	35.79	44.74	70	VFD	AFD	2	6
RTU-2	RTU #2 SUPPLY	20	480	3	0.95	17.05	27	28.42	35.53	50	VFD	AFD	2	6
RTU-1	RTU #1 SUPPLY	15	480	3	0.95	13.26	21	22.11	27.63	45	VFD	AFD	2	4
RTU-3	RTU #3 RETURN	15	480	3	0.95	13.26	21	22.11	27.63	45	VFD	AFD	2	4
RTU-2	RTU #2 RETURN	15	480	3	0.95	13.26	21	22.11	27.63	45	VFD	AFD	2	4
HWP-1	HEATING PUMP #1 - CHESA	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
HWP-2	HEATING PUMP #2 - CHESA	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
PWP	POOL PUMP	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
DWP-1	PUMP DWP #1	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
DWP-2	PUMP DWP #2	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
RTU-1	RTU #1 RETURN	5	480	3	0.95	4.80	7.6	8.00	10.00	15	VFD	AFD	0	4
BP-1	BOILER #1	3	480	3	0.85	3.39	4.8	5.65	7.06	15	ATC	FVR	0	3
BP-2	BOILER #2	3	480	3	0.85	3.39	4.8	5.65	7.06	15	ATC	FVR	0	3
BP-3	BOILER #3	3	480	3	0.85	3.39	4.8	5.65	7.06	15	ATC	FVR	0	3
Totals						244.23		294	367					68
													Sections:	6

Notes:
1) Manufacturer : Eaton Freedom 2100 Series, bucket size = 6"
2) MCC will be feed from the Main Switchboard (MDS)
3) The MDS will contain a 400A drawout type circuit breaker
4) The feed to the MCC will be 2 sets of 4#3/0 + 1#6GRD. in 3" C.

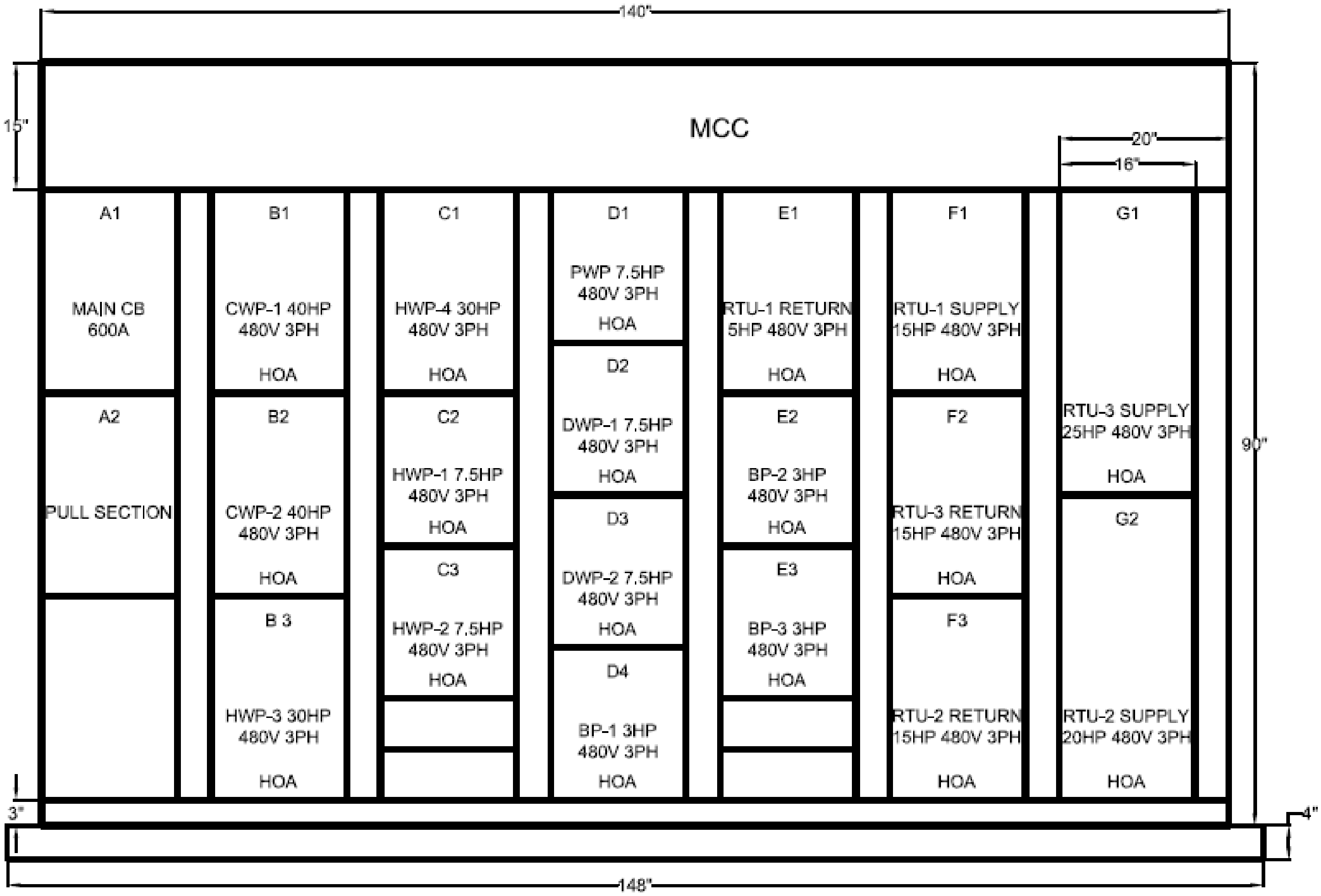
Table 36. MCC Calculations

MOTOR CONTROL CENTER: MCC LOCATION: MECHANICAL ROOM 137

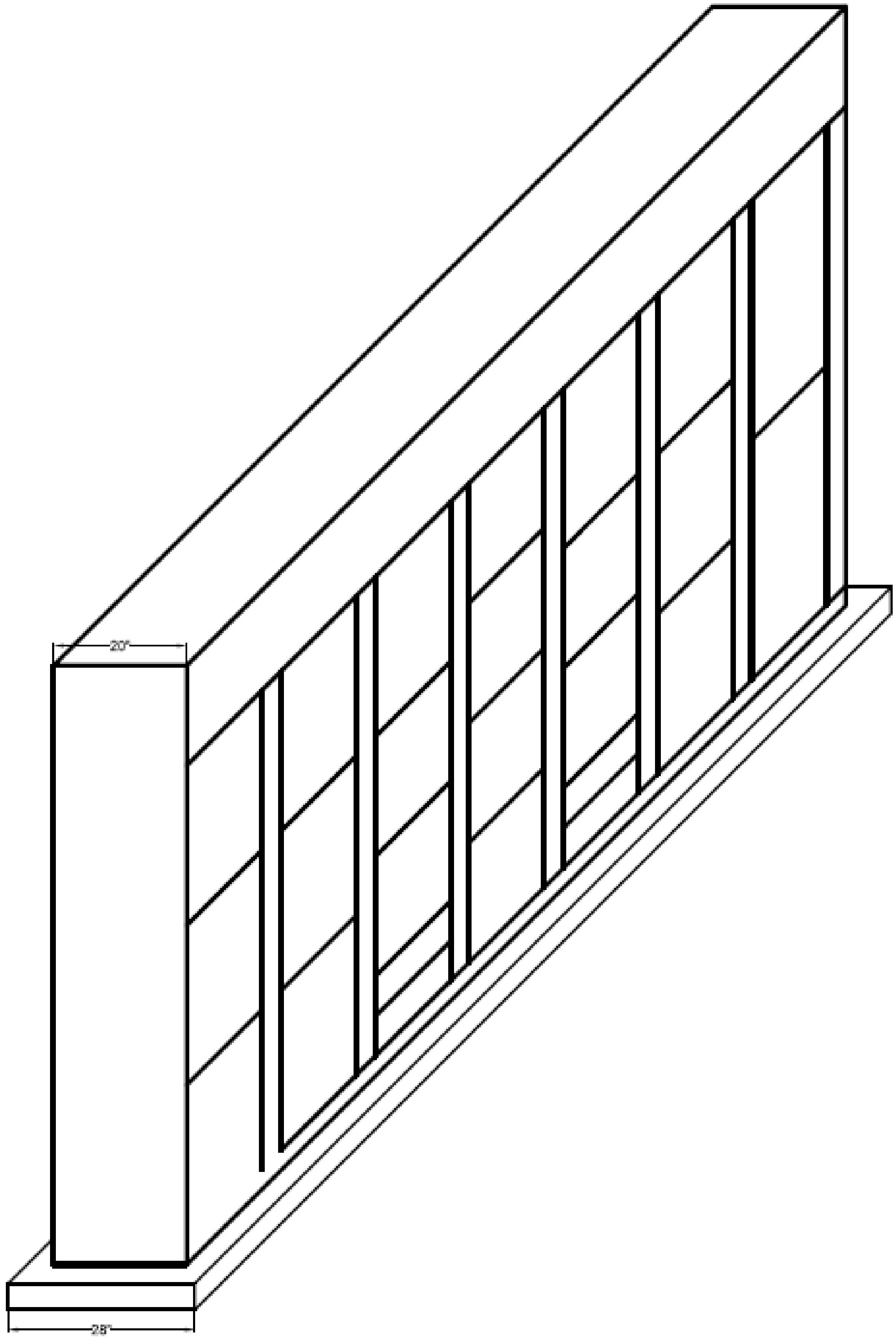
AMPS: 600 VOLTS: 480/277V 3 PH, 4 W, 60 Hz, NEMA: 2 AIC: 65,000

UNIT NO.	CIRCUIT	HP/KVA	FLA	STARTER		CIRCUIT PROTECTION		FEEDER	NOTES
				TYPE	SIZE	TYPE	TRIP		
A1	MAIN CB	–	–	-	–	-	–	(2)3#350MCM+1#6GRDIN3–1/2"C	-
A2	PULL SECTION	–	–	-	–	-	–	–	-
A3	SPARE	–	–	-	–	-	–	–	-
B1	CWP-1	40 HP	68	FVR	3	MCCB	100	3#3 + 1#8GRD. IN 1–1/4" C.	-
B2	CWP-2	40 HP	68	FVR	3	MCCB	100	3#3 + 1#8GRD. IN 1–1/4" C.	-
B3	HWP-3	30 HP	52	FVR	3	MCCB	70	3#4 + 1#8GRD. IN 1–1/4" C.	-
C1	HWP-4	30 HP	52	FVR	3	MCCB	70	3#4 + 1#8GRD. IN 1–1/4" C.	-
C2	HWP-1	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
C3	HWP-2	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D1	PWP	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D2	DWP-1	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D3	DWP-2	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D4	BP-1	3 HP	7	FVR	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
E1	RTU-1 RETURN	3 HP	7	AFD	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
E2	BP-2	3 HP	7	FVR	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
E3	BP-3	3 HP	7	FVR	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
F1	RTU-1 SUPPLY	15 HP	28	AFD	2	MCCB	45	3#8 + 1#10GRD. IN 3/4" C.	-
F2	RTU-3 RETURN	15 HP	28	AFD	2	MCCB	45	3#8 + 1#10GRD. IN 3/4" C.	-
F3	RTU-2 RETURN	15 HP	28	AFD	2	MCCB	45	3#8 + 1#10GRD. IN 3/4" C.	-
G1	RTU-3 SUPPLY	25 HP	45	AFD	2	MCCB	70	3#6 + 1#8GRD. IN 1" C.	-
G2	RUT-2 SUPPLY	20 HP	36	AFD	2	MCCB	70	3#8 + 1#10GRD. IN 3/4" C.	-

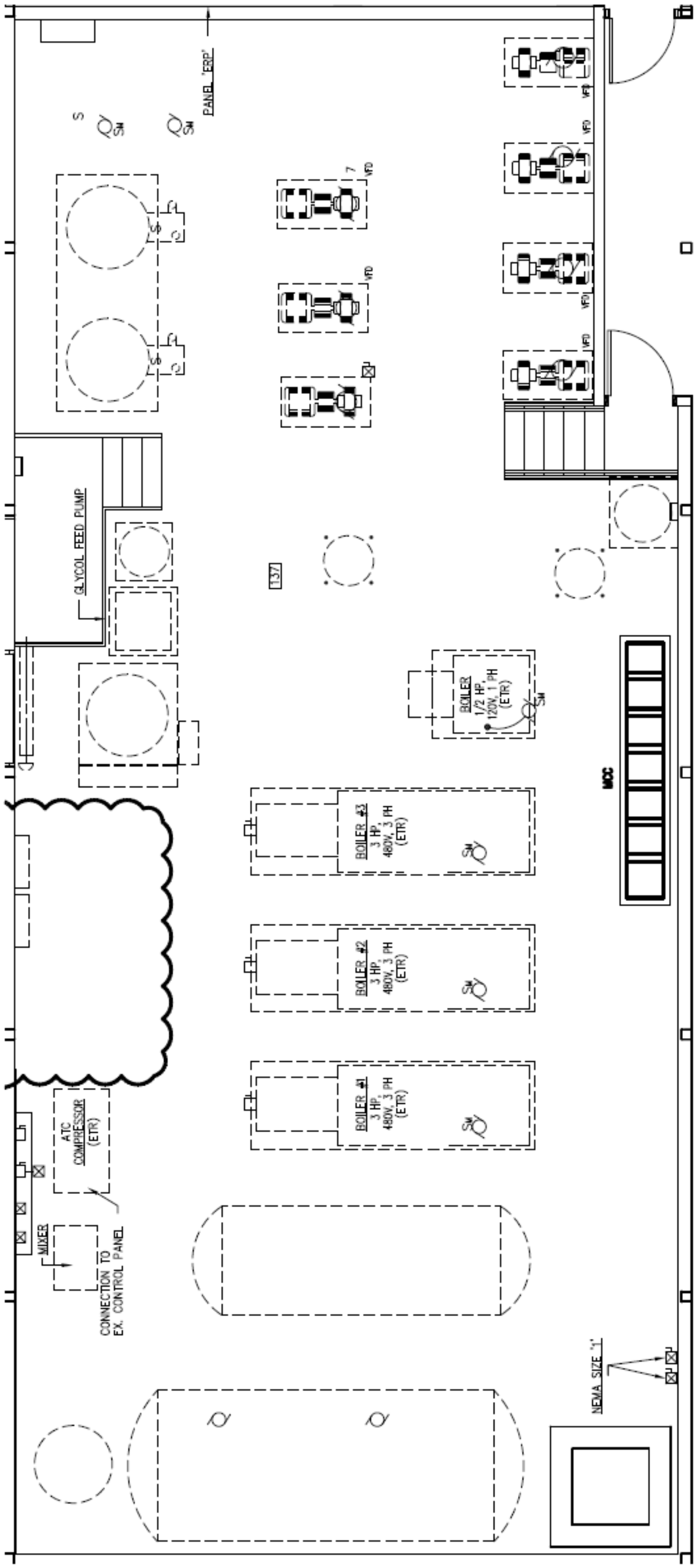
Table 37. MCC Schedule



Drawing 14. MCC Elevation



Drawing 15. MCC Isometric Veiw



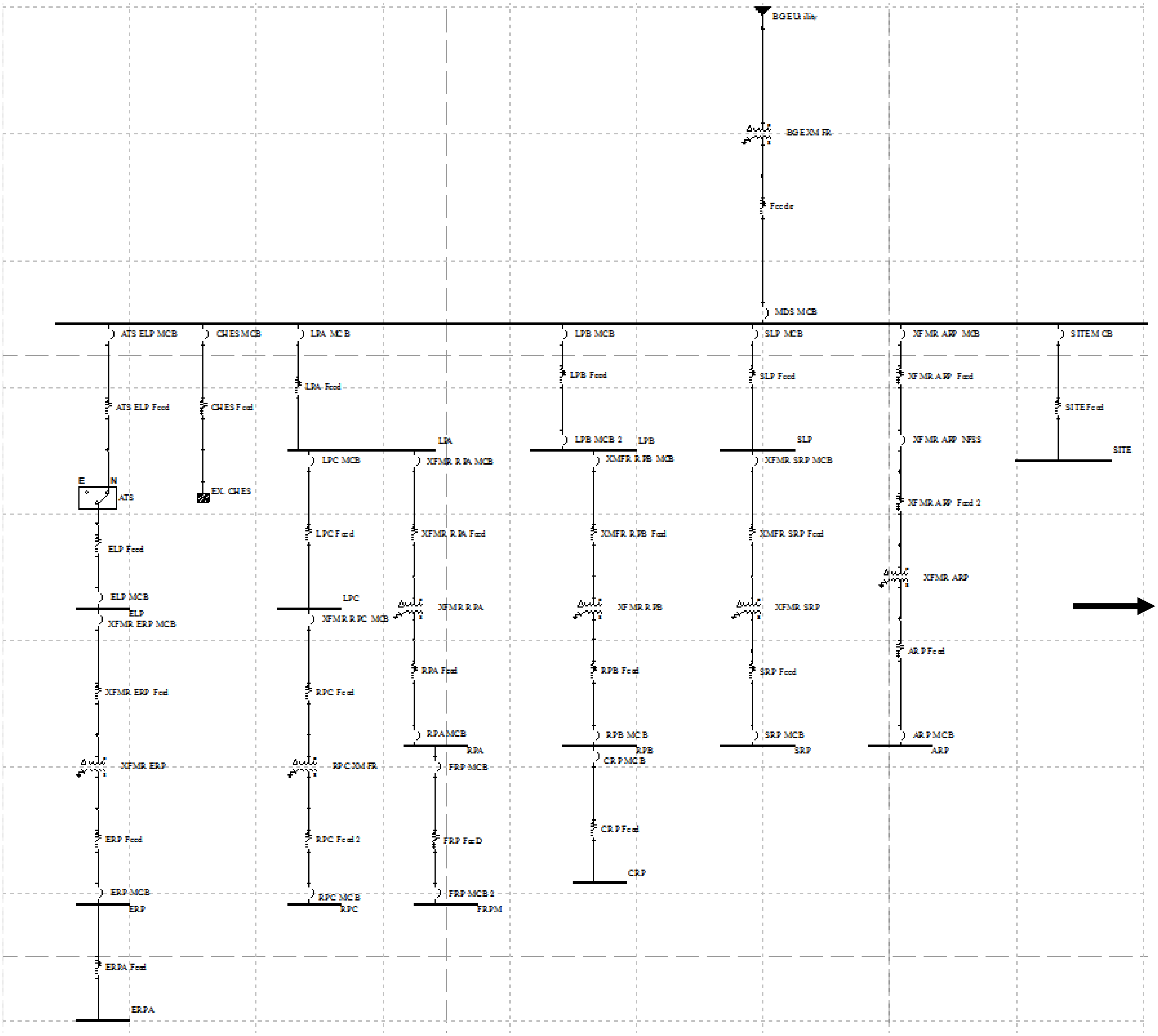
Drawing 16. Mechanical Room Floor Plan

Electrical Depth 2– SKM Analysis

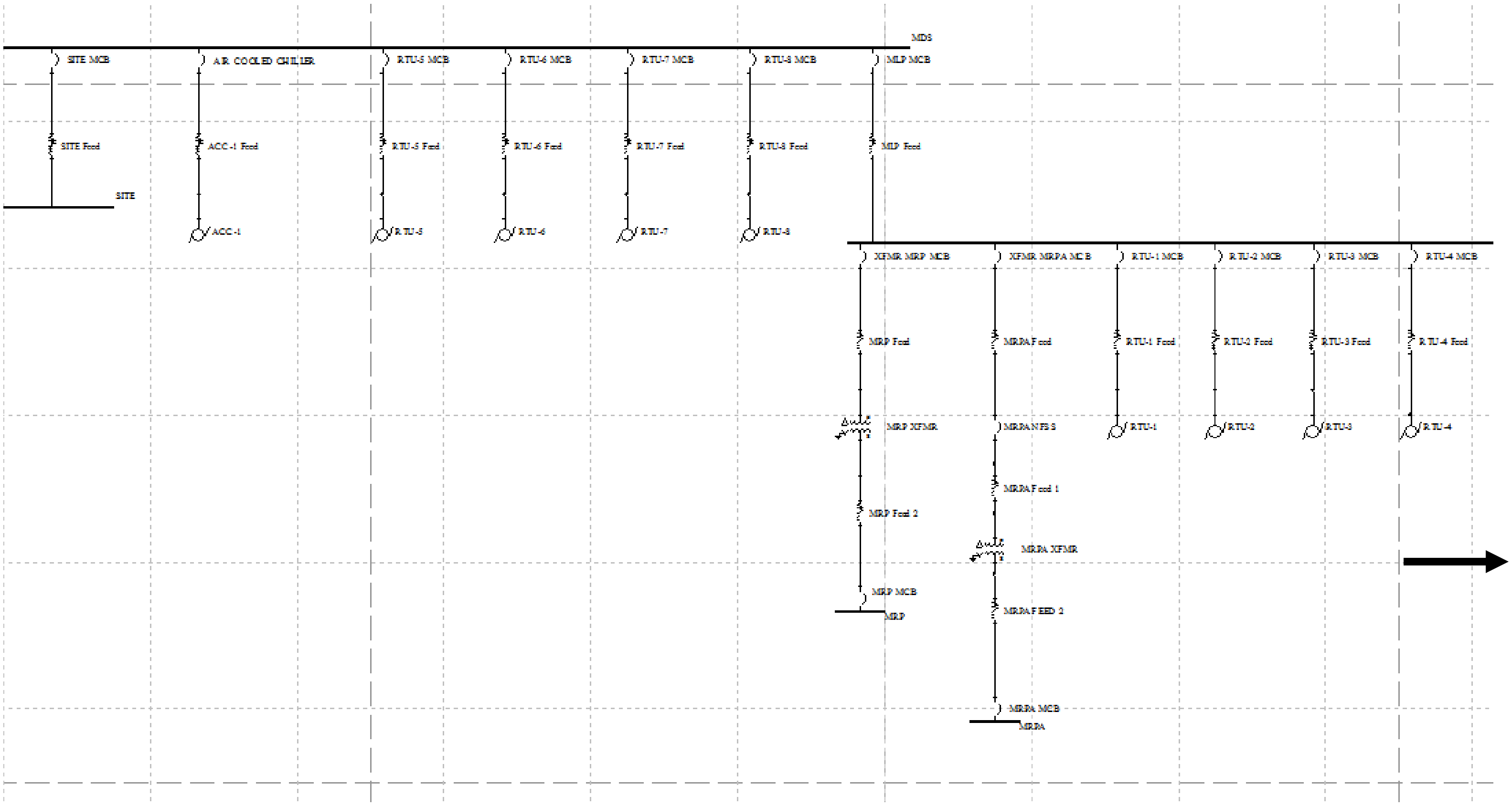
Description

This depth will use the Electrical Engineering Software known as SKM Power Tool Analysis. This program allows the user to input the main electrical components of the electrical system and run an extensive study on the equipment. This study includes short circuit analysis and arc fault studies. The model used for this analysis was based off of the riser diagram used in Tech Report II and includes all motors listed in the Motor Control Center in Electrical Depth 1. The following tables and screen shots from the program will show further details on the model and analysis completed.

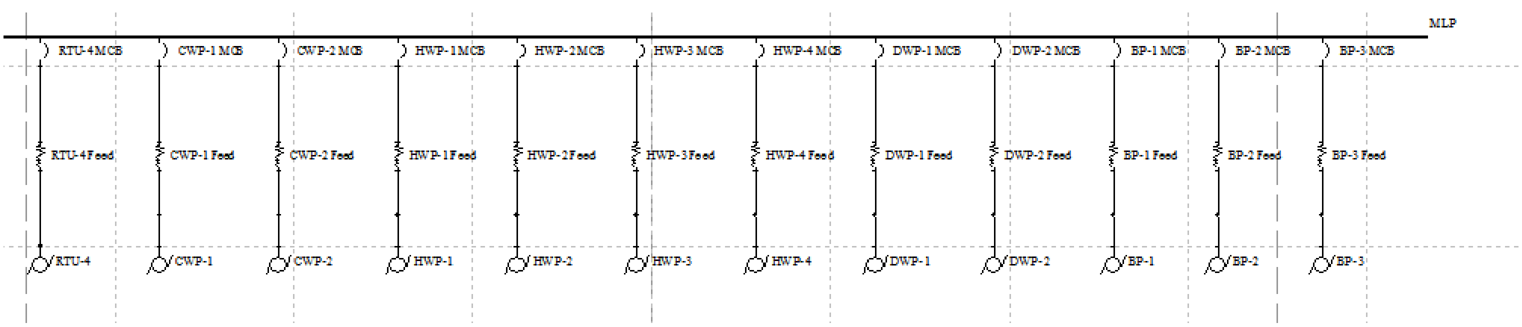
Riser Model



Drawing 17. SKM Riser Diagram Part I



Drawing 18. SKM Riser Diagram Part II



Drawing 19. SKM Riser Diagram Part III

Short Circuit Analysis

Bus Name	Voltage (L-L)	kAIC Rating	3-Phase (A)	X/R	Line/ Ground (A)	X/R	Protected
MDS	480	65	27,975	6.1	31,243	5.5	Yes
MLP	480	35	26,956	5.2	29,153	4.2	Yes
LPA	480	25	24,149	3.4	24,247	2.4	Yes
LPB	480	25	17,571	1.7	14,498	1.1	Yes
LPC	480	14	5,776	0.5	3,576	0.3	Yes
ELP	480	25	23,719	2.2	22,580	1.4	Yes
SLP	480	14	6,437	0.4	3,963	0.3	Yes
SITE	480	25	17,571	1.7	14.498	1.1	Yes
MRP	208	10	3,059	1.6	3,078	1.6	Yes
MRPA	208	10	1,649	0.7	1,676	0.6	Yes
RPA	208	35	6,907	1.6	7,054	1.5	Yes
RPB	208	35	3,008	1.7	3,044	1.6	Yes
RPC	208	10	1,588	0.6	1633	0.6	Yes
FRP	208	10	3,617	0.7	2,649	0.5	Yes
CRP	208	10	2,135	0.9	1,751	0.7	Yes
ARP	208	35	8,797	2.4	9,519	2.4	Yes
ERP	208	10	1,751	0.7	1,744	0.7	Yes
ERPA	208	10	1,741	0.7	1,728	0.7	Yes

Table 38. SKM Fault Analysis

Data Summary

The Short Circuit Study conducted by SKM illustrated that the specified fault current bus ratings on the equipment are higher than the simulated fault currents. This means that in the unlikely event of a fault, the equipment will not explode or create further damage to the system. There is, however, one section that draws attention and that is Panel LPA. Panel LPA's fault current bus rating is 25,000A, which is very near the simulated fault current that SKM is predicting could happen at this Panel. This may require Panel LPA to increase it's rating to a higher one of 35,000A.

Arc Flash Evaluation

Arc Flash Evaluation Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus Report   Project: Susquehanna Center, Base Project

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #
1	ARP	ARP MCB	0.208	8.80	3.38	8.80	3.38	2	0.000	Yes	PNL	25	101	18	20	Category 3 (*N3) (*N9)	# 0001
2																	
3	CRP	CRP MCB	0.208	2.14	1.47	2.14	1.47	2	0.000	Yes	PNL	25	59	18	8.3	Category 3 (*N9)	# 0002
4																	
5	ELP	ELP MCB	0.48	23.72	13.71	23.72	13.71	0.013	0.000	Yes	PNL	25	12	18	0.61	Category 0	# 0003
6																	
7	ERP	ERP MCB	0.208	1.75	1.28	1.75	1.28	2	0.000	Yes	PNL	25	54	18	7.2	Category 2 (*N9)	# 0004
8																	
9	ERPA	ERP MCB	0.208	1.74	1.27	1.74	1.27	2	0.000	Yes	PNL	25	54	18	7.1	Category 2 (*N9)	# 0005
10																	
11	FRPM	FRP MCB 2	0.208	3.62	2.13	3.62	2.13	0.02	0.000	Yes	PNL	25	5	18	0.12	Category 0	# 0006
12																	
13	LPA	LPA MCB	0.48	24.15	13.93	24.15	13.93	0.01	0.000	Yes	PNL	25	10	18	0.47	Category 0	# 0007
14																	
15	LPB	LPB MCB	0.48	17.57	10.61	17.57	10.61	0.01	0.000	Yes	PNL	25	9	18	0.35	Category 0	# 0008
16																	
17	LPC	LPC MCB	0.48	5.78	4.10	5.78	4.10	0.016	0.000	Yes	PNL	25	6	18	0.20	Category 0	# 0009
18																	
19	MDS	AIR COOLED CHILLER	0.48	27.98	14.84	2.27	1.20	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
20	MDS	MLP MCB	0.48	27.98	14.84	1.95	1.03	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
21	MDS	RTU-5 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
22	MDS	RTU-6 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
23	MDS	RTU-7 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
24	MDS	RTU-8 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
25	MDS	MaxTripTime @2.0s	0.48	27.98	14.84	22.92	12.57	2	0.000	Yes	SWG	32	321	24	54	Dangerous! (*N2) (*N9)	# 0010
26																	
27	MLP	MLP MCB	0.48	26.96	15.30	25.01	14.19	0.019	0.000	Yes	PNL	25	16	18	1.00	Category 0	# 0011

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Table 39. SKM Arc Flash Analysis Part I

Arc Flash Evaluation Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus Report   Project: Susquehanna Center, Base Project

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #
28	MLP	BP-1 MCB	0.48	26.96	15.30	0.02	0.01	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
29	MLP	BP-2 MCB	0.48	26.96	15.30	0.02	0.01	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
30	MLP	BP-3 MCB	0.48	26.96	15.30	0.02	0.01	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
31	MLP	CWP-1 MCB	0.48	26.96	15.30	0.31	0.17	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
32	MLP	CWP-2 MCB	0.48	26.96	15.30	0.31	0.17	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
33	MLP	DWP-1 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
34	MLP	DWP-2 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
35	MLP	HWP-1 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
36	MLP	HWP-2 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
37	MLP	HWP-3 MCB	0.48	26.96	15.30	0.23	0.13	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
38	MLP	HWP-4 MCB	0.48	26.96	15.30	0.23	0.13	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
39	MLP	RTU-1 MCB	0.48	26.96	15.30	0.12	0.07	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
40	MLP	RTU-2 MCB	0.48	26.96	15.30	0.15	0.09	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
41	MLP	RTU-3 MCB	0.48	26.96	15.30	0.19	0.11	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
42	MLP	RTU-4 MCB	0.48	26.96	15.30	0.12	0.07	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
43																	
44	MRP	XFMR MRP MCB	0.208	3.06	1.61	3.06	1.61	1.115	0.000	Yes	PNL	25	44	18	5.1	Category 2 (*N3)	# 0012
45																	
46	MRPA	MRPA MCB	0.208	1.65	1.04	1.65	1.04	2	0.000	Yes	PNL	25	47	18	5.7	Category 2 (*N3) (*N9)	# 0013
47																	
48	RPA	RPA MCB	0.208	6.91	2.85	6.91	2.85	1.894	0.000	Yes	PNL	25	87	18	16	Category 3 (*N3)	# 0014
49																	
50	RPB	RPB MCB	0.208	3.01	1.87	3.01	1.87	1.965	0.000	Yes	PNL	25	68	18	11	Category 3	# 0015
51																	
52	RPC	RPC MCB	0.208	1.59	1.19	1.59	1.19	2	0.000	Yes	PNL	25	51	18	6.7	Category 2 (*N9)	# 0016
53																	
54	SITE	SITE MCB	0.48	17.57	10.61	17.57	10.61	0.012	0.000	Yes	PNL	25	10	18	0.43	Category 0	# 0017
55																	

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Table 40. SKM Arc Flash Analysis Part II

Arc Flash Evaluation Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus Report   Project: Susquehanna Center, Base Project

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #
56	SLP	SLP MCB	0.48	6.44	4.50	6.44	4.50	0.01	0.000	Yes	PNL	25	5	18	0.14	Category 0	# 0018
57																	
58	SRP	SRP MCB	0.208	1.61	1.21	1.61	1.21	2	0.000	Yes	PNL	25	52	18	6.7	Category 2 (*N9)	# 0019
59																	
60	Category 0: Nonmelting, Flammable Materials with Weight >= 4.5 oz/sq yd	0.0 - 1.2 cal/cm^2													#Cat 0 = 8	(*N2) < 80% Cleared Fault Threshold	
61	Category 1: Arc-rated FR Shirt & Pants	1.2 - 4.0 cal/cm^2													#Cat 1 = 0	(*N3) - Arcing Current Low Tolerances Used	
62	Category 2: Arc-rated FR Shirt & Pants	4.0 - 8.0 cal/cm^2													#Cat 2 = 6	(*N9) - Max Arcing Duration Reached	
63	Category 3: Arc-rated FR Shirt & Pants & Arc Flash Suit	8.0 - 25.0 cal/cm^2													#Cat 3 = 4		
64	Category 4: Arc-rated FR Shirt & Pants & Arc Flash Suit	25.0 - 40.0 cal/cm^2													#Cat 4 = 0		
65	Category Dangerous!: No FR Category Found	Device with 80% Cleared Fault Threshold													#Danger = 1	IEEE 1584 - 2002/2004a Edition Bus Report (80% Cleared Fault Threshold, include Ind. Motors for 5.0 Cycles), mis-coordination not checked	

Table 41. SKM Arc Flash Analysis Part III

Data Summary

The Arc Flash Evaluation conducted by SKM demonstrated that most of protective devices fell into the appropriate category of protection. The main gear and higher ampacity Panels attained higher Personal Protective Equipment (PPE) ratings than Panels of smaller ampacity. One area of interest is the Main Switchboard, MDS, in which the rating was Dangerous, the highest possible rating, meaning that working on this piece of gear is of extreme hazard and no PPE clothing can protect you. This should raise a red flag and further analysis of this section needs to be conducted to further illustrate the effects.

Breadth I – Skylight Structural Analysis

Description

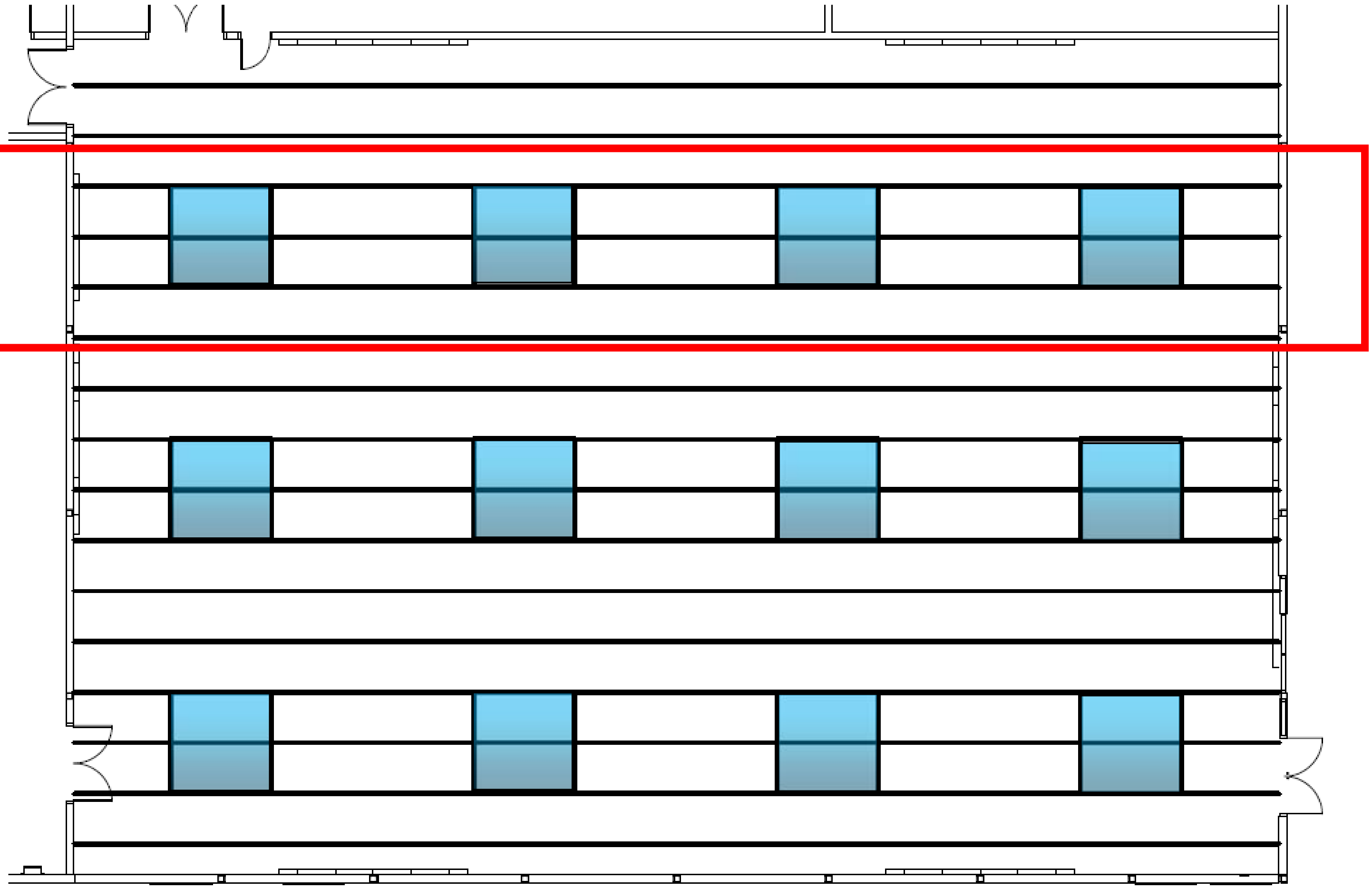
The introduction to skylights in the Auxiliary Gymnasium impacted the truss system that is supporting the roof. The truss is evenly spaced at 4'-0" on center and the truss runs on the edge and intersects the middle of the 8'-0" skylight. This analysis will look at eliminating the truss going through the skylight and adding a joist to support the roof along the edge of the skylight. This joist will be sized according to the load of the missing truss. The existing truss spacing is shown in plan with the skylights overlapping the truss to be sectioned.

Load Breakdown

Type	Source	Loading
Dead	Drawing S-10	20 PSF
Snow	Drawing S-10	30 PSF
Wind	ASCE -05 BLDG G	17.25 PSF
Total Load Eq.	1.2(DL) + 1.6(SL) – 17.25(4)	131 Plf
Factored Eq.	1.2(DL) + 1.6(SL)	288 Plf

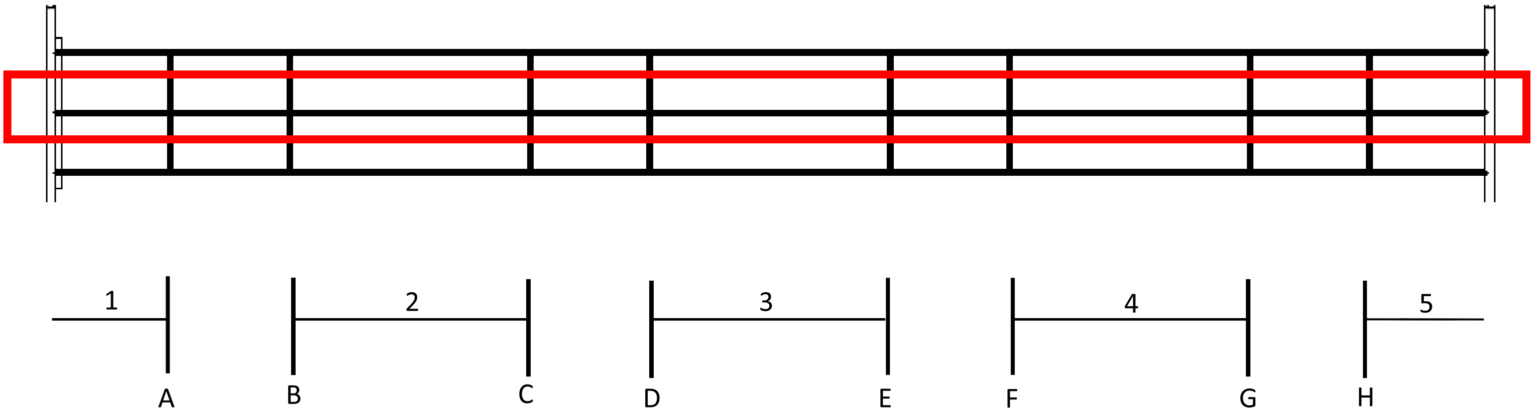
Table 42. Structural Loading

Existing Floor Plan

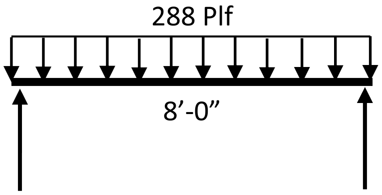


Drawing 20. Existing Roof Structure Floor Plan

Segmented

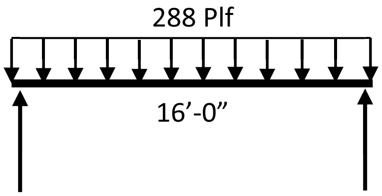


Segment 1 & Segment 5



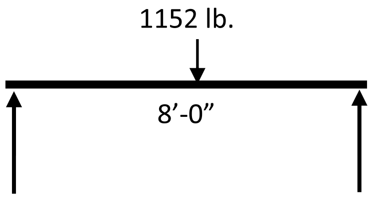
R = wl / 12 = 288(8) /12 = 1152 lb

Segment 2 & Segment 3 & Segment 4



R = wl / 12 = 288(16) /12 = 2304 lb

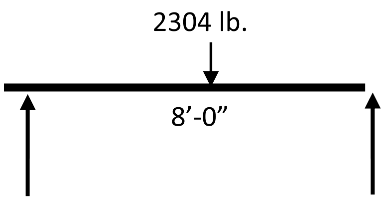
Segment A & Segment H



R = P / 2 = 1152 / 2 = 576 lb.

Moment = Pl / 4 = 1152(8) / 4 = 2304 ft-lb

Segment B, C, D, E, F, & G



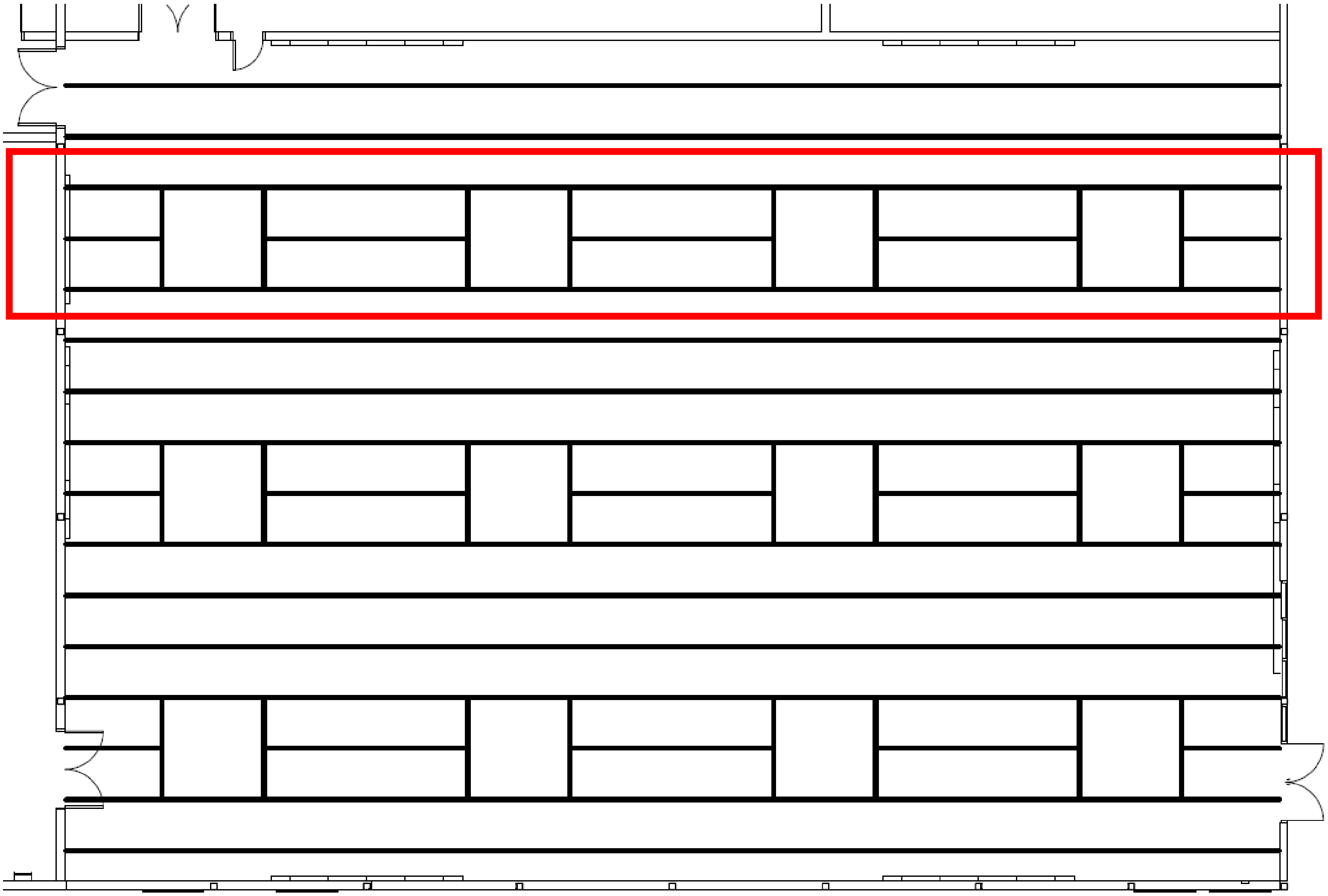
R = P / 2 = 2304 / 2 = 1152 lb.

Moment = Pl / 4 = 2304(16) / 4 = 9216 ft-lb

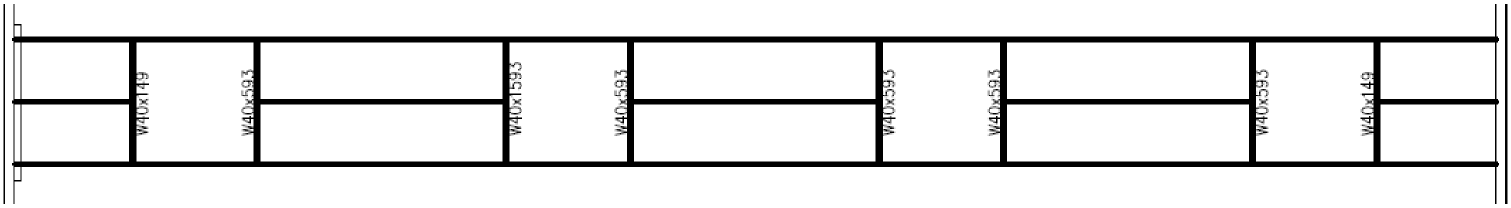
Segment	Steel Member
Segment A & H	W 40 x 149
Segment B, C, D, E, F, G	W 40 x 593

Table 42.Steel Member Selection

New Floor Plan

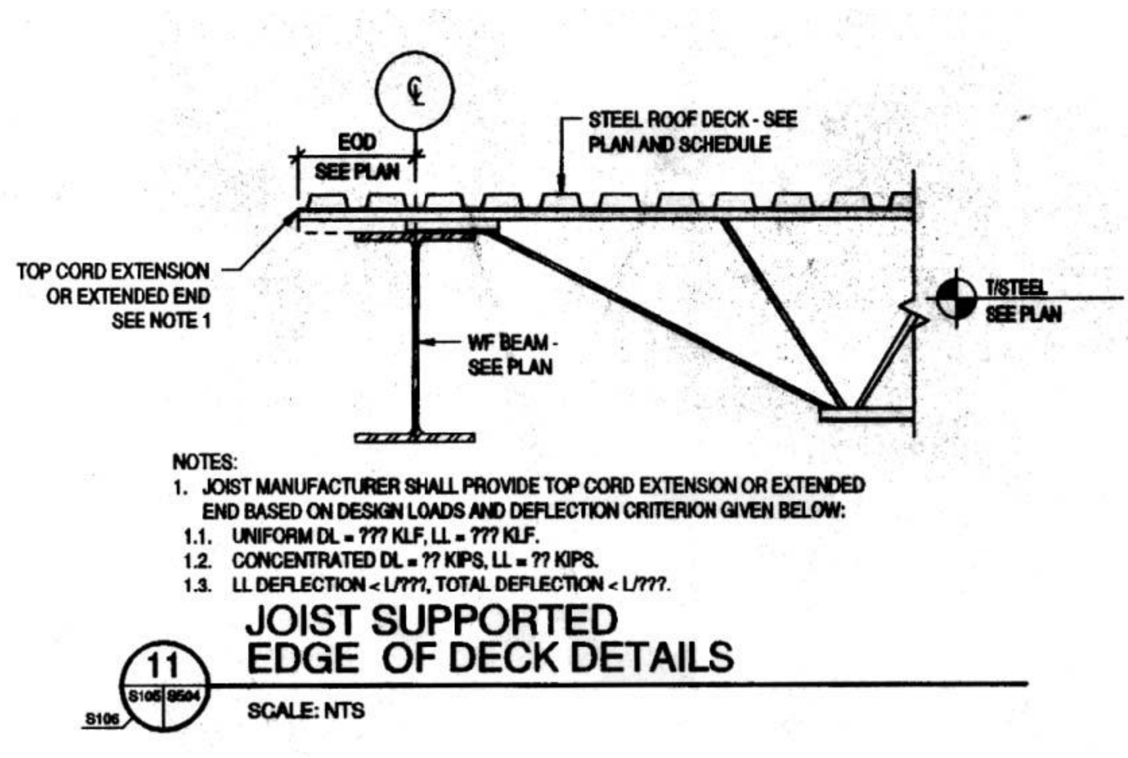


Drawing 21. Roof Structure New Floor Plan



Summary

The new joists supporting the roof on the edge of skylight eliminate the truss protruding through the center of the skylight. The load analysis on the beams used Table 3-23 of the AISC Construction Steel Manual to simplify calculations for loads and Table 3.2 of the AISC Steel Construction Steel Manual was used to size the members to their proper sheer and moment strength. The diagram bellow illustrates the details of the connection from the joist to the truss system.



Drawing 22. Joist Connection to Truss

Breadth II – Skylight Mechanical Analysis

Description

The addition of skylights in the Auxiliary Gymnasium will impact the amount of cooling needed to supply this space. This analysis will look at the new amount of cooling required with the addition of solar heat gain into the space. A Trane Trace model was built to simulate this situation and the results will dictate whether or not the specified chiller will be able to handle this new load.

The existing chiller was designed to meet all peaks at the same time, which will never occur in cooling mode due to usage of spaces and the sun's solar position. However the classrooms will peak in the middle of summer and the Fitness and Weight room will peak in the fall due to the high amount of glass in the space and solar position. The overall peak demand for the entire building is 204 tons of cooling.

Specified Chiller

Manu.	Unit Tag	Model #	Capacity (Tons)	Total kW	Volt	Min. Amp
York	CH-1	YCIV0227PA46	213.7	260.6	480	392

Table 43. Existing Chiller Schedule

Trace Model

The Trace model consisted of two identical rooms with the same material, occupancy, airflow, and lighting parameters of the Auxiliary Gymnasium. The only difference between the two rooms is that one room includes the twelve 8'-0" skylights. Below are screen shoots from the Trace outlining the parameters.

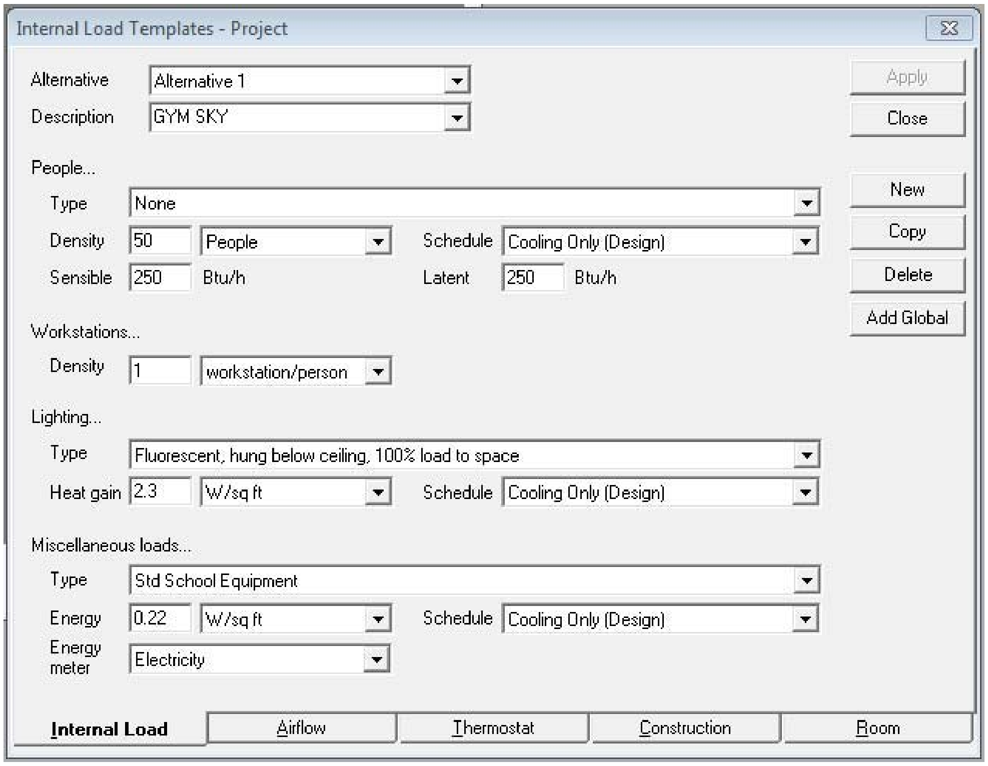


Image 26. Trace Internal Load Tab

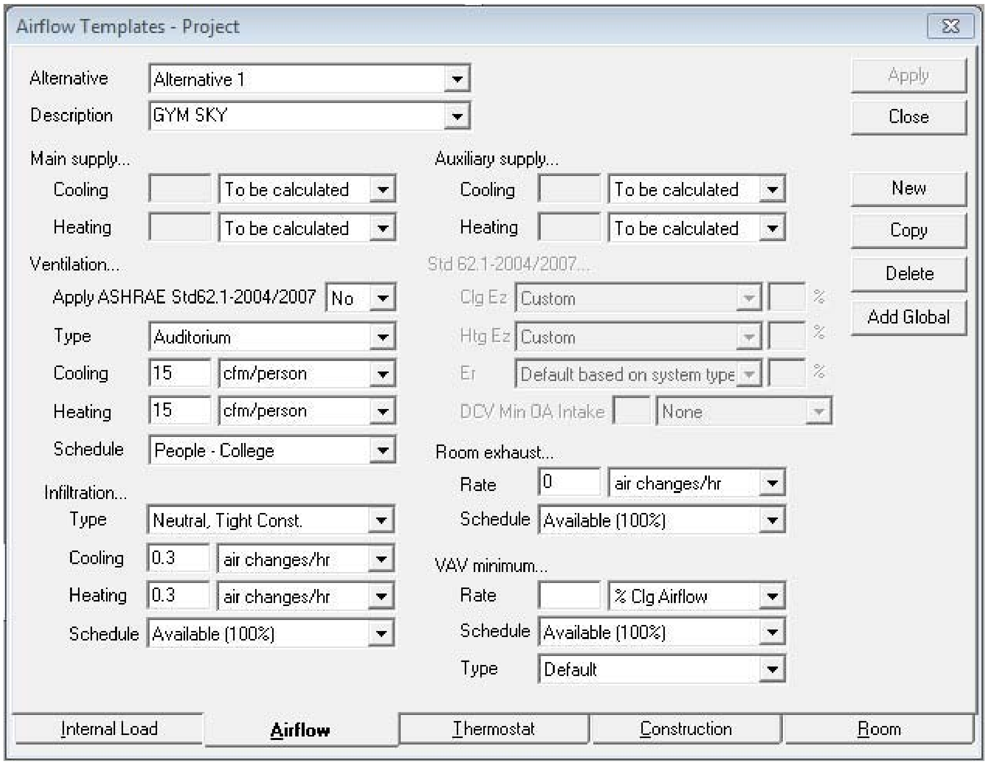


Image 27. Trace Airflow Tab

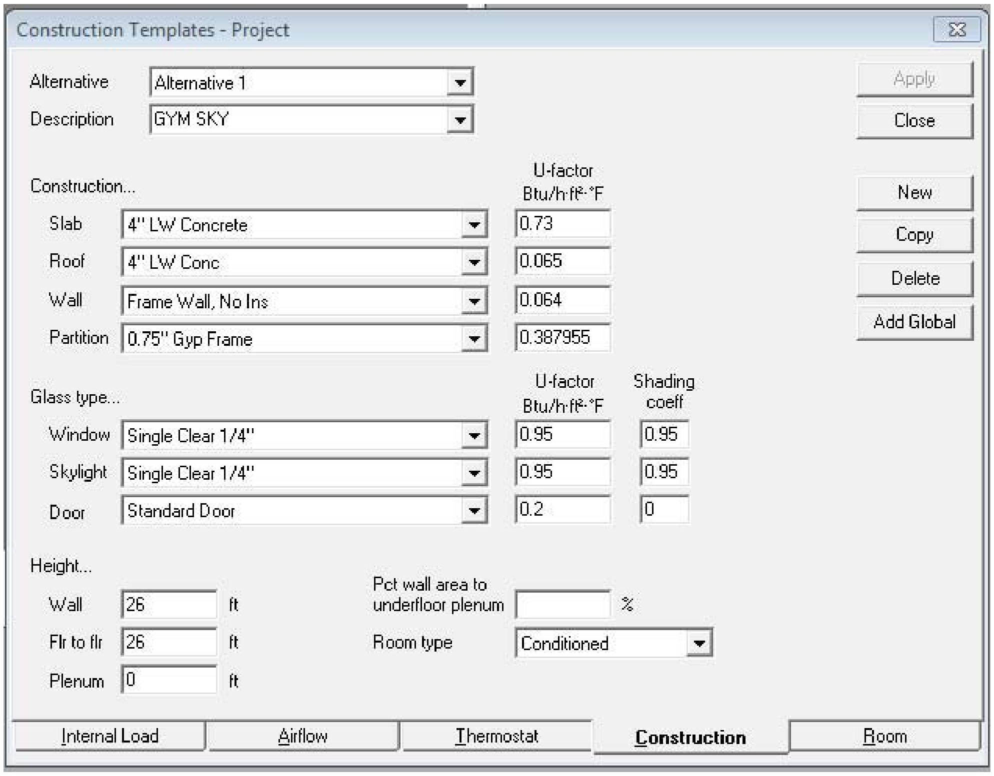


Image 28. Trace Room Construction Tab

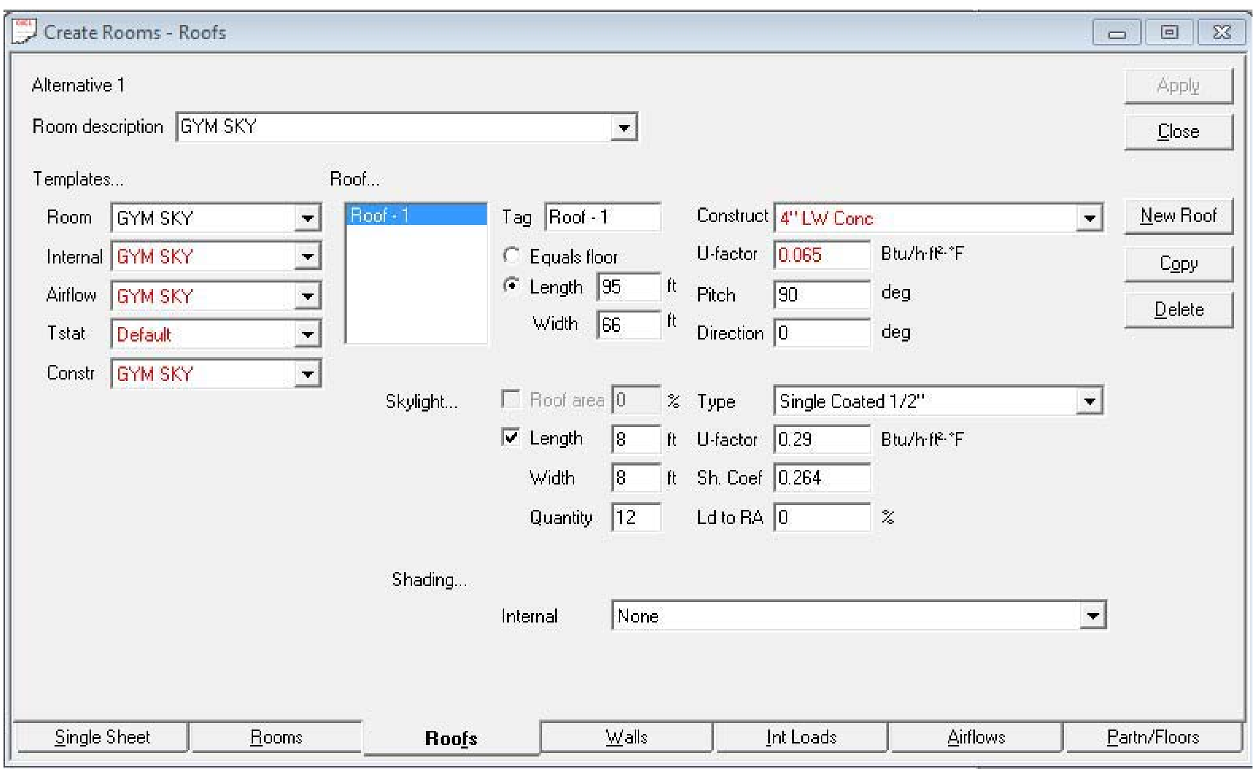


Image 29. Trace Roof Construction Tab

Summary

Originally the Auxiliary Gymnasium required 17.2 tons of the 204 tons of total cooling load on the Susquehanna Center. When skylights were added to the space the cooling load rose to 20.9 tons adding 3.7 tons on the chiller. This addition is then applied to the overall building load of 204 tons, which brings the new peak load of all systems for the building to be 207.7 tons. The specified chiller is capable of a max load of 213.7 tons, meaning that the addition of skylights will impact the chiller essentially, but it will not have to be resized.

COOLING COIL SELECTION

	Total Capacity		Sens Cap.	Coil Airflow	Enter DB/WB/HR			Leave DB/WB/HR		
	ton	MBh	MBh	cfm	°F	°F	gr/lb	°F	°F	gr/lb
Main Clg	17.2	206.0	135.7	4,986	77.4	65.0	73.4	52.9	51.1	53.3
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	17.2	206.0								

Table 44. Trace Cooling Load for NO Skylights

COOLING COIL SELECTION

	Total Capacity		Sens Cap.	Coil Airflow	Enter DB/WB/HR			Leave DB/WB/HR		
	ton	MBh	MBh	cfm	°F	°F	gr/lb	°F	°F	gr/lb
Main Clg	20.9	251.3	181.0	6,831	76.8	64.4	71.2	52.9	52.0	56.6
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	20.9	251.3								

Table 45. Trace Cooling Load for Skylights

Summary and Conclusions

In conclusion, the lighting redesign of the building compliments the festive and exciting atmosphere that surrounds every college athletic facility. The exterior lighting on the façade creates a visual interest into the building by high-lighting the aesthetically fascinating perforated aluminum shades. Once you are drawn to the building you enter in the lobby, which further emphasizes a stimulating atmosphere by accentuating the alternating ceiling mounted wavy pendants and higher illumination levels on a trophy display case. Past the lobby the cove lighting in the Fitness and Weight room greet and invite the visitor or guest into this relaxing open space. Further down the hallway, the Auxiliary Gymnasium's daylight incorporation draws an enlightening appeal, while playing a friendly game of basketball.

The electrical redesign continued to compliment the grandeur of this facility by adhering to power densities, providing adequate protection of electrical devices against short circuits and arc flashes. The Building is seeking LEED accreditation and the electrical design needed to be energy conscience. All lighting designs meet ASHRAE standards of Lighting Power Densities, by incorporating daylight, dimming capabilities, and energy efficient lamps. SKM provided further assurances with an accurate simulation of fault currents and arc flash studies to confirm that the electrical system was protected.

Lastly the two breadths provided additional data on the impact of the addition of skylights in the Auxiliary Gymnasium. The size and layout of the skylights required a redesign of the bracing for the truss system supporting the roof of the space. Also, the addition of solar heat gain impacted the cooling to the space, which required a redesign in the amount of cooling to space and implications to the specified chiller.

Overall the redesign reassures that the Susquehanna Center will serve as the new main attraction on the Harford Community Colleges Campus.

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Thank you to Penn State Architectural Engineering Faculty for the guidance, teaching, and preparation throughout the past five years for this extraordinary experience. Thanks to Professor Robert Holland and Professor Kevin Parfitt for the direction through AE 481W/482. Special thanks go out to:

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Lighting/ Thesis Advisor: Professor Richard Mistrick

Electrical Consultant: Ted Dannerth

Burdette Koehler Murphy Electrical Designer: Larry Fritts

Burdette Koehler Murphy Mechanical Engineer: Jack Stitz

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